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SHORT-TERM TECHNICAL ASSISTANCE TO COIME IN PROJECT IDENTIFICATION, PREPARATION AND PROMOTION
DP/RAS/85/010

Technical Report: Opportunity Study for Formic Acid Plant in ASEAN region (Thailand and Malaysia)*

Prepared for the Committee for Industry, Mining and Energy, ASEAN Secretariat by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development Programme

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I. EXECUTIVE SUMMARY

1.1 Project background and history (chapter II)

A project idea to produce formic acid in the ASEAN region under AIJV was identified during the first phase of DP/RAS/85/010. At its annual meeting in October 1987, the Committee for Industry, Mining and Energy (COIME) endorsed the undertaking of an opportunity study to investigate the financial and technical viability of a possible formic acid plant to be established either in Malaysia or Thailand.

Formic acid is being used in those two countries, mainly in the rubber industry for the coagulation of natural rubber.

The Malaysian Industrial Development Authority (MIDA) approved two applications for formic acid production three years ago. The estimated market size in the ASEAN region at that time was between 17,000 and 20,000 t/y. No follow-up action on these approved applications has ever been taken. In the meantime, an Indonesian company completed the pre-investment study for a formic acid plant to be established in Java and the plant is being launched in September 1988. This plant will produce 10,000 tons of formic acid per year.

Despite this Indonesian development, Malaysia and Thailand have expressed continuous interest in undertaking the approved opportunity study and the decision has been supported by COIME. This report reviews the opportunity of establishing a formic acid plant in these two countries, while leaving the decision on whether it should be established in Malaysia or Thailand in the hand of potential investors.

1.2 Market and plant capacity (chapter III)

The formic acid consumption in Thailand, the Philippines and Malaysia is forecasted as follows:

	1988	1989	1990	1991	1992	1993
Thailand	2,700	3,000	3,300	3,600	3,900	4,200
Malaysia	5,500	5,500	5,500	5,500	6,500	7,000
Philippines	400	500	550	550	550	550
Total	8,600	9,000	9,350	9,650	10,950	11,750

The proposed plant will require at least four or five years lead time until production starts. It would be realistic to consider 1992 as the first year of production. The sales prices are determined on the basis of a fair competitive nature, i.e. 10 per cent lower than one of the present major importers' price for Thailand and applying the latest winning tender price in Malaysia.

The production programmes and prices are set up as follows:

Thailand	Domestic Tonnes	Domestic US$/t	Export to Malaysia and elsewhere Tonnes	Export to Malaysia and elsewhere US$/t
1992	1,750	740	3,250	565
1993	2,450	740	4,550	565
1994	3,500	740	6,500	565
1995	3,500	740	6,500	565

Malaysia	Domestic Tonnes	Domestic US$/t	Export to Thailand and elsewhere Tonnes	Export to Thailand and elsewhere US$/t
1992	3,000	640	2,000	708
1993	4,200	640	2,800	708
1994	6,000	640	4,000	708
1995	6,000	640	4,000	708

It is assumed that the competitive price could bring the sales volume up to the full production level in three years. It would certainly require intensive marketing efforts to substitute the imported products.

The sales promotion costs are budgeted in order to ensure this sales programme. For Thailand, 10 per cent of the domestic sales turnover and 2 per cent of the foreign sales turnover are reserved for sales promotion. For Malaysia, only a standard 2 per cent of sales turnover is reserved for sales promotion since the major domestic sales are derived through tenders. The annual promotion costs for Thailand and Malaysia are US$ 332,450 and US$ 133,000 respectively.

1.3 Materials and inputs (chapter IV)

In Thailand the basic raw material, carbon monoxide, is obtained by reforming natural gas and separating pure CO-gas from it. The cost of raw material and utility for CO-gas thus obtained is US$ 0.138275/Nm^3.

In Malaysia the cheapest CO-gas is obtained by separating it from blast furnace off-gas. The cost of raw material and utility for obtained CO-gas is US$ 0.07184/Nm^3.

Natural gas in Thailand costs US$ 0.1039095/Nm^3.

The blast furnace off-gas in Malaysia is assumed to have zero value and is obtained at no cost.

The cost of raw material to manufacture 10,000 t/y of formic acid (90 per cent concentration) is US$ 974,135/year in Thailand, while it is US$ 609,760/year in Malaysia.

The cost of containers both in Thailand and Malaysia is assumed to be the same and amounts to US$ 302,000 per year.

The price of utilities is more advantageous in Thailand than in Malaysia.

The price of the most important utility, cooling water, is US$ 0.0227/m^3 in Thailand, while cooling water costs US$ 0.16/m^3 in Malaysia (Penang).

Electricity in Thailand costs US$ 0.067 per kWh, while in Malaysia (Penang) it is US$ 0.0576 per kWh.

Thus the total cost of utilities and energy for a 10,000 ton/year formic acid plant in Thailand will amount to US$ 1,164,000/year and in Malaysia (Penang) to US$ 1,844,000/year.

1.4 Location and site (chapter V)

The formic acid plant inducing carbon monoxide and off-sites requires a land surface of 24,000m^2, which is available at all discussed locations. From the point of view of availability of raw materials, utilities and infrastructure, one location was found to be suitable in Thailand: Ma Ta Phut on the Eastern Seaboard and four locations were found in Malaysia. From the viewpoint of the cheapest carbon monoxide and utilities the Malayawata Steel Works, Penang, was chosen as the best location in Malaysia, the other locations being less suitable.

1.5 Project engineering (chapter VI)

The methylformate process has been selected as most suitable for the stipulated capacity of 10,000 t/y of formic acid, because of the low consumption of raw materials and utilities, practically no waste and high standard of unit operation.

Due to different feedstocks, different carbon monoxide processes have been selected for Thailand and Malaysia. In Thailand, carbon monoxide will be produced by reforming natural gas. In Malaysia, CO-gas will be obtained by Pressure Swing Absorption from the existing blast furnace off-gas.

Some problems may be anticipated in licencing. The only potential suppliers of the process are Salzgitter Anlagenbau of the Federal Republic of Germany and CML of the United States.

The total cost of equipment for a plant to be built in Thailand will amount to US$ 14,020,000, of which some 25 per cent corresponding to US$ 4,434,000 will be locally supplied.

The total cost to install the entire plant, including civil engineering, buildings, labour, erection, indirect field expenses and services for the whole formic acid complex (CO + FA plants), will amount to US$ 29,637,000 in the case of Thailand and to US$ 30,328,000 in that of Malaysia.

1.6 Plant organization and overhead costs (chapter VII)

In the case of Thailand, the formic acid plant complex will be managed by a general manager, to whom the FA shift managers, CO-plant manager and technical, marketing and accounting departments will be responsible. In the case of Malaysia the PSA plant will be controlled by the formic acid shift manager. Otherwise, the organizational structure is the same as in the case of Thailand.

One of the major factors of overhead, i.e. repair and maintenance costs of the whole formic acid complex (incl. CO-plant), will amount to US$ 482,000/year in the case of Thailand and to US$ 396,000/year in the case of Malaysia.

Administrative overhead covering general supplies, communication, were calculated as US$ 4,000/year in the case of Thailand and US$ 4,500/year in the case of Malaysia.

Insurance on property amounts to US$ 53,700/year in the case of Thailand and to US$ 53,200/year in the case of Malaysia.

Plant land rent amounts to US$ 24,000/year in Thailand, while it is only US$ 5,160/year for 24,000 m^2 in Malaysia.

The sales promotion costs amount to US$ 133,000/year in the case of Malaysia and to US$ 332,450/year in the case of Thailand.

1.7 Manpower (chapter VIII)

In Thailand, the whole plant (CO + FA plant) will be operated in four shifts and will require 25 persons classified as factory labour and six persons classified as administrative staff, that is a total of 31 employees, 26 of which will be skilled workers. The total labour costs will amount to US$ 138,120/year.

In Malaysia, the total labour and administrative staff for the whole plant will be of 26 persons only (the PSA plant does not require anyone), from which 21 employees will be skilled. The total labour costs in the case of Malaysia will amount to US$ 169,700/year.

A team of four persons will have to undergo training at a reference formic acid plant. The CO-plant requires only in-plant training. The cost for training in the case of Thailand will be US$ 118,000, while it will amount to US$ 154,000 in the case of Malaysia.

The erection, commissioning and start-up of the formic acid complex (CO + FA plant) will require the presence of 20 expatriates in the case of Thailand at a cost of US$ 1,222,000, while 14 expatriates will be needed in Malaysia, at a total cost of US$ 801,000.

In either cases, it is recommended to obtain the assistance of one expatriate during the first year of operations.

1.8 Implementation and scheduling (chapter IX)

Two years before the start-up of the plant, a management team will have to be set up to implement the project.

Labour costs incurred in the implementation will amount to US$ 80,000 in the case of Thailand and to US$ 146,000 in the case of Malaysia.

The time schedule for the CO-plant and formic acid plant is about 33 months.

Total pre-production costs other than equipment will amount to US$ 15,617,000 in the case of Thailand, of which some 44 per cent or US$ 6,799,000 are local pre-production costs. The total pre-production costs in the case of Malaysia will amount to US$ 16,483,000, of which some 52 per cent corresponding to US$ 8,646,000 are local pre-production costs. It will probably require around two years to undertake a feasibility study, finalize negotiations and award the contract.

1.9 Final analysis (chapter X)

A. Total investment costs (US$ 1,000)

	Thailand	Malaysia
Building civil engineering	6,799	8,646
Equipment	14,020	13,845
Pre-production capital expenditure	8,898	7,983
Interest	2,519	2,368
	32,236	32,842

B. Project financing (US$ 1,000)

	Thailand	Malaysia
Equity	8,598	10,908
Foreign loans	19,318	17,248
Local loans	3,520	4,434
Bank overdraft	800	252
	32,236	32,842

C. Total production costs (US$ 1,000)(3rd year of operations)

	Thailand		Malaysia	
	fixed	variable	fixed	variable
Factory costs	853	2,682	628.2	2,956
Other costs				
Administration	97.7		102.5	
Sales and freight		605.15		368.2
Depreciation	1,962		1,988	
Financial charges	1,757		1,606	
	4,609.7	3,287.15	4,324.7	3,322.2

D. Financial evaluation

a. The cumulated cash balance is negative throughout, both for Malaysia and Thailand.

b. Losses for the first five years (US$ thousand)

Year	First	Second	Third	Fourth	Fifth
Thailand	-3,204	-2,617	-1,737	-1,697	-1,656
Malaysia	-2,625	-2,025	-975	-931	-887

c. Net present value and IRR:

	IRR	NPV at cut-off rate of:
Thailand	0.87%	12% = -16,563,880
Malaysia	3.04%	15% = -15,743,320

d. The break-even point is not found in either case.

e. Debt service ratio (net cash-flow/debt service) for the first ten years:

	Thailand	Malaysia
First year	-0.35	0.02
Second	0.53	0.68
Third	0.81	1.15
Fourth	0.96	1.31
Fifth	0.98	1.34
Sixth	1.00	1.37
Seventh	1.02	1.40
Eight	1.04	1.43
Ninth	1.06	1.47
Tenth	0.76	1.08

E. Sensitivity analysis

Alternative I: Higher sales prices

		US$/t
Case I.	Export to Malaysia and others	817
	Domestic to Thailand	667
Case II.	Export to Thailand and others	755
	Domestic to Malaysia	816

	Thailand	Malaysia
IRR:	4.2%	6.38%

Alternative II: Reduced investment (by 20%)

	Thailand	Malaysia
IRR:	2.59%	5.09%

Alternative III: Reduced variable costs: 20%

reduction on CO-gas generation, utility and energy, maintenance and sales promotion costs

	Thailand	Malaysia
IRR:	3.06%	5.07%

Alternative IV: The combination of the above three alternatives

	Thailand	Malaysia
IRR:	7.91%	9.75%

Alternative V: Tax holiday given to alternative IV

	Thailand	Malaysia
IRR:	8.57%	11.21%

1.10 Conclusions

The financial indicators for the base assumption are all negative. It implies that the formic acid plant would not operate profitably either in Malaysia or in Thailand. The reasons for this negative financial implication would be: (i) high initial investment, (ii) low sales prices due to prevailing low CIF prices in both Malaysia and Thailand, (iii) high costs of CO-gas generation and high utility and energy costs to process formic acid. This does not, however, lead to the conclusion that the AIJV project should be dropped and that no further follow-up be envisaged.

The above-mentioned three areas have a good reason to review the possibilities of improvement of the financial profitability. Lower initial investment and variable costs could be achieved through careful and skillful negotiations with suppliers and contractors while higher sales prices could be applied with the Government's support imposing a higher tariff rate.

According to the sensitivity analysis, however, the change of parameters in each area alone does not improve the financial indicators significantly. Combining the three only shows a somewhat remarkable improvement - but not sufficient enough to fully recommend the project for follow-up.

The IRR for both cases is still below the cut-off rate. In Alternative IV, however, it proves that the project would enjoy acceptable debt service ratio. On the basis of this cash generation capability, it would not be too difficult to obtain the loans required in the capital budgeting.

Furthermore, if the Government could provide tax incentives for this project, e.g. 10-year tax exemption, the financial indicators would further improve.

It should be noted that the production programme (sales forecast) has to be further reviewed carefully. The sales projection has been made assuming the originally quoted prices and even the higher prices supported by the higher tariff rate are "competitive" (10 per cent lower than that of competitors' products which are presently being sold and would be distributed in the future by non-ASEAN producers).

On this assumption, it has been projected that the sales volume would reach
10,000 t within three years. In order to achieve this sales volume, a very intensive marketing effort would be required in the first three years of operation. Particularly the Indonesian product which will soon be introduced to the ASEAN market will become a strong competitor although it is not taken into account in this report. If this projected sales volume is not achieved, it will obviously worsen the financial position. The break-even point for both cases in sensitivity 4, in combination with three areas of improvement, indicates that the minimum of 89 per cent and 70 per cent of full production volume in Thailand and Malaysia respectively should be secured. This does not seem to be an easy task.

In summary,

(1) The project with basic assumptions and cost estimation shows negative financial indicators for both Thailand and Malaysia;

(2) These negative indicators are attributable to (i) high initial investment, (ii) low sales price and (iii) high variable costs;

(3) Sensitivity analysis on changing parameters in the above three areas concludes that no drastic improvement can be expected by changing parameters of one single variable (area). The significant improvement could only be made by combining the three areas, i.e. 20 per cent lower initial investment, 20 per cent lower variable costs (selected), and higher sales price assuming the higher tariff rate which would protect the products in question.

(4) Even the above combined assumption shows vulnerable financial indications in both Thailand and Malaysia. However, it may be acceptable for individual entrepreneurs and/or the Government to pursue the possibility of naturalization in view of possible further improvement in its financial terms;

(5) The prices are established at 10 per cent lower than the present competitive prices to ensure the projected sales volume. The forecasted sales volume must be achieved in order to secure the estimated cash generation. A failure would make an extremely negative financial implication;

(6) No significant advantages have been identified to conclude where the plant is to be established, either in Thailand or in Malaysia. Even if the sales forecast in Thailand is increased to 5,000 t/y as shown in Sensitivity Analysis VI, the IRR would only improve very marginally;

(7) In the case that no entrepreneur in Thailand and Malaysia initiates immediate follow-up, possibilities of co-operation with the Indonesian formic acid plant under AITV should be pursued. The situation may be reviewed six months after formal submission of this report.

II. BACKGROUND AND HISTORY OF THE PROJECT

2.1 General outlook of formic acid

Formic acid has been imported and consumed in the ASEAN region mainly for rubber industry and marginally for the tanning and textile industries. Industrialists in ASEAN point out that a potential market in this region would be significant enough to establish a manufacturing facility. The major rubber producers in this region are Indonesia, Malaysia and Thailand. The product imported from the Federal Republic of Germany and other European countries has a concentration of 90 per cent and the one from China is at 85 per cent.

Specifically, the application pattern of formic acid in Malaysia and Thailand greatly differs from that of the industrialized countries where it is mostly used in fodder preservation (silage making), in the textile industry (acidification of vat dyes and as exhausting agent in the dyeing of cotton and wool), chemical synthesis, pharmacy, electroplating, leather tanning and so on.

In Malaysia and Thailand formic acid is mostly used in the coagulation of natural rubber. Here it competes with mineral acids like the sulphuric acid which is stronger and cheaper. The advantage of formic acid stems from the fact that it is safer to use than mineral acid.

The other uses of formic acid in Malaysia and Thailand are in the textile and tanning industries where it competes with acetic acid which is safer to use. However, taking into account that acetic acid is at least 70 per cent more expensive than formic acid and that its acidity is ten times less, the availability of cheap formic acid guarantees future increases in its consumption in industrial sub-sectors. Currently the consumption of natural fibres is steadily growing so that the use of formic acid, especially in the textile industry, will grow all the more since its application does not require as sophisticated an equipment as that of mineral acids in this industrial branch.

2.2 AIJV possibility of formic acid plant

A project idea for the production of formic acid in the ASEAN region under AIJV was identified during the first phase of DP/RAS/85/010. In view of expected larger sales volume between one among participating countries and 90 per cent of marginal tariff preference, it was considered that the AIJV scheme would be very advantageous. At its 1987 annual meeting (Oct. 1987), the Committee for Industry, Mining and Energy (COIME) endorsed the undertaking of an opportunity study to investigate the financial and technical viability of an eventual formic acid plant to be established either in Malaysia or Thailand.

In the meantime, an Indonesian company has completed the pre-investment studies for a formic acid plant in Java with the intention to cover mainly the Indonesian market. The construction will be completed in August 1988 and the production will start in September 1988. Eventually, the plant size was increased to 10,000 t/y. This plant will have excess products which would have to be sold in other ASEAN countries. In addition to this Java plant, Indonesia is contemplating a second 10,000 t/year capacity formic acid plant in Northern Smatora. This project does not seem to be immediately implemented because of various economic reasons.

Despite this Indonesian development, Malaysia and Thailand expressed continuous interest in undertaking the opportunity study. This decision is based on their assessment that the formic acid consumption in these two countries would justify the minimum plant capacity of 5,000 t/year and that future demand would increase to the extent that a plant of 10,000 t/y capacity would be fully justified commercially.

2.3 Purpose of the opportunity study

The manufacturing facility, if it were proven profitable, could be located either in Thailand or Malaysia. The project sponsors in Thailand have not been identified at this stage. The Malaysia Industrial Development Authority (MIDA) undertook a preliminary market investigation and forecasted a total consumption of formic acid in the range of 17,000 to 22,000 t/year for the ASEAN region.

On the basis of this study, MIDA has given approval for the establishment of the formic acid plant to two Malaysian companies. This was three years ago but no specific follow-up action has yet been taken. This opportunity study is aimed at promoting the materialization of formic acid plant either in Malaysia or Thailand under AIJV if proven commercially profitable. The opportunity study in general could investigate various alternatives before moving to the next step, i.e. the compilation of a feasibility study. For instance, even if the financial analysis shows vulnerable aspects for prime assumption, the opportunity study leaves room for further investigations on various alternatives. Thus, reviewing various alternatives would be the essential use of this study.

2.4 Specific remarks on this report

Ascertaining the market size, in this region as well as outside the ASEAN region, would thus be one of the most crucial factors. In addition to Chapter III, an in-depth market study on end-users' aspects in Thailand and Malaysia as well as gathering information on secondary demand and supply in the world market will be carried out separately from this opportunity study and annexed to this report upon its completion.

The other important factor in this study would be the raw material (CO gas) availability and its cost including CO-gas separation costs. Chapters IV to IX explain relevant aspects of both formic acid and CO-gas separation plant separately, since CO gas has to be separated to be used as main raw material for formic acid. These chapters therefore have sub-headings of CO-gas plant and formic acid plant. This means that a CO-gas plant is to be built within the premises of the formic acid plant.

As mentioned earlier, this study will investigate possibilities of establishing a formic acid plant either in Thailand or Malaysia. The cost investigation was carried out for each case. Except for chapter VI: Engineering, each chapter therefore also has sub-headings for Thailand and Malaysia.

III. MARKET AND PLANT CAPACITY

3.1 Guidelines of sales forecast and price determination

The sales forecast of formic acid is derived from the present and past import volume in Thailand and Malaysia and the estimation of future consumption of formic acid in rubber industry mainly in these two countries. In addition, the present import volume in the Philippines and other neighbouring countries such as Sri Lanka and India will also be taken into account as a marginally additional export volume from the proposed plant.

The estimation of future consumption is based on the investigation of the end-user consumption patterns and future growth rate of rubber products - particularly the products which require formic acid for coagulation such as SMR CV and SMR L, SMR LV, SMR 5 and SSR in the case of Malaysia and high quality products equivalent to the similar standard applied for Thailand.

The sales price of formic acid produced from the proposed plant is also a crucial dominant factor in determining the sales volume. The formic acid is presently being imported from Europe and China into the ASEAN region. Indonesian products will be penetrating into Malaysia and Thailand in the near future, as early as 1989. In view of this present and future competitive situation in the ASEAN region, the price to be set up for the proposed formic acid will infuence the sales volume substituting import products to a great extent. Presently, the sales prices of different products in the ASEAN region is rather low, possibly lower than the unit production cost of the originating factories.

No tariff is presently imposed on formic acid in Malaysia and no effects exist on import product protection. For Thailand, it is 20 per cent. One assumption which could be applied in this study is to lift the tariff to the level where the local products ensure the profit from higher sales price. However, the impact on lifting the tariff on formic acid may be extremely significant for rubber industry in both Malaysia and Thailand. Therefore, the study did not opt for the idea of lifting up the tariff rate as a prime assumption to enable the sales price to be set up higher than the present competitive price. However, the higher price range was set-up taking into account reasonably acceptable tariff increase for sensitivity analysis.

3.2 Demand forecast

Table 3.1 shows the import statistics of formic acid in Thailand, Malaysia and the Philippines.

Table 3.1 Import statistics of formic acid (tons)

Country	1982	1983	1984	1985	1986	1987
Thailand	880	953	1,396	1,188	1,402	2,477
Malaysia	4,958	5,516	5,437	6,438	4,340	n.a.
Philippines	227	401	357	232	299	n.a.

3.2.1 Thailand

The drastic increase of the figure, from 1,402 t/y in 1986 to 2,477 t/y in 1987 is attributable mainly to the encouragement of the Thai Rubber Research Institute to use more formic acid in order to improve rubber quality. Small rubber plantation holders in Thailand were not well acquainted with the organized and more effective coagulation process. There is an eminent trend towards improvement of rubber products by using formic acid in Thailand.

Table 3.2 Future prospect of NR products in Thailand

	1986	1987	1988	1989	1990	1991	1995	2000
Production (1,000 tons)	792	936	872	913	954	1,000	1,217	1,325

Source: Thai Rubber Research Institute

As shown in table 3.2, the natural rubber products in Thailand will grow to the level of 1,325,000 t by the year 2000. It is almost 70 per cent of the net growth as compared to the 1986 figure. It may be too optimistic to assume that the above-mentioned increase will continue in 1987 along the increase of natural rubber production. It may have to be rather conservatively assessed with respect to the recent hike of latex concentration price and the eminent corresponding shift of rubber production to this product. Latex concentration does not require formic acid.

In addition to the consumption of formic acid in the rubber industry, it is assumed that about 15 to 20 per cent of the consumption is derived from textile and tannery inustries in Thailand. This segment may increase constantly. Taking into account the above statistics and exported trend, the formic acid consumption in Thailand is forecasted as follows:

	1987	1988	1989	1990	1991	1992	1993
(t)	2,400	2,700	3,000	3,300	3,600	3,900	4,200

3.2.2 Malaysia

Table 3.1 shows an eminent decrease in formic acid import in Malaysia. This is mainly attributable to the above-mentioned shift of rubber products to latex concentration. Another reason might be the carried-over stock when relatively cheap products arrived from China and/or due to the increase of CIF price in 1986 as compared to that of 1985. It seems unrealistic to assume that the total rubber production in Malaysia would increase to meet the demand in latex concentration while keeping the production level of SMR LV and LS, L10 and RSS unchanged in the next several years. Therefore, a gradual decrease of formic acid consumption in the rubber industry is foreseen in the next few years. This trend, however, should not be considered as a constant shift. The trend would change corresponding to the price fluctuation of different rubber products. Taking into account the other uses of formic acid, which have not been studied in-depth in this opportunity study, it is assumed that the consumption of formic acid in Malaysia will come back to the level of 1985 (6,438 t) in five years. In other words, the increased demand for formic acid in textile and tannery may maintain the demand level at 5,500 t/y for the next few years and then reach the level of US$ 6,500 t/y in 1992, to become US$ 7,000 t/y in 1993. The demand forecast is as follows:

Forecast demand for formic acid

	1988	1989	1990	1991	1992	1993
(t)	5,500	5,500	5,500	5,500	6,500	7,000

3.2.3 Philippines

It shows an irregular trend in formic acid import volume in the Philippines. Due to lack of supporting data that would explain clearly its reason, this study assumes that the future demand will be based on this present import volume i.e. approximately 300 t/y. It may grow to the level of 500 t/y. This study did not consider Indonesia as a possible exporting country due to the recent establishment of a formic acid plant in Java which will most likely cover the entire domestic market. The following forecast is made for the Philippines:

	1988	1989	1990	1991	1992	1993
(t)	400	450	500	550	550	550

3.3 Price construction

Table 3.3 shows the CIF prices of competitors in 1986 for Malaysia, Thailand and the Philippines.

Table 3.3 Importers of formic acid in 1986 and their CIF price (US$/t)

	Thailand		Malaysia		Philippines	
	Volume	CIF	Volume	CIF	Volume	CIF
Switzerland	0.15	-	-	-	-	-
China	722	497	528	445	16	485
Fed.Rep.Germany	544	542	2,371	498	108	491
United Kingdom	417	661	215	482	41	439
Italy	101	442	-	-	-	-
Netherlands	62	537	0.3	-	20	470
USA	31	526	142	574	0.1	-
Australia	-	-	0.11	-	-	-
Japan	-	-	40	452	-	-
Singapore	-	-	12.5	519	98	491
People's Rep. of Korea	-	-	947	556	-	-
Hong Kong	-	-	-	-	16	485
France	-	-	-	-	0.02	-
Total	1,402		4,340		300	

3.3.1 Case I: Manufacturing facility established in Thailand

The CIF prices in Thailand are presently centered around US$ 550 and US$ 600/t. One of the importers in Thailand recently placed an order for US$ 600 for 1988. Thailand imposes 20 per cent of tariff and 1.923 per cent of business tax plus 0.195 per cent of municipality tax on imported formic acid at the importers' level. In addition, 3 per cent for handling and transportation charges are borne by importers and roughly 10 per cent of margin is granted by importers.

Thus, the price of formic acid to the large consumption end-users and/or retailers would be approximately US$ 820. It may be practical to deduct 10 per cent from this price in order to substitute the import products with effective price incentives to the existing rubber planters/ /retailers. In other words, the manufacturing plant in Thailand may be able to penetrate and substitute the imported products with the selling price of US$ 740.

The CIF prices to Malaysia fall into the range of US$ 450 to 570. The major consumers of formic acid in Malaysia call for tender once or twice a year. This means that the price incentives for penetration to Malaysian market is not considered since the end-user can change suppliers by a simple economic price advantage due to its tendering nature.

The price finalized in one of the recent tenders is somewhere around US$ 640. The importers in Malaysia should be able to bid lower than this price. Presently, no tariff is imposed on imported formic acid in Malaysia. Therefore, the CIF price should be set up at US$ 565 allowing them 10 per cent of profit margin, plus 3 per cent of handling charge.

The CIF prices to the Philippines do not differ so much from those of Malaysia; therefore, the same selling price to Malaysia was applied for financial analysis.

3.3.2 Case II: Manufacturing plant established in Malaysia

The plant in question will be able to participate in tenders directly without using sales agents. The selling price can thus be set up at US$ 640.

One of the recent CIF prices placed by an importer in Thailand is US$ 600. Assuming the product could enjoy 90 per cent of marginal tariff performance, the competitive price could be set up at 18 per cent higher than this CIF price, i.e. US$ 708.

The CIF prices to the Philippines are slightly lower than those of Thailand. However, the same selling price to Thailand was applied for financial analysis since a very little impact is anticipated in this price difference for the Philippines. The above price determination does not take into account the product which will soon be marketed from the newly established Indonesian plant. Their product may be sold in Malaysia and Thailand at a price lower than the recent CIF prices investigated for the products coming into these countries.

3.4 Tariff consideration vis-a-vis sales price

This study [illegible] not primarily consider the lifting up of the tariff. The rubber industry in Malaysia is one of the key sectors and increase of purchase price of formic acid at the end-users' level will have considerably negative impact. Particularly the recent rubber product mix trend does not grant any possible increase in production costs for the products using formic acid. It may accelerate the shift of the products to latex concentration and RRS. As a result, the future production volume of SMR, CV, L, S, 10 which use formic acid may not be maintained or even decreased against the above forecast. This is also applicable to Thailand. The formic acid price increase will discourage the small rubber plantation holders from its use. The sales forecast made above is therefore on the basis of purely economic competitiveness.

Since the tariff rate is always subject to changes and determined on the basis of political implications, however, the following alternate prices are put forward for sensitivity analysis. Those prices are calculated by adding a net 20 per cent more on the existing tariff. Each price is shown in the following table 3.4 and an example of the calculations is also shown in table 3.5.

Table 3.4 Competitive prices (US$)

		Basic assumption	When higher tariff is applied
CASE I:	Domestic to Thailand	740	817
	Export to Malaysia	565	667
CASE II:	Domestic to Malaysia	640	755
	Export to Thailand	708	816

Table 3.5 <u>Calculation of competitive price for domestic Thailand products</u> (US$ CIF)

	Base case (%)	Assuming a higher tariff[1/] (%)
Tariff	20	36
Business tax	1.953	1.953
Municipality tax	0.195	0.195
Handling charge	3	3
Margin for importer	10	10
	35.148	51.148

US$ 600 (CIF) X 1.35148 = US$ 820 less 10% for competitiveness = US$ 740

US$ 600 (CIF)X 1.51148 = US$ 907 less 10% = US$ 817

3.5 Production programme

It would take at least four to five years to launch the plant for production, even if a decision is made now to follow up this opportunity study for the further feasibility study and eventual start-up stage. As it will be further explained in Chapter IX, the construction period would be 33 months after signing contracts. It would probably take two additional years to complete a feasibility study and all the necessary negotiations prior to the construction start-up. This means that the earliest possible production year would be 1992. According to the demand forecast, the demand in Malaysia, Thailand and the Philippines are as follows:

	1992	1993	1994	....	....
Malaysia	6,500	7,000	7,000	....	....
Thailand	3,900	4,200	4,200	....	....
Philippines	550	550	550	....	....
Total	10,950	11,750	11,750		

The study assumes that the production of 1992 is 50 per cent of fall production, 1993 for 70 per cent, 1994 for 100 per cent and this level will continue. The plant may have difficulties in its sales in the first year. However, it should catch up in the second year at least 70 per cent of full production capacity and reach 100 per cent in the third year by effectively utilizing the sales promotion funds allocated. It requires intensive marketing efforts to materialize the following production programme.

1/ 90% of marginal tariff preference is being applied. Thus, 40% X 0.9 = 36%.

	1992	1993	1994	1995	1996	....
Malaysia	3,000	4,200	6,000	6,000	6,000	....
Thailand	1,750	2,450	3,500	3,500	3,500	....
Philippines	250	350	500	500	500	....
Total	5,000	7,000	10,000	10,000	10,000	

3.6 Sales promotion

It requires a strong sales promotion to penetrate into a new market by substituting the import products.

3.6.1 Case I: Manufacturing in Thailand

In this country, formic acid is directly distributed through importers and wholesalers to the end-users. It appears that business connexions of wholesalers and importers with ultimate end users are strong and price incentive to change products should be significant. Thus 10 per cent lower price is set up as competitive price. In addition, 10 per cent of sales turn-over is reserved as promotional funds. This is the figure used as a yard stick in other formic acid plants in industrialized countries. Export to Malaysia does not require such a high percentage since the product is to be sold to the appointed agent which could be one of the joint-venture partners. Nevertheless, approximately two per cent of sales turn-over is asumed for sales promotion. Thus, the total sales promotion budget required during the full production period would be US$ 332,450.

3.6.2 Case II: Manufacturing in Malaysia

Due to the nature of tendering in practice in Malaysia and possible large volume of sales to estates and corporations holding small planters, only two per cent of sales turn-over is assumed as sales promotion in Malaysia. The same percentage is also assumed for the foreign sales to Thailand because of the same reason mentioned in the above 3.5.1. The required budget would be US$ 133,000 during the full production period.

