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Sector Assessments

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Section 1

Executive Summary

PROVIDED AS A SEPARATE DOCUMENT

Section 2

Market Review and Assessment

2.1 INTRODUCTION

Romanian refining capacity far exceeds the level of capacity needed to satisfy current and near-term demand. This excess production capacity results in extremely high per-units costs, which in turn leads to severe economic losses.

In this section, we analyze Romanian markets for refined products, petrochemicals, and lubricants to project the probable demand for these products over a 10-year period, from 1995 to 2005. We then compare these product demand projections to current production capacity to determine the level of capacity that should be shut down to improve the economic performance of the sector.

Next, we evaluate general economic trends in Romania and assess the effects of these economic trends on the demand for petroleum products, including gasoline, kerosene, diesel, and fuel oil. Because the Romanian downstream sector is strongly influenced by global petroleum trends, we have included a forecast of international crude oil prices and international market factors. (All price forecasts presented in this section were developed by the global petroleum sector analysts of Bonner & Moore.) A price outlook for Romanian petroleum products is also provided. In addition to the demand levels for refined products, we also project future demand for petrochemicals to assess the need to maintain existing production capacity. There are no projections of future petrochemical prices – the economic analysis is based on flat petrochemical prices at mid-1995 levels.

In preparing the above projections, we knew the future demand would ultimately be compared to existing capacity and used to recommend shutdowns of refining capacity. To avoid premature shutdowns, in our projections we deliberately sought to err in favor of higher demand, while still remaining within the bounds of reasonableness. This results in a slightly optimistic view about the need for refinery capacity over the 10-year period.

2.2 METHODOLOGY

To develop projections for Romanian petroleum product demand for 1995 to 2005, we have relied on several data sources and demand analyses, including:

- Historical energy statistics from the International Energy Agency
- Historical and projected refined product demand (by product) provided by Rafirom
- Refined product delivery statistics supplied by PECO
- Country economic assessments by the World Bank
- Country economic assessments by the Economist Intelligence Unit
- Official Romanian statistical bulletins, including the Romanian Statistical Yearbook for 1994

- Bonner & Moore, a firm of petroleum economists

Our demand projections for refined products were based on fundamental assumptions regarding economic growth, disposable income growth, and macroeconomic trends in Romania. In formulating these assumptions, we used the country analyses prepared by the World Bank and the Economist Intelligence Unit.

Bonner & Moore provided Mediterranean price projections for key crude oils and petroleum products. These price and economic performance projections formed the basis of the petroleum product demand analysis below. The methodology employed focuses on matching overall trends to derive demand forecasts for each class of refined products – for instance, the demand for transportation fuels is affected by consumer disposable income, population growth, increases in the number of vehicles, and the effect of industrial production growth on the transportation needs to move goods. Similar sector-specific variables were considered in the demand analysis of industrial production-driven heavy petroleum products. The discussion below further addresses the specific assumptions and fundamentals that drive projections of Romanian petroleum product requirements for the next decade.

Consumer demand for petrochemical-based products drives both petrochemical production levels and the demand for naphtha and other refined products that serve as petrochemical feedstocks. Domestic petrochemical demand was projected for each petrochemical product based on current shipments to each customer group and on an estimated growth rate for each group. Export demand for petrochemicals was estimated assuming that exports will escalate at a rate corresponding to the average projected gross domestic product (GDP) growth rate for Europe as a whole.

2.3 OVERVIEW AND CURRENT STATUS

Romanian GDP, which had declined dramatically from 1989 to 1992, turned marginally positive in 1993. In 1994, the country's economic output grew by 3.5 percent; during the next decade, the World Bank and other agencies expect Romanian GDP to grow at an average annual rate of 4 percent, as shown in Figure 2-1. This level of growth, while faster than expected global trends, is considered to be sustainable if current economic improvements are maintained and the private sector continues to take on more of the nation's output.

The recent turnaround in the Romanian economy is evidence of a successful beginning for the transformation of the economy from a highly planned, heavy-industry-oriented system to a partly privatized, service and consumer-oriented economy. Prior to the 1990s, the Romanian economy emphasized heavy industrial development and industrial concentration. During the mid-1980s, almost 60 percent of the economy revolved around metallurgy, fuels, chemicals, machine building, and mining. This focus on heavy industry, at the expense of other sectors of the economy, resulted in one of the lowest per-capita GDPs in Eastern Europe.

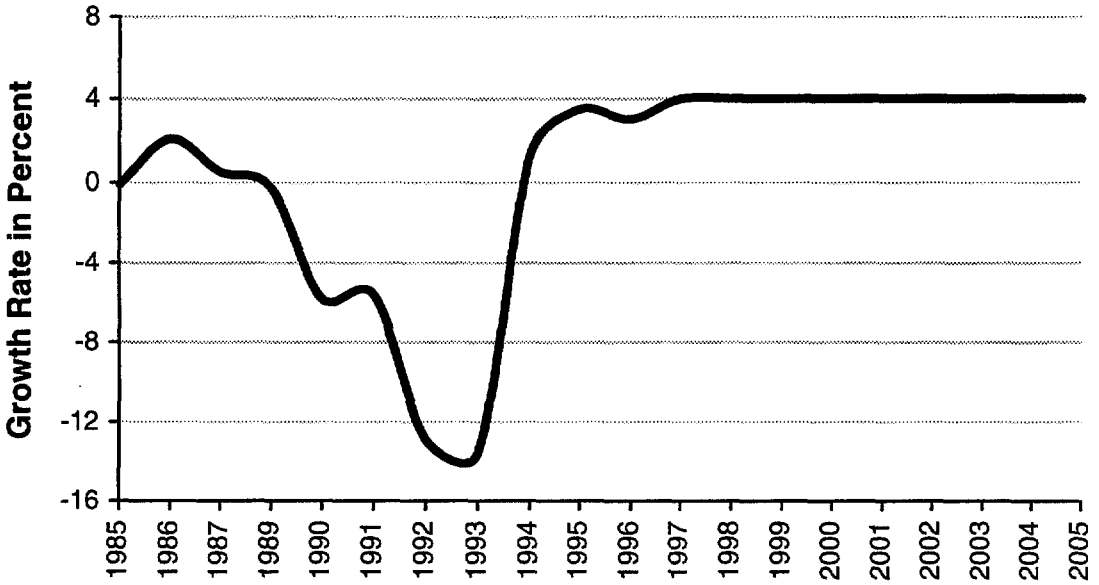

Figure 2-1 Romanian Real GDP Growth Rate

In the early 1990s, Romania liberalized foreign trade, introduced limited financial reforms and price liberalization, and embarked on a gradual process of restructuring, which included increasing levels of privatization in nonstrategic industries. Recent positive growth in GDP signals that the initial process of small-scale privatizations is working, and that the country is shifting away from a centralized and economically obsolete infrastructure base toward a more commercially viable and open economy. The outlook for GDP growth during the next decade is directly linked to expectations of the pace and degree of wide-scale privatization efforts. The forecast of GDP growth implies that recently sponsored privatizations, which have attracted foreign capital, will continue to proceed at a relatively brisk pace. If the transformation process gains further momentum, it is possible that the Romanian economy will grow at an even faster pace than projected; if it slows, the reverse will occur.

2.4 ROMANIAN PETROLEUM PRODUCT DEMAND

The projection of petroleum product demand is based on Bonner & Moore's crude oil price expectations of relatively flat real-world crude oil prices through 2005. Table 2-1 and Figure 2-2 show the outlook for total petroleum product demand for Romania by major petroleum product. Detailed tables of demand levels and growth rates are included in the Appendix. Oil demand has declined significantly in recent years due to the country's dramatic political and economic transformations. In 1994, however, oil product demand rebounded. Domestic oil demand is expected to strengthen again in 1995 and then continue to grow at 3 percent annually from 1995 to 2000 and 2.7 percent annually from 2000 to 2005. Oil demand in 1995 is expected to recover to 14.8 million tonnes (a level still 3 million tonnes lower than the 1980 consumption), and is

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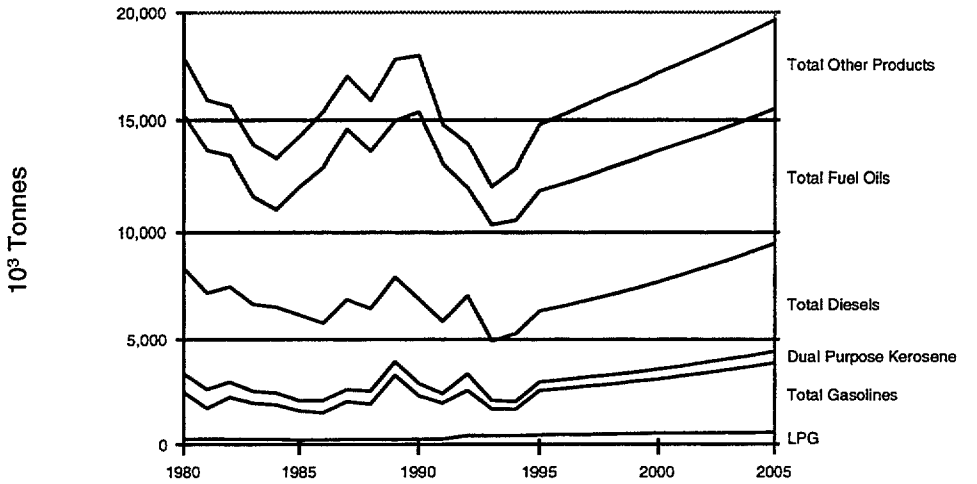
projected to reach 17.2 million tonnes in 2000 and 19.6 million tonnes by 2005. By 2005, oil product demand will have returned to just above 1980 levels.

Table 2-1 Projected Refined Product Demand

Item	10^3 tpy			Average Annual Growth, %		
	1995	2000	2005	1995-2000	2000-2005	1995-2005
Gasoline						
Unleaded Gasoline	347	681	1,695	14.4	20.0	17.2
Leaded Gasoline	1,603	1,691	1,333	1.1	-4.6	-1.8
Total Motor Gasolines	1,950	2,372	3,028	4.0	5.0	4.5
Diesel						
High-Sulfur Diesel (0.2% S)	912	800	471	-2.6	-10.1	-6.4
Low-Sulfur Diesel (0.1-0.5% S)	2,483	3,330	4,554	6.0	6.5	6.3
Total Diesels	3,395	4,130	5,025	4.0	4.0	4.0
Fuel Oil						
Low-Sulfur Fuel Oil (1%S)	1,448	1,855	3,717	5.1	14.9	9.9
High-Sulfur Fuel Oil (3.5%S)	4,028	4,044	2,332	0.1	-10.4	-5.3
Total Fuel Oils	5,476	5,899	6,049	1.5	0.5	1.0
Other Products						
LPG	440	522	577	3.5	2.0	2.7
Naphtha	177	215	275	4.0	5.0	4.5
Duel-Purpose Kerosene	390	463	550	3.5	3.5	3.5
Lube Base Stock	350	406	448	3.0	2.0	2.5
Coke for Export	280	309	333	2.0	1.5	1.7
Coke for Domestic Use	1,570	1,624	1,677	0.7	0.7	0.7
Bitumen	389	402	415	0.7	0.7	0.7
Miscellaneous	428	841	1,279	3.5	3.5	3.5
Total Other Products	4,024	4,782	5,554	3.5	3.0	3.3
Total Products	14,845	17,184	19,657	3.0	2.7	2.8



Source: 1990-1994 (1994 preliminary) International Energy Agency for major product category demand.
PECO for 1995 major product quality distribution.

Figure 2-2 Romania Product Demand Projections

In the early 1980s, consumption consisted mainly of heavy products and other fuel oils employed in industry; in the period 1995 – 2005, petroleum product demand is expected to shift significantly toward the lighter end of the barrel as a result of continued economic transformation and increased disposable income. Annual demand growth rates for light and transportation products are projected to be stronger than those for the heavier products. This is consistent with expectations about GDP growth and the current shift of the Romanian economy from heavy industry toward the consumer and service sectors. This shift is further reflected in the changing percentage of clean versus dirty product, which is expected to grow from 43 percent in 1995, to 45 percent in 2000, and 48 percent in 2005.

2.4.1 Gasoline

Gasoline demand is projected to grow at 4 percent per year through 2000 and 5 percent thereafter, reflecting the increased levels of personal disposable income resulting from healthy GDP growth. Demand for gasoline will reach 3.3 million tonnes by 2005. Pent-up demand for personal transport is especially high in Romania, even when compared with the rest of Eastern Europe, where economic recovery has generally led to large increases in the number of automobiles and in transport fuel consumption. Romania's historically low transport consumption is due to its low GDP per capita. While total gasoline demand could potentially grow at much faster rates than projected, it will be limited by the availability of passenger automobiles, which are still outside the range of most consumers' budgets.

Table 2-2 and Figure 2-3 depict the anticipated relative shares of leaded and unleaded gasoline for the projection period. According to PECO's statistics, unleaded gasoline represented about 14 percent of total gasoline demand in 1995. By 2000, the unleaded gasoline share of transport demand is projected to grow to 24 percent, and by 2005, demand is expected to reach 49 percent.

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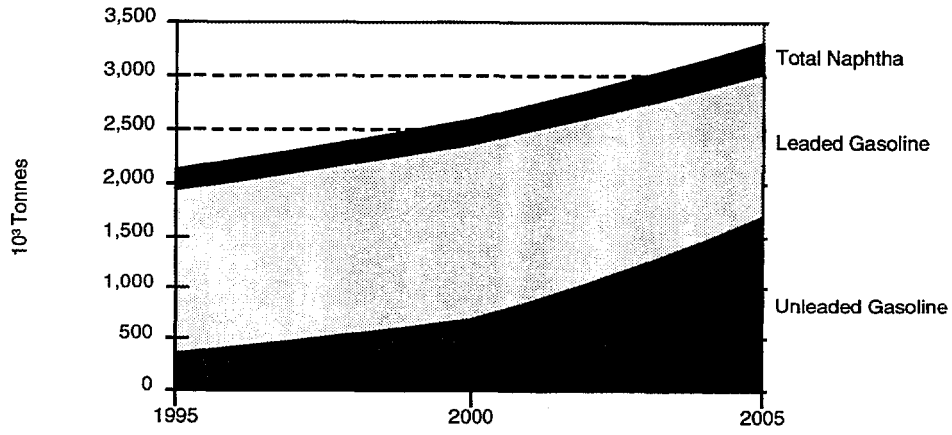
Table 2-2 Refined Product Demand Mix

Projected Products Mix	1995	2000	2005
Gasoline			
Unleaded Gasoline	14%	24%	49%
Leaded Gasoline	67%	54%	29%
Subtotal	81%	78%	78%
Other Gasoline			
Total Naphtha	19%	22%	22%
Total	100%	100%	100%
Diesel			
High-Sulfur Diesel (0.2% sulfur)	27%	19%	9%
Low-Sulfur Diesel*	73%	81%	91%
Total	100%	100%	100%
Fuel Oil			
Low-Sulfur Fuel Oil (1% sulfur)	26%	31%	61%
High-Sulfur Fuel Oil (3.5% sulfur)	74%	69%	39%
Total	100%	100%	100%

*0.1%S to 2000, 0.05%S thereafter
Source: International Energy Agency for major product category
PECO for 1995 major product quality



Source: PECO for 1995

Figure 2-3 Projected Gasoline Mix

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The pace of the adoption of unleaded gasoline by motorists is influenced by several factors that are currently undetermined in Romania. The most important of these factors is the timing of Romania's acceptance into the European Union (EU). Membership in the EU, among other things, would require adherence to specific quality targets for petroleum products. Another important factor affecting unleaded gasoline demand is the availability of passenger automobiles with catalytic converters. Because automobiles are particularly expensive in countries such as Romania, with low disposable income per capita, it is very likely that consumers will retain their existing vehicles longer (beyond the usual 7 to 10 years observed in the West). Furthermore, consumers will probably buy preowned, leaded-gasoline imported cars rather than new vehicles, which use unleaded fuel. Overall, since 10 years is a relatively short period of time, it is unlikely that a more dramatic, faster paced shift away from leaded gasoline will occur, despite more optimistic legislative mandates.

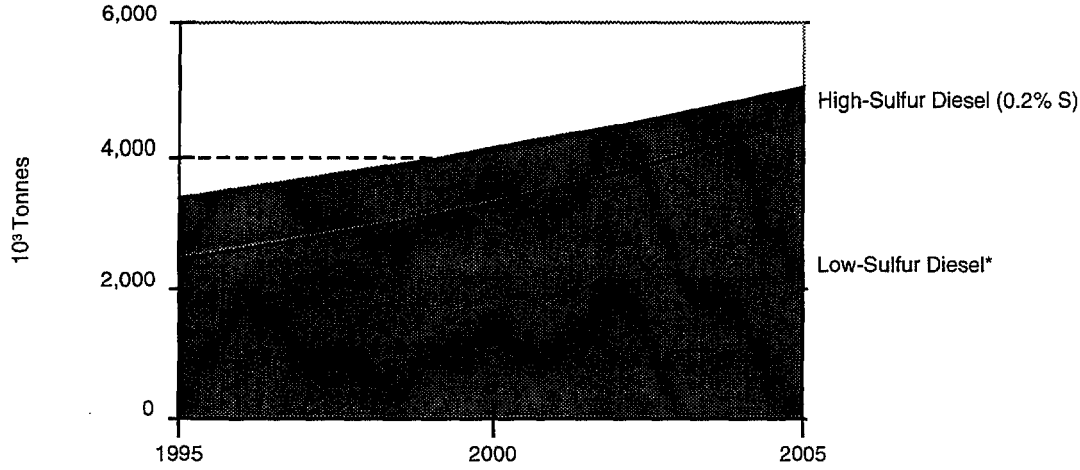
2.4.2 Diesel

Diesel demand, which is projected to grow 4 percent per year from 1995 to 2005, is also expected to shift from industrial use to transportation use, and is projected to reach 5.0 million tonnes by 2005. Industrial usage is expected to decline as heavy industry is shut down or reoriented toward consumer products production. Increased demand for diesel fuel will take place in the transportation sector, where trucking and passenger transport demand are expected to keep up with projected GDP growth rates. In addition, the relative increase in the consumer and service sectors of the economy will drive increasing needs to transport the growing volumes of consumer goods.

Table 2-2 and Figure 2-4 present the relative share of diesel products. High-sulfur diesel is expected to contain 0.2 percent sulfur, while low-sulfur diesel is expected to contain 0.1 percent sulfur through 2000, and 0.05 percent sulfur thereafter. This assumes that, given current refining realities, it is unlikely that Romania will produce significantly greater amounts of the cleaner, 0.05 percent diesel fuel before the year 2000. In 1995, low-sulfur diesel represents 73 percent of diesel demand. Its share is projected to increase to 91 percent by 2005 as cleaner transportation fuels are required.

2.4.3 Fuel Oil

Romanian fuel oil demand in 1994 accounted for almost 40 percent of total petroleum product demand, while in Western Europe fuel oil demand represents about 15 percent of the total. Even with the projected further growth in light petroleum products during the next 10 years, fuel oil demand is still projected to represent a relatively large portion of total petroleum product demand.



Source: PECO for 1995
*0.1% S to 2000, 0.05% S thereafter

Figure 2-4 Projected Diesel Mix

Fuel oil demand is projected to be the slowest growing among petroleum products, rising by only 0.6 million tonne over the decade, to reach 6.0 million tonnes in 2005. As mentioned previously, the Romanian economy will be retiring inefficient and obsolete heavy industry, significantly reducing demand for this product. Although fuel oil demand could, in a situation of economic transformation, actually decline in use over the period, electricity demand growth is projected to be based in part on fuel oil use, a moderating factor likely to sustain moderate positive net growth for this fuel.

As Romanians increase their per-capita electricity demand as a result of improved economics, fuel oil will probably continue to play a central role in the power generation sector. Currently, there is a shortage of electrical power; therefore, even with the planned addition of the nuclear power facilities near the Danube, heavy fuel oil will continue to play an important role. The country's electricity demand is projected to be quite healthy in the next few years. Increases in disposable income directly translate into higher demand for electricity. While the country may plan to meet this growing power demand with clean fuels, such as natural gas, switching to natural gas is not expected to displace the demand for fuel oil because it is unlikely that the necessary infrastructure for high-volume, sustained natural gas delivery will be put in place in such a relatively short period of time.

Even within the industry, renewed economic activity and short-term infrastructure development needs are projected to sustain current levels of demand for heavy fuel oil to the year 2000. High-sulfur fuel oil demand is projected to remain flat through 2000, but to start declining significantly (10 percent per year) from 2001 through 2005 as the privatization and industry rationalization processes gain momentum and result in the retirement or conversion of most fuel-oil-intensive industrial assets.

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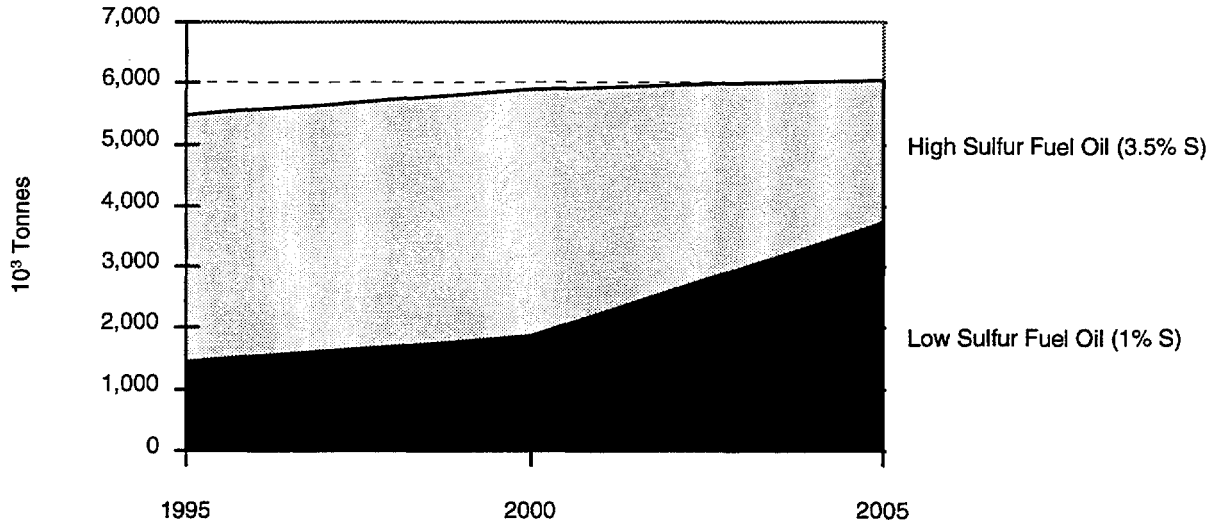
Table 2-2 and Figure 2-5 present the projected relative shares of each class of fuel oil. According to PECO's statistics, high-sulfur (3.5 percent sulfur) fuel oil demand accounts for 74 percent of fuel oil demand in 1995. This share is projected to decline marginally to 69 percent in 2000, but more significantly to 39 percent by 2005. Figure 2-5 shows the trend for the displacement of high-sulfur fuel oil by low-sulfur fuel oil (1.0 percent sulfur). The industrial sector is not likely to be able to switch to low-sulfur fuel oil in the next 5 years. However, it is projected that more stringent quality requirements and decreased power sector demand will result in a faster demand growth for low-sulfur fuel oil after 2000.



Source: PECO for 1995

Figure 2-5 Projected Fuel Oil Mix

2.4.4 Other Products

2.4.4.1 LPG and Naphtha

Demand for both LPG and naphtha, currently representing a small fraction of total demand, is expected to continue growing as end-user and petrochemical demand keeps up with rapidly increasing consumer demand. LPG demand is projected to grow 3.5 percent annually through 2000 and 2.0 percent annually from 2001 to 2005. LPG demand will reach 577,000 tonnes by the year 2005. Naphtha demand is projected to grow much faster, at 7.2 percent annually from 1995 to 2000. Naphtha growth, driven by high consumer demand for petrochemical-based products, is expected to decline to 5.4 percent per year from 2001 through 2005. Table 2-2 shows that naphtha's relative share of the gasoline product range is expected to remain generally stable at 19 to 22 percent throughout the projection period. This implies that projected gasoline demand will keep up with the healthy demand expected for end-consumer products.

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2.4.4.2 Kerosene

Kerosene demand is projected to grow at 3.5 percent per year through the decade and is expected to reach 550,000 tonnes by 2005. Kerosene usage is expected to shift away from some industrial applications and toward increased aviation applications. Increased and expanded international trade and consumer demand for personal travel are expected to drive up jet fuel demand.

2.4.4.3 Lubricants

Lube base stock is projected to be a fast-growing product in the "other products" category. The 1994 consumption of lubricants in Romania was roughly 350,000 tonnes, consisting of base stocks (320,000 tonnes) and additives (30,000 tonnes). Private vehicle owners accounted for about 40 percent of total domestic consumption, and it is estimated that practically all of the lubricant volume sold to these owners was supplied by imports. Commercial automotive consumers accounted for an estimated 23 percent of domestic demand (82,000 tonnes) and industrial consumers for 37 percent of domestic demand (129,000 tonnes). In addition, domestic manufacturers produced roughly 22,000 tonnes for export.

Growth rates for lubricants have been projected based on the following assumptions:

- Domestic consumption:
  - Private vehicle owners: 4.0 percent growth, equivalent to total gasoline demand growth
  - Commercial automotive: 4.0 percent growth, equivalent to Romanian GDP
  - Industrial: 2.5 percent growth, below Romanian GDP growth
- Imports: 4.0 percent growth, imports supplying lubricants for private vehicle purchases
- Exports: 3.4 percent growth, equivalent to projected GNP growth for Europe as whole

Based on these figures, net demand of 233,000 tonnes in 1994 is expected to rise to 327,000 tonnes by 2005.

Demand for the remaining products (coke, bitumen, and miscellaneous) is projected to closely track GDP growth and grow at a combined average annual rate of 3.5 percent per year from 1995 through 2000 and at a rate of 3.0 percent per year thereafter. The miscellaneous category includes volumes of other products that are currently being sold in Romania and the additional amount of unspecified product sales required to match the sum of individual product categories to the overall demand projection.

2.5 REFINERY OVERCAPACITY

The economic models used to evaluate the refineries are based on the product demand projections presented above and the product price and differential forecasts of Bonner & Moore presented in Section 2.6. The modeling approaches identify the proper mix of capacity utilization and yield that takes greatest advantage of domestic production or imports to derive the lowest cost of making or buying products. The single most important element in this model is product demand.

To the extent that future demand was projected to be too low, surplus capacity would be overstated and there would be a risk that our modeling would recommend premature closure of a refinery. To the extent that future demand was projected to be too high, there would be a risk that a desirable refinery closure would not be recommended. For these reasons, in this study we concluded that the demand forecast should be based on reasonable assumptions. However, where possible, we concluded that we should err in favor of an optimistic view of demand growth. In this way, no refinery would be recommended for closure if there was a reasonable prospect that its capacity would be needed to meet demand in the midterm.

Figure 2-6 shows the implications on capacity needs, assuming the demand projection used in our analysis is too high or too low by up to 3 percent per year over the entire 10-year period. Clearly, even a large error in the demand projection represents a capacity impact that is smaller than the capacity of one of the large refineries.

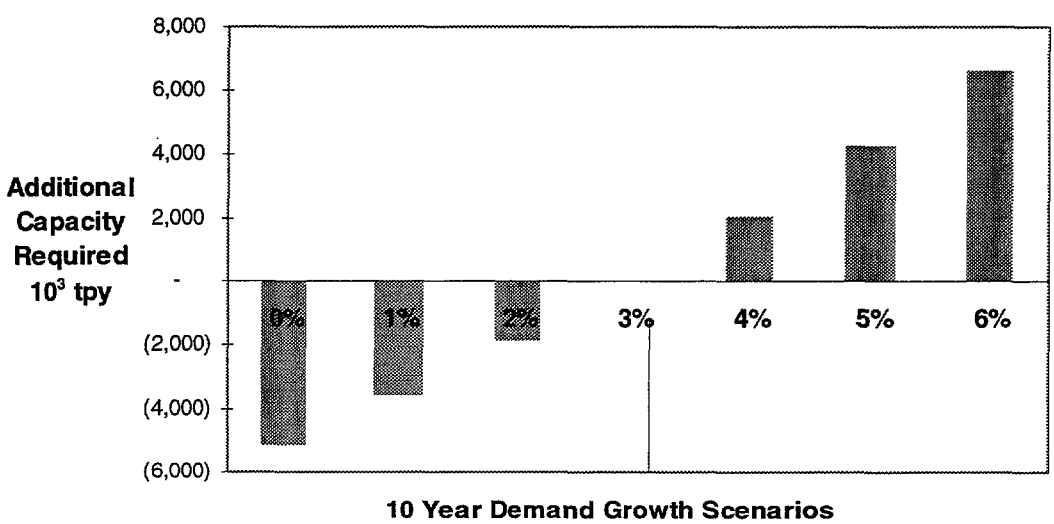

Figure 2-6 Refinery Capacity Sensitivity Analysis

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To justify the need for a single additional refinery, GDP growth would have to improve significantly, nearly doubling to a sustained rate of almost 7 percent per year from 1995 to 2005. In our view, growth rates at that level are simply not possible because so much industrial restructuring in the overall economy is still to take place. Accordingly, the economy will continue to experience downward pressure on "old" economic output at the same time "new" growth is occurring. On balance, a 4 percent sustained rate of growth in GDP will itself be difficult, but still possible. We believe that it is reasonable to premise decisions about Romania's refining capacity needs on growth at this level, but not at higher levels.

2.6 CRUDE OIL PRICE OUTLOOK

Table 2-3 shows the crude oil price assumptions used in this analysis for Brent, Iran Heavy, Iran Light, Urals, Libyan Es Sider, Dubai, and Suez blend. This price outlook was developed by Bonner & Moore. In this analysis, Brent is the reference crude oil, and all other crude prices have been determined using Brent quality differentials; Urals and Iran Light are the key crudes for the Mediterranean market.

The general outlook for Brent crude oil prices is shown in Figure 2-7. Bonner & Moore anticipates that constant U.S. dollar prices for Brent crude oil will increase at an average annual rate of only $1 to $2/tonne through 2005. The modest gains shown below are due to prospects for increases in both OPEC and non-OPEC crude production capacities.

According to Bonner & Moore, total OPEC production capacity was about 29.2 million barrels per day (BPD) in 1994, assuming an Iraqi capacity of 3 million BPD. Iraq is believed to have the crude reserve base to increase its capacity to more than 5.7 million BPD fairly quickly, once an agreement with the United Nations has been reached to allow that country to resume exports. Other Middle East OPEC members, led by Saudi Arabia, are expected to realize substantial gains in production capacity in the years ahead. Venezuela also appears to have the ability to increase its production capacities as well. Total OPEC crude oil capacity is projected to climb to about 40.5 million BPD by 2005. Bonner & Moore's forecasts are roughly in line with those made by other market analysts, including the OPEC Secretariat.

Non-OPEC production capacity is expected to be boosted by North Sea output from an average production level of 5.0 million BPD in 1994 to over 7.0 million BPD by 2000. With the estimated large reserve potential for the Shetland Islands region, North Sea output could climb further in the 2000 to 2005 period, in contrast to a decline previously anticipated. With the continued development of new fields in Colombia (such as the light Cusiana field), non-OPEC South American production is also expected to climb by almost 1.0 million BPD by 2000.

In Table 2-3, the term *Constant 1994 $* represents past and future prices expressed in terms of the 1994 purchasing power of the U.S. dollar; the term *Current $* represents past and future prices in terms of the purchasing power of the dollar in those respective years with the U.S. dollar inflation rate assumed to be approximately 3.5 percent per year after 1994.

Table 2-3 Crude Oil Prices

Year	Brent	Iran Light	Iran Heavy	Urals	Libyan ES Sider	Suez Blend	Dubai
Constant 1994 $ (FOB $/tonne)							
1989	161	139	132	150	156	135	136
1990	202	173	161	187	196	170	170
1991	163	137	126	151	157	131	132
1992	153	138	128	140	148	126	133
1993	131	113	106	116	125	102	113
1994	119	110	106	112	116	101	108
1995	125	117	112	118	123	111	115
1996	127	117	112	118	124	111	115
1997	128	117	112	119	125	107	115
1998	130	117	111	119	127	107	115
1999	131	117	112	120	128	107	116
2000	132	119	112	121	129	108	117
2001	134	120	113	122	130	109	117
2002	135	121	114	123	132	110	119
2003	137	122	115	125	133	111	120
2004	138	124	115	126	135	112	121
2005	140	125	116	127	136	113	122
Current $ (FOB $/tonne)							
1989	137	118	112	128	133	115	115
1990	178	154	143	166	174	150	150
1991	150	127	117	139	145	121	121
1992	145	131	121	133	140	119	127
1993	128	110	103	113	122	100	110
1994	119	110	106	112	116	101	108
1995	129	120	116	122	126	114	119
1996	135	124	119	126	132	118	123
1997	141	128	123	131	138	118	127
1998	148	133	127	135	144	122	131
1999	154	138	132	141	151	127	136
2000	162	145	137	147	158	132	142
2001	169	151	143	154	165	138	148
2002	177	159	149	161	173	144	155
2003	185	166	155	169	180	150	162
2004	193	173	161	176	188	157	169
2005	202	181	168	184	197	164	177

Source: Bonner & Moore

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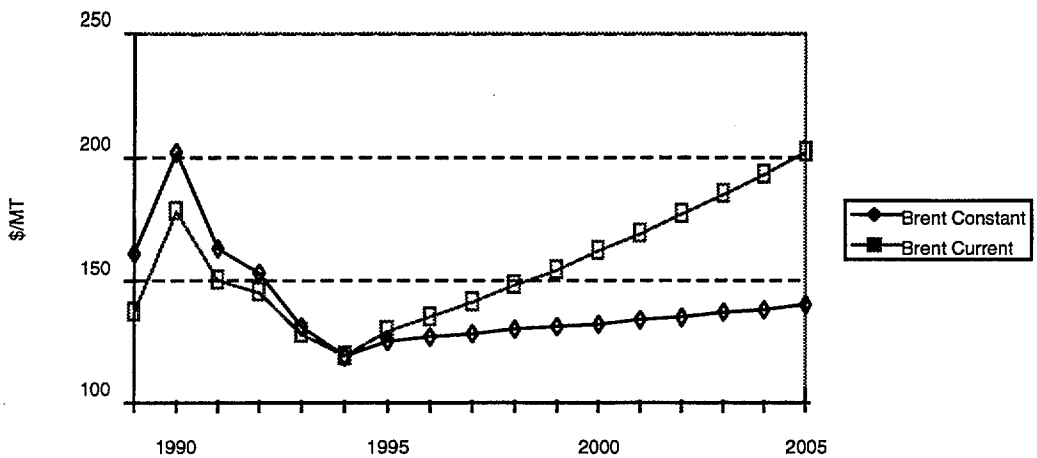

Source: Bonner & Moore

Figure 2-7 Brent (FOB) Constant and Current 1994

Despite reduced output in North America, total non-OPEC crude oil production is expected to increase by 2.5 to 3.0 million BPD from 1994 to 2000, and production could continue to grow thereafter.

Worldwide petroleum demand is expected to continue to increase in a stable price environment. World demand growth rates should on the whole remain moderate, averaging only 2 percent annually through 2000 and slowing a bit between 2000 and 2010. Strong growth of over 5 percent in the developing Asia-Pacific region is expected to be partially offset by modest 1 percent growth rates in the developed OECD economies.

Moderate increases in world oil demand are expected to be matched by increases in world crude oil production capacities. OPEC capacity utilization rates are projected to remain well below 90 percent through the forecast period, as shown in Figure 2-8. Thus, assuming that a reasonably significant supply cushion remains in place, very modest constant-dollar crude price increases are the likely outcome. The projections, however, anticipate that OPEC will continue managing supplies sufficiently to prevent further price declines, and that some modest constant-dollar price gains will result as OPEC capacity utilization rates edge upwards.

The return of Iraq to the world crude market will probably result in at least a temporary drop in crude oil prices, but the timing of this reentry is uncertain. Other OPEC members in the Persian Gulf have indicated some willingness to accommodate Iraq's return by trimming their own output rates, but these adjustments will be made less painful by a sustained increase in demand for OPEC crude in general. Therefore, Bonner & Moore does not expect that Iraq's return will have a sustained impact on crude oil and refined product pricing.

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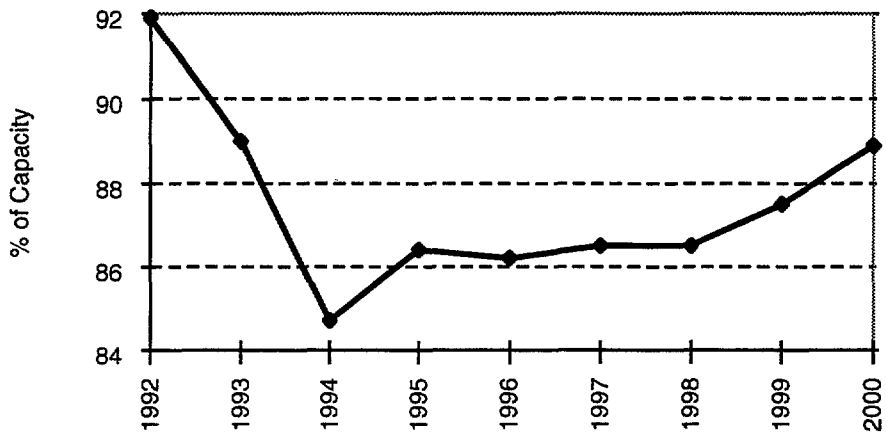

Source: Bonner & Moore

Figure 2-8 OPEC Crude Oil Capacity Utilization

Crude oil quality differentials are projected to widen slowly over the forecast period and are expected to return to the 1993 level by the year 2005. This is due to expected increases in North Sea crude oil production. As mentioned earlier, an additional 1.0 to 1.5 million BPD of production will be realized in the next 5 years, which will depress crude oil quality differentials in the region. While the demand for light products in Europe is expected to show healthy growth, the demand for heavy products is expected to decline slowly (less than 1 percent per year) during the decade. Normally, these trends should lead to improved light product margins, but the expected growing North Sea production will keep the European crude oil slate light, resulting in very slow gains in the light product differentials.

2.7 GLOBAL MARKET PRODUCT PRICES

The refined products market is very much an integrated global market – price trends by product in Europe are affected by the world supply/demand balance for each product. Bonner & Moore has developed the World Refining Industry Model to represent the world's refined products market. The model is used to determine trends in the product import/export position for major countries and regions, and determine likely trade movements.

Petroleum demand growth patterns worldwide are expected to be similar to those of Western Europe, in that growth rates for the middle of the barrel will outpace those of other major product categories. Gasoline consumption in the mature markets of the OECD countries (particularly the United States) accounts for about 70 percent of the world's total gasoline consumption. Gasoline demand growth worldwide is projected at 1.5 to 2.0 percent annually, lagging the distillates average of close to 2.5 percent annually. Natural gas competition in the boiler fuels market is also expected to limit residual fuel oil growth worldwide, with consumption increasing only marginally.

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Asia-Pacific also represents a major export market for European refiners, particularly for those in the Mediterranean region. Bonner & Moore's World Refining Industry Model results indicate that the Asia-Pacific region will increase its imports of distillates by the year 2000 by about 10 to 20 million tpy, and thus will continue to provide a potential export market for Mediterranean refiners. Gasoline imports into the region are projected to remain fairly constant. Perhaps more important, with respect to conversion requirements worldwide, the Asia-Pacific region is likely to shift to being a net exporter of fuel oil by 2000.

U.S. refiners operated at close to 93 percent of crude oil distillation capacity in 1994 and reached the 95 percent level during the summer peak demand period of 1995. Therefore, with U.S. refiners approaching the maximum sustainable operating rate, the potential U.S. market for European product exports is projected to grow.

2.8 MEDITERRANEAN MARKET PRODUCT PRICES

Table 2-4 summarizes the major petroleum product price projections. A more detailed tabulation of these projections is included in the Appendix.

Table 2-4 Projected Mediterranean Refined Product Prices

Item	Constant 1994 $ (FOB $/tonne)			Average Annual Increase	
	1995	2000	2005	1995 - 2000	2000 - 2005
Unleaded Gasoline	165	179	191	1.7%	1.3%
Leaded Gasoline	166	180	193	1.7%	1.4%
Naphtha	142	158	173	2.3%	1.9%
Kerosene	152	173	185	2.8%	1.4%
0.2 wt% Diesel	146	163	173	2.3%	1.2%
0.05 wt% Diesel	151	173	183	2.9%	1.2%
3.5 wt% Fuel Oil	84	86	91	0.5%	1.2%
1.0 wt% Fuel Oil	97	100	104	0.6%	0.8%

2.8.1 Gasolines

Octane capacity is likely to be sufficient, with only a modest widening in gasoline quality premiums. Ninety-eight RON (Research Octane Number) leaded gasoline will continue to be at a premium relative to 95 RON unleaded gasoline in the Mediterranean, mainly because (1) the leaded grade of gasoline has a higher octane level than the unleaded grade, and (2) the shrinking share of the leaded grade of gasoline has resulted in significantly higher storage costs for this grade to prevent cross-contamination.

The differential between naphtha and regular-unleaded gasoline has also narrowed to about $30/tonne in 1995 due to increased demand for naphtha as a petrochemical feedstock. Growth in

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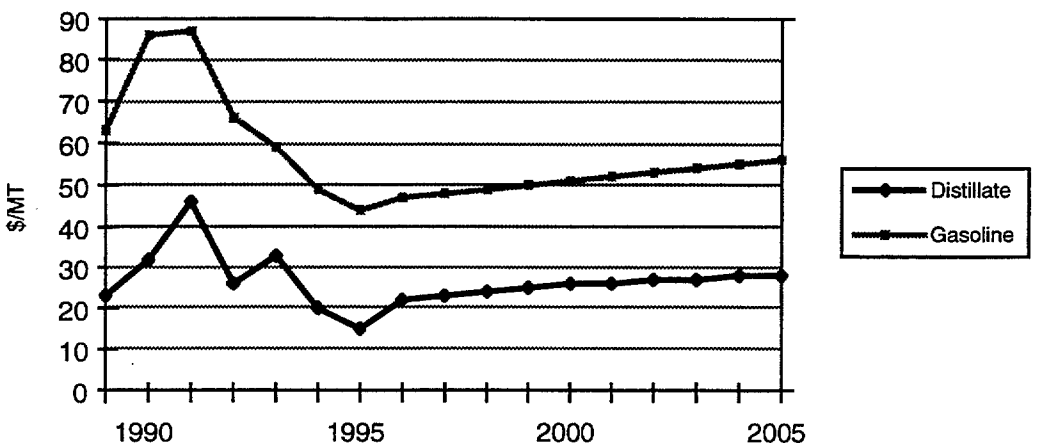
petrochemical consumption worldwide should continue to outpace that for gasoline, further reducing the naphtha/regular-unleaded gasoline differential to $22/tonne by 2005.

2.8.2 Distillates

Gas oil margins to Brent are also projected to increase by a net $12/tonne from 1995 to 2005, as shown in Figure 2-9.

The lightening in the European crude oil slate, coupled with improved distillates availability in the Asia-Pacific region (a result of the startup of two new grass-roots refineries and other expansions), led to a substantial erosion in gas oil margins in 1994. Gas oil margins continued to narrow in 1995 to an estimated $15/tonne. Growth in distillate product demand and increasing import requirements in Europe should support a slow but steady recovery in margins throughout the forecast period. Gas oil margins are projected to return to the 1992 level of $26/tonne by 2000, and then grow to $28/tonne by 2005.



Source: Bonner & Moore

Figure 2-9 Spot Mediterranean Light Product Differentials

Historically, the major price reporting services, such as Platt's, have not routinely reported prices for diesel. Bonner & Moore's sources indicate that 0.2 wt% and 0.05 wt% diesels currently command a $5/tonne and $10/tonne premium over gas oil, respectively. Price differentials for diesel with a sulfur content of 0.2 wt%S will steadily widen, relative to the standard European Union gas oil product in the Mediterranean, to $15/tonne in 2005. The change in price differential reflects transportation costs to move the product to distant export markets.

The demand for distillates is projected to remain strong, especially in Southern Europe where gasoline and diesel are expected to grow at 2 percent per year and 1.5 percent per year, respectively. Southern Europe gasoline demand growth is expected to outpace the demand

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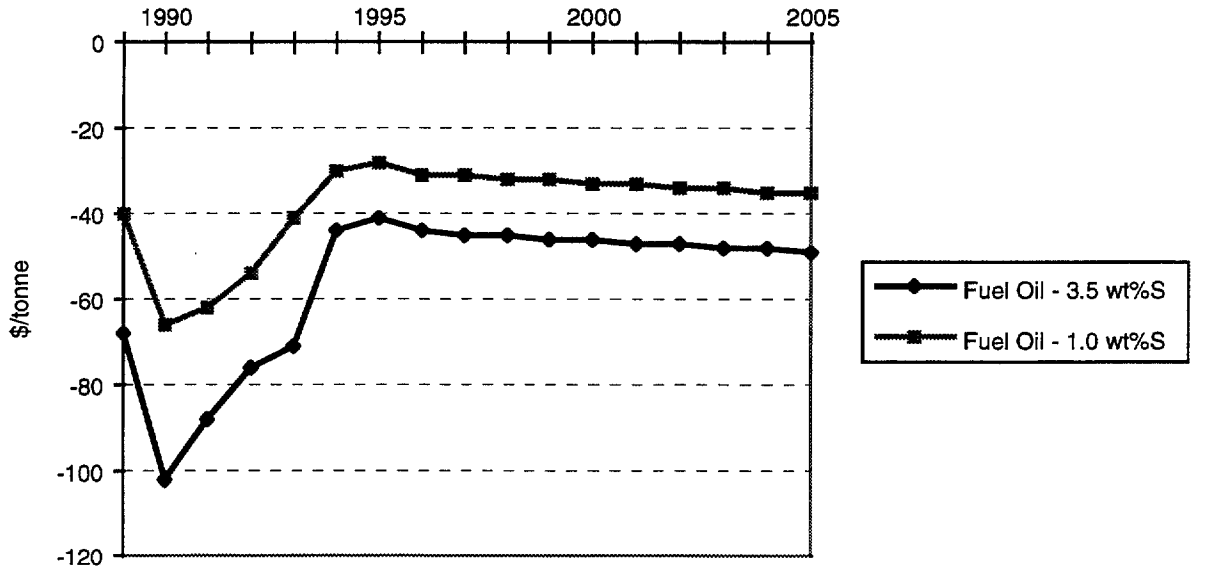
growth for diesel/gas oil. The tax advantages diesel fuel enjoyed in Italy have recently been removed, resulting in significantly stronger demand for gasoline. However, the reverse is true for Northern Europe, where the improvement in distillate margins is expected to widen.

Gross margins relative to Brent crude oil for jet kerosene have also tracked gas oil values downward since 1990, reflecting the easing in the international light products market. The differential between jet kerosene and gas oil also narrowed from $24/tonne in 1989 to $12/tonne in 1994. Growth in jet kerosene is expected to exceed growth in diesel, and the high growth for both jet kerosene and diesel is expected to tighten the supply picture for the swing cuts. The differential between jet kerosene and gas oil is also projected to steadily widen, in real terms, to $18/tonne by 2005.

2.8.3 Fuel Oils

As discussed earlier, the expected decline in fuel oil demand in Europe is due to its displacement by natural gas. The fuel oil market is slowly fading away, and the fuel oil to Brent differential reflects this transition. Figure 2-10 shows that by 2005 the fuel oil differential is projected to be between the 1993 and 1994 levels.



Source: Bonner & Moore

Figure 2-10 Spot Mediterranean Heavy Product Differentials

Increased processing of North Sea crude oil and the overall lightening of the crude oil slate worldwide have substantially firmed the international fuel oil market. In 1993, 3.5 wt%S fuel oil prices in the Mediterranean were $71/tonne below the dated Brent crude oil price, a price relationship similar to that in the late 1980s. The differential was reduced by almost half, to $41 to $44/tonne in 1994 and 1995.

Although the share of light North Sea crude oil is projected to continue to increase, exports of fuel oil are expected to rise from 1995 to 2005 owing to light product demand growth and a decline in fuel oil usage. At the same time, international market conditions are expected to ease. As the surplus of heavy fuel oil in Europe grows, the differential between 3.5 wt%S fuel oil and Brent is projected to widen steadily to $49/tonne by 2005. However, although the differential is expected to increase, levels will probably remain substantially less than those in the late 1980s and early 1990s.

