THE PACIFIC REFINERY CONCEPT:
A TECHNO-ECONOMIC ANALYSIS

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EXECUTIVE SUMMARY

A great deal has been discussed in the past few years on the pros and cons of an oil refinery in the Pacific Islands. Most of this discussion has focused on the following needs:

- to enhance energy security,
- to lower the costs of petroleum products,
- to capture value added from refining, and
- to provide profits and foreign exchange from the export of surplus products.

The Pacific Islands Energy Project of the East-West Center has carefully examined each of these arguments and has concluded that the heart of any regional refinery lies with its basic economic viability. In other words, on close examination, the supposed noneconomic advantages of a regional refinery are not sufficiently strong to support such an ambitious project unless the economics are reasonable. The East-West Center's examination of the noneconomic benefits strongly suggests that under current and foreseeable conditions oil security may not be increased at all by such a project.

To measure the economics of a refinery project, a computer program developed at the East-West Center was used to estimate capital and operating costs for a range of crude oil inputs and refinery configurations. This computer program, called PRYMO, then estimated an "exposure ratio" to evaluate the most cost-effective options. The exposure ratio measures import (of crude oil) plus necessary exports (of refinery product) against regional demand. A high exposure ratio indicates that the project is highly dependent on external supplies or product markets whereas a low exposure ratio suggests that the refinery closely approximates needs in the Pacific Islands region. From the exposure ratio the level of direct economic subsidy can be directly calculated.

The exposure ratio/subsidy studies clearly suggest that a regional refinery for the Pacific Island area is a poor and costly proposition. Depending on the crude oil source and the design of the refinery, initial capital for such a project would range from US$122 million to $250 million, and annual subsidies requirements would range between US$32.7 million and $68.4 million. The results of the studies are presented below.
A great deal of discussion has occurred in the past few years about the pros and cons of a refinery in the Pacific Islands. Studies have been undertaken by consultants and oil companies advocating a refinery in Papua New Guinea or Fiji to supply the refined product requirements of the islands. The present study was undertaken by persons with no special financial interest in refinery construction or in crude or product trading, and with the sole purpose of providing an objective review of the technical and economic feasibility of a new refinery in the South Pacific.

THE RATIONALE FOR DOMESTIC REFINING

Over the past decade developing countries have shown an increasing interest in building domestic refining capacity. Of the capacity presently planned or under construction, the bulk of it is slated for the developing countries, particularly the major oil exporters and a few of the largest oil-importing developing countries.

Four reasons are normally given as to why a developing country may wish to construct a domestic refinery:

1. to enhance energy security
2. to provide petroleum products at lower costs than petroleum product imports
3. to capture the value added from refining
4. to provide profits and foreign-exchange earnings from export of refined products

The energy-security argument bears close examination, not only because it is so frequently heard, but also because many countries have made massive investments on the strength of this belief. However, a refinery enhances a nation's energy security only if the nation has access to reliable supplies of crude oil of the appropriate quality. A refinery without crude oil is worse than useless; it is an expensive liability that, for a developing country, can drain away foreign exchange to service debt without performing any vital function. For an oil-importing developing country the energy-security problem still boils down to one of reliable
external supplies of oil, and the availability of domestic refining capacity is a secondary issue. There is little evidence to support the belief that in previous energy shortages countries with refineries have fared better than those without; in fact, during the 1979-80 oil price increases, refinery margins actually went negative in most major markets. This implies that many countries importing refined products actually suffered less than those importing crude oil. Thus, a refinery does not necessarily enhance a nation's energy security unless it is an integral part of some larger strategy.

Providing petroleum products for domestic markets at prices lower than petroleum product imports is a reasonable goal if it can be achieved. The transport of refined products is far more expensive than the transport of crude oil. A barrel of crude can be moved from the Persian Gulf to Suva for about the same cost as moving a barrel of gasoline from Singapore to Suva. Product transport is often 200-300 percent more expensive than crude oil transport, depending on the routes and quantities moved. Thus, if the sources of refined product imports are distant from the domestic market, it may often be cheaper to bring in crude oil and refine it locally. The economics of this situation for the Pacific Islands is discussed in detail in later sections.

Capturing the value added from refining is an illusory goal for many developing countries. First, if the refined products produced domestically are more expensive than refined product imports, then the value added is at least partially offset by losses elsewhere in the national economy. Second, in most cases refineries in developing countries are built with imported technology and a high debt/equity ratio. In such cases the vast bulk of the revenues from refining is promptly sent out of the country to pay for imports of crude oil and to service a debt that represents a high proportion of the total capital costs of the project. The actual return on domestic equity retained in the national economy may therefore be quite small.

Profits and foreign-exchange earnings from export of refined products are, of course, quite an attractive sideline to a domestic refining venture; many of the refineries built in developing countries have been justified on such grounds. The refining complexes in Singapore and the Netherlands Antilles have always been oriented toward export markets rather
than domestic consumption. One reason for the emphasis on export markets is that refineries are sensitive to economies of scale; a 200,000 barrel per day (b/d) refinery will have a much lower capital investment per barrel per day than a similar 10,000 b/d refinery. Furthermore, at larger scales more sophisticated processing can be justified, allowing more flexible refining plants to be constructed.

For reasons discussed in the next section, the 1980s promise to be a difficult time for export refining. The Pacific Islands are particularly poorly placed to enter the export market: Singapore and Japan both have massive refinery overcapacities; Australia, Thailand, Malaysia, New Zealand, China, and South Korea will all roughly balance capacity and demand in the decade; and Indonesia will have significant export capacity in some products when its present refinery expansion program is completed. Exports from a Pacific refinery to areas outside the Pacific Islands would thus encounter fierce competition from domestic refiners and export refineries elsewhere, most of which would have lower production costs and much lower transportation costs than the Pacific Islands.

In summary, we do not believe that energy-security arguments should be used to justify domestic refineries except in certain unusual circumstances. Neither do we think that capturing value added is as important for refining as many development economists might suggest. Thus, we believe that the decision to build a refinery should be based on the direct economic merits of the project alone. Since, for reasons discussed in the next section, export refining in the Pacific Islands is unlikely to be profitable, the analysis in this report focuses on one problem only: the economics of a refinery built to meet the domestic demands of the Pacific Islands.