3.7 Transportation costs related to sales

Case I: Manufacturing in Thailand

Case II: Manufacturing in Malaysia

Sea freight costs are estimated at US$ 30/t between Bangkok and any port on the peninsular island of Malaysia. Furthermore, local transportation for both cases is assumed at 3 per cent of sales turn-over, i.e. US$ 19.2/t for Malaysia domestic transportation and US$ 22.2/t for Thailand.

IV. MATERIALS AND INPUTS

4.1 General description of raw materials

The main raw materials for the selected methylformate process is high purity carbon monoxide (98-99 per cent), methanol and the catalyst. Methanol and the catalyst have tc be bought on the market while carbon monoxide has to be produced on the site.

4.1.1 Carbon monoxide

Carbon monoxide can be produced either by reforming a hydrocarbon feedstock or it may be separated from CO-containing streams. There exist two major feedstocks suitable for CO production. These are from:

1. Conventional sources

- light hydrobarbons as: natural gas, LPG, naphtha,
- heavy hydrocarbons as: fuel oil, heavy residue,
- coal or brown coal.

2. Non-conventional sources

- CO-containing gas streams from the chemical industry
- off-gases from steel industry and other by-product gas streams.

In the case of conventional feedstocks, the CO production plant consists of two process sections, namely: generation of CO syngas, and separation/purification of CO from the syngas.

For the generation of CO-syngas the following processes are available:

- for light hydrocarbons
  - reforming with stream and/or CO_2
  - autothermal reforming with oxygen and steam
  - partial oxidation with oxygen.
- for heavy hydrocarbons
  - partial orxidation with oxygen
- for coal or brown coal
  - gasification with oxygen or air.

In the case of non-conventional sources, only the separation/purification step will be applied eventually resulting in a considerable reduction in plant cost.

For the separation/purification of CO from the gas mixture, the following steps can be applied:

1. a pre-purification step to remove acidic components such as CO_2, water and S-components (COS, H_2S, RSH)

2. a final separation/purification step. The following technologies may be used:

(a) cryogene separation (Cold-Box)
(b) absorption technology (pressure swing absorption - PSA)
(c) membrane technology (MONSANTO prism filter)
(d) reversible complexation such as the COSORB process.

Eventually, the separation processes mentioned in the above two may be combined.

In order to reduce the price of formic acid it is necessary to find the cheapest source of carbon monoxide preferably one of those listed under non-conventional sources, since these do not require setting up costly reforming equipment and are generally cheaper than the conventional sources.

4.1.2 Methanol

Methanol can be bought on the local market both in Thailand and Malaysia. Methanol which is recycled in the process (serves as an agent) is actually the least important raw material as it is needed in quantities not exceeding 300 t/year which corresponds to US$ 58,000/y at full capacity in Malaysia and US$ 52,560/y in Thailand.

4.1.3 Catalyst

The catalyst has to be bought from the supplier of the process. The components of the catalyst are not openly disclosed. It has to be in stock for half a year which incurs a raw material outlay of US$ 75,000/half year to be stored.

At full production capacity, the catalyst cost is US$ 150,000.

4.1.4 Containers

Nowadays, the consumers in Thailand and Malaysia are used to receiving formic acid in 28-litre or 35-litre containers. In calculating the cost of containers the fact has been taken into account that the containers in Malaysia can be recycled so that only 3,000 containers at the a price of US$ 4 have to be replaced each year because of wear and tear (total US$ 12,000/year). The whole quantity of containers needed in Thailand, i.e. 72,500 pieces/y at an annual cost of US$ 290,000/year is unrecoverable. Thus the total cost of containers amounts to US$ 302,000 per year.

4.2 Sources of CO gas

Thailand

In Thailand, a non-conventional source of CO-gas was not identified and the only possibility found was to reform the available natural gas at the Ma Ta Phut Industrial Complex. Since inexpensive oxygen is not available, the autothermal reforming of natural gas was not chosen.

Natural gas is available as treated gas, raw gas I and raw gas II mainly differing in the content of CO_2 (see Annex I). Raw gas I contains 23 per cent CO_2 and raw gas II contains 14.57 per cent CO_2. Thus both gases are suitable for CO_2 reforming.

Since the 10,000 t/y formic acid plant needs about 600 Nm^3/hour CO gas which is quite a small quantity, it is necessary to choose the cheapest reforming and separation process which makes use of the CO_2 present in the gas.

Such cheap alternative presents the combination of the CALCOR C process of the Caloric Company of Munich, Fed. Rep. of Germany, and the Cold Box separation process of LINDE, Munich Fed. Rep. of Germany (see Annex II.2). There is no need to pre-treat the gas in a desulphurisation step, since this has been done in the gas pretreatment plant.

In order to decrease the quantity of additional CO_2 needed for the reforming it is recommended to use Raw Gas I as feedstock for the Calcor-C reformer. The necessary quantity of CO_2-gas (about 80 Nm^3/hour) is available at no cost from the PTT's gas separation plant.1/

The price for Raw Gas I has been calculated on the ratio of the price for natural gas (US\$13.5/10^6 Kcal) and the heating value of the gas (7,697 Kcal/Nm^3) to be US\$ 0.1039095/Nm^3.

The plant capacity was set up according to the available offers from Caloric and Linde to 830Nm^3/hour 100 % CO-gas. The purity of the produced gas is 99.16 per cent CO in the gas. Taking into account the formic acid plant needs, 566 Nm^3/hour CO gas, the Co-plant has about 40-45 per cent reserve.

Besides the CO gas product, the plant produces 462 Nm^3/hour H_2-rich gas containing 85.05 mol % H_2, and 10.76 mol % CO. This gas will be either burned or sold to the ammonia plant which is being planned in the framework of the fertilizer complex. This gas has been assumed in the present calculation as having zero value.

Malaysia

In Malaysia there are several non-conventional sources of CO-gas (see Annex III). The most significant source is blast furnace off-gas - BFO containing 25.4 mol % CO, 14 mol % CO_2, 5.5 mol % H_2, 0.7 mol % CH_4, the rest being nitrogen in the Malayawata Steel Company in Penang. The gas is available in sufficient quantity - 192 X 10^6 Nm^3/year at a pressure of 1.35 bar. The CO from this gas may be separated by the "Pressure Swing Absorption" consisting of two units where the first absorbs CO_2 and the second unit separates carbon monoxide. The plant will consume 5,650 Nm^3/hour or 45.2 $10^6 Nm^3$/year raw gas. It will produce 1,000 Nm^3/hour 98 per cent CO-gas and 4,650 Nm^3/hour off-gas containing mostly nitrogen and CO_2. This off-gas may be let out into the atmosphere.

1/ The CO_2 gas available will be desulphurized in the future.

Actually the PSA-plant will act as an antipollution measure, since it will purify the blast furnace off-gas from the toxic component, CO-gas. Since the BFO is currently let out into the air, it has been assumed that it has a zero value.

The description and cost of the PSA-plant are in Annex II.1.

The PSA-separation process has been given priority over the COSORB process because of its simplicity and ease of operation. The price of the produced CO-gas is US$ 0.07184/Nm^3. This is the lowest among other alternative sites which will be described below in Chapter V.

The Malayawata Steel Co. has also another source of CO. This is the off-gas from the basic oxygen furnace. However, this off-gas has proved to contain less CO than expected (8.8 per cent CO against the expected 60 per cent CO). Most probably the Malayawata Steel Co. does not carburate the BOF with butane at all. The composition of the off-gas (see Annex III.1) does not allow for economical separation of the CO.

4.3 Costs of CO gas to the formic acid plant

CO-gas will be generated within the premise of the formic acid plant. The costs of CO-gas consists of (i) cost of natural gas or blast furnace off-gas, (ii) utility and energy cost to produce CO-gas. The details of variable costs of 1 Nm^3 pure CO-gas are shown in Annex IV.

Carbon monoxide will be produced by CO_2-reforming of natural gas by the CALCOR-C process in an independent unit. The composition of natural gas is as follows: C_1-95.72 mol%, C_2-1.85 mol %, C_3-0.02 mol %, O_2-0.45 mol %, N_2-1.96 mol %.

The consumption of natural gas is 600 Nm^3/hour which corresponds to 4,800,000 Nm^3/year. The price of natural gas is US$ 0.1039095/Nm^3.

Unit	Price/unit (US$)	Consumption per hour	Cost/hour (US$)	Consumption per year	Cost/year (US$)
Natural gas Nm^3	0.1039095	600	62.35	4,800,000	498,765

The CO-gas production is 830 Nm^3 as 100 per cent.

In order to produce 10,000 t of 90 per cent pure formic acid, it requires 558 Nm^3 carbon monoxide. The unit cost for CO is US$ 0.138275. This unit cost is derived from calculating the cost of electricity, steam, cooling water, instrument air and Nitrogen. The cost of one ton of CO gas will be US$ 77.1575.

Carbon monoxide will be produced from the blast furnace off-gas by PSA separation in a capacity of 1,000 Nm^3/hour. The composition of the BFO is: CO - 25.4 mol%, CO_2 - 14 mol%, H_2 - 5.5 mol%, CH_4 - 0.7mol%, N_2 - the rest.

Consumption of the blast furnace off-gas is as follows:

	Unit	Price/unit (US$)	Consumption per hour	Consumption per year
Blast furnace off-gas	Nm^3	0	5,650	45,200,000

In order to produce 10,000 t of 90 per cent pure formic acid, 558 Nm^3 of carbon monoxide are required at a cost of US$ 0.07184/Nm^3. The cost of CO gas thus will be US$ 40.176/t.

4.4 Summary of all required raw material costs

The following table shows the raw material costs (US$) for the manufacturing of formic acid by the methylformate process, both in Thailand and Malaysia. It should be noted that, except for carbon monoxide in both cases (Thailand and Malaysia), the catalyst as well as the containers form a substantial portion of the raw material costs.

Thailand

Raw material	Supply1/ source	Specification	Unit	Unit cost	Consumption / t 90% FA	Cost /ton	Consumption /year	Cost /year
A.								
- carbon monoxide	L	toxic gas	Nm^3	0.138275	558	77.1575	5,580,000	771,575
- methanol	F/L	toxic liquid	t	180	0.0292	5.256	292	52,560
- catalyst	F	solid	Kg	6	2.5	15	60,000	150,000
						91.7505		974,135
B. containers								302,000

Malaysia

Raw material	Supply2/ source	Specification	Unit	Unit cost	Consumption per t 90% FA	Cost/t	Consumption per year	Cost /year
A.								
- carbon monoxide	L	toxic gas	Nm^3	0.072	558	40.176	5,580,000	401,760
- methanol	L	toxic liquid	t	200	0.029	5.8	292	58,000
- catalyst	F	solid	Kg	6	2.5	15	60,000	150,000
						60.976		609,760
B. containers								302,000

1/, 2/ L = local
F = foreign

The carbon monoxide cost comprises the cost of the raw materials (natural gas in the case of Thailand and blast furnace off-gas in the case of Malaysia) and utilities. Thus the cost of the utilities needed to produce 1 Nm^3 CO-gas is contained in the carbon monoxide cost. The calculation method is shown in Annex I.

As it can be gathered from the Annex IV, the cost of natural gas makes up more than 50 per cent of the variable costs of carbon monoxide production.

The price of raw material and utility for CO-gas produced in Ma Ta Phut, US$ 0.138275/Nm^3, is higher than the price of CO-gas produced from the blast furnace off-gas in Malayawata Steel, Penang, Malaysia - US$ 0.071840/Nm^3. This price does not reflect export of H_2 off-gas, since it has very little influence on it.

4.5 Utilities and energy

Thailand (formic acid plant)

Local	Unit	Price /unit (US$)	Consumption per ton	Price/ton FA (90%) US$	Consumption per year	Price /year (US$)
Electricity	kWh	0.067	260.0	17.42	2,600,000	174,200
Steam 10-13 bar	t	10.7	7.65	81.855	76,500	818,550
Nitrogen	Nm^3	0.37	18.0	6.66	180,000	66,600
Instrument air	Nm^3	0.02	18.0	0.36	180,000	3,600
Cooling water	m^3	0.0227	468.0	10.6236	4,680,000	196,236
Condensate return	m^3	1	-0.54	-0.54	-5,400	-5,400
Total cost of utilities per year				116.38		1.163,800

The CO-gas plant utilities are contained in the variable costs of the CO-gas which is used as raw material for formic acid. For COMFAR calculations, electricity and steam are classified as "ENERGY" and the rest as "UTILITY".

The total cost of utilities and energy for the formic acid plant in Thailand is US$ 1,164,000 per year.

<u>Malaysia</u> (formic acid plant):

Local	Unit	Price /unit (US$)	Consumption per ton	Price/ton FA 90% US$	Consumption per year	Price /year (US$)
Electricity	kWh	0.0576	260.0	15	2,600,000	150,000
Steam 10-13 bar	t	12.4	7.65	94.86	76,500	948,600
Nitrogen	Nm^3	-	18.0	-	180,000	-
Instrument air	Nm^3	0.01	18.0	0.18	180,000	1,800
Cooling water	m^3	0.16	468.0	74.88	4,680,000	748,800
Condensate return	m^3	1.0	-0.54	-0.54	-5,400	-5,400
Total cost of utilities per year				Σ 184.40		Σ 1.844,000

The total cost of utilities as energy for the formic acid plant amounts to US$ 1,894,000 per year. For COMFAR calculations, electricity and steam are classified as "Energy" and the rest as "Utility".

As far as the cost of the utilities of the PSA-plant is concerned, these utilities are comprised in the variable costs of CO-gas.

<u>Suppliers of raw materials and utilities</u>

All the raw material is available in the ASEAN region except the catalyst which must be supplied by the licensor. Utilities are of local origin.

4.6 <u>Other alternative carbon monoxide sources in Malaysia</u>

Another possibility to produce carbon monoxide is to use the unshifted slip stream from the ammonia plant of the ASEAN Bintulu Fertilizer complex. This alternative does not require generating of CO-gas but only separating it. The most appropriate method of separation is using the COSORB system of the KTI company of Holland which has integrated the COSORB plant with an ammonia plant and has a reference unit in the People's Republic of South Korea. As can be seen in the annexed calculation, even with high prices of cooling water, the COSORB system is able to produce relatively cheap carbon monoxide.

The composition of the slip stream is in Annex III.2.

According to the KTI offer to Chemoproject, Prag, 1984, the integrated COSORB plant produces 99 mol % CO-gas. For 1000 Nm^3/hour CO-gas, 5,862 Nm^3/hour unshifted slip stream are needed. Besides CO-gas, the COSORB unit returns 4590 Nm^3/hour H_2-rich gas (71% H_2) and 95 Nm^3/hour flash gas (64.1% H_2) to the ammonia plant. Taking into account the price for the return product the COSORB-ammonia integrated plant produces quite cheap carbon monoxide. At US$ 0.07986/Nm^3, this carbon monoxide is comparable to the CO-gas produced from BFO in Malayawata Steel.

It should be noted that this scheme of producing 1000 Nm^3/hour CO-gas requires only 1 per cent more fuel, 0.7 per cent more feed to the Bintalu 1000t/day ammonia plant without sacrificing any of its ammonia production. The carbon dioxide quantity will be reduced by 2 per cent.

Sabah Gas Company

The Sabah Gas Company has two possible sources of carbon monoxide:

- Off-gas from the hot briqueted iron plant (HBI-off-gas) which contains 25.2 mol % CO and is available at a pressure of 1.3 bar abs (composition, see Annex III.3).

- Methanol synthesis gas containing 21.75 per cent CO, available at a pressure of 48 bars abs. However, owing to the expansion plans at the methanol plant, this gas cannot be used for the manufacture of formic acid.

The HBI off-gas contains 3 per cent of methane which is very hard to separate from carbon monoxide. Thus PSA alone cannot separate CO from this feedstock. It is necessary to combine a simple PSA-unit consisting of four absorbers with the Cold-Box. PSA will separate CO_2 first and then Cold-Box will separate the CO gas. Another possibility is to use MEA-working for the separation of CO_2 and Cold-Box for the separation of CO. There is also the possibility of using the COSORB system. Prior to the separation the iron particles must be separated in a magnetic filter and hydrogen sulfide must be entrapped in an absorber filled with ZnO.

In any case, it will not be easy to provide CO-gas from the HBI off-gas.

V. LOCATION AND SITE

A formic acid plant, including carbon monoxide plant and off-site facilities, requires an area of about 24,800m² land along with full supporting infrastructure and utilities (electricity, water, steam, etc.). The criteria for selection of such a site are as follows:

1. Availability and access to CO gas,
2. Availability of cheap steam, electricity,
3. Access to market and port facilities for export,
4. Availability of own infrastructures such as telecommunications,
5. Environmental protection.

Investigation of these elements is to be made both in Thailand and Malaysia. In the case of Thailand, Mah Ta Phut is recommended and Penang for Malaysia. The location maps are attached as Annex V and the corresponding details follow:

5.1 Thailand

5.1.1 Ma Ta Phut complex

The Ma Ta Phut complex located west of Rayond (South Eastern seaboard) will be the gas-related and heavy industrial complex served by its own industrial deep-sea port. The Thai Government is providing full supportive infrastructure and utilities along with a waste water treatment facility.

The formic acid plant may well be located next to the national fertilizer complex (NCF), near the petrochemical complex which is presently being built. The NFC will be supplied with methane and raw gas I and II produced at the near-by gas-separation plant. Each of these gases can serve as raw material for the manufacture of CO-gas which is the main raw material.

The site has a railway, road connexions and easy access to the future port. The necessary utilities (water, cooling water, electric power) will be available at the site. Steam and nitrogen may be supplied from the near-by petrochemical complex.

Land may be rented for 30 years at US$1 per m² per year. An urban area supplying manpower will be erected next to the complex.

The location of the site is illustrated on the attached maps (Annex V.1 and Annex V.2).

5.1.2 Alternative locations in Thailand

Another alternative location is Loem Chabang which might have refinery off-gases containing CO. However, because of close distance to the Pathaya resort centre, this location is not recommended for setting up a formic acid plant.

5.2 Malaysia

Four sites have been identified for possible formic acid plant established in Malaysia in view of the availability of CO gas: Malayawata Steelwork in Penang, Bintal ASEAN Fertilizer complex in Bintal, Sabah Gas in Labuan and Perjawa Direct Reduction Steel plant. A brief investigation was made on each site. The most influential factor is the cost of CO gas to be generated. The comparative descriptions are shown in the following Table 5.1.

Table 5.1 Summary of locations and process survey

	Carbon monoxide production		Formic acid
Location	Raw material for carbon monoxide	Carbon monoxide process	Process
1. Thailand:			
- Mah Ta Phut (eastern seaboard)	Natural gas	CALCOR-C reforming and Cold-Box	Salzgitter MF
2. Malaysia:			
- Malayawaha Steel Co, Penang	Blast furnace off-gas	PSA	Salzgitter MF
- Malayawaha Steel Co, Penang	Basic oxygen furnace off-gas	not suitable	- - -
- Sabah Gas	HBI off-gas	PSA + Cold Box or MEA + Cold Box	Salzgitter MF
- Sabah Gas	Methanol synthesis gas	PSA + Cold Box or MEA + Cold Box	Salzgitter MF
- ASEAN Fertilizer Bintulu	Ammonia plant slip stream	COSORB + (MEA)	Salzgitter MF
- Perjewa direct reduction iron	steam reformer gas	insufficient data	

5.2.1 Malayawata Steelworks, Penang

The blast furnace off-gas available at Malayawata Steel Works contains 25 per cent carbon monoxide.1/ There is sufficient space next to the factory to build a formic acid plant. The site has access to the

1/ With today's technology this content of CO is easily recoverable by well known industrial methods.

utilities from the nearby steelworks and access to the port. The land rents for 5 Malaysian cents/sq foot which corresponds to about US$ 0.215/m^2/year.)

5.2.2 Bintulu ASEAN Fertilizer complex, SARAWAK

This is another possible location because of the presence of an ammonia plant which can provide an unshifted slip stream of the reformer gas. This can serve as source of carbon monoxide gas. There is enough available space in No. 6 plot indicated on the attached plant. This bunkering installation will be developed into an industrial site in the near future with all necessary infrastructure. The distance from the ammonia plant is about 1 Km. The cost of electricity and water is the highest among others.

5.2.3 Sabah gas, Labuan, Sabah

Another possibility of location for the formic acid plant is in the Sabah Gas industrial complex comprising a methanol plant and a Hot Briqueted Iron plant (HBI). The HBI off-gas as well as the methanol synthesis gas might be suitable sources of CO-gas. However, it seems to be difficult to separate as far as CO separation is concerned. There is enough space and all necessary utilities are available in the plant and access to the port. The cost of water is lower than at Bintulu but higher than in Penang.

5.2.4 Perjawa direct reduction steel plant

In this plant which is currently idle, there is a free unused reformer which could be adapted to reform natural gas and produce reformed gas rich in carbon monoxide. The present reformer produces syngas containing 20 per cent CO. No other details are known.

VI. PROJECT ENGINEERING

6.1 Scope of the plant

As outlined in the market survey, the formic acid (FA) plant capacity has been stipulated at the lowest economically feasible level corresponding to the production of 10,000 t/y, 90 per cent formic acid concentration. The semi-product carbon monoxide will be produced at a rate of 1,000 Nm^3/hour, 98-99 per cent CO-gas in the case of Malaysia and 1,830 Nm^3/hour in the case of Thailand. This is about 150-180 per cent of the necessary quantity.

Carbon monoxide has to be produced in larger volumes corresponding to at least 130 per cent of FA-plant capacity because of the possible oscillations in the FA output. The remaining free capacity is meant for future FA-capacity increases.

The FA production programme anticipated for the first year is 50 per cent, in the second year 70 per cent and in the third year 100 per cent. This sequence corresponds to future market development and share.

6.2 Plant configuration

6.2.1 Flow diagrammes The formic acid plant consists of:

in Thailand

1. a carbon monoxide generation plant (the CALCOR C unit) and the CO-separation/purification plant (Cold Box);
2. a formic acid plant.

A simplified flow diagramme of the whole plant is shown in Annex VI.1.

in Malaysia

1. a PSA-separation plant
2. a formic acid plant.

Thus, in this case, there is no primary reforming. The PSA-unit caters both for CO_2-removal and carbon monoxide separation.

A simplified flow diagramme of the whole plant is shown in Annex VI.2.

6.2.2 Lay-out

A. Manufacture of CO-gas

Thailand

An example of the lay-out of a CO-plant comprising the CALCOR C and the Cold-Box technologies is in Annex VII.1.

Malaysia

An example of the lay-out of a PSA-plant is in Annex VII.2.

B. Manufacture of formic acid

A typical lay-out of the formic acid plant using the methylformate technology is in Annex VIII.

6.3 Technology

6.3.1 Formic acid technology

The following main processes to manufacture formic acid are available:

6.3.1.1 Formic acid as by-product from butane oxidation

Formic acid is herein a by-product of the manufacture of acetic acid by oxidation of n-butane. This process cannot be applied because of the folllowing reasons:

(1) there exists a more economical method of producing acetic acid - the so-called carbonization of methanol (MONSANTO process);
(2) the formic acid by-product is only 0.076 t/t of the produced acetic acid. A plant of 130,000 t/y acetic acid would be required to produce the necessary 10,000 t/y of formic acid. The ASEAN region does not have such a high consumption of acetic acid.

6.3.1.2 Formic acid from sodium or calcium formeate

Formic acid is produced by decomposing sodium or calcium formate with sulphuric acid, which in turn are manufactured by reacting carbon monoxide with sodium or calcium lye. More than 1.35 t sodium or calcium sulphate are obtained per ton of formic acid. Calcium formate is also a by-product in the manufacture of Pentaerythritol. This method cannot be applied because of high prices of sulphuric acid and sodium lye in Malaysia and Thailand as well as due to the obsolete state of the process. This process was once used in Malaysia and was abandoned in 1983 because of poor economy.

6.3.1.3 Formic acid from formamide

Formic acid is produced by decomposition of formamide with sulphuric acid. For one ton of formic acid (85 per cent concentration) 1,35 t of ammonium sulphate are produced. Ammonium sulphate is used as fertilizer. Formamide is produced by reacting CO-gas and ammonia in the presence of methanol and a sodium methoxide catalyst. This process is operational in Csechoslovakia. With a good price of ammonium sulphate, this process may eventually compete with the more modern methylformate process. A more detailed description of the Formamide process is in Annex VIII.1.

6.3.1.4 Methylformate process

This is a two-step procedure: reaction of methanol and carbon monoxide to form methylformate, followed by hydrolysis to give formic acid and methanol which is recycled. The main raw material is thus carbon monoxide gas and water. This is the most modern and economical process which has been chosen for the purpose of this study (for details, see technical description in Annex VIII.2).

6.3.1.5 Selection of formic acid techno'ogy

As mentioned above the manufacturing pr...s of formic acid based on n-butane oxidation cannot be selected as a suitable process. The sample applies to the methods based on calcium or sodium formate which have the drawback that substantial quantities of sodium or calcium sulphate are formed. Sodium sulphate has limited use in the chemical industry, whereas calcium sulphate can hardly be made use of at all.

Thus, the only two processes to be chosen from are the methylformate process and the formamide process.

The formamide process has the disadvantage of using sulphuric acid and ammonia which are quite costly in the region. Moreover, substantial quantities of ammonium sulfate are obtained (1.3 t per ton of formic acid) as a by-product. Due to the method of formation, this ammonium sulphate is fine-grained and has to be recrystallized so that it may meet the specifications as a fertilizer. This results in high consumption of energy for recrystallization.

Another substantial drawback of this method is the separation of ammonium sulphate from formic acid. This is currently being done in distilling drums which cannot be designed larger than 1 drum for 2,500 t/y formic acid. Thus, 10,000 t/y formic acid have to be designed in four lines. This is the weak point of the process. However, it must be stated that attempts are now being made to redesign the process in two or one line by using the so-called plate evaporator instead of the distilling drums.

Characteristic features of the MF process:

The methylformate process stands out for the following reasons:

- It is a continuous one-line process using as sole raw materials carbon monoxide, methanol and catalyst;

- Formic acid is actually formed by reaction of carbon monoxide and water, methanol being only an agent which is recycled;

- Low consumptions of raw materials and utilities;

- Almost no wastes or by-products are formed in the process;

- There is no need to use sulphuric acid or ammonia which are costly in the region.

Drawbacks of the MF process:

- Necessity to use sophisticated construction materials like high-alloy steels;

- Requires skilled operators because of complicated unit operations.

However, these problems have been fully solved nowadays. In view of the above, it is concluded that the methylformate process is the one to be used for manufacture of formic acid in Thailand and Malaysia.

6.3.2 Carbon monoxide technology

Since CO is the main raw material, it has to be produced cheaply. An outline of the main processes used in CO manufacture is explained below (more details are also given in Chapter 4):

6.3.2.1 Reforming natural gas by CO_2, using the CALCOR-C process.

Basically this process consists in reforming the hydrocarbons contained in natural gas by the CO_2 present in the gas itself and in the flue gases from the firing and subsequent recovery of CO_2 by scrubbing with MEA-solution. Raw CO-gas is then concentrated in a Cold-Box unit. The process is cheap and has high carbon yield. Thus it has been chosen because of high content of CO_2 as the process to be used for the Mah Ta Phut, Thailand Natural Gas reforming.

The only disadvantage of the process is corrosion caused by the decomposition of methanolamine through O_2 present in the flue gases.

6.3.2.2 Separation of CO-gas from off-gases

Pressure swing absorption

CO-gas may be recovered from blast furnace off-gases, basic oxygen furnace off-gases or direct reduction of iron off-gases by the so-called Pressure Swing Absorption process (PSA) which uses molecular sieves and change in pressure to separate CO-gas. The process is fully automatized and almost barely needs any maintenance. That is why it was chosen to separate CO-gas from the blast furnace off-gases available at the Malayawata Steel Co. Works in Penang, Malaysia. PSA may also be used to separate off-gases from the direct reduction of iron available at the Sabah Gas Labuan factory and to separate CO from methanol synthesis gas in combination with a cold-box unit at the same factory.

Depending on the composition of the off-gas, the PSA may be combined with other separation processes like Cold-box or MEA-washing.

6.4 Means of acquisition of the above technologies and licence fees

6.4.1 Methylformate process for formic acid

The formic acid process know-how and licence could be available from the following companies:

- Kemira Oy, Finland:

This company has implemented the original patents of the Leonard Co. USA, claims to be completely independent. Kemira Oy has reference units in Finland, the People's Republic of Korea and India. A new 10,000 t/y FA plant is being started up at Kujang, Indonesia. It seems that the company has fully succeeded in overcoming the teething troubles with corrosion.

The Kemira Oy's licencing fee for a plant of 20,000 t/y of 85 per cent formic acid was FM 10,324,000 in 1984 (Finnish Marks) which corresponds to US$ 1,889,292 (lump sum without royalty payments).

Owing to changes in licencing policy due to erection of a second 10,000 t/y FA plant in Oulu, Kemira Oy may no longer be willing to licence its process.

Since Kemira Oy has most references on the formic acid process, her consumption standards were used in calculating the variable costs.

- Salzgitter Industriebau GmbH, Federal Republic of Germany

The Salzgitter group offers the Soviet process (acquired from Licencintorg and developed by the National Scientific Research and Design Institute of the Chlorine Industry of USSR) along with engineering, procurement and supply of equipment. The process has been tested out in a pilot plant. A commercial plant of 40,000 t/y FA is presently being started up in Saratow, USSR.

Salzgitter is willing to supply the process and readily supplies any data. All calculations therefore have been based on the Salzgitter data. However, these data have been slightly modified in order to make them more realistic. The modification were especially based on comparing with other processes, especially the Kemira Oy process.

The licence fee of Salzgitter for Thailand or Malaysia may amount to US$ 1,634,000, which is a lump sum cost without royalty payments. This fee concerns the 10,000 t/y, FA-plant capacity.

- CHEMTECA Management Limited (CML) USA

The CML is the follower of the Halcon-Scientific Design - Bethlehem Steel Group which jointly developed the known methylformiate process for the manufacture of formic acid. Leonard Co. and Kemira Oy have allegedly infringed the Halcon-Scientific Design-Bethlehem Steel patents. THe CML has no reference units, however, the Kemira's Oulu plant in Finland and the South Korean plant are said to have been supervised by Dr. Williams of the CML group.

The lump sum licence fee for a 10,000 t/y formic acid plant is estimated at US$ 250,000. This price has been derived from the cumulative price of licence plus basic engineering which amounts to US$ 750,000.

- BASF, Federal Republic of Germany

This company is the biggest producer of formic acid according to their own process. The total capacity of the two BASF formic acid plants amounts to 150,000 t/y. The smaller plant is said to have been closed, the larger plant being operated at 70 per cent capacity. BASF is the largest exporter of formic acid in the world and also in South-East Asia. BASF is not willing to licence its process.

6.4.2 Carbon monoxide generation and separation processes

Thailand

CALCOR-C natural gas CO_2 reforming process and Cold Box separation process

The owner of the CALCOR-C process is the Caloric Company, Fed. Rep. of Germany. The Cold Box separation process may be supplied by several companies like Union Carbide, Austria and Linde, Fed. Rep. Germany.

The Caloric Co. would require a lump-sum licence payment of US$ 120,000 for the CALCOR-C process. The Linde Co. would require a lump-sum licence fee amounting to US$ 80,000 for the Cold-Box process.

Malaysia

PSA separation process

The so-called polybed separation process suitable for the separation of CO from the BFO is owned by Linde of the Fed. Rep. of Germany and Union Carbide, Austria.

The lump sum licence fee for a capacity of 1,000Nm³/hour 99 per cent carbon monoxide would amount to US$ 150,000.

6.5 Equipment

6.5.1 CO-gas generation and separation/purification equipment

The plants in Thailand and Malaysia substantially differ in the CO-gas generation and separation equipment. In Thailand the CALCOR-C reformer is used for CO generation and the Cold Box unit for separation//purification.

In Malaysia, only a PSA-unit is needed to separate CO-gas from the blast furnace off-gas.

Thailand

Table 6.1 The CALCOR-C reformer and Cold-box unit equipment (US$ 1,000)

CALCOR-C	Foreign	Local	Total
- CO-gas production equipment 1/	2,443		
- CO-gas purification equipment 2/	1,585		
- Total mechanical equipment	Σ 4,028		4,028
- Electrical equipment 3/		262	262
- Spare parts	190		
- Maintenance costs 3% of B.L. equipment costs		128.7	

1/, 2/, 3/ The break-down of equipment is described in Annex IX.1.