The differential between 1.0 wt%S fuel oil and 3.5 wt%S has also narrowed as a result of the increased processing of the light crude oils, which are predominately sweet as well. The differential decreased from $30/tonne in 1993 to an estimated $13/tonne in 1995. Theoretically, with the reduction in the sulfur content of fuel oils that can be burned due to limitations on plant stack gas emissions, the sulfur differential is expected to widen. Bunker fuel consumption is expected to increase, in contrast with boiler fuel, the usage of which is expected to decline because of gas substitution; hence, the differential is likely to remain narrow, in historical terms, with a value of $14/tonne projected for 2005.

2.9 PETROCHEMICAL DEMAND

Petrochemical operations were evaluated at five major refining sites: Petrobrazi, Arpechim, Petrotel, Petromidia, and Rafo. Current petrochemical operations of the five major sites produce roughly 400,000 tonnes per year (tpy) of ethylene derivatives, propylene derivatives, and aromatics derivatives. Exports account for roughly 25 percent of production based on tonnage and roughly 25 percent based on market value. Significant volumes of these products are sold to domestic manufacturers of plastics products, synthetic yarns and fibers, paints and varnishes, and rubber products. Petrochemical products are sold in lower volumes to producers of automotive products, detergents, inks, dyes, and specialty metals, and for use in petroleum processing.

Table 2-5 presents current production volumes and projected demand through the year 2005. Aggregate production tonnage is projected to grow at about 5 percent per year during 1995 – 2000 and about 4.3 percent per year during 2000 – 2005.

Petrochemical product demand projections are estimated by making the initial (and imprecise) assumption that current production meets all demand within Romania. This approximation is necessary because information on domestic consumption and net exports is not available for most products. This demand table must of course be adjusted if new information reveals that current production does not meet domestic demand.

Domestic demand is projected for each petrochemical product based on current shipments to each domestic customer group and on estimated growth rates for each group. Estimates of current shipments are prepared from information provided by Rafirom and supplemented by information from the manufacturing sites. The Ministry of Industry (MoI) has furnished estimated growth rates for the major customer groups. For certain low-volume customer groups,

Table 2-5 Petrochemical Demand Projection (10^6 tpy)

Item	1995 Domestic	1995 Export	1995 Total	2000 Domestic	2000 Export	2000 Total	2005 Domestic	2005 Export	2005 Total
Ethylene Derivatives									
LDP	34.6	19.5	54.1	43.8	23.0	66.7	55.3	26.9	82.2
HDPE	18.3	3.7	22.0	23.1	4.4	27.5	29.2	5.2	34.3
ME + A/F	23.3	2.6	25.9	31.4	3.1	34.4	42.2	3.6	45.7
DE + PEG	2.5	0.0	2.5	2.9	0.0	2.9	3.5	0.0	3.5
Ethylene for PVC Export	0.0	67.2	67.2	0.0	79.2	79.2	0.0	92.6	92.6
Propylene Derivatives									
Polypropylene	14.6	15.2	29.7	18.4	17.9	36.3	23.3	20.9	44.2
Acrylonitrile	24.3	49.4	73.7	36.9	58.3	95.2	36.9	68.1	105.1
Sodium Cyanide	1.8	1.1	2.9	2.2	1.3	3.5	2.7	1.5	4.2
Phenol	9.1	0.0	9.1	14.1	0.0	14.1	21.7	0.0	21.7
Acetone	5.1	0.3	5.5	7.9	0.4	8.3	12.3	0.5	12.7
Nonyl Phenol	0.4	0.0	0.4	0.5	0.0	0.5	0.7	0.0	0.7
Ethoxylates	4.0	0.0	4.0	4.9	0.0	4.9	6.0	0.0	6.0
Aromatics and Derivatives									
Benzene sales	7.4	3.3	10.7	10.1	3.9	14.0	12.5	4.6	17.0
Toluene sales	18.9	7.0	25.9	29.2	8.2	37.5	36.5	9.6	46.2
Xylenes (Mixed)									
Maleic Anhydride	1.9	3.4	5.3	2.7	4.0	6.8	3.9	4.7	8.6
Phthalic Anhydride	1.1	7.5	8.6	1.6	8.8	10.4	2.2	10.3	12.5
DMT	18.0	35.0	53.0	27.3	41.2	68.6	41.5	48.2	89.7
Carbon Black	16.3	0.0	16.3	21.9	0.0	21.9	29.5	0.0	29.5
Total	201.7	215.2	416.8	279.0	253.7	532.8	359.8	296.7	656.5
Export Shipments % of Total		23.6			21.8			20.7	
Aromatics Intermediates									
Benzene (MAN + Phenol)			17.804			26.3			42.2
o-Xylene (PAN)			9.2			11.2			13.5
p-Xylene (DMT) (includes toll/import)			37.6			48.7			63.7
Benzene Total (sales + intermediates)			28.5			40.4			59.2

Average Growth Rates in Product Demand (Tonnage), %/Year	1995 – 2000	2000 – 2005
	5.0	4.3

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including ink and dye manufacturers, growth rates are not available and, in these cases, the projected Romanian GNP annual growth rate of 4.0 percent has been assumed.

Export demand growth is estimated assuming that exports will escalate at a rate corresponding to the average annual projected GNP growth rate for Europe as a whole, 3.4 percent during 1995 – 2000 and 3.2 percent during 2000 – 2005. Total demand is then computed as the sum of domestic and export demand.

These demand projections have influenced the assessment of the viability of petrochemical operations. Where unit processing and production costs are now unacceptably high as a result of low operating rates, costs have been reevaluated to determine whether cost performance is likely to improve significantly at expected future production rates. The demand projections also provide a means to identify near-term capacity constraints.

2.10 PETROCHEMICAL PRICING

International market prices of petrochemicals vary widely from year to year in response to global supply and demand patterns. Globally, demand follows overall economic growth trends. Capacity, however, is added erratically, usually through construction of very large, world-scale plants which are constructed during and immediately after a surge in product prices. As major capacity is added, global prices fall to lower levels.

In our analysis of the manufacturing complexes and petrochemical operations, we did not project future prices. Instead, we based all of our analysis on flat prices at the levels shown below.

Table 2-6 Petrochemical Prices (Delivered in Romania)

Item	$/tonne	Item	$/tonne
Ethylene Derivatives		Aromatics and Derivatives	344
LDPE	913	Benzene sales	216
HDPE	844	Toluene sales	1,189
MEG	693	Maleic Anhydride	1,471
Propylene Derivatives		Phthalic Anhydride	1,174
Polypropylene	913	DMT	450
Acrylonitrile	1,280	Carbon Black	
Phenol	863		
Acetone	621		

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Prices shown above have generally declined since this analysis was performed. We believe our conclusions about the economic viability of the petrochemical operations would not change if current prices had been used instead of those presented above.

2.11 CONCLUSIONS

Following the severe recession in Romania in 1992 and 1993, the economy has rebounded and is expected to maintain a real growth rate of 4 percent for the future. This growth rate will lead to a corresponding increase in demand for refined petroleum products. The consumption of fuel oils will be stable, and growth will be in the areas of gasoline, diesels, and LPG. Unleaded gasoline will make up half of all gasoline consumption by the year 2005, and the increase in diesel consumption will come entirely from greater demand in low-sulfur diesel. Within the fuel oil category, the demand will switch dramatically from high-sulfur to low-sulfur fuel oil.

Crude oil will continue to be in abundant supply, and the average price, in real terms, will increase only slightly during the next 10 years. OPEC capacity utilization will ratchet up during this period, but the effect will be offset by other supply factors. Mediterranean product prices will follow current trends and maintain present price differentials to crude indexes. Regional refinery margins declined from 1990 to 1995 and are expected to remain weak through the study period, creating minimal opportunities for product exports into the Black Sea market.

Section 3

Refinery Sector Assessment

3.1 INTRODUCTION

This section provides an overview of the Romanian refinery sector, one key element in the petroleum manufacturing sector, which includes integrated complexes consisting of refineries, petrochemical plants, and lubricant plants. In general, refineries supply feedstocks to petrochemical and lubricant plants; but in some cases these plants sell products back to the refineries and, in other cases, they obtain feedstocks from other sources. The unique aspects of petrochemicals and lubricants are discussed in Sections 5 and 6, respectively.

As mentioned in Section 1, refining utilization rates are unsustainably low. Romania possesses about twice as much refining capacity as it needs. Realistically, there is simply no way for Romania to economically utilize this surplus capacity because (1) processing imported oil for resale into the export market is structurally uneconomic, (2) it is much cheaper to buy fuel oil than import large volumes of crude oil for manufacturing fuel oil only to export the other products, and (3) despite robust growth, Romania's future domestic demand for refined products is projected to be far too low to use the surplus refining capacity. Despite this underutilization of capacity, all 10 Romanian refineries continue to operate, piling the cost burden of an inefficient 33 million tonne-per-year (tpy) sector onto a current domestic need for only 12 million tpy of refined oil (if the sector is fully optimized, total demand in 2000 of 17 million tonnes is best met by 5 million tonnes of product imports and 12 million tonnes of crude processing). To support this inefficiency, massive indirect subsidies are provided to the refineries. Consumers pay too much and oil producers are paid too little, and still the refiners are unable to generate sufficient capital to modernize and improve.

The obvious solution to the problem of overcapacity is to rationalize Romania's surplus capacity. The question, Which refineries should be rationalized? is, however, not easy to answer. Normally, a single refinery's refining assets would be divided into logical groups, and these groups would be ranked in order of their economic performance. For such analyses, a single refinery might be divided into two or three groups (e.g., basic distillation, FCC complex, lubricants) in order to allow the best units to be evaluated separately. This type of analysis of individual refineries would then be carried out across all refineries to develop the best solution for the entire refining sector. The ranking of available capacity from this analysis would usually be compared to current and projected levels of demand to identify which capacity is needed and which capacity is not needed or is surplus. Such an analysis for Romania clearly indicates that two large refineries are surplus. However, because the layout of each of the five large refineries is so similar and their interconnections to the petrochemical and lubricant sectors are so complex, this approach alone will not be sufficient.

As described in Section 1, our analysis resulted in recommendations that the Petrotel and Petrobrazi refineries be permanently shut down in order to establish balance and economic stability to the entire sector. To clarify why these units should be identified as surplus, we present the following information in Sections 3 and 4:

- An overview of the current environment
- Strategic assessment of Romanian refineries
- Analysis of the critical issues
- A strategic summarization of individual refinery performance
- Methodology for the Process Industry Modeling Simulation (PIMS) economic analysis
- Results of the PIMS analysis
- Conclusions and recommendations

3.1.1 Economic Evaluation Methodology

Several different economic evaluations were conducted as part of this study. The economic viability of the five large refineries was evaluated using the PIMS linear programming model, our projections of Romania's future domestic demand, and Bonner & Moore's projections of international market prices for crude oil and petroleum products. Detailed models covering each manufacturing complex were developed under several different operating scenarios. The economic models included not only the refineries but also the petrochemicals and lubricants activities within the same manufacturing complexes. Cash flow spreadsheets were prepared in combination with the PIMS model to generate projected future annual cash flows for the years 1995 through 2005. From these cash flows, the net present value (NPV) of future cash flows was calculated assuming a 10 percent discount rate over a 20-year period; after 2005, the projected results were held constant for 10 additional years. In addition, a foreign exchange NPV was calculated to summarize the amount of foreign currency that the downstream sector would require under each scenario. These NPVs, together with a strategic assessment of the underlying assets, served as the primary factors guiding our optimization and rationalization recommendations for the five large refineries. The economic viability of the five small refineries was evaluated using a simpler, qualitative process.

3.1.2 Key Terms

Two economic terms are used extensively in this report: real prices/costs and net present value. For clarity, they are defined and discussed below:

3.1.2.1 Real Prices/Costs

The term *real prices/costs,* also referred to as *expenses and costs/constant dollar*, indicates future prices or costs, excluding future inflation. For example, if the price of oil is $150 per tonne on January 1 and during the year inflation is 10 percent, making the price $165 per tonne at year-end, then market prices have not changed, apart from inflation. Our analysis ignores inflation and would price oil at both points at $150 per tonne.

3.1.2.2 Net Present Value (NPV)

The term *net present value* is used to indicate today's value of a series of future annual cash flows adjusted to reflect the time value of money at a discount rate (or interest rate). It is expressed as the single dollar amount required today to exactly equal, from an economic standpoint, the value of an entire series of future cash flows. NPV is dependent upon the prevailing rate of return or discount rate used to compensate for the time value of money. As these rates increase, cash flows in the future are less valuable from an NPV standpoint. In all the NPVs presented herein, an annual discount rate of 10 percent is employed. Oil company investors, for example, commonly use discount rates of 15 percent to 25 percent in such analyses which, if used in this analysis, would have dramatically lowered the NPVs. This 10 percent discount rate is considered reasonable since the cash flows to be discounted do not include inflation and our purpose was not to evaluate the resale value of the plants or to assess whether to build them but rather to determine which ones should remain open and which should be shut down. All future revenues and costs of feedstock are priced at international market prices, using U.S. dollar equivalents for lei costs.

3.2 OVERVIEW OF THE CURRENT ENVIRONMENT

There are currently 10 refineries operating in Romania, with a total refining capacity of approximately 33 million tpy (roughly 720,000 barrels per stream day). Five of these refineries are mid-sized, fuel-producing facilities (average capacity, each, of 5.5 million tpy), each having an associated petrochemical or lubricant operation. This group of refineries represents 85 percent of the refining capacity in Romania and employs a workforce of just over 30,000. The remaining five refineries are small regional plants (average capacity, each, of 1.0 million tpy), some of which have unique operational or logistical advantages. Table 3-1 summarizes refining capacities and capabilities; Figure 3-1 shows the location of refineries and crude pipelines.

Apart from small amounts of intermediate product transferred between refineries within Romania and a small amount of condensate from domestic oil and gas fields, crude oil is the exclusive feedstock in all Romanian refineries. All of the crude oil production from domestic fields is utilized by the domestic refineries; in other words, there are no crude exports. Domestic oil production, however, has been declining, and the country currently produces only 6.5 million tonnes annually.

Romania imports the balance of its crude supplies from international markets via the Black Sea. A common oil receiving and distribution system with adequate capacity is shared by the five large refineries (the five smaller refineries process only domestic crudes). It is centered on (1) a deep-water terminal (Oil Terminal), located in Constanta, which is able to handle 150,000 dead-weight-tonne vessels (the Black Sea limit), and (2) a set of large-diameter crude oil pipelines operated by Conpet. These pipelines connect Oil Terminal with each of the five large refineries. Terminal, storage, and pipeline infrastructure represents a strategic asset providing each of the connected refineries with efficient access to international feedstock markets.

Table 3-1 Refining Capacities and Capabilities

Item	10^3 tpy Crude Distillation	(As Percent of Crude Distillation) Reform	FCC	Visbkng	Coking	PChem[1]	Lubes[2]	Bitumen
Large Refineries								
Arpechim	6,500	15%	29%	15%	0%	6%	6%	6%
Petrobrazi	7,500	25%	15%	0%	26%	2%	3%	0%
Petromidia	3,500	14%	29%	0%	23%	7%	0%	0%
Petrotel	5,000	10%	20%	1%	14%	1%	8%	4%
Rafo	5,250	19%	24%	1%	6%	0%	6%	0%
Subtotal	27,750							
Small Refineries								
Astra	2,000	0%	0%	0%	23%	0%	12%	2%
Darmanesti	1,500	0%	0%	27%	31%	0%	0%	0%
Petrolsub	400	0%	0%	0%	0%	0%	0%	44%
Steaua	400	0%	0%	0%	0%	0%	8%	8%
Vega	800	0%	0%	0%	0%	0%	4%	8%
Subtotal	5,100							
Total	32,850	15%	19%	5%	14%	3%	5%	3%

Source: Davy McKee "Characterization Report Romanian Refining," 1992
1. Lube capacity based on furfural extraction
2. Petrochemical capacity based on net product production

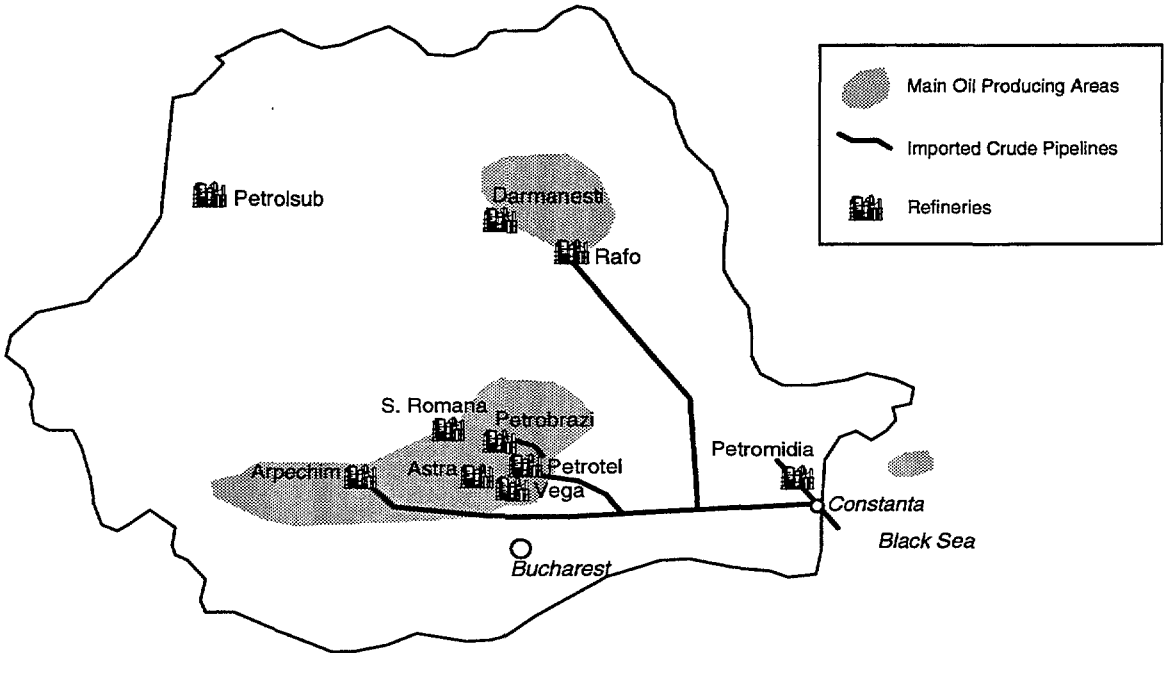

Figure 3-1 Location of Refineries and Crude Pipelines

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Assuming a relatively rapid overall economic growth (4 percent increase in GDP), total refined products demand is projected to grow significantly over the coming decade. Despite this robust growth, the overall level of demand is projected to remain significantly below the current level of crude distillation capacity. Figure 3-2 illustrates the overhang of refining capacity by comparing current capacity to total product demand. Demand for 1995 and 2005 (14.8 million tonnes and 19.6 million tonnes, respectively) represents less than 60 percent of total current capacity. Surplus capacity is 18.0 million tpy in 1995. Projected demand growth, if realized, would reduce this surplus to 13.2 million tpy by 2005. A surplus of 13.2 million tpy is roughly equivalent to two average large refineries (5.5 million tpy each) and two small refineries (1.0 million tpy each).

It is extremely costly to process a small demand across multiple refineries that have large aggregate surpluses of capacity. Refinery profitability is heavily dependent upon the rate of capacity utilization. Typically, refineries are profitable when average capacity utilization is within ±5 percent of 90 percent. In Romania, however, the current level of capacity utilization is only 45 percent (14.8 million tonnes out of a total 32.8-million-tonne capacity), if certain crude runs that supply only export markets (and fund crude acquisition) are excluded. Eliminating some existing capacity is clearly one of several prerequisites for restoring Romania's refining sector to profitability.

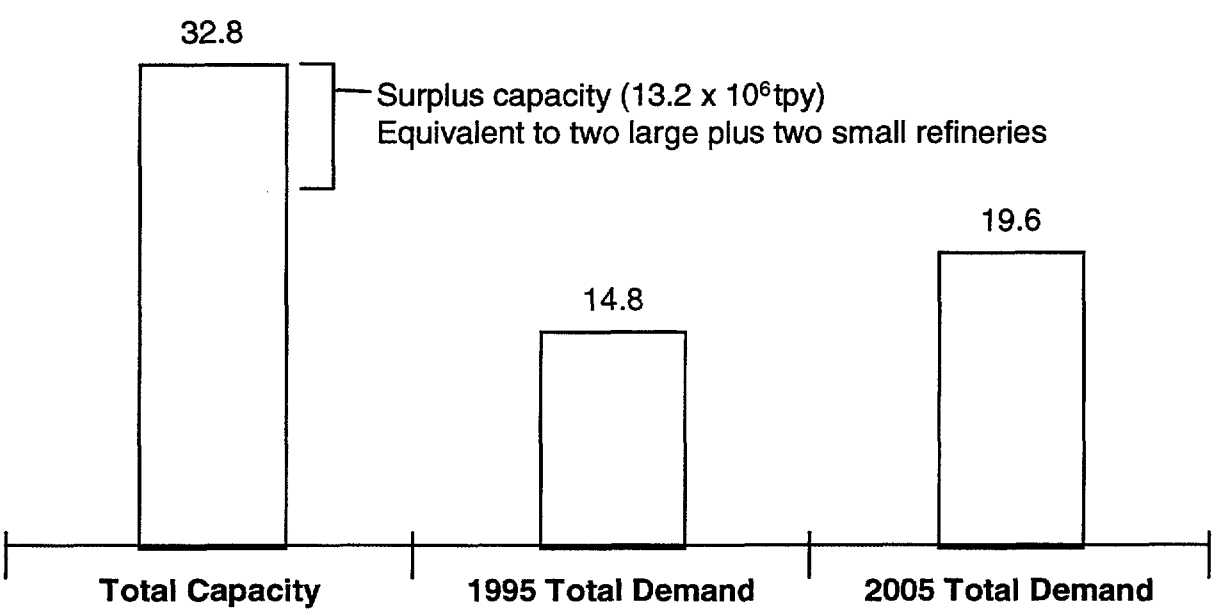

Figure 3-2 Overhang of Romanian Refining Capacity (10^6 tpy)

The financial statements of the five largest refineries reflected a profit of 189 billion lei in 1994, roughly equivalent to $118 million. Allowing for proportional profitability at the five small refineries would increase the reported level of profit to $139 million per year. However, only huge subsidies from other sectors of the economy made this positive result possible since (1) domestic crude is now sold to the refineries at prices that are about one-third below international market equivalents and (2) many refined products are sold at refinery gate prices that are substantially higher than international market equivalents (gasoline prices, for example, are up to $100 per tonne above market prices).

Under Romania's distorted price controls, the downstream sector appears to be profitable but, in fact, manufacturing alone is losing almost $1.0 million per day, a total of $305 million per year when market prices are taken into account. Market-priced economic results for the sector are difficult to obtain, as all reported results are heavily distorted by cross-subsidies into and out of the sector and between members within the sector. Table 3-2 shows our calculation of the economic loss for manufacturing based on market prices for this important part of the sector. Because not all data were available on a consistent basis, the results had to be estimated using a combination of 1994 and 1995 data obtained from a variety of sources. The net result is imprecise, but the order of magnitude of the loss is believed to be correct in all material respects.

Table 3-2 Current Economic Loss from Manufacturing (10 Refining Complexes)

Item	$ Million
Reported "Operating Profits" from Manufacturing	139
Eliminate Subsidies Reflected in the "Operating Profits"	
Domestic Oil Purchased Below Market[1]	(269)
Refined Products Sold Above Market[2]	(230)
Petrochemicals Sold Below Market to Others[3]	55
Total Net Subsidies	(444)
Actual Economic Loss from Manufacturing Per Year	(305)

1. In late 1995, the market price of oil delivered in Romania was $134 per tonne as compared with the $92 per tonne paid to Petrom. This represents a $42-per-tonne subsidy from Petrom to the refiners on an annual volume of 6.5 million tonnes of domestic crude oil, a total of $269 million a year.
2. Refinery gate prices of $162 per tonne charged by the refiners in 1995 were approximately 12 percent higher on average than international prices. For the 11.8 million tonnes of refined product sold in the domestic market, this $20-per-tonne charge represents a subsidy from consumers to refiners, a total of $230 million per year.
3. Petrochemical products used in the domestic market in 1995 were sold at prices which, on average, were 36 percent lower than the $790 per tonne average international price. For the 193,000 tonnes sold, the petrochemical sector subsidized other industries at a total cost of $55 million, net.

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The $305 million annual economic loss from manufacturing results from two major, interrelated factors.

First, the manufacturing sector is plagued with huge overcapacity; in refining, 10 plants are operating when 6 would suffice to fulfill the nation's needs. This leads to massive economic losses, for the following reasons:

- Too many people are employed. The 10 plants employ 37,700, where only 12,900 employees and contract workers are really needed. Employing 24,800 excess people at an annual average cost of wages and benefits, totaling $3,076 per person, imposes a needless cost of $76 million per year and contributes significantly to the sector's real economic loss.
- To keep all 10 plants operating, the refineries process 18 million tonnes of crude oil when about 10 million tonnes would produce better results. The extra crude oil is cycled into the refineries from imports and virtually all products are then exported, an activity that produces losses, which we estimate at $20 per tonne on the extra 8 million tonnes. This contributes an avoidable loss of $160 million per year to the sector's total loss.
- Maintenance, utilities, insurance, and taxes for the four unneeded plant complexes contribute an avoidable cost of $85 million per year to the sector's loss.

Second, the existing plants are badly operated:

- The operating practices used are based upon unchanging (set-it-and-forget-it) operating paradigms which reduce product yields and contribute to excessive destruction of products through fuel use and loss in manufacturing. We estimate that the costs in substandard yields (product giveaways) and excessive hydrocarbon losses (or unaccounted-for losses) total at least $130 million per year. This further contributes to the sector's real economic loss.
- To pay for crude oil, the refineries engage in costly barter arrangements which destroy value through transportation and uneconomic pricing. The costs of these practices are included in the second bulleted item above. The foreign currency costs of barter arrangements are discussed in subsequent sections.

Assuming a net loss of $305 million per year (see Table 3-2), the NPV of the manufacturing complexes is less than zero, a negative $2.7 billion, using a 10 percent discount rate and 20 years of net cash flows. The assets used in manufacturing represent a major investment for the nation. Their value is unknown, but to replace all of them would involve a new construction cost estimated to approach $10 billion, before reductions for depreciation and obsolescence, which would bring the value down significantly. These facilities would not be rebuilt under any circumstances. However, this figure gives an indication of the value of assets that are being deployed with no economic returns and, in fact, with an enormous destruction of value.

3.3 STRATEGIC ASSESSMENT OF ROMANIAN REFINERIES

Our evaluation of the Romanian refineries begins by putting them in the context of the worldwide matrix of demand and production centers. Large international trading centers for petroleum feedstock and refined products exist in the Mediterranean region, Northwest Europe, the U.S. Gulf Coast, and Singapore. These trading centers enable tributary refineries to economically optimize their overall production by selling or buying marginal quantities for a small portion of their throughput. However, prices in these markets are dominated by the incremental decisions of the largest and most efficient refineries associated with them. The Mediterranean trading centers are intensely competitive, as sellers are seeking a market of last resort to get rid of unwanted products, and in these centers pricing is typically at such low levels that an average refiner is unable to recover its fixed costs. Consequently, refining margins in these markets are usually negative, or at least very small. Virtually no refineries can be financially successful by depending entirely on international trading centers as their primary market.

Most successful refineries sell the bulk of their production to sheltered tributary markets. A sheltered market, for this analysis, can be defined as any market that is insulated from the hyper-competitive pricing of an international trading center by some sort of transportation barrier. Potential importers cannot easily bring cheap products from a trading center to a sheltered market. If they do, they must rely on high-cost rail or truck transportation, which makes the final cost of these movements very high (i.e., the cost of oil plus the high cost of transport). Because it is usually cheaper to transport crude oil in bulk than to import finished petroleum products (which require special handling to protect quality), refineries serving sheltered markets normally realize higher margins because their competitors must increase their price to recover the higher transportation cost, while the local refiner does not.

The strategic competitiveness of any given refinery can be assessed by considering four fundamental components, as shown in Figure 3-3:

- Efficient access to feedstock markets
- Access to sheltered tributary markets
- Facilities configured according to regional economic incentives
- Efficient operations and strong cost control

For a refinery to be regarded as strategically competitive, it must show strength in each of these components. It is unusual for a refinery with a serious weakness in any single category to survive over a long period. In the following sections, we evaluate the strengths and weaknesses of the five large refineries for each of these four strategic components.

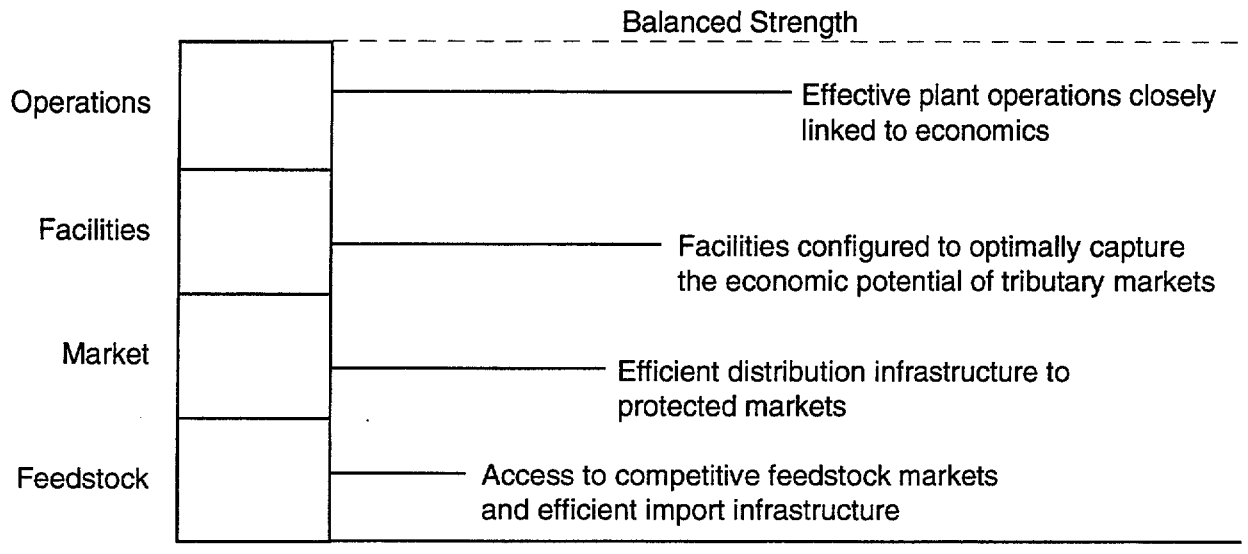

Figure 3-3 Strategic Competitiveness of Refineries

3.3.1 Access to Feedstock Markets

Romanian refineries technically have three sources for obtaining crude:

- Domestic crudes from Petrom
- Imported crudes via Rafirom
- Direct commercial arrangements (either purchase or processing)

3.3.1.1 Domestic Crude Oil

As mentioned previously, Romania's pricing system results in an artificially low price for domestic crudes, providing a $269 million subsidy ($42 per tonne) for those refineries fortunate enough to process domestic crude.

Petrom supplies the oil produced in Romania to the refineries according to an allocation plan developed primarily by Rafirom under guidelines established by the Ministry of Industry (MoI). Allocation of this crude is determined by internal negotiation between Rafirom, the refineries, Petrom, and the MoI. The price of domestic supplies is set by the Ministry of Finance (MoF) and is not effectively linked to international markets. A pricing committee establishes a theoretical market price for domestic crude oils by adjusting the price of Brent crude to the average for Romanian crudes. Further adjustments based on quality variations and other factors are internally negotiated between Rafirom, Petrom, the MoF, and the refineries to arrive at official prices for each crude. The official prices apply irrespective of the point of delivery. Prices are not regularly updated to reflect changes in international markets or currency exchange rates. The frequency of updates is increasing, but has yet to reach even regular monthly intervals.

3.3.1.2 Imported Crude Oil

The existing pipelines of Oil Terminal and Conpet, together with deep-water access to the Mediterranean market, give the five larger refineries efficient access to a wide variety of international feedstocks. Oil Terminal can receive 150,000 dead-weight-tonne vessels and has adequate tankage to receive and segregate cargoes of crude oil. The Conpet pipelines have in-place capacity sufficient to fully deliver enough imported crude to each of the five large refineries to meet projected domestic demand. However, the structure of the Romanian petroleum industry prevents the refineries from being able to effectively use this infrastructure.

Rafirom supplies virtually all the imported crude oils to the refineries. Rafirom possesses several privileges that enable it to acquire oil from international markets:

- Romanian Bank letters of credit (L/Cs)
- The ability to convert large sums of lei to dollars within 90 days
- Access to international markets via PetrolExportImport (PEI)

Rafirom has used Romanian State Bank L/Cs to establish commercial L/Cs with at least one international bank. Backed by internationally recognized credit, Rafirom purchases oil from international markets with payment terms of 90 days. Payment is 50 percent (of value) by cash and 50 percent (of value) by product export (mostly gasoline). PEI acts as a captive trading agent for Rafirom and provides trading expertise in negotiating crude acquisition arrangements.

Rafirom resells the purchased crude oil to each of the five larger refineries. Payment by the refineries to Rafirom is approximately 50 percent (of value) by product delivered to Constanta for export and approximately 50 percent (of value) in lei. Payment is due in sufficient time to enable Rafirom to settle its obligations to the crude oil suppliers. Rafirom negotiates the terms (price, percent payable in money or in kind, due dates, etc.) with each refinery in accordance with MoI guidelines, but, as the monopoly supplier of imported oil, it is essentially able to unilaterally impose terms upon the refineries.

Under this arrangement, Rafirom plays two basic roles: financial clearinghouse for petroleum product sales (converting lei from petroleum product sales to dollars), and national oil trading company (purchasers of international crudes via PEI).

The availability of a financial clearinghouse has permitted the refining sector to acquire and pay for significant quantities of imported oil, despite the payment gridlock within the country. This clearinghouse represents a positive cooperation between government and industry to work in the overall national interest of the country. Until liquidity is restored to Romanian financial markets and the lei becomes rapidly convertible into hard currency in large volumes, some sort of financial clearing system will remain critical for the downstream petroleum industry. This is demonstrated clearly when one considers that a single import cargo of delivered imported crude (less than 4 days of supply for the country) trades at roughly $20 million.

Apart from its financial clearinghouse role, it is questionable whether Rafirom's role as a national oil trading company offers more advantages than disadvantages. Among major international oil companies, the overwhelming trend has been to link individual refinery operations more closely with trading activities. In these companies, centralized supply departments and regional refining structures are being replaced by profit center structures within and around individual refineries. This trend is supported by technology that makes real-time market information readily available to remote locations. Using real-time market information together with advanced computer-based planning technology, these refineries can optimize their operating plans several times a day in response to market incentives. Accordingly, refineries are also installing plant control systems and instrumentation in order to better control and harmonize the ever-changing economic incentives in the market.

Under Romania's current system, crude acquisition decisions are made by Rafirom with little detailed understanding as to how the crude will be processed at each refinery and with no ability to control refining operations. Moreover, lacking the ability to detect and seize market opportunities, the refineries are processing oils and blending products without consideration of incremental profit opportunities and are not adjusting operating parameters of their refineries based on the economic opportunities available in the market. Market and operating information is cross-matched only when each refinery purchases another cargo of oil for a given refinery. Consequently, the cycle time for information exchange is several weeks and the transfer of opportunity information is indirect, limited, and ineffective. The system is further distorted by the imbalance of power between Rafirom and the refineries. This effectively cuts off the flow of useful economic information from the refineries upward as Rafirom imposes operating goals on the refineries.

This is not to imply that Rafirom or the refineries are doing their jobs poorly; the problem is that the inefficient structure within which Rafirom and the refineries must operate leads to degraded refinery performance. The system is neither a true market, where competition and liquidity drive players toward efficiency, nor a centrally optimized system, such as the one major oil companies used in the 1970s.

In practice, there are many barriers preventing Romania's refineries from implementing direct commercial arrangements. The most obvious barriers are the refineries' lack of access to international credit and hard currency. Less obvious barriers include the refinery managements' lack of access to timely market information, limited skills in analyzing markets, and lack of experience in negotiating and executing international transactions. In addition, the financial gridlock in settling commercial transactions between government entities has desensitized the refineries to the time value of money. Commercial arrangements with outside traders who might wish to employ Romania's relatively strong refinery assets for third-party processing are further impeded by (1) the refineries' inability to control the quantity and quality of inbound or outbound crude product shipments outside the refinery gate, (2) the problems facing nongovernment clients in dealing with the bureaucracy, and (3) a poorly motivated workforce. Consequently, with only minor exceptions, virtually no oil is currently being received by the refineries through their own direct commercial arrangements.

3.3.1.3 Direct Commercial Arrangements

The controlled price structure for petroleum products, the historic gap between lei costs and their free-market equivalent, and the separation between the decision-makers and the full economic consequences of their decisions have fostered different types of toll processing arrangements at Romanian refineries over the past several years. As the market evolves, the economics for bringing crude oil to Romania and exporting the products for profit will become increasingly dependent upon Mediterranean prices.

As discussed above, the intense competition in all international trading centers, including the Mediterranean market, generally results in low or negative refinery margins over time. Occasional spot processing opportunities will exist from time to time (and may be proposed to Romanian refineries by independent trading companies), but there is no evidence to indicate that sustained toll processing of oil through any Romanian refinery (including Petromidia) will be either strategically required or economically attractive over time. Processing of uncracked residual oil from the former Soviet Union on the other hand may present periodic medium-term opportunities if the existing conversion capacity of Romania's refineries is not fully utilized in meeting Romanian domestic demand.

The level of crude oil processing being done currently in Romania is inflated because of the uneconomic level of toll processing. Barter processing, a form of toll processing, is being used inappropriately to generate sufficient export products to pay for 50 percent of the cost of imported crude oil. This type of barter processing does moderately reduce the net overall need for hard currency imports, but it also leads to large economic losses and should be discontinued.

Table 3-3 presents an analysis of the economies of purchasing 100.0 tonnes of crude oil, refining it into refined products (consuming 11.3 tonnes through fuel use and loss), and selling the products (the remaining 88.8 tonnes) in the Mediterranean market. All yields, prices, and costs are based on actual 1995 data for the three best performing refineries. As the table shows, crude costs are $127.35 per tonne while the products sell for only $117.72 per tonne, yielding a gross margin loss of $9.63 per tonne before any operating costs are included. Variable operating costs are $2.60 per tonne, bringing the net margin loss to $12.22 per tonne overall. Although fixed costs are important, they are not included in the tables below; if they were included, the loss would be significantly larger. This case clearly demonstrates that Romanian refineries cannot cover out-of-pocket expenses by processing imported oil and reselling refined products in the Mediterranean market. Coverage of the refineries' fixed cost and a third party's profit margin (a profit component for the processor is a normal element for all toll processing) can be provided only if another sector of Romania's economy is sacrificed through provision of subsidies to keep the unneeded refineries operating.

Table 3-3 Export Refining Economics

Case: Import 100 Tonnes of Crude and Export All Products
Average Yields and Prices for 1995: Arpechim, Petromidia, and Rafo

Item	Quantity (tonnes)	Revenue ($/tonne)	Amount ($)
Imported Crude Oil	100.0	(127.35)	(12,735)
Fuel Use + Loss	11.3	–	–
Products Refined and Sold			
LPG/Naphtha	5.3	130.04	693
Petrochemical Naphtha	7.9	130.04	1,019
Unleaded Gasoline 82 RON	3.3	131.46	432
Unleaded Gasoline 90 RON	5.7	139.63	792
Unleaded Gasoline 95 RON	20.2	154.04	3,123
Kerosene	3.6	143.87	520
Diesel	32.8	138.38	4,529
Low-Sulfur Fuel Oil	4.2	87.30	357
High-Sulfur Fuel Oil	3.0	72.89	222
Fuel Coke	2.2	32.33	44
Needle Coke	0.0	215.69	0
Other	0.5	78.64	40
Total	88.7	–	–
Revenue If All Products Are Exported		117.77	11,772
Gross Margin (Loss)		(9.62)	(962)
Variable Costs (Excluding Fuel Use + Loss)		(2.60)	(260)
Net Margin (Loss)		(12.22)	(1,222)

Reductions of either fixed or variable costs will not reverse the above negative margins and make toll processing attractive. The value of products refined and sold ($117.72 per tonne) is significantly below the cost of crude oil ($127.35 per tonne), resulting in a negative gross margin of $9.63 per tonne before any costs are considered. No matter how much variable or fixed costs are reduced, they will always be greater than zero and will further reduce the already negative gross margin.

Economic results similar to the above are experienced by all refineries selling to the Mediterranean market. Figure 3-4 shows typical Mediterranean refining margins for a conversion refinery over the past several years (source: Bonner & Moore). It can be seen that

gross margin (i.e., incremental profit before expenses) is barely positive and net margin (i.e., incremental profit after variable costs) has been consistently negative.

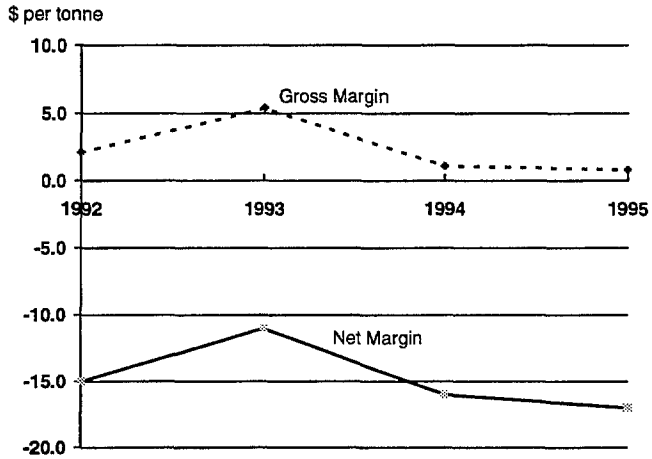

Figure 3-4 Typical Mediterranean Refining Margins

3.3.2 Access to Sheltered Tributary Markets

Romania has the potential to be a fundamentally attractive marketplace for refiners, provided that total refining capacity can be reduced to better match demand. The absence of a large, low-cost product import infrastructure and the potential for tapping into attractive export markets to the north and west should eventually result in a sheltered market with attractive refining margins. However, the market is significantly overbuilt. If surplus capacity is not eliminated, current and future competition between Romanian refineries will continue to depress the sector's overall economic performance.

3.3.2.1 Product Imports and Exports

Romanian refineries can expect only limited competition from product imports. Major competitors could include OMV (Austria), MOL (Hungary), INA (Croatia), and Russian/Ukrainian refiners and trading companies. However, the lack of efficient transportation infrastructure will make the cost of any product imports high. Romania may enjoy a modest strategic advantage for exporting products to the north and west of its borders, particularly if investments in low-cost transportation are made. It seems more likely that Romania will face its most serious external competition in export markets such as Serbia, Slovakia, and Ukraine, rather than within the borders of Romania.

3.3.2.2 Excessive Fuel Oil Demand

Romanian demand is excessively shifted toward heavy products, as illustrated in Figure 3-5. Because of an abnormally large demand for fuel oil from the electric power sector, the overall product demand mix within Romania includes a higher proportion of heavier products than in

Western Europe or the United States. In Western Europe, fuel oil accounts for only 15 percent of total demand and the balance of 85 percent consists of other, primarily lighter, products. If Romania's demand were to match the same 85/15 proportions, the country would have only 1.6 million tpy of fuel oil demand as compared with its 1995 fuel oil demand of 5.5 million tonnes. The 3.9 million tonnes difference (5.5 million tonnes - 1.6 million tonnes) represents Romania's abnormal fuel oil demand. Over time, Romania's requirement for high-sulfur fuel oil (HSFO) for power generation is projected to decline for environmental reasons while the demand for low-sulfur fuel oil (LSFO) is projected to grow. Although overall demand for fuel oil is projected to grow only 10.4 percent between 1995 and 2005, the absolute level of total fuel oil demand will still be an unusually large component (34 percent) of total refined products in 2005.

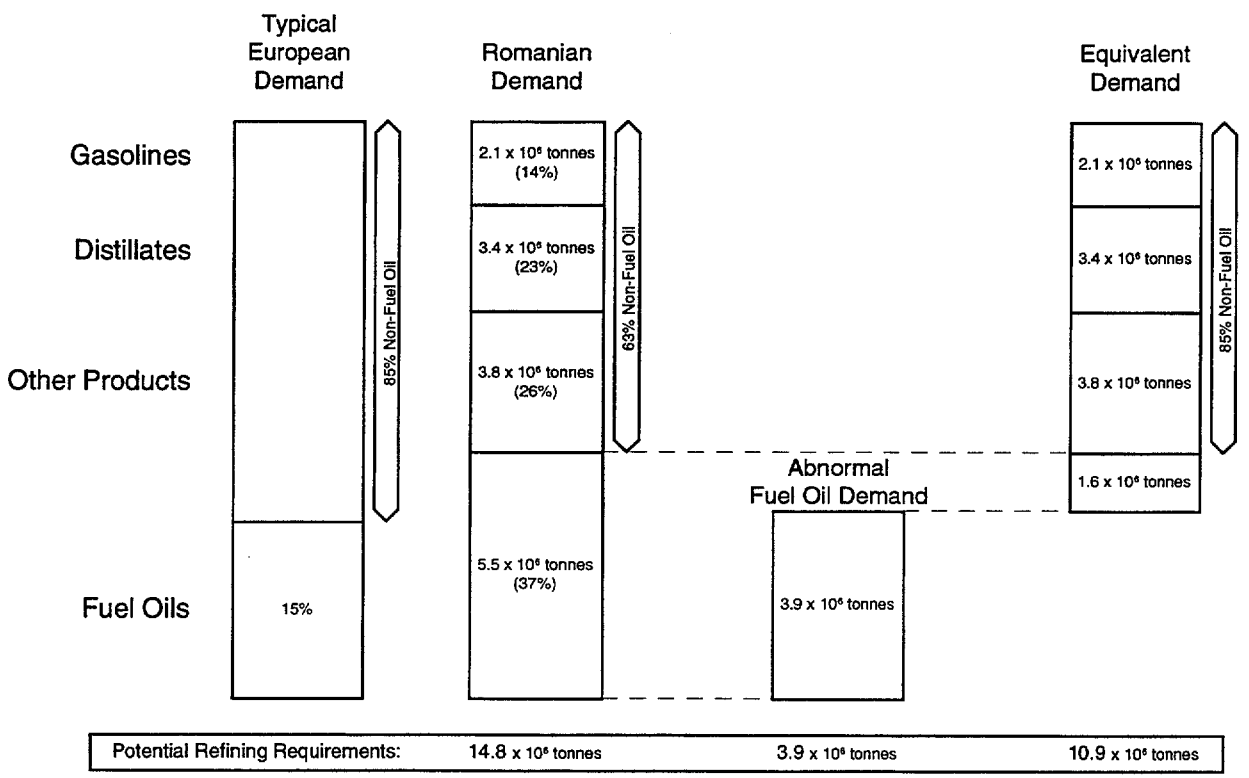

Figure 3-5 Characterization of Romanian Product Demand

Romania's demand for fuel oil stands in stark contrast to the configurations of its five large refineries, each of which has a core group of deep conversion units designed to yield light products rather than fuel oil. For over 20 years, the economic incentives in all major petroleum markets have favored deep-conversion refining. In other words, the deeper the conversion (i.e., the lower the yield of fuel oil), the more economically attractive the plant. The configuration of the refining assets in Romania is consistent with the typical refining economic incentives of the past 20 years, but such refineries are not properly configured to satisfy Romanian fuel oil demand without export/import product trading which, as shown earlier, is not economic.

The sector's operating response to the imbalance between conversion capacity and fuel oil demand has been to process the maximum amount of crude oil which, after export of light products, will supply all the domestic market's current needs for diesel, distillates, fuel oil, etc. Large amounts of crude oil are imported and refined only to export a large quantity of the light products yielded from that refining. As is shown below, the cost of procuring such products this way is far greater than the cost of purchasing them on the open market.

Our analysis clearly demonstrates that domestic demand for petroleum products can be most economically met by a combination of (1) refining all domestic crude oil and some imported crude oil and (2) directly importing heavy distillates and fuel oil rather than manufacturing them. The gap between Romania's unusually high demand for fuel oil and the Romanian refineries' plant configuration makes importation of heavy products inevitable. It simply is not economical to import crude oil and export clean products in order to retain distillates and fuel oil for the domestic market. Table 3-4 shows the economics of importing crude oil and processing it to retain the fuel oil.