THE CURRENT REFINING SITUATION

Refining capacity worldwide has grown rapidly since the 1940s. Installed capacity grew at annual rates of 6.5 percent during 1940-60, 7.2 percent during 1960-73, and 4.5 percent during 1973-80. In the period 1940-73 petroleum product demand grew slightly faster than refining capacity, thereby putting pressure on supply and leading to large refinery profit margins and high capacity utilization rates.
In the period 1973-80, however, demand for petroleum products grew at only about 1.2 percent annually, far below the growth in refinery capacity. Utilization rates worldwide dropped to the 70-75 percent range, and in 1981 and 1982, as demand fell in absolute terms in most areas, capacity utilization dropped further and refining margins went negative in many regions. Losses in the refining industry in 1981 have been estimated at around $10 billion and were about the same in 1982-83.

To be profitable, most refineries need to be run at 85-95 percent of calendar-day (effective) capacity. Few regions are now achieving this rate. As Table 1 shows, 1982 capacity utilization was around 66 percent in North America, 55 percent in Western Europe, and 64 and 58 percent in Singapore and Japan, respectively. It would take a massive revival in demand, or significant capacity scrapping, to raise these figures to a respectable level.

TABLE 1. Estimated refinery capacity and utilization rates

<table>
<thead>
<tr>
<th>Region</th>
<th>1980 capacity 1,000 b/d</th>
<th>Utilization, % of calendar day</th>
<th>1979</th>
<th>1980</th>
<th>1981</th>
<th>1982*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>2,179.0</td>
<td></td>
<td>.72</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North America</td>
<td>20,631.2</td>
<td></td>
<td>81</td>
<td>76</td>
<td>68</td>
<td>66</td>
</tr>
<tr>
<td>Oceania</td>
<td>861.0</td>
<td></td>
<td>83</td>
<td>74</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Latin America</td>
<td>8,673.8</td>
<td></td>
<td>70</td>
<td>77</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td>4,063.7</td>
<td></td>
<td>67</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrally planned Asia</td>
<td>1,850.1</td>
<td></td>
<td>100</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrally planned Europe</td>
<td>13,724.1</td>
<td></td>
<td>80</td>
<td>77</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>Far East</td>
<td>9,763.5</td>
<td></td>
<td>80</td>
<td>72</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>(Indonesia)</td>
<td>(515.0)</td>
<td></td>
<td>(87)</td>
<td>(90)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Japan)</td>
<td>(5,662.0)</td>
<td></td>
<td>(82)</td>
<td>(73)</td>
<td>(65)</td>
<td>(64)</td>
</tr>
<tr>
<td>(Singapore)</td>
<td>(1,048.8)</td>
<td></td>
<td>(63)</td>
<td>(68)</td>
<td>(61)</td>
<td>(58)</td>
</tr>
<tr>
<td>Western Europe</td>
<td>20,189.7</td>
<td></td>
<td>66</td>
<td>61</td>
<td>56</td>
<td>55</td>
</tr>
<tr>
<td>World</td>
<td>81,936.1</td>
<td></td>
<td>75</td>
<td>71</td>
<td>71</td>
<td>70</td>
</tr>
<tr>
<td>World excluding centrally planned Europe</td>
<td>68,212.0</td>
<td>74</td>
<td>69</td>
<td>69</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

a. Preliminary estimates.
Although contract prices for refined products such as gasoline continue to hover around $42/b, spot prices for gasoline have slipped to about $39/b, and large amounts of refined products are now being sold on a spot or discount basis. The netbacks from crude purchased at official government prices are still negative in many cases; that is, the cost of the crude exceeds the value of the product output after processing costs are accounted for. Although the market may tighten somewhat as product demand recovers, the current product contract prices are probably a good indication of future margins in the industry.

At the prevailing 1982-83 crude costs many analysts predicted f.o.b. contract prices of gasoline at $45-46/b. These expectations were based on historical margins, which were measured during periods in which demand growth was exceeding capacity growth. This situation is unlikely to recur in the foreseeable future. Present contract prices are indicative of an "acceptable" profit level in existing, largely amortized refineries; although the rates of return on investment may be below historical averages, they are liable to persist into the future.

In addition to the present refinery overcapacity, substantial additions to capacity are likely to be made by the mid-1980s. At year-end 1981 there were plans to add 10 million b/d of new refining capacity, which, at current demand levels, would increase the world capacity surplus by about 50 percent. About 3.7 million b/d of this planned capacity is actually under construction.

Much of this capacity has now been suspended or deferred. A substantial proportion, however, is likely to be completed. OPEC capacity is slated to expand by 2.8-3.1 million b/d. Capacity in non-OPEC oil exporters has been planned to expand by 1.4 million b/d, although Mexico's current financial crisis will likely wipe off 700,000 b/d from that figure. Other developing countries have plans for just short of 1 million b/d of new capacity. In total at least 4-5 million b/d of new capacity is likely to come onstream by the late 1980s—far more than enough to negate the effects of a demand revival or a major scrapping program.

In the changed market conditions many refineries planned for the export market have been shelved, especially in countries relying on imported crude. Major import/export refining schemes have been dropped or held in abeyance in South Korea, Tunisia, Sudan, Italy, and other nations.
Furthermore, traditional entrepôt refining centers with well-established marketing networks, such as Singapore and the Netherlands Antilles, have been running at rates only slightly above half capacity. As new OPEC export refineries come onstream, backed by cheap financing and low-cost gas supplies for refinery fuel, the pressure on export refineries is bound to increase.

In the areas adjacent to the Pacific Islands the export market is liable to remain unattractive. Singapore could readily supply an additional 400,000 b/d to the region if demand warranted, and Singapore's available capacity is going to increase when Indonesian processing contracts disappear as a result of Indonesian refinery expansions. Indonesia itself will have spare capacity to provide various products to export markets.

Australia and New Zealand are both approaching a balanced situation, and Australian oil companies already have engineering designs to add considerable new capacity at two or three sites if demand warrants. Thailand is embarked on an expansion and modernization plan in its refineries that should bring supply and demand into balance. Malaysia is constructing a new refinery. China is now an important refined-products supplier to Southeast Asian spot markets, and its government has even announced plans for a major export refinery based on imported crude—although we doubt that this plan will come to pass.