6.4.1.2 Malaysia

The PSA-separation plant equipment is shown in the following table:

Table 6.2 PSA-separation plant equipment
(US$ 10,000)

Equipment	Specification	Foreign	Local	Total
Compressors:				
- feed to CO_2-absorber	piston, 550 KW, P_s = atm. Pd = 7 bar abs, 2,500 Nm^3/hour	600		
- vacuum pump	roots, 130 kW, P_s = 0.2 bar abs Pd = 1 bar abs	410		
- product compressor	3-stage piston, 460 kW P_s = 1 bar abs Pd = 35 bar abs	1,931		
Other equipment:				
- CO_2 absorbers	4 pieces		1,176	
- CO absorbers	4 pieces			
- product tank	1 piece			
- buffer tank	1 piece			
- knock-out drum	1 piece			
TOTAL		2,941	1,176	

Spare parts: The PSA plant requires practically no spare parts during the lifetime of the unit.

Maintenance: The maintenance cost is very low and amounts to 1 per cent of B.L. equipment cost, that is US$ 42,000/year.

6.5.2 Formic acid production equipment

Since the same technology has been chosen both for Malaysia and Thailand, the production equipment is also identical. For the purpose of this study, it is assumed that the cost of the equipment produced locally is the same.

Table 6.3 Formic acid equipment cost (US dollars)

Equipment	Foreign	Local	Total
1. Formic acid			
- apparatus and equipment + spare parts	4,099,340	547,660	
- insulation and paints	-	117,640	
- piping	-	1,764,700	
- electrical parts	588,230		
- control and instruments	1,764,700		
Σ machinery and equipment + instruments (production equipment)	6,470,000	2,430,000	8,900,000
- cooling water tower		210,000	
- steam generation		353,000	
- chilled water		89,000	
- tanks		176,000	
Σ off-sites (auxiliary equipment)		828,000	
Σ total machinery equipment including instrumentation and off-sites	6,470,000	3,258,000	9,728,000

Spare parts for formic acid: amount to about 3% of B.L. investment that is about US$ 300,000/year.

Maintenance of FA-plant: US$ 353,000/year (3.6% of machinery and equipment including off-sites and instrumentation)

Detailed cost of equipment is found in Annex IX.2.

6.5.3 Procurement of equipment

The necessary equipment is available in Europe, America, Japan as well as in Taiwan, Province of China. Part of the equipment especially steel structures, tanks, simple vessels, electrical equipment etc. may be supplied locally. The crucial equipment on which guarantees depend is generally selected and supplied by the supplier of the process. Thus, the CALCOR-C process equipment may be best supplied by the CALORIC Co. of Fed. Rep. Germany. The PSA equipment may be almost integral supply of Union Carbide of Austria or Linde of Fed. Rep. of Germany. The Cold-Box unit may be supplied by a number of companies all over the world.

Because of guarantees and problems with maintenance and corrosion, it is necessary that the supply of formic acid equipment be closely linked with the supplier of the process. In this case, supply of equipment may depend on the selection of the process as well as selection of the general contractor. If the Soviet process is selected then the equipment will be supplied by Salzgitter Anlagenbau of Fed. Rep. Germany who has acquired the rights to sell the process. If the CML or Kemira processes are selected, the equipment may be supplied by any renowned engineering company since these process-owners are open to co-operation with any international or local engineering company.

As far as flexibility of operation is concerned, it is known that the formic acid plant may be operated at 80 per cent capacity with 8,000 operational hours during a year. Lower production figures are obtained by decreasing the number of working hours. After successful running-in of the plant, the nominal capacity of the formic acid plant may be intensified by at least 10 per cent. Thus, the formic acid plant will have a production flexibility in a range of 8,000-11,000 t/year.

The CO-gas plant will be operated according to the needs of the formic acid plant. Especially high flexibility of operation shows the PSA plant which can be operated between 40 and 100 per cent capacity.

6.6 Civil engineering works

6.6.1 Site preparation and related cost

The plant will be located in already existing industrial areas, both in Thailand and Malaysia.

Thailand: The construction site is currently being prepaied and will be provided with all utility connexions. Electric power and water will be provided by the public networks. Steam and eventually condensate and refrigeration water will b provided by the nearby petrochemical complex.

In Ma Ta Phut, Thailand, there is a road connexion and railway siding being built. No site preparation costs are envisaged in the pre-production phase but it will be charged to the plant as "rent" and thus be reflected in the production costs.

Malaysia: There are not sufficient data about the Malayawata Steel Works available. However, it can be expected that the steelworks will provide the necessary utilities. Water and electricity will be taken from the public networks. For the same reason mentioned above, no site preparation costs are envisaged for this case either.

6.6.2 Civil engineering works

The unit engineering works will mainly consist of a foundation for chemical equipment and a building containing laboratories and offices.

Manufacture of CO-gas

Thailand The CO-plant will be located in open air on a foundation consisting of driven piles and a reinforced concrete grating finished with reinforced concrete slabs on which a steel structure with equipment will stand.

There will be a utility building provided.

The foundation for the CO-plant and the utility building will cost US$ 302,000. The erection costs will be US$ 32,000. The erection cost is low since part of it is included in foreign equipment supplies. Both are local costs.

Malaysia: The PSA-separation plant will be erected in the same open-air manner mentioned for Thailand. In addition, there will be a small one-floor control room building (10 m x 5 m).

The foundations with the control room building for the PSA plant will amount to US$ 300,000 (local currency component).

The erection work will cost US$ 765,000. The necessary steel structures will cost about US$ 500,000. Both are local costs.

Formic acid plant

It is supposed that in both Thailand and Malaysia the civil engineering works will be similar.

The civil engineering works will mainly consist of providing the foundations for the formic acid plant consisting of driven piles and a reinforced concrete grating finished with reinforced concrete slabs on which the formic acid structure with equipment will be located. Thus the equipment will not be covered and will stand in open air.

There will be a one-storey (two floors) building with spaces for laboratories, offices, sanitary installations and maintenance (instrumentation, electrical, mechanical).

The total costs for civil engineering, steel structures and the building plus office equipment will be local and will amount to US$ 2,2670,000.

The erection work will be local cost and amount to US$ 2,100,000.

6.7 Waste materials and by-products

6.7.1 Formic acid process (Thailand and Malaysia)

The formic acid process using the methylformate technology is actually a non-waste process, since off-gas from the methylformiate synthesis is a by-product which can be burnt as fuel. Recycle condensate is recycled into the energetic system.

The only non-utilizable waste from the formic acid production is the degraded catalyst which has to be disposed of in a quantity totalling 36 t/year. The composition of the catalyst is a protected property of the owner of the process. It may be expected that the degraded catalyst will be harmless.

6.7.2 Manufacture of CO-gas

Thailand:

The CALCOR-C process produces 100 kg/hour waste water which has to be neutralized in a small neutralization station. The cost of this neutralization station is included in the B.L. equipment. The neutralized water will be sent to the nearby biological waste water treatment unit planned by the local authorities.

The Cold-Box unit produces about 462 Nm^3/hour H_2-rich gas (85% H_2). This gas will be burnt in a small waste gas incinerator included in the B.L. equipment. It may alternatively be sent to the future ammonia plant as a source of hydrogen.

Malaysia:

PSA-unit treating the blast-furnace off-gas (Malagawata Steel, Penang)

From this unit some 4,650 Nm^3/hour harmless off-gas per each 1,000 Nm^3/hour of produced CO-gas (99 per cent) will result. This gas has almost no heating value and contains mostly inert components like N_2, CO_2 and very little oxygen, carbon monoxide. It will be vented into the atmosphere without any treatment.

Wastes and by-products are summarized as follows:

A. Formic acid

The following wastes are expected from the formic acid plant both in Thailand and Malaysia.

1.1 Utilisable waste	Quantity
- off-gas from methylformate synthesis with a calorific value between 7.5 and 11 MJ/.Nm^3	1,755 GJ/t
will be used as fuel gas	250 N^3/t
1.2 Recycled condensate from steam condensation	
- with 77% recycle the quantity of condensate is	2.4 t/t
- a part will be used as reaction water for methylformiate hydrolysis	0.4 t/t
- to be returned into the energetic system	2 t/t
1.3 Non-utilisable waste	
degraded catalyst	3.6 kg/t
to be disposed of in a deponie	

B. <u>CO-gas preparation</u>	<u>Quantity</u>

1. <u>Thailand CALCOR-C reforming</u> and Cold-Box separation unit

   - <u>Liquid waste</u>
     Waste water max. temp. 70 per cent to neutralization — 100 kg/hour

   - <u>Gaseous waste</u>
     H_2-gas (85% mol. H_2) to waste gas incinerator — 462 Nm^3/hour

2. <u>Malaysia</u>

   <u>The PSA-separation unit</u>

   - off-gas containing inert compounds (N_2, CO_2, O_2 and traces of CO) — 4,650 Nm^3/hour

VII. PLANT ORGANIZATION AND OVERHEAD COSTS

7.1 Organizational structure

Thailand: The organizational structure of the Ma Ta Phut formic acid factory is proposed in Annex X.1.

Malaysia: The organizational structure of the Malayawata formic acid factory is proposed in Annex X.2.

7.2 Overhead costs

The overhead costs are twofolds: (1) factory overheads, (2) administrative overheads.

7.2.1 Factory overheads. Those to be considered in this chapter are maintenance and rent costs only.

Repair and maintenance

It has been assumed that they are not totally fixed. Particularly in the first two years oi operation, the maintnance costs are lower than those of the full production years.

Thailand: FA plant: Because of high corrosion, maintenance costs make up 3.6 per cent of machinery and equipment including off-sites and instrumentation and amount to US$ 353,000/year.

CO plant: Maintenance costs make up 3 per cent of battery-limit costs and amount to US$ 128,700/year (due to high corrosion).

The total maintenance and repair costs amount to US$ 482,000/year.

Malaysia: FA plant: Maintenance and repair costs amount to US$ 353,000/year.

PSA-separation plant: Maintenance costs make up 1 per cent of B.L. equipment costs, that is US$ 42,600/year.

The total maintenance and repair costs amount to US$ 396,000/year.

7.2.2 Administration overhead

7.2.2.1 General

These overhead costs include communication, office supplies, etc. and are calculated as 10 per cent of wages of administrative labour, i.e. US$ 4,000/year for Thailand and US$ 4,500/year for Malaysia.

7.2.2.2 Insurance on property

Insurances have been calculated at the rate of 0.35 per cent of total battery-limit equipment and at the rate of 0.145 per cent of the building value.

<u>Thailand</u>: The insurance cost <u>on equipment</u> is (corresponding to US$ 14,020,000 of equipment value).	US$ 49,000/year
The insurance cost <u>on buildings</u> is (corresponding to US$ 3,242,000 of building value).	US$ 4,700/year
Total insurance cost	US$ 53,700/year

<u>Malaysia</u>: The insurance cost <u>on equipment</u> is (corresponding to US$ 13,845,000 of equipment value).	US$ 48,500/year
The insurance cost <u>on buildings</u> is (corresponding to US$ 3,242,000 of building value).	US$ 4,700/year
Total insurance cost	US$ 53,200/year

7.2.2.3 <u>Rents</u>[1]/ The plant will be located in a selected industrial zone or estate which will provide production and office premises on a rental basis. The rent differs from region to region.

<u>Thailand</u>: The factory will pay US$ 1/m^2/year rent to the industrial estate authority, which amounts to US$ 24,000/year.

<u>Malaysia</u>: The factory will pay US$ 0.215/m^2/year (correspnding to cM5/sq. foot) rent to the industrial estate authority. This amounts to US$ 5,160/year.

1/ For COMFAR calculations, this cost is included in factory cost since the factory premises are much larger than the office premises.

VIII. MANPOWER

8.1 Factory and administrative labour

8.1.1 Formic acid plant: Since the same formic acid process has been chosen for both Thailand and Malaysia, the same composition of staff is proposed.

The plant will be operated in four shifts. The following factory labour and administrative staff are anticipated:

Labour	Level	Administrative	Level
1 driver	semi-skilled	1 general manager	skilled
4 packaging operators	unskilled	1 accountant	skilled
4 operators in plant	skilled	2 marketing executives	skilled
4 control-room operators	skilled	2 secretaries	skilled
2 maintenance engineers	skilled		
1 technician (R+D)	skilled		
4 shift managers	skilled		
Total 20		Total 6	

There will be a total of 21 skilled, one semi-skilled and four unskilled employees required. The outline of responsibilities and required qualifications for each post is shown as Annex XI.

Labour costs: Labour costs have been calculated according to the current salary levels in Thailand and Malaysia (for calculation, see Annex XII).

Thailand:	Factory labour	US$ 72,000/year
	Administrative staff	US$ 39,480/year
	Total	US$ 111,720/year
Malaysia:	Factory labour	US$ 124,000/year
	Administrative staff	US$ 45,000/year
	Total	US$ 169,700/year

8.1.2 Carbon monoxide production

CO production differs in both countries. In Thailand the CO-plant consists of the CALCOR and Cold-Box processes. In Malaysia the PSA-separation plant is sufficient.

Thailand: (CALCOR + Cold Box)

These plants will be operated in four shift operations with the following labour:

Factory labour	Level		Costs (US$/year)
1 plant manager	skilled		7,200
4 shift operators	skilled		19,200
		Total	26,400

The administrative staff will be shared with the formic acid plant.

Malayawata Steel Co., Penang, Malaysia (PSA-separation):

The PSA-plant is completely automatic and will not require any labour. It will be controlled from the formic acid control room. It will be staffed by the administrative staff of formic acid. As to maintenance, it will require 0.1 man/month. This will be covered by the formic acid maintenance labour.

8.2 Training

8.2.1 Formic acid training requirements

Because of the same process to be used, the same training is envisaged both for Thailand and Malaysia. Owing to the complexity of the plant and maintenance, the following training is envisaged:

- practical in-plant training during the construction period for all labour except packaging operators and driver;

- theoretical training and schooling of all labour except driver and packaging operators, in total 15 persons, during a period of four weeks, in formic acid chemistry and plant operation on the model by skilled tutors from the licensor. The licensor will prepare training manuals beforehand.

- a three-week practical training at a reference unit of the licensor for a team of four persons:
  - 2 shift engineers
  - 2 maintenance engineers (mechanical and instrumentation)

8.2.2 Carbon monoxide production training requirements

Thailand (CALCOR + Cold Box)

The four shift operators as well as the plant director will undergo a theoretical and practical on-site training during the construction and test operation phases of the plant.

The cost of training is thus inclded in the supervision cost as explained in chapter IX (under IX.2).

Malaysia (PSA-separation plant)

Even if the PSA-plant does not require any operational staff, since it operates completely automatically, two men of the licencee staff will be trained during two weeks in the following operations:

- filling of the absorbent (technician of formic acid)
- control equipment operation and repair (maintenance labour of formic acid)

This training will be performed during commissioning of the plant.

8.2.3 Cost of training

The costs of training were taken from relevant offers:

- Formic acid (same for Thailand and Malaysia): US$ 118,000 (ref. 9.2.1 and 9.2.2)

- CALCOR and Cold Box (Thailand) (included in licence fee) (ref. 9.2.1)
- PSA-separation plant (Malaysia) US$ 36,000 (ref. 9.2.2)

8.3 Expatriates

A. Formic acid plant (same for Thailand and Malaysia)
The assistance of the following expatriates will be needed:

Phase	Function	Duration (days)
Erection	1 installation supervisor	45
Pre-commissioning	2 expatriates	2 x 30
Commissioning	2 expatriates	2 x 30
Start-up	1 start-up manager	45
	2 process engineers	2 x 30
	2 operators	2 x 30
	1 maintenance engineer	30
One-year of production	1 expatriate	364

The total cost for expatriates except for the assistance during the first year of production is included in the services, under supervision of erection and start-up, and amounts to US$ 765,000 (ref. 9.2.1).

B. Carbon monoxide production

Thailand (CALCOR-C + Cold Box): The following supervision is needed:

Phase	Function	Duration (days)
Erection	1 erection supervisor	75
Pre-commissioning	2 expatriates	2 x 30
Commissioning	2 expatriates	2 x 30
Start-up	4 expatriates	4 x 30

The total cost of supervision is US$ 457,000 and is included in the services (ref. 9.2.1).

Malaysia (PSA-separation unit)

The following services of expatriates are needed:

Phase	Function	Duration (days)
Erection supervision plus adsorbent filling	1 erection supervisor	21
- instrumentation and pre-commissioning - commissioning	1 supervisor	35

The total costs are US$ 72,500, half of which is charged for training.

IX. PROJECT IMPLEMENTATION AND SCHEDULING

9.1 Implementation scheduling

Owing to the complexity of the formic acid plant as well as that of the CALCOR CO_2-reforming plant or the COSORB and Pressure Swing Absorption plant, some 33 months will be needed after contracting. This period will be preceeded by at least two years of negotiations and contracting. During the construction and testing period, a project implementation team will be set up. It will form a task force for pre-production and most likely become the core staff of the formic acid plant after the launching of operations.

This team will consist of the following:

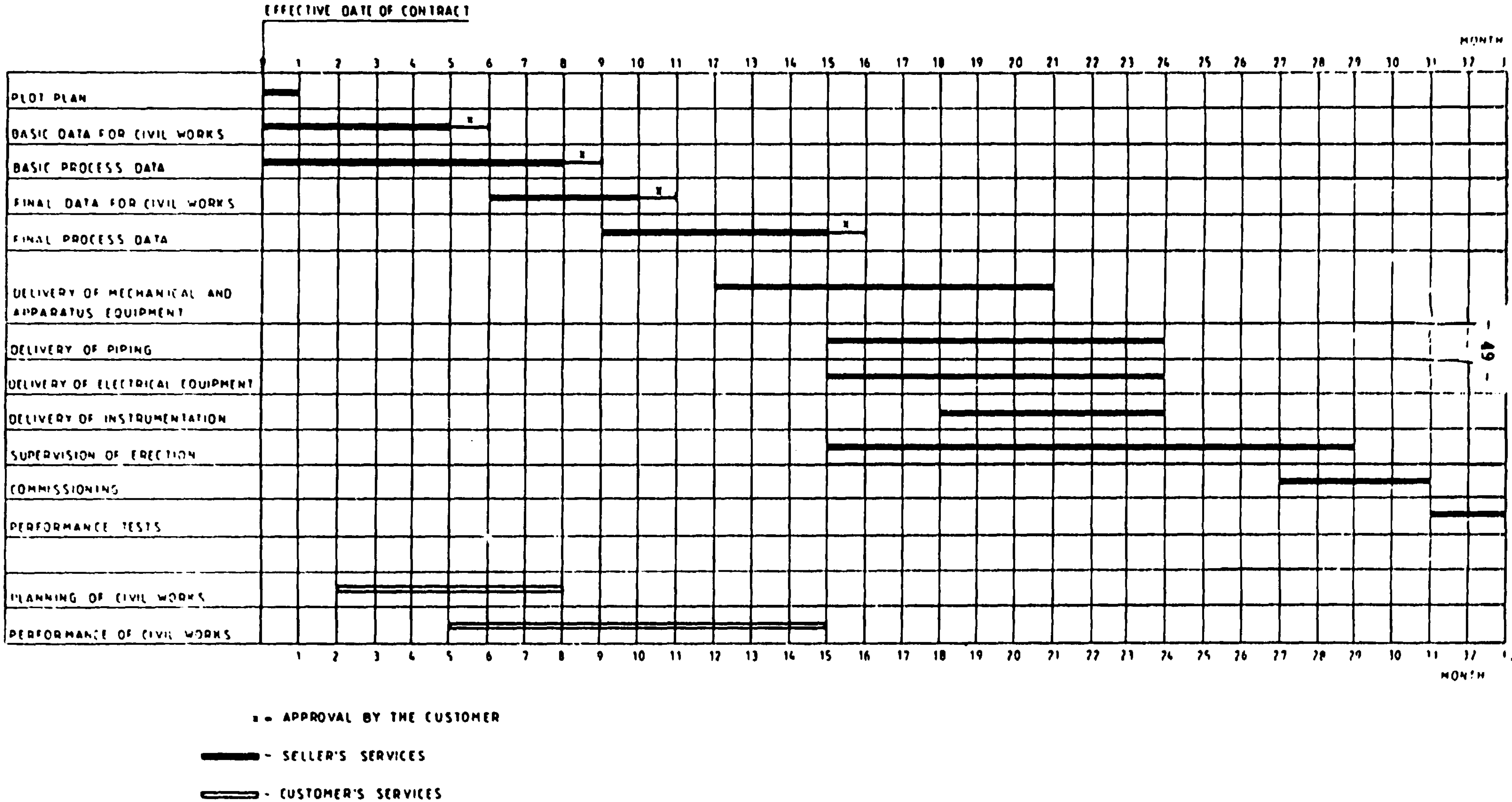
	Salary in US$			
	Thailand		Malaysia	
Functions	Month	Year	Month	Year
2 process engineers	800	9,200	1,100	13,200
1 civil engineer	400	4,800	550	6,600
1 accountant	400	4,800	500	6,000
1 instrumentation engineer	400	4,800	550	6,600
1 administrator	100	1,200	200	2,400
1 marketing executive	320	3,840	1,250	15,000
1 staff recruitor	320	3,840	400	8,800
1 group leader	600	7,[illegible]0	1,200	14,400
		39,360		73.000

These costs will occur in the second, third, fourth and fifth half-years according to the following pattern:

	1st year		2nd year		3rd year	
half-year	1st	2nd	3rd	4th	5th	6th
Thailand	0	20	20	20	20	0
Malaysia	0	36.5	36.5	36.5	36.5	0

A typical implementation schedule for formic acid is shown in the following table:

Table 9.1 Formic acid implementation schedule



9.2 Pre-production expenditures (US thousand dollars)

All pre-production costs, except direct equipment and machinery costs for the CO-gas generating plant and formic acid plant (in Thailand) as well as for the PSA-separation plant and formic acid plant are listed in the following tables.

9.2.1 Thailand

	US$ 1,000 Foreign	Local
CO-gas plant		
- spare parts	190	
- civil engineering materials		211
- direct labour costs:. erection		32
. civil engineering works		91
- ocean freight, insurance, handling		103
Indirect field expenses		
- special site facilities	included in FA plant	
- field office expenses	included in FA plant	
- insurance and miscellaneous	318	36
Services		
- licence fee	200	
- basic engineering	377	
- detailed engineering	969	33
- supervision of general contractor	65	
- vendors supervision	457	
- procurement	242	
Σ CO-gas plant pre-production costs	Σ 2,818	Σ 506

Note: This table corresponds to an actual offer. The erection costs are too low, since part of it is included in mechanical equipment.

	US$ 1,000 Foreign	Local
Formic acid plant		
- spare parts	included in equipment	
- steel structures		753
- civil engineering + structures + office building and furniture		2,670
- travel costs		70
- erection costs		2,100
- ocean freight, insurance, local handling		150
Indirect field expenses		
- special site facilities		200
- field office expenses		300
- insurance	130	50
Services		
- licence fee	1,634	
- basic engineering	1,353	
- detailed engineering and documentation	1,700	
- procurement	300	
- training	118	
- supervision of erection (32 man/month)	471	
- start-up (18 man/month)	294	
Σ Formic acid plant pre-production costs	Σ 6,000	Σ 6,293

	US$ 1,000 Foreign	Local
CO-plant	2,818	506
FA-plant	6,000	6,293
Total pre-production costs for CO plant and FA plant	8,818	6,799

9.2.2 Malaysia

Pre-production expenditures for the PSA plant

	US$ 1,000	
	Foreign	Local
PSA-plant		
- spare parts	0[a]	0
- steel structures		500
- civil engineering materials and work (foundations + control room building)		300
- travel costs		50
- erection		765
- ocean freight, insurance, local handling		100
Indirect field expenses		
- special site facilities		100
- field office expenses		200
- insurance	300	38
Services		
- licence fee	150	
- absorbent filling	144	
- basic engineering	288	
- detailed engineering	800	
- procurement	82	
- supervision, start-up, training	73	
- contingency for miscellaneous local services		300
Pre-production expenditures	1,837	2,353

a/ PSA plant does not need any spare parts.

Pre-production cost for the formic acid plant

The pre-production costs for the formic acid plant in Malaysia are the same as for Thailand, thus:

	US$ 1,000	
	Foreign	Local
Pre-production costs for the formic acid plant	6,000	6,293
Total pre-production costs for CO plant and FA plant	7,837	8,646

X. FINANCIAL EVALUATION

10.1 Basic assumption

The financial analysis has been carried out using the UNIDO Computer Model for Feasibility Study and Reporting (COMFOR) and the result of this model is given in Annex XIII of this report.

10.1.1 Currency and exchange rate

All the figures are converted into US dollars in order to compare two alternatives (Malaysia and Thailand) in a standardized manner. The exchange rate used for that purpose is 25 BH = US$ 1.00 and 2.5 Malaysian Ringgit = US$ 1.00.

10.1.2 Project lifetime

The project is evaluated over a period of 18 years, the first 2½ years being the pre-production period followed by 15 years of production.

10.1.3 Depreciation

The same depreciation method is applied for Thailand and Malaysia, i.e. straight line, for both machinery and buildings, 20 years for buildings and 12 years for machinery and equipment with 10 per cent of salvage value.

10.1.4 Corporate tax

Fourty per cent of corporate (income) tax is applied for both Malaysia and Thailand.

10.1.5 Source of financing

At this stage, no decision has been taken with regard to the capital budgeting. The basic assumption is to finance the foreign equipment and pre-production capital expenditure from foreign loans, the local equipment by a local loan, and the local civil engineering and pre-production capital expenditure from local equity. Since the project will obtain foreign equity because of AIJV status, it is assumed that 20 per cent of equity forms the foreign component. This portion can finance part of the foreign pre-production capital expenditure, mainly interests incurred during the pre-production phase. COMFAR automatically calculates its financial charges during the pre-production phase.

The equity/loan composite (US$ 1,000) is as follows:

	Thailand	Malaysia
Equity share	8,598	10,907.5
Loan composite	22,838	21,682
	31,436	32,589.5
Equity	Thailand: 6,878.4 Malaysia: 1,719.6	Malaysia: 8,726 Thailand: 2,181.5

10.1.6 Loan conditions

Seven per cent of the interest rate is applied to the foreign long-term loan, since this would be somewhat close to the average of the long-term soft loan-interest rates granted by Japanese financial institutions such as OECF, the EXIM bank and the World Bank. An interest of 11.5 per cent is applied to the local loan in Thailand and 10 per cent for Malaysia, following the guidelines of local banks in each country.

It has been foreseen that the project may not generate sufficient cash in-flow to repay the principal in the early stage of the operational phase. Therefore, the amortisation period for the foreign long-term loan is assumed as 25 years and a 10-year grace period.

For the local loan, the conditions prevailing in Malaysia and Thailand are applied, i.e. 10-year amortization period with a 2-year grace period and the same amortization period with a 3-year grace period respectively.

10.1.7 Working capital requirement

The required working capital is calculated on the basis of the minimum coverage of days for current assets and liabilities. The following days of coverage are assumed:

Current assets	Foreign	Local
Account receivables	15	90
Cash in hand	15	15
Raw material (catalyst)	120	-
Other input (container)	-	60
Spare parts	360	-
Finished products	30	30
Current liability		
Account payable	15	30

It should be noted that, since CO gas is generated internally and will not be considered an inventory item, it has not been included in this calculation. COMFAR automatically proportions the foreign and local mission days of coverage in terms of values.

At the full production stage, the level of working capital, US$ 1,578,000 for Thailand and US$ 1,368,588 for Malaysia is required. The difference stems mainly from the full one-year spare-parts requirement, i.e. US$ 490,000 for Thailand and US$ 300,000 for Malaysia, due to different CO-gas separation technologies applicable in each case (ref. COMFAR print-out, Annex XIII.1.1 and XIII 1.2).

10.2 Total initial investment (ref. COMFAR print-out Annex XIII.2.1)

Thailand

The total initial investment is US$ 29,717,000 consisting of US$ 20,819,000 of fixed investment comprising US$ 6,799,000 on building and US$ 14,020,000 for equipment and machinery. Pre-production capital expenditures amount to US$ 8,898,000. In addition, US$ 2,519,390 is required to pay interest during the pre-production phase.

Malaysia

The total initial investment is US$ 30,474,000 consisting of US$ 22,491,000 of fixed investment comprising US$ 8,646,000 on building for formic acid and CO-gas separation plant and US$ 13,845,000 on plant, machinery and equipment. Pre-production capital expenditures amount to US$ 7,983,000 including licencing, training, pre-production costs etc. In addition, the interest during the pre-production phase amounts to US$ 2,367,640.

10.3 Project financing (ref. COMFAR printout Annex XIII.3.1 and XIII.3.2)

In order to meet the investment costs plus interest during the pre-production phase (2.5 years), a total of US$ 32,236,000 and US$ 32,841,000 is required for Thailand and Malaysia respectively.

Assuming that the above-mentioned capital structure finances this project, this initial source of funds does not cover the entire expenditure during the pre-production phase. An additional bank overdraft of US$ 800,390 and US$ 252,141 are required for Thailand and Malaysia respectively. During the production phase, due to shortage of cash-in flow, the following amount of bank overdraft (US dollars) will be required:

	1992	1993	1994	1995	1996	1997
Malaysia	1,626	660	-	-	-	-
Thailand	2,376	832	392	87	46	6

According to the cash-flow of Case I (producing in Thailand), the repayment of the principal may not be possible before the year 2004. Otherwise, additional bank overdraft will be needed in the years 2001 to 2003. No bank overdraft is required from the full production year for Case II (producing in Malaysia).

10.4 Total production cost (ref. COMFAR print-out Annex XIII.4.1 and XIII.4.2)

The total production cost (1994, the first full year of production) apparent in COMFAR schedule is summarized as follows:

	Thailand		Malaysia	
	fixed	variable	fixed	variable
Factory costs	853	2,682	628.2	2,954
Other costs				
- Administration	97.7	605.15	102.5	368.2
- Sales promotion and distribution costs (freight)				
Depreciation	1,962		1,988	
Financial charges	1,757	______	1,606	______
	4,609.7	3,287.15	4,324.7	3,322.2
Total	7,957		7,647	

The breakdown of the factory cost is shown below (US$ 1,000):

	Case I	Case II
	Thailand	Malaysia
Raw material (I)(CO gas and catalysts)	975	610
Containers	302	302
Utility and energy	1,164	1,844
Direct labour	98	125
Repairs and maintenance	482	396
Spares	490	300
Rent	24	5.2
	3,535	3,582.2

There are differences between the two cases on each item but the total factory costs for both cases are more or less the same. The cost of CO gas in Thailand is higher than in Malaysia while the cost of steam (utility and energy) in Malaysia is much higher than in Thailand. This high-utility cost in Malaysia offsets the cost advantage of CO gas, repairs/spare parts and the rent. Thus, the major difference in production costs stems from freight costs and sales promotion costs. The market size in Thailand is about half that of Malaysia and the marketing exercise may require higher sales promotion costs in Thailand.

10.5 Financial evaluation (ref. COMFAR print-out Annex XIII.5.1 and XIII.5.2)

10.5.1 Cash flow

Thailand

The cumulated cash balances are negative throughout. Repayment of foreign loan starting in 2001 cannot be made without employing a bank overdraft. This indicates that a longer grace period may have to be secured. The cash surplus appears only in the 6th year of operation. As shown in the above project financing, the project should use bank overdraft during the first six years of deficit. The payback period is not found. The cash-flow table is shown in the COMFAR print-out (Annex XIII.5.1).

Malaysia

The cumulated cash balance will become positive in the 7th year of operation. Repayment of foreign loan can be made as scheduled, while repayments of local loan starting in the second year of operation would have to be made by short-term bank overdraft or deferred till the third year of operation. The first two years of operation also need US$ 1,625,748 and US$ 659,760 of bank overdraft respectively. The project can only pay back all the initial investment in the 13th year. The cash flow table is shown in the COMFAR print-out (Annex XIII.5.2).

10.5.2 Net income statement

Thailand

The net income statement (ref. COMFAR print-out Annex XIII 6.1 and XIII 6.2) shows losses throughout. Alone the non-variable costs including depreciation almost offset the variable margins in the third year of operation (1994).