Table 3-4 Excess Costs of Manufacturing Fuel Oil

Case: Import 100 Tonnes of Crude and Keep the Fuel Oil Versus Import Only Fuel Oil

Item	Quantity (tonnes)	Revenue ($/tonne)	Amount ($)
Manufacture Fuel Oil[1]			
Purchase Crude Oil	100.0	(127.35)	(12,735)
Incur Variable Costs	—	(2.60)	(260)
Sell All Products Except Fuel Oil	81.6	137.24	11,194
Consume Oil Through Fuel and Loss	11.2	—	—
Fuel Oil Yield	7.2	—	—
Cost of Retained Fuel Oil		(250.28)	(1,801)
Import Same Amount of Fuel Oil			
Low Sulfur Fuel Oil	4.2	(106.70)	(443)
High Sulfur Fuel Oil	3.0	(93.70)	(285)
Cost of Imported Fuel Oil	7.2	(101.20)	(728)
Excess Cost of Manufacturing Fuel Oil		149.08	1,073

1. Import crude; keep fuel oil and export the rest

Based on the same data used in the previous example, the cost of the crude oil is $127.35 per tonne for 100 tonnes, an aggregate of $12,735. To this is added a variable cost per tonne of

$2.60 per tonne, yielding another $260 in cost. From the 100.0 tonnes of crude oil, 81.6 tonnes are sold at an average price of $137.24 per tonne, yielding $11,194 of revenue. About 11.2 tonnes are lost through refinery fuel use and loss, leaving 7.2 tonnes of fuel oil at a net cost of $1,801 ($12,735 + $260 - $11,194). That same 7.2 tonnes could be purchased on the open market for $728. Thus, refining 7.2 tonnes of fuel oil costs $1,801 whereas buying 7.2 tonnes costs only $728, a difference of $1,073, or $149.08 per tonne. Romania cannot afford to pay $149.08 per tonne extra to make fuel oil instead of purchasing it. This $149.08 per tonne represents a direct loss to Romania, but it is not the only loss. There are other costs of running the refineries, and there are negative environmental impacts in processing 100 tonnes to keep 7.2 tonnes. Clearly this practice should be discontinued.

Section 3.3.1 indicates that toll processing is not feasible, which means that demand for processing capacity by Romanian refineries will be determined by the level of demand for petroleum products within Romania. The analysis above reveals that Romania's demand for clean products (not total demand, which includes fuel oil) is the factor which will establish the country's demand for refining capacity. This demand amounted to only 9.3 million tonnes in 1995, less than one-third of the 33 million tonnes of existing capacity. Even after robust growth in demand, our analysis shows that, if the most economical approach is followed, just 14 million tonnes of crude processing capacity will be needed through 2005. Three large refineries and three small ones can readily meet this refining demand.

3.3.3 Configuration of Facilities

3.3.3.1 Core Assets at the Five Large Refineries

The five largest refineries have very similar core assets, centered on reforming, catalytic cracking, and coking units (except Arpechim, which uses visbreaking instead of coking). Although the configuration of core assets is similar for each of the five large refineries, the performance of individual units varies significantly between refineries. This difference can be seen by comparing operating statistics for the fluid catalytic cracking units (FCCUs). FCCUs convert low-value fuel oil into high-value gasoline and generally are the most attractive units within a refinery from an economic standpoint. The performance of FCCUs can be assessed by comparing (1) the yield of catalytic gasoline produced (effectiveness), (2) the size of the unit (scale), and (3) the octane of the resulting gasoline (quality). As can be seen in Figure 3-6, Petromidia has the highest gasoline yield and the second highest octane. Arpechim has the highest octane and the second highest yield and is also the largest unit. The good performance of these units is one reason that Arpechim and Petromidia performed well during the PIMS computer modeling. Petrotel's FCCU is clearly the poorest performer (small, low quality, and low yield). This is one reason that Petrotel performed so poorly in the PIMS analysis.

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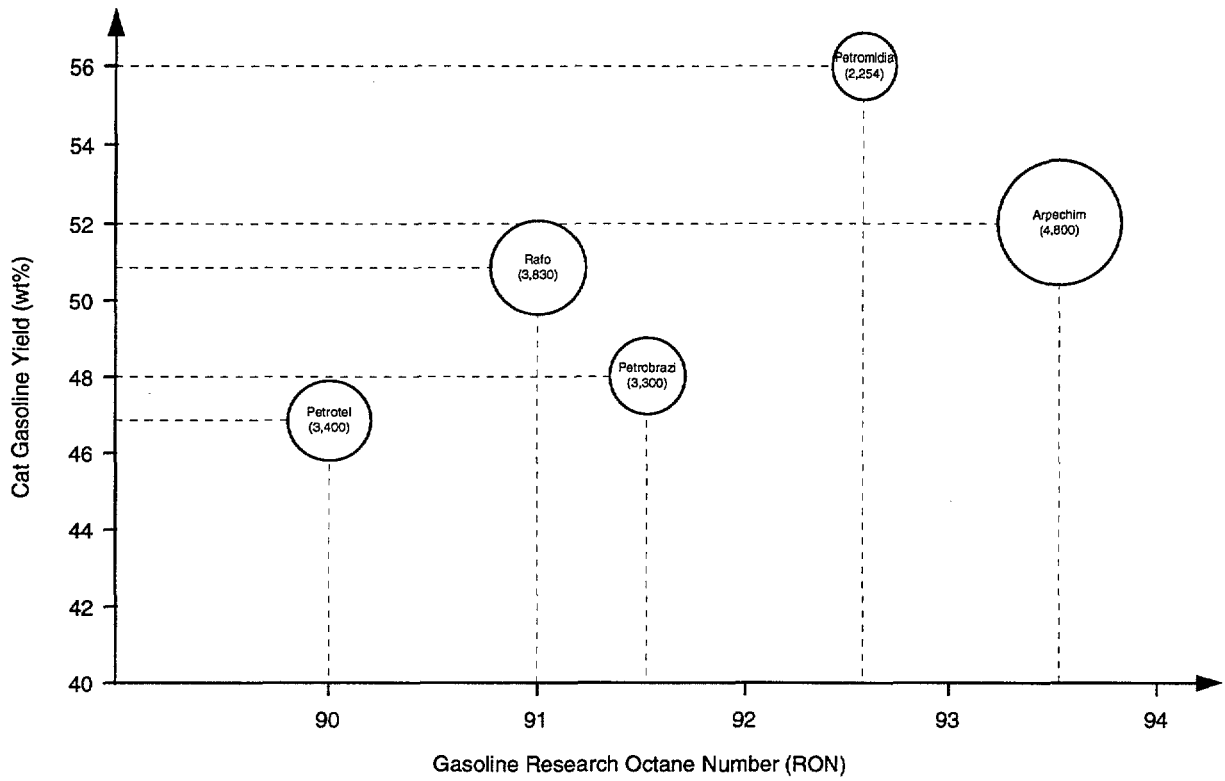

Note: Numbers in parentheses stand for plant capacity in tonnes per day

Figure 3-6 FCC Performance

3.3.3.2 Non-Core Assets at the Five Large Refineries

Surrounding the competitive cores at each of the five large refineries are layers of lower quality refining capacity, consisting of surplus crude distillation units, unused coking capacity, and retired units. These facilities lack the economic strength of the core assets and should be the first facilities shut down during rationalization. The non-core assets are poor economic performers, even though they are physically adjacent to the stronger core assets. The results of the PIMS computer model identified the facilities that are non-core. They represent the idle units at operating refineries for the cases where surplus refineries are assumed to have been decommissioned.

3.3.3.3 Small Refineries

The five smaller refineries suffer from a variety of competitive disadvantages. All lack balanced conversion facilities such as fluid catalytic cracking or hydrocracking complexes. All are small-scale refineries. Generally, they utilize older technology than the non-core assets at the larger refineries. Three of these refineries, however, do have strategic significance. Darmanesti and Astra possess facilities for producing anode-grade coke and naphthenic lubricating oils,

respectively. Petrolsub is separate from other refineries as it is linked to crude oil from a fire flooding oil field. Its viability depends solely on the combined refinery/oil field performance as a single entity.

Accordingly, the PIMS analysis assumes continued operations at these three plants. Vega and Steaua Romana have no identified strategic advantages and have been identified as surplus and are recommended for closure. The PIMS analysis was conducted assuming these two refineries were decommissioned.

3.3.4 Operations and Cost Control

Worldwide refinery margins are generally quite small. For example, typical U.S. refinery gross margins during 1994/1995 were roughly 21 percent of the value of feedstock. Net margins, however, were never less than 6 percent of the value of feedstock. With so little economic room in which to maneuver, successful refineries take great pains to maximize the economic benefit from every tonne. Daily operating practices strive toward:

- Maximizing yield of high-value products
- Minimizing fuel usage and oil loss
- Minimizing variable operating costs
- Reducing fixed costs (focused on investment and labor)

We believe that Romania's current industry structure and the operating practices at each refinery are not consistent with the objective of maximizing economic performance.

3.3.4.1 Refinery Operating Practices

A detailed review of daily operating and maintenance practices was beyond the scope of this project. However, during the course of plant interviews, sufficient information was gathered to provide a high-level overview of current practices and their consequences.

The management and operators at each refinery seem to have a good understanding of the technology used by each unit under their control, and to be aware of the technical consequences of changing operating parameters and of safety limits. Operators, however, appear to have only a rudimentary understanding of the overall targets the refinery is trying to achieve, and appear to have little awareness of (or interest in) prevailing economic incentives. Furthermore, there does not appear to be any routine exchange of economic information between management and plant operators, nor is there routine analysis of the economic results of current operations.

We believe that operating parameters are routinely set at overly conservative levels, and are not closely monitored for deviations. This operating practice deviates significantly from standard practices in market economies, where significant effort is expended to (1) determine what the economically optimal parameters are, (2) communicate this information to unit operators, and

(3) closely monitor and maintain actual operations at desired levels. There was no evidence of any meaningful Refinery Information System (RIS) to gather, organize, and communicate vital operational and economic data. Such a system is essential to enable these refineries to operate economically. Unfortunately, the lack of such a system obscures the very information necessary to demonstrate the need for such a system.

The refinery managers had a better understanding of each refinery's overall targets and seemed to have a rudimentary understanding of conventional oil processing economics. They did appear to be partially applying this knowledge; for example, they appeared to be doing an acceptable job of configuring units interconnections given the very low utilization rates resulting from low levels of feedstock supply. They also seemed to be doing an acceptable job in applying limited capital to upgrade the balanced capability of their core assets (considering the unavoidably low levels of processing). However, they appeared overly focused on adding new processing technology, and far less interested in improving operating, information, and management practices to more effectively derive value from the assets already under their command. They were also overly concerned with keeping plants and departments working (even at low levels) to justify the large number of staff assigned to these units/departments. In addition, they were very concerned with meeting the physical delivery requirements of the crude supply terms imposed by Rafirom. While many expressed awareness that their actions were probably not in the overall best interest of the country, they did not possess the necessary information to confirm such a hypothesis.

A great deal of opportunity exists for improving operating practices, but the current industry structure prevents the industry from implementing the necessary changes. Individual refineries are not required to meet economic targets; rather, they are judged on the basis of physical-delivery targets. They do not have direct access to markets, commercial information, and (perhaps most importantly) to international credit and currency. Even if they had such access, they do not have the autonomy and authority and, therefore, the responsibility to determine and undertake the economically best course of action.

3.3.5 Industry Structure and Policy

The current structure of the refining sector creates significant and excessive interdependence between the companies in the sector. At the same time, the individual companies enjoy little control or independence. The fundamental decisions that any refining industry must make are:

- Which feedstocks to select and how to procure them
- How to operate the units at each refinery in the most economic manner
- Which products to produce in order to create the highest value
- How to blend products in better ways to minimize quality giveaway and create more value
- Which markets and customers to serve

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- What investments to make in operating assets

Ideally, any sector should be organized to allow each enterprise to evaluate all aspects of these issues, to make decisions, to implement action consistent with these decisions, and to disclose sufficient information to allow these decisions to be fairly judged. In contrast to this ideal, the Romanian refining sector is organized such that many entities have partial responsibility, no entity has full information to evaluate the fundamental decisions, no entity has authority to implement action on decisions, and the sector obscures rather than discloses information on its performance. The current industry structure is shown in Figure 3-7. Rafirom makes feedstock supply and planning decisions, each refinery makes configuration decisions, and other entities make decisions regarding petrochemicals and lubricants. Decisions are divided across many entities. The absence of competitive and market prices means that there is no mechanism for sharing economic information.

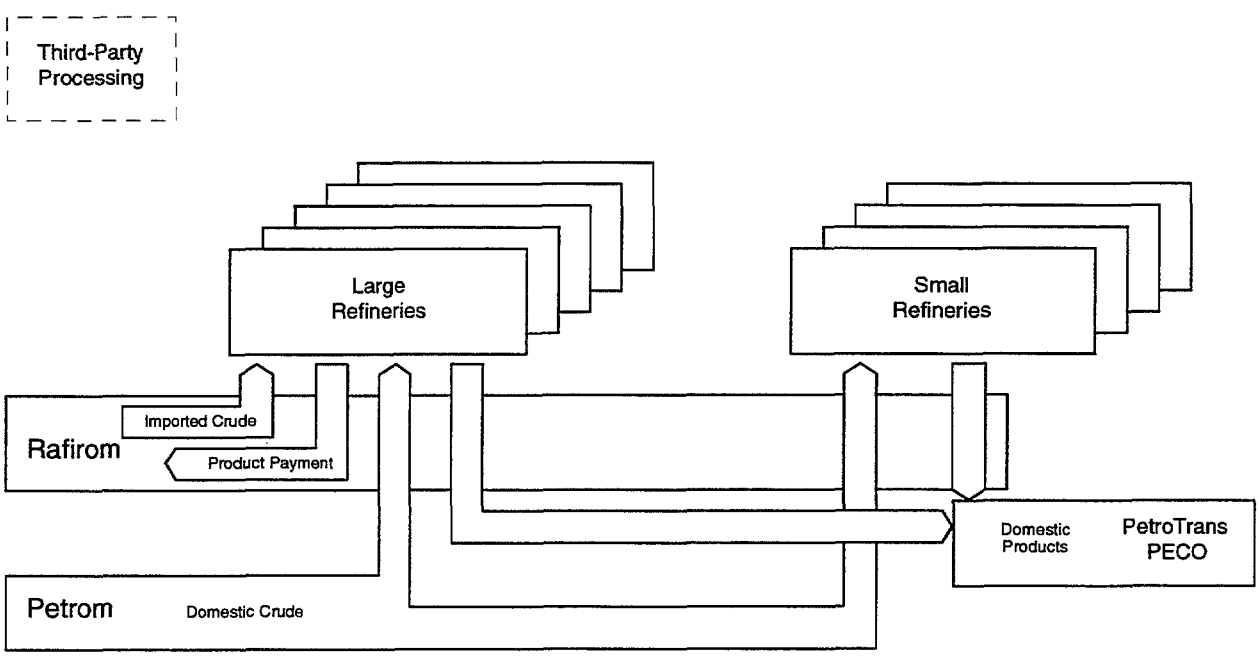

Figure 3-7 Current Industry Organization

The problem is not just between entities in the sector, but also within each entity. For example, the organizational structure of each refinery represents a classic command-and-control pyramid of functional departments. At the base of the pyramid, there are management organizations dedicated to each individual refinery unit (e.g., a distillate hydrotreater) and each functional specialization (e.g., rotating equipment maintenance). Each of these organizational units, in turn, has its own separate complement of staff to cover virtually all potential activities associated with the unit, including basic support such as cleaning.

On top of these basic units are multiple layers of consolidating management which have management responsibility for the layers beneath them. Direct communication between parallel organizational units appears to be limited. Instead, communication channels push decisions up through the functional hierarchy of one department, across to the top of the next department, and down through the second department to the point at which action is taken. This type of indirect communication and decision-making leads to delays, losses of clarity, and staff redundancy, and substantially increases the probability that errors will occur. In addition to the pyramid hierarchy, there are side branches of staff departments, each having sufficient staff to perform analyses independently of the operating structure. This structure gives rise to bureaucratic organizations with layers of duplication, needless hierarchy, and excessive staffing levels.

3.4 ANALYSIS AND RECOMMENDATIONS

Romania has a highly developed, yet operationally ineffective, refining sector that perpetuates some of the vestiges of central planning. The original basis for the decisions and the economics that led to the current design has radically changed as a result of changes in conditions in Romania, in the former Soviet Union, and throughout the world. Regardless of the reasons, the Romanian refinery sector is burdened by substantial unusable refining capacity that negatively impacts all aspects of the sector. Design and implementation of a plan to rationalize this surplus refinery capacity are prerequisites for restoring Romania's refining sector to a state of economic self-sufficiency.

Once such a rationalization plan is implemented and true economic operating profits rise from a loss of $305 million per year to a profit of $142 million per year, the six remaining manufacturing complexes will have a positive NPV of $1.2 billion over 20 years, fully $3.9 billion more value than the sector has under current policies and practices.

Table 3-5 shows the gains in profitability of this downstream sector, and in addition shows that using market-based prices the upstream sector would receive $269 million more per year to use in exploring, developing and producing crude oil to reduce the nation's dependency on imports. The economic value of reduced imports has an NPV of another $4.8 billion over the next 20 years. Table 3-2 also shows that either (1) consumers could enjoy lower prices of up to $230 million (net) per year or (2) alternatively, the government could impose excise taxes to fund other vital national interests, such as restoration and expansion of the nation's highways, roads, and mass transit systems.

Many important changes to assets, operating practices, organization structure, information systems, staffing levels, and decision processes are necessary to make Romania's refining sector internationally competitive. However, these changes will produce little benefit unless the fundamental problems of overcapacity are addressed. The results of our analysis of capacity rationalization are shown in Table 3-5.

Table 3-5 Potential Annual Profits After Capacity Reductions with Rationalization and Improvements in Operating Practices Using Market Prices

Item	$ Million
Actual Economic Loss of 10 Manufacturing Complexes	(305)
Estimated Improvements	
Eliminate unnecessary labor	76
Eliminate excess crude runs that produce losses	160
Save maintenance, utilities, insurance, etc., for four unneeded plants	85
Eliminate excess fuel use and product losses in manufacturing	130
Total Identified Improvements	451
Other	(4)
Total of All Improvements	447
Typical Operating Profit with Only Six Manufacturing Complexes	142

3.4.1 Five Large Refineries Operating

If Romania continues to operate all five large refineries, great gains can be realized through refinery optimization and capital investment. We have examined the sector's basic operating practices and facilities constraints, and have modeled the effects of improving them.

Our calculations show that removing the impact of all regulations and government controls, investing $264 million, and optimizing the processing of crude oils while keeping all five large refineries operational would increase the NPV of future cash flows. Instead of an annual loss of $305 million with a negative $2,572 million NPV (which includes a contribution from petrochemical operations), there would be a positive $203 million, as shown in Table 3-6 excluding petrochemicals (which have a positive NPV of $675 million). For the refining sector, this represents a huge improvement, with an incremental NPV of $2,775 million. This difference reflects the impact of fully abandoning Romania's complex structure of government controls and operating each of the existing refineries in alignment with economic incentives. It assumes that all processing under the barter arrangements are eliminated and that staffing levels are reduced, as described in the labor analysis. It also assumes that instead of using highly conservative operating parameters which are seldom adjusted, dynamic setpoints are used which change often according to economic incentives, thereby resulting in improved yields and reduced fuel use and loss. Hundreds of changes to operating practices would be required to transform Romania's manufacturing sector into a collection of commercially focused enterprises with a set of behaviors that are motivated purely by economic incentives. Though the effort would be difficult, the rewards of the transformation clearly justify its undertaking.

Table 3-6 Five-Refinery Case (Optimized)
Annual Cash Flows for an NPV of $203 Million

Item	1995	2000	2005
		10^3 tpy	
Domestic Crude	5,500	5,500	5,500
Imported Crude	4,007	6,585	13,471
Other	149	185	212
Total Supply	9,656	12,269	19,183
Product Exports	(1,009)	(1,578)	(3,892)
Product Imports	6,501	6,777	4,796
Net Imports	5,492	5,199	904
		10^6 $/yr	
Domestic Sales (Production)	1,355	1,810	2,560
Domestic Sales (Import)	484	554	391
Export Sales	157	265	694
Less: Transport	(33)	(46)	(85)
Petrochemical Profits	(72)	(79)	(86)
Total Revenues	1,891	2,504	3,474
Crude Purchases	1,241	1,616	2,594
Product Imports	484	554	391
Other Costs	283	310	350
Total Expenses	2,008	2,480	3,335
Net Cash Flow	(117)	24	139

Experience in other countries has shown that the most efficient method for transforming state-owned companies into economic enterprises is through some form of privatization. However, Romania's downstream sector cannot undergo any type of privatization at present; the fundamental problems of massive overcapacity, intrusive government control, and excessive employment would prevent the Romanian refining sector from operating at sustainable levels and hence must be addressed before privatization is undertaken.

We conclude that operating the five refineries more effectively offers huge gains, but that the five-refinery option falls short and would not permit the Romanian refining sector to operate at sustainable levels.

3.4.2 Four Large Refineries Operating

Decommissioning one large refinery would dramatically increase plant utilization rates, reduce redundant overhead costs, and increase the sector's NPV by $211 million, to $414 million, excluding petrochemicals ($675 million NPV). Table 3-7 shows the basis for this increase.

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Table 3-7 Four-Refinery Case (Optimized)
Annual Cash Flows for an NPV of $414 Million

Item	1995	2000	2005
		10^3 tpy	
Domestic Crude	5,500	5,500	5,500
Imported Crude	4,007	6,927	11,713
Other	149	179	238
Total Supply	9,656	12,606	17,451
Product Exports	(603)	(1,247)	(2,276)
Product Imports	6,516	7,133	4,721
Net Imports	5,913	5,886	2,445
		10^6 $/yr	
Domestic Sales (Production)	1,345	1,890	2,433
Domestic Sales (Import)	493	630	395
Export Sales	167	219	498
Less: Transport	(33)	(47)	(75)
Petrochemical Profits	(72)	(79)	(86)
Total Revenues	1,900	2,613	3,165
Crude Purchases	1,241	1,650	2,303
Product Imports	493	630	395
Other Costs	283	257	319
Total Expenses	2,017	2,537	3,017
Net Cash Flow	(117)	76	148

Our analysis indicates that Petrobrazi is the poorest economic performer among the five large refineries. Table 3-8 lists the incentives (expressed in millions of dollars of NPV) for decommissioning Petrobrazi in the four-large-refineries scenario relative to decommissioning either Petrotel or Arpechim. The Appendix shows the economic calculations used to obtain the detailed PIMS/Economic Model results.

Decommissioning Petrobrazi would lower the investment needed to $215 million at the other refineries and would significantly improve the utilization rates of the remaining four refineries' core refining units (i.e., those units which drive economic performance).

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Table 3-8 Incentive to Decommission Petrobrazi Versus Other Refineries ($ Million NPV)

Optimized Four-Refinery Case	Alternate Cases		
	Petrobrazi In Petrotel Out	Petrobrazi In Arpechim Out	Nonoptimized Four-Refinery Case
$414	$(26)	—	$388
$414	—	$(40)	$374

The closure of Petrobrazi would still not allow the Romanian refining sector to operate at normally sustainable levels. Even after improvement, the utilization rates would reach only the lower end of the range considered normal for sustainable operations. These utilization rates are shown in Table 3-9.

Table 3-9 Utilization Rates

Item	Five Large Refineries		Four Large Refineries		Change	
	2000	2005	2000	2005	2000	2005
Atmospheric Distillation	42%	62%	60%	84%	18%	22%
Catalytic Reforming	45%	62%	75%	83%	30%	21%
Catalytic Cracking	60%	83%	71%	96%	11%	13%
Coking	56%	70%	67%	76%	11%	6%

3.4.3 The Optimal Solution – Three Large Refineries

Decommissioning a second large refinery would further improve the performance of the sector, raising plant utilization rates, reducing redundant overhead costs, and increasing the sector's NPV by another $98 million, to $512 million, excluding petrochemicals. Table 3-10 presents the three-large-refineries case.

In this case, because two refineries are closed, the level of critical investments would drop to $170 million. Our analysis demonstrates that Petrotel and Petrobrazi are the two worst economic performers among the five large refineries. The PIMS/Economic Model results show the comparison of the Petrotel/Petrobrazi analysis versus other combinations.

Table 3-10 Three-Refinery Case (Optimized)
Annual Cash Flows for an NPV of $512 Million

Item	1995	2000	2005
		10^3 tpy	
Domestic Crude	5,500	5,500	5,500
Imported Crude	4,007	6,549	7,820
Other	149	187	229
Total	9,656	12,236	13,549
Product Exports	(543)	(1,111)	(820)
Product Imports	6,928	6,316	6,822
Net Imports	6,385	5,205	6,002
		10^6 $/yr	
Domestic Sales (Production)	1,345	1,865	2,030
Domestic Sales (Import)	566	502	709
Export Sales	167	183	316
Less: Transport	(33)	(45)	(60)
Petrochemical Profits	(72)	(79)	(86)
Total Revenues	1,973	2,426	2,909
Crude Purchases	1,241	1,614	1,834
Product Imports	566	502	709
Other Costs	283	201	221
Total Expenses	2,090	2,317	2,764
Net Cash Flow	(117)	109	145

Decommissioning Petrotel and Petrobrazi would increase the utilization rates of the sector's core refining units to economic levels of performance that are considered acceptable for sustained operations. Table 3-11 compares the utilization rates of the three-refinery and four-refinery cases.

Table 3-11 Comparison of Utilization Rates – Three Large Refineries vs Four Large Refineries

Item	Four Large Refineries		Three Large Refineries		Change	
	2000	2005	2000	2005	2000	2005
Atmospheric Distillation	60%	84%	78%	86%	18%	2%
Catalytic Reforming	75%	83%	85%	88%	10%	5%
Catalytic Cracking	71%	96%	82%	100%	11%	4%
Coking	67%	76%	74%	70%	7%	(6)%

3.4.4 Closing of Two Small Refineries

All five of the small Romanian refineries are economically inferior to the larger refineries and add to the uneconomic surplus in refining capacity. We recommend that two of these refineries (Steaua Romana and Vega) be decommissioned and that a third (Darmanesti) be integrated into Rafo, an adjacent large refinery, to reduce cost. The remaining two refineries, which serve niche markets that are remote from the other large refineries and can economically serve markets in their immediate vicinity, should remain open.

3.4.5 Tankage and Storage Alternatives at Closed Refineries

The refinery rationalization strategy recommends decommissioning two large and two small refineries. The closure of refineries now served by Conpet and PetroTrans would reduce the need for modernization of some portions of these transportation systems, and create the need for flow reversals and new interconnect points. These closures would also eliminate local access to products at these refineries for trucks, railcars, distribution pipelines, local pipelines to industrial users, and bulk product carriers. To avoid or minimize significant disruption to the existing distribution systems and reduce the overall impact on the consumer, the crude and supply storage tankage, shipping, and loading facilities at these sites should remain in operation for the foreseeable future. This would reduce or avoid the need for significant investment in the alteration of the transportation system to accommodate these closures.

Additional benefits could be realized through preservation of the storage capabilities of the refineries that will be closed. Crude feed to, and products from, the remaining operating refineries could be distributed to depots at these sites in quantities significant enough to buffer variability in demand and smooth transport requirements. This should result in reduced growth pressure on the transport system, alternate routing capabilities in cases of transportation system disruptions, and strategic reserve capability for situations such as unusual demand levels, temporary shutdowns at the operating refineries, supply delays, or supply/demand market price arbitration. Additionally, the availability of multiple product storage tanks would be useful to handle the growing number of blend stocks typical of a multisupplier competitive environment that the local bulk terminals are not currently prepared to store. Employment for 50 to 100 people per terminal site can also reduce the overall impact of employment reductions and layoffs.

3.4.6 Reduction in Refinery Staffing Levels

Reducing the staffing levels to standard levels at the remaining operating refineries would result in additional efficiency gains and increase the NPV of the sector's annual cash flows. A total NPV of $62 million is included in the figures above with regard to these staff reductions. The staffing levels at all of Romania's plants are over twice as high as equivalent plants in other parts of the world. These staffing levels result in waste, which depresses the sector's economic stability. If the workforce at the six refineries that remain operational are brought into alignment with customary levels, the sector's workforce would be reduced by 24,800 people to 12,900.

This residual staffing level includes 2,500 workers assigned to contract-maintenance firms in an outsourcing arrangement.

3.4.7 Reduction in Rafirom's Role

Rafirom's monopoly over crude oil supply and its allocation of that supply serve as an important barrier to achieving economic performance in refining and, therefore, should be eliminated. There are many barriers preventing refineries from implementing direct commercial arrangements in international markets to optimize their own operations. The most obvious barriers are the refineries' lack of access to bank letters of credit and hard currency. Less obvious barriers include the refinery managements' lack of access to timely market information, limited skills in analyzing markets, and lack of experience in negotiating and executing international transactions. In addition, the financial gridlock in settling commercial transactions between government entities has desensitized the refineries to the time value of money, further aggravating the lack of financial accountability.

Commercial arrangements with international traders are further impeded by (1) the refineries' inability to control the quantity and quality of incoming crude oil supplies or refined product shipments to and from the refineries, (2) the problems facing nongovernment clients in dealing with the bureaucracy, and (3) a poorly motivated workforce. Consequently, with only minor exceptions, virtually no oil is currently being received through direct commercial arrangements. Also, as previously discussed, the refineries are engaging in uneconomic bartering through arrangements organized by Rafirom, a practice we believe destroys value and should be stopped.

3.4.8 Refining Critical Investments

The following critical investments are required assuming that the recommendation to close Petrobrazi and Petrotel is implemented:

- $11.1 million to enhance feedstock processing capabilities at Arpechim, Petromidia, and Petrotel
- $27.1 million for additional hydrotreating capacity at Arpechim
- $24.3 million for additional hydrotreating capacity at Rafo
- $0.8 million for additional hydrotreating capacity at Petromidia
- $11.3 million to expand Petromidia's FCC
- $63.4 million for environmental projects at refinery sites
- $10.5 million to decommission Petrobrazi, Petrotel, Steaua Romana, and Vega

The above investments total $162.9 million.

3.4.9 Foreign Currency Costs

In efforts to minimize the foreign currency drain of the downstream petroleum sector, Romania is employing crude oil procurement methods which are causing economic losses. Other government policies are creating a massive increase in net foreign currency outlays. In particular, the price subsidy from the producer, Petrom, to the refiners is preventing development of oil production that would have the greatest impact on reducing the hard currency cost of imports. Below we summarize the adverse consequences of both of these policies and the benefits of changing them.

3.4.9.1 Summary of Foreign Currency Impacts

The recommended rationalization offers important opportunities to dramatically reduce Romania's foreign currency costs of importing crude oil and refined products. Over time, the reductions could reduce these costs by more than half, saving on an NPV basis more than $2.4 billion over 20 years. The detailed calculations are very complicated and are not shown here. However, a simplified representation of the most important impacts is presented in the manufacturing section and is summarized in Table 3-12.

Table 3-12 Foreign Currency Costs
($ Million, Using Market Prices)

Item	Annual Cost[1]			
	1995	2000	2005	NPV
Costs Under Existing Operating Practices[2]	985	1,273	1,635	10,825
Improvement Under the Proposed Rationalization[3]	16	378	595	2,439
Costs Under Our Rationalization Recommendations[3]	969	895	1,040	8,386

1. All amounts exclude capital investments in the manufacturing complexes and any costs other than hydrocarbons used in the sector. Oil prices are based on 1995 levels, rising $1.50 per annum thereafter. Net exports of petrochemicals are also excluded but would be the same under both scenarios.
2. Represents 10 refineries operating and initial processing of 18 million tonnes of crude oil, rising with demand.
3. Primarily represents new domestic oil supplies discovered using the $269 million per annum subsidy by Petrom to the refining sector which can be eliminated in the rationalization and six-refinery manufacturing sector. Excludes four closed refineries and assumes no barter processing is performed.

Clearly, there are exceptional benefits to the petroleum sector and to customers in implementing the recommendations reflected in this report.

3.4.9.2 Analysis of Foreign Currency Impacts

Romania's demand for domestic petroleum products must be met by (1) manufacturing products from domestic crude oil, (2) net imports of finished petroleum products, and (3) manufacturing products from imported crude oil. In 1995, domestic demand was 14.8 million tonnes, as shown in Table 3-13. Domestic production of crude oil was 6.5 million tonnes and, after allowing for

11 percent consumption during the refining process, it contributed 5.8 million tonnes of refined products to meet demand. We estimate that net imports of refined products were 3.2 million tonnes, leaving 5.8 million tonnes of domestic product demand (14.8 million tonnes minus 5.8 million tonnes minus 3.2 million tonnes) to be supplied from refining of imported crude oil.

Table 3-13 Projected Demand and Imports

Item	Tonnage Under Current Operating Practices (10^6 tpy)			Tonnage Under Recommended Rationalization (10^6 tpy)		
	1995	2000	2005	1995	2000	2005
Total Domestic Demand for Refined Products	14.8	17.2	19.7	14.8	17.2	19.7
Amount Supplied from Domestic Crude Oil[1]	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8
Amount Supplied by New Romanian Crude Oil[2]	—	—	—	-0.9	-3.8	-5.4
Amount That Must Be Supplied from Imports	9.0	11.4	13.9	8.1	7.6	8.5
Amount of Imported Products	-3.2	-3.7	-4.3	-3.2	-3.7	-4.3
Amount That Must Be Supplied from Imported Crude Oil	5.8	7.7	9.7	4.9	3.9	4.3
Amount of Imported Crude Oil[3]	11.3	15.0	19.0	5.5	4.4	4.8
Less Amount Consumed in Refining (11% Fuel & Loss)	-1.2	-1.7	-2.1	-0.6	-0.5	-0.5
Products Exported as Partial Barter Payment for Crude Oil[4]	-4.3	-5.7	-7.2	0.0	0.0	0.0
Remaining Products Supplied to Domestic Market	5.8	7.7	9.7	4.9	3.9	4.3

1. Represents 6.5 million tpy of domestic crude oil production less 11% fuel and loss, yielding 5.8 million tonnes of production
2. Based on $269 million additional production expenditure per year, $37.50/tonne finding and development costs, 12% of proven reserved initial production, and 12% production decline per year
3. Calculated assuming 50% of the cost of imported crude oil is paid for by the delivery of gasoline
4. Represents 50% of the crude oil import cost divided by the price of gasoline

To supply this remaining 5.8 million tonnes from imported crude oil under Romania's current operating practices (barter processing) requires importing and processing 11.3 million tonnes of crude oil. The cost of half this amount (5.65 million tonnes) is defrayed by using foreign currency. The other half (5.65 million tonnes) is paid for by exporting 4.3 million tonnes of gasoline. Because gasoline is more expensive than crude oil, only 0.75 tonne of gasoline is needed to pay for 1.0 tonnes of crude oil, and 4.3 million tonnes of gasoline are sufficient to fully pay for 5.65 million tonnes of crude oil. When refined, the 11.3 million tonnes of crude oil produces a total of 10.1 million tonnes of products (1.2 million tonnes is consumed in the refining process). Given the barter requirement for 4.3 million tonnes of gasoline, only 57 percent of these refined products are available for domestic demand, which exactly equals the requirement of 5.8 million tonnes.

Projected foreign currency requirements are shown in Table 3-14. Roughly $985 million of foreign currency was required to support this activity in one year. Paying for 50 percent of the crude imports requires $679 million (5.65 million tonnes times $120/tonne). Another $306 million is required to pay for the product imports (3.2 million tonnes times $96/tonne). As demand grows in the future, the net requirement for foreign currency would rise to $1,273 million per year in 2000 and $1,635 million per year in 2005. Combining these annual requirements by using a 10 percent discount rate, the foreign currency requirement yields an NPV of $10,825 million for the next 20 years of imports.

Table 3-14 Projected Annual Foreign Currency Requirements

Item	1995	2000	2005	1995	2000	2005
Foreign Currency Cost of Imported Crude Oil						
Imports Paid for with Hard Currency (tonnes)[1]	5.7	7.5	9.5	5.5	4.4	4.8
Price of Imported Crude Oil ($ per tonne)	120	121	126	120	121	126
Cost of Imports (10^6)	679	908	1,198	663	530	603
Foreign Currency Cost of Imported Products						
Imports Paid for with Hard Currency (10^6 tonnes)	3.2	3.7	4.3	3.2	3.7	4.3
Price of Imports (mostly fuel oil) ($ per tonne)	96	98	103	96	98	103
Cost of Imports	306	365	437	306	365	437
Total Foreign Currency Cost of Imports (10^6)	985	1,273	1,635	969	895	1,040
NPV of Foreign Currency Costs[2]	10,825			8,386		

1. Represents 50% of crude oil imports under current operating practices and 100% under recommended practices
2. Represents annual costs over 20 years discounted at 10% per year

Under our recommended rationalization approach, however, the overall requirement for foreign currency would be reduced in all periods by an enormous sum in just a few years. Two factors drive this change. First, eliminating the need to make product for barter trading significantly reduces the amount of crude oil purchased. Unfortunately, all of the remaining tonnes of imported oil must then be paid for using foreign currency. The result of this factor by itself is a slight increase in the requirement for hard currency in each period. This negative effect is offset first by better economics on the sector through savings of lei-based costs and second by the other rationalization benefits discussed below.

Second, implementing the recommended rationalization program improves the financial performance of the sector from a $305 million loss to a $142 million average profit, as shown previously. This includes the adoption of market pricing, which would free Petrom and Romanian consumers from having to subsidize the refining sector. In Petrom's case, this will mean higher cash flows of $269 million per year, which can be used to significantly reduce foreign currency requirements. If Petrom invests this money annually in oil production activities

inside (or outside) Romania, and even if Petrom's performance is worse than average (finding and development costs of $5 per barrel or $37.50 per tonne, about 25 percent higher than private-sector companies costs), then this additional investment will result in discovery of 7.2 million tonnes of new reserves each year. Again, using industry averages, this level of new reserves would result in an initial year's oil production of 0.9 million tonnes of new oil. This 0.9 million tonnes of additional production directly reduces Romania's crude oil import requirement by $108 million (based on a market crude oil price of $120 per tonne). Each year Petrom could invest a similar amount, resulting in a cumulative 3.8 million tonnes per year increase in production by 2000 and 5.4 million tonnes per year increase in production by 2005. These levels of production take into account an assumed 12 percent per year decline in production for each tranche of investment.

Undertaking all the steps of our rationalization strategy would result in a downstream sector which imports significantly less crude oil. These steps include: (1) eliminating the barter payment for crude, (2) decommissioning two small and two large refineries, (3) reducing staffing to typical levels, (4) selectively investing in the remaining refineries, (5) lifting the intrusive government regulations, (6) economically optimizing the operations of the downstream sector and (7) redirecting the subsidies into productive investments.

While the net foreign exchange required for the recommended case in 1995 is close to the amount required in the current practices case ($969 million versus $985 million), a tremendous benefit can be developed by the year 2000. The recommended rationalization approach requires substantially lower annual net foreign currency outlays in 2000 and 2005 compared with current practices and policies. The NPV of the annual foreign currency requirements for our recommended approach, using a 10 percent discount rate over 20 years, is only $8,386 million, or $2,439 million below the levels under current practices and policies.

3.5 INDIVIDUAL REFINERY ANALYSES

3.5.1 Petromidia

Located on the Black Sea coast, Petromidia is farther from domestic oil fields and has more limited access to domestic oil fields than the other refineries. This disadvantage is not economically significant, as domestic production covers less than half of the country's requirement for crude oil. The rest is imported, and during the next 10 years Romania will import between 4 and 13 million tonnes of foreign crude oil annually. Petromidia is ideally suited to refine this imported oil because it is located closest to Romania's primary oil import terminal and can most economically access the international crude markets.

As discussed previously, the margins for toll processing (importing crude oil and exporting all products) in this region are very poor, because the Mediterranean market serves as a market of last resort for surplus refined products. Although Petromidia is best suited among Romania's refineries to serve the international markets, these poor market conditions will make any sustained toll processing unprofitable. However, the ongoing transformation of the economies of

the former Soviet block may present temporary opportunities for Petromidia to toll process profitably. We expect even these opportunities to vanish in only a few years as more rational economic behavior establishes itself in those countries. As shown in Table 3-15, at Petromidia the costs of purchasing imported crude oil ($122.01 per tonne) and incurring the variable costs for processing ($1.90 per tonne) are higher than the value of products refined ($120.23 per tonne) if all products are exported, resulting in a negative processing margin of $3.68 per tonne.

Petromidia has logistical advantages for delivering product to the eastern and coastal regions of the country, but these markets are not large enough to consume all of Petromidia's products, and the rest must be sold in the centrally located Muntenia market. Petromidia is geographically remote from central markets compared to the Ploiesti refineries, leaving it disadvantaged relative to the other large refineries.

Table 3-15 Petromidia Export Processing Economics

Case: Import 100 Tonnes of Crude and Export All Products
Average Yields and Prices for 1995

Item	Quantity (tonnes)	Revenue ($/tonne)	Amount ($)
Crude Oil Feedstock	100.0	(122.01)	(12,201)
Fuel Use + Loss	12.7	–	–
Products Refined and Sold			
LPG/Naphtha	6.0	132.87	795
Petrochemical Naphtha	3.6	132.87	479
Unleaded Gasoline 82 RON	2.5	132.87	332
Unleaded Gasoline 90 RON	0.0	139.62	0
Unleaded Gasoline 95 RON	31.4	156.87	4,919
Kerosene	10.8	143.87	1,561
Diesel	27.0	142.87	3,862
Low-Sulfur Fuel Oil	0.0	90.13	0
High-Sulfur Fuel Oil	0.0	72.88	0
Fuel Coke	5.8	10.66	61
Needle Coke	0.0	215.69	0
Other	0.2	77.13	13
Total	87.3	–	–
Revenue from Products		120.23	12,023
Gross Margin		(1.78)	(178)
Variable Costs (Excluding Fuel Use + Loss)		(1.90)	(190)
Net Margin (Loss)		(3.68)	(368)

At 3.5 million tpy of processing capacity, Petromidia is the smallest of the five large Romanian refineries. It is, however, very well balanced in that all of its basic distillation capacity is backed by conversion and coking capacity. Petromidia's catalytic cracking complex, the single most important refining unit for generating economic value, was recently upgraded with world-class technology. It produces the nation's highest yield of gasoline (56 wt%) and the nation's second highest level of quality (92.5 RON). In many ways, Petromidia represents a model for the type of value-adding, operationally balanced core refining facilities that are needed at the other refineries. Petromidia's advantages in superior design and technology far outweigh its logistical disadvantages. For these reasons, Petromidia performed best in our economic evaluations, and we recommend that it remain operational.

To enhance the balance between Petromidia's core refining units and to address tightening sulfur specifications, we recommend the following critical investments totaling $31.5 million for Petromidia:

- $3.7 million to enhance feedstock processing capabilities
- $6.8 million for sulfur plant refurbishments
- $0.8 million for revamping the kerosene hydrotreater
- $11.3 million to revamp FCC and expand capacity by 30 percent
- $8.9 million for environmental projects

Despite its technological and logistical advantages, Petromidia exhibits many of the poor operating and managerial practices which reduce performance in all of the Romanian processing plants. Under the Rafirom-dominated central planning system, the refinery is constrained from optimizing is feedstock selection and product mix. Its staffing is excessive. Advanced instrumentation is not used. The operating paradigm is passive and risk-aversive. Consequently, the full capabilities of the existing equipment are not being achieved. As mentioned in the Labor Section, we recommend that Petromidia reduce its staffing levels from 4,754 employees to a total of 2,732 permanent employees plus 238 employees to be included in separate contract maintenance companies.

3.5.2 Arpechim

Located 70 kilometers west of Ploiesti, Arpechim is the westernmost large refinery in the country. In many ways, Arpechim represents the classic inland refinery, in that it is well suited to receive crude oil and produce products for local market consumption. With access to an adequate system of pipelines, Arpechim has ready access to both domestically produced and imported crude oils. While in the past there has been some interest by international companies in toll processing at Arpechim, their primary goal was to exploit Romanian naiveté, which was reflected in the artificial distortions between local-currency costs for transport and manufacturing and their international market equivalents. These opportunities have been discovered and eliminated, making toll processing structurally unattractive at Arpechim over the long term. As shown in Table 3-16, the costs of purchasing imported crude oil ($128.24 per tonne) and

incurring the variable costs for processing at Arpechim ($1.20 per tonne) are significantly more than the value of products received ($113.17 per tonne) if all products are exported, resulting in a $16.28 per tonne negative processing margin.

Table 3-16 Arpechim Export Processing Economics

Case: Import 100 Tonnes of Crude and Export All Products
1995 Yields and Prices

Item	Quantity (tonnes)	Revenue ($/tonne)	Amount ($)
Crude Oil Feedstock	100.0	(128.24)	(12,824)
Fuel Use + Loss	9.8	–	–
Products Refined and Sold			
LPG/Naphtha	2.7	128.62	354
Petrochemical Naphtha	15.7	128.62	2,017
Unleaded Gasoline 82 RON	0.0	132.87	0
Unleaded Gasoline 90 RON	17.0	139.62	2,377
Unleaded Gasoline 95 RON	6.4	152.62	970
Kerosene	0.0	143.87	0
Diesel	32.2	133.62	4,301
Low-Sulfur Fuel Oil	8.7	85.88	744
High-Sulfur Fuel Oil	6.2	72.88	449
Fuel Coke	0.0	10.66	0
Needle Coke	0.0	215.69	0
Other	1.4	72.88	106
Total	90.2	–	–
Revenue from Products		113.17	11,317
Gross Margin		(15.08)	(1,508)
Variable Costs (Excluding Fuel Use + Loss)		(1.20)	(120)
Net Margin (Loss)		(16.28)	(1,628)

Arpechim has slightly more limited access to the large Muntenia demand center than Petrotel or Petrobrazi. However, this logistical disadvantage is small (only 50 kilometers) and results in only very minor transportation disadvantages. On the other hand, Arpechim has a logistical advantage for delivering product to Banat and Transylvania via existing product pipelines.

At roughly 6.5 million tpy of processing capacity, Arpechim is one of the largest refineries in Romania. Arpechim has a small design disadvantage in that it does not possess a coking plant. Our projection of prices indicates that coking margins are attractive in Romania, and the lack of

this capability is a disadvantage. Arpechim's strength lies in the capabilities of its catalytic cracker. Catalytic crackers convert low-value fuel oil into high-value gasoline, and generally add more economic value than any other refining process unit. At 4.8 million tpy of capacity, Arpechim's catalytic cracking complex is the largest in Romania. This plant is by far the largest producer of high-octane (93.5 RON) gasoline components in the country and has the second highest gasoline yield (52 percent). The capabilities of Arpechim's catalytic cracking complex and its relatively strong logistical position combine to far outweigh its lack of coking facilities and make it one of the best performing refineries in our economic analysis.

To debottleneck the capacity of Arpechim's core refining units and to address tightening sulfur specifications, we recommend the following critical investments, totaling $48.5 million, at Arpechim:

- $3.7 million to enhance feedstock processing capabilities
- $3.1 million to revamp existing hydrotreating
- $10 million to revamp existing naphtha hydrotreating and debottleneck FCC capacity
- $14 million for new hydrotreating capacity
- $17.9 million for environmental projects

Like Petromidia, Arpechim suffers from many of the operational inefficiencies common to all Romanian processing plants. The refinery is constrained from optimizing its feedstock selection and product mix by the Rafirom-dominated central planning system. Staffing is excessive, advanced instrumentation is missing, and the operating paradigm is passive and risk-aversive. Consequently, the full capabilities of the in-place equipment are not achieved. As mentioned in the labor section, we recommend that Arpechim reduce its staffing levels from 8,056 employees to a total of 3,754 employees, plus 1,192 employees to be placed in separate contract maintenance companies.

3.5.3 Rafo

Rafo is set apart from the other refineries, being located in the northeastern corner of Romania. Like Arpechim, Rafo is an inland refinery designed to efficiently import crude oil and serve the Moldavia and Transylvania markets. The existing Conpet pipeline and similar pipelines for carrying crude oil from Moldavia oil fields provide Rafo with adequate access to both domestic and imported crude. Its only regional competitor is the smaller Darmanesti refinery. Like Arpechim and Petromidia, we project negative margins for toll processing at Rafo.

At 5.2 million tonnes per year of processing capacity, Rafo is an average large Romanian refinery. Its design and capabilities are similar to those of Petrotel. Rafo's core refining facilities are centered on average size and performance catalytic cracking and coking plants. To enhance its design strength, we recommend that the nearby Darmanesti refinery be consolidated

with Rafo, which will protect Darmanesti's needle coke facilities (the only such facilities in Romania) while trimming Darmanesti's marginal and redundant basic refining capacity. The integrated Rafo/Darmanesti plant performed well in our economic evaluations, aided by its logistical advantage in serving the Moldavia and Transylvania markets. However, our evaluation methodology did not compare Rafo directly to either Petrotel or Petrobrazi, as Rafo's logistical strengths were considered sufficiently great to retain it as a future refining center.