Thus, no one constructing a refinery in the Asian-Pacific region should assume that profitable export markets will be available in the Far East in the foreseeable future. Not only will many countries be in rough supply-demand balance, or even have small volumes available for export, but also the Singapore refining industry will be fighting for survival throughout the rest of the decade. Given its largely depreciated plants, its strategic location, its established market position, the technical sophistication of its refineries, and current low utilization rates, Singapore can likely undercut most new entrants into the market. Anyone planning an export refinery to deliver products into Singapore's traditional markets should be prepared to run the risk of major losses for sustained periods. For this reason our analysis focuses on a refinery designed to meet domestic demands in the Pacific Islands, and we treat export markets as a market of last resort for surplus products.
Analyzing the capabilities of a refinery, and the consequent economics, is a time-consuming and somewhat arcane exercise. An accurate and detailed engineering study can cost millions of dollars. On the other hand, quick linear programming methods are often unsuited to analysis of refineries that must respond to demand patterns different from those seen in the OECD nations.

To solve this problem, RSI has built a model called PRYMO for providing rapid analyses of refinery capabilities. A detailed description and flow diagram of the model is shown in Appendix 1.

Table 2 and Figure 1 show an example of the output of PRYMO for a relatively complex refinery. Such a refinery is far more complex than would be called for in the case of the Pacific Islands; it is included to give the reader some insight into the workings of the model.

<table>
<thead>
<tr>
<th>No.</th>
<th>Source</th>
<th>Product</th>
<th>B/D</th>
<th>API</th>
<th>% Sulf</th>
<th>LB/HR</th>
<th>MBP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coker</td>
<td>Fuel gases</td>
<td>9,409</td>
<td>314.48</td>
<td>15.15</td>
<td>43,582</td>
<td>0.</td>
</tr>
<tr>
<td>2</td>
<td>Cat cracker</td>
<td>Fuel gases</td>
<td>5,877</td>
<td>262.91</td>
<td>9.67</td>
<td>30,779</td>
<td>0.</td>
</tr>
<tr>
<td>3</td>
<td>Distillation</td>
<td>Fuel gases</td>
<td>4,987</td>
<td>171.71</td>
<td>0.00</td>
<td>33,937</td>
<td>34.</td>
</tr>
<tr>
<td>4</td>
<td>Coker</td>
<td>Butanes</td>
<td>970</td>
<td>117.40</td>
<td>15.15</td>
<td>8,054</td>
<td>0.</td>
</tr>
<tr>
<td>5</td>
<td>Cat cracker</td>
<td>Butanes</td>
<td>3,450</td>
<td>116.71</td>
<td>9.67</td>
<td>28,711</td>
<td>0.</td>
</tr>
<tr>
<td>6</td>
<td>Distillation</td>
<td>Butanes</td>
<td>1,613</td>
<td>116.04</td>
<td>0.00</td>
<td>13,449</td>
<td>79.</td>
</tr>
<tr>
<td>7</td>
<td>Distillation</td>
<td>Gasoline</td>
<td>23,171</td>
<td>80.89</td>
<td>0.02</td>
<td>225,122</td>
<td>155.</td>
</tr>
<tr>
<td>8</td>
<td>Distillation</td>
<td>Naptha</td>
<td>13,714</td>
<td>60.35</td>
<td>0.05</td>
<td>147,507</td>
<td>260.</td>
</tr>
<tr>
<td>9</td>
<td>Cat cracker</td>
<td>Gasoline</td>
<td>10,835</td>
<td>56.48</td>
<td>0.31</td>
<td>118,991</td>
<td>0.</td>
</tr>
<tr>
<td>10</td>
<td>Coker</td>
<td>Gasoline</td>
<td>8,082</td>
<td>55.00</td>
<td>1.73</td>
<td>89,515</td>
<td>0.</td>
</tr>
<tr>
<td>11</td>
<td>Distillation</td>
<td>Middle dist.</td>
<td>61,027</td>
<td>41.91</td>
<td>0.73</td>
<td>726,189</td>
<td>475.</td>
</tr>
<tr>
<td>12</td>
<td>Coker</td>
<td>Middle dist.</td>
<td>8,312</td>
<td>29.10</td>
<td>5.29</td>
<td>106,909</td>
<td>0.</td>
</tr>
<tr>
<td>13</td>
<td>Blended</td>
<td>Vac. gasoils</td>
<td>51,702</td>
<td>20.93</td>
<td>3.16</td>
<td>700,642</td>
<td>850.</td>
</tr>
<tr>
<td>14</td>
<td>Cat cracker</td>
<td>Vac. gasoils</td>
<td>5,351</td>
<td>10.12</td>
<td>2.07</td>
<td>78,046</td>
<td>540.</td>
</tr>
<tr>
<td>15</td>
<td>Cat cracker</td>
<td>Residuum</td>
<td>800</td>
<td>-1.33</td>
<td>4.65</td>
<td>12,695</td>
<td>0.</td>
</tr>
</tbody>
</table>

Table 2. Petroleum refinery yields model (PYRMO) version 4.0 (1/21/83): Refinery output after catalytic cracking

Light products: 61,836. 29.5%
Middle distillates: 69,338. 33.1%
Heavy products: 57,853. 27.6%
Fuel gases: 20,273. 9.7%
Total products: 209,300. 100.0%
FIGURE I. Downstream processing flows

(C=vacuum gas oil; R=residuum; T=topped crude)

CRUDE
cap=200.

VACUUM
cap=100.

RESID HDC
cap=0.

VISBRKR
cap=0.

COKER
cap=40.

CAT CRACKER:
cap=20.

DIST HDC:
cap=0.

(fcc resid)=5.
PRYMO is not a substitute for detailed engineering studies. Although it gives a fairly accurate picture of refinery operations and costs, there are a number of constraints, such as octane and cetene numbers, blending schedules, trace metals, and the naphthene-paraffin nature of the residuum that the model does not address. Nonetheless, the output from PRYMO gives what we feel is a reasonable estimate of refinery yields and economics, and it provides better results than "back-of-the-envelope" methods commonly employed.

ANALYSIS OF THE PACIFIC REFINERY OPTIONS

Any study of a proposed refinery requires a large number of assumptions. The assumptions we have employed are discussed below. It is important to keep in mind that we have employed the most favorable assumptions consistent with our view of common sense. The results in this section are therefore not the likely results, but the results from the most favorable set of circumstances.