Malaysia

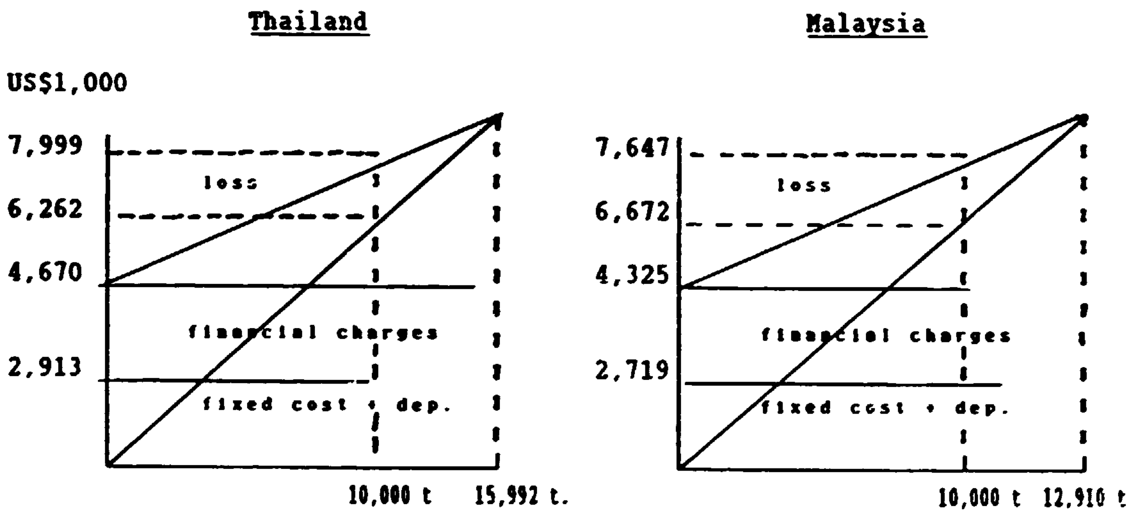
The project only starts generating profit from the 13th year after full depreciation. The cost of finance is much greater than the operational margin. If the loan is reduced by one-third and the interest rate of foreign loan to 2.5 or 3 per cent, the net income statement will show a profit even after the 3rd year.

The summary of the net income status in the third year of operation for both Malaysia and Thailand is shown below:

	Thailand	Malaysia
Total sales	6,262	6,672
Variable cost	3,330	3,322
Variable margin	2,932	3,350
Non-variable costs (including depreciation)	2,913	2,719
Operational margin	20	631
Financial charges	1,757	1,606
Gross profit (loss)	(1,737)	(975)

10.5.3 Break-even analysis

As shown in the chart below, the break-even point is not found in either case for the third year (full production).



at 10,000 t, loss = 1,737

Break-even point = 15,992 t/y

at 10,000 t, loss = 975

Break-even point = 12,910 t/y.

10.5.4 Net present value and IRR

Thailand The net present value of the project at 12 per cent discount rate is US$ 16,563,880 and IRR, 0.87 per cent.

Malaysia The net present value of the project at 15 per cent discount rate is US$ 15,743,320 and IRR, 3.04 per cent.

The sensitivity of IRR is shown in the chart (Annex XIII.7.1 and XIII.7.2). The sales price is the most sensitive one, followed by operating costs and initial investment in that order.

10.5.5 Debt-service ratio

The value of debt service ratio is shown below and the charts are attached as Annex XIII.9.1 and Annex XIII.9.2. Both cases (Malaysia and Thailand) show unfavourable ratio, i.e. never reach the minimum acceptable level of 1.5.

VALUES chart description [STANDARD]

Debt Service Ratio, by year — FORMIC ACID - THAILAND

net cashflow/debt service — BASE VERSION

year	base case
1	-0.35
2	0.53
3	0.81
4	0.96
5	0.98
6	1.00
7	1.02
8	1.04
9	1.06
10	0.76
11	0.79
12	0.82
13	1.01
14	1.04
15	1.07

year

VALUES chart description [STANDARD]

Debt Service Ratio, by year — FORMIC ACID - MALAYSIA

net cashflow/debt service — BASE VERSION

year	base case
1	0.02
2	0.68
3	1.15
4	1.31
5	1.34
6	1.37
7	1.40
8	1.43
9	1.47
10	1.08
11	1.12
12	1.45
13	1.36
14	1.38
15	1.41

year

10.6 Sensitivity analysis

The base versions show negative financial implications for both cases. In order to investigate the possibilities in financial indicators, the major areas on which the sensitivity analysis will focus are: (1) lower initial investment costs, (2) higher sales price, (3) reduced variable costs. In addition, combination of the above three are also looked into in this section.

Sensitivity Analysis I: Higher sales price
(ref. Summary sheet of COMFAR, Annex XIII.9.1 and XIII.9.2).

The following sales prices are applied for the sensitivy analysis:

		(US$/t)
Case I	Export to Malaysia and others	817
	Domestic to Thailand	667
Case II	Export to Thailand and others	755
	Domestic to Malaysia	816

As shown in Chapter III, the original prices were set up according to present competitive prices without lifting up the tariff. However, the prices quoted today in the ASEAN region are lower than those in Europe, the U.S.A. and Japan. The prices may be considered as "unrealistically low". The tariff protection may be justified for that. It should be noted, however, that this increase in sales price may have a significant negative impact on the rubber industries.

	Thailand	Malaysia
IRR	4.2%	6.38%

The above would not make a significant impact to prove the project as financially profitable. However, as shown in the sensitivity of IRR chart (Annex XIII.7.1 and XIII.7.2), the sales price is the most sensitive variable that influences IRR among other variables such as initial investment costs and operating costs.

Sensitivity Analysis II: Initial investment at 20 per cent lower than the base assumption
(ref. Summary Sheet of COMFAR Annex XIII.10.1 and XIII.10.2)

Cost estimations on foreign equipment and pre-production expenditure (mainly licencing, training etc.) are calculated on the basis of offers obtained through suppliers. These are preliminary offers and tend to be higher than actual ones. When negotiations come, the actual costs may be lowered to 80 per cent. Furthermore, it is assumed that costs for civil engineering work with a local contractor could be reduced to 80 per cent through negotiations.

	Thailand	Malaysia
IRR	2.59%	5.09%

This reduction of initial investment alone does not make a significant improvement in the financial indicators.

Sensitivity Analysis III: Reduced variable costs
(ref. Summary sheet of COMFAR Annex XIII.11.1 and XIII.11.2).

Co-gas generating costs, utility/energy costs and sales promotion were estimated at a relatively high level. Particularly, costs of steam, water, electricity were estimated on the basis of standard costs published by the authorities. In fact, these unit costs are negotiable with local authorities during finalization of contractual arrangement. In addition, maintenance costs (50 per cent variable) and sales promotion costs also could be reduced to 80 per cent if the plant can be run effectively. The result is:

	Thailand	Malaysia
IRR	3.06%	5.07%

Sensitivity Analysis IV: Combination of the three parameter changes (higher sales price, lower initial investment, and lower production costs)
(ref. COMFAR Summary Sheet, Annex XIII.12.1 and XIII.12.2).

This sensitivity analysis investigates the results of three different parameter changes combined into one. It would require careful negotiations with suppliers of various equipment and contractors for civil engineering as well as Government support for higher tariff on imported formic acid. This assumption does not seem so unrealistic and could be used as future follow-up guidelines. For this reason, an overall financial analysis is given below.

Total initial investment (US$ thousand)

	Thailand	Malaysia
Total initial investment	23,790	24,262,40
Interests during pre-production period	2,005	1,891.42
	25,795	26,299.82

Source of finance

	Thailand	Malaysia
Equity	6,799	8,745
Foreign loan	15,445	13,798
Local loan	2,816	3,546
Bank overdraft	735	210.82
Total	25,795	26,299.82

Additional financing during production phase

Additional US$ 1,130,920 and US$ 334,166 will be required for the first year of operation in Cases I and II respectively.

Total production costs

Total production costs in the third year (ful production year) are shown below:

	Thailand		Malaysia	
	fixed	variable	fixed	variable
Factory costs	805	2,206	589	2,424
Other costs				
- Administration	98		102	
- Sales promotion and freight costs		539		341
Depreciation	1,570		1,592	
Financial charges	1,404		1,285	
	3,877	2,745	3,568	2,765

Cash flow

Thailand

The cumulated cash balance will become positive in the third year of operation. The project pay back period is in the 9th year. The bank overdraft, US$ 1,156,119 is only needed in the first year. Repayment of the foreign loan can be advanced in order to reduce financial charges.

Malaysia

The cumulated cash balance will become positive in the second year of operation. The project's payback period is in the 8th year of operation. The bank overdraft, US$ 334,166 is only needed in the first year. Repayment of the foreign loan can be advanced even over to the 3rd year of operation.

Net income statement

A summary of the income statement in the third year is shown below:

	Thailand	Malaysia
Total sales	7,195	7,794
Variable costs	2,787	2,764
Variable margins	4,408	5,030
Non-variable costs (including depreciation)	2,473	2,283
Operational margin	1,935	2,746
Financial charges	1,405	1,285
Gross profit	530	1,461

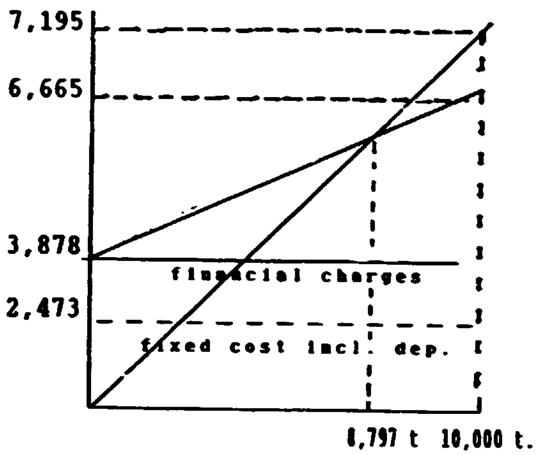
The variable margins (contribution) in the third year are approximately .15 per cent of fixed costs in Thailand, and 140 per cent in Malaysia. This ratio does not ensure an easy profit-making operation in either case.

Break-even point

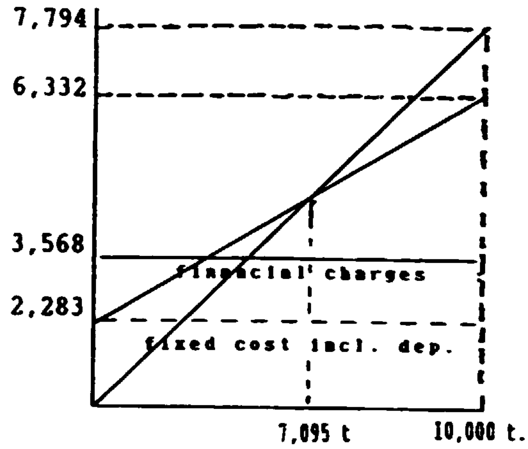
The following break-even point is found in both cases:

Thailand

US$1,000



Malaysia



at 10,000 t, profit = US$ 530,000

Break-even point = 8,797 t/y

at 10,000 t, profit = US$ 1,461,000.

Break-even point = 7,093 t/y.

Both break-even points are relatively high, i.e. 87 per cent and 70 per cent of full capacity in Thailand and Malaysia respectively.

Net present value and IRR

Thailand

NPV with 12 per cent of cut-off rate: US$ -5,359,620
IRR : 7.95%

Malaysia

NPV with 15 per cent of cut-off rate: US$ -6,502,320
IRR : 9.75%.

The IRR will only reach the cut-off rate of 15 per cent by applying additional 20 per cent higher sales price in Case II (Malaysia). For Case I (Thailand), it additionally requires 11.2 per cent higher sales price to reach 12 per cent of IRR cut-off rate for Thailand. It does not seem possible to set up prices at that high level in view of the negative impact on the rubber industry. Charts of IRR sensitivity of this assumption (Sensitivity Analysis 4) are attached as Annex XIII.13.1 and XIII.13.2.

Debt-service ratio

The ratio shown below shows a preferable debt-service position in both cases, i.e. the range falls into 1.5 - 3.0. The project can generate sufficient cash to pay interest and make repayment of loans.

VALUES chart description [STANDARD]

Debt Service Ratio, by year — FORMIC ACID - THAILAND

net cashflow/debt service — SEN.ANAL.4

	base case
1	0.18
2	1.45
3	1.83
4	1.93
5	2.01
6	2.05
7	2.08
8	2.12
9	2.15
10	1.54
11	1.55
12	1.63
13	1.77
14	1.81
15	1.85

year

VALUES chart description [STANDARD]

Debt Service Ratio, by year — FORMIC ACID - MALAYSIA

net cashflow/debt service — SENSITIVITY ANALYSIS 4

	base case
1	0.75
2	1.60
3	2.15
4	2.33
5	2.37
6	2.42
7	2.47
8	2.52
9	2.57
10	1.88
11	1.94
12	2.50
13	2.32
14	2.37
15	2.43

year

Sensitivity Analysis V: 10-year tax holiday provided to the assumption reviewed by Sensitivity Analysis IV.
(ref. Summary Sheet, Annex XIII.15.1 and 15.2)

The attempt is to investigate how IRR would improve by providing ten years tax holiday for the assumption investigated in Sensitivity analysis IV. The result shows somehow improved financial indications in both cases, though IRR is still lower than the cut-off ratio for both cases.

Sensitivity Analysis VI: Sales volume in Thailand 5,000 t/y and 4,500 t for Malaysia and others (keeping all the assumptions of Sensitivity Analysis IV unchanged)
(ref. Summary Sheet, Annex XIII.16.1)

The sensitivity analysis was conducted in order to investigate how the IRR would improve, if the proposed plant in Thailand could sell 5,000 t/year instead of 3,500 t/y. The market study which is concurrently being compiled indicates that the potential formic acid demand in Thailand may reach higher than the projection made in this report, mainly because of the high growth rate of formic acid consumption in the dyeing and tanning industries. This estimation would not automatically ensure higher sales volume. It would be of interest, however, to potential investors in Thailand to learn how this impact will be.

The result shows that the IRR improved from 7.95 per cent to 8.06 per cent. Only insignificant improvement was made. Even if the sales promotion cost were reduced to the amount equivalent to 3 per cent of sales revenue (originally 10 per cent of sales turn-over had been applied), the IRR would improve to 8.46 per cent. It would prove that the contribution margin has to be enlarged by increasing the price or reducing the fixed costs to become commercially profitable. Both cases do not seem to be a realistic assumption.

CONCLUSIONS

Financial indicators for the base assumption are all negative. This implies that the formic acid plant would not make profitable operation, either in Thailand nor in Malaysia. The reasons for this negative financial implication are: (1) high initial investment, (2) low sales prices due to prevailing low CIF prices both in Malaysia and Thailand, (3) high costs of CO gas generation and high utility and energy costs to process formic acid. This, however, does not lead to the conclusion that the AIJV project idea should be dropped without further follow-up envisaged.

In the above-mentioned three areas, there is good reason to review possibilities of improvement of the financial profitability. Lower initial investment and variable costs could be achieved through careful and skillful negotiations with suppliers and contractors, while higher sales prices could be applied with the Government's support by imposing a higher tariff rate. Furthermore, if the Government could provide tax exemptions for this project, e.g. ten-year tax holiday, the financial indicators would further improve.

According to the sensitivity analysis, however, changes of parameters in each area alone do not improve the financial indicators significantly. Only the three combined show a somewhat remarkable improvement - but not enough to fully recommend the project for follow-up.

The IRR in both cases is still below the cut-off rate. This proves, in Alternative IV of the Sensitivity Analysis that the project would enjoy acceptable debt-service ratio. Based on this cash generation capability, it would not be too difficult to obtain the required loans in the capital budgeting.

It should be noted that the production programme (sales forecast) may have to be further reviewed. The sales projection was made assuming the prices originally quoted and even higher prices supported by higher tariff rates are "competitive" (10 per cent lower than that of the competitors' products which are presently sold and would be distributed by non-ASEAN producers in the future).

On this assumption, it has been projected that the sales volume would reach 10,000 t within three years. In order to achieve this sales volume, a very intensive marketing effort will be required in the first three years of operation. Particularly the Indonesian product which will soon be introduced to the ASEAN market will become a strong competitor which is not taken into account in this report. If this projected sales volume is not achieved, it will obviously worsen the financial position. The break-even point for both cases in the Sensitivity 4 (combined three areas of improvement) indicates that the minimum of 89 per cent and 70 per cent of full production volume in Thailand and Malaysia respectively should be secured. This does not seem to be an easy task.

Lastly, some indicators show that production facilities to be established in Malaysia will be slightly better off than those in Thailand. It is mainly attributable to the larger Malaysian market which in turn enables the Malaysian plant to enjoy cost advantages over the lower freight and sales costs. However, no significant advantages have been identified through this study to conclude where the plant is to be located. It should be left to individual entrepreneurs and/or the Government to decide.

The Government would play a limited role in the process of materialization of this project. The decision for a follow-up would rather depend on the entrepreneurs' assessment on the business opportunity of this project. There still seems to be room for further reduction of production costs and lowering down of initial investment costs which in turn "improve" profitability. If no immediate follow-up for materialization is envisaged, however, a practical co-operation scheme with the Indonesian plant may be sought under the AIJV arrangement in light of ASEAN co-operation.

In summary,

(1) With basic assumptions and cost estimation, the project shows negative financial indicators both for Thailand and Malaysia.

(2) These negative indicators are attributable to (a) high initial investment (b) low sales price and (c) high variable costs.

(3) Sensitivity analysis on changing parameters in the above three areas concludes that no drastic improvement can be expected by changing parameters of one single variable (area). The significant improvement can only be made by combining the three areas, i.e. 20 per cent lower initial investment, 20 per cent lower variable costs (selected) and higher sales price assuming higher tariff rate which would protect the product in question.

(4) Even the above combined assumption shows vulnerable financial indicators both in Thailand and Malaysia. However, it may be acceptable for individual entrepreneurs and/or the Government to pursue the possibility of materialization in view of possible further improvement in financial terms.

(5) Prices are established at 10 per cent lower than present competitive prices to ensure the projected sales volume. Forecasted sales volume must be achieved in order to secure estimated cash generation.

A failure would make an extremely negative financial implication.

(6) No significant advantages have been identified to conclude where the plant is to be established, in Thailand or in Malaysia. Even if the sales forecast in Thailand is increased to 5,000 t.y as shown in Sensitivity Analysis VI, the IRR would improve very marginally.

(7) In the case that no entrepreneur in Thailand or Malaysia initiates immediate follow-up, it should be noted that the Indonesian government submitted their proposal for AIJV for formic acid project. The project is awaiting confirmation as AIJV. The situation should be reviewed by COIME if the situation remains unchanged or not six months after the official submission of the report.

Annexes I to IV related to Chapter 4

Annex I.

SPECIFICATION OF NATURAL GAS AVAILABLE IN THE MA TA PHUT INDUSTRIAL COMPLEX, THAILAND

Natural gas

The following grades of natural gas will be available:

- Treated gas, treated gas comes from PTT's Gas Separation Plant operating to recover C2+.

- Raw gas I or II
  Raw gas I or II is pipeline gas treated in the PTT dew point control unit. Raw gas I or II will be supplied during the shutdown of the Gas Separation Plant.

Component	Treated gas Mol %	Raw gas I Mol %	Raw gas II Mol %
N2	1.96	0.81	1.37
CO_2	0.45	23.06	14.57
C1	95.72	65.59	67.41
C2	1.85	5.82	9.07
C3	0.02	2.87	4.88
i C4	-	0.65	1.11
n C4	-	0.64	0.97
i C5	-	0.22	0.27
n C5	-	0.14	0.16
C6	-	0.12	0.09
C7-plus	-	0.07	0.10
Water	-	0.01	-
	100.00	100.00	100.00

	Treated gas	Raw gas I	Raw gas II
Average molecular weight:	16.7	25.1	24.2
LHV kcal/Nm3	8,480	7,697	9,040
LHV BTU/scf	952	865	1,016
H_2O ppm vol	-	-	3
H_2S ppm vol	5	-	20-80
S other than H_2S	10	-	25
Conditions at PTT B.L.:			
Pressure kg/cm2g (min.)	40	40	40
Temperature (degrees C max.)	49	43	43
Fuel gas system:			
Pressure kg/cm2g	16	16	16
Temperature (degrees C)	30	30	30

Utilities and feedstock costs in Ma Ta Phut, Thailand

Utilities and feedstock costs (expressed in mid-1984 US dollars) for economic evaluations only are as follows:

Utilities

- natural gas	US$/$10^6$Kcal	13.5
- electric power	US$/kWh	0.067
- high pressure steam	US$/t	13.9
- medium pressure steam	US$/t	10.7
- low-pressure steam	US$/t	7.7
- demineralized water	US$/$m^3$	1.0
- steam condensate	US$/t	1.0
- cooling water	US$/1,000$m^3$	22.7
- raw water	US$/$m^3$	0.185
- treated water	US$/$m^3$	0.24
- potable water	US$/$m^3$	0.3
- waste water disposal	US$/$m^3$	0.3
- instrument air	US$/$Nm^3$	0.02
- plant air	US$/$Nm^3$	0.02
- nitrogen	US$/$Nm^3$	0.37
- oxygen	US$/$Nm^3$	0.21

Feedstock

- ethane	US$/t	227
- propane	US$/t	250

Annex II

CO-GAS PROCESS DESCRIPTION

Annex II.1 **PSA plant**

Annex II.2 **CALCOR-C**

Annex II.1

PROCESS DESCRIPTION OF PSA PLANT

(Please refer to the attached flow diagram)

The feed gas containing H_2, N_2, CO, CO_2, traces of Ar + C_1 and saturated with H_2O is separated in two PSA units into the CO product and a waste gas containing CO_2, N_2, H_2O and CO losses.

In the first PSA unit, the so-called CO_2-PSA unit CO_2 is rejected. This CO_2-PSA unit is a typical PSA unit where the light product consists of H_2, N_2, CO and the heavy product is CO_2. In order to achieve a high CO recovery, purge gas for regeneration is taken from the second PSA unit, the so-called CO unit. Therefore the waste gas from the CO_2-PSA unit contains all the CO_2, H_2O and also H_2, N_2 and CO.

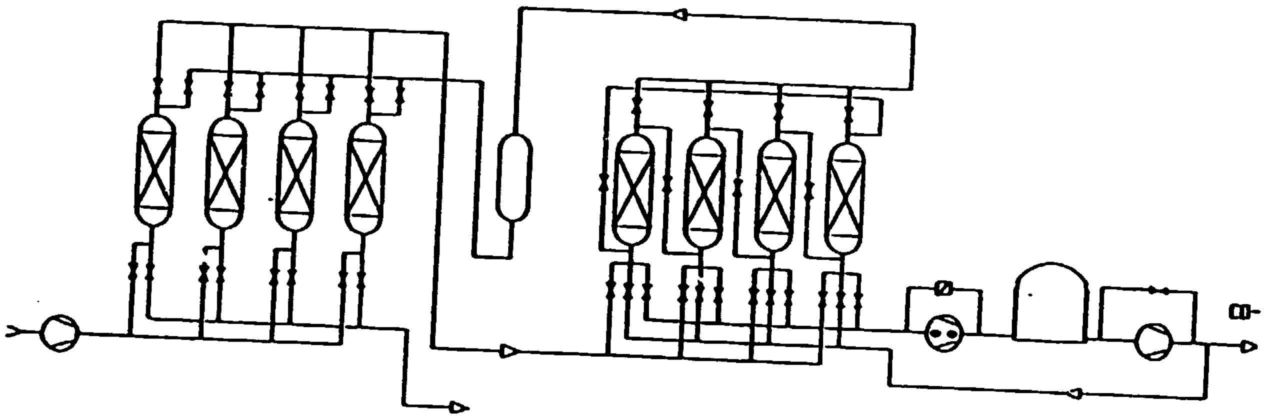
The light product from the CO_2-PSA unit is further separated into CO-product and H_2, N_2 in the CO-PSA unit. This PSA unit deviates from a typical PSA unit in two steps.

1. In order to recover the adsorbed component CO at high recoveries the description step has to be carried out under vacuum.

2. In order to achieve a good separation between CO and the light components H_2, N_2 a recycle stream with pure CO is necessary.

The CO-product is compressed in the product gas compressor to the required pressure level.

Simplified flow-scheme of the pressure swing absorption unit



Annex I.:.2

PROCESS DESCRIPTION OF CALCOR-C PLANT

With the CALCOR-C process a CO raw gas (feed gas to cold-box) with a high concentration of CO is produced by reforming natural gas with carbondioxide in the presence of a catalyst.

The natural gas is used as feed. After hydrogen has been added the gas is preheated in a heater exchanger. In the desulphurizer the sulphur content of the feed stock is hydrated on a catalyst and subsequently absorbed by the catalyst.

The purified feed gas is now mixed with carbondioxide and sent through the reformer. These reformers are top-fired by burners and by burning natural gas. In the reformer tubes the mixture of feed gas and carbondioxide is converted into a syngas consisting of CO, H_2, CO_2 and H_2O. At the outlet of the reformer tube this syngas is quenched by injection of water. From the collector vessels, the syngas is sent to a cooler where it is cooled to ambient temperature by a closed cooling water cycle. Subsequently the syngas is sent to an absorber in which the carbondioxide part is removed by a MEA solution. After removing droplets in a demister the CO raw gas is available as feed gas to the cold-box. During start-up and shut-down periods and interruptions in the down-stream equipment the CO raw gas will be sent to the flare.

The hot flue gas from the reformer together with the flue gas of the burner is sent to a two-path waste heat boiler where the sensible heat is used for the production of steam. The partially cooled flue gas at the outlet of the first path of the boiler is used to preheat the natural gas feedstock and the carbondioxide in heat exchangers before it is passing the second path of the waste heat boiler. The flue gas leaving the boiler is quenched to ambient temperature in a cooler in a direct contact tower before it is sent to an absorber in which the carbondioxide is removed by a MEA solution. After removal of droplets in a demister the flue gas is released to atmosphere at the top of the absorber.

The rich MEA solution from the absorbers is preheated in a heat exchanger and returned to the top of the stripper and the reboiler in which the CO_2 part is separated and recovered for the reforming process. After water vapor has been knocked out in a condenser and separator the CO_2 is stored intermediately in a buffer tank before being sent to the reformers. The reboiler is heated by the generated and additionally imported steam. A split stream of the rich MEA solution is passing an activated carbon filter. The lean MEA solution leaving the reboiler is flowing through a heat exchanger and a cooler before being returned to the top of the absorbers.

The CO raw gas produced in the CALCOR-C process is sent to the cold-box for purification. The tail gas from this cold-box is returned and used as fuel in the reformer.

Purification of raw CO gas

A. Introduction

The cryogenic process, which is used for CO purification is based on the partial condensation principle.

The following essential process steps will be mentioned:

- Compression of the feed gas together with a recycle stream to approximately 10 bars

- Drying of the gas and residual CO_2 removal by means of an adsorber unit. For a smaller design of the adsorber station a cooling step up-stream of the adsorbers is provided

- Cryogenic separation of the feed gas with following product streams:

  . CO product
  . H_2 fraction as fuel gas
  . Recycle stream, wich is routed back to the feed gas in order to improve the recovery of CO

- Generation of cold by means of an expansion turbine.

B.

1. Feed gas compression and drying

Feed gas from battery-limit is mixed with a recycle stream coming from the cold-box. The gas enters the three-stage piston compressor. H_2O which condenses in the intercoolers is separated in the two drums and sent to battery limits. The gas passes the aftercooler and the chiller where it is cooled down to +5° C by cold water. The condensed H_2O is separated.

In the interchangeable adsorbers, CO_2 and H_2O are removed down to traces.

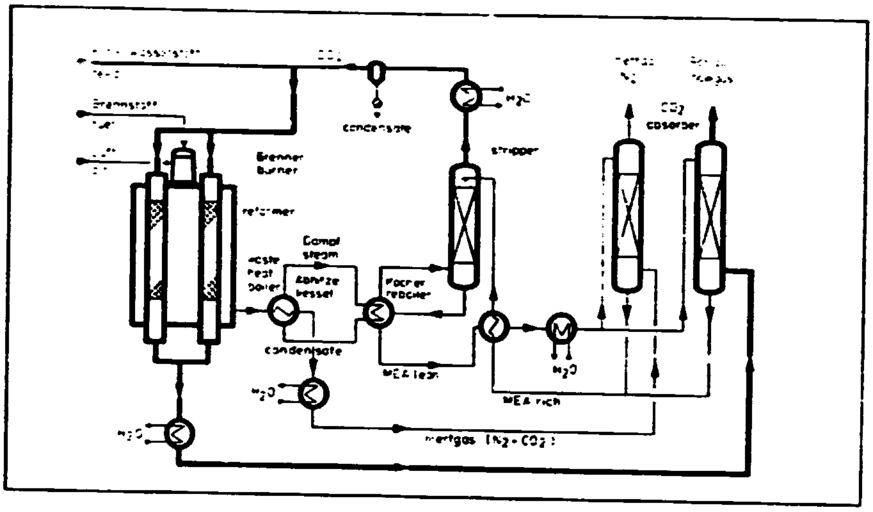
2. Cryogenic section

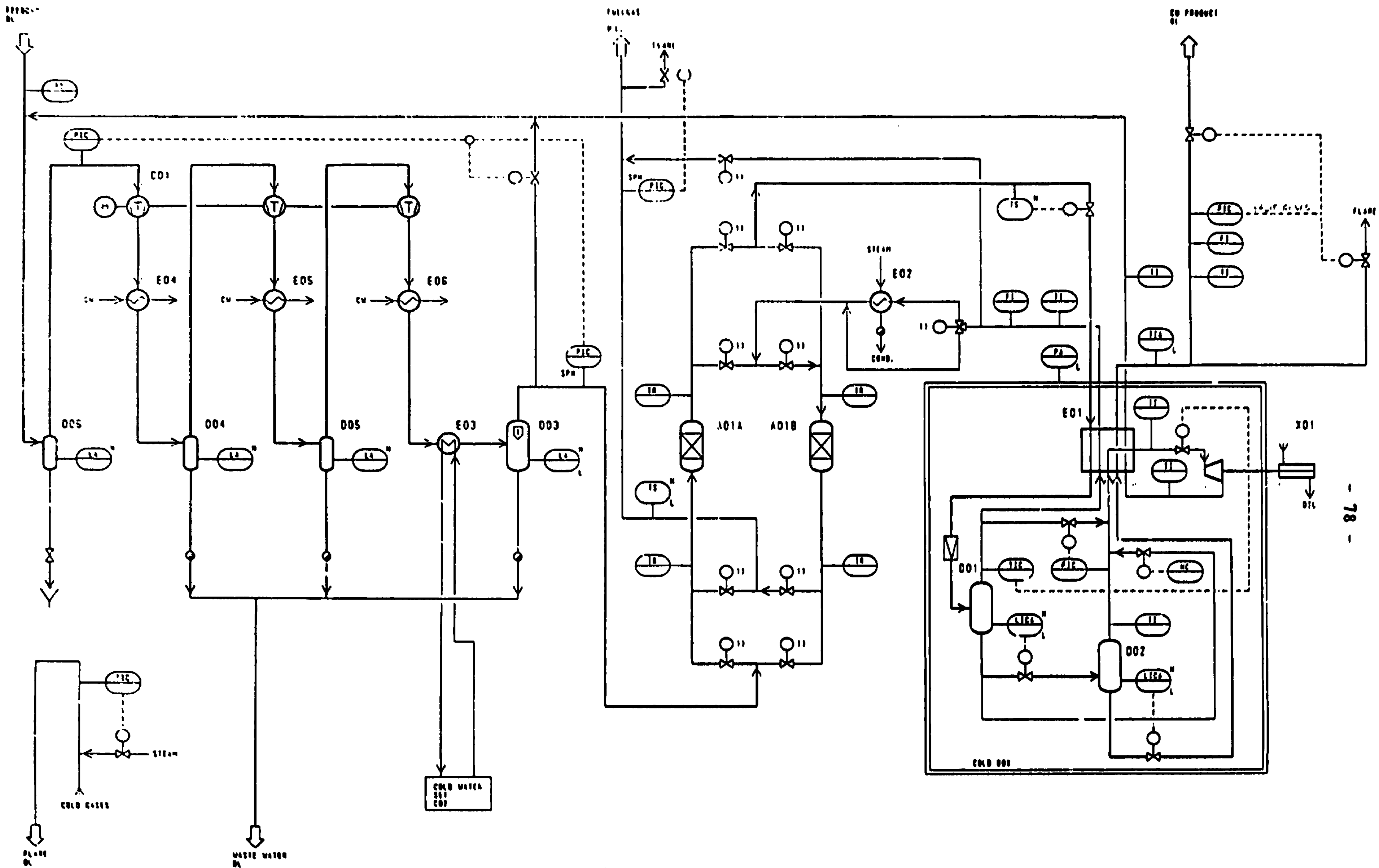
The gas enters now the cold-box, it is cooled down by cold separation products. CO condenses and will be separated. The gas phase is warmed up and used as regeneration gas for the adsorbers (heating by steam, cooling by by-passing it). It leaves the plant as fuel gas with variable temperature.