Rafo also suffers from many of the operational inefficiencies common to all Romanian processing plants, though somewhat less so. The refinery is constrained from optimizing its feedstock selection and product mix by the Rafirom-dominated supply and allocation monopoly. Staffing is excessive, advanced instrumentation is missing, and the operating paradigm (setpoints) is passive and risk-aversive. Consequently, the full capabilities of the equipment are not achieved. We recommend that Rafo reduce its staffing levels from 3,804 employees to a total of 1,982 employees plus 417 contract maintenance personnel.

3.5.4 Petrotel

Located in central Romania, near the Muntenia demand center, Petrotel is configured as yet another inland refinery. Petrotel is capable of receiving domestic oil produced regionally and imported oil through the Conpet pipeline system, and has adequate access to feedstock supply. Like all the other large refineries, there is virtually no possibility of employing Petrotel's capacity for toll processing.

Petrotel is ideally suited to serve the large Muntenia demand center, in competition with Petrobrazi and Arpechim. With the close proximity of these three large refineries, central Romania is the region where refining overcapacity is greatest. In fact, our analysis showed that there is no realistic possibility to economically keep more than one of these refineries operational given the projected levels of demand in the region.

In many ways, Petrotel typifies a large Romanian refinery. It possesses average-sized catalytic cracking and coking units, whose performance is inferior to the performance of the corresponding units of Arpechim, Petromidia, or Rafo. Petrotel is a large plant, with many units, some dating back to the inception of oil refining is central Europe. While this makes for proud tradition and rich heritage, in the arena of intense economic competition only superior technology and balanced operations will produce bottom-line results. Our economic evaluation determined that Petrotel's overall performance is inferior to that of Petromidia, Arpechim, or Rafo, not because of any single compelling flaw, but because of its lower performance across virtually all units and the lack of an offsetting and compelling advantage rendered Petrotel's position relatively weak economically as compared to the others.

Unlike the other large refineries, Petrotel has a significant lubricant operation that currently loses money but is potentially capable of profitable operation even if the refinery is closed. This lubricant plant processes about 240,000 tonnes of feedstock per year to produce about 60,000 tonnes of lube base stock and about 170,000 tonnes of other lubricant products. Although it is

very small in relation to the Petrotel refinery, this lube plant is an important producer within the small, but important, lubricant sector, accounting for about 25 percent of the lube base stock produced in Romania. As indicated in the lubricant section of this report, this lube plant is only marginally viable, and operates at breakeven on a variable-margin basis, losing money when fixed costs are taken into account. Because the lube plant is small relative to its associated refinery and only marginally viable, it creates no advantage for the Petrotel refinery. Furthermore, the lubricant operation provides no rationale for continued operation of the refinery because it is potentially capable of stand-alone operation. Therefore, these two issues, the operation of the refinery and of the lube plant, should be evaluated independently of one another.

3.5.5 Petrobrazi

Like Petrotel, Petrobrazi is located in the intensely competitive central region of the country. It has similar access to domestic and international feedstocks, and virtually identical access to domestic markets. Once again, losses on toll processing will prevent this capacity from being employed for toll processing.

Unlike Petrotel, Petrobrazi has core refining facilities whose performance is below that of the other large refineries. Petrobrazi does have a large petrochemical complex. However, as explained in Section 5 of this report, this complex is not economically viable, and should be closed even if the Petrobrazi refinery remains operational despite our recommendation to close it. Unfortunately, the combined effects of below-average performance of both the refining and petrochemical facilities makes Petrobrazi the poorest economic performer of the five large Romanian refineries.

3.5.6 Small Refineries

We did not directly evaluate any of the five smaller refineries during this study, but an overview of the existing facilities indicates that they lack sufficient scale and use less-advanced technology relative to all of the large refineries. For this study, we assumed that most of the small refineries would be decommissioned. The exceptions are Darmanesti (mentioned above together with Rafo), Petrolsub, and Astra.

Petrolsub is remotely located in the far northwest corner of Romania, and is fed solely from an oil field producing crude oil by in-situ combustion. This oilfield and Petrolsub form an integrated unit, as neither is capable of operating independently of the other. We have assumed that the combined economics of both plants were positive (although we did not validate this assumption). In addition, we assumed that Astra had marginally profitable operations due to its unique capabilities to manufacture lubricants from the regionally produced naphthenic crude oils. Accordingly, we adjusted downward both the domestic demand requirements and the domestic crude oil production projections available to the large refineries for all periods by roughly 1 million tonnes to reflect continued minimal operations at Astra and Petrolsub.

Section 4

Refinery Sector Modeling Approach

4.1 COMPUTER MODELING OVERVIEW

This section describes the computer modeling process employed to evaluate the decommissioning economics for the five large refineries. A four-stage modeling process was employed, as depicted in Figure 4-1. The stages were as follows:

- Data preparation and file research
- Development of scenarios
- PIMS least-variable-cost evaluations
- Comprehensive economic evaluations

The modeling framework evaluated results during three time periods, as follows:

- 1995 – representing the current reality within Romania
- 2000 – representing a horizon for short-term change
- 2005 – representing a horizon for long-term change

Section 4.1.1 describes how model data were gathered and verified to filter out distortions and improve consistency. After this stage had been completed, a valid set of modeling data was produced. Sections 4.1.2 and 4.1.3 describe an iterative process whereby the scenarios were developed for running each model. This approach capitalized on the capabilities of the PIMS software to improve the overall result. At the completion of these stages, least cost optimization results based on variable costs were produced. Section 4.1.4 describes the process whereby the additional data (e.g., fixed costs) were introduced to fully describe the economic results of the modeling effort.

4.1.1 Data Preparation and Field Research

Data for the evaluation came from three sources:

- Romanian sources, including the refineries, PetroTrans, and PECO
- The petrochemical evaluation in Section 5 and the lubricants economic evaluation in Section 6
- A study of the international market for crude oil and oil products in Section 2

The management of the Romanian refineries supplied data on the configuration of the refineries and details on the technical and economic performance of individual units. To assist these managers, a pro-forma questionnaire was prepared and discussed with each management team during a first visit to the refineries. At a second visit, the data that had been prepared by the

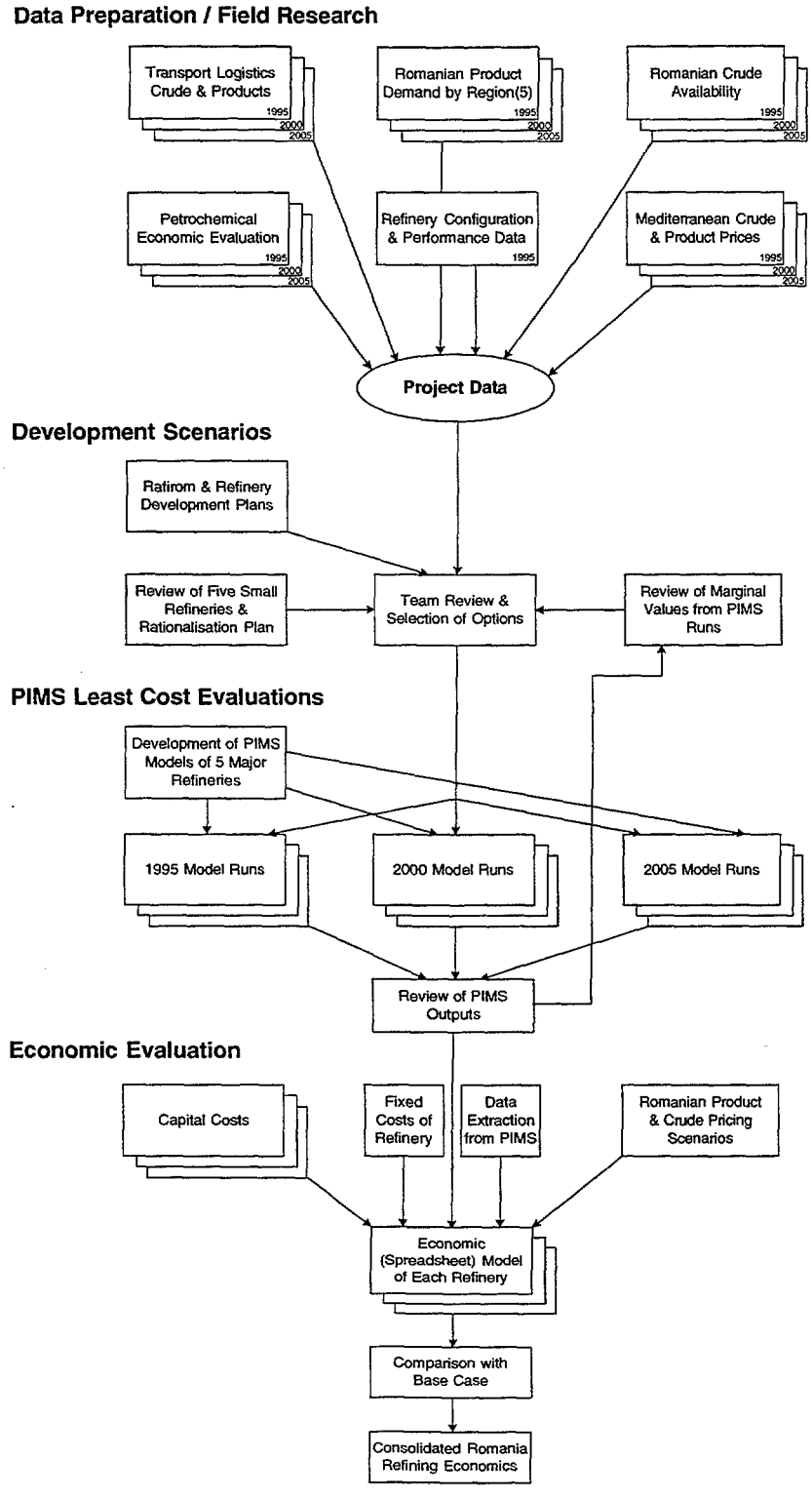

Figure 4-1 Refinery Rationalization Study and Evaluation Schematic

refineries were collected and discussed with the refinery management teams to ensure that they were consistent and accurate. Samples of the questionnaires have been included in the Appendix along with summaries of the key data provided by the refineries.

Data on the availability of Romanian crude oils, both now and in the future, were also collected from Rafirom and the refineries. Romanian crude oils are not currently traded on the world market, since all are consumed within country. As a consequence, no data on the analysis of the various Romanian crude oils were available in the forms used for internationally traded oils. The team undertook some additional modeling work to characterize the physical properties of these crude oils based on the actual product slate achieved from processing them. This work is described below. Data on the price paid for Romanian crude oils were also obtained, and some modeling work was undertaken to determine the value of these crudes to the Romanian refineries. As discussed elsewhere in this report, the parameters describing the costs and constraints on the transportation of crude oil and products to and from the refineries were also determined.

Romanian domestic demand for refined products was also obtained. A major driving force for the efficient utilization of the Romanian refineries was the matching of refinery capability to the available market on a regional basis. An estimate of the transport cost of each refinery serving each region of Romania was used to determine the optimum configuration for the refining industry in Romania. This estimate was based on breaking down Romanian product demand into five major regions and deriving the cost of moving product to the center of each market from each refinery.

The economics of the petrochemical industry and the lubricants industry in Romania are discussed in Sections 5 and 6. Where a demand for feedstock was identified, the quantity and the maximum price that the petrochemical industry could sustain was calculated as part of the petrochemical assessment. Similarly, for by-products from the petrochemical complexes that were returned to the refineries, the quantity available was calculated, together with the minimum price that the petrochemical industry could sustain. This technique ensured that any excess value added was credited back to the refining industry, rather than to the petrochemical industry, and prevented the latter from shutting down profitable petrochemical facilities. The PIMS model permitted the purchase of these feedstocks from the world market at appropriate prices, if this was more economically efficient than supply from the Romanian refineries.

Prices for imported crude oils and products traded on the world market were obtained from Bonner & Moore (see Section 2). All the prices used in the evaluation were based on Mediterranean price levels and were adjusted for the cost of sea freight to Romania via the Black Sea and for overland transport to the appropriate refinery or region.

4.1.2 Development of Scenarios

The second stage in the evaluation process was to develop the scenarios under which the models were to be tested. One basis for this evaluation was the data provided by Rafirom and the

refineries on their identified development plans. These were screened and the relevant aspects incorporated into the evaluation.

The five smaller refineries are not significant in relation to the total refining industry in Romania. Therefore, they were evaluated outside the main economic modeling effort. One exception was made for the Darmanesti refinery. Darmanesti produces needle coke, which attracts a high price. We have suggested that Darmanesti could be more closely integrated with the Rafo refinery, and for this reason it was modeled as an integral part of Rafo.

The primary method of developing scenarios for more detailed evaluation was to utilize the powerful marginal value reporting facility built into the PIMS Linear Programming Modeling software. For every solution determined by PIMS, in addition to reporting the details of the solution found, the program also reports the marginal value of relaxing every constraint that the model is limited by. For example, if the hydrotreater was fully utilized, then PIMS would report the increase in gross margin that could be obtained by increasing the capacity of the hydrotreater by one unit of capacity (usually 1 tonne). By scanning the marginal values reported by PIMS, one can easily identify the constraints limiting performance and the constraints that offer the higher increases in gross margin in exchange for relaxing them. The scenarios to be evaluated could then be simply developed from the process units that appeared to be constraining earlier PIMS optimizations.

4.1.3 PIMS Least Cost Evaluations

The core of the rationalization study was the least cost evaluation of the refineries using the PIMS linear programming software. Refineries are very complex units that are capable of making a wide variety of products from a range of different feedstocks using a combination of different processing units. It is widely recognized that the economic optimum refinery operational plan for a given set of market demands and prices can be determined only by linear programming techniques. PIMS is the market leader in linear programming software for the refining industry worldwide and is used by refineries, oil traders, and consultants. PIMS has a number of different capabilities in addition to the standard linear programming optimization of a refinery; these include the ability to handle more than one refinery and to plan the optimum usage of the refineries, given the limitations of each plant, and any transport cost penalties. The philosophy behind the evaluation was to optimize the economic utilization of the available refinery capacity at the five major refineries, based on the following assumptions:

- A fixed quantity of Romanian crude oil is available and will be used only domestically, but an unlimited quantity of imported crude oil is available at international prices. (It is assumed that the economics of transporting Romanian crude out and replacing it with imported crude will always ensure that Romanian crude is consumed preferentially in domestic refineries.)
- In any one year, there is a fixed demand for products in Romania, and this demand can be met either from the domestic refineries or from imports of products, which

must be paid for at international prices. Similarly, products produced in Romania can be exported to the international market at similar prices.

- Costs, such as wages, maintenance, and capital expenditure, are fixed and therefore not relevant to the variable-cost optimization. (Fixed costs are incorporated later in the economic model after completion of the variable-cost optimization.)

In the scenarios described above, PIMS was run without either domestic crude prices or prices for products sold on the domestic market. Since the quantity of both of these are fixed, inclusion of a price for them does not affect the variable cost optimization. Using this technique avoids prejudging the value of the Romanian crude oils, which are not traded internationally and also avoids the problems of domestic product prices, which are currently not in alignment with market prices.

In most cases, three sets of PIMS models were completed for each scenario, one model using the data appropriate for 1995, one for 2000, and one for 2005. Each of the PIMS models was identified by a unique run number. The results of the PIMS models are the optimum for an average day in each of the years; i.e., all quantities reported in PIMS are per operating day.

4.1.4 Economic Evaluation

The PIMS optimization provides only the least-variable-cost solution to a given scenario with all fixed costs disregarded. To evaluate the overall economic and cash position of the refineries and to determine the optimum when the fixed costs are included, a spreadsheet economic model was constructed of each refinery. This model extracted data from the relevant PIMS solutions. The model consisted of five separate refinery cash flow models, each of which consisted of a comparison between a base case and a new case. The comparison allows the improvement produced by the new case (e.g., generated by some new investment in process units) to be clearly identified.

The economic model calculates year-by-year profitability for each refinery by including fixed costs, capital expenditures, pricing scenarios for domestic product markets, and pricing scenarios for domestic crude. The model reports the net present value (NPV) of the projected year-by-year profitabilities for each refinery for the base case, new case, and comparison. It also reports the overall NPV for all refineries.

4.2 DATA PREPARATION, FIELD RESEARCH, AND EVALUATION PROCEDURE

The approaches and methodologies for the data preparation, field research, and evaluation procedure are discussed below.

4.2.1 Transport Logistics and Costs

All five refineries receive imported crude oil from Constanta by pipeline. Crude reaches this pipeline from either Black Sea locations (e.g., Russian crude oil) or the Mediterranean. As all prices used by the model are based on Mediterranean price levels, additional ocean freight is payable on most crudes that must be brought from the Mediterranean to Romania. However, since Urals will be shipped direct from Black Sea port, the Mediterranean price for Urals crude has been reduced by the net difference between the ocean freight cost from a Russian Black Sea port to the Mediterranean and the ocean freight from a Russian Black Sea port to Constanta.

Domestic supplies of crude oil are received from a number of central collection terminals. To simplify the analysis, the following assumptions were made:

- For the Moldova District, the major terminal is near the refinery at Rafo. Transport costs are based on the distance from Rafo to the other refineries.
- For Black Sea crude, the transport costs are from the port of Constanta.
- The crude oil in the Muntenia District has been centralized between the three refineries: Arpechim, Petrobrazi, and Petrotel.

No financial differences were assumed between pipeline and rail transportation of crude of refined product. A single, zone-based flat rate is used for both by PetroTrans, and the fundamental underlying cost buildups for pipeline or rail are not known to them. To obtain a common distance-based tariff useful in modeling the comparative logistical advantages of the refineries, the Romanian National Railroad (RNC) tariffs were used as a proxy. RNC tariffs provide the only bulk transport competition to PetroTrans and are the price umbrella under which PetroTrans tariffs are set. Cross comparisons with sample Ukraine, Western European, and U.S. rates indicate that this transport cost model is reasonable.

Products are transferred to the domestic markets almost entirely by rail. For export, products are transferred by pipeline to the terminal at Constanta and then proceed by ship. Ocean freight charges are set by product type, being differentiated into white, black, and solid product.

It is assumed that transport costs are maintained constant in real terms over the period of study; i.e., transport costs will rise only in alignment with general inflation, which is excluded from the economic models.

4.2.2 Romanian Product Demand by Region

Romanian domestic demand for refined products was obtained. The data are presented in Section 4.5.

4.2.3 Crude Availability

Each refinery was asked to complete forms describing the feed and product slate for 1994. For each blended product, forms were supplied to define product specifications. The refinery definition of the feed slate provided a reasonable description of the distribution of imported crude feeds. The assays for these imported crudes were taken from the BP crude assay library available with PIMS. It is not known how accurate this allocation of imported crudes supplied by the Romanian refineries was or whether the PIMS assay library adequately described the blend supplied. One refinery stated that the crude feed description supplied by the Constanta oil terminal for imported crudes produced yields from the crude tower that disagreed with those predicted by the BP assay library. This difference may be due to operational difficulties with the crude supply or in the refinery.

The refineries had very little information on the Romanian crudes refined. The crudes were differentiated into land and marine types. Four sets of assay data including a limited description of each crude were supplied by Rafirom from the Research Institute for Petroleum Processing and Petrochemistry S.A. (ICERP) for the land-based crudes. These data were assumed to represent crudes available in the Muntenia and Moldavia regions. For the land-based crudes, no clear definition of the crude assays refined at each refinery could be determined. For the Black Sea crude, the assay was supplied by Petrotel refinery, the major refiner of this crude in 1994. Again, this assay did not give detailed information. To complete the gaps in this information, this assay information for the crudes was overwritten onto PIMS library crude packs for international crudes similar to the Romanian crudes.

The distribution of total Romanian domestic crude production from the three major oil producing districts to the five larger refineries was as follows (figures were supplied by Rafirom):

	wt%
▪ Muntenia	77.6
▪ Moldova	11.1
▪ Black Sea	11.3

These numbers do not reflect crude produced by the fireflood operation in the Surplacu District. For the purpose of this study, this crude is assumed to be refined in the local refinery for the production of bitumen and gas oils and is excluded from the modeling process. The total domestic crude production available for the five larger refineries was set at 5.5 million tpy.

The product information on the 1994 refinery operation varied, depending on the refinery. Product specifications were generally consistent from all refineries and for the modeling were identical. A PIMS global model of the refineries was constructed with the above information. When domestic crude feed rates to a refinery were known, these were applied. It was further assumed that Muntenian crudes were delivered to Petrobrazi and Petrotel and Moldova crudes fed to Rafo and Darmanesti (which was combined with Rafo). The information supplied by Arpechim and Petromidia indicated that they refined predominantly imported crudes in 1994.

This PIMS model determined the blend of crudes from the assays supplied to satisfy the product requirements; i.e., the model determined the quantities of each Romanian crude oil that must have been available to produce the mix of products specified at each refinery. Once run, the distribution of domestic crudes by region and their assay was fixed for the period of the study, that is 1995 to 2005. The structure of the PIMS model for this determination of domestic crude assays is shown in Figure 4-2.

The 1994 PIMS model was rerun with the global supply of crudes fixed, but the allocation to individual refineries free. The model optimized the allocation of crudes to suit the fixed product slate at each refinery. This gave an indication of the value of using PIMS in a multirefinery operation. If the refinery gate products had been known by region, this information could have been incorporated in the model, thereby providing greater savings.

4.3 DEVELOPMENT SCENARIOS

4.3.1 Rafirom and Refinery Development Plans

Table 4-1 presents the development plan for the refineries described in the Rafirom report "Investment Projects," dated May 1995. The list does not include purely environmental and petrochemical investment projects.

Current and future market demand for gasolines can be met with the existing refineries; hence, there is no economic rationale for revamping FCC and reformer units to increase gasoline production. Current PIMS work has shown the Petromidia FCC revamping to be worthwhile, as the present FCC unit represents a major bottleneck and revamping provides opportunities for product export. There is also no clear reason for revamping other upgrading units such as the alkylation unit and coker at Petrotel, since both of these units increase distillates production, which is in excess, and reduce fuel oil production, which is in deficit.

Crude and vacuum towers at all sites require revamping to enhance product quality, but not to increase capacity. Likewise, gas desulfurization and sulfur recovery units at all sites require either revamping or rebuilding. These units are currently inefficient and impose a huge drain on site utilities.

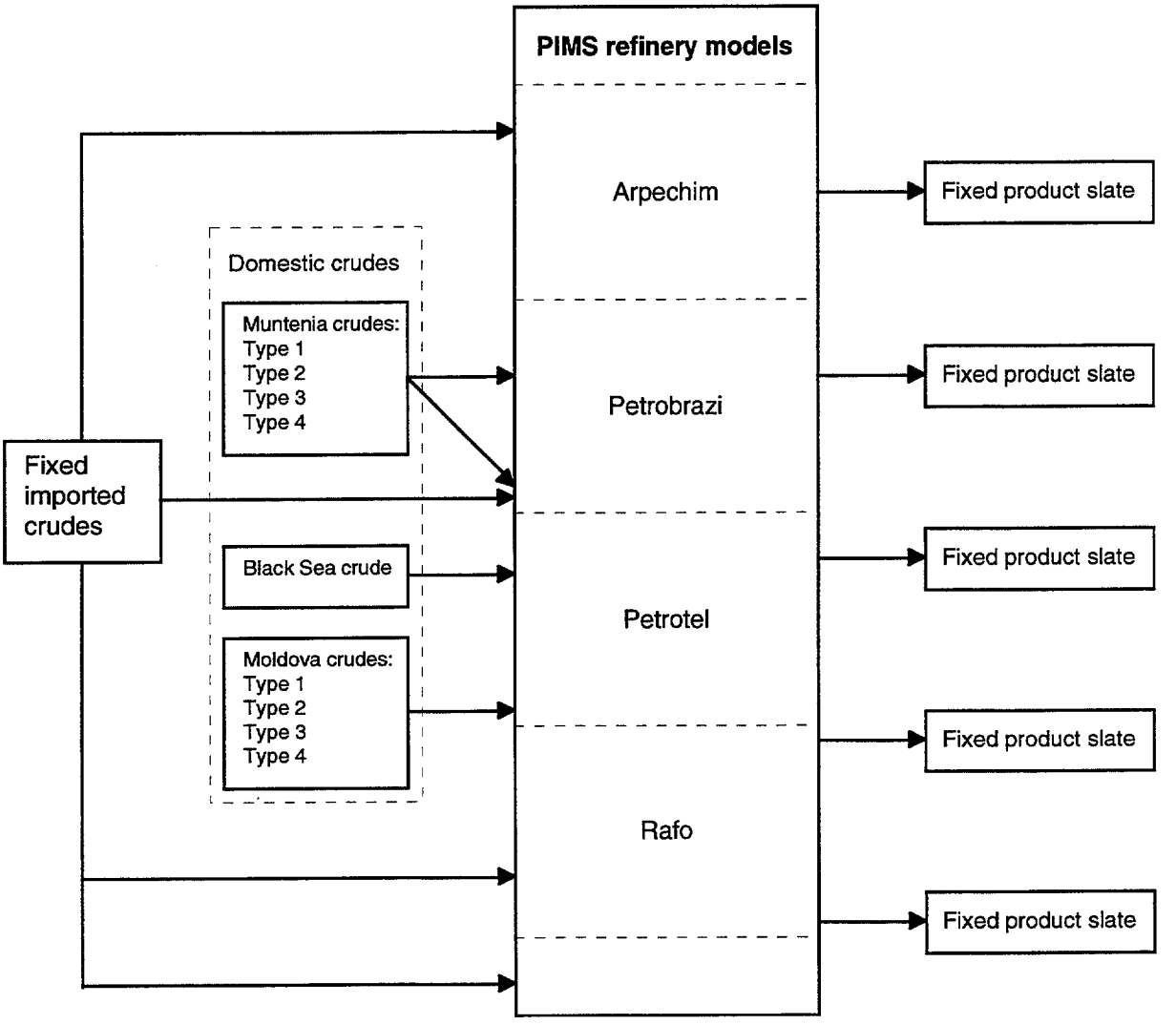

Figure 4-2 Determination of Domestic Crude Assays

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Table 4-1 Rafirom Proposed Investment Projects

Refinery	Proposed Project	Description
Arpechim	Revamp crude oil distillation unit (DAV2)	Increase capacity from 3.5 to 4.85 x 10^6 tpy and improve heat exchange network
	Revamp visbreaker (RV2)	Increase capacity from 0.6 to 0.8 x 10^6 tpy and improve utility consumption
	Revamp FCC	Reduce catalyst loss, improve regeneration, and add turbo expander to generate electric power
	Revamp lube oil production	Reduce dependence on crude type, improve blending, and finish plant
Petrobrazi	Revamp CDU and VDU No. 2 (DAV2)	Increase capacity from 3.8 to 5.0 x 10^6 tpy and improve heat exchange network
	Revamp FCC	Increase capacity from 1.1 to 1.5 x 10^6 tpy, allow heavier feed, and revamp reaction/regeneration section
Petromidia	Revamp gas oil hydrofining	Improve catalyst, increase capacity from 0.69 to 0.83 x 10^6 tpy, and improve heat exchange network
	Revamp catalytic reforming	Install new reactor and furnace, improve heat exchange network, improve automation, and replace catalyst
	Revamp gas desulfurization, SRU, and sour water stripper	Replace catalyst and improve Claus plant
Petrotel	Revamp catalytic reforming	Modify CCR to improve yield, quality of reformate. Replace catalyst. The project aims to increase RON from 91 to 97 and yield by 32 x 10^3 tpy. Hydrogen yield will rise by 6 x 10^3 tpy
	Revamp FCC	Reactor/regeneration upgrade, including metallurgy, riser extension, catalyst stripping, and cyclone improvement. Aim to increase gasoline yield by 157 x 10^3 tpy and RON by 1.5 units, improve conversion (min. 77%) and utility consumption
	Revamp HF alkylation plant	Rebuild unit, improve alkylate yield, and reduce utilities
	Revamp delayed coker	Improve plant metallurgy and redesign for maximum heat recovery to feed. Add automation and safety equipment. Better suited for higher sulfur crude feeds
	Revamp gas desulfurization and SRU	Purify amine solution and add closed system collection for leaks. Renew catalyst and install H_2S/SO_2 analyzer for SRU flue gas. Improve liquid sulfur degasing, storage, and transport from flue gas after SRU treatment
Rafo	Revamp medium-pressure catalytic reformer (RC_2)	Replace reactor and catalyst, improve reactor volume, and reduce catalyst residence time, increasing yield. Add sulfur guard bed prior to unit and replace naphtha hydrofining catalyst upstream. This should improve RON to 95 and H_2 yield
	Revamp FCC (CC_3)	Modernize reactor/regenerator cyclones, riser inlet system, air distribution in regenerator, and stripper-riser end assembly. Renew catalyst. The aim is to improve gasoline yield by 25,000 tpy and RON and increase petrochemical feed by 4.9 x 10^3 tpy

Note: This table does not include environmental projects (e.g., water treatment revamps) and petrochemical projects unless they affect refinery operation (e.g., sulfur plant revamps).

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4.3.2 Review and Rationalization of Five Smaller Refineries

An analysis of the five smaller refineries – Petrolsub, Darmanesti, Astra, Vega, and Steaua Romana – is presented below, along with a rationalization strategy for each refinery.

4.3.2.1 Petrolsub

The Surplacu refinery is in northwest Romania and is isolated from the rest of the industry. It processes locally derived oil produced by a system termed fireflood. The refinery and associated production facilities are considered a single unit. The fireflood operation produces about 500,000 tpy of oil, nearly all of which is processed at the nearby refinery. In the past, some of this oil was transferred to the Darmanesti refinery.

The fireflood operation in simplified form is shown in Figure 4-3.

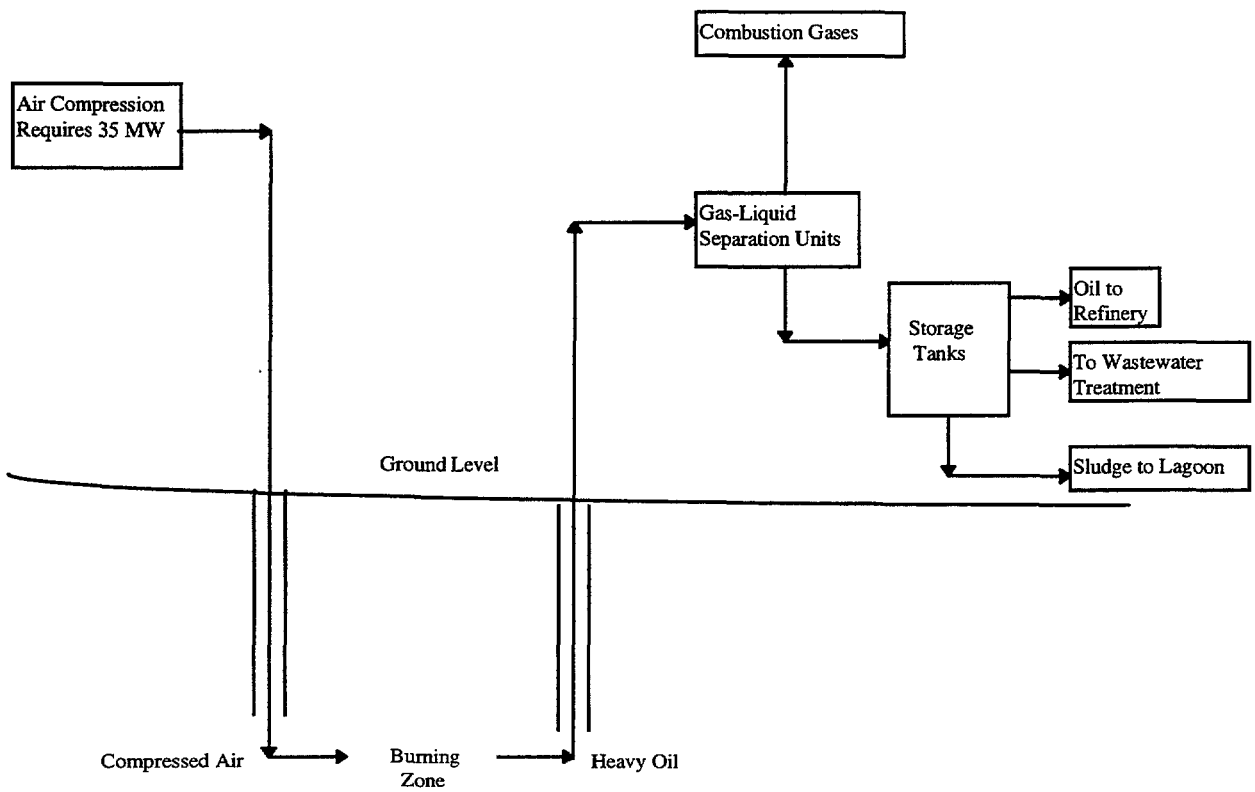

Figure 4-3 Schematic Fireflood Oil Field

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The air compression system provides air at 18 bar pressure using about 80 compressors. The total electric power consumption by the site is 40 MW, of which 85 percent is used in this primary stage. After compression, the air is forced into the ground via downpipes, which can extend up to 200 meters. The air feeds the burning zone, and the rate of supply determines the rate of oil production. The combustion process cracks some of the oil residue held in the porous rock structure, which, together with the heat of combustion, causes the oil to flow up the production well.

The heavy oil produced includes combustion gases and is therefore sent to a series of separators. The combustion gases (carbon monoxide, dioxide, etc.) are emitted to the atmosphere while the heavy oil product is sent to storage tanks. In these tanks, the oil settles and separates into three products: the heavy oil is sent to the refinery, the water is sent to the wastewater treatment plant, and the sludge goes to a lagoon. After treatment, the water enters the local water system.

The oil from this fireflood process is suitable only for the manufacture of heavier products such as bitumen and fuel oils. The refinery in simple block flow format is shown in Figure 4-4.

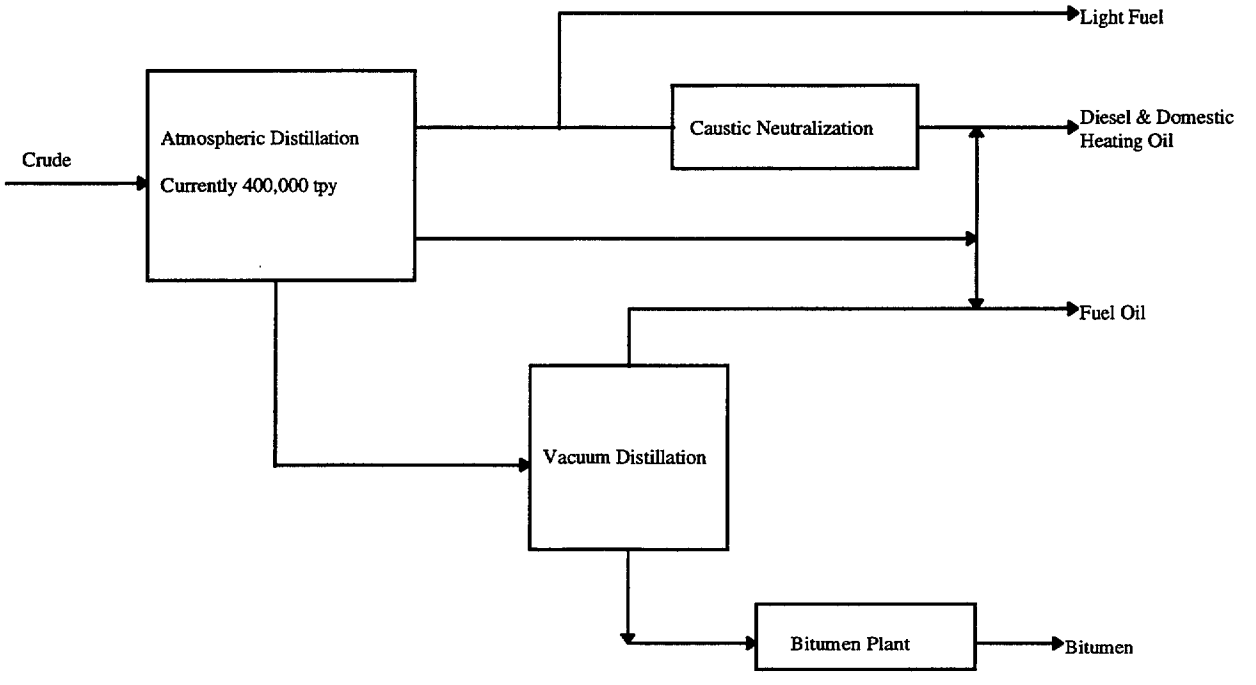

Figure 4-4 Schematic of Petrolsub Refinery

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The crude supplied to the refinery enters the atmospheric distillation unit, which produces straight run products for sales as fuel oil, diesel, and heating oil. Prior to export, the diesel and heating oil are treated by caustic washing. The atmospheric residue that forms over 60 wt% of the crude entering the refinery is sent to the vacuum distillation unit. The distillate either feeds the refinery boiler system or is exported to RENEL for power production. The vacuum residue that comprises 50 wt% of the original crude feed is passed to the bitumen plant.

The refinery and oil production facility are assumed to form a single operating unit and to continue in operation for the period of the study.

4.3.2.2 Darmanesti

The Darmanesti refinery is located in the north of Romania in the Moldavia District. Its major product of value is needle coke. The refinery model for the production of needle coke has been included in the PIMS model, with the exception of the gas streams. A simplified block flow diagram is shown in Figure 4-5.

It is assumed that Darmanesti continues to operate on its present site producing the needle coke, with the liquid products (naphtha, diesel, and fuel oils) being sent to Rafo for final processing and blending to refinery-gate products, and the gases being used in the refinery fuel system.

4.3.2.3 Astra

The Astra refinery is located in Ploiesti. It is predominantly a lubes refinery and is assumed to remain a lubes refinery after restructuring. The major change to the operation will be that it will no longer refine crude oil but will receive from Petrotel atmospheric residue or vacuum gas oil for the production of lubes. The refinery structure is indicated in Figure 4-6.

4.3.2.4 Vega and Steaua Romana

Vega is a small refinery, also located in Ploiesti. It has many standard refinery units, together with a catalyst manufacturing unit. The current study considers the refinery to have no special features that would enable it to operate at an advantage over the larger sites. The refinery is not likely to produce a positive cash margin. Therefore, it is not considered economic to continue the operation, and its crude has been allocated to the other refineries.

Steaua Romana is located to the north of Ploiesti, in Cimpina, far from the main crude producing regions and the markets. The refinery produces a wide variety of lube oil products. Although there is a long-standing tradition of refining in this location, it is not considered economic to continue the operation of this small unit.

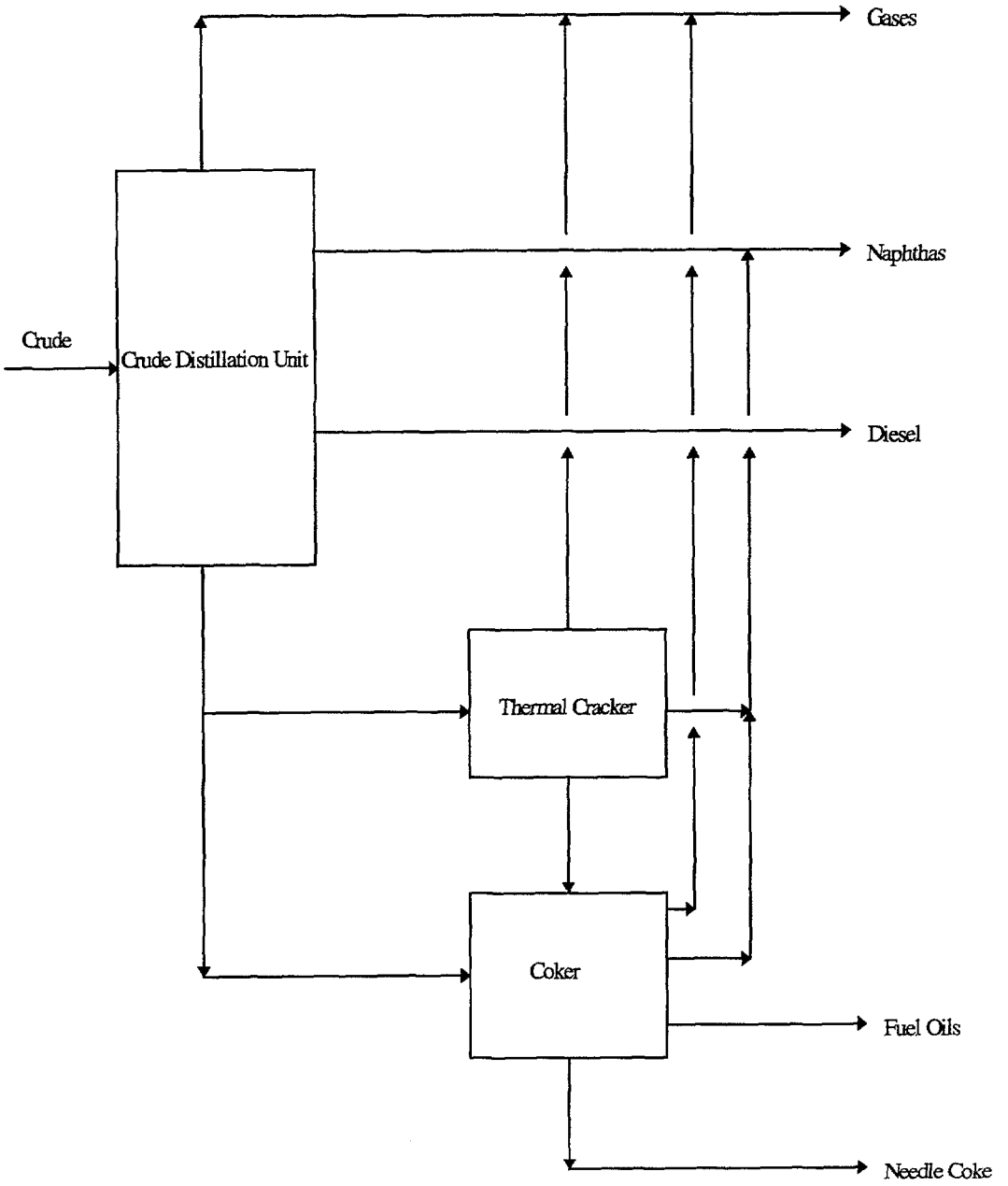

Figure 4-5 Schematic of Darmanesti Refinery

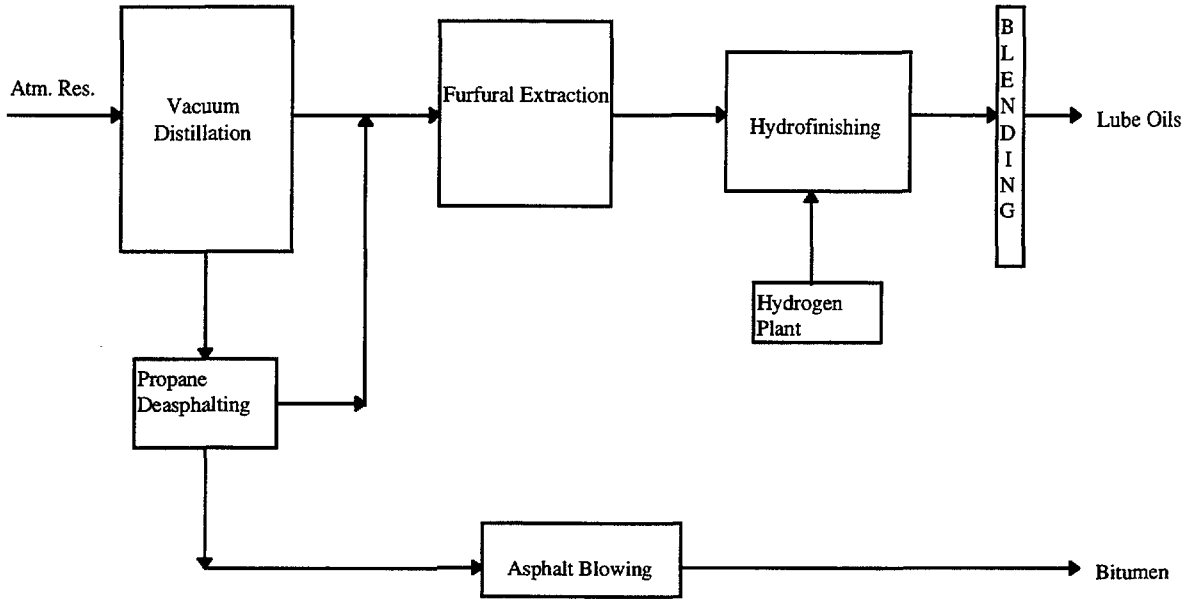

Figure 4-6 Schematic of Astra Refinery

4.4 PIMS LEAST COST EVALUATION – LARGE REFINERIES

4.4.1 Development of PIMS Models of Five Major Refineries

Stand-alone PIMS models of each of the five major refineries were built, with their operating capacities producing maximum yield for the units on site. Fuel, electric power, and steam usage were limited to the feed rate. Following that, the multiplant PIMS model linked the refineries to the domestic and export markets. The shipping costs between the refineries and the markets were set for both refinery feeds and products.

The yields from the crude and vacuum towers were determined from the blend of crudes feeding the units and the column cut points. For each crude feed, the assay provided information on the properties of the side-draws. These properties were blended to determine the overall stream properties. Where two crude trains are operational, crudes were restricted if one of the columns was identified as suitable for low-sulfur feeds only.

Downstream unit yields were defined relative to a typical feed composition. For hydrotreaters, visbreakers, and the FCC units, the yield was modified as a result of feed sulfur. For the reformers, the yield was modified by the naphthenes and aromatics content of the feed. The

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delayed coker yields were modified by the feed sulfur and concarbon content. Product properties (e.g., specific gravity, sulfur wt%) were determined mainly from the blended feed properties.

Where petrochemical complexes were linked to refineries, the feeds were allowed from both the associated refinery and other domestic refineries. The petrochemical by-products were returned to the associated refinery or shipped to other refineries for blending to final products. Transport costs were applied to both the feedstocks and by-product transfers. The maximum yield of by-products from the petrochemical complexes was based on the total feed to the complex. The total flow of by-products to the refineries did not have to equal the maximum yield. If the refineries found it economic to use a smaller amount of petrochemical by-products they could do so, with the surplus assumed to be exported. Exported petrochemical by-products were not modeled.

No refinery was required to remain operational to support a market or associated petrochemical complex. The only global assumption was the requirement that the domestic crude production, currently processed by the five major refineries, continue over the time period under study. The allocation of crude to the individual refineries was determined by PIMS such that sector-wide refining costs were minimized. The price of domestic crudes was therefore not required since the tonnage of each was fixed and their allocation determined by refinery unit efficiency and market demand for products.

The international market supplied imported crude at Mediterranean prices to which transport costs were added to give crude prices at the refinery gate. Thus, for refineries near the Constanta oil terminal, imported crude prices at the refinery gate were lower as a result of the lower inland transport costs. The international market was assumed to be able to supply products to the domestic markets. Again, these were Mediterranean-priced products to which transport costs were added.

The domestic market was divided into five regions centered on the Banat, Moldavia, Transylvania, Dobrogea, and Muntenia districts. For each of these regions, the demand for the refinery gate products was specified. This product demand was fixed and had to be satisfied either from the refineries or from the international market. For each refinery, transport costs to deliver the products to the regional markets were applied and depended upon the distance of the refinery to the perceived center of the regional market. The specifications for the standard products for the domestic market with fixed demands are shown in Table 4-2.

Table 4-2 Romania Product Specifications

Item	Major Product Specifications		
LPG Gasoline			
Unleaded RON 87	max. SPG 0.76	max. 1 wt% S	min. RON 87
Leaded RON 87	max. SPG 0.76		min. RON 87
Unleaded RON 95	max. SPG 0.76		min. RON 95
Leaded RON 95	max. SPG 0.76		min. RON 95
Dual-Purpose Kerosene (DPK)	max. SPG 0.825		min. smoke 20 mm
Diesel			
0.20 wt% S	max. SPG 0.825	max. 0.2 wt% S	min. cetane 45
0.05 wt% S	max. SPG 0.85	max. 0.05 wt% S	min. cetane 45
Fuel Oil			
Low-sulfur	max. SPG 0.935	max. 1 wt% S	
High-sulfur	max. SPG 0.935	max. 3.5 wt% S	
Bitumen Coke			
Needle			
Anode		max. 1 wt% S	
Fuel		max. 5.5 wt% S	

Note: Product of the Darmanesti refinery incorporated into the Rafo refinery model

Because product demands in each region were fixed for each time period modeled, there was no requirement to incorporate domestic product prices in this model. PIMS determined which source (refinery or international market) could supply the product at the least cost. Each product in each region could be supplied from any combination of refineries and the international market.

Lube oil products, because they were produced at only two refineries, were not given a fixed demand – a price based on the international market price was used. If demand had been fixed, then the model could have been distorted, since it would have required either or both of these refineries to operate.

The refinery schematics are illustrated in Figures 4-7 through 4-11. For the purpose of simplicity, not all blending and processing options are shown. Only those units that affect product yield and quality were modeled. Furthermore, only those units currently operational or due to be fully commissioned and operating towards the end of 1995 were considered. Units that were to begin commissioning tests leading into 1996 were not modeled.