Site Selection

The location of the refinery should be determined by two factors: the centrality of the location with respect to the markets and the existence of fairly well-developed port infrastructure. The ideal location in the Pacific would thus be on an island having a large proportion of the total demand and a good port. Only Papua New Guinea and Fiji meet these twin requirements. Of the two, Fiji is more centrally located. If the refinery were located in PNG, it would have lower crude transport costs and lower imported product costs but higher costs to deliver products to the other Pacific Islands. Since product transport is more expensive than crude transport, we have decided to locate our hypothetical refinery near Suva. The economics would not change much if Port Moresby was selected instead.

Construction Cost Differentials

The presence of adequate port infrastructure dramatically affects construction costs for chemical plants and refineries. Costs are invariably much higher in developing countries than on the U.S. Gulf Coast. In Saudi Arabia, where billions of dollars have been spent to construct elaborate roll-on, roll-off ports suitable for modular construction of plants, the construction cost differential has narrowed to about 30 percent
above OECD costs. In areas where ports are less developed, the differential may rise to 50-150 percent, depending on conditions. Given a moderately developed port, such as Suva or Port Moresby, a differential of 50-70 percent is likely. For this study we have assumed a low-side estimate of 50 percent above U.S. Gulf Coast costs, plus additional costs for terminal and tank farm construction.

**Financing Terms**
We have assumed a 75:25 debt:equity ratio with concessionary financing at 2 percent real interest. The loans are assumed to be rolled over during construction and then repaid over a five-year levelized schedule. Accelerated depreciation is allowed over five years. Local taxes of the host government are assessed at 35 percent of operating profits net of depreciation and interest.

The required internal rate of return (IRR) is taken at 12 percent real. Although it would be possible for a lower return on equity to be taken, we believe that there are other investments in the Pacific that would yield a 12 percent IRR. If the equity receives a lower return than available elsewhere, this would constitute a hidden subsidy to the project that ought to be kept explicit.

**Delivered Crude and Product Costs**
Our assumptions are shown in Table 3. The crude costs are based on a declining real price of Arab Light to $24/b in 1990 at real 1984 prices and the resumption of something near historical crude price differentials. The product costs are based on 1982 Singapore contract prices; spot prices would be much lower.

Transport costs for crude assume that the tanker market will firm somewhat with continued scrapping, with 70,000-90,000 dwt carriers rising to about 100 Worldscale (Jan. 1982 basis). Current forecasts for this class range from 80-130 Worldscale. Transport costs for products are estimated from freight, loss, and wharfage statistics gathered for the Singapore-Suva trades by Newcombe et al. in their *Energy Mission Report for Fiji* (East-West Center, 1982).

**Demand Forecast**
Table 4 shows the demand forecast employed in this study. We have designed a refinery to meet the 1990 demand pattern.
### TABLE 3. Estimated crude, products, and transport costs for 1990 (real 1984 prices)

<table>
<thead>
<tr>
<th>Types of crude and products</th>
<th>Selling price</th>
<th>Transport</th>
<th>c.i.f. Suva</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crude:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arab Light</td>
<td>$24.00</td>
<td>$2.45</td>
<td>$26.45</td>
</tr>
<tr>
<td>Kuwaiti</td>
<td>$22.30</td>
<td>$2.45</td>
<td>$24.75</td>
</tr>
<tr>
<td>Murban</td>
<td>$24.50</td>
<td>$2.45</td>
<td>$26.95</td>
</tr>
<tr>
<td>Minas</td>
<td>$24.55</td>
<td>$1.18</td>
<td>$25.68</td>
</tr>
<tr>
<td><strong>Products:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasoline-Singapore</td>
<td>$28.50</td>
<td>$2.72</td>
<td>$31.22</td>
</tr>
<tr>
<td>Middle dist-Singapore</td>
<td>$27.90</td>
<td>$3.09</td>
<td>$30.99</td>
</tr>
<tr>
<td>HS fuel oil-Singapore</td>
<td>$20.69</td>
<td>$3.10</td>
<td>$23.79</td>
</tr>
<tr>
<td>LS fuel oil-Singapore</td>
<td>$22.40</td>
<td>$3.10</td>
<td>$25.50</td>
</tr>
</tbody>
</table>

a. Crude based on 70,000-90,000 dwt ships at Worldscale 100; product transport based on PIDP data provided by Newcombe et al.

### TABLE 4. Oil product forecast (b/d)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>3,708</td>
<td>4,241</td>
<td>4,863</td>
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<tr>
<td>Kerosene</td>
<td>944</td>
<td>1,138</td>
<td>1,390</td>
</tr>
<tr>
<td>Diesel</td>
<td>9,884</td>
<td>13,209</td>
<td>17,504</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>4,104</td>
<td>5,162</td>
<td>7,092</td>
</tr>
<tr>
<td>Avgas</td>
<td>235</td>
<td>251</td>
<td>284</td>
</tr>
<tr>
<td>Avtur</td>
<td>1,316</td>
<td>3,053</td>
<td>4,139</td>
</tr>
<tr>
<td>Bunkers</td>
<td>2,280</td>
<td>2,280</td>
<td>2,280</td>
</tr>
<tr>
<td><strong>Total b/d</strong></td>
<td><strong>22,471</strong></td>
<td><strong>29,334</strong></td>
<td><strong>37,552</strong></td>
</tr>
</tbody>
</table>

Source: PIDP estimates based on statistics gathered by Newcombe et al.
Refinery Configuration
An infinite number of configurations is possible. The first to consider is a simple hydroskimming plant. Beyond this, upgrading facilities may be added. Residuum hydrocracking and visbreaking do not provide enough upgrading to be useful in meeting the 1990 demand pattern. Catalytic cracking is oriented toward gasoline production, which is a product class in low demand in the Pacific. This leaves coking and distillate hydrocracking as the options. The installed costs are comparable; we have therefore selected distillate hydrocracking for our second refinery type, largely because of its great flexibility in meeting a range of demand patterns.

Crude Slate
About 90 crudes are important in international trades, but only a handful are moved in really large quantities. We have ignored African and U.S. crudes because of the large transport distances. The four selected—Arab Light (Saudi Arabia), Kuwaiti, Murban (UAE), and Minas (Indonesia)—cover a fairly broad range of qualities and prices.