The liquid is expanded to flash out the main part of the dissolved H_2, the remaining liquid is CO with product purity. It is evaporated and warmed up and leaves the plant as CO product. The refrigeration necessary for the operation of the plant is produced in an expansion turbine: The flash gas is mixed with a part of liquid and gas, warmed up and expanded. Then the gas is rewarmed and recycled to the feed gas.

The CALCOR-C process flow diagram

Generation of a raw gas with high CO-concentration





Simple flow diagram of the CO purification (cold-box)

Annex III

NON-CONVENTIONAL SOURCES OF CO-GAS IN MALAYSIA

Annex III.1

BLAST FURNACE GAS (BFG) - MALAYAWATA STEEL, PENANG

III.1.1 Average composition (percentages)

CO - 25.4
CO_2 - 14.0
H_2 - 5.5
N_2 - the rest

III.1.2 Temperature of the gas after cleaning - 35°C.

III.1.3 Discharged pressure for the cleaned gas abs. 350 mmhg

III.1.4 Average BFG generated - 362 x $10^6 Nm^3/y$

III.1.5 Surplus of BFG after being used by Malayawata Steel = 192 x $10^6 Nm^3/y$

Annex III.2

BINTULU CO-GAS SPECIFICATION

III.2.1 Bintulu Ammonia plant slip stream composition:

	H_2	Ar	N_2	CH_4	CO	CO_2
% per volume	56.77	0.28	21.27	0.56	12.43	8.19

Pressure : 31.5 bar gauge
Temperature : 378°C
Price for 10,000 Nm^3/hour: M$ 186 = US$ 74.41

The above price is assumed without H_2-return to system.

II.2.2 Price specification of utilities

	M$	US$
- Electricity 3,3 kV, 415 V, 230 V	0.20 kWh	0.08/kWh
- Steam low pressure 4 bar g	9.1/t	3.64/t
- medium pressure 44 bar g	9.1/t	3.64/t
- Cooling water	1.57/m^3	0.668/m^3
- Process water (demin.)	1.51/m^3	0.604/m^3

Perujawa Steel Plant syngas composition from the reformer:

	H_2	CO	CH_4	CO_2	H_2O
% per volume	67	20	5	2	6

Annex III.3

HOT BRIQUETED IRON SHAFT FURNACE TOP GAS, LABUAN, SABAH

III.3.1 Composition (vol.%)

CO - 25.2
CO_2 - 15.5
N_2 - 1.5
H_2 - 48.8
CH_4 - 3.0
H_2O - 6.0
HCN - 0.58 mg/m^3
H_2S - 1.55 mg/m^3
O_2 - 36 mg/m^3
Fe - (0.025 mibron) - 1 mg/m^3

III.3.2 Temperature - 40°C

III.3.3 Pressure - 1.3 bar abs

III.3.4 Calorific value

Net 243 btu/scf (2 162.5 $kcal/Nm^3$)
Gross 270 btu/scf (2 402.73 $kcal/Nm^3$)

III.3.5 Quantity

45-47,000 Nm^3/hour

Annex IV

CALCULATION OF VARIABLE COSTS
OF INm³ pure CO-gas

Annex IV.1 Ma ta Phut, Thailand

Annex IV.2 Malayawata, Malaysia

Annex IV.1

CALCULATION OF VARIABLE COST OF 1 Nm^3 PURE CO-GAS AT THE MA TA PHUT CO-PLANT, THAILAND

The CALCOR-C and Cold Box plant produces 830 Nm^3/hour CO-gas as 100% CO-gas (actual output is 838 Nm^3 CO-gas as 99.19 per cent)

Raw materials		Price per unit US$	Consumption per hour	Total US$/hour	Note
Natural gas	Nm^3	0.1039095 *	600	62.35	without H_2 gas export
Total raw material				62.35	
Utilities					
- Instrument air	Nm^3	0.02	32	0.64	
- Electricity	kWh	0.067	294	19.698	
- Nitrogen	Nm^3	0.37	50	18.5	
- Steam	Gj	3.831	1.2	4.272	
- Make-up water	m^3	0.24	0.1	0.024	
- Cooling water		0.0227	409	9.2843	
Total utilities				52.4183	

Total variable cost per 830 Nm^3 pure CO-gas US$ 114.7683

Variable cost of 1 Nm^3 pure CO-gas ----> US$ 0.138275

<u>Calculation of the price of Raw Gas I</u>

Price of natural gas: US$ 13.5/10_6 kcal (see Annex IV.2.1)
LHV of Raw gas I : 7,697 kcal/Nm^3
Price of 1 Nm^3 of Raw gas I: $\frac{7697}{10^6} \times 13.5$ = US$ 0.1039095

Annex IV.2

CALCULATION OF VARIABLE COST OF 1 Nm^3 PURE CO-GAS AT THE MALAYAWATA STEEL WORKS, MALAYSIA

The PSA-unit produces 1,000m^3 of 98% CO-gas at 35 bar

Raw materials		Price per unit US$	Consumption per hour	Total US$/hour	Note
Blast furnace off-gas	Nm^3	0	5,650	0 *	
Total raw material				0	
Utilities					
- Electricity	kWh	0.0576	1,000	57.6	
- Cooling water	m^3	0.16	80	12.8	
- Nitrogen	Nm^3	-	little	-	
Total utilities				70.4	

Total variable cost per 1,000 Nm^3 pure CO-gas US$ 70.4

Correction to 100% CO-gas -----> US$ 71.84

Variable cost of 1 Nm^3 100% pure CO-gas -----> US$ 0.07184

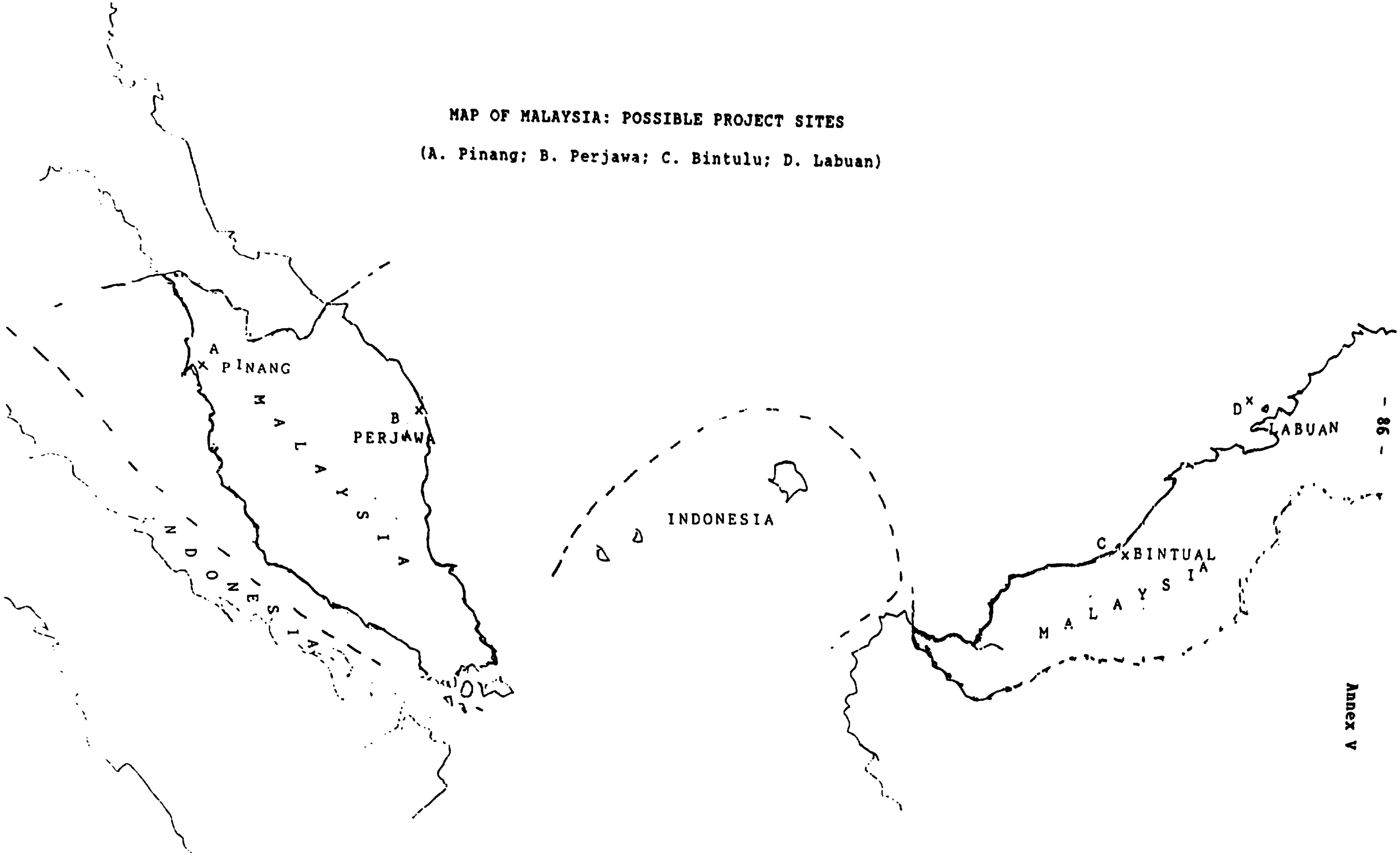
---

* Blast furnace off-gas is considered to have zero value.

Annex V

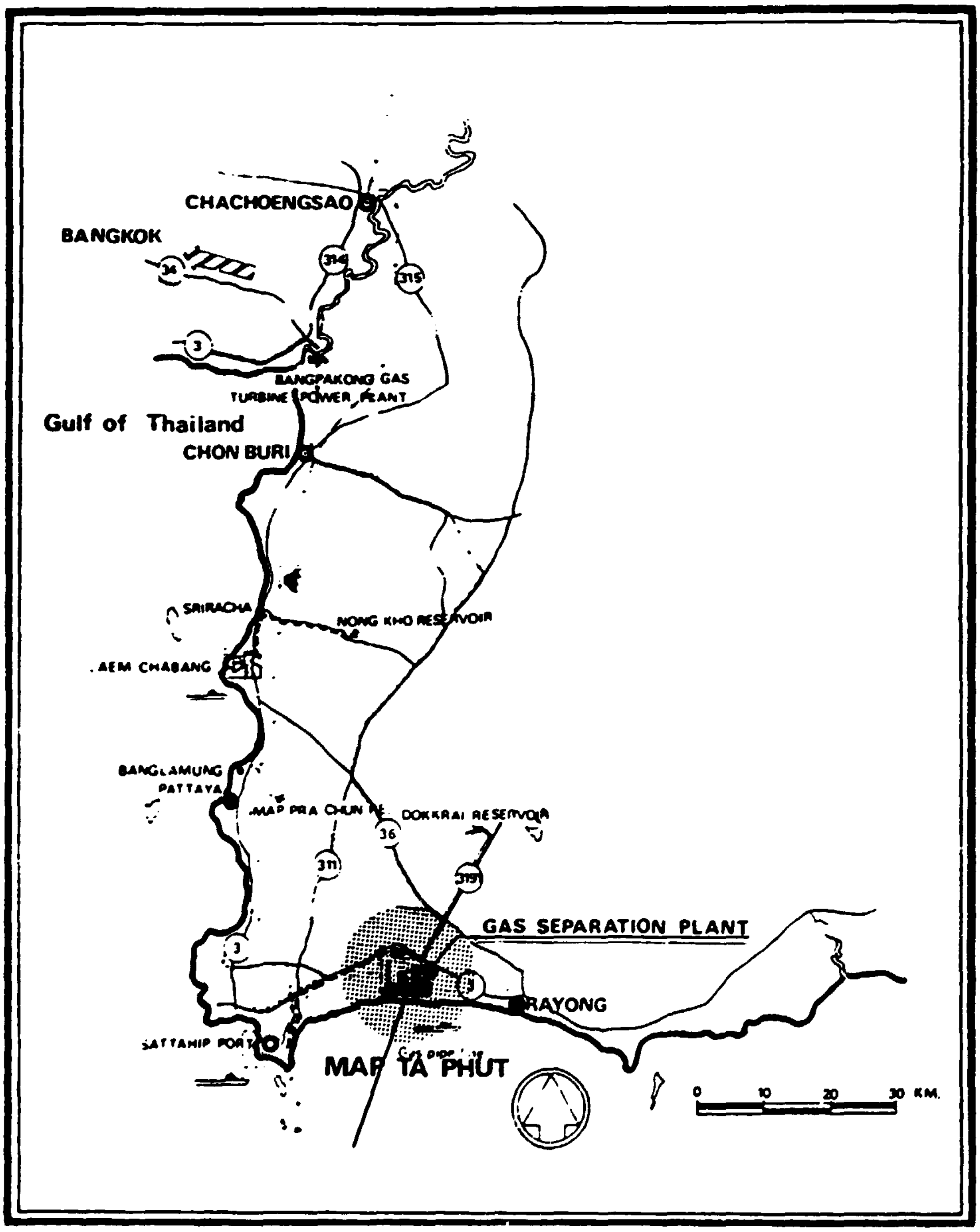
MAP OF MALAYSIA: POSSIBLE PROJECT SITES

(A. Pinang; B. Perjawa; C. Bintulu; D. Labuan)



Annex V.1

SITE LOCATION OF MA TA PHUT, Thailand



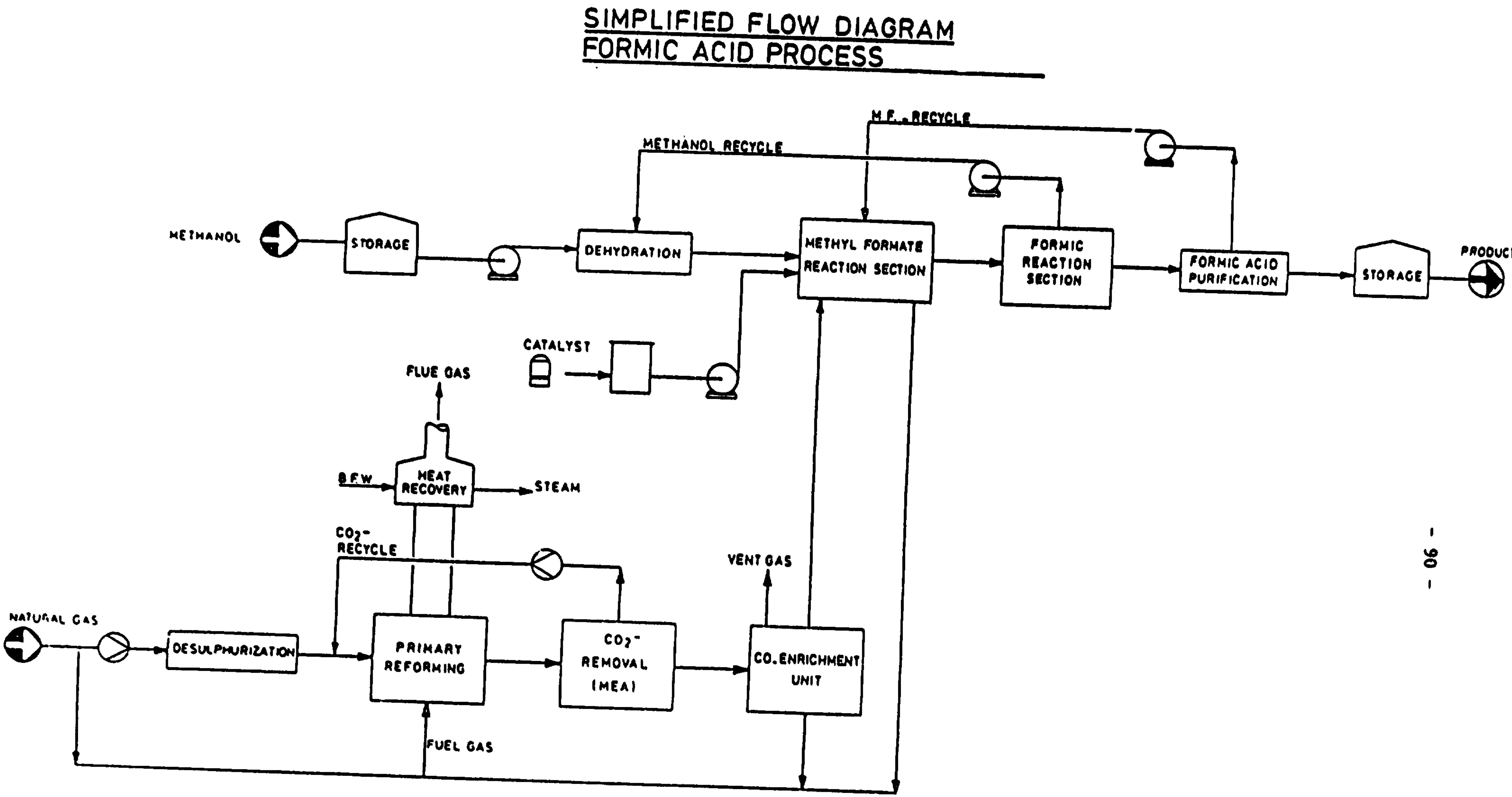
Annexes related to Chapter VI:

Annex VI

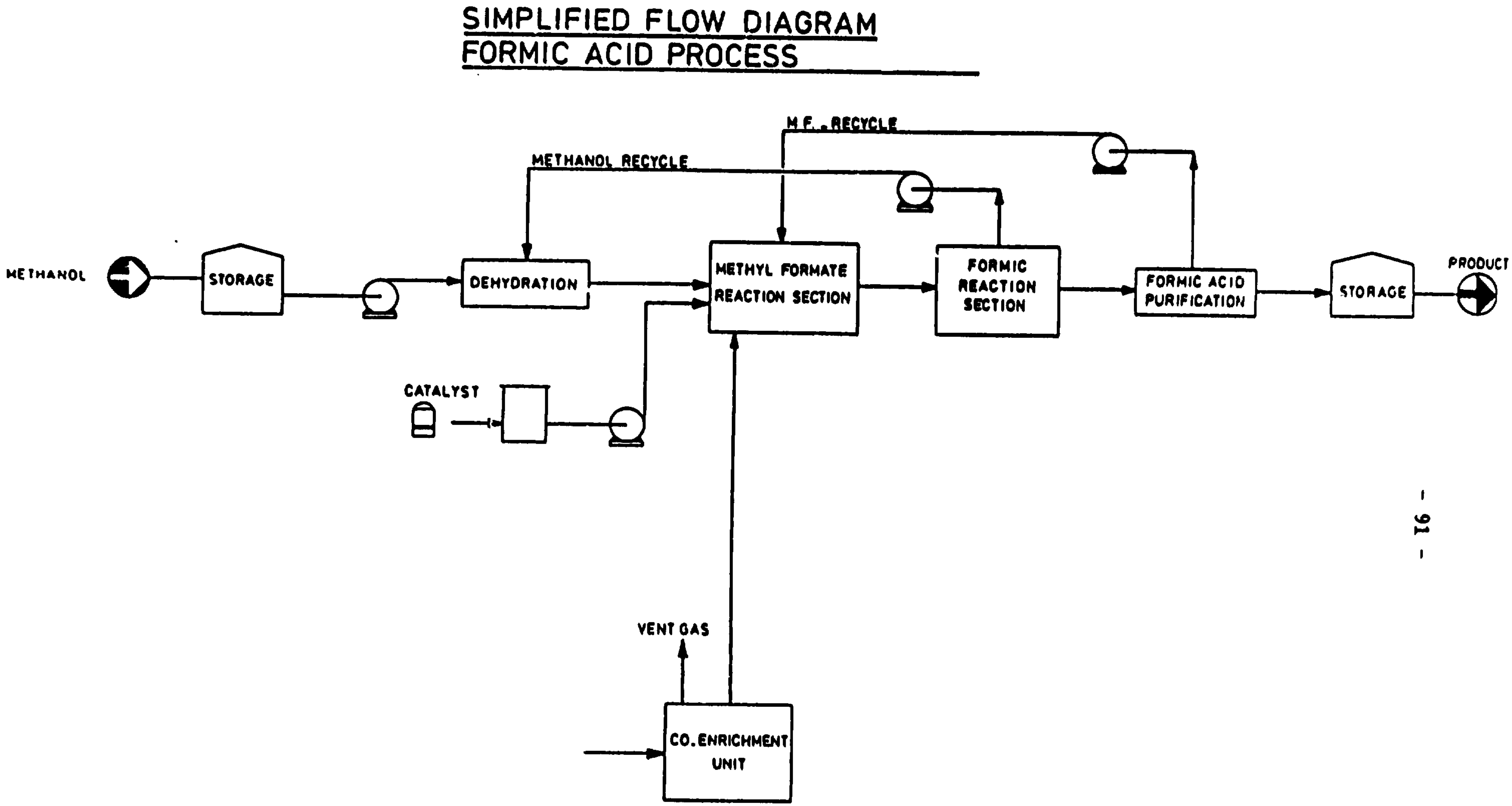
FLOW DIAGRAMS

Annex VI.1 Thailand

Annex VI.2 Malaysia



Annex VI.1 SIMPLIFIED FLOW DIAGRAM - FORMIC ACID PROCESS (CALCOR-C)



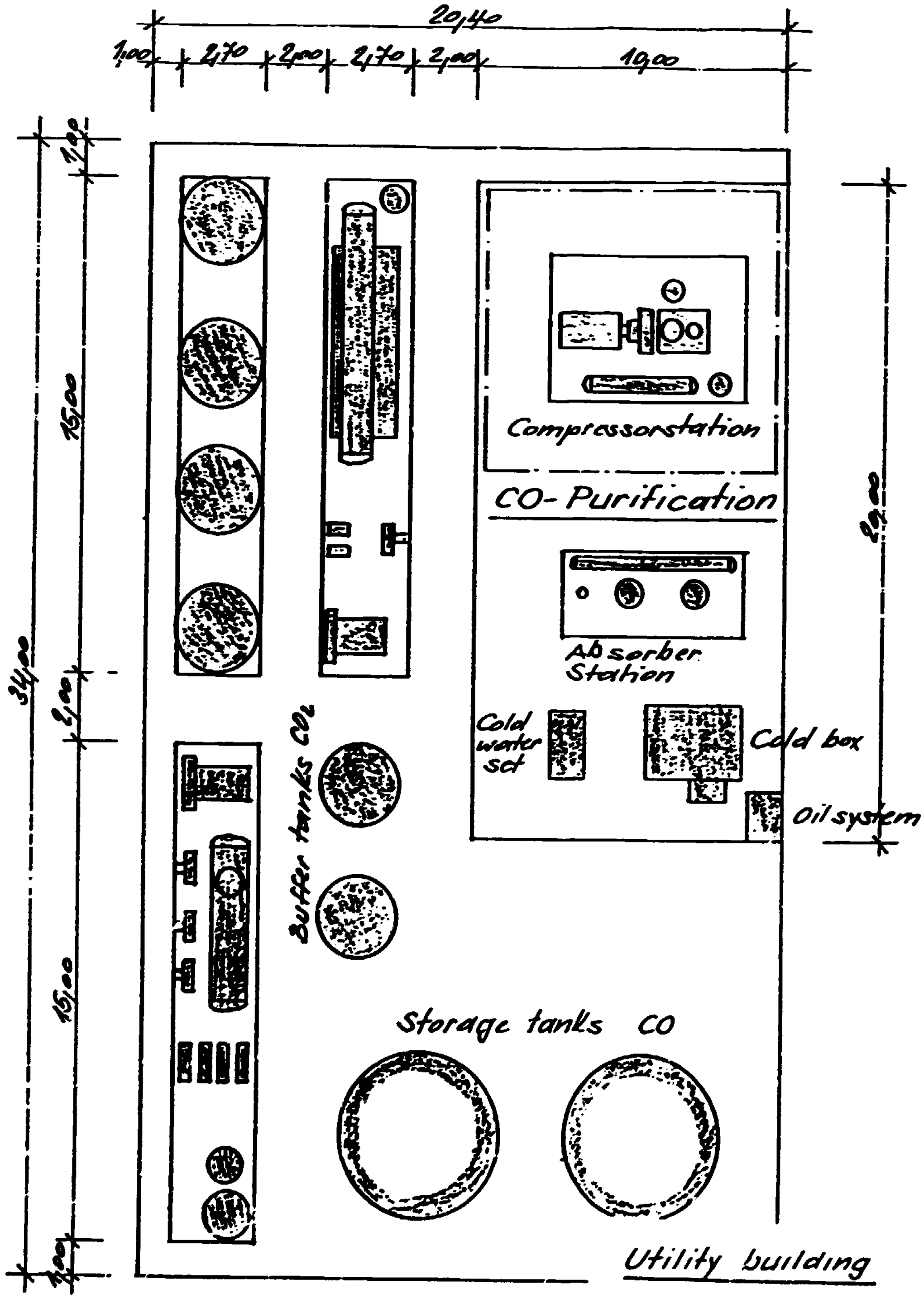
Annex VI.2 SIMPLIFIED FLOW DIAGRAM - FORMIC ACID PROCESS (BFO)

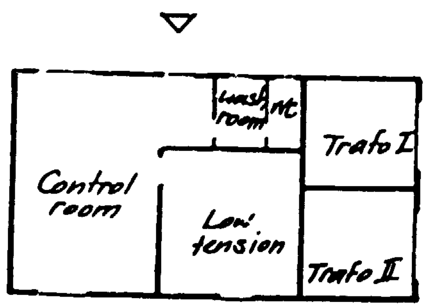
ANNEX VII

PLANT LAYOUT FOR CO-GAS

Annex VII.1

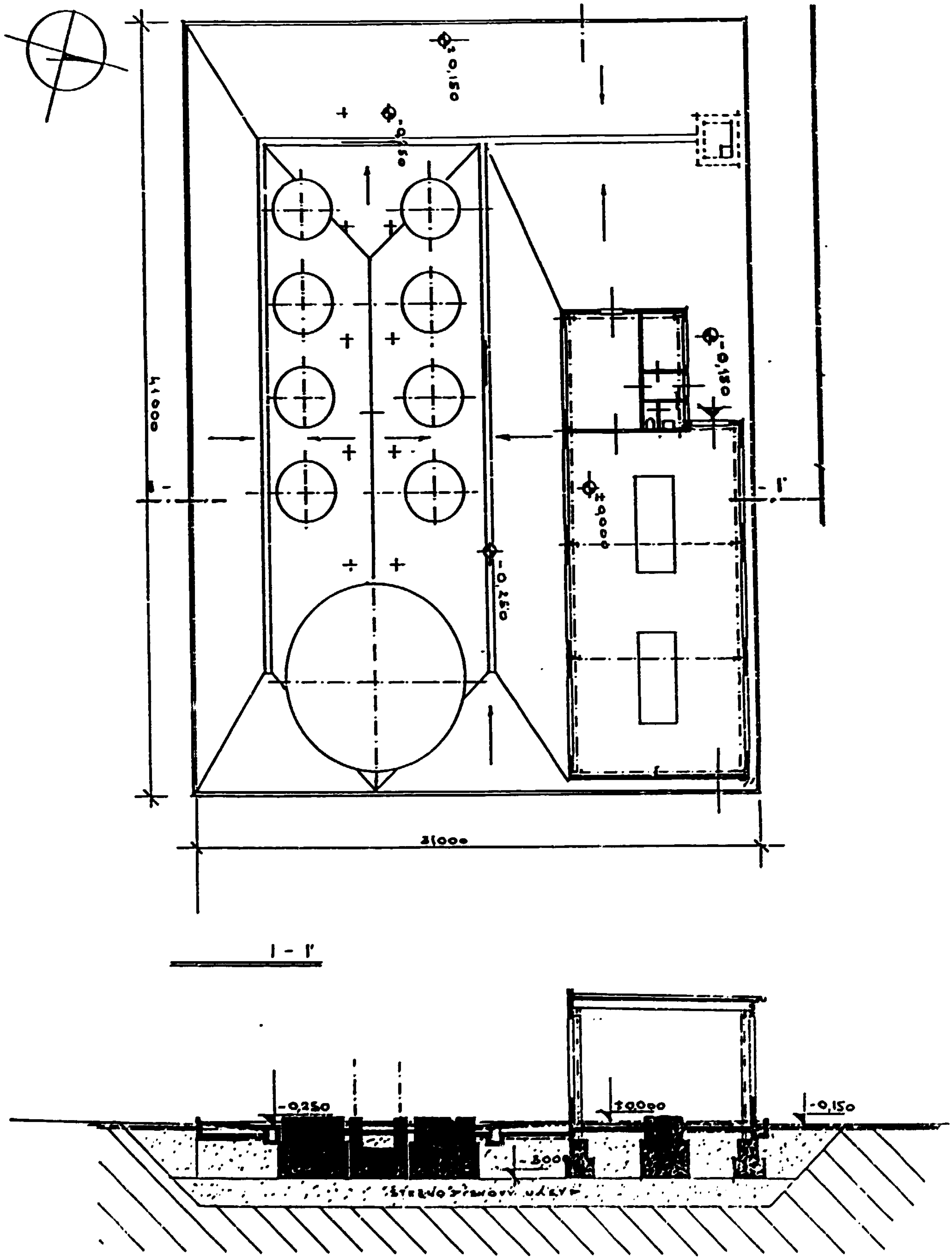
LAY-OUT OF THE CO-PLANT: THAILAND





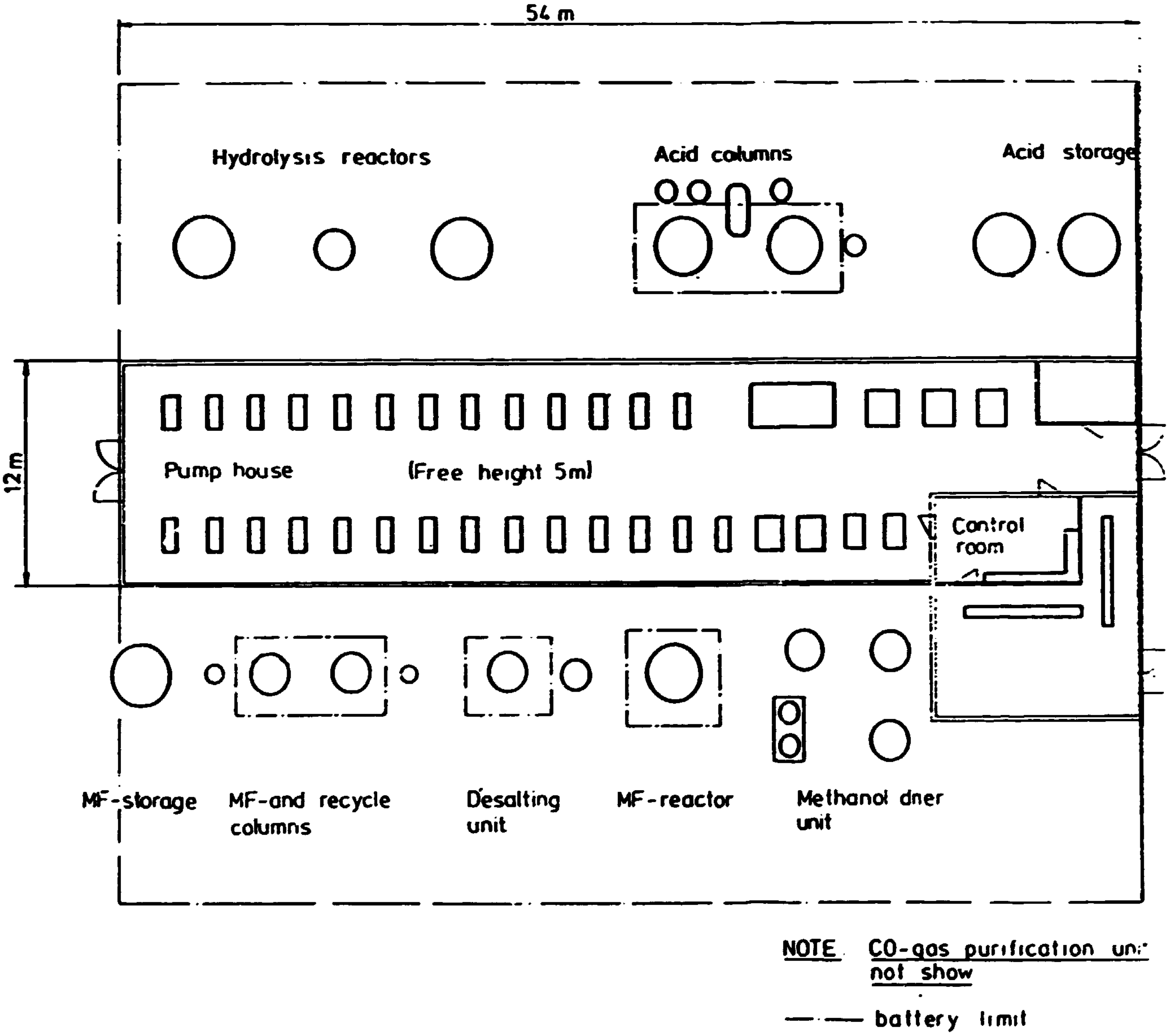
Annex VII.2

CO-GAS SEPARATION FOR MALAYSIA BY PSA



Annex VIII

FORMIC ACID LAY-OUT PLAN



Annex VIII

FORMIC ACID PROCESS DESCRIPTION

Annex VIII.1

MANUFACTURE OF FORMIC ACID VIA FORMAMIDE

VIII.1.1 Process description

A. Synthesis to produce formamide

Formamide is manufactured by adding liquid ammonia to carbon monoxide under the catalytic effect of sodium methanolate. The reaction takes place at a temperature ranging from 95° C to 110 °C and a presure 17.6 - 19.6 MPa. This reaction may thus be termed as one-stage homogeneous catalysis taking place in a through-flow reactor of cylindric shape.