A more detailed description of the refinery model is included in the Appendix.

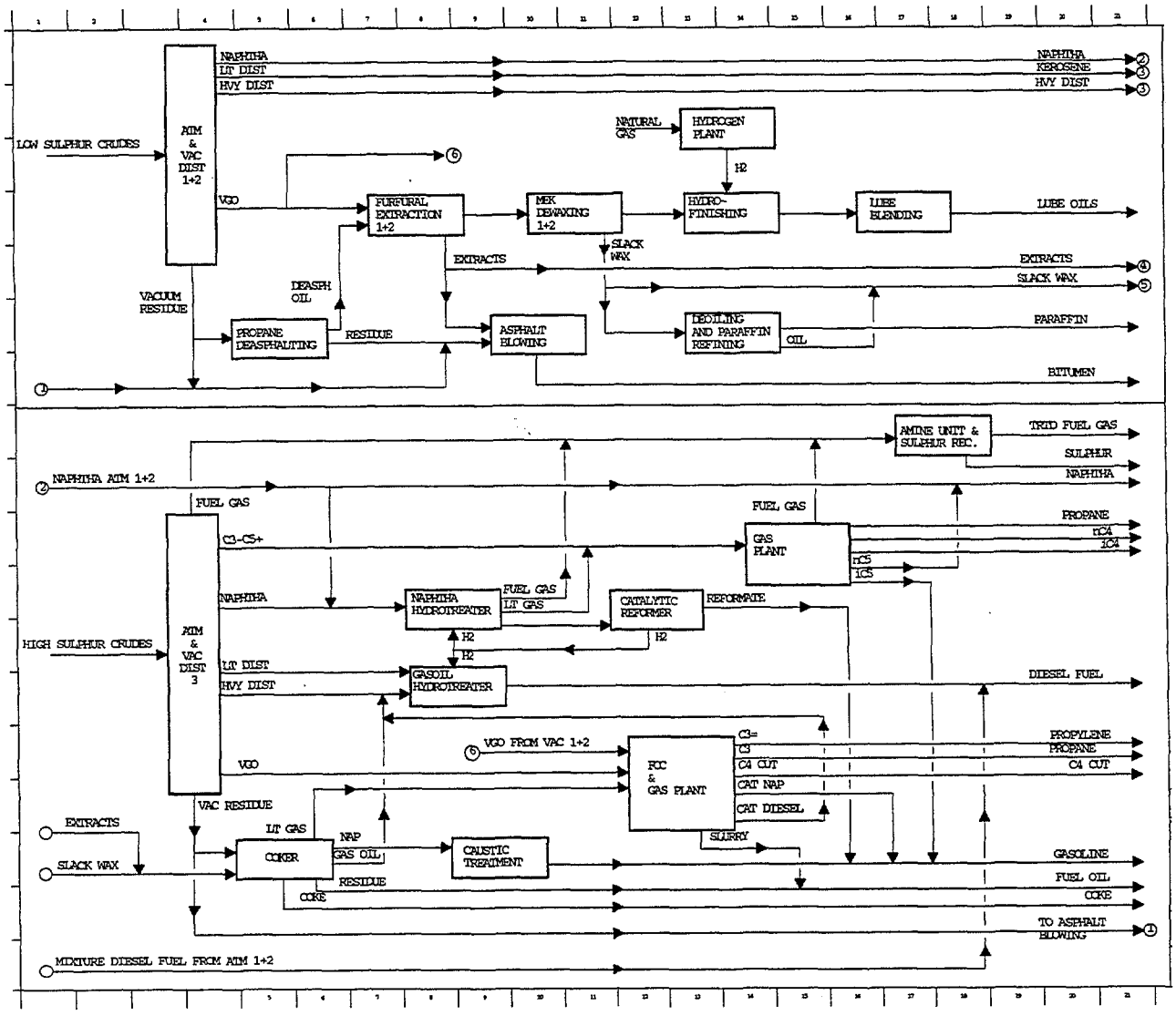

Figure 4-7 Petrotel Process Flow Diagram

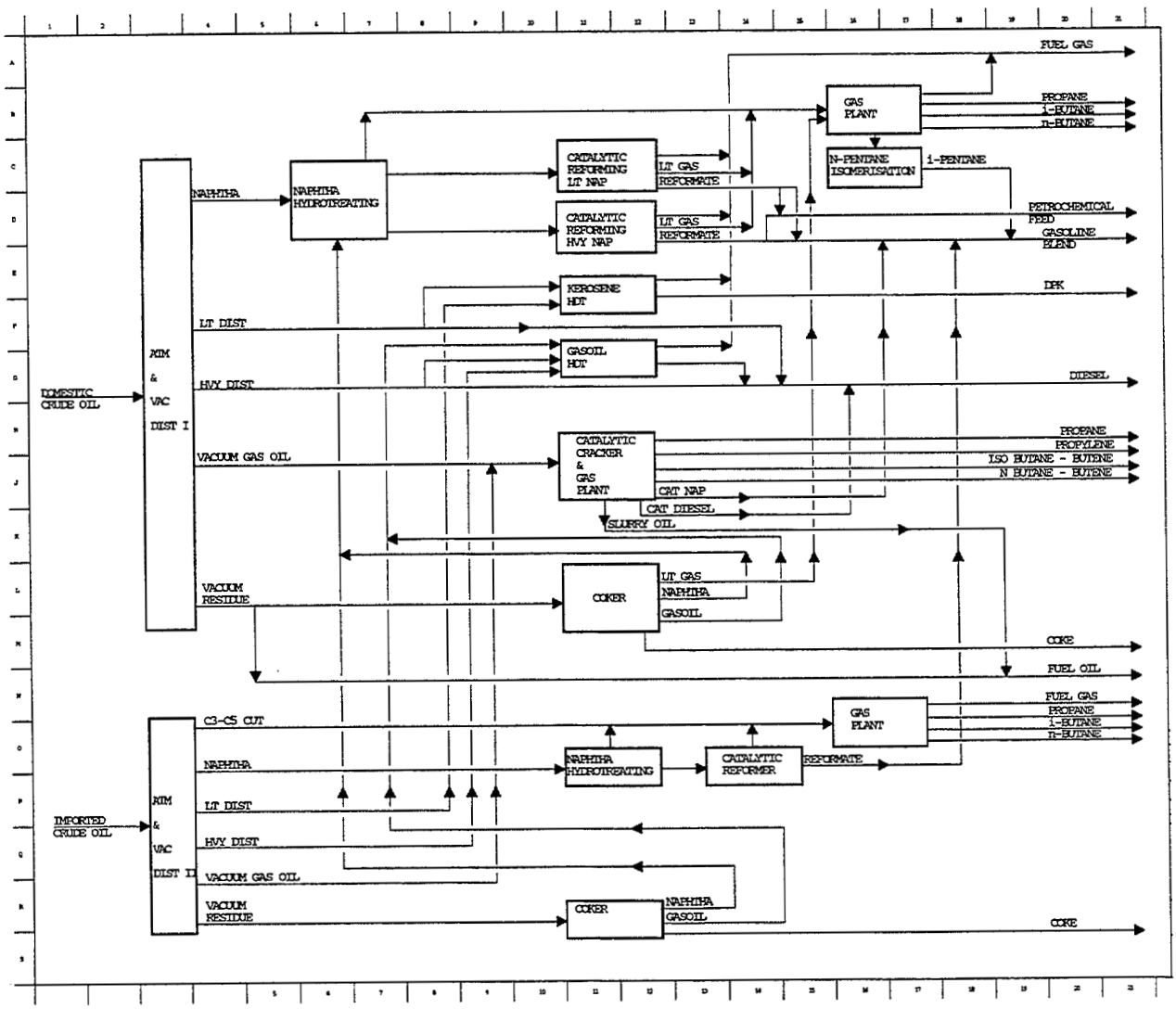

Figure 4-8 Petrobrazi Process Flow Diagram

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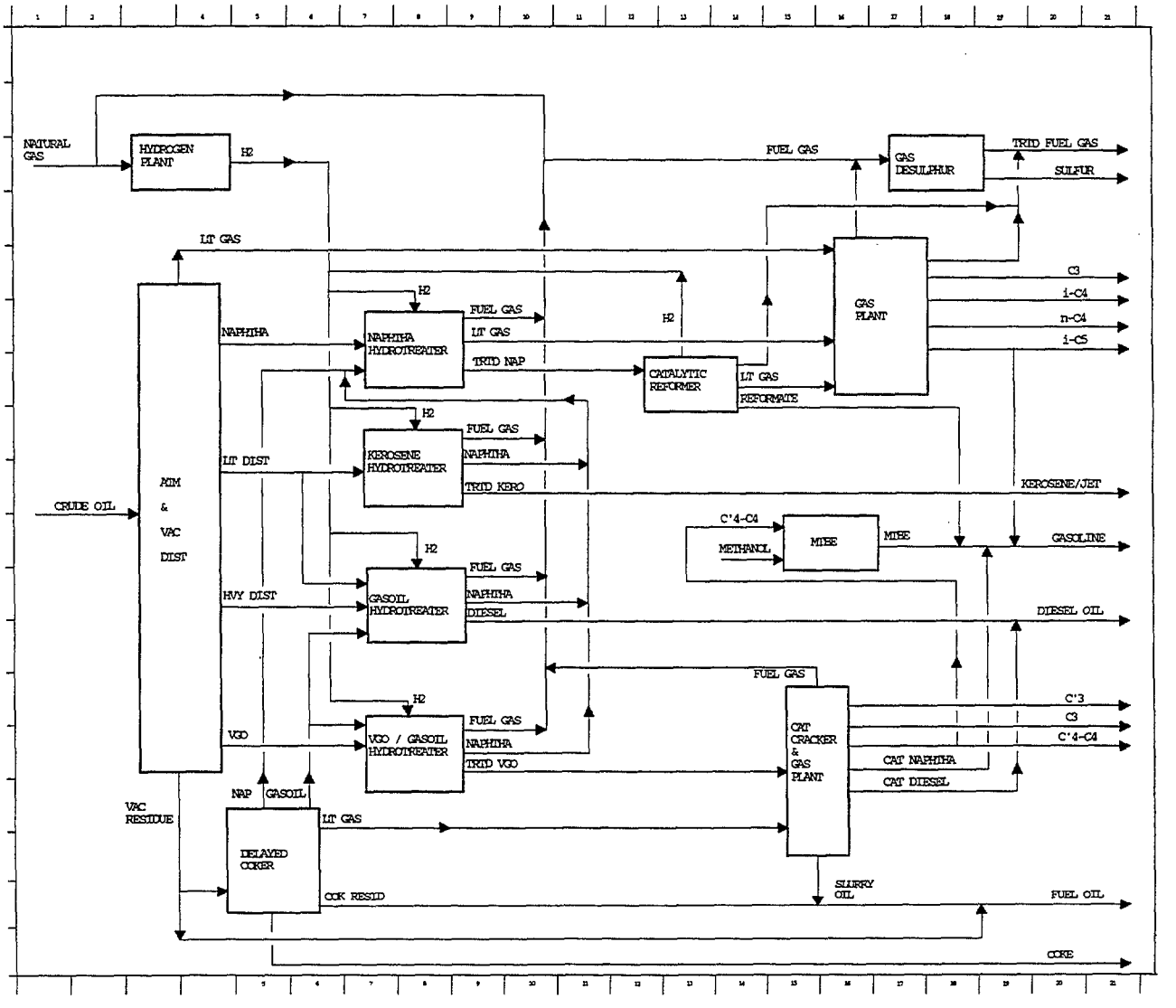

Figure 4-9 Petromidia Process Flow Diagram

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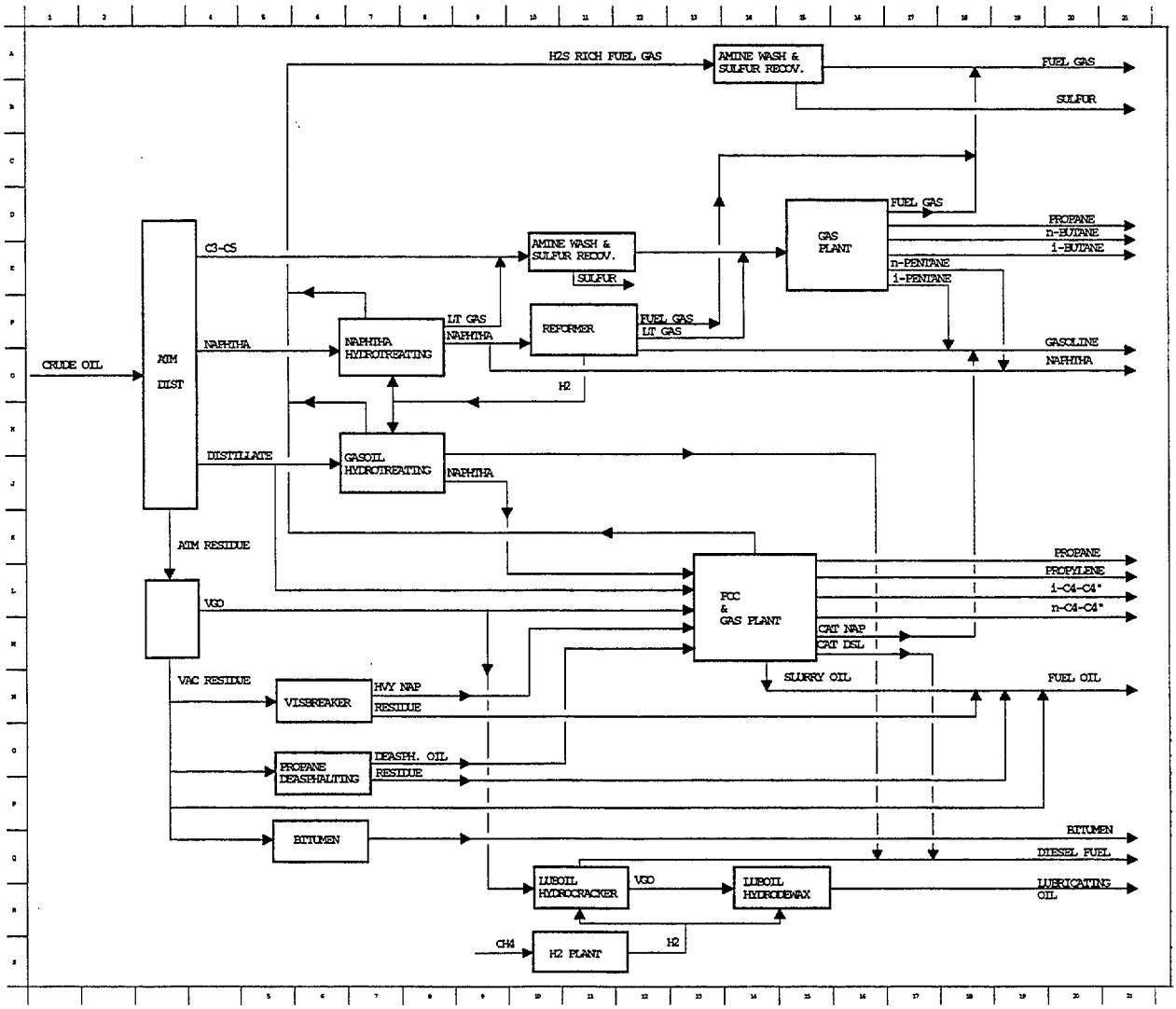

Figure 4-10 Arpechim Process Flow Diagram

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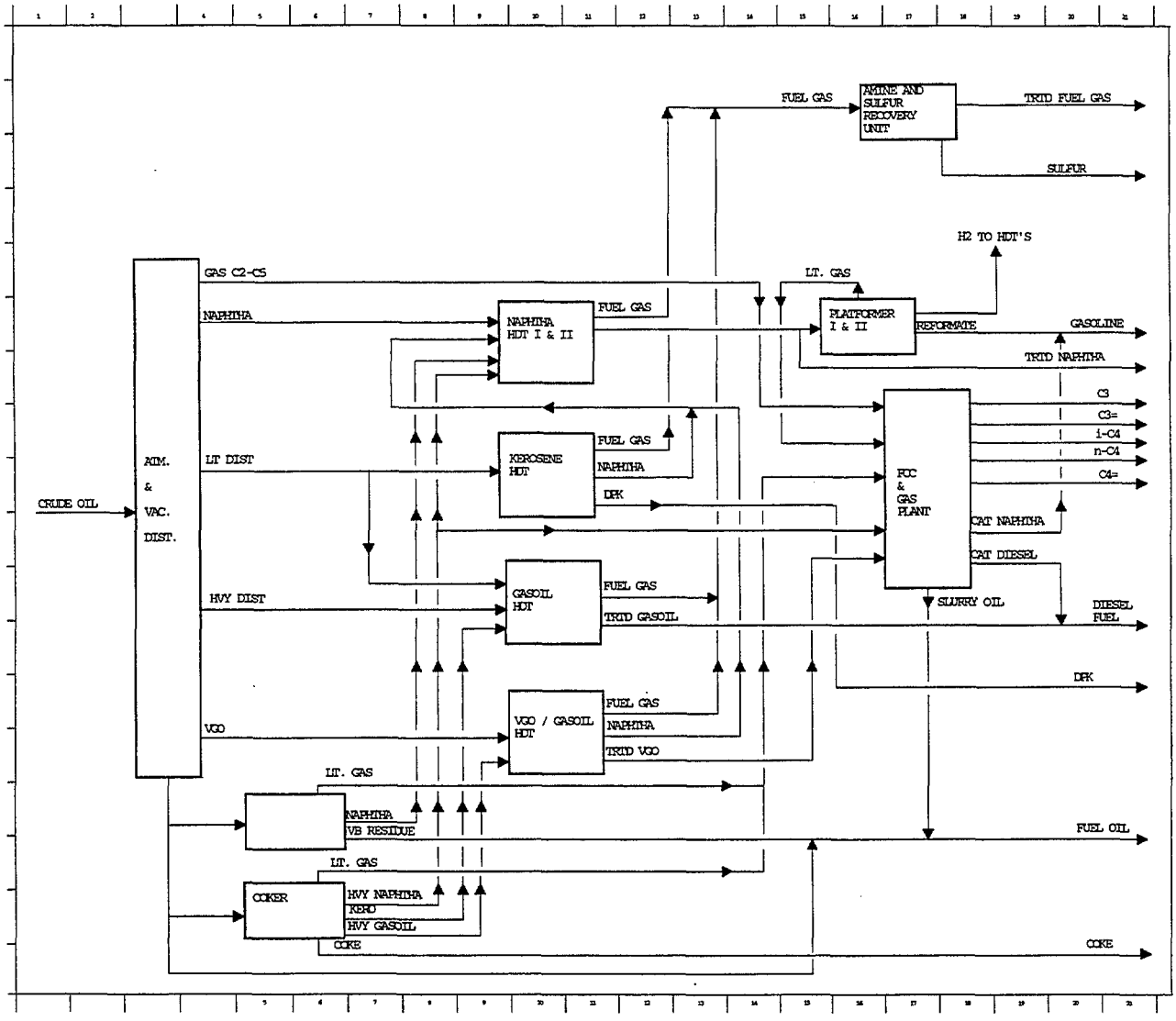

Figure 4-11 Rafo Process Flow Diagram

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4.4.2 PIMS Optimization Models

The optimization models were aimed at minimizing cost. This was normally achieved by minimizing product imports and enhancing refinery operation as defined by the PIMS marginal value parameter. This parameter indicates for constrained items how the refining industry gross margin would vary for an extra unit per day increase. For example, if after the run, the FCC unit at Petromidia were operating at maximum capacity and the marginal value parameter equaled 20, this would indicate that if the FCC operating capacity were increased by 1 tonne per day the gross margin would increase by $20 per day.

The PIMS global model investigated refinery operation for the years 1995, 2000, and 2005. The procedure to achieve least cost investment was as follows:

- *Step 1.* The refineries were modeled without modification for the three time periods. This used the global supply of feedstocks and demand data for products for the period under study with the imposed product characteristics. The global supply allowed imported feedstocks and products.

  Case Name for Model Results: Base (Base Case Model)

- *Step 2.* The crude tower cut points were modified and the three cases (1995, 2000, and 2005) rerun. The intent was to align the column yields with the downstream unit capacities and the final product requirements. This unified the basic refining approach among the five refineries and resulted in a significant improvement in the sector's overall economic performance.

  Case Name for Model Results: A (Crudes Recut Only)

- *Step 3.* From the PIMS modeling of the refineries in 1994, total SO_2 emissions and total crude throughput for all five refineries were calculated. It was assumed that by 2005 the Romanian refining industry would have to reduce these emissions by about 80 percent, although this reduction would be proportional to the crude processing rate. This reduction was considered reasonable and in line with the European Union Large Combustion Plants Directive.

  Thus, if the refining production doubled by 2005, the SO_2 emission would be allowed to double after first falling by 80 percent, the result being a net decline of 60 percent. The 2005 case from Step 2, was rerun with:

  1) The amine and sulfur treatment units revamped and tailgas treatment units installed, and

  2) The 60 percent SO_2 emission reduction

  The 2000 case from Step 2 was also rerun with the revamped units identified above but no SO_2 limitation set.

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The revamping and additions described above constitute the minimum investment requirement affecting the PIMS work. These improvements are termed the essential investments since they are required in order to meet environmental legislation.

Case Name for Model Results: B (Essential Environmental Actions)

- *Step 4.* The revamped 2005 case was used to develop the investment plan. Either the units identified as constraining the gross margin were revamped or additional units of this type were added to the refinery. Where products are imported, the aim has been to revamp units to minimize the imports. The result is a series of cases that identify the high and low investment scenarios with some sensitivity cases between.

  The yield and utility data for the new and revamped units were drawn from the PIMS library of unit operations. This library furnishes data for major refinery units, the data being derived from either Bechtel files or literature. The information serves as a reliable source of data and was considered suitable for this study.

  Case Names for Model Results:

  - C1 (High Investment)
  - C2 (Low Investment)
  - C3 (C1 without DHT at Rafo)
  - C4 (C3 without FCC revamp at Petromidia)

- *Step 5.* For the high and low cases of Step 4, the sensitivity of the model to refinery closure was considered, with Arpechim, Petrobrazi, and Petrotel sequentially shut down. Rafo and Petromidia have been identified as refineries with strong capacity loading and will therefore remain operational.
- *Step 6.* The 2000 case from Step 3 was rerun with all revamps previously identified in Step 4. New units were considered to be available only by 2005.
- *Step 7.* The case from Step 6 above was again rerun for the high and low investment scenarios, with each of the identified refineries sequentially shut down.
- *Step 8.* The base case for 1995 was rerun with the sequential closure of refineries.

  Case Names for Model results:

  - D /2 (shut down Arpechim)
  - E 1/2 (shut down Petrobrazi)
  - F 1/2 (shut down Petrotel)
  - G1 (shut down Arpechim and Petrobrazi)
  - G2 (shut down Petrobrazi and Petrotel)
  - G3 (shut down Arpechim and Petrotel)

This procedure ensured that the refinery investments were minimized, either to enhance the gross margin of the global model or to reduce imports for the year 2005 scenario. Working back from the 2005 case reduces the number of cases studied while ensuring that the refineries are developed in accordance with market predictions of 2005.

4.4.3 Review of PIMS Outputs

The PIMS results are tabulated in the Appendix. In this section, the PIMS optimized results are given for each of the investment scenarios, and a brief explanation of the solution is presented of the processing units on the sites. Table 4-3 lists the principal cases evaluated and identifies the PIMS runs relevant to each case. For each case, there are three PIMS outputs from which the economic model is constructed: the 1995 model, the 2000 model, and the 2005 model.

4.4.3.1 Review of Marginal Values from PIMS Models

A global PIMS model was constructed and represents a single model linking the five major refineries for the year 2005. The crude unit cut points were modified for each site to maximize the yield of straight run products for downstream units and thus minimize product imports. Essential environmental investments were assumed complete, namely the refurbishment of the gas desulfurization and sulfur recovery units. From the results of this global model, the marginal value study was performed.

Table 4-4 shows the results of the PIMS runs. The table gives the optimum operating capacity of each unit and the effect on the gross margin if the capacity of each unit increases independently of the others by 1 tonne. For units at their maximum capacity, this delta on the gross margin is positive; for units at the optimum capacity, it is zero. With the cut point improvements and basic environmental modifications in place, the delta values for the major constrained process units are as shown.

The units requiring modification were determined from Table 4-4. The Rafo atmospheric column with a positive marginal value was discounted since the other atmospheric unit was well below capacity. The reason for this delta value was a small difference in utility consumption for the smaller unit.

The significant marginal values reported were for the kerosene and diesel hydrotreaters. In this area, the market was importing products; hence, these units were considered important investment items to achieve 2005 specifications. The FCC at Petromidia, while feeding the gasoline market, was also considered for expansion since the marginal value was strong.

All other positive marginal values were weaker and were associated either with gasoline production or residue upgrading. Since the domestic market was not deficient in gasolines, the revamping of hydrotreater and reformers was not considered essential. Likewise, the visbreaker and delayed coker units at Rafo were not revamped since the market was deficient in fuel oil.

Table 4-3 Summary of Economic Evaluations

Case Name	Description	PIMS Model Number		
		1995	2000	2005
Base	Base Case Model	11	12	13
A	Crudes Recut Only	17	18	19
B	Essential Environmental Actions	17	21	20
C1	High Investment	17	44	29
C2	Low Investment	17	44	36
C3	As C1, but No DHT at Rafo	17	44	35
C4	As C3, but No FCC Revamp at Petromidia	17	44	39
D1	Shut Down Arpechim (High Investment)	52	45	32
D2	Shut Down Arpechim (Low Investment)	52	45	56
E1	Shut Down Petrobrazi (High Investment)	53	46	33
E2	Shut Down Petrobrazi (Low Investment)	53	46	57
F1	Shut Down Petrotel (High Investment)	54	47	34
F2	Shut Down Petrotel (Low Investment)	54	47	58
G1	Shut Down Arpechim and Petrobrazi	76	73	70
G2	Shut Down Petrobrazi and Petrotel	77	74	71
G3	Shut Down Arpechim and Petrotel	78	75	72

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Table 4-4 Constrained Process Unit Delta Values

		Operating Capacity KT/D	Minimum KT/D	Maximum KT/D	Delta Margin
AT PLANT: BRAZI					
AT1	CDU1 DOM T/D	8.6778	0.0000	10.6060	0.0000
AT2	CDU2 DOM & IMP T/D	1.0264	0.0000	10.6061	0.0000
NHT	NAP HDT 1 (D&I) T/D	0.3396	0.0000	3.3333	0.0000
NH2	NAP HDT 2 (D&I) T/D	1.5546	0.0000	2.7273	0.0000
LPR	LT NAP REF (D&I) T/D	0.2767	0.0000	1.5151	0.0000
MPR	MD NAP REF (D&I) T/I	0.0000	0.0000	1.5151	0.0000
FPR	RF NAP REF (D&I) T/D	1.4550	0.0000	1.5151	0.0000
EXL	ARO EXTRACT T/D	0.1725	0.0000	999.0000	0.0000
EXM	XYLENE COMPL T/D	0.0000	0.0000	999.0000	0.0000
IS5	NC5 ISOM T/D	0.0000	0.0000	0.6000	0.0000
KH2	KERO&DSL T/D (D&I)	1.0610	0.0000	1.0610	44.6352
DH2	GASOIL HDT (D&I) T/I	1.0610	0.0000	1.0610	45.3431
CCU	CAT CRACKER T/D	3.2726	0.0000	3.3330	0.0000
DLC	D/COKER (DOM) T/D	0.0000	0.0000	1.5000	0.0000
DL2	D/COKER (D & I) T/D	1.4821	0.0000	2.5000	0.0000
AT PLANT: PTEL					
AT1	CDU1 ROM CRUDE M	2.1569	0.0000	4.0000	0.0000
AT2	CDU2 IMP CRUDE MT	6.7249	0.0000	11.0000	0.0000
NHT	NAPH HDS-1 MT/D	1.3891	0.0000	2.1000	0.0000
LPR	CAT REFORMER MT	1.3000	0.0000	1.3000	2.0633
DHT	DIST HYDROTRT MT	2.3000	0.0000	2.3000	33.3896
CCU	CAT CRACKER MT/	2.1583	0.0000	3.4000	0.0000
HYM	H2 EX PLT, T/D	0.0000	0.0000	0.0050	0.0000
DLC	DELAYED COKER M	1.3442	0.0000	1.7000	0.0000
DAS	DEASPHALTER MT/	0.0405	0.0000	0.4000	0.0000
FEU	FURFAL EXTRACT M	0.0687	0.0000	0.7000	0.0000
DMW	SOLV DEWAXING M	0.0464	0.0000	0.5000	0.0000
HDF	LUBE HYDROFIN MT	0.0245	0.0000	0.4000	0.0000
WAX	WAX TREATING MT/	0.0219	0.0000	0.1000	0.0000
AT PLANT: ARPE					
AT1	CDU1 MT/D	0.0000	0.0000	10.6000	0.0000
AT2	CDU2 MT/D	10.7290	0.0000	11.5000	0.0000
NHT	NAPH HDS-1 MT/D	2.0000	0.0000	2.0000	5.8458
LPR	CAT REFORMER MT	0.9365	0.0000	1.6000	0.0000
DHT	DIST HYDROTRT MT	0.8752	0.0000	3.0000	0.0000
CCU	CAT CRACKER MT/	4.1595	0.0000	4.8000	0.0000
HYM	H2 EX PLT, T/D	0.0000	0.0000	0.0200	0.0000
VB1	VBU No.1 T/D	0.0000	0.0000	1.8000	0.0000
VB2	VBU No.2 T/D	0.1356	0.0000	1.8000	0.0000
HDC	VGO H/CRACKER T/D	0.3600	0.0000	0.3600	1.9960
HDW	HYDRO DEWAXING T	0.1483	0.0000	0.6500	0.0000
BIT	BIT PRODUCTION T/D	0.0000	0.0000	0.6660	0.0000

		Operating Capacity KT/D	Minimum KT/D	Maximum KT/D	Delta Margin
AT PLANT: RAFO					
AT1	CDU1 (TR 1) T/D	2.5760	0.0000	2.5760	14.8193
AT2	CDU2 (TR 2) T/D	7.6061	0.0000	10.6060	0.0000
NHT	NAP HDT 1 (TR 1) T/D	1.8180	0.0000	1.8180	0.7693
NH2	NAP HDT 2 (TR 2) T/D	0.6737	0.0000	2.6420	0.0000
FPR	RF NAP REF (TR 1) T/	0.9926	0.0000	1.5150	0.0000
FP2	RF NAP REF (TR 2) T/	0.9348	0.0000	1.5150	0.0000
ARU	COMB AROM UNITS T/D	0.8650	0.0000	1.1660	0.0000
KH2	K&D HDT (TR 2) T/D	1.0392	0.0000	1.0400	0.0000
DH2	DIST HDT (TR 2) T/D	2.1360	0.0000	2.1360	11.2218
VH2	VGO HDT (TR 2) T/D	3.4844	0.0000	3.7270	0.0000
FCC	FCC TOTAL CAPY T/D	3.3871	0.0000	3.8300	0.0000
HYM	H2 EX PLT, T/D	0.0000	0.0000	0.0227	0.0000
VBR	VISBREAKER T/D	1.0910	0.0000	1.0910	11.6906
DLC	D/COKER (TR 1) T/D	0.9090	0.0000	0.9090	8.5067
AT PLANT: PMED					
AT1	CDU1 MT/D	10.6060	0.0000	10.6060	0.4845
NHT	NAPH HDS-1 MT/D	2.4850	0.0000	2.4850	23.3205
LPR	CAT REFORMER MT/D	1.5150	0.0000	1.5150	18.8556
ARU	COMB ARO UNITS	0.7891	0.0000	1.3470	0.0000
KHT	LT/HY DIST HDT T/D	1.0300	0.0000	1.0300	1.4464
DHT	DIST HDT T/D	0.1672	0.0000	2.1810	0.0000
VHT	DSL & VGO HDT T/D	3.6285	0.0000	3.6850	0.0000
FCC	FCC TOTAL CAPY T/D	2.2540	0.0000	2.2540	46.7824
HYM	H2 EX PLT, T/D	0.0238	0.0000	0.0300	0.0000
DLC	DELAYED COKER MT/D	2.2141	0.0000	3.5100	0.0000
MTB	MTBE UNIT T/D	0.1060	0.0000	0.1060	0.0000

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4.4.3.2 Base Case Study

For the base case analysis, the refineries undergo no modification. However, it is assumed that the operations of the refineries would be planned using a linear programming package.

The PIMS outputs for these runs are summarized in the Appendix. It can be seen that the gross margin increasingly falls with the difference between 1995 and 2005, showing an increased cost of $211 million per year. Crude refining increases from 8.8 to 15.5 million tpy to supply the rising market demand. The additional crude tonnage is balanced between Iranian heavy and Es Sider, which maintains the total sulfur in the feed at about 0.8 wt%.

The major effect on the industry is the change of the market specification of diesel from high to low-sulfur. For the PIMS modeling, this is assumed to occur in the year 2000. The result is that in 1995 the diesel production in Romania is in surplus. By 2005, there is significant import of low-sulfur diesel to supply the increased demand in the domestic market and a minimal export of high-sulfur diesel.

The refineries produce low-sulfur diesel by balancing the domestic low-sulfur crudes with the high-sulfur imported crudes. This is particularly the case for Arpechim, Petrobrazi, and Petrotel. The Rafo refinery receives both local crudes and the low-sulfur imported Es Sider crude. In this way, these refineries produce a gas oil that, after hydrotreatment in the existing units, achieves the required 0.05 wt% sulfur.

Petromidia produces high-sulfur diesel from an Iranian heavy crude feed, which it then exports. The location of this refinery has a major influence on its operation. Although the cost of importing crude to the refinery is relatively low, Petromidia is distant from the major domestic crude production, and if its products are to supply the domestic markets, they must compete with the refineries in the Ploiesti region, which are nearer to the center of the large Muntenia market. The Dobrogea market can be supplied from the international market or the Ploiesti refineries.

These base case models incur no investment, and thus the refineries are badly positioned to satisfy the environmental requirements expected by 2005. The emission of SO_2 from all the refineries exceeds the required 80 percent reduction, with Petromidia producing the worst result, being about 10 times greater in 2005.

4.4.3.3 Case A – Crude Recut Study

This series of models investigated the effect of modifying the cut points on the atmospheric and vacuum distillation towers. Refinery models in PIMS can be written with swing-cut side-draws from the crude and vacuum towers. These streams are intermediate between the major draws and can flow up or down to simulate, within each run, the effect of modifying the column cut points. With a single refinery model, the increase in complexity of adding one or two swing-cuts produces an acceptable rise in run-time. For this particular study, if swing-cuts had been added to all five refineries, the time to achieve solution and interpret the final result would have

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been prohibitive. As a result, it was considered sufficient to recut the crudes outside of the multi-PIMS refinery model.

The recutting was performed using the PIMS assay cutting system with cut points that were comparable to those on similar deep-conversion refineries found in Europe, balanced with the need to provide sidestreams with yield and property attributes to suit the downstream processing units. The similarity between the refineries and the need to simplify the approach resulted in a single cut point pattern being applied to all the refineries.

It should be stressed that no detailed study optimizing the cut points for each refinery was undertaken. In a study of this depth, the crude assays, particularly of the domestic crudes, require greater definition and more detailed information on the operation of the downstream processing units is essential. Even with this information, the market demand for products and associated transport methods and costs would have to be performed in greater depth for each refinery to ensure that the complexity of the refinery models was not excessive in comparison with the marketing data.

The original cut points supplied by the refineries are shown in Table 4-5.

Table 4-5 Refinery Cut Points (°C)

Item	Arpechim	Petrobrazi	Petromidia	Petrotel	Rafo
Naphtha / Light Distillate	180	220	185	185	185
Light Distillate / Heavy Distillate	260	240	216	255	220
Heavy Distillate / Vac. Gas Oil	370	350	380	370	350
Vac. Gas Oil / Vac. Residue	550	520	550	525	520

For this evaluation, the endpoint of the naphtha cut was extended to increase the yield of gasoline products. The reason for doing this was that while the domestic market demand for gasoline is not in deficit the naphtha hydrotreater and reformers are underutilized. The increased yield of naphtha would improve the profitability of the refining industry by increasing the export of the high-value gasoline. With the gasoline endpoint extended, the naphtha draw becomes heavier, higher in sulfur, with a lower vapor pressure, and lower octane. The sulfur level rise places a greater strain on the hydrotreaters while the higher specific gravity can have an impact on the final specific gravity of the gasoline pool. The vapor pressure/octane effect may partially offset one another since the lower vapor pressure of the naphtha draw may allow lighter components with higher octanes to be blended more substantially into the gasoline pool. The revised endpoint has been placed at 200°C, which is considered a reasonable compromise to maximize yield without the properties adversely affecting the final gasoline products.

Petrobrazi, Petromidia, and Rafo all produce dual-purpose kerosene (DPK) from the light distillate cut. This product covers the range of kerosene products from domestic to aviation use. Since the model was found to be importing this product, the range of this cut was increased until limited by the specifications, principally the smoke point. The endpoint of the light distillate was set at 270°C. This cut point would be too high for some markets, e.g., for aviation kerosene, where a lower cut point would be necessary. For the refineries with kerosene hydrotreaters, this improved yield resulted in all the units rising to full capacity. In these cases, after treatment the light distillate could pass either to the DPK pool or into the diesel pool. The model would choose the direction to maximize gross margin. For Arpechim and Petrotel, the light distillate was either hydrotreated or blended directly to diesel. The change of cut point for Petrotel would reduce the light distillate yield at the expense of the gasoline, while for Arpechim the yield would also be lower but predominantly due to the reduction of the endpoint.

The heavy distillate endpoint was set at 360°C to ensure that the distillation characteristics of the final diesel could be met, especially in future years. This endpoint was considered a reasonable compromise between the current refinery settings. The deep cut reported for the gasoil at Petromidia was considered too high an endpoint for the future market requirements.

For the vacuum gas oil, it was assumed that with some modification to the vacuum distillation unit it would be possible to achieve an endpoint of 550°C at all the refineries. This is already reported at Arpechim and Petromidia.

With the new cut points, the gross margin reported by the model did not improve for the 1995 case. For 2000 the improvement was $3 million; for 2005 it was $10 million.

With the new cut points, the crude processing capacity increases for the year 2005, but for the interim year, 2000, Arpechim's crude processing capacity falls 30 percent while Petrobrazi's capacity rises by a similar figure. The sulfur content for the crude processed increases.

As expected, the revised cut points reduced the product imports to the Romanian domestic market, especially for the year 2005. Export of naphthas and distillates from the refineries to the international market for 2005 increased from 2.5 to 3.7 million tpy. Supplies to the domestic fuel oil market are also improved, with imports falling from 4 to 3.5 million tpy.

Naphtha processing capacity increased with recutting the crudes from 3 to 3.5 million tpy in 2005, a direct result of the increased yield of naphthas from the atmospheric towers. Distillate hydrotreating capacity is reduced even though the crude feed sulfur has risen, due to a redistribution of crudes to each refinery. The model has been able to use the refinery units more efficiently to meet the market demand. The increased sulfur in the feed is dealt with through greater SO_2 emissions, as a direct result of using higher sulfur fuel oil in the plant fuel system, and through increased sales of high-sulfur fuel oil.

As previously found, the SO_2 emission fails to meet the assumed requirement of 80 percent reduction by the year 2005. Thus, although this development improves the gross margin, it is insufficient to meet the minimal requirements of the refining industry.

4.4.3.4 Case B – Essential Environmental Study

For this series of models, the assumption was made that the assays would be recut for 1995 and applied to 2000 and 2005. By the year 2000, modifications would be made to the sulfur recovery units (SRUs). This is contrast to the base case environmental limits on SO_2 emissions which would not be imposed until the year 2005. In this way, the Romanian refining industry would aim to reduce SO_2 emissions over a 10-year period.

The assumed modifications to the refinery units include the refurbishment of the amine units, the addition of extra reactor stages to the current Claus plants, and the fitting of new tail gas treatment units. For Petrobrazi, where these units have been inoperative for about 8 years, new units will have to be built. The refurbishment of the units will not only improve the sulfur recovery but also reduce the utility requirements. This has a significant effect on the overall utility usage and thus the gross margin.

The gross margin for the PIMS runs improves by $27 million in the year 2005. The environmental restrictions reduce the crude processing capacity by about 5 percent for the year 2005. The crude slate increases in sulfur from 0.86 to 1.27 wt%. The refineries are processing higher sulfur feeds since they now have more efficient SRUs. Because of the improved efficiency, the units no longer use plant fuel oil; they generate, as opposed to consume, high-pressure steam, but, as a deficit, consume more electric power. The model therefore identifies some advantage to processing higher sulfur crudes since the fuel oil consumption falls, as a result of the export of steam from the SRU, which is related to the sulfur production. In effect, the SRUs are steam generators. The disadvantage is increased consumption of electric power by the SRUs, which is more than offset by these other factors.

The model shows for the years 2000 and 2005, the overall export of naphtha, gasoline, and distillates decreases after these environmental modifications. Sulfur exports jump by a factor of 6. Imports of dual-purpose kerosene and low-sulfur diesel increase slightly while fuel oil imports fall for 2005. Imports of coke and bitumen tend to fall for higher sulfur products.

After the addition of the environmental restrictions (year 2005), naphtha hydrotreating remains constant while distillate hydrotreatment increases from 4.5 to 5.5 million tpy, which removes some of the feed sulfur. FCC and coking capacity remain stable, the increased residue yield being sent directly to fuel oil production. This increased production of fuel oils per tonne of crude increases the yield of high-sulfur oil sold to the domestic markets.

The conclusion is that revamping the units associated with sulfur recovery will improve the refinery performance. The current units are expensive to operate and fail to achieve the sulfur recovery associated with refinery operations in Western Europe. After revamping, the fuel oil

production from the refineries increases while the yield of other products is unaffected. The overall loss of crude to refinery fuel is reduced. The model finds that there is no longer a penalty in producing fuel gases with hydrogen sulfide, and in fact there may be some benefit. Hence, the crude feed switches to a higher sulfur level and distillate hydrotreaters operate at greater capacity, allowing lower sulfur products to be produced that better fit the market requirement. Thus the refining industry contracts by the year 2005 after the refurbishment, but the product imports remain nearly constant due to an improved conversion per tonne of crude.

4.4.3.5 Cases C(n) – Refinery Investment Study

The refinery investment studies covered scenarios of high investment and low investment, with some intermediary cases. The highest level of investment was identified from the PIMS run of 2005, with the essential environmental modifications in place. Investments were made to units which were shown to have the greatest impact on the gross margin and where it was considered that the revamped or new units would reduce the higher value product imports. Therefore, units that produced dual-purpose kerosene and diesel were of particular interest. The economic results of these cases are summarized in Section 4.6.

Case C1 – High Investment Study. For this study, the following improvements are assumed to be made:

- Distillate hydrotreaters at Petrobrazi, Petrotel, and Rafo are revamped and new capacity installed. Revamping these units implied improvements to catalyst and control systems and improvements to the utility consumption. For the existing units, the revamp should increase capacity, improve liquid yield, reduce gas production, improve desulfurization levels, and reduce utility consumption.
- Kerosene hydrotreaters at Rafo and Petromidia are revamped with improvements to the control system, the addition of new catalyst charges, and improvements to the utility usage. This should increase liquid yield by reducing gas production and improve utility consumption.
- The distillate hydrotreater at Arpechim are modified so that it can be used in blocked operation desulfurizing distillates or vacuum gas oils. This should improve catalyst performance, reduce light gas production, and reduce utility consumption. The ability to desulfurize vacuum gas oil will become increasingly necessary as environmental restrictions apply and will make better use of the processing capacity of this unit.
- The FCC at Petromidia is revamped to increase capacity by 30 percent.

It was assumed that the revamp of the hydrotreaters could be achieved by the year 2000 while the addition of new units and revamp of the FCC at Petromidia would be completed by the year 2005.

Comparing the results from the 2005 case with the case where the essential environmental actions were complete shows the crude consumption to rise from 17 to 19 million tpy. The crude slate moved from 1.27 to 1.15 wt% sulfur with Es Sider crude consumption rising by 2.3 million tpy. The gross margin improves by $39 million.

The exports for 2005 increased for naphthas and gasolines, and the refineries are now able to export both high- and low-sulfur diesel. Imports of dual purpose kerosene are reduced from 196,000 to 50,000 tpy, while low-sulfur diesel imports are reduced to zero. Fuel oil and coke imports remain constant. The increased crude refined is therefore being used to improve gasoline and distillate production, which is reflected in the increased hydrotreating capacity of the associated units. The increased yield of residue due to the higher crude loading is reflected in the rise in FCC capacity from 5 to 5.6 million tpy. Since the coking capacity remains constant, a greater proportion of the residue flows directly to the fuel oil pool to maintain fuel oil production.

Comparing the results for the 2000 case in the same way, one can again see that gasoline exports rises and high-sulfur diesel exports is reduced. The import of kerosene has increased, but overall the distillates imports are substantially reduced by 50 percent. Fuel oil imports are slightly down but coke imports remain constant. These results are consistent with the loading of the process units.

The increased hydrotreating capacity results in the refineries repositioning their production to fit the Romanian market requirements in distillates and improve exports. The debottlenecking of the distillate hydrotreaters enables the refining industry to process imported crudes which offer higher yields of distillates and naphthas. The improved FCC capacity at Petromidia increases the production of gasolines which are effectively exported.

Case C2 – Low Investment Study. For this case, the assumption is made that no new units are constructed other than those required at Petrobrazi for the environmental requirements. The work will therefore concentrate on revamping and refurbishing units as specified in the high investment scenario. This revamping is assumed to be complete by 2000.

The results up to 2000 are the same as for the high investment study. The following discussion compares the high- and low-level investment studies in the final year of study.

In 2005, the distillate hydrotreatment is limiting, and the crude slate is heavier and higher in sulfur. This reduces the distillate yield per tonne of crude refined with the yield of residue being maintained. Crude processing capacity for the industry falls from 19 to 17.5 million tpy. Thus, overall the flow of distillates is reduced to suit the hydrotreating capacity available, while the residue flow rate falls less so with coking capacity remaining constant.

Exports of naphtha and gasoline fall as a result of the shift of crude feeds. The limited hydrotreating capacity for distillates causes the overall distillates exports to rise, but this rise is

due to a sharp rise in the export of high sulfur diesel. There are no longer low-sulfur diesel exports.

Imports of low-sulfur diesel and DPK rise sharply. Fuel oil imports rise slightly while coke and bitumen imports remain constant.

Case C3 – Intermediate Investment Study 1. For this series of runs, the high investment study is used but no new distillate hydrotreater is constructed at Rafo. This option was chosen since the Rafo hydrotreater showed the smallest effect on gross margin per tonne of distillate hydrotreated.

The results are the same as for the high investment study to the year 2000. Thus, the following discussion compares the changes that occur in 2005. The crude slate becomes heavier, reducing the processing of Es Sider by 1 million tpy and increasing Iranian heavy by a similar amount. The changes in slate have only a small impact on sulfur level of the feed.

Exports of naphtha are comparable with the high investment case while distillates again switch to high-sulfur diesel (compare low investment scenario).

Imports of low-sulfur distillates also rise while fuel oil imports fall marginally. The change in fuel oil imports shows the refineries have improved the supply of fuel oil to the domestic market. This is due to a number of minor changes between the runs, e.g., a small increase of total crude refined and an increase in the usage of Arpechim's visbreaking capacity. These factors account for the rise in fuel oil production of 0.23 million tpy.

This result is somewhat of a compromise between the strategies above.

Case C4 – Intermediate Investment Study 2. This study again uses the high investment study and, as above, does not include the new Rafo distillate hydrotreater. In addition, the FCC unit at Petromidia is not revamped. The aim here was to reduce investment by investing only in those items having a major effect on the gross margin but in doing so also aim to reduce product imports. The FCC revamp at Petromidia would mainly increase gasoline production. Since Romania is an exporter of this product, increasing the capacity of this unit would raise the gross margin by increasing gasoline exports.

Again, the early years of this study are identical to the early years in the high investment scenario. The results show the crude refining capacity and blend of crudes to be similar to the first intermediate investment study. The exports of gasoline are reduced as expected. High-sulfur diesel is again the only distillate export. Imports are similar to those in the first intermediate study.

4.4.3.6 Refinery Shutdown Studies

The refinery shutdown cases were run with both one and two refineries closed. The single refinery shutdown cases were run under two scenarios. These are discussed below.