Exposure Ratios and Subsidies
The chances of supply and demand balancing over time at a given refinery are remote. Some level of imports or exports will probably be needed. Yet there is little point in building a domestic refinery if it does not greatly limit product import needs, or if it demands large exports of surplus products. The amount of market interaction required to balance supply and demand is best measured by an "exposure ratio." This ratio is measured by the sum of required product imports plus required product exports, divided by domestic consumption. A high exposure ratio indicates that the refinery does a poor job of matching domestic demand patterns.

Two kinds of subsidies may be required to keep a refinery going, subsidies on domestic consumption and subsidies (losses incurred) on required product exports. The subsidies on domestic consumption are straightforward; they are merely the excess paid for domestic refined products over the cost of equivalent product imports. If domestic products are cheaper, they represent a savings rather than a subsidy.

Subsidies on exports are more complicated. In the case of a refinery in Suva, most of the product exports will have to be delivered back into South or Southeast Asia. To compete with exports from Singapore, which is
closer to market, the Pacific refinery will have to absorb the transport cost differential, corrected for any cost advantage/disadvantage in production. For example, if Singapore's transport cost to A is $2.50/b and Suva's is $3.00/b, the Suva refinery will have to absorb a 50¢/b loss to export to A. If in addition the Pacific refinery has a production cost disadvantage relative to Singapore of 50¢/b, the required export subsidy will rise to $1.00/b, whereas a 75¢/b advantage would result in a 25¢/b export gain in profits.

An example of subsidy analysis is given in Table 5. The required transport differential is impossible to assess without an explicit export pattern. In general, however, we believe that the market for products from a Pacific refinery will usually suffer a $2-3/b transport disadvantage relative to Singapore, or other Southeast Asian producers, in reaching markets. Considering that the new Pacific producers may have to undercut existing supplies to enter markets, we have assumed a figure of $3/b export cost exclusive of production advantages/disadvantages.

Results
Appendix 2 shows the detailed results of the analyses of refinery alternatives. Table 6 summarizes the key economic parameters and conclusion.

CONCLUSION
Excess worldwide refining capacity has made refining a bad business. Many refiners are losing money or merely breaking even today, and the situation is likely to get worse. Singapore, the Pacific's major refining center, is operating at capacity utilization rates of around 60 percent. Refined product prices are weak and will weaken even further over the remainder of this decade. In general, it makes little economic sense to add capacity to the overcrowded, money-losing, Pacific refining sector.

In the case of the Pacific Islands the situation is even more worrisome than elsewhere. Because of the structure of demand, it is not possible to construct an economic refinery that can supply the types of refined products needed in the region. The exposure of the Pacific Island nations to the international product market cannot be avoided by building a
<table>
<thead>
<tr>
<th>Product</th>
<th>Production b/d</th>
<th>Demand b/d</th>
<th>Deficit b/d</th>
<th>Import price $/b</th>
<th>Refinery price $/b</th>
<th>Gain (Loss) $/b</th>
<th>Savings (Subsidy) mm$/year</th>
</tr>
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<tbody>
<tr>
<td>Product A</td>
<td>8,000</td>
<td>9,000</td>
<td>1,000</td>
<td>$45</td>
<td>$42</td>
<td>$3</td>
<td>$8.76</td>
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<tr>
<td>Product B</td>
<td>10,000</td>
<td>5,000</td>
<td>0</td>
<td>$40</td>
<td>$39</td>
<td>$1</td>
<td>$1.82</td>
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<tr>
<td>Product C</td>
<td>9,000</td>
<td>10,000</td>
<td>1,000</td>
<td>$35</td>
<td>$36</td>
<td>($1)</td>
<td>($3.29)</td>
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<tr>
<td>Product D</td>
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<td>0</td>
<td>$40</td>
<td>$39</td>
<td>$1</td>
<td>$2.92</td>
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<table>
<thead>
<tr>
<th>Product</th>
<th>Production b/d</th>
<th>Demand b/d</th>
<th>Surplus b/d</th>
<th>Export costs $/b</th>
<th>Export gain (loss) $/b</th>
<th>Export profits (subsidy) mm$/year</th>
<th>Total savings (subsidy) mm$/year</th>
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<tbody>
<tr>
<td>Product A</td>
<td>8,000</td>
<td>9,000</td>
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<td>$2.50</td>
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<td>Product B</td>
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<td>5,000</td>
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<td>$2.75</td>
<td>($1.75)</td>
<td>($3.19)</td>
<td>($1.37)</td>
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<tr>
<td>Product C</td>
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<td>0</td>
<td>$3.00</td>
<td>($4.00)</td>
<td>0</td>
<td>($3.29)</td>
</tr>
<tr>
<td>Product D</td>
<td>10,000</td>
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<td>2,000</td>
<td>$3.25</td>
<td>($2.25)</td>
<td>($1.64)</td>
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<td>($4.83)</td>
<td>$5.38</td>
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<td>Factor</td>
<td>Hydroskimming configuration</td>
<td>Hydrocracking configuration</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arabian Light</td>
<td>Murban</td>
<td>Kuwaiti</td>
<td>Mines</td>
<td>Arabian Light</td>
<td>Murban</td>
<td>Kuwaiti</td>
</tr>
<tr>
<td>Capital cost, M$/$</td>
<td>$141</td>
<td>$122</td>
<td>$138</td>
<td>$108</td>
<td>$248</td>
<td>$225</td>
<td>$250</td>
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<tr>
<td>Required imports, b/d</td>
<td>9,038</td>
<td>6,997</td>
<td>10,828</td>
<td>12,474</td>
<td>445</td>
<td>4,936</td>
<td>3,405</td>
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<tr>
<td>Required exports, b/d</td>
<td>9,756</td>
<td>8,736</td>
<td>12,321</td>
<td>14,499</td>
<td>2,690</td>
<td>4,833</td>
<td>3,497</td>
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<tr>
<td>Exposure ratio</td>
<td>50%</td>
<td>42%</td>
<td>61%</td>
<td>72%</td>
<td>8%</td>
<td>26%</td>
<td>18%</td>
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<tr>
<td>Domestic subsidy, M$/year</td>
<td>$44.5</td>
<td>$28.7</td>
<td>$13.3</td>
<td>$13.8</td>
<td>$54.4</td>
<td>$43.6</td>
<td>$58.6</td>
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<tr>
<td>Export subsidy, M$/year</td>
<td>$23.6</td>
<td>$17.8</td>
<td>$19.4</td>
<td>$23.4</td>
<td>$6.8</td>
<td>$11.7</td>
<td>$9.8</td>
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<tr>
<td>Total subsidy, M$/year</td>
<td>$68.1</td>
<td>$46.5</td>
<td>$32.6</td>
<td>$37.2</td>
<td>$61.1</td>
<td>$55.3</td>
<td>$68.3</td>
</tr>
</tbody>
</table>
Refined products will still need to be imported and exported to balance supply with demand after the refinery is constructed.