The reaction is as follows:

$$CO + NH_3 \xrightarrow{\text{catalyst}} HCONH_2$$

(carbon monoxide and ammonia to formamide)

Carbon monoxide will be obtained by reforming natural gas and will be delivered to the plant. Harmful impurities shall be removed from the feed gas.

The ctalyst is Sodium methanolate which is prepared by dissolving metallic sodium in methanol under nitrogen atmosphere. The reaction is as follows:

$$2\ CH_3OH + 2Na \longrightarrow 2\ CH_3ONa + H_2$$

(methanol and metallic sodium to sodium methanolate)

Carbon monoxide is compressed in a high pressure compressor. The compressed CO-gas then enters the high-pressure reactor where it meets with the mixture of ammonia, methanol and sodium methanolate dosed into the reactor by means of a high-pressure pump. The CO-gas enters the reactor at the bottom. The liquid raw materials enter the reactor from the top.

Sodium methanolate [catalyst] is prepared by dissolving metallic sodium in methanol under nitrogen atmosphere.

The main formamide production equipment is the high-pressure reactor. The reactor is of vertical cylindric shape without filling. Mixing is ensured by the action of bubbling CO-gas and a circulating pump.

The reaction is highly exothermic. The reaction heat is removed by means of cooling in the recycle. The reaction mixture is let off at the bottom of the reactor at such speed that ensures constant level of liquid reactants in the reactor. After cooling and pressure reduction, the waste gas is burnt off and liberated into the atmosphere.

After pressure reduction the reaction mixture flowing out of the reactor is led into an expansion tank where gases are liberated. The mixture is then sent through a preheater into film evaporator where the main part of excess methanol and volatile components is distilled off. The film evaporator works under atmospheric pressure. The vapours pass through a condenser where condensation of methanol takes place. The condensed methanol flows into the return methanol receptacle or into the storage of combustible substances.

The mixture flowing out of the bottom of the film evaporator goes into a vacuum evaporator where the last portion of volatile components is distilled off. After condensation they are sent into the combustibles storage area. The necessary vacuum is produced by means of vacuum pumps.

The distillation residue is actually raw formamide. The cooled formamide is sent into the formamide storage tank. After quality control formamide is sent into the formic acid plant.

VIII.1.2 Hydrolysis to produce formic acid from formamide

The process consists in principle of formamide decomposition into formic acid and ammonium sulphate using sulfuric acid as decomposing medium. The reaction is as follows:

$$2\ HCONH_2 + H_2SO_4 + 2\ H_2O \qquad 2\ HCOOH + (NH_4)_2SO_4$$

(hydrolysis of formamide and sulphuric acid to formic acid and ammonium sulphate)

The principal raw materials formamide, sulphuric acid and watr are pumped into the hydrolyzing reactor by means of four-component dosing pumps. Pure water or sulphate water is used. One of the four dosing compartments of each pump serves to pump pure water into the absorption columns. The obtained absorbate is used to adjust the formamide concentration to 80 per cent by weight. After the reaction has taken place the obtained reaction mixture falls down into the distilling drums, where formic acid is passed through a trap where ammonium sulphate flue dust is extrapped. Then the formic acid vapours pass a partial condensor (deflegmator) where partial condensation to formic acid takes place. This deflegmated formic acid then washes the ammonium sulphate down into the hydrolyzing reactors. Formic acid vapour which passed through the deflegmator is led into condensation wherefrom they flow down into HCOOH receptacles.

The HCOOH vapours which had been sucked off from the condensing equipment due to the evacuating effect of a vacuum pump pass through an absorption column and drop trap into the vacuum pumps and atmosphere.

The absorbate obtained in the absorption columns containing 15-35 per cent HCOOH is mostly used for adjustment of formamide. The remaining part flows into the hydrolyzing reactors.

Ammonium sulphate which has been dried in the distilling drum falls through into the ammonium sulphate storage tanks. From the storage tanks it is transported by means of screw conveyors into the solution tank of the recrystallisation plant.

Together with the feed solution the runback solutions are transported from the pre-thickener and the centrifuge to the collector from which the level controlled solution is fed due to a filter and a tank for adjusting the ph-value with H_2SO_4 into the crystallizing plant, which consists mainly of the evaporator/crystallizer the circulation conduct, the radiator and the circulating pumps.

Part of the exhaust vapours from the crystallizer are taken in by the thermal exhaust vapour condensor are precipitated in the surface condensor and pressure control.

The condensed heating steam and exhaust vapours are evacuated by means of pump via the condensate cooler.

The saline suspension is fed into the separator plant and to the sieve from where the bigger and smaller grain is led back to the crystallisation plant. The final product is going to the storage tank and the bagging unit.

Formic acid in technical quality is pumped from the receptacles into expedition where concentration is adjusted and finished formic acid is pumped into tanks or small containers.

Formic acid for foodstuff or in pure quality can be obtained by rectification in a separate column where lower boiling portions are separated. This column is part of this plant.

Annex VIII.2

MANUFACTURE OF FORMIC ACID BY THE METHYLFORMATE PROCESS

A. Process description

1. Chemical reaction

The synthesis of formic acid by carbon monoxide and water is shown in the following overall reaction:

$$CO + H_2O \text{ -----> } HCOOH$$

This reaction takes place in two steps:

In the first step, carbon monoxide and methanol react in presence of a catalyst to form methyl formate,

$$CH_3OH + CO \text{ -----> } HCOOCH_3$$

In the second step, the formed methylformate hydrolyzes with water to form methanol and the product formic acid

$$HCOOCH_3 + H_2O \text{ -----> } NCOOH + CH_3OH$$

2. Methylformate synthesis

Fresh methanol from the storage and recycle methanol is pumped to the reactor and mixed with catalyst solution before entering the reactor. The compressed carbon monoxide is fed to the bottom of the reactor.

In the reactor the methanol reacts in presence of a catalyst with the carbon monoxide to methylformate which is separated from surplus methanol ir the methylformate separation column.

Methanol is recycled. Off-gas is sent through a scrubber to absorb residual methylformate.

3. Formic acid production and distillation

Methylformate is hydrolized with water in a fixed bed catalytic reactor. Expansion of the mixture and cooling down avoids reversed esterification.

The hydrolysis mixture s separated by a distillation column into methylformate methanol at the top and aqueous formic acid at the bottom.

Methanol and methylformate are recycled.

Formic acid is concentrated in the product column to 85 per cent wt., and is then available for further processing. If 90 per cent wt. formic acid is needed an additional column has to be used.

B. Raw materials

1. Methanol

The methanol to be used shall correspond to a normal purity (U.S. Fed. grade A or equivalent), but shall be nearly free of iron.

Typical Analysis

Apparent specific gravity	0.792-0.793 at 20/20°C
Boiling range, °C	0.5 max. falling between 64°and 65°C
Precipitated by water	Clear
Reducing $KMnO_4$	Min. 30 minutes at 15°C
Darkened by sulfuric acid	20 (max.) (Pt-Co Scale)
Acetone and aldehyde	0.003 wt. % (max.)
Alkalinity (as NH_3)	0.0003 wt. % (max.)
Water	0.10 wt. % (max.)
Iron	0.05 ppm (max.)
Color	5 (max.) (Pt-Co Scale)
Non-volatile residue	0.001 wt. % (max.)
Acidity (as acetic acid)	0.003 wt. % (max.)

2. Carbon monoxide

Pressure	36 bar
Temperature	ambient
Carbon monoxide	98.2 % vol.
Nitrogen	1.78 % vol.
Methane	0.02 % vol.

3.0 Consumption figures

A standard plant based on a feed gas with approx. 98 % vol. CO will require the following raw material and utilities per metric ton (MT) of 85 % wt. formic acid at 100 per cent capacity utilization.

3.1 Raw materials

Methanol	7 kg
Carbon monoxide (100%)	610 kg
Catalyst and stabilizer+	0.5 kg

3.2 Utilities

Steam (10 bar)++	6,900 kg
Cooling water (t = 10°C)	250 m^3
Cooling brine (T = -25°C)	1.1 Gcal
Process water	490 kg
Power	175 kWh

\+ Estimated price: DM 10,- (Index 1982)

++ For reasons of purity, the product is removed vaporous.

3.3 Personnel

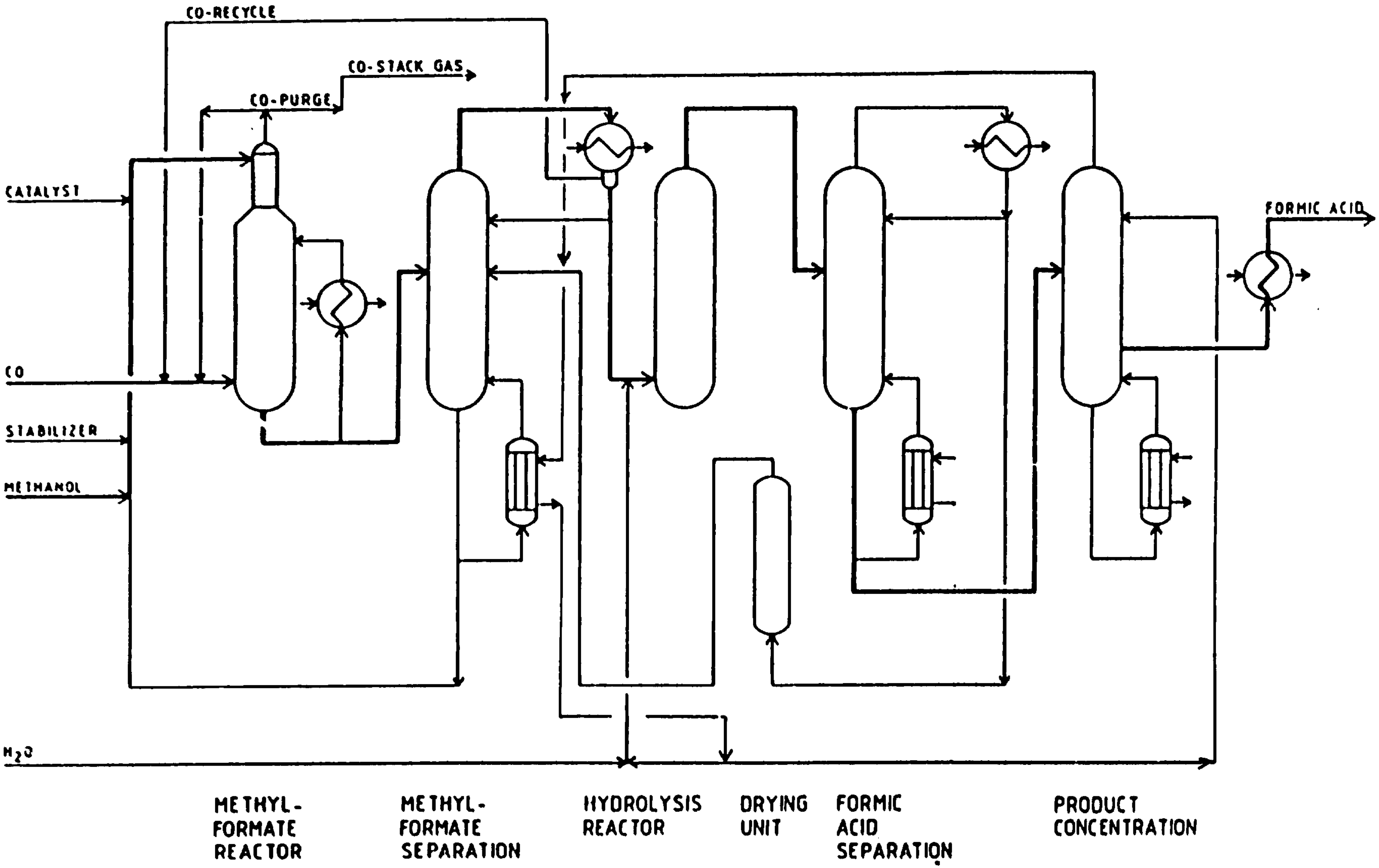
Operators	2 per shift
Shift foreman	1 per shift
Supervisor	1

4. Product quality

The quality of the formic acid obtained in the production plant is as follows:

Formic acid	85 % wt
Water	15 % wt
Iron content	5 ppm wt (max.)
Sulphate content	50 ppm wt (max.)
Non-volatile matter	100 ppm wt (max.)

FORMIC ACID USING CARBON MONOXIDE AND WATER VIA METHYLFORMATE



Annex IX

BREAK-DOWN OF EQUIPMENT COSTS

Annex IX.1

BREAK-DOWN OF EQUIPMENT COSTS (MANUFACTURE OF CO-GAS)

VIII.1 List of main equipment for CO-gas generation (CALCOR-C unit)

	FOB price in US$ 1,000	
	Foreign	Local
Reformer vessel with burner and tubes filled with catalyst	F	
Waste heat boiler	F	
Flue gas boiler	F	
Flue gas CO_2 absorber		
MEA reboiler	2,035	
MEA stripper		
MEA/MEA heat exchanger		
MEA cooler		
Raw gas CO_2 absorber		
MEA pumps with stand-by		
CO-detection and alarm system		
Control room equipment	167	
Piping, valves etc. / Lightning system, catalyst	108	
CO-tanks	133	
	2,443	

VIII.1.2 List of equipment for CO-gas purification (Cold-box unit)

	FOB price in US$ 1,000	
	Foreign	Local
2 absorber vessels with internals / Steam heater / Cold water cooler / Water separator	202	
Process heat exchanger / Feed gas separator / Flash drum	437	
Feed gas compressor / Cold water set / Expansion turbine / Analyzing equipment	630	
Piping, steel structure	141	
Control room equipment	175	
	1,585	

VII.1.3 List of electrical equipment for CALCOR-C and Cold-Box units

	FOB price in US$ 1,000	
	Foreign	Local
13.8 KV switch gear 6 KV switch gear 6 KV capacitors 0.4 KV switch gear Control board 2 transformers Cabling system Fixtures, installation materials, switches, sockets, etc.		262
		262

Annex IX.2

MANUFACTURE OF FORMIC ACID - LIST OF MAIN EQUIPMENT

IX.2.1 Methyformate synthesis

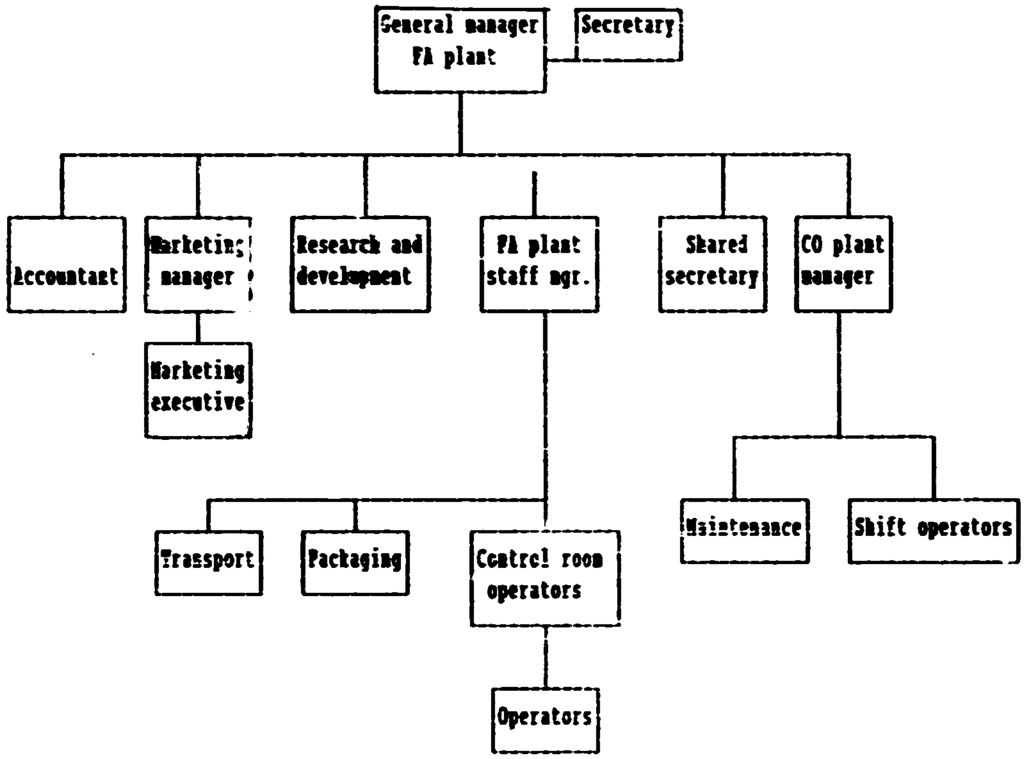
	FOB price in US$ 1,000	
	Foreign	Local
Synthesis gas compressor		
Methylformate reactor		
Reactor cooler		
Reactor overhead condensor		
2 reactor pumps		
Reactor agitator		
2 MeOH-MF colun bottom pumps		
Spent catalyst filter		
Methyl formate reactor		
Refrigeration unit		

IX.2.2 Purification of methylformate, hydrolysis and product purification

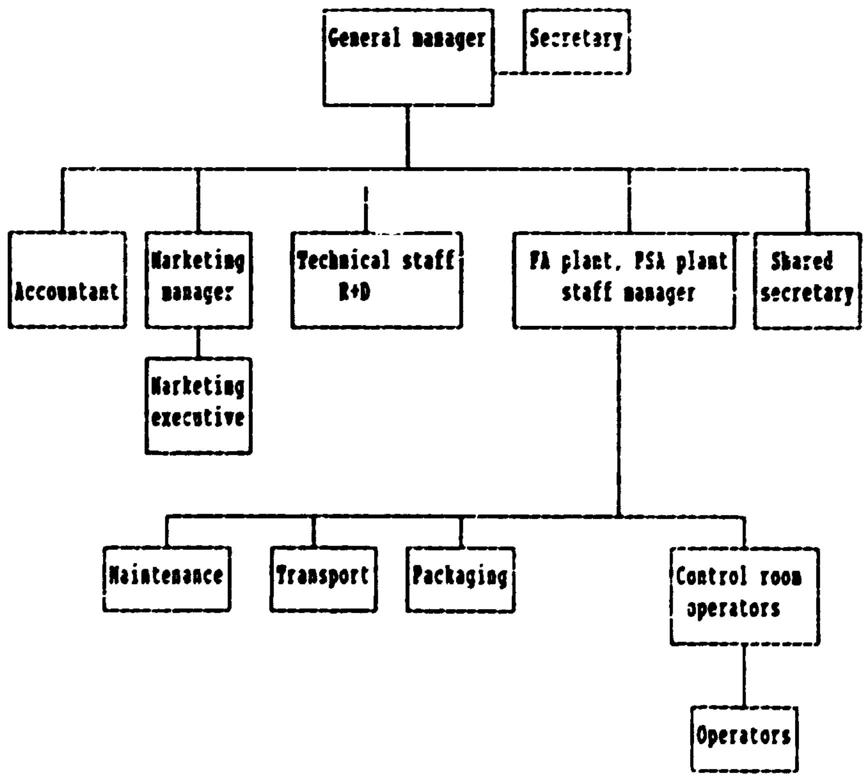
	FOB price in US$ 1,000	
	Foreign	Local
Methanol-methyl formate column reflux drum		
Hydrolysis product splitter reflux drum		
Product column reflux drum		
Methanol-Methyl formate column reboiler		
Methanol-Methyl formate column condensor		
Methanol-Methyl formate column vent condensor		
Trim heater		
Hydrolysis product splitter reboiler		
Hydrolysis product splitter condensor		
Hydrolysis product splitter trim reboiler		
Product column reboiler		
Product column overhead condensor		
Product cooler		
Product column feed bottom exchanger		
Product column vent condensor		
2 MeOH column reflux pumps		
2 hydrolysis product splitter bottom pumps		
2 hydrolysis product splitter reflux pumps		
2 product column reflux pumps		
Hydrolysis reactor with agitator		
Methanol-Methyl formate column		
Hydrolysis product splitter		
Product column		
Total	Σ 4,099.34	547.66

Annex X.1

Organizational structure for Thailand



Organizational structure for Malaysia



Annex XI

RESPONSIBILITIES AND QUALIFICATIONS OF FORMIC ACID FACTORY AND ADMINISTRATIVE LABOUR

The staff of the factory consists of the following:

<u>Formic acid</u>

1 general manager	-	having good knowledge of economics
1 accountant	-	graduate in commerce with experience in bookkeeping and accountancy
1 marketing manager	-	engineering graduate having experience in marketing chemical products and able to negotiate directly with higher authorities
1 marketing executive	-	engineering graduate with good experience in marketing chemical products, having experience in setting up and handling dealer networks
4 operators in FA	-	medium engineering graduates, having at least 5-year experience in chemical plants especially in organic chemistry
4 control-room operators	-	technical university graduates skilled in chemistry as well as instrumentation and control with at least 5-year experience in manufacturing
2 maintenance engineers	-	engineering graduates - medium-level, having 10-year experience in control and instrumentation in chemical factories
4 shift managers	-	technical university graduates with 10-year experience in chemical industry
1 technician	-	technical university graduate, skilled in organizing research and development work
4 packaging operators		
1 driver		
2 secretaries		

<u>Carbon monoxide manufacture</u>

- <u>CALCOR-C - Cold Box process (Thailand)</u>

The staff of the plant consists of:

1 plant manager	-	university graduate with good experience in managing chemical plants especially plants producing toxic gaseous products
4 shift operators	-	chemistry graduates - medium-degree of schooling having 5 to 7-year experience in operating chemical plants and some knowledge in process control and automation.

Annex XII

CALCULATION OF LABOUR COST

1. Carbon monoxide production

Thailand:	Factory labour	Administrative staff
1 foreman	US$ 7,200	shared with formic acid
4 operators	US$ 19,200	
	US$ 26,400	

Malaysia

The PSA plant does not require any operator. The plant will be monitored from the formic acid control room.

2. Formic acid production

	US$/annum	
Direct factory labour	**Thailand**	**Malaysia**
1 driver	1,200	1,500
4 packaging operators	4,800	8,000
4 plant operators	9,606	19,200
4 control room operators	19,200	38,400
2 maintenance engineers	3,840	4,800
1 technician (R+D)	4,800	4,800
4 shift managers	28,800	48,000
Total direct factory labour	72,240	124,700
Administrative staff		
1 director	15,000	19,200
1 accountant	7,200	6,000
2 marketing staff	14,400	15,000
2 secretaries	2,880	4,800
Total administrative staff	39,480	45,000
Total formic acid plant direct labour and administrative staff	117,720	169,700

Annex XIII

COMFAR SCHEDULES AND GRAPHICS

XIII.1.1	Working capital requirement	(Thailand)
1.2	Working capital requirement	(Malaysia)
2.1	Total initial investment	(Thailand)
2.2	Total initial investment	(Malaysia)
3.1	Source of financing, construction	(Thailand)
3.2	Source of financing, construction	(Malaysia)
4.1	Production cost	(Thailand)
4.2	Production cost	(Malaysia)
5.1	Cash-flow tables, Production	(Thailand)
5.2	Cash-flow tables, Production	(Malaysia)
6.1	Net income statement	(Thailand)
6.2	Net income statement	(Malaysia)
7.1	Sensitivity of IRR	(Thailand)
7.2	Sensitivity of IRR	(Malaysia)
8.1	Debt:service ratio chart	(Thailand)
8.2	Debt:service ratio chart	(Malaysia)
9.1	Summary sheet for Sensitivity Analysis I	(Thailand)
9.2	Summary sheet for sensitivity Analysis I	(Malaysia)
10.1	Summary sheet for Sensitivity Analysis II	(Thailand)
10.2	Summary sheet for Sensitivity Analysis II	(Malaysia)
11.1	Summary sheet for Sensitivity Analysis III	(Thailand)
11.2	Summary sheet for Sensitivity Analysis III	(Malaysia)
12.1	Summary sheet for Sensitivity Analysis IV	(Thailand)
12.2	Summary sheet for Sensitivity Analysis IV	(Malaysia)
13.1	Sensitivity of IRR for Sensitivity Analysis IV	(Thailand)
13.2	Sensitivity of IRR for Sensitivity Analysis IV	(Malaysia)
14.1	Debt:service ratio chart of Sensitivity Analysis V	(Thailand)
14.2	Debt:service ratio chart of Sensitivity Analysis V	(Malaysia)
15.1	Summary sheet for Sensitivity Analysis V	(Thailand)
15.2	Summary sheet for Sensitivity Analysis V	(Malaysia)
16.1	Summary sheet for Sensitivity Analysis VI	(Thailand)

Annex XIII.1.1

WORKING CAPITAL REQUIREMENT
(Thailand)

COMFAR 2.1 UNIDO

COMFAR 2.1 - FEAS - Demo Version, 01327

Net Working Capital in 000 US$

Year	adc	coto	1992	1993	1994	1995-2006
Coverage	adc	coto				
Current assets &						
Accounts receivable	74	4.9	510.369	560.290	885.145	885.145
Inventory and materials	84	4.3	59.000	82.600	116.000	116.000
Energy	0	---	0.000	0.000	0.000	0.000
Spares	360	1.0	490.000	490.000	490.000	490.000
Work in progress	0	---	0.000	0.000	0.000	0.000
Finished products	30	12.0	199.868	234.508	301.558	301.558
Cash in hand	15	24.0	44.050	46.058	49.071	49.071
Total current assets			1293.229	1513.447	1843.775	1843.775
Current liabilities and Accounts payable	27	13.3	158.189	201.196	265.708	265.708
Net working capital			1135.040	1312.251	1578.067	1578.067
Increase in working capital			1135.040	177.211	265.816	0.000
Net working capital, local			537.436	696.105	934.109	934.109
Net working capital, foreign			597.604	616.146	643.958	643.958

Note: adc = minimum days of coverage ; coto = coefficient of turnover .

Annex XIII.1.2

WORKING CAPITAL REQUIREMENT
(Malaysia)

-- COMFAR 2.1 - FEAS - Demo Version. 01323 -----

Net Working Capital in 000 US$

Year	mdc	coto	1992	1993	1994	1995-2006
Coverage	mdc	coto				
Current assets &						
Accounts receivable	78	4.6	501.283	653.727	882.392	882.392
Inventory and materials	84	4.3	59.833	83.767	119.667	119.667
Energy	0	---	0.000	0.000	0.000	0.000
Spares	360	1.0	300.000	300.000	300.000	300.000
Work in progress	0	---	0.000	0.000	0.000	0.000
Finished products	30	12.0	182.725	231.958	305.805	305.805
Cash in hand	15	24.0	33.946	35.596	38.071	38.071
Total current assets			1077.787	1305.047	1645.938	1645.938
Current liabilities and Accounts payable	28	12.9	158.600	206.100	277.350	277.350
Net working capital			919.188	1098.948	1368.588	1368.588
Increase in working capital			919.188	179.760	269.640	0.000
Net working capital, local			535.854	697.281	939.421	939.421
Net working capital, foreign			383.333	401.667	429.167	429.167

Note: mdc = minimum days of coverage ; coto = coefficient of turnover .

Annex XIII.2.1

TOTAL INITIAL INVESTMENT
(Thailand)

COMFAR 2.1 - FEAS - Demo Version, 01323

Total Initial Investment in 000 US$

Year	1989.1	1989.2	1990.1	1990.2	1991.1	1991.2
Fixed investment costs						
Land, site preparation, development	0.000	0.000	0.000	0.000	0.000	0.000
Buildings and civil works	0.000	680.000	2040.000	2040.000	1359.000	680.000
Auxiliary and service facilities	0.000	0.000	0.000	0.000	0.000	0.000
Incorporated fixed assets	0.000	0.000	0.000	0.000	0.000	0.000
Plant machinery and equipment	0.000	1402.000	4558.000	4558.000	2452.000	1050.000
Total fixed investment costs	0.000	2082.000	6598.000	6598.000	3811.000	1730.000
Pre-production capital expenditures	0.000	2719.783	2956.458	2343.825	1650.605	1746.720
Net working capital	0.000	0.000	0.000	0.000	0.000	0.000
Total initial investment costs	0.000	4801.783	9554.457	8941.825	5461.605	3476.720
Of it foreign, in %	0.000	78.297	63.067	59.632	64.785	74.044

FORMIC ACID - THAILAND --- 24.8.88, JM

TOTAL INITIAL INVESTMENT (Malaysia)

Total Initial Investment in 000 US$

Year	1989.1	1989.2	1990.1	1990.2	1991.1	1991.2
Fixed investment costs						
Land, site preparation, development	0.000	0.000	0.000	0.000	0.000	0.000
Buildings and civil works	0.000	865.000	2594.000	2594.000	1729.000	864.000
Auxiliary and service facilities .	0.000	0.000	0.000	0.000	0.000	0.000
Incorporated fixed assets	0.000	0.000	0.000	0.000	0.000	0.000
Plant machinery and equipment . . .	0.000	1384.000	4597.000	4597.000	2325.000	942.000
Total fixed investment costs	0.000	2249.000	7191.000	7191.000	4054.000	1806.000
Pre-production capital expenditures.	0.000	2397.300	2636.610	2116.050	1592.865	1607.815
Net working capital	0.000	0.000	0.000	0.000	0.000	0.000
Total initial investment costs . . .	0.000	4646.300	9827.610	9307.050	5646.865	3413.815
Of it foreign, in %	0.000	71.610	54.506	51.008	57.160	67.128

FORMIC ACID - MALAYSIA --- 26/8/1988, jm

Annex XIII.3.1.