High-Investment Study. For this series of investigations, Arpechim (Case D1), Petrobrazi (Case E1), and Petrotel (Case F1) were shut down one at a time (i.e., three scenarios with four operating refineries). For the 2005 cases, the closure of refineries produces a fall in the total crude refined. The total export of gasolines and naphtha falls from 3.7 million tpy to about 2.2 million tpy. Imports of these products rise, particularly with the closure of either of the Ploiesti refineries, Petrobrazi or Petrotel. By comparison, fuel oil imports noticeably rise when Arpechim is closed while they fall when closing the other refineries. This latter result was not unexpected since Arpechim has no delayed coker for upgrading residues but does have visbreaking capacity that is suited to fuel oil production. Furthermore, the close proximity of the Ploiesti refineries to one another and the Muntenia market result in these refineries transferring some of the production on closure.

For the three refinery closures, naphtha hydrotreating is lowest when Arpechim is closed with distillate hydrotreatment highest. This is due to a combination of factors, including the naphtha and distillate hydrotreating capacities available at the different sites, the crude processing levels, and the crude blend qualities. Coking capacity is greatest when Arpechim is closed for reasons mentioned above, while FCC capacity is lowest.

For the year 2000, crude oil refined rises slightly on closure of the refineries. Because Petrotel is operating at only 20 percent of single-train capacity, closure of this refinery has the least effect on the operation. Closure of Petrotel or Petrobrazi benefits Arpechim; thus, at this time, the Ploiesti refineries are not transferring production between the two centers.

The fuel oil imports in 2000 are greater for the case with Arpechim closed, which coincides with lower levels of sulfur in the imported crude feed and higher exports of white products. The reverse is the case when either of the Ploiesti refineries is closed.

Comparison of the cases for the year 1995 show refinery closure to have a much smaller effect on crude refining capacity and product imports/exports. The closure of Arpechim benefits Petrotel, while the closure of either of the Ploiesti refineries benefits Arpechim directly. The smaller domestic market is unable to support the five larger refineries so closure of any refinery is quickly absorbed by the other sites.

Low-Investment Study. As in the case of the high-level study, three refineries were closed one at a time. The cases are referred to as Arpechim (Case D2), Petrobrazi (Case E2), and Petrotel (Case F2). For the years 1995 and 2000, the cases are as above. For 2005, the total refined crude falls from 17.5 to 15 million tpy. The gasoline and distillate exports are reduced, with Arpechim's closure having the greatest effect. Fuel oil imports increase when Arpechim is closed. Closure of Petrobrazi and Petrotel has a smaller effect on these imports. When either of the Ploiesti refineries is closed, some of the remaining refineries benefit in terms of capacity

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used. If Arpechim is closed, no other refinery has a clear advantage. The hydrotreaters at all the refineries operate at reduced capacities in the refinery closure scenarios.

Two-Refinery-Shutdown Study. In this series of investigations, two refineries were closed simultaneously. Three scenarios, each with a different combination of closed sites, were evaluated. The cases are referred to as:

- G1 - Arpechim and Petrobrazi closed
- G2 - Petrobrazi and Petrotel closed
- G3 - Arpechim and Petrotel closed

In the evaluation of each of these scenarios, the high investment case (as in Case C1) was used for the remaining operational refineries while investment in the closed refineries was eliminated.

Rafo and Petromidia are not considered for closure since they show strong performance through all three periods of study.

Closure of the refineries causes about a 35 percent fall in total crude refined in the year 2005. Because of the fall in total refining capacity available, the transfer of capacity between the operating centers is now restricted. When operating, Arpechim does not show any improvement in capacity on closure of the Ploiesti refineries. For the other two cases, closure of Arpechim and one of the Ploiesti refineries results in the other Ploiesti refinery raising crude throughput by about 20 percent. This would appear to be a locational advantage since the Ploiesti refineries are relatively close to one another and the center of the Muntenia market. Arpechim, by comparison, is also the most distant from the international market for the import of crude feed.

The white product exports for 2005 fall from the original five-refinery figure of 3.7 million tpy to between 0.6 million tpy (Case G3) and 1.0 million tpy (Case G2). As in the case of single-refinery closures, imports of these products rise although in the three refinery cases the gasoline and distillate imports are substantial, especially for the case where both Ploiesti refineries are closed (2.4 million tpy Petrobrazi and Petrotel closed). These is as expected since the Ploiesti refineries both have cokers, while Arpechim does not.

For the refinery closures, the highest level of naphtha hydrotreatment occurs when Petrotel and Arpechim are closed; this case also provides a high degree of distillate hydrotreatment.

FCC capacity falls from about 4.4 million tpy to about 3.3 million tpy when all the refineries operate, and is independent of the specific refinery or refineries closed.

4.5 ECONOMIC EVALUATION

The economic spreadsheet models of the five refineries all use data directly extracted from the PIMS outputs and covering:

- Crude utilization by refinery

- Other feedstocks, including petrochemicals by refinery
- Petrochemical sales by refineries to petrochemical complexes
- Refined product sales by region and by refinery
- Utilities consumption by refinery

Each economic model uses three sets of PIMS runs to provide data for 1995, 2000, and 2005. It is assumed that the data for 1995 apply to all years from 1995 to 1999, inclusive; data for 2000 apply to 2000 to 2004, inclusive; and 2005 to the years from 2005 to 2015.

4.5.1 Product and Crude Cost and Price Assumptions

In the PIMS optimizations, no assumptions were made about the pricing of products for the Romanian market or for Romanian crude oil. The economic model was run with three different pricing scenarios, as listed below. All reported results in this study are quoted using Pricing Scenario 3, as it is the best representation of free market economics.

- *Pricing Scenario 1.* This scenario assumes that current Romanian domestic prices would apply in 1995, and market prices based on Mediterranean prices would apply from the year 2000. Between 1995 and the year 2000, prices are assumed to gradually align to Mediterranean prices in a linear fashion.
- *Pricing Scenario 2.* This scenario is based domestic crude prices equal to import prices less the cost of transport to the port of entry.
- *Pricing Scenario 3.* This scenario is the same as pricing Scenario 2, but with domestic crude prices at import parity prices.

4.5.2 Refining Fixed Costs

Refinery fixed costs are generally of second order of importance to overall refinery economics – the gross margin (product value minus feedstocks) is more important. To provide a realistic, but not overcomplex representation, the refinery fixed costs were divided as shown below.

4.5.2.1 Capital-Dependent Costs

These costs include maintenance expenditure and insurance of the plant. They have been modeled as a percentage of the replacement capital cost of the refinery. In the case of new investments, the capital costs of these investments have been used in the evaluation. In the case of the existing assets of the refineries, the replacement capital costs have been estimated. Insurance of the assets can be a major cost, and this cost is often self-insured or carried by a Government. In any case, the charge each year can be thought of as the probability of a major loss occurring multiplied by the cost of the loss. On this basis, self or government insurance is rarely significantly cheaper than commercial insurance.

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4.5.2.2 Employee Costs

These costs have been estimated based on data provided by the refineries for the number of staff employed and the total cost of all employee benefits. Average costs per employee in the Romanian refining industry are currently very low, but the numbers of employees are very high and the total cost of employees is therefore not exceptionally low. It has been assumed that over the period for which this evaluation is projected (i.e., until 2015) employee numbers will be reduced and salary levels rise. However, the total cost of employees has been assumed to be constant.

4.5.2.3 Overheads

These costs have been assumed to be based on a percentage of sales revenue. The allowance is intended to cover all overhead costs, apart from those mentioned above. These overhead costs would include financing of working capital, sales costs, bad debts, communication costs, legal and audit fees, etc. Depreciation and capital recovery have been excluded.

4.5.2.4 Taxation and Financing Costs, etc.

The principal objective of the exercise has been to examine the refineries in the context of their added value within the Romanian economy, and for this reason, taxation, which is merely a transfer from the enterprise to the government, has been excluded. Since the existing assets, including stocks, are a sunk cost, the cost of financing these assets has also been excluded from the analysis. Neither of these effects will have a significant impact on the selection of the most advantageous development path for the Romanian refineries.

4.5.3 Capital Costs of Improvements

The capital costs of the various improvements have been estimated based on data from past refinery projects and from curve type estimates. The costs have been adjusted to take account of the very significant advantage of a large and competent Romanian equipment, engineering, and construction industry.

4.5.4 Refinery Spreadsheet Economic Models

The refinery financial spreadsheet models draw their data directly from PIMS spreadsheets and from the pricing scenario and parameter spreadsheets. The models are annual cash flow models covering the years 1995 to 2015. This period was selected to allow 10 years of operation after the last major capital investment (2005). The spreadsheet model includes an analysis of the revenue from products and of all costs, including the cost of transport, to each market for each product.

The model permits sensitivity analysis to be performed on a number of parameters (e.g., capital costs, product prices) by varying sensitivity parameters globally across all models. The model

can also incorporate general inflation. The model is denominated in a single currency. Since all crude oils and products are traded internationally in U.S. dollars, all calculations have been carried out in constant 1995 U.S. dollars.

The cash flows have been analyzed on the basis of their NPV. The models differentiate between local and foreign exchange costs, and these are reported separately.

The overall structure of the models consists of a number of spreadsheets that extract data, such as product volumes and prices, from the source files. Product volumes and prices are then multiplied to yield each cost or revenue component. The first three spreadsheets of the model provide the consolidated summary of the economics.

4.5.6 Comparison with the Base Case

The primary purpose of the analysis is to support decisions on the future configuration and capacity of the refining industry in Romania. In this case, the difference between options is the primary focus. The spreadsheet models have all been built to include two different cases and to compare the two cases. For example, the case of recutting the crudes (Case A) can be compared with the case where no capital investment is carried out. In this way, the improvement brought about by each capital investment option can clearly be identified.

Given the likely feasible time scale for improvements, it has been assumed in most cases that refinery operations will not be affected by any actions resulting from this analysis until after January 1997.

4.5.7 Consolidated Romania Refining Economics

This model consolidates the output of all five major refinery models. The consolidated model includes the overall economics spreadsheets for each refinery for the new case, base case, and the difference between the two (three spreadsheets per refinery). The consolidated model also adds each of these three spreadsheets from each of five refineries to produce the overall new case, base case, and difference.

The consolidated summary spreadsheets evaluate the impact of developments on the overall refinery sector. Often, a case will show a significant drop in the performance of one refinery, but an overall increase in the performance of the sector due to the gain achieved by the other four refineries.

4.5.8 Principal Assumptions

4.5.8.1 Product Demand

Table 4-6 shows the assumptions made about the demand for refined products by region in Romania.

Table 4-6 Refined Product Demand Assumptions

Year/Item	Muntenia	Dobrogea	Transylvania	Moldavia	Banat	Total
	Demand Figures in Tonnes per Day					
1995						
LPG	735	125	225	190	59	
RONL 87	206	13	285	166	141	
RONC 87	0	0	0	0	0	
RONL 95	1,909	214	1,063	374	420	
RONC 95	440	42	412	56	90	
Dual-Purpose Kerosene	646	20	273	153	45	
Low-Sulfur Diesel	0	0	0	0	0	
High-Sulfur Diesel	1,337	715	2,655	1,215	611	
Low-Sulfur Fuel Oil	502	133	2,967	642	143	
High-Sulfur Fuel Oil	5,246	788	2,136	3,610	166	
Bitumen	667	0	91	0	0	
Needle Coke (ex Darmanesti)	0	0	0	109	0	
Low-Sulfur Coke	991	0	0	0	0	
Fuel Coke	1,061	1,818	0	779	0	
Lube Oil Products	184	0	0	0	0	
Total	13,924	3,868	10,107	7,294	1,675	36,868
2000						
LPG	922	156	283	239	74	
RONL 87	218	14	301	176	149	
RONC 87	150	14	137	19	30	
RONL 95	2,016	226	1,122	395	444	
RONC 95	724	69	671	91	147	
Dual-Purpose Kerosene	767	24	333	182	53	
Low-Sulfur Diesel	5,976	869	3,239	1,478	743	
High-Sulfur Diesel	0	0	0	0	0	
Low-Sulfur Fuel Oil	644	171	3,800	823	183	
High-Sulfur Fuel Oil	5,267	791	2,145	3,624	167	
Bitumen	1,125	0	94	0	0	
Needle Coke (ex Darmanesti)	0	0	0	116	0	
Low-Sulfur Coke	1,025	0	0	0	0	
Fuel Coke	1,097	1,880	0	805	0	
Lube Oil Products	184	0	0	0	0	
Total	13,495	4,214	12,125	7,948	1,990	39,772

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Table 4-6 (Cont'd)

Year/Item	Muntenia	Dobrogea	Transylvania	Moldavia	Banat	Total
	Demand Figures in Tonnes per Day					
2005						
LPG	963	163	296	250	77	
RONL 87	17	11	237	138	117	
RONC 87	374	35	342	46	75	
RONL 95	1,578	178	884	311	350	
RONC 95	1,813	171	1,670	226	365	
Dual-Purpose Kerosene	911	28	404	216	63	
Low-Sulfur Diesel	7,426	1,074	4,012	1,827	918	
High-Sulfur Diesel	0	0	0	0	0	
Low-Sulfur Fuel Oil	1,290	342	7,615	1,650	367	
High-Sulfur Fuel Oil	2,999	456	1,165	0	96	
Bitumen	1,162	0	97	0	0	
Needle Coke (ex Darmanesti)	0	0	0	116	0	
Low-Sulfur Coke	1,058	0	0	0	0	
Fuel Coke	1,133	1,942	0	832	0	
Lube Oil Products	184	0	0	0	0	
Total	20,908	4,400	16,722	5,612	2,428	50,070

4.5.8.2 *Crude Availability*

Table 4-7 shows the assumptions made about domestic crude production by region in Romania.

Table 4-7 Domestic Crude Production by Region

Region	10^6 tpy	Percent
Muntenia (Ploiesti / Pitesti)	4.268	77.6
Moldova (Rafo)	0.610	11.1
Black Sea	0.622	11.3
Total	5.500	100

Note: Excludes Surplacu production and smaller refinery consumption

4.5.8.3 *Product Pricing*

Product pricing has been based on the data provided in Section 2 of this report for the Mediterranean market. The following three product price sets are required for each evaluation:

- *Products Imported from the World Market to Meet Shortfalls in Supply to Particular Regions in Romania.* These products have been priced at Mediterranean prices plus the cost of transport to the market.

- *Products Exported to the World Market That Have Been Produced in Excess by Romanian Refineries.* These products have been priced at Mediterranean prices and the cost of transportation to the Mediterranean has been charged; i.e., the price realized by the Romanian refinery is Mediterranean less transportation cost.
- *Products Sold on the Domestic Market.* These have been priced according to the price scenarios mentioned previously. Where prices are referenced to the Mediterranean market, it is assumed that the Romanian refineries will charge the same as imports; i.e., the price in each Romanian market is the Mediterranean price plus the cost of transporting product from the Mediterranean market to the Romanian market. This price basis is the most favorable to the Romanian refining industry, but does have cost implications to other industries in Romania in that they will be paying a premium over industries located in countries that can purchase products at Mediterranean prices without a premium. This price basis also ignores the possibility that other regional refiners might be attracted to sell to the Romanian market because of the premium over the Mediterranean market price. The cost of transporting product by the Romanian refinery to the domestic market is charged as a cost to the refinery.

Data for pricing have been provided to the spreadsheet model for the years 1995, 2000, and 2005. Prices for years between 1995 and 2000 have been linearly interpolated between these years. Prices for years between 2000 and 2005 have been calculated similarly. Prices for years after 2005 have been assumed to be the same as 2005.

4.5.8.4 Crude Pricing

The price of imported crude oil has been based on the data provided earlier in this report by Bonner & Moore. The transport cost of shipping the crude to Romania and transporting on to the refineries has been shown as a cost.

Romanian domestic crude is not traded internationally, and a market price is not available. All crude oils are different. Some crude oils, like the Romanian crudes, have little sulfur and are more valuable for this reason. Other crudes contain a relatively high proportion of the more valuable light products. To generate a fair market price, significant cargoes of Romanian crude oils would have to be traded so that its value to refineries in market economies could be fairly judged. As a substitute for this, the value of the Romanian crude to the Romanian refineries has been estimated using the PIMS model of the refineries. The method of carrying out this valuation is described below. The method provides the breakeven price to the refineries when compared with the alternative of processing an imported crude oil; i.e., it provides the refineries with the same gross margin as processing a barrel of imported crude.

The price generated represents the point of indifference for the Romanian refineries; i.e., the price includes the cost paid for transporting imported crude to Romania. If the position of the Romanian crude oil producer is considered, then their next best alternative would be to sell the

crude on the Mediterranean market. To do this, they would incur transportation costs for shipping the crude to the market, i.e.; the price generated by PIMS offers the Romanian crude oil producer a premium. This premium is generated because the refineries are located in Romania. As this advantage in location fairly belongs to the refineries and not to the crude oil producer, the price generated has been adjusted downwards to the price that the crude oil producer would earn if the oil were sold on the Mediterranean market; i.e., all the advantage in location is given to the refineries and the transport premium is deducted.

It is true that if the refineries competed with one another for the domestic crude oil, then each refinery would be willing to pay a price equivalent to its next best alternative, which would be to import foreign crude. In that case, the price advantage would actually flow to the Romanian crude oil producer and not to the refinery.

Calculations of the base case NPV of the Romanian refining industry were undertaken using price scenarios that reflected both cases; i.e., the location value captured by the refineries and the location value captured by domestic producers. Because all further economic evaluations, with crude volumes held constant, were based on the differential between proposed improvements and the base case, the actual crude price value no longer had any impact on the change in NPV.

The price of the six domestic crudes was determined by running the PIMS models of the global refining industry over three time periods: 1995, 2000, and 2005. For the 1995 case, the refineries were assumed to be operating as they are now with only cut point modifications (Case A). For the other two periods, the essential environmental modifications were assumed to be in place (Case B).

The process by which the crude price for each of the six crudes was established was to run the PIMS model at three rates of crude availability. Thus, for the year 1995 the model was run with the full slate of Romanian crudes fixed and imported crudes allowed as required at the internationally derived price (this is the normal reported results for the case). This procedure was then repeated with one of the six domestic crudes fixed at about 50 percent of its production rate. Then, a third run was completed with this crude flow at zero. Dividing the change in marginal value (the cash generated) by the change in crude rate (volume of crude oil) established the value of the crude.

$$\text{Value of Crude A (\$/tonne)} = \frac{\text{Cash Generated 100\% Domestic Crude A (\$)} - \text{Cash Generated with No Crude A (\$)}}{\text{Quantity of Crude A (tonne)}}$$

The marginal value function in PIMS also provides a price for each domestic crude, since the optimum solutions are always constrained by domestic crude availability. This marginal value represents the price that PIMS would pay for 1 additional tonne of domestic crude to displace 1 tonne of imported crude. Thus, for three PIMS runs carried out for each domestic crude six values can be calculated. These are, in descending order of magnitude:

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- Marginal value for the first tonne of domestic crude (PIMS run 0 percent of domestic crude)
- Value interpolated between 0 and 50 percent of domestic crude from gross margin
- Marginal value for the next tonne above 50 percent of domestic crude (PIMS run 50 percent)
- Value interpolated between 0 and 100 percent of domestic crude from gross margin
- Value interpolated between 50 and 100 percent of domestic crude from gross margin
- Marginal value for the next tonne above 100 percent of domestic crude (PIMS run 50 percent)

The decline in value as more domestic crude oil is available is an illustration of the law of diminishing returns. In the cases evaluated, the values did not vary significantly and the lowest value was used.

The method of valuation illustrated above will yield a slightly higher valuation than one that is based on a typical Mediterranean market. The higher value is not considered significant and is caused by the following:

- The Romanian refineries are deficient in sulfur removal capacity, and hence low-sulfur crude oils are more highly valued by Romanian refineries than high-sulfur crudes. Romanian crude oils are low-sulfur.
- The Romanian refineries have high conversion capability, hence do not need to run lighter crudes to meet the demand for light products. This reduces the premium they would pay for light crudes. Romanian crudes are not light.

The procedure was repeated for the other five crudes to establish the market price of each in 1995, and repeated again for the years 2000 and 2005. The price of the crudes for the three periods was then reduced by the cost of transport from the field to the Mediterranean to give the values shown in Table 4-8.

Table 4-8 Crude Values per Tonne at the Oil Field in Current Dollars

Crude	1995	2000	2005
Muntenia 1	121.8	131.9	142.4
Muntenia 3	128.4	137.7	147.4
Black Sea	134.3	142.8	147.4
Moldova 1	112.2	119.8	117.6
Moldova 2	123.0	135.8	103.9
Moldova 3	126.8	138.2	133.3

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Data for pricing have been furnished to the spreadsheet model for the years 1995, 2000, and 2005. Prices for years between 1995 and 2000 have been linearly interpolated between those years. Prices for years between 2000 and 2005 have been similarly calculated. Prices for years after 2005 have been assumed to be the same as 2005. The domestic crude prices used in Price Scenario 2 are based on the valuation method described above. The domestic crude prices used in Price Scenario 1 are similar to those for product pricing, in that the prices used for 1995 are current Romanian prices, which are allowed to become world market prices over the period 1995 to 2000.

4.5.8.5 Petrochemicals Evaluation

A discussion of the economics of the various petrochemical facilities is presented in Section 6. For the purposes of the refinery evaluation, the following bases are used:

- If the petrochemical operation is viable, the demand for feedstock and the availability of by-products as feedstock to the refinery are included in the model.
- The price set for transferring feedstock to the petrochemicals is the highest acceptable to the petrochemical operation for continued operation. If the price required for feedstock is lower than world market prices, then the petrochemical operation is deemed nonviable. The feedstock will be supplied by the refineries or from the Mediterranean market. Supplies from the Mediterranean market will be priced at Mediterranean market plus transport cost. Hence, the refineries will supply feedstock only if it is more efficient to do so, and the petrochemical operation will have alternative sources of supply should be the refinery not be able to supply feedstock.
- The transportation costs of transferring petrochemicals to and from the refineries are included in the analysis.

4.5.8.6 Logistics Costs

All costs of moving crude to refineries from whatever source are included in both the PIMS evaluation and the economic model. All costs of moving product to each of the five regional markets in Romania or to the export market are included in both the PIMS evaluation and the economic model. Similarly, the costs of transferring petrochemicals and semifinished products between refineries and petrochemical complexes is also included in both the PIMS and the economic model.

Table 4-9 shows the cost that have been assumed in the modeling.

Table 4-9 Transport Prices ($/tonne)

Item						
External Market to Refinery	**Arpechim**	**Petrobrazi**	**Petromidia**	**Petrotel**	**Rafo**	
Crude Oil	11.12	9.94	6.87	9.93	11.10	
Urals Crude Oil	6.00	4.82	1.75	4.81	5.98	
Methanol / MTBE	12.38	11.20	8.13	11.19	12.36	
Natural Gas	0.00	0.00	0.00	0.00	0.00	
Domestic Crude Oil to Refinery	**Arpechim**	**Petrobrazi**	**Petromidia**	**Petrotel**	**Rafo**	
Muntenia District	0.59	0.59	4.47	0.60	3.84	
Moldova District	4.42	3.25	4.23	3.23	0.00	
Black Sea	4.75	3.57	0.50	3.56	4.73	
Arpechim Refinery to Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	**Export**
White Products	7.75	5.90	8.33	2.85	6.49	12.38
Fuel Oils	7.75	5.90	8.33	2.85	6.49	11.12
Solids	5.43	4.13	5.83	2.00	4.54	9.32
Petrobrazi Refinery to Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	**Export**
White Products	8.70	4.72	7.16	2.09	6.22	11.20
Fuel Oils	8.70	4.72	7.16	2.09	6.22	9.94
Solids	6.09	3.30	5.01	1.46	4.35	8.49
Petromidia Refinery to Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	**Export**
White Products	11.89	1.66	7.37	4.54	9.76	8.13
Fuel Oils	11.89	1.66	7.37	4.54	9.76	6.87
Solids	8.32	1.16	5.16	3.18	6.83	6.35
Petrotel Refinery to Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	**Export**
White Products	8.71	4.71	7.14	2.10	6.23	11.19
Fuel Oils	8.71	4.71	7.14	2.10	6.23	9.93
Solids	6.10	3.30	5.00	1.47	4.36	8.49
Rafo Refinery to Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	**Export**
White Products	10.21	5.88	4.68	5.03	7.28	12.36
Fuel Oils	10.21	5.88	4.68	5.03	7.28	11.10
Solids	7.15	4.12	3.28	3.52	5.10	9.31
Mediterranean Market to Domestic Market	**Banat**	**Dobrogea**	**Moldavia**	**Muntenia**	**Transylv**	
White Products	19.09	7.85	14.34	10.92	16.51	
Fuel Oils	17.83	6.59	13.08	9.66	15.25	
Inter Refinery Transfers	**Arpechim**	**Petrobrazi**	**Petromidia**	**Petrotel**	**Rafo**	
Arpechim Refinery to	–	2.43	6.30	2.44	5.67	
Petrobrazi Refinery to	2.43	–	5.13		4.50	
Petromidia Refinery to	6.30	5.13	–	5.11	5.48	
Petrotel Refinery to	2.44		5.11	–	4.48	
Rafo Refinery to	5.67	4.50	5.48	4.48	–	

4.5.8.7 Refinery Configuration and Performance

A detailed discussion of the PIMS models of each of the five major refineries is found in the Appendix. The Appendix also includes schematics of the refineries, details of capacities of the major units, yield data on the processes, and a description of the procedure used to generate the data for this model, including the pro-forma questionnaires submitted to the refineries.

4.5.8.8 Refinery Fixed Costs

Refinery fixed costs have been estimated using data furnished from a number of sources. The total cost of employees has been estimated based on the data in Table 4-10. These data were extracted from the budget data provided by the refineries. The discrepancy between the total cost per worker at Petromidia and the other four sites was noted, but no explanation was given.

Table 4-10 Employee Salaries

Refinery	Total Number of Workers	Apparent Cost per Worker per Year (1995 $)
Petrobrazi	7,800	2,800
Petrotel	6,490	2,700
Arpechim	3,390	2,900
Petromidia	4,760	4,790
Rafo	3,790	2,510

The cost of maintenance and insurance has been estimated on the basis of a percentage of the replacement capital cost of the plant. This replacement capital cost in the model includes both the existing facilities and the new capital expenditure described below. This approach will result in a much higher charge for annual maintenance and insurance than has been the custom in recent years in Romania. The rationale for this higher number is that:

- It is in alignment with such costs at refineries in other parts of the world. However, a lower than usual figure has been used for the annual charge in Romania to reflect the fact that a large portion of the maintenance labor is permanent staff of the refinery, rather than contractors.
- It must be sufficient to maintain the existing equipment in an economically productive and efficient condition. The recent level of maintenance expenditure has clearly been below a level that is capable of ensuring safe and efficient operation of the refineries.

The basis for maintenance and insurance costs in the models was 1 percent and 0.5 percent of capital replacement cost, respectively, which is in line with international refinery averages.

The capital replacement costs assumed for each refinery are summarized in Table 4-11.

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Table 4-11 Capital Replacement Cost

Refinery					Total ($ million)
Arpechim ($ million)	Petrobrazi ($ million)	Petromidia ($ million)	Petrotel ($ million)	Rafo ($ million)	
1,880	2,250	1,500	2,000	1,900	9,530

Notes:

1) All prices in 1995 $ million
2) Petromidia based on *Evaluation of Midia Refining & Pet Chem* by Muse Stancil, May 1991
3) Petrotel based on *Valuation of Petrotel* by Coopers and Lybrand, March 1992
4) Arpechim based on *Pitesti Plant Evaluation for M Rich* by Wright Killin, February 1991
5) Petrobrazi based on the estimate for Petromidia
6) Rafo based on the estimate for Petromidia and Arpechim

Little information on overhead costs has been made available to the team. It is recognized that overhead costs in Romania are generally low, particularly as the cost of all staff has been included elsewhere. A figure of 1 percent of sales revenue has been used to cover these costs which is typical in other markets.

Table 4-12 shows the estimates used for capital costs of new facilities.

The final result of the economic evaluation is a series of future revenue and expense numbers that net out as cash flows. As mentioned above, the changes in these revenue and expense categories have been built in to reflect changes in quantities, demands, trends, and the sum of all factors that influence prices in the future. The critical and final step in the analysis is the process of taking these discrete future cash flows and translating them into a single NPV.

The economic evaluation is based on the concept that the ownership and operation of the refineries uses capital. Capital is a scarce resource and has a real cost associated with its use. Conversely, capital can generate a return with no risk if it is invested in totally risk-free vehicles, which are generally government obligations such as U.S. treasury securities. Investing capital in the downstream refinery sector has a measurably higher degree of risk than investing in risk-free government securities. For example, the price of oil can decline below the estimates used, additional and competitive refinery capacity could come on stream in adjacent markets, the Romanian economy may not achieve the growth targets estimates, and so forth. These specific risk factors further devalue the cash flow to be received in future years.

The time value and risk of future cash flows – often stated informally as the fact that a dollar today is worth more then a dollar tomorrow – can be quantified by the present value process, which is done by a calculation of a sum of the discounted cash flows. To perform this calculation, one must discount each future cash flow from the specific point in the future back to

Table 4-12 Capital Costs – New Facilities

Case	Description	Refinery					Total ($ million)
		Arpechim ($ million)	Petrobrazi ($ million)	Petromidia ($ million)	Petrotel ($ million)	Rafo ($ million)	
A	Crudes Recut	4	4	4	4	4	18
B	Environmental Case	10	22	10	10	12	64
C1	High Investment	14	42	23	38	36	152
C2	Low Investment	14	27	23	20	22	106
C3	Case C1, No DHT at Rafo	14	42	23	38	22	139
C4	Case C3, No FCC Revamp at Petromidia	14	42	11	38	22	127
C5	Case C3, Accelerated Investment	14	42	34	38	22	150
D1	Arpechim Shut – High Investment	0	42	23	38	36	139
D2	Arpechim Shut – Low Investment	0	27	23	20	22	92
D5	Arpechim Shut – Accelerated Investment	0	42	34	38	22	136
E1	Petrobrazi Shut – High Investment	14	0	23	38	36	110
E2	Petrobrazi Shut – Low Investment	14	0	23	20	22	79
F1	Petrotel Shut – High Investment	14	42	23	0	36	115
F2	Petrotel Shut – Low Investment	14	27	23	0	22	85

Note: All prices in 1995 $ million

the present by a discount rate. This unique discount rate is a factor that includes the basic risk-free return of capital as well as the specific risk factors for the evaluation in question. The current yield on 1-year U.S. Treasuries is approximately 5.3 percent. Securities of international oil companies yield approximately 3 percent above this amount to account for the specific risk of the oil business. Because of the extra risk of operating solely in Romania, as opposed to spreading operations around the world and other factors, an additional risk premium of 4 to 5 percent is added. Once the effect of inflation has been subtracted, the resulting total discount rate for this evaluation is set at 10 percent. The determination of the specific discount rate is not

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critical in this evaluation since it is fixed for all cases, and therefore the differences between cases is the relevant issue.

Once this discount rate has been determined, it is applied, per year, to each of the future cash flows to discount them to the present. For example, the present value of a cash flow of $100 next year is $90.91. The present value of the same $100 to be received 10 years from now is $42.41. The sum of all future cash flows, discounted to the present is the NPV, which is the basis of comparison between various economic evaluations.

Section 5

Petrochemical Sector Assessment

5.1 INTRODUCTION

This petrochemical sector assessment covers the petrochemical facilities operating at four large refining sites: Arpechim, Petromidia, Petrotel, and Petrobrazi. The sector comprises both viable production units that are capable of sustained value creation and nonviable operations that destroy value and waste the resources of the sector. Table 5-1 summarizes our assessment of the viability of petrochemical manufacturing operations. Viable units include those that produce polyolefins (polyethylene and polypropylene) as well as those that produce petrochemicals for textile fibers (including acrylonitrile and DMT).

A number of secondary and redundant units are nonviable because of obsolescent technology, small operating scale, and low capacity utilization. In the case of Petrotel, all of the petrochemical units currently in operation are nonviable and should be shut down. At Petrobrazi, most of the petrochemical units are nonviable, and those that are presntly viable based on current cost performance will be rendered nonviable by the recommended shutdown of the Petrobrazi refinery because of feedstock supply disruption. Moreover, these otherwise viable units cannot contribute sufficient value to justify continued operation of the Petrobrazi refinery.

Our assessment reveals that the petrochemical sector is hampered by government regulation of prices. Petrochemical price controls create noncommercial price levels, dysfunctional incentives, and market shortages. We recommend that all petrochemical price controls be eliminated and that petrochemical feedstocks and products be sold at market prices.

In addition, current management practices are not adequate to meet the competitive challenges confronting the sector. Manufacturing operations must be strengthened through the disciplined use of Key Performance Indicators (KPIs) in the management of petrochemical processes. Also, the operating performance of petrochemical units must be benchmarked against competitors to identify significant opportunities to improve performance. Improvements are also needed to increase the effectiveness of petrochemical capacity planning and to enhance marketing effectiveness.

In the analysis that follows, changes are specified that are necessary to establish the basis for competitive operation within the sector. When these recommendations are implemented, they will mitigate the effects of current problems and weaknesses and they will position the enterprises to capitalize on future petrochemical opportunities and to manage strategic threats.

The recommendations given here are premised on the overriding need to make the Romanian petrochemical sector commercially competitive and economically viable. Enterprise managements must guide the transformation of the petrochemical sector within the broad process of Romania's transition to a competitive, market-based economy.

Table 5-1 Viability Summary for Petrochemical Units*

	Units	Plant Sites				Comments
		Arpechim	Petrobrazi	Petrotel	Petromidia	
Units Supplied by the Arpechim Steam Cracker	LDPE	Operating			Idle	• Arpechim's LDPE, HDPE, ethylene oxide, and ethylene glycol units are viable. The units at Petromidia are based on similar technology and scale. Because of increasing demand for these ethylene derivatives, the idle Petromidia units will be needed within 5 years.
	HDPE	Operating			Idle	
	Ethylene Oxide	Operating			Idle	
	Ethylene Glycols	Operating			Idle	
	EPDM Rubber	*Operating*				• The EPDM unit is not viable (small-scale, noncompetitive technology).
	Acrylonitrile I	Operating				
	Acrylonitrile II	Operating				• The two acrylonitrile units at Arpechim are viable.
	Ethyl Benzene	*Operating*				• The ethyl benzene unit at Arpechim is not viable. Styrene, which is produced from ethyl benzene, and the other styrenics units (polystyrene and ABS) are not viable at either petrochemical site.
	Styrene	*Idle*		*Operating*		
	Polystyrene	*Idle*		*Operating*		
	ABS	*Idle*		*Operating*		
	Ethoxylate Units		*Operating*			• The ethoxylate units at Petrobrazi are not viable (ethoxylated phenols, demulsifiers, ethanolamines, choline chloride, polyethylene glycols, and antifreeze).
Polypropylene Units	Polypropylene			*Operating*	Operating	• Current polyethylene demand is low compared to total capacity. The consolidation of Petrotel's production into Petromidia, the superior unit, will make the Petromidia unit viable.
Aromatic Derivative Units	Phthalic Anhydride		*Operating*			• The anhydride units at Petrobrazi are viable based on cost/value ratios. However, the shutdown of the Petrobrazi refinery will disrupt feedstock supply. Accordingly, these units should be shut down.
	Maleic Anhydride		*Operating*			
	Phenol/Acetone		*Operating*			
	DMT	Operating	*Operating*		Idle	• The phenol/acetone unit is not viable based on available cost information.
						• Total DMT capacity is low relative to demand. The Arpechim unit has adequate capacity to meet current and near-term DMT requirements.
Carbon Black	Carbon Black	Operating				• The carbon black unit at Arpechim is viable based on current carbon black demand.

*Italics signify nonviability.

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5.2. OVERVIEW AND CURRENT STATUS

5.2.1 Chem Systems Study (1993)

The study described here takes into account the conclusions reached in 1993 by Chem Systems upon the completion of their assessment of the Romanian chemical industry. Chem Systems noted the following strengths of Romania's petrochemical sector: extensive experience in petrochemical operations, combined with a proud technical tradition; a large associated refining industry potentially capable of furnishing reliable feedstock supply to petrochemicals; a domestic economy with the potential to generate demand for chemical products through economic recovery; and access to regional export markets, strengthened by the capability to ship products by sea.

The Chem Systems report also noted that the following weaknesses limited Romania's petrochemical performance: a noncommercial pricing structure that creates disincentives, impeding the competitive reorientation of petrochemical operations; a petrochemical sector that operates with extreme overcapacity in most products, suffering severe cost penalties (disadvantages) as a result; feedstock shortages that cause frequent shutdowns in petrochemical operations, leading to product supply interruptions and to increased operating costs; and aging, ill-maintained facilities and obsolete, noncompetitive process technology that provide a weak operational platform for petrochemical manufacturing.

In the present study, Romanian petrochemical sector conditions were reevaluated and Chem Systems' prior conclusions were revisited in light of current facts.

5.2.2 Major Strengths and Weaknesses

The operational strengths described by Chem Systems have also been noted in this study. In particular, Romania's vigorous engineering tradition has been evident to us in our many interactions with the staffs of the petrochemical sites. Arpechim, for example, has significantly increased its sales of ethylene and ethylene derivatives within the last 2 years. A technical plan to revamp the Arpechim steam cracker furnaces will, if implemented, provide the basis for future improvements in ethylene yield and cost performance. At Petrobrazi, the petrochemical team recently completed the startup of a new process to produce maleic anhydride. Licensed from Scientific Design, this process offers the potential to reduce maleic anhydride manufacturing costs through the use of normal butane as a feedstock instead of the more costly benzene. However, as discussed in preceding sections and below, Petrobrazi should not continue to operate.

In discussions with site managements, we learned about useful and creative marketing efforts. At Petromidia, for example, sales of polypropylene to both domestic and export customers have increased dramatically. A small fabricated-products operation developed at the site now serves as a means to gain important knowledge of customer applications. Based upon their improved

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understanding of customer needs, the site marketing and manufacturing managers intend to enhance their effectiveness as polypropylene wholesalers.

In our visits to each of the petrochemical sites, we have observed instances of skill and energy. At the same time, we have observed serious weaknesses in the structure and the management of the sector, and in the operation of enterprises in the sector. These weaknesses must be addressed if the petrochemical sector is to be successfully restructured. Figure 5-1 presents these issues in relation to a value chain which links the petrochemical sector with the oil refining sector, the source of petrochemical feedstocks, and downstream chemical customers.

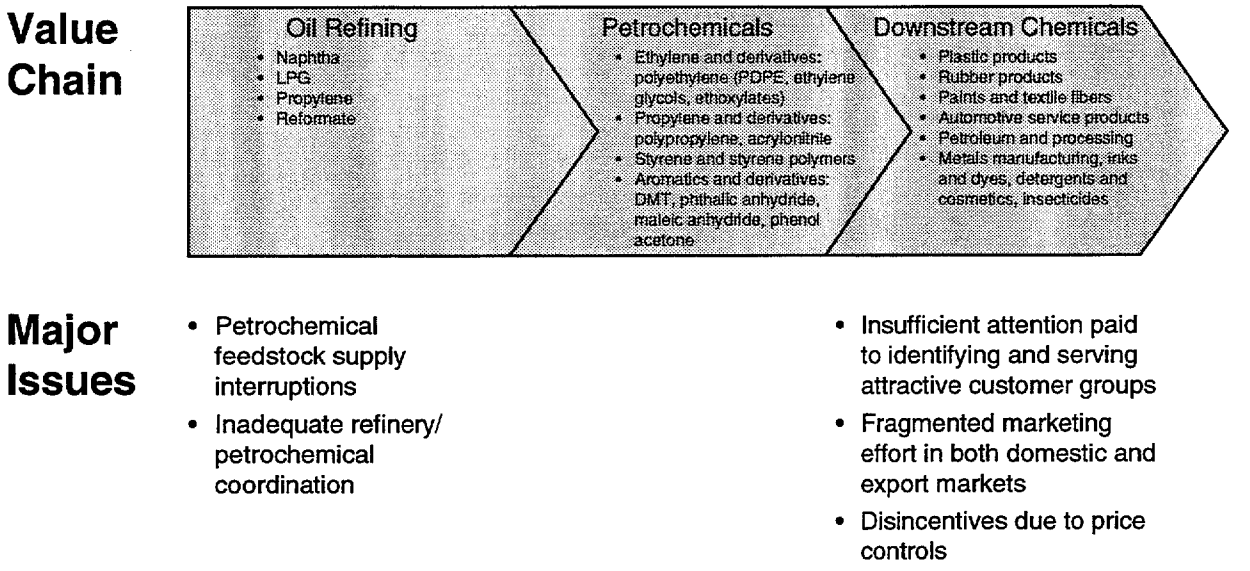

Figure 5-1 Romanian Petrochemicals

5.2.3 Issues to Be Addressed to Enhance the Effectiveness of Petrochemical Operations

- *Issue 1. Petrochemical Capacity Utilization Remains Low for Many Products.* Some capacity rationalization has occurred since the 1993 Chem Systems study was performed, especially in ethylene production. Also, operating rates have risen somewhat in response to rising demand. However, despite capacity reductions and higher operating rates, low capacity utilization is still keeping operating costs high.
- *Issue 2. Management Focus Is Weak at Many Sites Due to Diverse and Unrelated Operations.* Operation of too many noneconomic units continues to diffuse managements' attention. Where operational diversity is extreme, management attention to important tasks has been compromised.

- *Issue 3. Inadequate Levels of Integration Still Hamper Petrochemical Operations.* Stranded, nonintegrated units that are remote from feedstock supplies chronically operate at a cost disadvantage. In addition, inadequate coordination between refineries and the petrochemical units they supply has lessened the ability of nominally integrated sites to capture value through petrochemicals.
- *Issue 4. The Effects of Obsolescent Petrochemical Technology Are Still Apparent.* The problem of outmoded technology persists. In several cases, the existing noncompetitive processes cannot be revamped cost-effectively. The styrene polymer units at Petromidia and Arpechim are examples of outmoded technology.
- *Issue 5. Instrumentation and Process Controls Are Inadequate.* Petrochemical staffs lack the means to measure and control key process variables on a timely basis and are therefore unable to adopt optimal strategies to control raw material and energy usage.
- *Issue 6. Improvements Are Needed in Cost Reporting Systems.* While the use of cost data as a feedback performance tool is evident in some cases, communication between manufacturing and financial staffs is inadequate. This problem was noted particularly at Petrobrazi. Also, cost systems are generally not aligned with reporting needs. The problem of misalignment is specifically reviewed, later in this section, in relation to the Arpechim steam cracker.
- *Issue 7. Marketing Lacks Direction and Focus.* At most sites, the need to systematically identify attractive customer groups that can be effectively served through existing products has not been recognized. A corollary requirement is the abandonment of products that cannot add business value.

Issues 1, 2, and 3 are closely linked. Where the physical splintering of petrochemical manufacturing has led to redundant units, subscale and high-cost operations have obviously resulted. Economies of scale are important in all of the petrochemical processes. Low operating rates result in high production costs and impair the prospects for profitability.

Less obviously, the fragmentation of operations makes it more difficult for management and staff to focus attention on truly important issues and retards learning-based improvement. Focused management attention is a limited resource, a resource that is squandered when multiple, unrelated tasks must be performed across a wide span of activities. Also, due to the fragmentation of operations in Romania, petrochemical staffs cannot benefit optimally from the well-documented and favorable impact of learning-curve cost improvement. For example, it is well documented for ethylene-based and propylene-based products that manufacturing costs fall when experience is gained through cumulative production and when the incentive exists to reduce costs.

In multisite manufacturing, site-to-site communication is the only way to provide an adequate means to share experience from one site to another. In Romania, however, because of infrastructure limitations and because the enterprise managements are operationally independent

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of one another, such communication does not occur and little sharing of experience results. Petrochemical manufacturing must be consolidated to increase the rate of learning through experience. The physical concentration of production can enhance learning-curve benefits. The overall consolidation of production will lead to scale-based cost improvements and will accelerate experience-based advances in skills and methods.

Issues 4 and 5 highlight the limitations imposed by process technology and instrumentation. Where these limitations are severe, cost performance cannot be enhanced merely by improved operating practices, supervisory vigilance, or management direction. Investment is required. Process technology limitations and instrumentation needs are discussed below as part of the viability assessments of specific units.

Where performance measurement data are not captured, KPIs cannot be used to detect errors or opportunities. KPIs provide the manufacturing organization with economically oriented values that are vital to success. They direct management's focus on the improvements around which staff skills and energies can be effectively organized to create value.

Technical benchmarking against industry leaders is also impossible when performance data are not captured. Benchmarking compares the performance of a given petrochemical unit with the best demonstrated industry performance in order to identify significant opportunities for performance improvement. In a later section, the value of KPIs and technical benchmarking is reviewed with respect to the Arpechim steam cracker, the most important petrochemical unit now operating in the sector.

Performance measurement is essential if companies in the sector are to reduce variable costs, which are excessive relative to those of commercially oriented plants. Manufacturing cost data for the five sites indicate that raw material and energy account for 80 to 85 percent of total manufacturing costs. Each 1 percent reduction of both energy consumption and raw material usage for the petrochemical units assessed in this study would result in a cost reduction of more than $2 million per year.

Issue 6 points out the need to improve cost reporting systems. In several cases, cost reporting systems are not aligned with the natural operational boundaries of plant operations. Improved alignment can increase the relevance and value of reported information by providing cost feedback that operating staffs can more readily act upon. In this way, the financial function provides not only cost results, but also guidance for cost improvement.

Issue 7 emphasizes the need to refocus marketing efforts toward valuable products that serve customers. Petrochemical and commercial directors at Arpechim, Petrobrazi, and Petrotel have expressed reluctance to discontinue production of products that are neither cost-competitive nor value-adding. The reluctance to abandon these products is due, in part, to a desire to promote self-sufficiency in Romanian petrochemicals. In these cases, managers are clearly interpreting their mission in terms of physically supplying products to domestic customers for the purpose of avoiding imports even if that avoidance leads to a greater loss of economic value. Certainly

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imports point to domestic demand in downstream chemical businesses where opportunities should be analyzed. However, financial analysis alone should guide the decision to supply products in response to local or domestic demand.

The foregoing issues are elaborated upon in later sections covering the assessment of the viability of the operating units. Our recommendations are designed to permit the immediate rationalization and reorganization of operations to prepare the petrochemical sector for the effective implementation of strategic decisions.

5.2.4 Price Controls

We recommend changes in Romania's regulatory framework to facilitate the commercial restructuring of petrochemical operations. In particular, the control of prices, through both direct and indirect regulation, has impeded the commercial transformation of the petrochemical sector.

Prices of most primary petrochemicals, including propylene, benzene, toluene, para-xylene, and ortho-xylene, are directly regulated. All of the regulated primary petrochemicals, with the exception of toluene, serve as feedstocks for petrochemical processes. Benzene and toluene are also sold to downstream domestic and export chemical customers. Price levels for these materials are analyzed by the Department of Financial Operations of Rafirom, and this department periodically proposes changes in regulated price levels. The decision within the department to review price levels is prompted by changes in the lei/$US exchange rate, movements in international market prices, and requests from interested parties, including both the refining enterprises and their customers, the petrochemicals producers. When requests by the refining enterprises and their customers are in conflict, the Ministry of Industry (MoI) may become involved in a mediating role. Once Rafirom has established a recommended price level for each directly regulated petrochemical, the Rafirom proposal is reviewed by the Ministry of Finance (MoF), where authority resides to approve or veto the proposed pricing.

Figure 5-2 compares controlled prices and market prices for these primary petrochemicals during April 1995 – October 1995. The October price change moved regulated prices closer to market prices from their earlier levels approved in April. The prices approved in April ranged from about 45 percent to 140 percent of then current market prices, those approved in October, from about 80 percent to 120 percent of current market prices. While this change led to a more appropriate and realistic valuation of these materials, one more closely aligned with market conditions, the lifting of price controls is recommended. Rafirom, acting in concert with the MoF does not and cannot respond to changing market conditions on a timely basis. Furthermore, the current process for establishing price levels is subject to influence by parties having either financial interests or political agendas. Results may therefore reflect relative political influence rather than economic realities.

	Prices Approved in April 1995				Prices Approved in October 1995			
	Regulated Price, Lei/tonne	Regulated Price, $US/tonne	Estimated Market Price, $US/tonne	Regulated Price, as a % of Market Price	Regulated Price, Lei/tonne	Regulated Price, $US/tonne	Estimated Market Price, $US/tonne	Regulated Price, as a % of Market Price
Propylene	537,400	269	605	44	698,000	317	399	80
Benzene	750,000	375	315	119	600,000	273	254	107
Toluene	710,000	355	244	145	595,000	270	222	122
Para-xylene	637,800	319	728	44	1,775,000	807	830	97
Ortho-xylene	861,400	431	952	45	1,000,000	455	589	77

Notes:

Market price estimates are based on import parity (NW Europe price quotations). October 1995 market prices are based on September 1995 quotations.

Exchange rates: April 1995 – 2,000 lei/$US; October 1995 – 2,200 lei/$US.