The economics of a Pacific Island refinery are discouraging. Even if loans could be obtained and capital costs kept under control, subsidies would still be needed to keep the refinery going. Alternatively, the governments would have step in and control prices to make the refinery profitable. For all these reasons we recommend against undertaking such a venture. It would neither enhance oil security nor make economic sense.
APPENDIX 1. DESCRIPTION OF PRYMO MODEL

Each of the boxes shown in Figure 2 represents a model designed to simulate the operations of a particular process unit. Few, if any, refineries will have all of the units shown in the model.

Although the model cannot be characterized as a linear programming model, it does employ simplex methods in certain subroutines. To begin, the model selects the data on crude oil characteristics demanded by the user and runs the crude through the crude distillation tower. The "topped crude" left is then charged to the vacuum distillation unit if one is available. This process is repeated for a series of sets of "cutpoints," varying the proportions of products yielded by distillation. The value of each set is computed by multiplying each product stream by its market price. Of the possible sets, the most valuable is selected from each of two categories: Category One, which has a final middle distillate cut of about 550°F, and Category Two, which has a final middle distillate cut of 650°F. Thus, the main difference between the two categories is the amount of topped crude produced.

The residuum or topped crude from the Category One set is then passed to the resid processing section, which controls the residuum hydrocracker, the visbreaker, and the coker. The section then performs the following functions, if the relevant process units are available:

1. Runs vacuum residuum to the resid hydrocracker and determines the value of the output.
2. Runs vacuum residuum to the visbreaker and determines the value of the output.
3. Runs vacuum residuum to the coker and determines the value of the output.
4. Repeats steps 1-3 with topped crude.
5. Runs resid hydrocracker residuum to the coker and determines the value of the output.
6. Runs visbreaker residuum to the coker and determines the value of the output.
7. Loads a simplex tableau with the available streams and process unit capacities along with the prices determined in 1-6.
8. Runs a simplex algorithm to determine the optimal loading of the process units and determines the overall value of the output.
FIGURE 2. Flow diagram of PRYMO

- **C** = Crude Oil
- **P** = Light Products
- **T** = Topped Crude
- **R** = Residuum
- **V** = Vacuum Gas Oil
- **HDC** = Hydrocracker

**Intermediate Products**
- **Gases** → Refinery Fuel
- **LPG**
- **Gasoline**
- **Naphtha** → Sulfur Removal
- **Kerosene** → Sulfur Removal
- **Diesel** → Sulfur Removal
- **Fuel Oils** → Sulfur Removal

**Final Products**
- **LPG**
- **GASOLINE**
- **KEROSENE**
- **DIESEL**
- **FUEL OILS**

**ECONOMICS**

- **ALYSIS**
After the residuum-processing analysis is completed, the vacuum gas oils (VGO) produced are combined with the other vacuum gas oils provided by the vacuum distillation unit.

The VGO section controls the distillate hydrocracker and the fluid catalytic cracker. The VGO section performs the following functions if the relevant process units are available:

1. Runs VGO to the fluid catalytic cracker at a starting severity and determines the value of the output.
2. Runs VGO to the distillate hydrocracker at a starting amount of hydrogen per barrel of feed and determines the value of the output.
3. Runs VGO produced by the fluid catalytic cracker to the distillate hydrocracker at the starting amount of hydrogen per barrel of feed and determines the value of the output.
4. Loads a simplex tableau with available streams and process unit capacities along with prices determined in 1-3.
5. Runs a simplex algorithm to determine the optimal loading of the process units and the value of the output.
6. Performs steps 1-5 at possible combinations of severity and hydrogen per barrel.
7. Selects the most valuable combination of routings, severity, and hydrogen per barrel.
8. Runs the units as determined in 7.

The program then charges gases to the alkylation unit (if available) and runs the naptha to the catalytic reformer (if available). Desulfurization capacity and hydrogen production capacity are then assessed. The model then deducts energy consumption from the fuel gas streams; if the energy is insufficient, it makes deductions from residuum streams; if energy is still insufficient, it makes deductions from topped crude. If the combined energy from these three sources is insufficient to meet the energy needs of the refinery, then it calculates the deficit. The deficit is assumed to be made up by outside purchases of fuel rather than burning of lighter products.

The final value of the refinery output is then assessed. The model then returns to the residuum processing section and performs all of the foregoing on the Category Two set of products. The aggregate values of
the Category One and Category Two runs are compared, and the higher is selected. One final pass is made through the model to produce the final output slate.

The model then moves on to economic analysis. Using Nelson Cost Curves, the model calculates the U.S. Gulf Coast construction cost for each process unit at the specified capacity. The refinery complexity is then calculated, and nonprocess-unit costs are assessed as a function of the Nelson Complexity. Terminal facility and product export terminal costs are estimated if desired. The user is then asked to specify the construction cost differential, if any, between the site in question and the U.S. Gulf Coast. Finally, the nonenergy operating costs are estimated, and the annual feedstock costs are calculated from the c.i.f. price per barrel of crude.

The final economic analysis is designed to determine the required real selling price (RRSP) of the products. The user is asked to adjust a set of economic parameters describing the project financing and to set a required real IRR for the project. Unlike most discounted cash-flow analyses, this method does not assume prices and then determine an IRR, but rather determines the RRSP needed to achieve a predetermined IRR. This allows the user to determine the economics of the venture relative to market prices.

The model adjusts the selling price of an average barrel of product until the discounted cash flow of the project, discounted at the required IRR, equals zero. This is the RRSP.