SOURCE OF FINANCING, CONSTRUCTION
(Thaiiand)

- COMFAR 2.1 - FEAS

Source of Finance, construction in 000 US$

Year	1989.1	1989.2	1990.1	1990.2	1991.1	1991.2
Equity, ordinary ..	0.000	8598.000	0.000	0.000	0.000	0.000
Equity, preference.	0.000	0.000	0.000	0.000	0.000	0.000
Subsidies, grants .	0.000	0.000	0.000	0.000	0.000	0.000
Loan A, foreign .	0.000	3695.000	5795.000	4914.000	2982.000	1932.000
Loan B, foreign..	0.000	0.000	0.000	0.000	0.000	0.000
Loan C, foreign .	0.000	0.000	0.000	0.000	0.000	0.000
Loan A, local....	0.000	352.000	1408.000	1408.000	352.000	0.000
Loan B, local....	0.000	0.000	0.000	0.000	0.000	0.000
Loan C, local....	0.000	0.000	0.000	0.000	0.000	0.000
Total loan	0.000	4047.000	7203.000	6322.000	3334.000	1932.000
Current liabilities	0.000	0.000	0.000	0.000	0.000	0.000
Bank overdraft	0.000	0.000	0.000	0.000	0.000	800.393
Total funds	0.000	12645.000	7203.000	6322.000	3334.000	2732.393

FORMIC ACID - THAILAND ---

Annex XIII.3.2

SOURCE OF FINANCING, CONSTRUCTION
(Malaysia)

COMFAR 2.1 - PFAS -

Source of Finance, construction in 000 US$

Year	1989.1	1989.2	1990.1	1990.2	1991.1	1991.2
Equity, ordinary ..	0.000	10907.500	0.000	0.000	0.000	0.000
Equity, preference.	0.000	0.000	0.000	0.000	0.000	0.000
Subsidies, grants .	0.000	0.000	0.000	0.000	0.000	0.000
Loan A, foreign .	0.000	3276.000	5152.000	4376.000	2732.000	1718.000
Loan B, foreign..	0.000	0.000	0.000	0.000	0.000	0.000
Loan C, foreign .	0.000	0.000	0.000	0.000	0.000	0.000
Loan A, local....	0.000	443.000	1774.000	1774.000	443.000	0.000
Loan B, local....	0.000	0.000	0.000	0.000	0.000	0.000
Loan C, local....	0.000	0.000	0.000	0.000	0.000	0.000
Total loan	0.000	3719.000	6926.000	6150.000	3175.000	1718.000
Current liabilities	0.000	0.000	0.000	0.000	0.000	0.000
Bank overdraft	0.000	0.000	0.000	0.000	0.000	252.141
Total funds	0.000	14626.500	6926.000	6150.000	3175.000	1970.141

FORMIC ACID - MALAYSIA -

-- COMFAR 2.1 - FEAS - Demo Version, D

Total Production Costs in 000 US$

Year	1992	1993	1994	1995	1996	1997	1998
% of nom. capacity (single product).	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Raw material 1	487.500	682.500	975.000	975.000	975.000	975.000	975.000
Other raw materials	151.000	211.400	302.000	302.000	302.000	302.000	302.000
Utilities	85.500	119.700	171.000	171.000	171.000	171.000	171.000
Energy	495.500	695.100	993.000	993.000	993.000	993.000	993.000
Labour, direct	98.000	98.000	98.000	98.000	98.000	98.000	98.000
Repair, maintenance	361.500	409.700	492.000	482.000	482.000	482.000	482.000
Spares	490.000	490.000	490.000	490.000	490.000	490.000	490.000
Factory overheads	24.000	24.000	24.000	24.000	24.000	24.000	24.000
Factory costs	2194.000	2730.400	3535.000	3535.000	3535.000	3535.000	3535.000
Administrative overheads	83.700	83.700	83.700	83.700	83.700	83.700	83.700
Indir. costs, sales and distribution	180.225	246.715	346.450	346.450	346.450	346.450	346.450
Direct costs, sales and distribution	136.350	190.890	272.700	272.700	272.700	272.700	272.700
Depreciation	1962.277	1962.277	1962.277	1962.277	1962.277	1962.277	1962.277
Financial costs	1757.060	1757.060	1757.060	1716.580	1676.100	1635.620	1595.140
Total production costs	6313.612	6971.042	7957.187	7916.707	7876.227	7835.747	7795.267
Costs per unit (single product) .	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Of it foreign, %	53.301	49.416	44.793	45.022	45.253	45.487	45.723
Of it variable,%	26.032	33.008	41.310	41.522	41.735	41.951	42.169
Total labour	138.000	138.000	138.000	138.000	138.000	138.000	138.000

FORMIC ACID - THAILAND --

PRODUCTION COSTS (Thailand) - A

Total Production Costs in 000 US$

Year	1999	2000	2001	2002	2003	2004	2005	2006
% of nom. capacity (single product).	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Raw material 1	975.000	975.000	975.000	975.000	975.000	975.000	975.000	975.000
Other raw materials	302.000	302.000	302.000	302.000	302.000	302.000	302.000	302.000
Utilities	171.000	171.000	171.000	171.000	171.000	171.000	171.000	171.000
Energy	993.000	993.000	993.000	993.000	993.000	993.000	993.000	993.000
Labour, direct	98.000	98.000	98.000	98.000	98.000	98.000	98.000	98.000
Repair, maintenance	482.000	482.000	482.000	482.000	482.000	482.000	482.000	482.000
Spares	490.000	490.000	490.000	490.000	490.000	490.000	490.000	490.000
Factory overheads	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
Factory costs	3535.000	3535.000	3535.000	3535.000	3535.000	3535.000	3535.000	3535.000
Administrative overheads	83.700	83.700	83.700	83.700	83.700	83.700	83.700	83.700
Indir. costs, sales and distribution	346.450	346.450	346.450	346.450	346.450	346.450	346.450	346.450
Direct costs, sales and distribution	272.700	272.700	272.700	272.700	272.700	272.700	272.700	272.700
Depreciation	1962.277	1962.277	1962.277	1962.277	1962.280	910.819	910.819	910.827
Financial costs	1554.660	1514.180	1473.700	1379.130	1284.559	1189.989	1135.898	1081.906
Total production costs	7754.787	7714.307	7673.826	7579.256	7484.689	6338.657	6284.567	6230.484
Costs per unit (single product)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Of it foreign, %	45.962	46.203	46.447	46.313	46.175	41.247	40.741	40.227
Of it variable,%	42.389	42.611	42.876	43.370	43.918	51.859	52.305	52.759
Total labour	138.000	138.000	138.000	138.000	138.000	138.000	138.000	138.000

Total Production Costs in 000 US$

Year	1992	1993	1994	1995	1996	1997	1998
% of nom. capacity (single product).	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Raw material 1	305.000	427.000	610.000	610.000	610.000	610.000	610.000
Other raw materials	151.000	211.400	302.000	302.000	302.000	302.000	302.000
Utilities	372.500	521.500	745.000	745.000	745.000	745.000	745.000
Energy	549.500	769.300	1099.000	1099.000	1099.000	1099.000	1099.000
Labour, direct	125.000	125.000	125.000	125.000	125.000	125.000	125.000
Repair, maintenance	297.000	336.600	396.000	396.000	396.000	396.000	396.000
Spares	300.000	300.000	300.000	300.000	300.000	300.000	300.000
Factory overheads	5.200	5.200	5.200	5.200	5.200	5.200	5.200
Factory costs	2105.200	2696.000	3582.200	3582.200	3582.200	3582.200	3582.200
Administrative overheads	87.500	87.500	87.500	87.500	87.500	87.500	87.500
Indir. costs, sales and distribution	81.500	108.100	148.000	148.000	148.000	148.000	148.000
Direct costs, sales and distribution	117.600	164.640	235.200	235.200	235.200	235.200	235.200
Depreciation	1988.166	1988.166	1988.166	1988.166	1988.166	1988.166	1988.166
Financial costs	1650.760	1650.760	1606.420	1562.080	1517.740	1473.400	1429.060
Total production costs	6030.726	6695.166	7647.486	7603.146	7558.806	7514.466	7470.126
Costs per unit (single product)	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Of it foreign, %	47.327	43.610	39.466	39.696	39.929	40.164	40.403
Of it variable,%	27.544	34.735	43.442	43.695	43.951	44.211	44.473
Total labour	170.000	170.000	170.000	170.000	170.000	170.000	170.000

PRODUCTION COSTS (Malaysia) - A

Total Production Costs in 000 US$

Year	1999	2000	2001	2002	2003	2004	2005	2006
% of nom. capacity (single product).	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Raw material 1	610.000	610.000	610.000	610.000	610.000	610.000	610.000	610.000
Other raw materials	302.000	302.000	302.000	302.000	302.000	302.000	302.000	302.000
Utilities	745.000	745.000	745.000	745.000	745.000	745.000	745.000	745.000
Energy	1099.000	1099.000	1099.000	1099.000	1099.000	1099.000	1099.000	1099.000
Labour, direct	125.000	125.000	125.000	125.000	125.000	125.000	125.000	125.000
Repair, maintenance	396.000	396.000	396.000	396.000	396.000	396.000	396.000	396.000
Spares	300.000	300.000	300.000	300.000	300.000	300.000	300.000	300.000
Factory overheads	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200
Factory costs	3582.200	3582.200	3582.200	3582.200	3582.200	3582.200	3582.200	3582.200
Administrative overheads	87.500	87.500	87.500	87.500	87.500	87.500	87.500	87.500
Indir. costs, sales and distribution	148.000	148.000	148.000	148.000	149.000	148.000	148.000	148.000
Direct costs, sales and distribution	235.200	235.200	235.200	235.200	235.200	235.200	235.200	235.200
Depreciation	1988.166	1988.166	1988.166	1988.166	1988.160	949.832	949.832	949.833
Financial costs	1384.720	1340.380	1296.040	1203.406	1110.771	1062.477	1014.182	965.888
Total production costs	7425.786	7381.446	7337.106	7244.472	7151.831	6065.209	6016.915	5968.622
Costs per unit (single product)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Of it foreign, %	40.644	40.888	41.135	40.995	40.850	35.736	35.220	34.696
Of it variable, %	44.739	45.007	45.279	45.858	46.452	54.775	55.214	55.661
Total labour	170.000	170.000	170.000	170.000	170.000	170.000	170.000	170.000

CASH-FLOW TABLES, PRODUCTION - 1

COMFAR 2.1 - FEAS - Demo Version, 01323

Cashflow tables, production in 000 US$

Year	1992	1993	1994	1995	1996	1997	1998
Total cash inflow	3268.069	4396.843	6284.277	6219.764	6219.764	6219.764	6219.764
Financial resources	158.189	43.009	64.512	0.000	0.000	0.000	0.000
Sales, net of tax	3109.882	4353.834	6219.764	6219.764	6219.764	6219.764	6219.764
Total cash outflow	5644.563	5228.984	6677.238	6306.430	6265.950	6225.470	6184.990
Total assets	1293.227	220.219	330.329	0.000	0.000	0.000	0.000
Operating costs	2594.275	3251.705	4237.850	4237.850	4237.850	4237.850	4237.850
Cost of finance	1757.060	1757.060	1757.060	1716.580	1676.100	1635.620	1595.140
Repayment	0.000	0.000	352.000	352.000	352.000	352.000	352.000
Corporate tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dividends paid	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Surplus (deficit)	-2376.493	-832.142	-392.961	-86.666	-46.186	-5.706	34.774
Cumulated cash balance	-3176.883	-4009.025	-4401.986	-4488.652	-4534.837	-4540.543	-4505.769
Inflow, local	1407.173	1824.401	2609.240	2547.265	2547.265	2547.265	2547.265
Outflow, local	2981.052	3087.891	4406.629	4066.170	4025.690	3985.210	3944.730
Surplus (deficit)	-1573.879	-1263.489	-1797.389	-1518.905	-1478.425	-1437.945	-1397.465
Inflow, foreign	1860.896	2572.441	3675.037	3672.500	3672.500	3672.500	3672.500
Outflow, foreign	2663.510	2141.093	2270.610	2240.260	2240.260	2240.260	2240.260
Surplus (deficit)	-802.614	431.348	1404.427	1432.240	1432.240	1432.240	1432.240
Net cashflow	-619.433	924.919	1716.098	1981.915	1981.915	1981.915	1981.915
Cumulated net cashflow	-30336.430	-29411.520	-27695.420	-25713.500	-23731.590	-21749.680	-19767.760

FORMIC ACID - THAILAND --- 24.8.88, JM

CASH-FLOW TABLES, PRODUCTION - B (Thailand)

Cashflow tables, production in 000 US$

Year	1999	2000	2001	2002	2003	2004	2005	2006
Total cash inflow	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764
Financial resources	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sales, net of tax	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764	6219.764
Total cash outflow	6144.510	6104.030	6836.270	6741.699	6647.129	6200.559	6146.468	6092.377
Total assets	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Operating costs	4237.850	4237.850	4237.850	4237.850	4237.850	4237.850	4237.850	4237.850
Cost of finance	1554.660	1514.180	1473.700	1379.130	1284.559	1189.989	1135.898	1081.808
Repayment	352.000	352.000	1124.720	1124.720	1124.720	772.720	772.720	772.720
Corporate tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dividends paid	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Surplus (deficit)	75.254	115.734	-616.505	-521.935	-427.365	19.206	73.296	127.387
Cumulated cash balance	-4430.514	-4314.780	-4931.285	-5453.220	-5880.585	-5861.379	-5788.083	-5660.696
Inflow, local	2547.265	2547.265	2547.265	2547.265	2547.265	2547.265	2547.265	2547.265
Outflow, local	3904.250	3863.770	3823.290	3782.810	3742.330	3349.850	3349.850	3349.850
Surplus (deficit)	-1356.985	-1316.505	-1276.025	-1235.545	-1195.065	-802.585	-802.585	-802.585
Inflow, foreign	3672.500	3672.500	3672.500	3672.500	3672.500	3672.500	3672.500	3672.500
Outflow, foreign	2240.260	2240.260	3012.990	2958.890	2904.799	2850.708	2796.618	2742.528
Surplus (deficit)	1432.240	1432.240	659.520	713.610	767.700	821.791	875.881	929.972
Net cashflow	1981.915	1981.915	1981.915	1981.915	1981.915	1981.915	1981.915	1981.915
Cumulated net cashflow	-17785.850	-15803.930	-13822.020	-11840.110	-9858.191	-7876.277	-5894.362	-3912.448

COMFAR 2.1 - FEAS - Demo Version, D132'

Cashflow tables, production in 000 US$

Year	1992	1993	1994	1995	1996	1997	1998
Total cash inflow	3494.600	4717.900	6743.250	6672.000	6672.000	6672.000	6672.000
Financial resources	158.600	47.500	71.250	0.000	0.000	0.000	0.000
Sales, net of tax	3336.000	4670.400	6672.000	6672.000	6672.000	6672.000	6672.000
Total cash outflow	5120.348	5377.660	6443.610	6058.380	6014.040	5969.700	5925.360
Total assets	1077.787	227.260	340.890	0.000	0.000	0.000	0.000
Operating costs	2391.800	3056.240	4052.900	4052.900	4052.900	4052.900	4052.900
Cost of finance	1650.760	1650.760	1606.420	1562.080	1517.740	1473.400	1429.060
Repayment	0.000	443.400	443.400	443.400	443.400	443.400	443.400
Corporate tax	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dividends paid	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Surplus (deficit)	-1625.748	-659.760	299.640	613.620	657.960	702.300	746.640
Cumulated cash balance	-1877.888	-2537.647	-2238.007	-1624.387	-966.427	-264.127	482.513
Inflow, local	2061.767	2733.767	3908.650	3840.000	3840.000	3840.000	3840.000
Outflow, local	3048.821	3620.633	4578.150	4223.020	4178.680	4134.340	4090.000
Surplus (deficit)	-987.054	-886.867	-669.500	-383.020	-338.680	-294.340	-250.000
Inflow, foreign	1432.833	1984.133	2834.600	2832.000	2832.000	2832.000	2832.000
Outflow, foreign	2071.527	1757.027	1865.460	1835.360	1835.360	1835.360	1835.360
Surplus (deficit)	-638.693	227.106	969.140	996.640	996.640	996.640	996.640
Net cashflow	25.012	1434.400	2349.460	2619.100	2619.100	2619.100	2619.100
Cumulated net cashflow	-30448.990	-29014.590	-26665.130	-24046.030	-21426.930	-18807.830	-16188.730

FORMIC ACID - MALAYSIA --- 26/8/1988, in

CASH-FLOW TABLES, PRODUCTION - B
(Malaysia)

Cashflow tables, production in 000 US$

Year	1999	2000	2001	2002	2003	2004	2005	2006
Total cash inflow . .	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000
Financial resources .	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sales, net of tax . .	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000	6672.000
Total cash outflow . .	5881.020	5836.680	6482.260	6389.626	5853.591	6048.013	6019.037	5990.060
Total assets	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Operating costs . . .	4052.900	4052.900	4052.900	4052.900	4052.900	4052.900	4052.900	4052.900
Cost of finance . . .	1384.720	1340.380	1296.040	1203.406	1110.771	1062.477	1014.182	965.888
Repayment	443.400	443.400	1133.320	1133.320	689.920	689.920	689.920	689.920
Corporate tax . . .	0.000	0.000	0.000	0.000	0.000	242.716	262.034	281.352
Dividends paid . . .	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Surplus (deficit) .	790.980	835.320	189.740	282.374	818.409	623.987	652.963	681.940
Cumulated cash balance	1273.493	2108.813	2298.552	2580.926	3399.335	4023.322	4676.285	5358.226
Inflow, local	3840.000	3840.000	3840.000	3840.000	3840.000	3840.000	3840.000	3840.000
Outflow, local	4045.660	4001.320	3956.980	3912.640	3424.900	3667.616	3686.935	3706.251
Surplus (deficit) .	-205.660	-161.320	-116.980	-72.640	415.100	172.384	153.065	133.749
Inflow, foreign . . .	2832.000	2832.000	2832.000	2832.000	2832.000	2832.000	2832.000	2832.000
Outflow, reign . . .	1835.360	1835.360	2525.280	2476.986	2428.691	2380.397	2332.102	2283.808
Surplus (deficit) .	996.640	996.640	306.720	355.014	403.309	451.603	499.897	548.192
Net cashflow	2619.100	2619.100	2619.100	2619.100	2619.100	2376.384	2357.065	2337.748
Cumulated net cashflow	-13569.630	-10950.530	-8331.432	-5712.332	-3093.232	-716.849	1640.217	3977.965

Annex XIII.6.1

NET INCOME STATEMENT (Thailand) - A

COMFAR 2.1 - FEAS - Demo Version, 01322

Net Income Statement in 000 US$

Year	1992	1993	1994	1995	1996
Total sales, incl. sales tax	3131.250	4383.750	6262.499	6262.499	6262.499
Less: variable costs, incl. sales tax	1664.942	2330.920	3329.885	3329.885	3329.885
Variable margin	1466.307	2052.829	2932.615	2932.615	2932.615
As % of total sales	46.828	46.828	46.828	46.828	46.828
Non-variable costs, incl. depreciation	2912.978	2912.977	2912.977	2912.978	2912.977
Operational margin	-1446.671	-860.148	19.637	19.637	19.637
As % of total sales	-46.201	-19.621	0.314	0.314	0.314
Cost of finance	1757.060	1757.060	1757.060	1716.580	1676.100
Gross profit	-3203.731	-2617.208	-1737.423	-1696.943	-1656.463
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-3203.731	-2617.208	-1737.423	-1696.943	-1656.463
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	-3203.731	-2617.208	-1737.423	-1696.943	-1656.463
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-3203.731	-2617.208	-1737.423	-1696.943	-1656.463
Accumulated undistributed profit	-3203.731	-5820.939	-7558.362	-9255.305	-10911.770
Gross profit, % of total sales	-102.315	-59.702	-27.743	-27.097	-26.451
Net profit, % of total sales	-102.315	-59.702	-27.743	-27.097	-26.451
ROE, Net profit, % of equity	-37.261	-30.440	-20.207	-19.736	-19.266
ROI, Net profit+interest, % of invest.	-4.699	-2.772	0.063	0.063	0.063

FORMIC ACID - THAILAND --- 24.5.88. 3M

Annex XIII.6.1

NET INCOME STATEMENT (Thailand) - B

COMFAR 2.1 - FEAS - Deec Version, B13

Net Income Statement in 000 US$

Year	1997	1998	1999	2000	2001
Total sales, incl. sales tax	6262.499	6262.499	6262.499	6262.499	6262.499
Less: variable costs, incl. sales tax.	3329.885	3329.885	3329.885	3329.885	3329.885
Variable margin	2932.615	2932.615	2932.615	2932.615	2932.615
As % of total sales	46.828	46.828	46.828	46.828	46.828
Non-variable costs, incl. depreciation	2912.978	2912.977	2912.978	2912.977	2912.977
Operational margin	19.637	19.637	19.637	19.637	19.637
As % of total sales	0.314	0.314	0.314	0.314	0.314
Cost of finance	1635.620	1595.140	1554.660	1514.180	1473.700
Gross profit	-1615.983	-1575.503	-1535.023	-1494.543	-1454.063
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-1615.983	-1575.503	-1535.023	-1494.543	-1454.063
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	-1615.983	-1575.503	-1535.023	-1494.543	-1454.063
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-1615.983	-1575.503	-1535.023	-1494.543	-1454.063
Accumulated undistributed profit	-12527.750	-14103.250	-15638.280	-17132.820	-18586.880
Gross profit, % of total sales	-25.804	-25.158	-24.511	-23.865	-23.219
Net profit, % of total sales	-25.804	-25.158	-24.511	-23.865	-23.219
ROE, Net profit, % of equity	-18.795	-18.324	-17.850	-17.382	-16.912
ROI, Net profit+interest, % of invest.	0.063	0.063	0.063	0.063	0.063

Annex XIII.6.1

NET INCOME STATEMENT (Thailand) - C

COMFAR 2.1 - FEAS - Demo Version, BI

Net Income Statement in 000 US$

Year	2002	2003	2004	2005	2006
Total sales, incl. sales tax	6262.499	6262.499	6262.499	6262.499	6262.499
Less: variable costs, incl. sales tax.	3329.885	3329.885	3329.885	3329.885	3329.885
Variable margin	2932.615	2932.615	2932.615	2932.615	2932.615
As % of total sales	46.828	46.828	46.828	46.828	46.828
Non-variable costs, incl. depreciation	2912.977	2912.980	1861.519	1861.519	1861.527
Operational margin	19.637	19.635	1071.096	1071.096	1071.088
As % of total sales	0.314	0.314	17.103	17.103	17.103
Cost of finance	1379.130	1284.559	1189.989	1135.899	1081.808
Gross profit	-1359.492	-1264.925	-118.893	-64.803	-10.720
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-1359.492	-1264.925	-118.893	-64.803	-10.720
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	-1359.492	-1264.925	-118.893	-64.803	-10.720
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-1359.492	-1264.925	-118.893	-64.803	-10.720
Accumulated undistributed profit	-19946.370	-21211.300	-21330.190	-21394.990	-21405.710
Gross profit, % of total sales	-21.708	-20.198	-1.898	-1.035	-0.171
Net profit, % of total sales	-21.708	-20.198	-1.898	-1.035	-0.171
ROE, Net profit, % of equity	-15.812	-14.712	-1.383	-0.754	-0.125
ROI, Net profit+interest, % of invest.	0.063	0.063	3.423	3.423	3.423

Annex XIII.6.2

NET INCOME STATEMENT (Malaysia) - A

COMFAR 2.1 - FEAS - Demo Version, 01

Net Income Statement in 000 US$

Year	1992	1993	1994	1995	1996
Total sales, incl. sales tax	3336.000	4670.400	6672.000	6672.000	6672.000
Less: variable costs, incl. sales tax.	1661.100	2325.540	3322.200	3322.200	3322.200
Variable margin	1674.900	2344.860	3349.800	3349.800	3349.800
As % of total sales	50.207	50.207	50.207	50.207	50.207
Non-variable costs, incl. depreciation	2718.865	2718.865	2718.866	2718.866	2718.865
Operational margin	-1043.966	-374.005	630.934	630.934	630.934
As % of total sales	-31.294	-8.008	9.456	9.456	9.456
Cost of finance	1650.760	1650.760	1606.420	1562.080	1517.740
Gross profit	-2694.726	-2024.766	-975.486	-931.146	-886.806
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-2694.726	-2024.766	-975.486	-931.146	-886.806
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	-2694.726	-2024.766	-975.486	-931.146	-886.806
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-2694.726	-2024.766	-975.486	-931.146	-886.806
Accumulated undistributed profit	-2694.726	-4719.491	-5694.977	-6626.123	-7512.929
Gross profit, % of total sales	-80.777	-43.353	-14.621	-13.956	-13.291
Net profit, % of total sales	-80.777	-43.353	-14.621	-13.956	-13.291
ROE, Net profit, % of equity	-24.705	-18.563	-8.943	-8.537	-8.130
ROI, Net profit+interest, % of invest.	-3.325	-1.185	1.981	1.981	1.981

FORMIC ACID - MALAYSIA --- 26/8/

Annex XIII.6.2

NET INCOME STATEMENT (Malaysia) - B

COMFAR 2.1 - FEAS - Demo Version. D132.

Net Income Statement in 000 US$

Year	1997	1998	1999	2000	2001
Total sales, incl. sales tax	6672.000	6672.000	6672.000	6672.000	6672.000
Less: variable costs, incl. sales tax.	3322.200	3322.200	3322.200	3322.200	3322.200
Variable margin	3349.800	3349.800	3349.800	3349.800	3349.800
As % of total sales	50.207	50.207	50.207	50.207	50.207
Non-variable costs, incl. depreciation	2718.866	2718.866	2718.865	2718.866	2718.866
Operational margin	630.934	630.934	630.934	630.934	630.934
As % of total sales	9.456	9.456	9.456	9.456	9.456
Cost of finance	1473.400	1429.060	1384.720	1340.380	1296.040
Gross profit	-842.466	-798.126	-753.786	-709.446	-665.106
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-842.466	-798.126	-753.786	-709.446	-665.106
Tax	0.000	0.000	0.000	0.000	0.000
Net profit	-842.466	-798.126	-753.786	-709.446	-665.106
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-842.466	-798.126	-753.786	-709.446	-665.106
Accumulated undistributed profit	-8355.395	-9153.521	-9907.307	-10616.753	-11281.859
Gross profit, % of total sales	-12.627	-11.962	-11.298	-10.633	-9.969
Net profit, % of total sales	-12.627	-11.962	-11.298	-10.633	-9.969
ROE, Net profit, % of equity	-7.724	-7.317	-6.911	-6.504	-6.098
ROI, Net profit+interest, % of invest.	1.981	1.981	1.981	1.981	1.981

FORMIC ACID - MALAYSIA --- 26/5/

Annex XIII.6.2

NET INCOME STATEMENT (Malaysia) - C

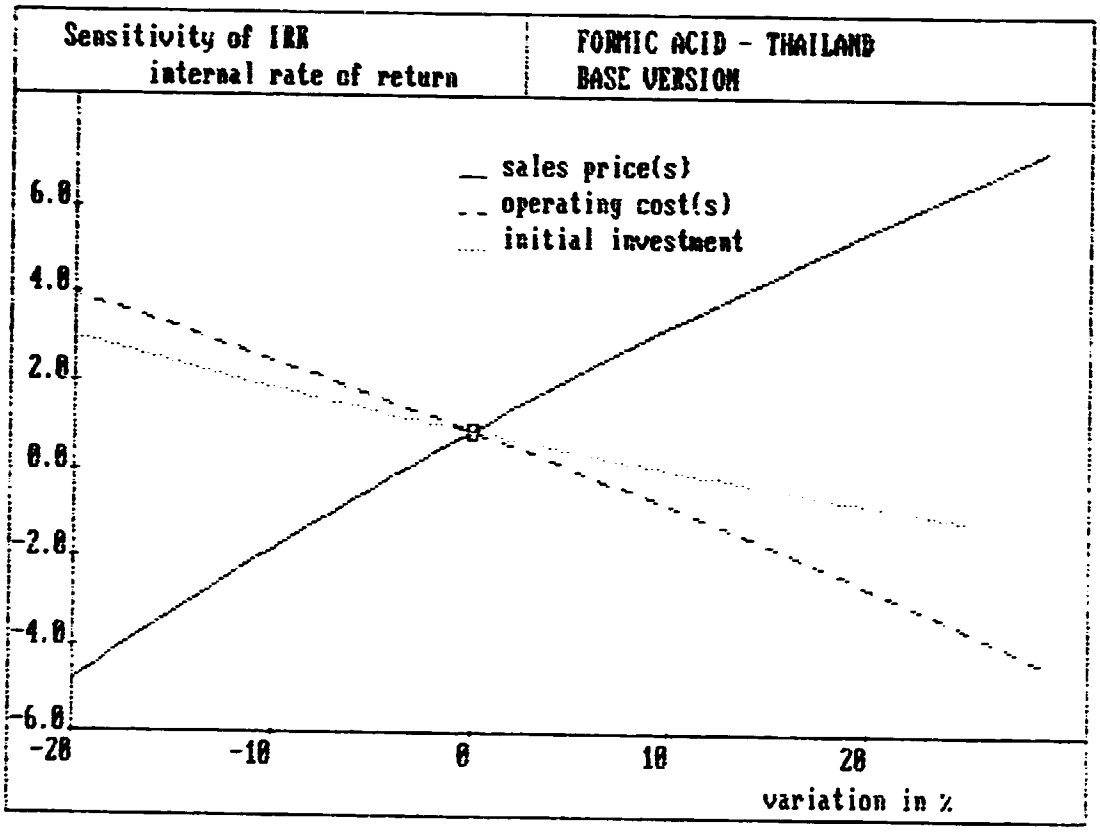
COMFAR 3.1 - PEAS - Demo Version. DI

Net Income Statement in 000 US$

Year	2002	2003	2004	2005	2006
Total sales, incl. sales tax	6672.000	6672.000	6672.000	6672.000	6672.000
Less: variable costs, incl. sales tax.	3322.200	3322.200	3322.200	3322.200	3322.200
Variable margin	3349.800	3349.800	3349.800	3349.800	3349.800
As % of total sales	50.207	50.207	50.207	50.207	50.207
Non-variable costs, incl. depreciation	2718.866	2718.860	1680.532	1680.531	1680.533
Operational margin	630.934	630.940	1669.268	1669.268	1669.267
As % of total sales	9.456	9.457	25.019	25.019	25.019
Cost of finance	1203.406	1110.771	1062.477	1014.182	965.8[illegible]
Gross profit	-572.472	-479.831	606.791	655.086	703.379
Allowances	0.000	0.000	0.000	0.000	0.000
Taxable profit	-572.472	-479.831	606.791	655.086	703.379
Tax	0.000	0.000	242.716	262.034	281.352
Net profit	-572.472	-479.831	364.075	393.052	422.027
Dividends paid	0.000	0.000	0.000	0.000	0.000
Undistributed profit	-572.472	-479.831	364.075	393.052	422.027
Accumulated undistributed profit	-11854.330	-12334.160	-11970.090	-11577.036	-11155.010
Gross profit, % of total sales	-8.580	-7.192	9.095	9.818	10.542
Net profit, % of total sales	-8.580	-7.192	5.457	5.891	6.325
ROE, Net profit, % of equity	-5.248	-4.399	3.338	3.603	3.869
ROI, Net profit+interest, % of invest.	1.981	1.981	4.480	4.419	4.359

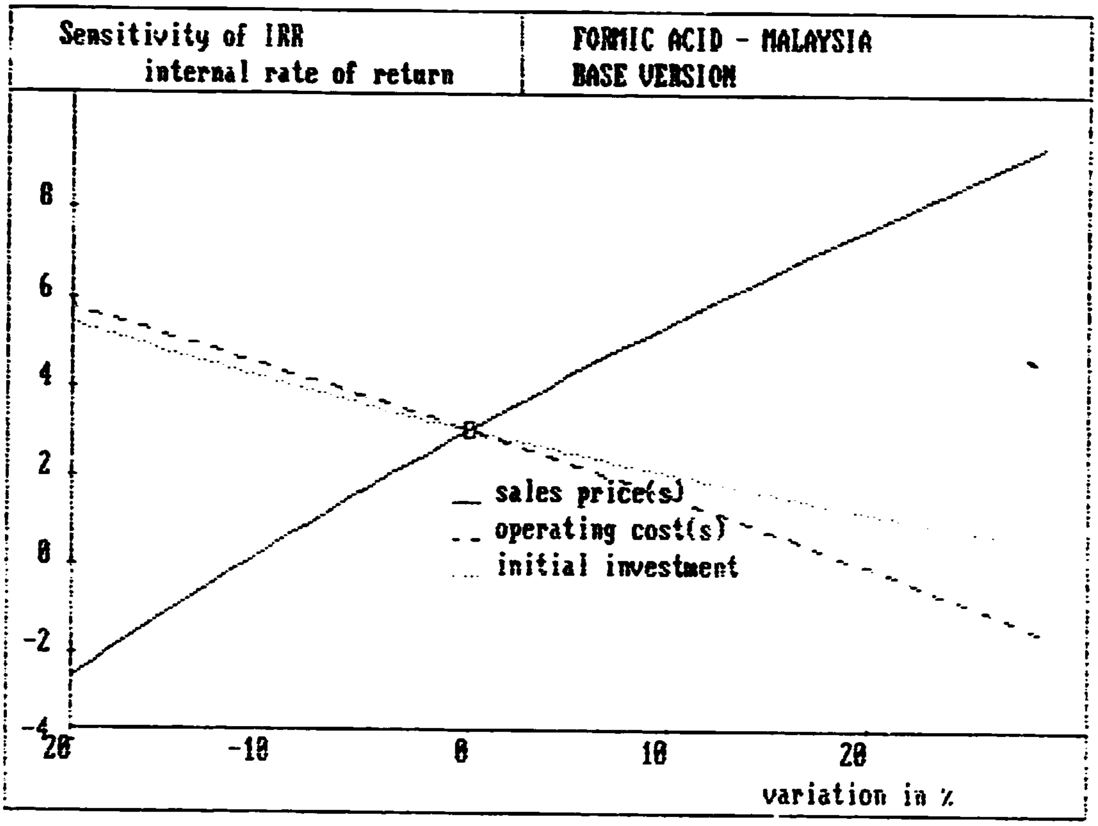
Annex XIII.7.1

SENSITIVITY OF IRR (Thailand)