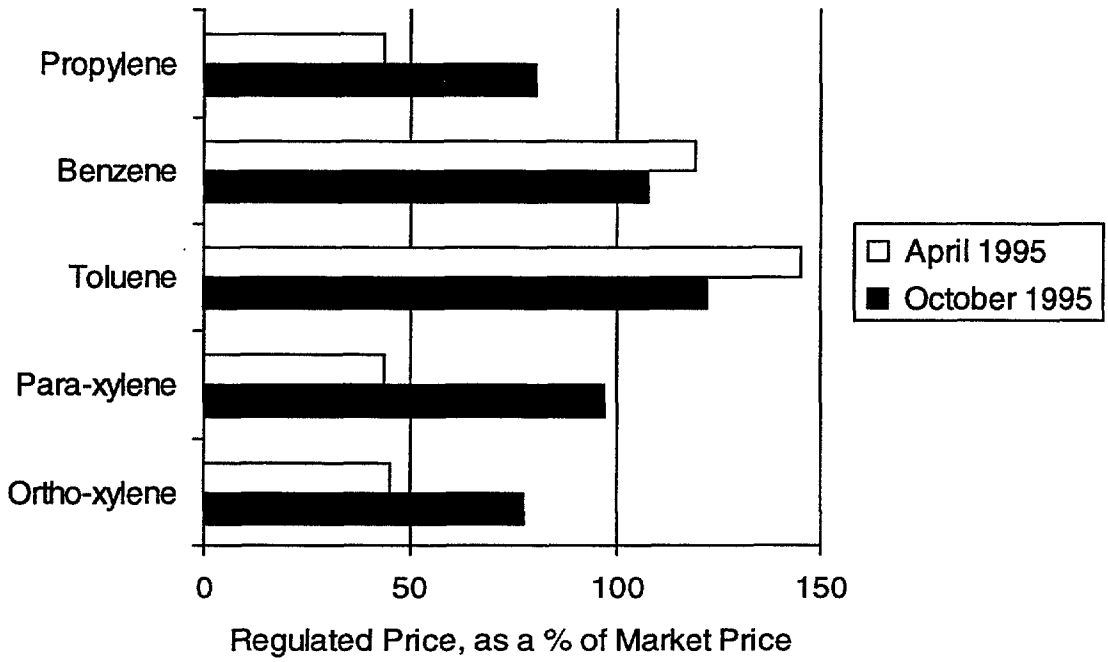

Figure 5-2 Price Controls – Directly Regulated Petrochemicals

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Para-xylene offers an example of the adverse effects of direct price controls. Para-xylene is a raw material for production of dimethyl terephthalate (DMT), a petrochemical required for textile fiber manufacture and for other downstream chemical applications. Demand for both DMT and its precursor rose during 1995 in response to increased textile fiber demand. The regulated price of para-xylene, far below market prices in April, contributed to a shortage of this material in Romania by diminishing the incentive to produce it. Reliance on market pricing would have helped to prevent this supply failure.

The prices of most petrochemical products in Romania are subject to *indirect* regulation, a process that involves both Rafirom and the MoI as mediators in negotiations between the refining enterprises and their downstream chemical customers. Individual customers have joined together to form associations within customer industries for price negotiation purposes.

A customer association typically asks Rafirom to sponsor negotiations with the refining enterprises. Government sponsors include Rafirom's Department of Financial Operations or Department of Production Strategy and may include the MoI's Department of Strategy for the Chemical Industry. Representatives of these government bodies arrange the negotiations, provide facilities for meeting, and attend the negotiations in mediating roles. Representatives of the MoF may also play a consultative role but do not have explicit authority to approve or reject the negotiated outcome. Negotiations culminate in a contractual price agreement that is binding on all signatories.

From the producer's perspective, these procedures provide a means by which undue government influence is exerted to suppress prices. All recent negotiations have been prompted by requests from customer associations, and government-sponsored price negotiations have resulted in prices that are persistently lower than those in international markets. A review of domestic prices versus export prices at Arpechim, for example, indicated that domestic prices were 50 to 80 percent of export prices for several products sold to both domestic and export consumers during the first half of 1995. Negotiations are likely to lead to the suppression of domestic product prices under indirect regulation because of Rafirom's strong influence over the refining enterprises as their feedstock allocator under supply-limited conditions.

We recommend that price controls of petrochemicals be removed. The removal of price controls will eliminate artificial influences created by both the direct regulation of primary petrochemicals and the indirect regulation of petrochemical products. We further recommend that laws or regulations be implemented to prevent collective price negotiations by either customer groups or selling groups.

Price is a key factor in competitive product positioning. At present, the enterprise managements are severely restricted in their use of this important marketing mechanism in their transactions with domestic customers. Elimination of both direct and indirect price regulation will remove these restrictions and permit commercial managers at the petrochemical sites to strengthen marketing programs through the effective use of product pricing.

5.2.5 Petrochemical Demand

Current petrochemical operations of the five major sites produce roughly 400,000 tonnes per year (tpy) of ethylene derivatives, propylene derivatives, and aromatics derivatives. Exports account for roughly 25 percent of production based on tonnage and roughly 25 percent based on market value. Significant volumes of these products are sold to domestic manufacturers of plastics products, synthetic yarns and fibers, paints and varnishes, and rubber products. Petrochemical products are sold in lower volumes to producers of automotive products, detergents, inks, dyes, and specialty metals, and for use in petroleum processing.

Table 5-2 presents current production volumes and projected demand through the year 2005. Aggregate production tonnage is projected to grow at about 5.0 percent per year during 1995 – 2000 and about 4.3 percent per year during 2000 – 2005.

Petrochemical product demand projections are estimated by making the initial (and imprecise) assumption that current production meets all demand within Romania. This approximation is necessary because information on domestic consumption and net exports is not available for most products. This demand table must of course be adjusted if new information reveals that current production does not meet domestic demand.

Domestic demand was projected for each petrochemical product based on current shipments to each domestic customer group and on estimated growth rates for each group. Estimates of current shipments were developed from information provided by Rafirom and supplemented by information from the manufacturing sites. The MoI has furnished estimated growth rates for the major customer groups. For certain low-volume customer groups, including ink and dye manufacturers, growth rates were not available and, in these cases, the projected Romanian GNP annual growth rate of 4.0 percent was assumed.

Export demand growth was estimated assuming that exports will escalate at a rate corresponding to the average annual projected GNP growth rate for Europe as a whole, roughly 3.4 percent during 1995 – 2000 and 3.2 percent during 2000 – 2005. Total demand was then computed as the sum of domestic and export demand.

These demand projections have influenced the assessment of the viability of petrochemical operations. Where unit processing and production costs are now unacceptably high due to low operating rates, costs have been reevaluated to determine whether cost performance is likely to improve significantly at expected future production rates. The demand projections also provide a means to identify near-term capacity constraints.

As shown in Section 5.3, this demand projection served as a framework for the evaluation of future capacity requirements. Alternate demand growth scenarios involving demand growth rates above the projected rates for specific products were also evaluated.

Table 5-2 Petrochemical Demand Projection (10^6 tpy)

Item	1995 Domestic	1995 Export	1995 Total	2000 Domestic	2000 Export	2000 Total	2005 Domestic	2005 Export	2005 Total
Ethylene Derivatives									
LDPE	34.6	19.5	54.1	43.8	23.0	66.7	55.3	26.9	82.2
HDPE	18.3	3.7	22.0	23.1	4.4	27.5	29.2	5.2	34.3
MEG	23.3	2.6	25.9	31.4	3.1	34.4	42.2	3.6	45.7
DEG + PEG	2.5	0.0	2.5	2.9	0.0	2.9	3.5	0.0	3.5
Ethylene for PVC Export	0.0	67.2	67.2	0.0	79.2	79.2	0.0	92.6	92.6
Propylene Derivatives									
Polypropylene	14.6	15.2	29.7	18.4	17.9	36.3	23.3	20.9	44.2
Acrylonitrile	24.3	49.4	73.7	36.9	58.3	95.2	36.9	68.1	105.1
Sodium Cyanide	1.8	1.1	2.9	2.2	1.3	3.5	2.7	1.5	4.2
Phenol	9.1	0.0	9.1	14.1	0.0	14.1	21.7	0.0	21.7
Acetone	5.1	0.3	5.5	7.9	0.4	8.3	12.3	0.5	12.7
Nonyl Phenol	0.4	0.0	0.4	0.5	0.0	0.5	0.7	0.0	0.7
Ethoxylates	4.0	0.0	4.0	4.9	0.0	4.9	6.0	0.0	6.0
Aromatics and Derivatives									
Benzene Sales	7.4	3.3	10.7	10.1	3.9	14.0	12.5	4.6	17.0
Toluene Sales	18.9	7.0	25.9	29.2	8.2	37.5	36.5	9.6	46.2
Xylenes (Mixed)									
Maleic Anhydride	1.9	3.4	5.3	2.7	4.0	6.8	3.9	4.7	8.6
Phthalic Anhydride	1.1	7.5	8.6	1.6	8.8	10.4	2.2	10.3	12.5
DMT	18.0	35.0	53.0	27.3	41.2	68.6	41.5	48.2	89.7
Carbon Black	16.3	0.0	16.3	21.9	0.0	21.9	29.5	0.0	29.5
Total	201.7	215.2	416.8	279.0	253.7	532.8	359.8	296.7	656.5
Export Shipments % of Total		23.6			21.8			20.7	
Aromatics Intermediates									
Benzene (MAN + Phenol)			17.8			26.3			42.2
o-Xylene (PAN)			9.2			11.2			13.5
p-Xylene (DMT) (Includes Toll/Import)			37.6			48.7			63.7
Benzene Total (Sales + Intermediates)			28.5			40.4			59.2

Average Growth Rates in Product Demand	1995 – 2000	2000 – 2005
(Tonnage), %/ Year	5.03	4.27

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5.3 ASSESSMENT OF VIABILITY

5.3.1 Assessment Scope

Figure 5-3 shows the general structure of current petrochemical operations, indicating major feedstock streams and products. The matrix indicates the petrochemical process capabilities of each plant site.

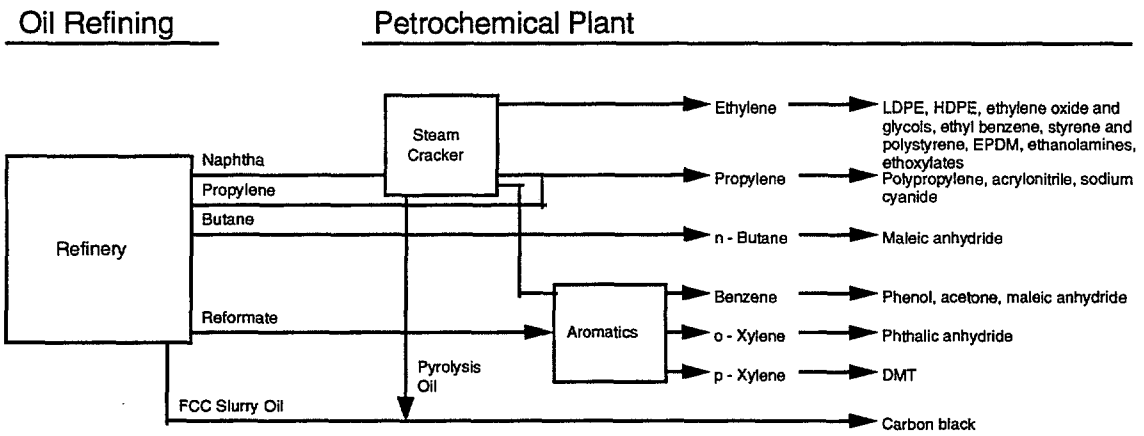
Steam cracking of naphtha and refinery gases produces ethylene, which in turn is converted to polyethylene (LDPE and HDPE), ethylene glycols, EPDM rubber, ethanolamines, ethoxylates, ethyl benzene, and styrene for polystyrene and ABS (acrylonitrile-butadiene-styrene polymer). Propylene from steam cracking and from refinery FCC units is converted to polypropylene and acrylonitrile (ACN). Arpechim, Petrotel, and Petrobrazi currently produce ethylene derivatives, and Petromidia's petrochemical plant, now out of service except for polypropylene, is capable of producing ethylene derivatives as well. Our study analyzed the viability of these ethylene-based products, beginning with steam cracking.

Aromatic precursors for petrochemical conversion include benzene, ortho-xylene, and para-xylene. This study does not fully cover the viability analysis of those aromatics units fed by pyrolysis gasoline and reformate because cost information was not made available for the unit at Petrobrazi, the largest of the aromatics units in current operation. Instead, the aromatics extraction units were incorporated into the PIMS refinery model. The analysis, however, does deal with petrochemical units converting aromatics to derivative products at Petrobrazi and at Arpechim.

5.3.2 Economic Model

To exploit their petrochemical capability, Romania's enterprises must identify operations that are capable of creating sustained economic value, and must direct resources to strengthen these operations. On the other hand, operations that are not currently creating value and not capable of future value creation must be discontinued to eliminate the cost burden they impose on the enterprises.

An economic model was developed to characterize value creation or destruction by each of the petrochemical units. First, the value of all products was determined based on market pricing. Product value includes the value of products sold to customers outside the sector, in domestic and export markets, and the value of intermediates transferred to downstream units and to other petrochemical sites. Next, all costs were evaluated. Costs included (1) the cost of raw materials, including the cost of petrochemical feedstocks, (2) the cost of utilities, (3) and fixed costs, including the costs of maintenance, direct labor, and allocated overhead, but excluding noncash depreciation and amortization of capitalized costs.



	Ethylene Derivatives										
	LDPE	HDPE	Ethylene Oxide	Ethylene Glycols	Ethyl Benzene	Styrene	Poly-styrene	ABS Polymers	EPDM	Ethanol-mines	Ethoxylates
Arpechim	WC	WC	WC	WC	WC	SD	SD	SD	WC		
Petrobrazi			SD	WC						WC	WC
Petrotel						WC	WC	WC			
Petromidia	SD	SD	SD	SD							
Rafo											

	Propylene Derivatives			Aromatics Derivatives									Carbon Black
	Polypro-pylene	Acrylo-nitrile	Sodium Cyanide	Benzene	Toluene	o-Xylene	p-Xylene	Phenol	Acetone	Phthalic Anhy-dride	Maleic Anhy-dride	DMT	
Arpechim		WC	WC	WC	WC							WC	WC
Petrobrazi				WC	WC	WC	WC	WC	WC	WC	WC	WC	
Petrotel	WC					WC	WC	WC					
Petromidia	WC			SD	SD	SD	SD					SD	
Rafo				WC	WC								

WC = working capacity SD = nonworking capacity (shut down)

Figure 5-3 Petrochemical Operating Structure, Primary Petrochemicals, and Products

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Transfer prices must be considered when the product of one unit serves as the feedstock for another unit. Transfer prices were determined in two ways. In the first approach, the two units were evaluated on the basis of integrated operation. The transfer price charged to the downstream unit was calculated as follows:

- The transfer price of the intermediate was calculated as the cost per tonne required for manufacture of the material by the upstream unit.
- Market values were assigned to the feedstocks for the upstream unit. Other operating costs incurred by the upstream unit (all raw material costs, utility costs, and fixed costs) were added to compute the manufacturing cost of the intermediate.

The product value assigned to the upstream unit for the intermediate was calculated as follows:

- The value of the intermediate was calculated as the netback value based on operation of the downstream unit.
- Market values were assigned to products from the downstream unit. Manufacturing costs incurred by the downstream unit (other raw material costs, utility costs, and fixed costs) were subtracted from product value to compute the netback value of the intermediate.

In this approach, the performance of each unit influences the viability assessment of the other unit. If either unit was judged to be nonviable, a second approach was tried.

In the second approach, the economic value of each unit was reexamined based on the estimated market value of the intermediate, and each unit was evaluated on a stand-alone basis. The price charged to the downstream unit was the estimated market value based on import parity. The product value assigned to the upstream unit was the estimated market value based on export parity. This approach treats the two units on an individual, nonintegrated basis and ensures that neither unit is judged to be nonviable because of inadequate performance by the other.

Once costs and product values had been determined for a given petrochemical unit, the ratio of cost to product value was computed. A value of less than 1 indicates positive value creation by operation of the unit; a value higher than 1 indicates value is being destroyed. Where a high cost/value ratio indicated unambiguously that value destruction was resulting from operation of the unit, the following additional questions were addressed to evaluate economic viability:

- Is value enhancement possible through simple means? Minor investments and improved operating procedures were evaluated.
- Will increased production in response to increasing demand lower the unit production costs to a sufficient degree to enable the unit to become economically viable? This evaluation depends on projected demand levels and on the level of fixed costs.

- Does the financial model indicate that value destruction occurred solely because of a low netback price from a downstream unit? If so, does an assessment based on the market price of the material indicate that the unit is otherwise viable?

If this evaluation revealed no way of significantly enhancing the value of the unit, the unit was judged to be economically nonviable. Where an alternate manufacturing site exists with the capability of making the product, a transfer of production to the alternate site was considered after first determining:

- Whether the alternate unit is economically viable
- Whether the alternate unit has adequate available capacity

Where a suitable alternate exists, a shift of production to that unit was recommended, followed by shutdown of the nonviable unit. For all nonviable units that were also studied by Chem Systems, those 1993 recommendations by Chem Systems have also been cited.

The transfer of production to an alternate unit provides a means to supply customers in the future. Where no such option exists, however, product imports must be evaluated as a source of supply to the downstream industrial customers. In those cases, available information regarding current domestic customers has been furnished.

Operating cost information was not available for several petrochemical units during the period of the study because those units were idle. In the case of idle units, we inferred viability by a comparison with operating units of comparable technology and scale. For example, Petrotel's styrenics units (styrene, polystyrene, and ABS) were in service and were judged to be nonviable. The corresponding units at Arpechim were idle during the study period. Because the Arpechim styrenics units are based on similar technology and operating scale, we inferred that the Arpechim units are also nonviable.

For redundant units, we tested the impact of closing one unit and consolidating all production into the other unit. In two specific cases, polypropylene and DMT, the analysis of individual units suggested that they were uneconomic owing to low utilization rates caused by the sharing of production volume. Low utilization rates led to very high per-unit costs. In these cases, we consolidated the total volume into the unit with lower per-unit costs and then found this unit to be viable. The more favorably positioned unit was deemed to be viable; the other unit, nonviable. On this basis, the Petromidia polypropylene unit is economically viable while the Petrotel unit is not, and the Arpechim DMT unit is economically viable while the Petrobrazi unit is not.

At Petrobrazi, the small operating units producing phthalic anhydride and maleic anhydride were found to be viable because of their cost/value ratios, but their positive contribution cannot economically sustain the operation of the Petrobrazi refinery. The decision to shut down the Petrobrazi refinery will disrupt the supply of feedstock to these units. These units cannot be

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operated economically in the absence of reliable and cost-effective feedstock sources. Therefore we recommend closure of these units.

5.3.3 Market Pricing

Because products sold domestically and many feedstocks provided domestically are subject to price regulation, market prices were estimated for these materials to ensure that economic model results were consistent with open market conditions. Prices covering naphtha, reformate, and FCC slurry oil and a number of other feedstocks supplied to petrochemicals from refineries are not subject to regulation. For these feedstreams, prices were based on export parity for naphtha and reformate, and on import parity for FCC slurry oil. For regulated feedstocks, including benzene and the xylenes, market prices were estimated based on import parity.

In certain cases, market prices for raw materials cannot be determined because the materials in question cannot be readily matched to globally traded products with equivalent properties and specifications. Examples include polybutadiene latex (PBL) and styrene-butadiene rubber (SBR) for styrene polymer manufacture at Petrotel and creosote oil for carbon black manufacture at Arpechim. In those cases, the domestic transfer prices reported by plant staffs were used. However, uncertainty in the pricing of PBL and SBR has an insignificant impact on the assessment of the viability of Petrotel's styrene polymer operation because those raw materials are used in very low volume.

5.3.4 Manufacturing Costs

The economic model must take into account all significant manufacturing costs. During the fact-gathering phase of the petrochemical assessment, cost data for 1994 operations and the first half of 1995 were reviewed with plant staffs. These data included feedstock usage figures, other raw material costs, utility usage levels, and fixed costs. Feedstock usages and feedstock market price estimates (determined as cited above) were used to establish feedstock costs. Reported costs were used for other raw materials, including catalysts, chemicals, and auxiliary materials. To estimate utility costs, a consistent set of utility unit costs for electricity ($/kWh), cooling water ($/tonne), steam ($/tonne), fuel ($/tonne), nitrogen, and instrument air ($/m^3) were used for all sites.

Fixed costs required special treatment. In most cases, reported fixed costs were much lower than fixed costs normally experienced in similar operations in international private-sector plants. A review of fixed costs indicated that this difference could not be explained by labor cost differences alone. Note that Chem Systems also found that the fixed costs reported by the plant staffs appeared to be unreasonably low.

Our review of fixed costs indicates that low reported costs are often due to the deferral of maintenance or to the underreporting of maintenance costs. To adjust maintenance costs for use in the financial model, sustainable maintenance costs have been computed as 4.0 percent of estimated facility replacement costs for those units producing solid polymer products and 3.0

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percent of estimated replacement cost for all other units. Maintenance cost adjustments are discussed below, in detail, for the Arpechim steam cracker. Low reported fixed costs may also result from low costs for liability insurance and reduced efforts for sales and marketing. These costs have not been analyzed systematically, but are probably small compared to maintenance costs.

For operations with relatively high fixed costs, unit costs of production were found to be very sensitive to changes in production rates. Where such a unit was found to be nonviable due to its current production rate, the unit cost effect of future production rates was also taken into account. Feedstock and other raw material costs were assumed to be fully variable with production rates. Utilities were assumed to be partially variable, in recognition of the fact that utility unit costs do not increase in direct proportion to production in petrochemical operations.

5.3.5 Judgments Based on Economic Model Results

In using the economic model to judge viability, one should bear in mind the model's financial basis. Recall that the economic model merely compares product value with manufacturing cost and takes no account of the investment returns demanded by owners and potential investors. Because the economic model does not take into consideration the opportunity cost of capital, its evaluation approach is very liberal or generous. In other words, units judged to be viable, with cost/value ratios less than 1, may not be financially attractive in the light of alternate uses of capital. A more thorough valuation approach, one taking into account working capital, risks associated with anticipated income streams, terminal salvage value, and potential exit costs, will be necessary to fully assess financial values from the standpoint of owners or investors.

Because the model relies on a liberal assessment of economic value, its results should be regarded very seriously in cases where nonviable units are identified. Nonviable units waste not only financial resources but also the management talent that is committed to them. Romanian petrochemical managers must evaluate the opportunity costs that their enterprises bear as a result and must focus on value-generating products that merit the commitment of their considerable talents and capabilities.

5.3.6 The Arpechim Steam Cracker and Dependent Units

5.3.6.1 Olefin Derivatives

Figure 5-4 indicates the processes that are fed by olefins (ethylene and propylene) from the Arpechim steam cracker. All of Arpechim's ethylene and propylene derivative units are currently in operation, with the exception of the styrene and styrene polymers units. In addition to the units shown, pyrolysis gasoline from the steam cracker feeds a downstream aromatics unit which produces benzene, toluene, and xylene. Arpechim supplies ethyl benzene as a feedstock for the production of styrene and styrene polymers at Petrotel and ethylene oxide for the production of ethoxylates at Petrobrazi. Also, the Arpechim carbon black unit is fed by FCC slurry oil and by pyrolysis oil from the steam cracker.

The Arpechim viability analysis began with a determination of the cash production cost of the olefins, ethylene and propylene, that were produced by the steam cracker for downstream units. Because costs reported by Arpechim indicate that maintenance charges were far below the levels normally associated with sustained operation, maintenance costs have been adjusted based on a rough estimate of steam cracker replacement cost.

The resulting ethylene cost of $420/tonne was used as a transfer price. This transfer price establishes the feedstock cost basis for assessment of the viability of the downstream units at Arpechim. This figure is roughly 12 percent below Chem Systems' 1993 cost estimate of $480/tonne.

Cost analysis of this unit was complicated by the inclusion of a portion of the pyrolysis gasoline hydrogenation costs with the costs reported for the unit that extracts aromatics. This method of specifying costs does not permit straightforward assessment of steam cracker costs and complicates benchmarking against competitive steam cracker installations elsewhere. In our analysis, costs for these two units were combined, and the values of aromatics by-products were credited to the steam cracker.

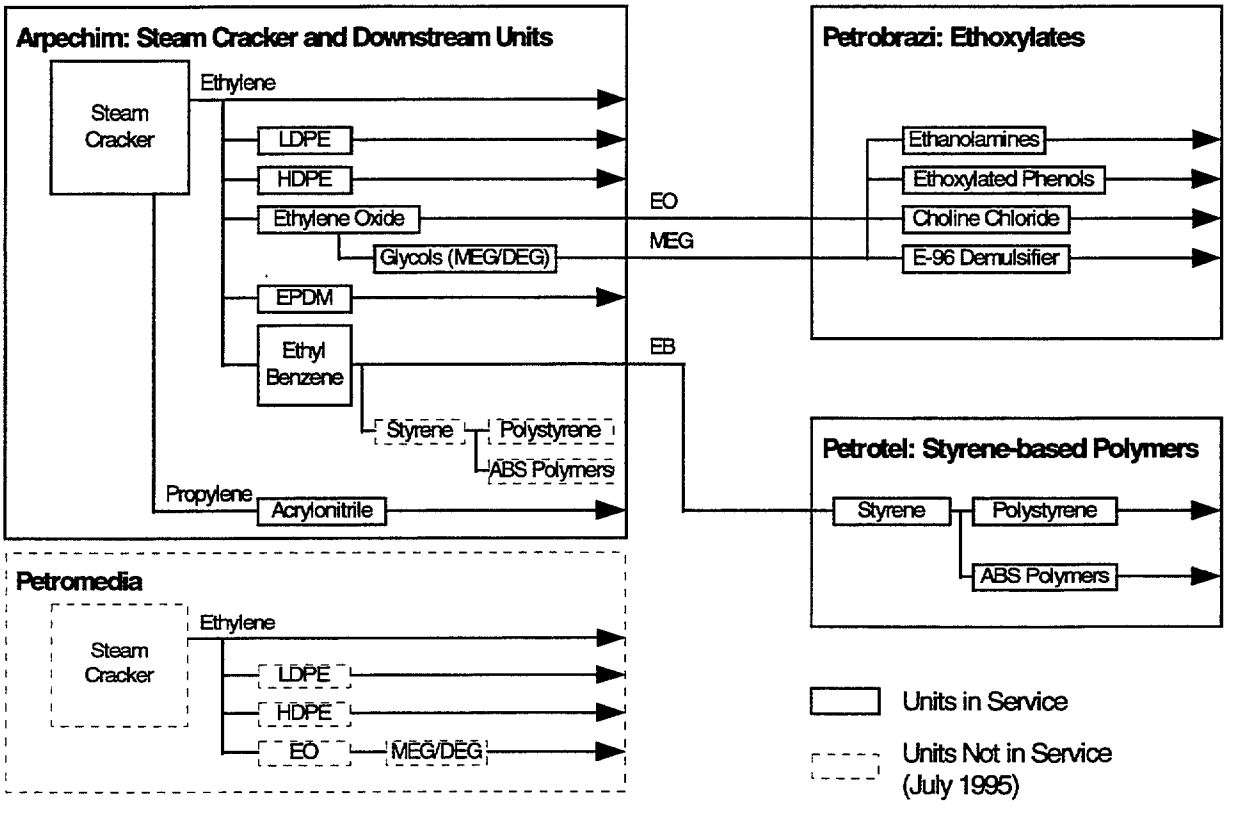

Figure 5-4 Ethylene Derivatives and Acrylonitrile

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Available data indicate an ethylene yield of 30 percent of cracker feed. Consultations with the Arpechim staff and with a Bechtel technology specialist have brought out these points:

- Fuel gas, a by-product stream accounting for an estimated 30 percent of cracker output, is not metered. This stream is assumed to be the residual after all other material streams have been accounted for. This procedure leaves material losses in doubt and hence leaves in doubt the true ethylene yield.
- An increase in ethylene yield (to 36 percent) is expected as a result of a planned revamp project.
- While an increase from 30 to 36 percent in ethylene yield is significant, the improved yield falls short of the estimated attainable yield of 37 to 41 percent.

Given the great importance of the Arpechim steam cracker for the overall competitiveness of ethylene derivatives in Romania, several steps are recommended:

- Establish processes and reporting that will segregate the steam cracker performance from the aromatics operation for measurement and costing purposes.
- Install appropriate instrumentation to measure fuel gas, and ensure that all other output stream and feed streams are accurately measured. Use metered values to assess both material losses and product yields, and define a steam cracker KPI based on each of these measurements. Material loss and yield can be usefully expressed as a percentage of steam cracker feed. Use these KPIs for routine monitoring of steam cracker performance. Investigate and act on short-term increases in losses or decreases in yield.
- Benchmark this unit to other competitive steam cracker installations for competitive evaluation of losses and yield. Investigate and act on appreciable discrepancies between Arpechim performance and best demonstrated performance.
- Resolve the elements of the discrepancy between the yield expected after revamp and the estimated attainable yield.

Thus, the Arpechim steam cracker provides an illustration of improvements in cost reporting, process monitoring, and technical benchmarking that are needed throughout the petrochemical sector. Operating cost incentives compel this effort. In the case of the Arpechim steam cracker, a material loss of 1 percent of feed results in an annual cost exceeding $500,000.

5.3.6.2 Viability of the Arpechim Units

Calculated cost/value ratios appear below. Two units, producing ethyl benzene (EB) and EPDM, have extremely high cost/value ratios.

High EB costs can be largely explained by operating scale. This unit currently operates at about 20 percent of capacity, and its capacity is small with respect to world-scale units. Because this

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unit supplies ethyl benzene for styrene manufacture at Petrotel, the assessment of this unit is influenced by the performance of the Petrotel styrenics operation.

A review of the criteria for viability leads to the conclusion that the unit is nonviable, for the following reasons:

- No significant improvement can be achieved through minor investments or operating changes.
- An increased production rate will not lead to viable operation.
- The cost/value ratio given in Figure 5-5 is based on netback evaluation of the ethyl benzene consumed by the Petrotel styrene unit. The EB unit remains nonviable if a market value is assumed for the sale of ethyl benzene.

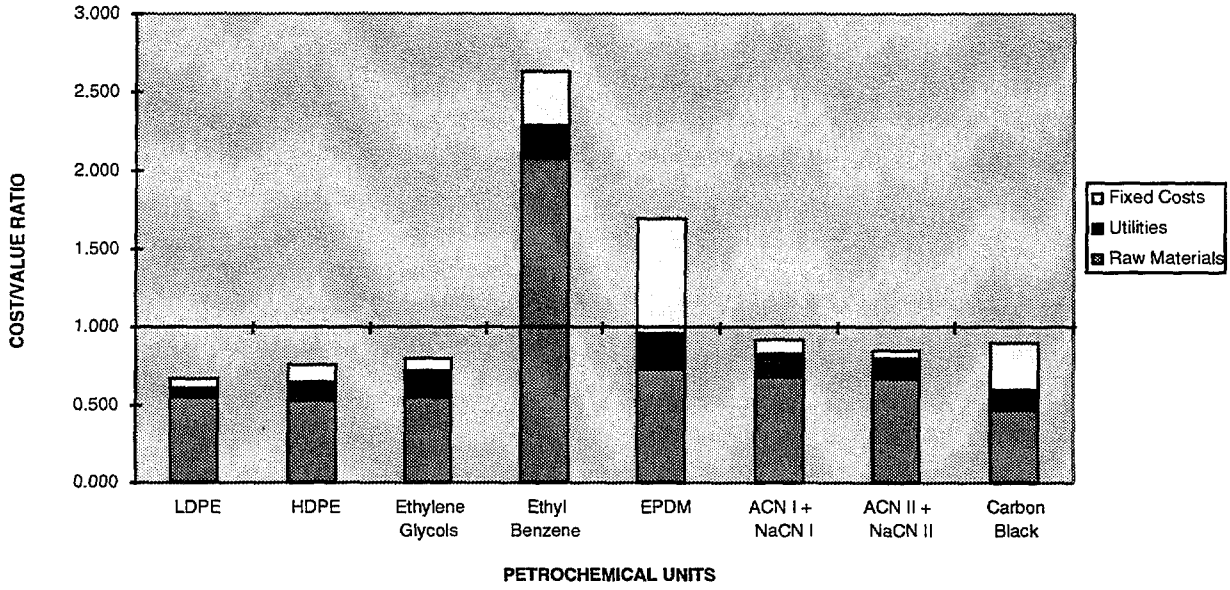

Figure 5-5 Arpechim Viability Assessment

We recommend that the Arpechim EB unit be shut down. Chem Systems also recommended shutdown of this unit. The Petrotel styrene unit, the principal consumer of Arpechim's ethyl benzene, is assessed in the next section.

Similar reasoning applies to the EPDM unit. This unit currently operates at about 20 percent of capacity, and its capacity of 3,000 tpy is less them one-tenth the capacity of competitive world-scale units. In the case of EPDM, the current Romanian transfer price to domestic customers was used because no equivalent standard traded product can be identified. The Arpechim unit is simply incapable of meeting the product quality standards that have been established by globally competitive EPDM producers.

A review of the viability criteria again leads to the conclusion that the unit is nonviable. We recommend shutdown of the Arpechim EPDM unit and importation of EPDM. Current domestic customers purchase EPDM from Arpechim for the manufacture of tire sidewalls and other automotive rubber products. Chem Systems did not make a recommendation regarding this unit.

5.3.6.3 Viability of the Styrene and Styrene Polymer Units at Petrotel

Figure 5-6 shows the Petrotel processes for styrene, polystyrene, and ABS; Figure 5-7 indicates high cost/value ratios for the units and for the site. About 60 percent of current styrene production is consumed in the production of styrene polymers. The styrene unit has been

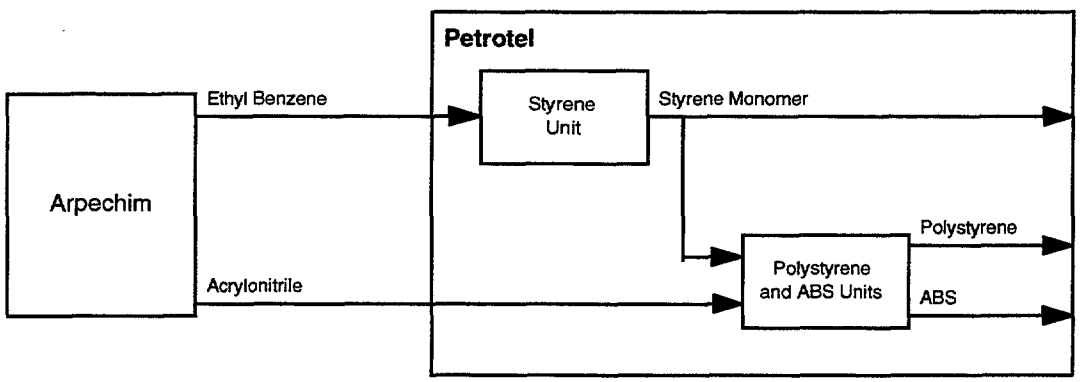

Figure 5-6 Petrotel – Styrene, Polystyrene, and ABS

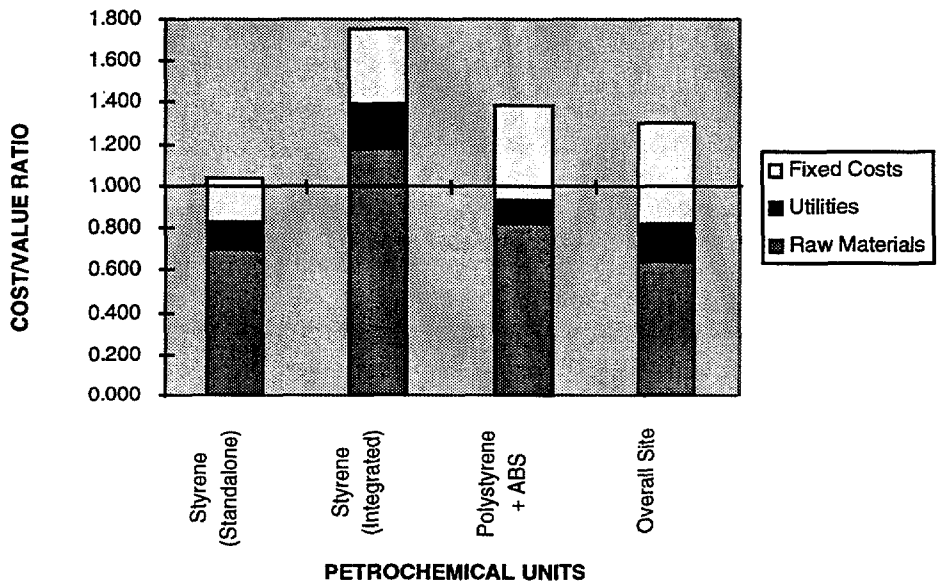

Figure 5-7 Petrotel Viability Assessment

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assessed on both an integrated basis, reflecting transfer of 60 percent of its output to the polymer unit, and on a nonintegrated basis, assuming the sale of all styrene at market price. Neither assessment indicates an economically viable operation.

The high cost of polystyrene and ABS production is partly a consequence of the installed technology, which is based on a costly batch polymerization process followed by rate-limiting centrifugation and drying steps. This technology is highly inefficient, and no revamp option is available.

Transfer of Petrotel's polystyrene and ABS production to the Arpechim styrenics units would yield little benefit, since with minor exceptions, those units are based on similar technology. For example, we believe the Arpechim process for conversion of ethyl benzene to styrene is even less efficient than the Petrotel styrene process because the Petrotel process is designed to provide more uniform reactor temperature control. The Arpechim polystyrene unit is capable of producing expanded polystyrene through pentane injection in the polymer finishing step, but this process feature does not represent a significant advantage given the high operating cost of the overall process.

The transfer of production to Arpechim would more closely integrate styrenics with the ethyl benzene unit, reducing material losses as well as the costs of inventory and coordination. However, because these cost burdens were not incorporated into the assessment of the Petrotel units, the elimination of these costs cannot alter the fundamental conclusion that the styrenics units at Petrotel are nonviable.

We recommend shutdown of the polystyrene and ABS units at both Petrotel and Arpechim and importation of these products. Roughly 90 to 95 percent of current polystyrene shipments are high-impact polymers sold to domestic manufacturers of home appliances, consumer electronics products, and footwear. ABS is used in the manufacture of similar products, as well as in the manufacture of food contact appliances. Chem Systems recommended shutdown of the styrenics units at both Petrotel and Arpechim.

5.3.6.4 Viability of Ethoxylates at Petrobrazi

The ethoxylate section of the Petrobrazi petrochemical plant comprises several small units producing low-volume products using ethylene oxide feedstock supplied from Arpechim. These products include ethoxylated phenols, ethanolamines, demulsifiers, choline chloride, polyethylene glycols, and antifreeze. The information furnished by the Petrobrazi staff was not adequate for a viability assessment, and the Petrobrazi staff declined to supply the needed data.

In the absence of full information on costs, usages, and product volumes, reliance was placed on the 1994 income statement for Petrobrazi petrochemicals. This income statement supplied profit-and-loss information segregated by product and indicated a substantial loss for ethoxylates. Combined results for ethoxylated products indicated a loss equivalent to roughly 47 percent of the value of products sold.

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The following factors adversely influence the viability of the ethoxylate units at Petrobrazi:

- The ethoxylate units are essentially unrelated to other petrochemical and refining operations at Petrobrazi in terms of process technology or markets served.
- All feedstocks, including ethylene oxide, are purchased from other chemical sites. The procurement of ethylene oxide, a volatile material, involves railcar transport from Arpechim and several transfer steps. Ethylene oxide shipping losses are not known.
- All of the ethoxylate units are small in scale, and all currently operate at low production rates relative to their capacities.

In addition, polyethylene glycols and antifreeze accounted for roughly 25 percent of product tonnage in the first half of 1995. A portion of this production can be made at Arpechim, the ethylene oxide feedstock source.

Given the above information, we recommend the shutdown of the Petrobrazi ethoxylate units and the transfer of glycol-based products to Arpechim where feasible. Domestic customers currently purchase ethoxylates from Petrobrazi for a variety of uses. Choline chloride is sold to the agricultural sector for use as a livestock growth stimulator. Other uses of ethoxylates include detergent synthesis, explosives, and petroleum processing applications, including aromatics extraction, gas desulfurization, and oil demulsification. Chem Systems did not provide recommendations regarding these units.

5.3.7 Polypropylene Production at Petromidia and Petrotel

5.3.7.1 The Petromidia and Petrotel Units

Polypropylene is now produced at both Petromidia and Petrotel. The two polypropylene units have the same production capacity, 60,000 tpy, and employ the same process technology. Current polypropylene demand is estimated at 30,000 tpy, roughly 50 percent of the capacity of a single unit and 25 percent of the capacity of the two units taken together.

Neither unit is integrated with an operating propylene source that is capable of providing sufficient propylene for sustained operation. Each unit must rely on propylene supplied at low volume from the local refinery, supplemented by outside propylene purchases. Chemical-grade propylene from the FCC of each refinery is purified to polymerization specifications using distillation equipment associated with the local steam cracker located within the petrochemical plant. Figure 5-8 illustrates the operating configuration of both propylene units.

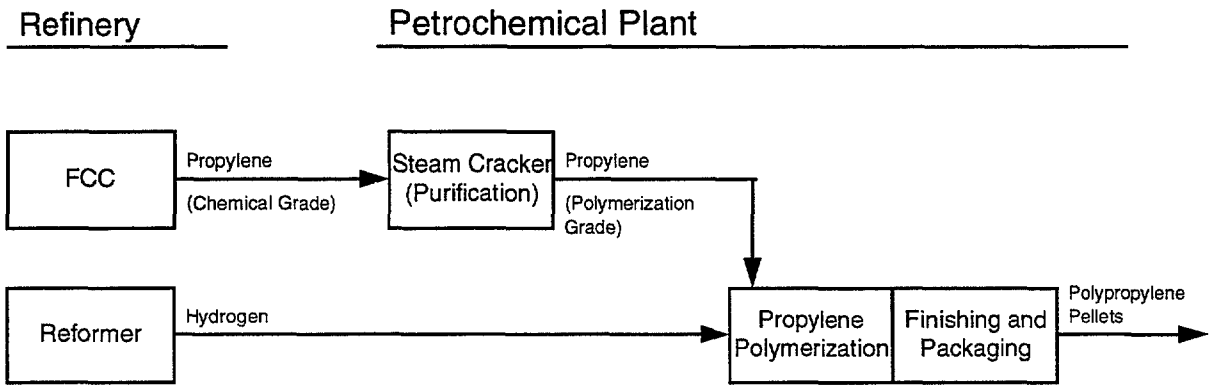

Figure 5-8 Operating Configuration of Polypropylene Units at Petromidia and Petrotel

Continuous operation based on FCC propylene alone is not feasible because the supply is too small. In the absence of additional propylene, batched operation is necessary, with alternating periods of operation and shutdown. At Petromidia, propylene from the local FCC has been supplemented by outside feedstock purchases of both chemical-grade and polymerization-grade propylene to permit extended polypropylene operating runs.

Petromidia's polypropylene unit has operated in all years since its startup in 1988. The Petromidia steam cracker has been operated successfully and could be restarted in the future to provide sufficient propylene volume to supply the Petromidia polypropylene unit at capacity. Petrotel's polypropylene unit has experienced lengthy shutdown periods; for example, it was restarted in July 1995 after a shutdown lasting 18 months. The Petrotel steam cracker was disabled in a serious accident and only its back-end purification system is now operable. Therefore, no foreseeable scenario can provide the Petrotel unit an integrated source of polymerization-grade propylene that is adequate to sustain its operation at its capacity production rate.

Petromidia is the more experienced of the two plants in polypropylene production, and its staff has implemented several improvements and innovations. Petromidia's product handling and shipping capabilities are vastly superior to Petrotel's. Petromidia's advantages include superior packaged quality and bulk product shipment capability. Petromidia also has developed an onsite pilot plant where plastic products, including film bags, bottles, and pipe, are produced under test conditions. The Petromidia staff intends to utilize this pilot plant to strengthen the company's position as a polypropylene wholesaler through an improved understanding of customer applications and product performance requirements.

5.3.7.2 Viability Assessment

Application of the viability model to the polypropylene units involved two special considerations. First, no recent cost data were available for the Petrotel unit because of its prolonged outage during 1994 and early 1995. Second, a cost basis for chemical grade propylene, the major feedstock, had to be established.

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When a market price based on international trade was applied to the chemical-grade feedstock, the financial assessment indicated a high cost/value ratio based on Petromidia's 1995 operating costs for polypropylene – total costs, including steam cracker operating costs for propylene purification, exceeded feedstock value. Since no practical means currently exist for refineries to trade propylene in world markets, feasible local uses provide the only means for establishing price. For this reason, it could be argued that FCC chemical-grade propylene should be priced at its fuel value at all Romanian sites.

In our analysis, an estimated market price (assuming international trading capability) was used. Market pricing supports the goal of analyzing Romania's petrochemical operations in a manner consistent with market conditions in the long run. This approach is also consistent with the long-range requirements of regional and global competitiveness.

In the absence of cost data for Petrotel, Petromidia's cost information for 1995 was applied to both units on the basis of equivalent technology and capacity. This approach probably understates Petrotel's costs because of Petromidia's greater cumulative experience in polypropylene manufacture. Petromidia's greater experience suggests that its operating costs are lower because of greater learning-curve benefits.

The use of equivalent cost data for both Petromidia and Petrotel provides a measure of the cost penalty for operation of two units rather than one. Figure 5-9 gives cost/value ratios for four operating scenarios.

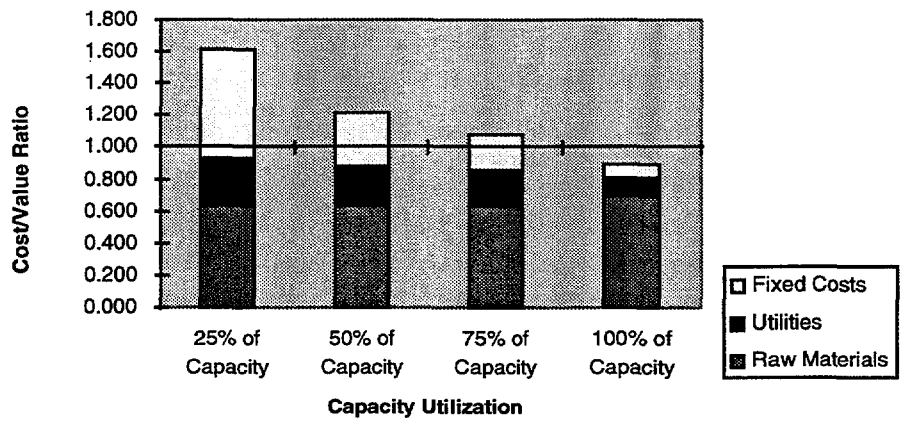

Figure 5-9 Polypropylene Viability Assessment

In the first scenario, current polypropylene volume is equally divided between Petromidia and Petrotel and each operates at 25 percent of capacity. In the second scenario, current volume is produced by a single unit operating at 50 percent of capacity. In the third scenario, a single unit

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operates at 75 percent of capacity, producing a volume of polypropylene consistent with demand levels in the year 2005, based on the demand projection presented earlier.

In the last scenario, full capacity utilization is assumed, and the polypropylene unit is supplied with polymerization-grade propylene at an estimated market price. The cost/value ratio shown above at 100 percent of capacity is an upper estimate of this ratio because polymerization-grade propylene could probably be supplied by a local stream cracker at a transfer price lower than the estimated market price. Thus, if future operation of the Petromidia steam cracker is feasible, the viability of the Petromidia polypropylene unit would be significantly enhanced. Cost-effective operation of the Petromidia steam cracker is feasible only when the demand for ethylene-based products justifies sustained steam cracker operation. The startup of the Petromidia steam cracker to supply both ethylene and propylene in response to rising polyolefin demand is reviewed elsewhere in this report.

This viability assessment illustrates the severe disadvantage that high fixed costs impose on petrochemical units operated at production rates that are low relative to capacity. Current propylene operation should be limited to a single unit. We recommend operation at Petromidia (rather than Petrotel) because of Petromidia's greater experience level, its shipping capability, its export position, and its superior marketing program. In addition, an integrated, cost-effective source of propylene for future operation is potentially available only at Petromidia.

Given Petromidia's decisive advantage, the Petrotel unit is nonviable because:

- Petrotel's operating costs cannot be improved by simple means.
- Based on the demand projections, near-term demand does not justify operation of the Petrotel unit.

The need for Petrotel's polypropylene capability might be argued under a demand scenario involving high short-term polypropylene requirements. However, the fixed costs for combined operations of the Petrotel steam cracker purification system and the Petrotel polypropylene unit are simply too high to justify continued polypropylene production at Petrotel. Furthermore, Petrotel's erratic, low-volume operation precludes real improvement in manufacturing effectiveness.