Determination of the prices of individual products is difficult conceptually; this is the so-called "joint-cost" issue that remains an unsolved problem in the general case. The assumption of the model is that market price ratios reflect marginal cost ratios. If $P_1$, $P_2$, $P_3$... are market prices for products 1, 2, 3...; if $Q_1$, $Q_2$, $Q_3$... represent quantities of the respective products; and if $D$ represents a multiplicative differential percentage between market prices and the required selling prices of the products, then:

$$P_1DQ_1 + P_2DQ_2 + P_3DQ_3... = RRSP Q_1.$$

Rearranging, we obtain:

$$P_1D (Q_1 + Q_2P_2/P_1 + Q_3P_3/P_1) = RRSP Q_1.$$
The equation can now be solved for $P_1D$. The other prices, $P_2D$, $P_3D$, ... can be obtained by multiplication by $P_1D$. This does not say what price the products will fetch in the market; it merely allocates the advantage or disadvantage of the refinery's production costs across the products in a proportional fashion.
APPENDIX 2. SUMMARY OF REFINERY CASE STUDIES

ARABIAN LIGHT CRUDE - 40,000 b/d Hydroskimmer

Estimated delivered crude cost, 1990: $26.45/b (real 1984 prices)

Crude distillation 40,000 b/d
Catalytic reforming 3,000 b/d
Desulfurization 14,000 b/d
LPG recovery 640 b/d

Nonenergy operating costs: $15.9 million/year
Capital cost: $141 million
Required IRR: 12%
25% equity, 75% debt at 2% real interest
Taxes at 35% on operating profit
5-year depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>--</td>
<td>669</td>
<td>$22.40</td>
<td>$25.74</td>
<td>($3.34)</td>
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<tr>
<td>Gasolines</td>
<td>5,147</td>
<td>5,914</td>
<td>$31.22</td>
<td>$35.87</td>
<td>($4.65)</td>
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<td>Middle dist.</td>
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<td>13,995</td>
<td>$30.99</td>
<td>$35.61</td>
<td>($4.62)</td>
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<tr>
<td>Fuel oils</td>
<td>9,372</td>
<td>17,692</td>
<td>$23.79</td>
<td>$27.34</td>
<td>($3.55)</td>
</tr>
</tbody>
</table>

Supply/Demand: Required imports: 9,038 b/d Required exports: 9,756 b/d
Exposure Ratio: 50%

Required Subsidies:
On domestic consumption: $44.5 million/year
On exports outside Pacific: $23.6 million/year
Total: $68.1 million/year
**KUWAITI EXPORT CRUDE - 40,000 b/d Hydroskimmer**

Estimated delivered crude cost, 1990: $24.75 (real 1984 prices)

<table>
<thead>
<tr>
<th>Process</th>
<th>Capacity (b/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude distillation</td>
<td>40,000</td>
</tr>
<tr>
<td>Catalytic reforming</td>
<td>2,800</td>
</tr>
<tr>
<td>Desulfurization</td>
<td>13,000</td>
</tr>
<tr>
<td>LPG recovery</td>
<td>480</td>
</tr>
</tbody>
</table>

Nonenergy operating costs: $16.0 million/year

Capital cost: $138 million

Required IRR: 12%

25% equity, 75% debt at 2% real interest

Taxes at 35% on operating profit

5-year depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
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<td>6,990</td>
<td>$31.22</td>
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<td>Fuel oils</td>
<td>9,732</td>
<td>19,778</td>
<td>$23.79</td>
<td>$24.93</td>
<td>($1.14)</td>
</tr>
</tbody>
</table>

**Supply/Demand:** Required imports: 10,828 b/d   Required exports: 12,321 b/d

**Exposure Ratio:** 61%

**Required Subsidies:**

- On domestic consumption: $13.3 million/year
- On exports outside Pacific: $19.4 million/year

**Total:** $32.7 million/year
MURBAN (UAE) CRUDE - 40,000 b/d Hydroskimmer

Estimated delivered crude cost, 1990: $26.95/b (real 1984 prices)

Crude distillation  40,000 b/d
Catalytic reforming  3,800 b/d
LPG recovery  167 b/d

Nonenergy operating costs: $13.5 million/year
Capital cost: $122 million
Required IRR: 12%
25% equity, 75% debt at 2% real interest
Taxes at 35% of operating profit
5-year depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
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<tbody>
<tr>
<td>LPG</td>
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<td>9,732</td>
<td>14,861</td>
<td>$23.79</td>
<td>$25.91</td>
<td>($2.12)</td>
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</table>

Supply/Demand: Required imports: 6,997 b/d  Required exports: 8,736 b/d
Exposure Ratio: 42%

Required Subsidies:
On domestic consumption: $28.7 million/year
On exports outside Pacific: $17.8 million/year
Total: $46.5 million/year
MINAS (INDONESIAN) CRUDE – 40,000 b/d Hydrocracking

Estimated delivered crude cost, 1990: $25.68/b (real 1984 prices)

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
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<td>$24.46</td>
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<td>Gasolines</td>
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<td>5,574</td>
<td>$31.22</td>
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<td>9,732</td>
<td>9,768</td>
<td>$25.50</td>
<td>$27.85</td>
<td>($2.35)</td>
</tr>
</tbody>
</table>

Supply/Demand: Required imports: 0 Required exports: 1,188 b/d

Exposure Ratio: 3%

Required Subsidies:
- On domestic consumption: $37.4 million/year
- On exports outside Pacific: $3.1 million/year

Total: $40.5 million/year
ARABIAN LIGHT CRUDE - 44,000 b/d Hydrocracking

Estimated delivered crude cost, 1990: $26.45/b (real 1984 prices)

- Crude distillation: 44,000 b/d
- Catalytic reforming: 3,300 b/d
- Hydrocracking: 10,000 b/d
- Desulfurization: 16,000 b/d
- LPG recovery: 900 b/d
- Hydrogen: 22 MMSCFD