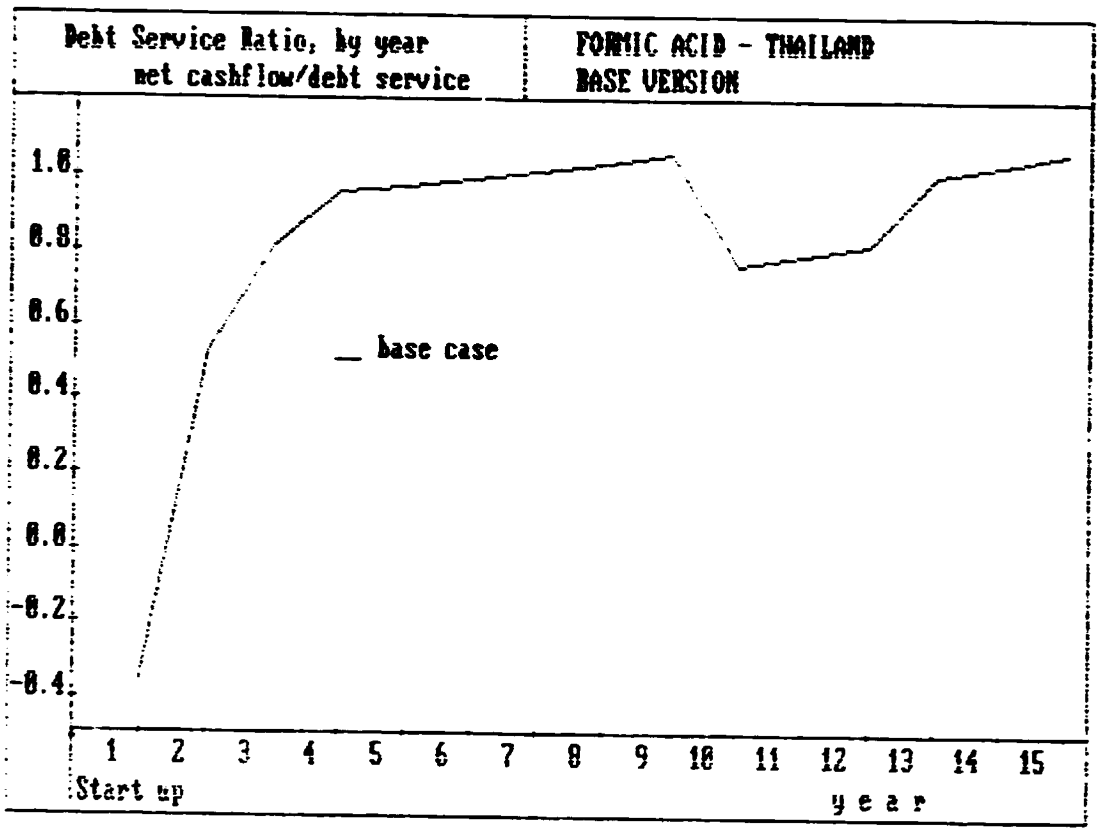
Annex XIII.7.2

SENSITIVITY OF IRR (Malaysia)



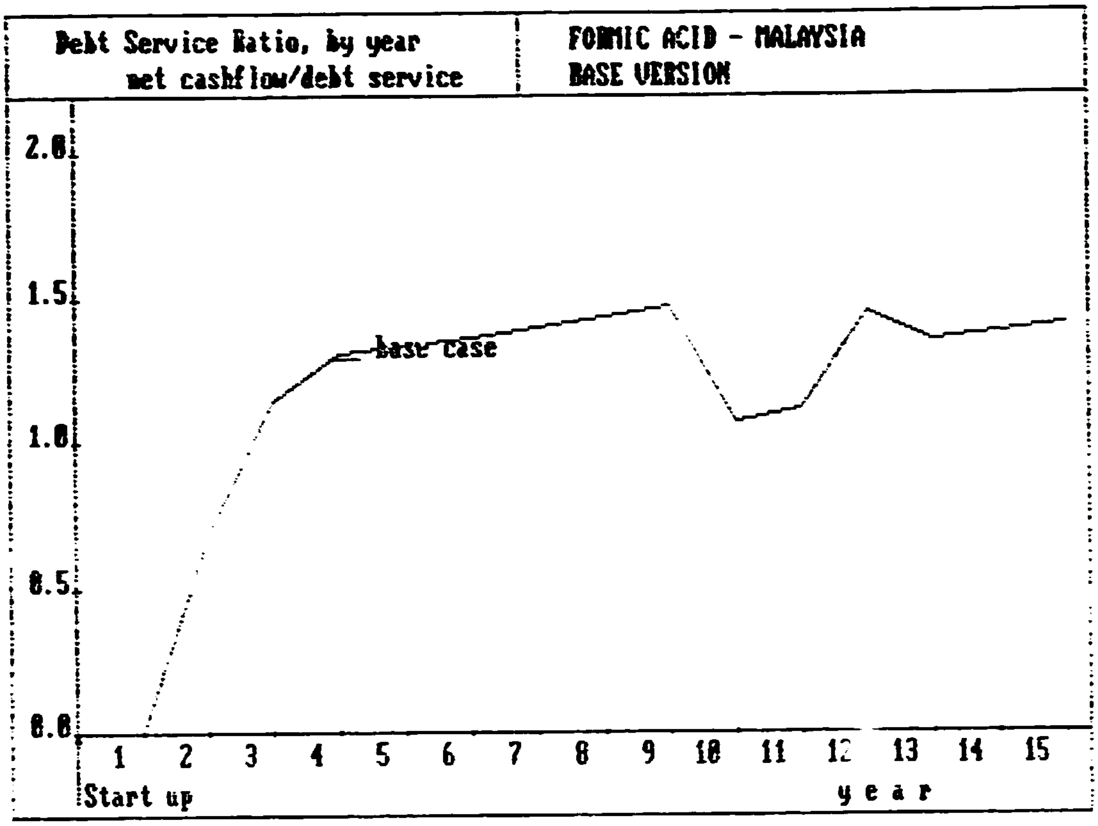
Annex XIII.8.1

DEBT:SERVICE RATIO CHART (Thailand)



Annex XIII.8.2

DEBT:SERVICE RATIO CHART (Malaysia)



Annex XIII.9.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS I
(Thailand)

-- COMFAR 2.1 - FEAS - Test Version, 81322 -----

FORMIC ACID - THAILAND
26.8.86, JM
SENS.ANAL. - HIGHER SALES PRICE

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	32236.39	65.858 % foreign
current assets:	0.00	0.000 % foreign
total assets:	32236.39	65.858 % foreign

Source of funds during construction phase

equity & grants:	8598.00	19.993 % foreign
foreign loans :	19318.00	
local loans :	3520.00	
total funds :	31436.00	66.920 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2457.92	3965.15	3965.15
depreciation :	1962.28	1962.28	1962.28
interest :	1757.06	1676.10	1473.70
production costs	6177.26	7603.53	7401.13
thereof foreign	52.96 %	44.31 %	45.52 %
total sales :	3597.50	7195.00	7195.00
gross income :	-2737.48	-723.96	-521.56
net income :	-2737.48	-723.96	-521.56
cash balance :	-1910.24	886.31	316.00
net cashflow :	-153.18	2914.42	2914.42

Net Present Value at: 12.00 % = -12180.22
Internal Rate of Return: 4.20 %
Return on equity1: -22.48 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.9.2

SUMMARY SHEET FOR SENSITIVITY ANALYSIS I
(Malaysia)

-- COMFAR 2.1 - FEAS - Demo Version. D1323 -----

FORMIC ACID - MALAYSIA
26/8/1986. jk
HIGHER SALES PRICE

3 year(s) of construction. 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	32841.64	57.783 % foreign
current assets:	0.00	0.000 % foreign
total assets:	32841.64	57.783 % foreign

Source of funds during construction phase

equity & grants:	10907.50	20.000 % foreign
foreign loans :	17246.00	
local loans :	4434.00	
total funds :	32589.50	59.619 % foreign

Cashflow from operations

Year:	1	5	15
operating costs:	2274.20	3817.70	3817.70
depreciation :	1986.17	1986.17	1986.17
interest :	1650.76	1517.74	1296.04
production costs	5913.13	7323.61	[illegible]
thereof foreign	47.25 %	39.57 %	40.81 %
total sales :	3897.00	7794.00	7794.00
gross income :	-2133.73	235.19	456.89
net income :	-2133.73	141.12	274.14
cash balance :	-1064.75	1685.88	1126.98
net cashflow :	586.01	3647.02	3555.34

Net Present Value at: 15.00 % = -11837.55
Internal Rate of Return: 6.38 %
Return on equity1: -7.27 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.10.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS II
(Thailand)

COMFAR 2.1 - FEAS - Demo Version, 81323 --

FORMIC ACID - THAILAND
26.8.88, JM
sens.anl. - reduced investment

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	25794.65	65.894 % foreign
current assets:	0.00	0.000 % foreign
total assets:	25794.65	65.894 % foreign

Source of funds during construction phase

equity & grants:	6799.00	20.003 % foreign
foreign loans :	15445.00	
local loans :	2816.00	
total funds :	25060.00	57.059 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2457.92	3965.15	3965.15
depreciation :	1570.10	1570.10	1570.10
interest :	1404.99	1340.22	1178.30
production costs	5433.01	6875.47	6713.55
thereof foreign	50.27 %	41.20 %	42.20 %
total sales :	3131.25	6262.50	6262.50
gross income :	-2459.48	-928.41	-766.49
net income :	-2459.48	-928.41	-766.49
cash balance :	-2024.42	360.09	-95.79
net cashflow :	-619.43	1981.91	1981.91

Net Present Value at: 12.00 % = -11664.64
Internal Rate of Return: 2.59 %
Return on equity1: -38.62 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.10.2

SUMMARY SHEET FOR SENSITIVITY ANALYSIS II
(Malaysia)

COMFAR 2.1 - FEAS - Demo Version, 0132

FORMIC ACID - MALAYSIA
25/5/1988, ja
SENS.ANAL. - REDUCED INVESTMENT

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	26299.82	57.643 % foreign
current assets:	0.00	0.000 % foreign
total assets:	26299.82	57.643 % foreign

Source of funds during construction phase

equity & grants:	8745.00	20.000 % foreign
foreign loans :	13798.00	
local loans :	3546.00	
total funds :	26089.00	59.592 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2274.20	3817.70	3817.70
depreciation :	1591.83	1591.83	1591.83
interest :	1320.46	1214.08	1036.78
production costs	5186.49	6623.61	6446.31
thereof foreign	44.66 %	36.54 %	37.54 %
total sales :	3336.00	6672.00	6672.00
gross income :	-1968.09	-186.81	-9.51
net income :	-1968.09	-186.81	-9.51
cash balance :	-1295.45	1050.42	675.80
net cashflow :	25.01	2619.10	2619.10

Net Present Value at: 15.00 % = -10859.68
Internal Rate of Return: 5.09 %
Return on equity1: -12.68 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.11.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS III (Thailand)

COMFAR 2.1 - FEAS - Demo Version. 013

FORMIC ACID - THAILAND
26.8.88, JM
SENS.ANAL. - REDUCED VARIABLE COSTS

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	32236.39	65.858 % foreign
current assets:	0.00	0.000 % foreign
total assets:	32236.39	65.858 % foreign

Source of funds during construction phase

equity & grants:	8598.00	19.993 % foreign
foreign loans :	19318.00	
local loans :	3520.00	
total funds :	31436.00	66.920 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2138.68	3374.66	3374.66
depreciation :	1962.28	1962.28	1962.28
interest :	1757.06	1676.10	1473.70
production costs	5858.02	7013.04	6810.64
thereof foreign	55.78 %	48.04 %	49.47 %
total sales :	3131.25	6262.50	6262.50
gross income :	-2884.49	-1065.97	-863.57
net income :	-2884.49	-1065.97	-863.57
cash balance :	-1974.44	544.30	-26.02
net cashflow :	-217.38	2572.40	2572.40

Net Present Value at: 12.00 % = -13676.65
Internal Rate of Return: 3.06 %
Return on equity1: -34.37 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.11.2

SUMMARY SHEET FOR SENSITIVITY ANALYSIS III (Malaysia)

COMFAR 2.1 - FEAS - demo version, UNIDO

FORMIC ACID - MALAYSIA
26/8/1988, jn
SENS. ANAL. - REDUCED VARIABLE COSTS

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	32841.64	57.703 % foreign
current assets:	0.00	0.000 % foreign
total assets:	32841.64	57.703 % foreign

Source of funds during construction phase

equity & grants:	10907.53	20.000 % foreign
foreign loans :	17248.00	
local loans :	4434.00	
total funds :	32589.50	59.619 % foreign

Cashflow from operations

Year:	1	3	10
operating costs:	1933.95	3220.78	3220.78
depreciation :	1986.17	1986.17	1986.17
interest :	1653.76	1517.74	1296.04
production costs	5594.88	6726.61	6504.91
thereof foreign	49.94 %	43.08 %	44.55 %
total sales :	3336.00	6672.00	6672.00
gross income :	-2376.48	-259.81	-66.11
net income :	-2376.48	-289.51	-68.11
cash balance :	-1225.47	1254.96	786.74
net cashflow :	425.29	3216.10	3216.10

Net Present Value at: 15.00 % = -13389.13
Internal Rate of Return: 5.07 %
Return on equity1: -13.46 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.12.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS IV
(Thailand)

-- COMFAR 2.1 - FEAS - Demo Version.

FORMIC ACID - THAILAND
26.8.88. JM
RED.INVEST./RED.VAR.COST/HIGHER SALES PR

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	25794.65	65.834 % foreign
current assets:	0.00	0.000 % foreign
total assets:	25794.65	65.834 % foreign

Source of funds during construction phase

equity & grants:	6799.00	20.000 % foreign
foreign loans :	15445.00	
local loans :	2816.00	
total funds :	25060.00	67.059 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2138.68	3374.66	3374.66
depreciation :	1570.10	1570.10	1570.10
interest :	1404.99	1340.22	1178.30
production costs	5113.77	6284.98	6123.06
thereof foreign	53.41 %	45.07 %	46.26 %
total sales :	3597.50	7195.00	7195.00
gross income :	-1673.99	594.58	756.50
net income :	-1673.99	356.75	453.90
cash balance :	-1156.12	1645.25	1124.60
net cashflow :	248.87	3267.07	3202.30

Net Present Value at: 12.00 % = -5359.62
Internal Rate of Return: 7.95 %
Return on equity1: -1.62 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.12.2

SUMMARY SHEET FOR SENSITIVITY ANALYSIS IV
(Malaysia)

COMFAR 2.1 - FEAS - Demo Version, 0137

FORMIC ACID - MALAYSIA
26/5/1988, jm
RED.INVEST/RED.VAR.COST/HIGHER SALES PR.

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	26299.82	57.643 % foreign
current assets:	0.00	0.000 % foreign
total assets:	26299.82	57.643 % foreign

Source of funds during construction phase

equity & grants:	8745.00	20.000 % foreign
foreign loans :	13798.00	
local loans :	3546.00	
total funds :	26089.00	59.592 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	1955.95	3220.70	3220.70
depreciation :	1591.83	1591.83	1591.83
interest :	1320.46	1214.08	1036.78
production costs	4868.24	6026.61	5849.31
thereof foreign	47.57 %	40.16 %	41.37 %
total sales :	3897.00	7794.00	7794.00
gross income :	-1088.84	1532.19	1709.49
net income :	-1089.84	919.31	1025.69
cash balance :	-334.17	2156.54	1711.00
net cashflow :	936.29	3725.22	3654.30

Net Present Value at: 15.00 % = -6052.32
Internal Rate of Return: 9.75 %
Return on equity1: 3.77 %
Return on equity2: 3.19 %

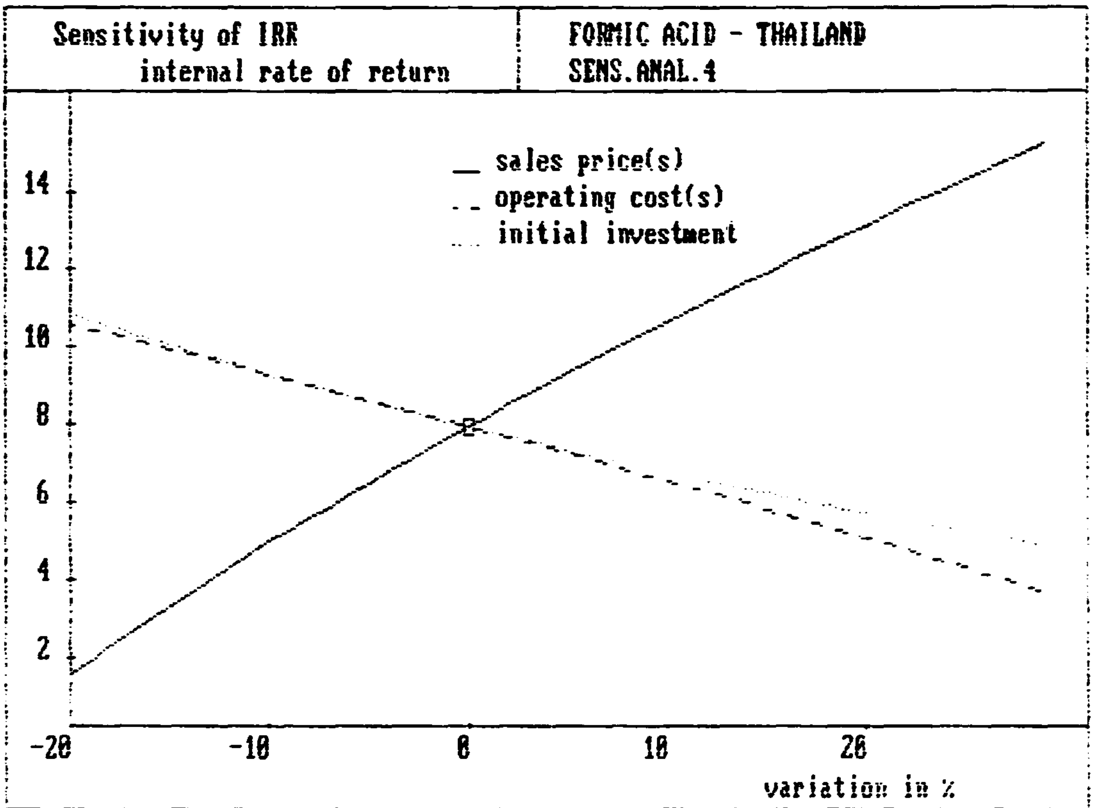
Index of Schedules produced by COMFAR

Total initial investment
Total investment during production
Total production costs
Working Capital requirements
Cashflow Tables
Projected Balance
Net income statement
Source of finance

Annex XIII.13.1

SENSITIVITY OF IRR FOR SENSITIVITY ANALYSIS IV
(Thailand)

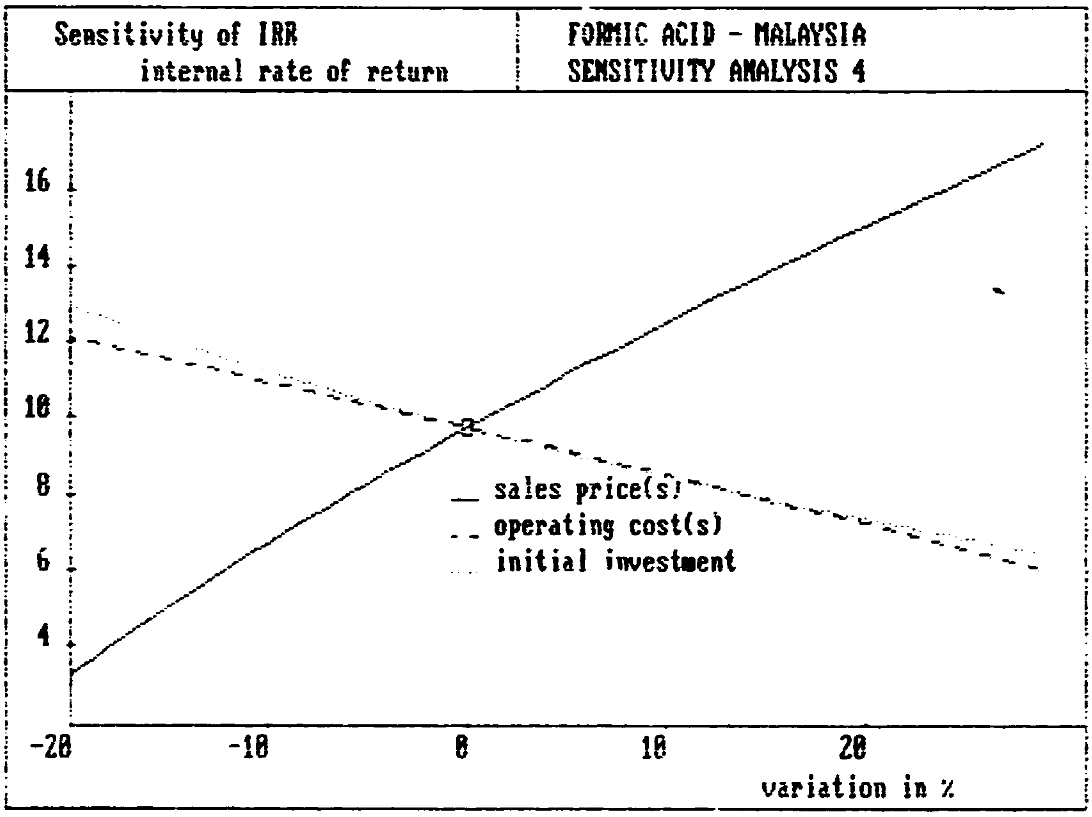
COMFAR 2.1 - FEAS - Demo Version.



Annex XIII.13.2

SENSITIVITY OF IRR FOR SENTIVITY ANALYSIS IV
(Malaysia)

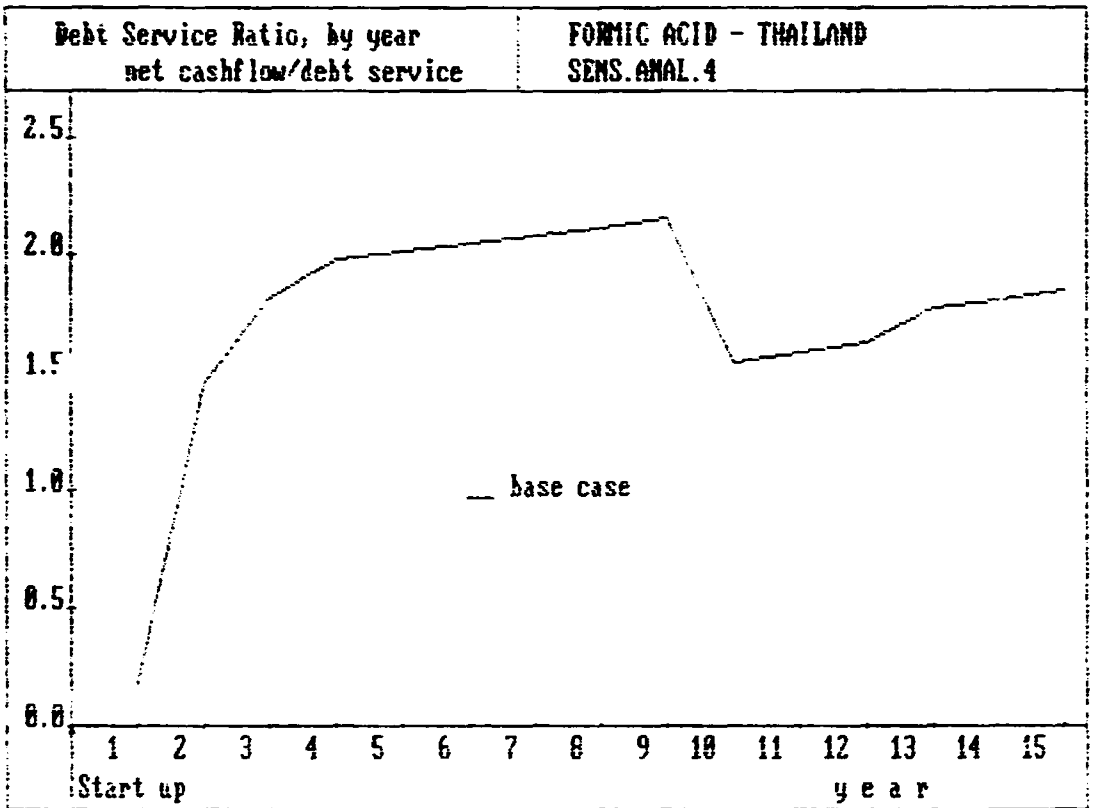
COMFAS 2.1 - FEAS - Demo Ver



Annex XIII.14.1

DEBT:RATIO CHART OF SENSITIVITY ANALYSIS V
(Thailand)

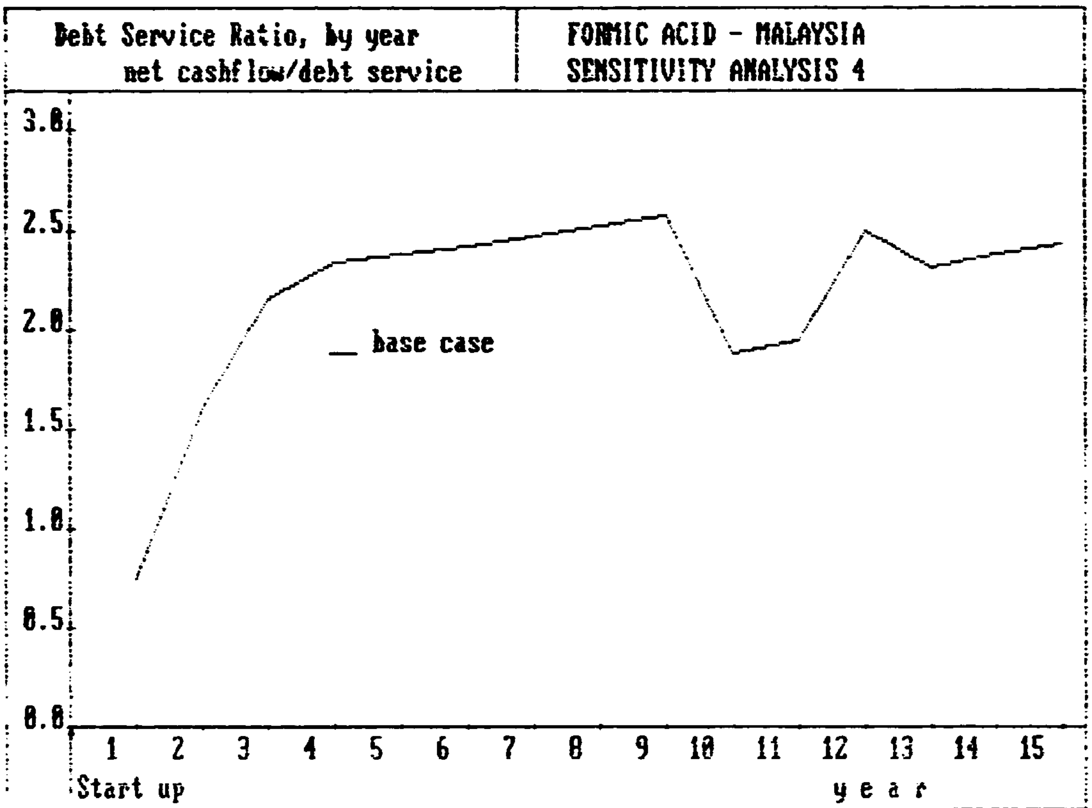
COMFAR 2.1 - FEAS - Demo Version.



Annex XIII.14.2

DEBT:SERVICE RATIO CHART OF SENSITIVITY ANALYSIS V
(Malaysia)

COMFAR 2.1 - FEAS - Demo Version



Annex XIII.15.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS V
(Thailand)

-- COMFAR 2.1 - FEAS - Demo Version. D13

FORMIC ACID - THAILAND
26.3.88. JM
FAMAL 4 plus 10 years tax holiday

3 year(s) of construction. 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	25794.65	65.804 % foreign
current assets:	0.00	0.000 % foreign
total assets:	25794.65	65.804 % foreign

Source of funds during construction phase

equity & grants:	6799.00	20.003 % foreign
foreign loans :	15445.00	
local loans :	2816.00	
total funds :	25060.00	67.059 % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2135.68	3374.66	3374.65
depreciation :	1570.10	1570.10	1570.10
interest :	1404.99	1340.22	1178.30
production costs	5113.77	6284.98	6123.06
thereof foreign	53.41 %	45.07 %	46.26 %
total sales :	3597.50	7195.00	7195.00
gross income :	-1673.99	594.53	756.50
net income :	-1673.99	594.58	756.50
cash balance :	-1156.12	1883.08	1427.20
net cashflow :	248.87	3504.90	3504.90

Net Present Value at: 12.00 % = -4571.43
Internal Rate of Return: 3.57 %
Return on equity1: 0.29 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.15.2

SUMMARY SHEET FOR SENSITIVITY ANALYSIS V
(Malaysia)

COMFAR 2.2 - FEAS - Demo Version.

FORMIC ACID - MALAYSIA
26.6 1988. jr
PAMAL 4 plus 10 years tax holiday

2 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	26299.82	57.643 % foreign
current assets:	0.00	0.000 % foreign
total assets:	26299.82	57.643 % foreign

Source of funds during construction phase

equity & grants:	8745.00	20.000 % foreign
foreign loans :	13798.00	
local loans :	3546.00	
total funds :	26089.00	59.592 % foreign

Cashflow from operations

Year:	[illegible]	[illegible]	[illegible]
operating costs:	1955.96	3222.73	3222.73
depreciation :	1591.83	1591.83	1591.83
interest :	1320.45	1214.[illegible]5	1036.73
production costs	4868.24	6026.61	5849.32
thereof foreign	47.57 %	40.16 %	41.37 %
total sales :	3697.00	7794.00	7794.00
gross income :	-1188.84	1532.19	1739.49
net income :	-1188.84	1532.19	1739.49
cash balance :	-334.17	2769.42	2394.80
net cashflow :	386.29	4338.10	4336.23

Net Present Value at: 15.00 % = -4451.47
Internal Rate of Return: 11.21 %
Return on equity1: 7.39 %
Return on equity2: 12.99 %

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance

Annex XIII.16.1

SUMMARY SHEET FOR SENSITIVITY ANALYSIS VI
(Thailand)

COMFAR 2.1 - FEAS - Demo Version

FORMIC ACID - THAILAND
11.10.88.JM
REVISED FATHA6 - DOM.50%.EXP.50%

3 year(s) of construction, 15 years of production
currency conversion rates:
foreign currency 1 unit = 1.0000 units accounting currency
local currency 1 unit = 1.0000 units accounting currency
accounting currency: 000 US$

Total initial investment during construction phase

fixed assets:	25794.65	65.904 % foreign
current assets:	0.00	0.000 % foreign
total assets:	25794.65	65.904 % foreign

Source of funds during construction phase

equity & grants:	6779.0[illegible]	[illegible] % foreign
foreign loans :	15445.00	
local loans :	3816.00	
total funds :	[illegible]	[illegible] % foreign

Cashflow from operations

Year:	1	5	10
operating costs:	2244.2[illegible]	3585.7[illegible]	3585.7[illegible]
depreciation :	1570.16	1570.1[illegible]	1570.16
interest :	1404.99	1341.[illegible]	1178.3[illegible]
production costs	5219.29	649[illegible]	6334.[illegible]
thereof foreign	52.3[illegible] %	4[illegible] %	44.72 %
total sales :	3710.00	742[illegible]	7420.00
gross income :	-1667.16	609.24	770.16
net income :	-1667.16	324.9[illegible]	452.10
cash balance :	-1180.39	1653.45	1132.90
net cashflow :	224.60	3275.27	3210.50

Net Present Value at: 12.00 % = -5203.64
Internal Rate of Return: 8.06 %
Return on equity1: -1.48 %
Return on equity2: not found

Index of Schedules produced by COMFAR

Total initial investment	Cashflow Tables
Total investment during production	Projected Balance
Total production costs	Net income statement
Working Capital requirements	Source of finance