Nonenergy operating costs: $30.7 million/year

Capital cost: $248 million

Required IRR: 12%

25% equity, 75% debt at 2% real interest

Taxes at 35% on operating profit

5-year depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>—</td>
<td>895</td>
<td>$22.40</td>
<td>$25.47</td>
<td>($3.07)</td>
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<td>6,799</td>
<td>$31.22</td>
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<td>($4.28)</td>
</tr>
<tr>
<td>Middle dist.</td>
<td>23,033</td>
<td>23,176</td>
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<tr>
<td>Fuel oils</td>
<td>9,372</td>
<td>8,927</td>
<td>$23.79</td>
<td>$27.05</td>
<td>($3.26)</td>
</tr>
</tbody>
</table>

Supply/Demand: Required imports: 445 b/d  Required exports: 2,690 b/d

Exposure Ratio: 8%

Required Subsidies:

- On domestic consumption: $54.4 million/year
- On exports outside Pacific: $6.8 million/year

Total: $61.2 million/year
KUWAITI EXPORT CRUDE - 41,000 b/d Hydrocracking

Estimated delivered crude cost, 1990: $24.75/b (real 1984 prices)

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Options Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td></td>
<td>589</td>
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<td>$25.92</td>
<td>($3.52)</td>
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<td>Gasolines</td>
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<td>6,940</td>
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<td>$27.53</td>
<td>($3.74)</td>
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</table>

Supply/Demand: Required imports: 3,405 b/d Required exports: 3,497 b/d

Exposure Ratio: 18%

Required Subsidies:
- On domestic consumption: $58.6 million/year
- On exports outside Pacific: $9.8 million/year
Total: $68.4 million/year

Nonenergy operating costs: $33 million/year
Capital cost: $250 million
Required IRR: 12%
25% equity, 75% debt at 2% real interest
Taxes at 35% on operating profit
5-year depreciation
MURBAN (UAE) CRUDE - 40,000 b/d Hydrocracking

Estimated delivered crude costs, 1990: $26.95/b (real 1984 prices)

Crude distillation 40,000 b/d
Catalytic reforming 3,500 b/d
Hydrocracking 8,000 b/d
LPG recovery 400 b/d
Hydrogen 18 MMSCFD

Nonenergy operating costs: $26 million/year
Capital cost: $225 million
Required IRR: 12%
25% equity, 75% debt at 2% real interest
Taxes at 35% of operating profit
5-year depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Options Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPC</td>
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<td>Middle dist.</td>
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<td>23,033</td>
<td>$30.99</td>
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<td>Fuel oils</td>
<td>9,732</td>
<td>4,796</td>
<td>$23.79</td>
<td>$26.66</td>
<td>($2.87)</td>
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</table>

Supply/Demand: Required imports: 4,936 b/d Required exports: 4,833 b/d

Exposure Ratio: 26%

Required Subsidies:

On domestic consumption: $43.6 million/year
On exports outside Pacific: $11.7 million/year
Total: $55.3 million/year
MINAS (INDONESIAN) CRUDE - 40,000 b/d Hydroskimmer

Estimated delivered crude cost, 1990: $25.68/b (real 1984 prices)

Crude distillation  40,000 b/d
Catalytic reforming  2,000 b/d
LPG recovery  130 b/d

Nonenergy operating costs: $13.5 million/year
Capital cost: $108 million
Required IRR: 12%
25% equity, 75% debt at 2% real interest
Taxes at 35% on operating profit
5-year Depreciation

<table>
<thead>
<tr>
<th>Product</th>
<th>1990 Demand</th>
<th>1990 Production</th>
<th>Import Option Cost/Barrel</th>
<th>Refinery Cost/Barrel</th>
<th>Gain (Loss)</th>
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</thead>
<tbody>
<tr>
<td>LPG</td>
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<td>Gasolines</td>
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<td>Middle dist.</td>
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<td>Fuel oils</td>
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<td>24,022</td>
<td>$25.50</td>
<td>$26.82</td>
<td>($1.32)</td>
</tr>
</tbody>
</table>

Supply/Demand: Required imports: 12,474 b/d Required exports: 14,499 b/d
Exposure Ratio: 72%

Required Subsidies:
- On domestic consumption: $13.8 million/year
- On exports outside Pacific: $23.4 million/year
Total: $37.2 million/year
EAST-WEST CENTER
The East-West Center is a public, nonprofit educational institution with an international board of governors. Some 2,000 research fellows, graduate students, and professionals in business and government each year work with the Center's international staff in cooperative study, training, and research. They examine major issues related to population, resources and development, the environment, culture, and communication in Asia, the Pacific, and the United States. The Center was established in 1960 by the United States Congress, which provides principal funding. Support also comes from more than 20 Asian and Pacific governments, as well as private agencies and corporations.

Situated on 21 acres adjacent to the University of Hawaii's Manoa Campus, the Center's facilities include a 300-room office building housing research and administrative offices for an international staff of 250, three residence halls for participants, and a conference center with meeting rooms equipped to provide simultaneous translation and a complete range of audiovisual services.

PACIFIC ISLANDS DEVELOPMENT PROGRAM
The Pacific Islands Development Program helps meet the special development needs of the islands through cooperative research, education, and training. Its analytical research provides Pacific island leaders with detailed information on alternate strategies for reaching development goals.

PIDP also serves as the secretariat for the Pacific Islands Conference, a regional heads of government organization, and its Standing Committee, composed of eight island leaders. PIDP initiates its activities in direct response to requests from the Standing Committee and works in close cooperation with the Pacific island governments, ensuring that the focus of each project addresses the islands' needs.

Since 1980, PIDP has conducted research in eight project areas: energy, disaster preparedness, aquaculture, government systems, nuclear waste disposal, indigenous business development, roles of multinational corporations, and regional cooperation.

RESOURCE SYSTEMS INSTITUTE
The Resource Systems Institute (RSI) carries out policy-oriented research on issues in energy and minerals resource assessment, development policy, trade, and economic growth in the Asia and Pacific region. RSI's projects are conducted within the context of three major programs: Energy, Minerals Policy, and Development Policy and International Studies. The current research agenda includes projects on regional energy security, technical and economic assessment of land and marine resources, rural development, and trade and investment patterns. Projects are also under way that examine Pacific Basin economic cooperation, ASEAN regional cooperation, and international relations issues.

Research and related activities are undertaken by RSI project teams consisting of an international research staff, invited scholars, and graduate students. These project teams, working in cooperation with regional research groups, help realize the Center's goals of promoting better relations and understanding among the nations of the region through cooperative study, training, and research.