We recommend shutdown of the Petrotel polypropylene unit. The Chem Systems study also recommended shutdown of this unit.

5.3.8 Aromatics Derivatives

5.3.8.1 Aromatics Production

Benzene, toluene, and mixed xylenes (collectively, BTX) are currently produced at Petrobrazi, Arpechim, and Rafo. The aromatics unit at Petromidia is not in service. At Petrobrazi, a xylene separation unit produces the xylene isomers para-xylene and ortho-xylene. Projects planned at Petromidia and Rafo will, if implemented, provide the capability to produce para-xylene and

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ortho-xylene through the installation of PAREX separation technology licensed from UOP. The PAREX process, based on molecular sieve absorption, is also scheduled for installation at Petrobrazi to improve para-xylene yields.

The aromatics units with xylene isomer separation at Petrobrazi, Petromidia, and Rafo have been incorporated into the PIMS refinery model. The overall refinery optimization by PIMS will allocate reformate feedstock to these aromatics units.

The viability of units that convert para-xylene, ortho-xylene, benzene, and propylene to petrochemical products is assessed below. The assessment also covers the new butane-based process to produce maleic anhydride. Figure 5-10 shows the units at Petrobrazi that produce dimethyl terephthalate (DMT), phthalic anhydride, maleic anhydride (from two different precursors), acetone, and phenol. The Petrobrazi refinery is capable of producing feedstocks for all those processes.

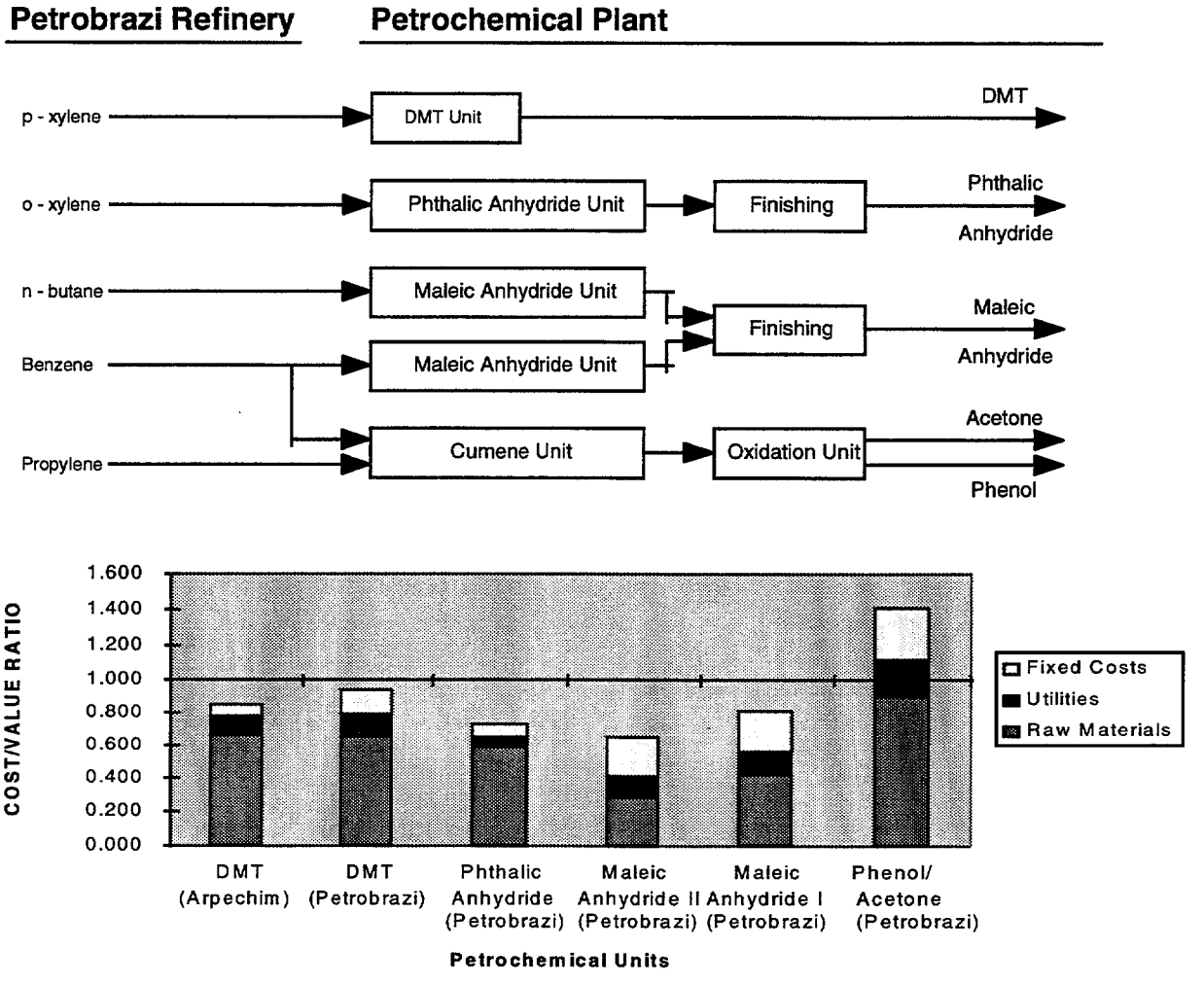

Figure 5-10 Aromatics Derivatives Flowchart and Cost/Value Ratios for Petrobrazi

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Since DMT is also produced at Arpechim, the Arpechim unit is compared with the Petrobrazi unit in the bar chart in Figure 5-10. The DMT unit is the only unit at Arpechim that is not integrated with its steam cracker. Arpechim must purchase the major DMT feedstock, para-xylene, from outside sources. A third DMT unit, at Petromidia, is now shut down.

5.3.8.2 Viability Assessment

Figure 5-10 shows the cost/value ratios for the six units. Note that the cost/value ratio for the phenol/acetone unit is high, indicating value destruction. In fact, conclusions regarding this unit are difficult because the cost data provided by the Petrobrazi staff were incomplete and because production outages (caused by refinery FCC outages and other feedstock interruptions) severely penalized the phenol/acetone unit's cost performance during the data collection period.

Arpechim's lower cost/value ratio for DMT is not surprising since its DMT production rate is higher, as shown in Table 5-2.

Table 5-2 Comparison of Arpechim and Petrobrazi Production of DMT

Item	Arpechim	Petrobrazi
Annualized DMT volume, 10^3 tpy	35	18
Nominal DMT capacity, 10^3 tpy	70	50
Current DMT capacity utilization, %	50	36

At present, DMT utilization levels are low for both the Arpechim and the Petrobrazi units. Because only the Arpechim unit has adequate capacity to meet current demand, production can be consolidated only by halting the production at Petrobrazi. Therefore, we recommend the consolidation of DMT production at Arpechim and the shutdown of the Petrobrazi DMT unit. Operation of the third DMT unit at Petromidia, does not appear justified for the foreseeable future.

Figure 5-10 indicates low cost/value ratios for the Petrobrazi units that produce phthalic anhydride and maleic anhydride. The decision to close the Petrobrazi refinery will, of course, disrupt current feedstock supplies to all of the petrochemical units producing aromatic derivatives at Petrobrazi. While the anhydride units appear to be economically viable, these operations cannot be sustained in the absence of reliable and cost-effective feedstock sources. We therefore recommend closure of the Petrobrazi units producing phthalic anhydride and maleic anhydride as well as the unit producing phenol/acetone.

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5.4 STRATEGIC RECOMMENDATIONS

5.4.1 Petrochemical Opportunity

The rationalization steps presented in the previous section will lead to a more viable and focused manufacturing system. Rationalization will strengthen the manufacturing base to meet growing domestic and regional demand.

Particularly in the area of polyolefins, demand scenarios should be considered that take into account the potential requirements of new customer groups. Based on a review of polyolefin demand with Rafirom, potential demand for film products (packaging) for agricultural uses and for cement packaging and other heavy-duty packaging applications may increase domestic demand for polypropylene, low-density polyethylene, and high-density polyethylene by roughly 20,000 to 25,000 tpy by the year 2000. Figure 5-11 illustrates this polyolefin demand scenario as an increment to the demand projection presented earlier.

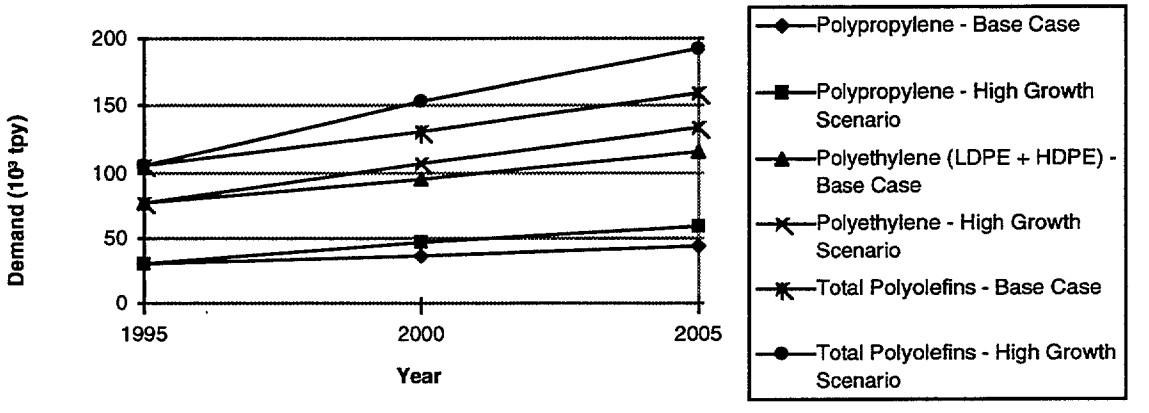

Figure 5-11 Polyolefin Demand Scenarios

The opportunity to meet rising petrochemical demand from a strengthened operational base must be balanced by a keen awareness of competitive threats:

- The rationalized system in Romania will continue to operate at a cost disadvantage relative to leading global competitors, some of which will enter the Romanian market.
- Limitations in Romania's installed process technology will restrict product flexibility, quality, and product value relative to major foreign competitors.
- International petrochemical producers pose a continuing threat to Romania's exports.

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The cost advantage enjoyed by major competitors results from both scale advantages and process advantages. For example, the capacities of leading Western European polypropylene plants lie in the range of 100,000 to 300,000 tpy, compared to Petromidia's capacity of 60,000 tpy. A comparison of polyethylene plant capacities reveals a similar contrast; Arpechim's LDPE and HDPE capacities of 80,000 tonnes and 60,000 tonnes, respectively, are small with respect to the capacities of global cost leaders. Leading Western European producers also benefit from technology advantages. For example, linear low density polyethylene (LLDPE) technology offers processing flexibilities that improve production costs and broaden the range of feasible value-added polymers.

A review of petrochemical exports reveals general weakness in Romania's commercial position. Practically all exports are sold through chemical traders on a spot basis and without long-term contractual commitments. Efforts by both the enterprises and by Romanian export agents to secure term contracts have been unsuccessful. Site commercial managers and export agents interviewed in Romania expressed the opinion that export customers, particularly those in Western Europe, are unwilling to accept term contracts because Romania is not perceived to be a fully reliable supplier. The reluctance of export customers to approve term contracts probably reflects a view of Romania as a marginal petrochemical supplier and an appropriate source to fill only temporary product needs.

5.4.2 Petrochemical Strategy

5.4.2.1 Strategy Summary

A balanced review of these opportunities and threats leads to two recommendations:

- Enhance the cost-effectiveness of the sector by maintaining high capacity utilization to satisfy rising demand as production rates increase
- Enhance marketing effectiveness by targeting viable and growing domestic customers and by forming direct relationships with export customers, rather than intermediary agents

These recommendations imply two significant changes in operational and marketing management: a willingness to selectively forgo short-term sales, and unifying mechanisms in petrochemical management to effectively coordinate operational changes.

5.4.2.2 Capacity Utilization

An appropriate strategy for capacity planning will be an essential element of Romania's strategy for manufacturing cost control. Figure 5-12 presents three fundamentally different capacity strategies: in the first strategy, capacity is added before demand arises; in the second, capacity increments are planned to roughly match demand; and in the third, capacity lags demand. The appropriate choice of strategy depends on a weighing of financial risks. Where lost potential sales result in an unacceptable opportunity cost, the first strategy is appropriate. Where high unit costs of production pose an unacceptable risk, the third strategy is appropriate.

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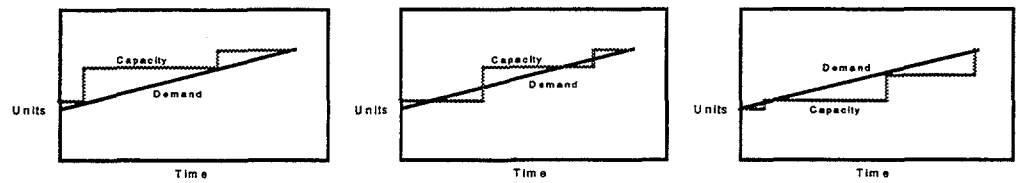

Planning Policy:	Capacity leads demand	Capacity/demand equilibrium	Capacity lags demand
Advantages:	Effective response to unanticipated demand	Reduced risk in case actual demand is different from projected demand	High capacity utilization and low unit cost of production
Disadvantages:	Low capacity utilization and high unit cost of production	Intermediate risks of high production costs and lost sales	Lost sales

Figure 5-12 Three Capacity Strategies

The second, intermediate strategy is appropriate when demand growth rate cannot be projected with high accuracy and when feasible capacity increments are large (and costly) with respect to incremental demand. In such a situation, the first strategy would lead to very low capacity utilization and high costs following the expansion of capacity; the third strategy would lead to a very high opportunity cost due to lost sales prior to the expansion of capacity. An enterprise that adopts the second strategy is compelled to forgo sales selectively when capacity falls short of demand. The second strategy is recommended for the management of Romanian polyolefins and for the other major petrochemicals assessed within the scope of this project.

In broad terms, capacity planning for Romanian petrochemicals has historically been conducted in accordance with the first strategy, leading to excessively high costs. These costs have been explicitly reviewed for both polypropylene and DMT. Our viability assessments lead to recommendations for rationalization to create a manufacturing system that can be effectively managed under the second strategy, balancing the risk of high production costs against the risk of lost sales. Figure 5-13 presents a two-step scenario for the expansion of ethylene capacity which is consistent with this strategy. The first step represents the completion of the planned Arpechim steam cracker revamp, the second the startup of the Petromidia steam cracker. The graphic indicates a production shortfall prior to each of the capacity increments. The allure of short-term sales opportunities, however, must be resisted for the sake of high-capacity utilization and low unit costs under this approach.

In fact, the ethylene capacity increment shown (100,000 tpy) is about half of the full capacity of the steam cracker at Arpechim. Operation at this production level would require partial shutdown of furnace capacity and operation of the compression and purification sections of the steam cracker unit at high recycle rates. We have assumed that this production rate is the lowest feasible operating level for reasonable steam cracker operation and control.

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5.4.2.3 Petromidia Steam Cracker Startup

Figure 5-13 indicates startup of the Petromidia steam cracker prior to the year 2000. The optimal startup schedule cannot be precisely determined based on current information. Table 5-3 shows some of the key factors that will influence the timing of this decision.

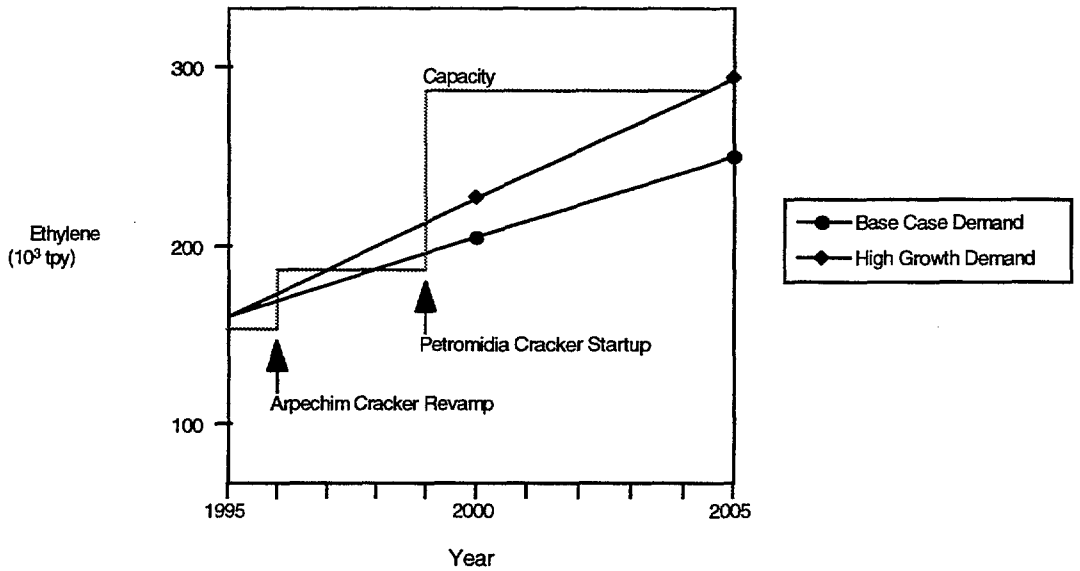

Figure 5-13 Ethylene Capacity Expansion

Table 5-3 Factors Affecting Startup

Issue	Impact on Startup Timing
Potential rapid growth in demand for ethylene derivatives	High growth in demand would permit cost-effective steam cracker operation at an earlier date.
Rapid demand growth in propylene derivatives, creating an overall propylene shortage	Increased propylene requirements for derivatives including polypropylene and ACN, coupled with unanticipated problems in the transport of FCC propylene, could threaten propylene supply for polypropylene manufacture at Petromidia.
Capacity constraints affecting Arpechim's polyethylene or glycol units	Very high near-term demand growth in HDPE, LDPE, or glycols could create a derivative capacity constraint at Arpechim, with lost sales in spite of adequate ethylene supply. The resulting sales opportunity would increase the incentive to accelerate the Petromidia steam cracker startup.

5.4.2.4 Marketing

The enterprises must improve their understanding of domestic and export customers in order to identify attractive customer groups and to develop effective strategies for serving them. Figures 5-14 and 5-15 indicate estimated 1995 petrochemical shipments. The estimates are based on tonnage and current market value, to customer groups in Romania and to export customers.

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Estimated current sales to these customer groups are based on information obtained from the enterprises and from Rafirom. Major domestic customer groups identified in this study include manufacturers of synthetic yarns and fibers, plastics products, construction products, paints and varnishes, automotive products, and rubber products. Low-volume customer applications include detergents, petroleum processing, metals processing, inks and dyes, and pesticides.

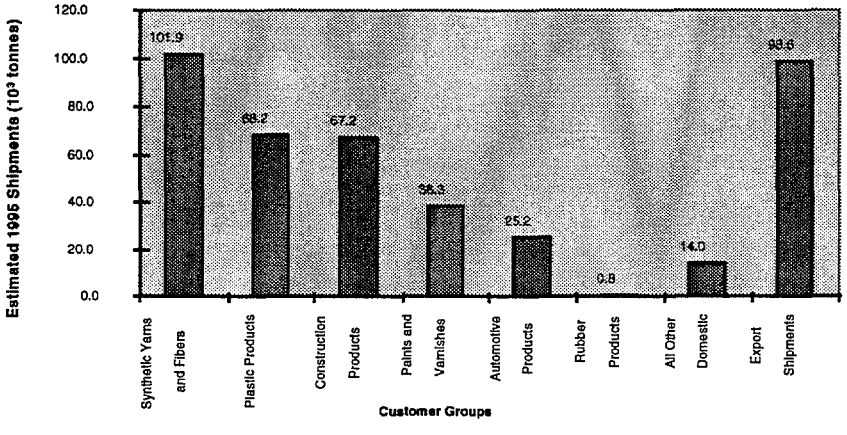

Figure 5-14 Petrochemical Shipments (Tonnages)

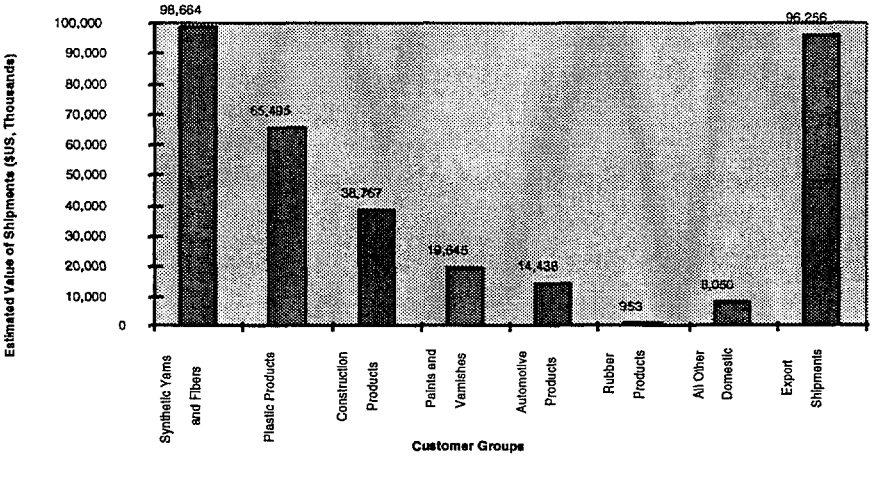

Figure 5-15 Petrochemical Shipments (Estimated Market Value)

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A review of the customer data presented here indicates that the current segmentation of customers is not adequate for market planning purposes. The definition of these segments is largely technical and product-based, rather than customer-based. Plastics customers, for example, include customers in packaging, construction, agriculture, and other distinct industries. Thus, the current categorization of product volumes to customer segments does not permit a clear assessment of customer viability or potential growth. To provide information that can support market planning for Romanian petrochemicals, customer sales information should be evaluated on the basis of customer segments that are:

- Measurable, in terms of sales volumes, contribution margin levels, and growth rates
- Distinctive, in ways that lead to effective, tailored strategies for serving each group
- Substantial, in terms of current or prospective sales

These enhancements in market information will make it easy to identify truly attractive customer segments, those capable of providing large and growing sales margins. Furthermore, the reliability of product demand projections can be improved. An improved understanding of future shifts in product volumes will result, leading to more effective planning of manufacturing technology and capacity.

In the case of export sales, current reliance on chemical traders poses a barrier to the meaningful understanding of customer requirements and attractiveness. Direct contacts with current and potential export consumers are the only feasible means to establish firm export partnerships and to gain useful customer insights. In addition, direct linkages to customers in export markets probably provide the only means to secure term contract commitments for export sales. By shifting export sales from spot trades to term contracts, the enterprises can extend and stabilize manufacturing planning.

Table 5-4 summarizes the petrochemical policy, market, and operational issues.

Table 5-4 Summary of Policy, Market, and Operational Issues

	Issue	Implications	Recommendations
Policy Issues	Direct and indirect price controls	Market distortions and disincentives	Eliminate all formal and informal regulations
	Petrochemical sites operate independently, and without clear strategic direction in areas of common interest	The manufacturing system as a whole does not capture optimal financial value due to lack of coordination in capacity planning, technology, and market strategy	Provide integrating and coordinating management to optimize capacity increments and technology investments
Market Issues	Failure to identify viable and financially attractive customer groups	Marketing strategies are less than optimum, and do not direct plans and resources toward profitable sales	Evaluate domestic and regional customers using segments that are measurable, distinctive and substantial
	Vulnerability in exports, with reliance on spot trades through agents	Uncertainty in future sales. No basis to form meaningful export partnerships	Form direct relationships with current and potential export customers
Operational Issues	Fragmented and poorly focused manufacturing	High production costs and low rates of learning-based improvements	Rationalize the manufacturing system based on financial viability
	Inadequate monitoring and benchmarking of manufacturing processes	Failure to adopt optimal process control strategies and operating practices penalizes cost performance	Improve process instrumentation, define and manage to KPIs, and benchmark to industry leaders
	Excess capacity	Low capacity utilization, leading to high unit costs	Rationalize manufacturing. Pursue a capacity strategy that balances capacity utilization with lost sales
	Cost reporting systems do not fully support operations management at the unit level	Reported costs do not facilitate technology benchmarking, and do not provide adequate guidance for cost improvement	Align cost systems with the natural operating boundaries of individual units
	Inadequate communication across business functions	Weak communication across vertically defined organizational boundaries retards information flow and impedes planning	Form cross-functional teams to enhance information and planning processes

Section 6

Lubricants Sector Assessment

6.1 INTRODUCTION

Lubricant facilities are integrated in five of the state-owned manufacturing complexes: Astra, Petrotel, Arpechim, Vega, and Steaua Romana. Lubrifin, a privately owned lubricant refining operation, processes intermediate feedstocks from state-owned lubricant plants. All of these facilities are seriously disadvantaged with respect to foreign competitors. Our analysis of the lubricant sector has shown that immediate changes are urgently required to mitigate the effects of the most severe weaknesses in manufacturing and marketing. This analysis has taken into account the recommendations of the refinery rationalization strategy, which calls for the closure of two large refineries, Petrobrazi and Petrotel, and two small refineries, Vega and Steaua Romana.

Figure 6-1 shows the value chain for Romanian lubricants in generalized form, linking lubricant production with the oil refining sector, the source of feedstocks, and with lubricant distribution and marketing. The figure highlights significant problems at each step of the value chain. Lubricant manufacturing is plagued by obsolete technology, low yields, and inflexible process configurations. Very high manufacturing costs and poor product quality result from these operational inadequacies. Of the five state-owned manufacturing sites, three – Arpechim, Vega, and Steaua Romana – are not viable and should be closed.

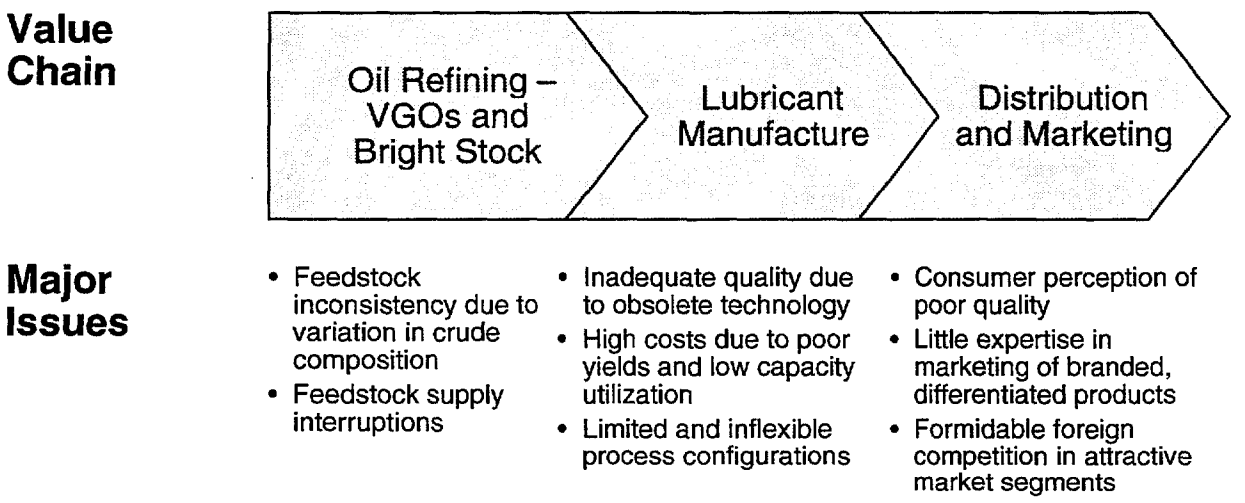

Figure 6-1 Romanian Lubricants

Marketing efforts are hampered by poor product quality and by a lack of marketing expertise. Owing to this poor quality, private vehicle owners, who represent the most attractive customer segment, have abandoned Romanian lubricants in favor of imported lubricants. Romanian manufacturers cannot recapture the private vehicle segment because they lack essential capabilities and skills, and because they cannot acquire these capabilities and skills at reasonable cost. Romanian manufacturers are capable of serving their captive industrial and commercial

necessary capabilities and skills to serve the increasingly stringent requirements of their industrial and commercial automotive customers, or risk the loss of these customer groups, as well.

The sections that follow present an overview of the Romanian lubricant market, an assessment of manufacturing viability, and recommendations for the management of Romanian lubricants following the severe rationalization of the lubricant manufacturing sector.

Our recommendations are based on a realistic appraisal of operational capabilities and of market requirements. Rapid and vigorous implementation of these recommendations is necessary to stem the financial losses caused by the nonviable operations within the sector and to more favorably position the potentially viable operations.

6.2 OVERVIEW AND CURRENT STATUS

6.2.1 Lubricant Market

Table 6-1 presents a very simple market segmentation scheme for Romanian lubricants, indicating representative customers, products and applications, purchasing decision-makers, and buyer values. In general, the market may be divided into two customer segments: industrial (primarily lubrication for stationary equipment) and automotive (primarily lubrication for automobiles and trucks). A further segmentation of automotive customers between commercial customers and private vehicle owners is useful because these two groups adopt significantly different decision processes for the purchase of lubricants.

Table 6-1 Market Segmentation for Romanian Lubricants

	Industrial	Commercial Automotive	Private
Representative Customers	Fabricated metal manufacturers Chemicals and allied products Transportation equipment Mining operators Pulp and paper	Agriculture Construction firms Fleet operators Mining operators	Private vehicle owners
Products and Applications	Industrial engine oils (railroad, marine, gas) General industrial oils (hydraulic, gear) Metalworking fluids	Commercial engine oils Gear, hydraulic, and transmission oils Greases	Passenger car motor oils Brake and transmission fluids
Purchasing Decision Maker	State sector procurement agent representing a state firm		Individual customer
Buyer Values	Price, and lei denomination of purchases State sector supply relationships Product availability and reliability of deliveries Product quality		Product quality Product availability Price

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Note that buyer values which influence private vehicle owners are dramatically different from those which influence purchasers within the industrial and commercial automotive segments. These values reflect profound differences in the motives underlying lubricant purchasing decisions.

In the industrial and commercial automotive segments, lubricants are purchased within an institutional setting dominated by traditional supply linkages between state-sector organizations. State-sector purchasing agents appear to be motivated by a desire to promote Romanian self-sufficiency through procurement from Romanian suppliers. In addition, state agents are limited to lei-denominated purchases at low prices. Private vehicle owners, on the other hand, place high value on the perceived quality of a lubricant for the protection of private autos, which represent significant personal investments.

These conclusions regarding purchaser motivation are drawn from interviews with manufacturing site personnel, with PECO staff, and with representatives of multinational petroleum firms engaged in the importation of automotive lubricants to Romania. The conclusions are supported by the lubricant demand analysis presented Section 6.2.3.

Figure 6-2 shows the distribution of lubricants to the three major customer segments and highlights three primary channels of legitimate distribution: (1) direct shipment from domestic lubricant manufacturers, (2) distribution via county PECO packaging and distribution centers, and (3) distribution via other domestic and foreign retailers.

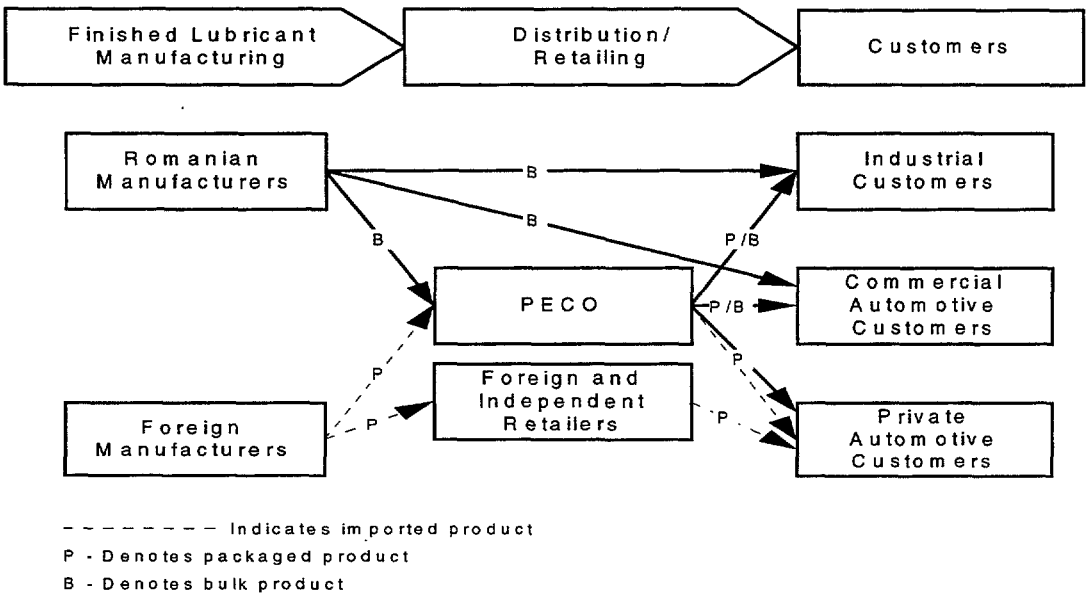

Figure 6-2 Distribution of Lubricants

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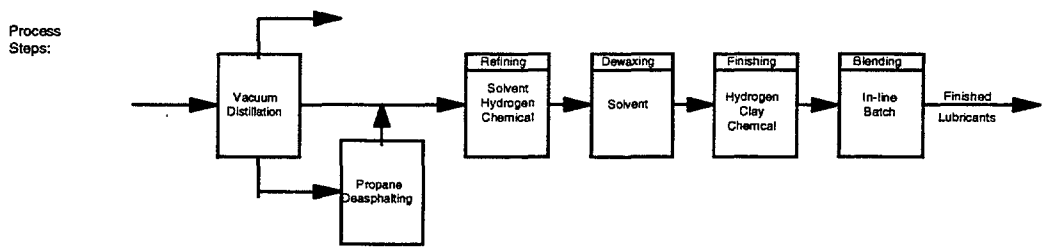
Industrial and commercial customers normally receive large volume deliveries of bulk oil directly from Romanian lubricant manufacturing plants, and smaller deliveries of either bulk or packaged product from the county PECO facilities. Virtually all of the domestic finished lubricant packaging capacity in Romania resides in the county PECOs. Manufacturers ship bulk finished lubricants (base oils plus additives) to these PECO sites in railcars or tank trucks for repackaging into bottles, pails, and drums for resale at retail stations or for shipment to industrial and commercial automotive customers. Private consumers may purchase either Romanian or imported lubricants from PECO retail stations, or imported lubricants from retail stations operated by other domestic or foreign firms.

Our team visited a number of PECO retail stations in Romania. Romanian packaged lubricants were less attractive in appearance than imported lubricants. They were dark, cloudy, and in some cases contaminated with large particulates. Although it is not possible to precisely identify the points in the lubricant value chain where the products are compromised, we suspect that contamination may occur throughout the manufacturing and distribution systems. Poor color and clarity probably result from base stock manufacture at Romanian plants. Particulate contamination may be introduced at refineries, in blending, in bulk distribution to the county PECOs or in the packaging process.

6.2.2 Lubricant Manufacturing

Figure 6-3 characterizes the finished lubricant manufacturing configurations of five of the six Romanian plants, listed in descending order of 1994 production.



	Distillation	Deasphalting	Refining	Dewaxing	Finishing	Blending	1994 Production (10^3 tonnes)
Astra*	✓	✓	S	●	CL H	B	130
Petrotel	✓	✓	S	S	CL H	B	65
Lubrifin**	●	●	S	S	CL	B	35
Arpechim	✓	◍	◍ H	◍	H	I	9
Vega	✓	●	C	●	●	B	6
Steaua Romana	?	?	?	?	?	?	4

● No capacity
◍ Shutdown capacity
✓ Working Capacity

* Runs primarily naphthanic crude (no dewaxing necessary)
** Privately owned

S = Solvent
H = Hydrogen
C = Chemical
CL = Clay
I = In-line
B = Batch

Figure 6-3 Lubricant Manufacturing

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The block diagram presents the essential processing steps necessary to produce finished lubricants. Technologies available to carry out each processing step are indicated. For example, the process step labeled "refining" involves the removal of aromatics to improve the viscosity attributes of the lubricant. There are three process technologies represented in the Romanian plants: extraction via furfural solvent, hydrocracking, and chemical treatment with sulfuric acid followed by neutralization with caustic soda. The tabulation in Figure 6-3 indicates the technology practiced at each plant.

A brief plant-by-plant summary follows.

6.2.2.1 Astra (Ploiesti)

Astra is the largest producer and was configured to process domestically sourced naphthenic crudes, which contain very little wax. As a result, the plant has no dewaxing capability. Over the past several years, wax contamination, primarily introduced by substitution of paraffinic crudes for unavailable naphthenic crudes, has caused both operating and quality problems for the plant. Astra has responded in two ways: (1) it has attempted to use its hydrofinishing area as a catalytic dewaxing unit, with unsatisfactory results in terms of lubricant quality; and (2) it has shipped the solvent-extracted stocks to Lubrifin for dewaxing. This approach adds cost due to transport and losses.

6.2.2.2 Petrotel (Ploiesti)

Petrotel processes paraffinic crudes into bulk finished lubricants through furfural-based aromatics extraction, MEK dewaxing, and both clay and hydrofinishing steps. The solvent extraction and dewaxing processes were both introduced in the 1950s. They were based on Russian technology and appear to be in generally poor mechanical condition. With technology of this vintage, it is unlikely that Petrotel can produce a private vehicle motor oil of a color and clarity that consumers will find appealing.

Our recommended shutdown of the Petrotel refinery will remove the local source of hydrogen used on the hydrofinishing step. Because of the cost and difficulty of transporting hydrogen from remote sources, Petrotel's lubricant operation will probably be limited to clay treatment, a more costly and less effective process, for lube base stock finishing. This restriction will further increase the technological challenges that Petrotel's lubricant management must overcome to become commercially viable.

6.2.2.3 Lubrifin (Brasov)

Lubrifin is a privately held lubricants refining operation located in Brasov. Lubrifin's configuration is notable for two reasons. First, Lubrifin operates at a severe logistical disadvantage because the site has no distillation capacity. This means that Lubrifin must process intermediate feedstocks from the other plants and manage all of the associated variability in supply. Second, owing to its remote location, Lubrifin has no hydrogen source. Lubrifin utilizes

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an antiquated clay-based finishing process which, in the long run, will be unable to produce lubricants that meet increasingly stringent quality standards.

6.2.2.4 Arpechim (Pitesti)

Arpechim has two lubricant plants. Its solvent extraction plant (which in profile closely resembles the Petrotel process) was shut down in 1983 because of crude supply interruption. Since 1990, Arpechim has experimented on a pilot basis with a Romanian technology, and in 1994 produced 9,000 tonnes. In its current configuration, the operation is incapable of producing high-quality lubricants. The hydrodewaxing unit (which is actually the hydrofinishing operation from the original solvent extraction lubricant block) is mismatched in capacity with the hydrocracker, and resulting operations degrade the product viscosity characteristics. Arpechim has responded by selling the hydrocracked waxy intermediate to Lubrifin for further processing.

6.2.2.5 Vega (Ploiesti)

Vega produces a small quantity of low-quality lubricants through an obsolete, environmentally unsound chemical refining technology. Exceedingly low yields result in high processing cost, and product quality is poor and erratic. Our refinery rationalization strategy calls for shutdown of the Vega refinery. The shutdown of this refinery will eliminate the local feedstock source for Vega's lubricant operation, further weakening the viability of lubricant manufacture at Vega.

6.2.2.6 Steaua Romana (Ploiesti)

Steaua Romana was not visited as a part of this program. It is believed that the site produces very low volumes of petrolatums (specialized white oils for personal care and cosmetic applications). Our refinery rationalization strategy calls for the shutdown of the Steaua Romana refinery. As in the case of Vega, the shutdown of the associated refinery will eliminate the local feedstock source, further weakening the viability of the lubricant operation.

6.2.3 Lubricant Demand

A 1994 lubricant supply/demand balance is shown in Table 6-2, indicating the relative demand for industrial, automotive, and export lubricants. Table 6-2 also gives supply levels from imports and from each of the six manufacturing sites. The two largest Romanian manufacturers, Astra and Petrotel, produce lubricants for both industrial and automotive customers. Lubrifin and the two smallest manufacturers, Vega and Steaua Romana, produce only industrial lubricants.

The figures in the table represent volumes of finished lubricants consisting of base stocks and additives. Total Romanian domestic demand in 1994 was 350,000 tonnes, consisting of 320,000 tonnes of base stock plus 30,000 tonnes of additives. The estimate of total domestic consumption was provided by Rafirom. The data needed to estimate domestic sales of Romanian lubricants (211,000 tonnes) and total Romanian production (233,000 tonnes) were supplied by

plant staffs. Imports (139,000 tonnes) were computed as the difference between Romanian consumption and domestic production sold to Romanian consumers.

Table 6-2 Finished Lubricant Supply and Demand (10^3 Tonnes, 1994)

Supply Sources	Automotive Demand	Industrial Demand	Romanian Demand	Exports	Romanian Production
Romanian Plants					
Astra, Ploiesti	26	78	104	22	126
Petrotel, Ploiesti	47	14	61		61
Lubrifin, Brasov		27	27		27
Arpechim, Pitesti	9		9		9
Vega, Ploiesti		6	66		6
Steaua Romana, Ploiesti	—	4	4	—	4
Subtotal	82	129	211	22	233
Imports	139	0	139	–	
Total	221	129	350	22	

While these data provide a fact-based picture of lubricant supply, domestic consumption, and exports, the information available from Rafirom and the plant staffs does not provide the relative consumption levels of the three major customer groups: industrial, commercial automotive, and private vehicle consumers. The PECO staff was also unable to furnish this information.

Important assumptions are required to estimate the relative consumption levels of the three customer segments. If it is assumed that all imports (139,000 tonnes) were purchased by automotive consumers, then the resulting proportion of automotive lubricant purchases (roughly 60 percent of total domestic purchases) is reasonable based on known lubricant consumption levels in comparable economies. Two simple observations support the assumption that virtually all imports were sold to automotive consumers. First, interviews with representatives of foreign multinationals indicated that those firms provided automotive lubricants only. Second, essentially all of the industrial demand for lubricants is derived from state-owned firms, and those organizations appear unlikely to purchase imported products. Given their lack of hard currency, these state companies are unlikely to purchase high-priced imports using hard currency and, instead, prefer to engage in lei-based transactions. Moreover, purchases of imported lubricants by state companies appears improbable in view of the strength of traditional supply relationships with PECO.

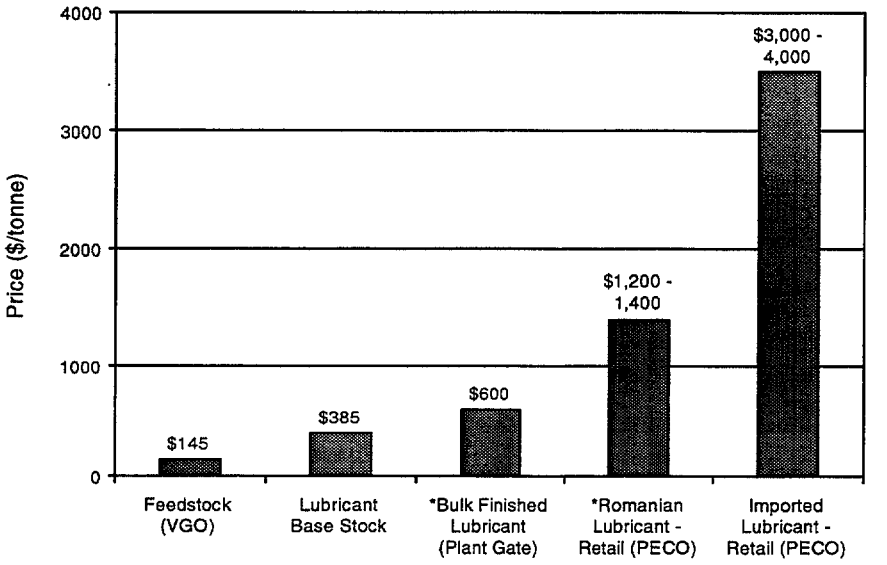
Further assumptions were necessary to develop reasonable estimates of the relative proportions of commercial and private sales within the automotive segment. Interviews with representatives of multinational lubricant importers again provided an important insight. Representatives of the firms interviewed made clear their intention to distribute lubricants only to private vehicle owners, and not to commercial enterprises. In the opinion of these representatives, only private

buyers in Romania would accept the higher cost of imported lubricants (because of perceived quality differentiation), and the marketing of imported lubricants to commercial automotive firms would be difficult because the vast majority of such companies are state-owned. These observations suggest that the import volume, 139,000 tonnes, was directed entirely to private vehicle owners.

These observations led to the conclusion that imported lubricants account for a very high proportion of the lubricant sales to private vehicle owners in Romania. This is a vital point, since it implies that foreign suppliers have succeeded in capturing this quality-sensitive customer segment, composed of purchasers who accept high price levels for branded, differentiated lubricants.

6.2.4 Lubricant Pricing

The predominance of imports within the private vehicle owner segment takes on greater significance when lubricant pricing is evaluated. Figure 6-4 presents a value chain pricing profile for automotive lubricants, beginning with vacuum gas oil (VGO) feedstock ($145/tonne); followed by lubricant based stock, priced prior to additive blending ($385/tonne); bulk finished lubricant transferred to PECO at the plant gate ($600/tonne); and, finally, packaged lubricant sold at PECO retail outlets to private vehicle owners ($1,200-1,400/tonne). The retail price for imported lubricants sold at PECO retail outlets is, in contrast, roughly $3,000-$4,000/tonne.



Notes:
- Feedstock (VGO) and base stock prices are import parity estimates (Med. price plus $20 per tonne for transport).
- Asterisk (*) indicates a state controlled price (Rafirom).

Figure 6-4 Lubricant Value Chain Pricing

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Finished lubricant prices (plant gate) and retail prices for Romanian products sold at PECO outlets are state-controlled. Industrial lubricant prices are also state-controlled. In the case of industrial lubricants, relevant market prices for comparable products were not determined.

The automotive lubricant pricing profile dramatizes the value added in distribution, as well as the large premium paid by private vehicle owners for high-quality imported lubricants. Lubricant costs and retail margins were not studied, but simple estimates reveal the high margin potential that could be realized if Romanian lubricants could be sold in volume to private vehicle owners. Assuming a variable distribution cost for transport, packaging, and handling below $100/tonne, the successful distributor purchasing finished lubricants at the plant gate should realize a variable margin exceeding $200/tonne, roughly one-third of the purchase cost. This is based on the pricing profile presented above, allowing a retail margin of up to 30 percent. In the case of imported lubricants, variable margins are appreciably higher.

6.3 VIABILITY ASSESSMENT

6.3.1 The Private Vehicle Segment

Imported lubricants account for an overwhelming share of the sales to private vehicle owners. Romanian capabilities in both manufacturing and distribution must be assessed in order to determine whether or not Romanian suppliers are capable of recapturing this customer segment. This section assesses the viability of providing Romanian lubricants to private vehicle owners in competition with imports.

Based on visits to retail outlets in Romania and on an understanding of lubricant purchase decisions in the Western Europe and United States, we conclude that the following factors are important in the marketing of lubricants to private vehicle owners: strong perception of product quality, effective brand management, and effective distribution channel management. The rationale and support for each of these factors are summarized in Table 6-3.

The first of these factors, perceived product quality, begins with the manufacture of a lubricant that has a clear and consistent appearance, and extends through packaging and distribution. Product contamination must be prevented in distribution, and attractive packaging is necessary to inspire customer confidence in lubricant quality. The second and third factors are important in distribution and retailing.

An assessment of Romanian manufacturing and distribution leads to the conclusion that organizational capabilities are inadequate in each of these areas. In the manufacturing assessment presented in Section 6.2.2, limitations are outlined that adversely affect quality and that can be corrected only by large investments.

Table 6-3 Key Factors in Marketing of Lubricants to Private Vehicle Owners

Key Success Factors	Rationale and Support
Strong perception of product quality	Private vehicle owners are powerfully influenced by perceptions of quality based on the appearance of both the product itself and the package in which the product is presented. Perceived quality can be enhanced through merchandising efforts, including advertising and effective product display. In developing markets, a foreign brand name is tantamount to a quality image
Effective brand management	Product differentiation achieved through effective product branding reinforces the customer's purchase response. Brand recognition facilitates the initial purchase decision by new buyers and encourages continued purchases by experienced buyers
Effective distribution channel management	Retail outlet operators and other market channel agents lend crucial support to favored brands through product placement and display decisions. Pricing and retail margin adequacy are important factors in gaining retail operator support

Our inspection of Romanian lubricants offered for sale at PECO service stations in Muntenia, Dobrogea, and eastern Transylvania revealed serious weaknesses with respect to merchandising, brand management, and distribution channel management. The package quality of lubricants distributed by PECO was clearly inferior to that of foreign competitors. In addition, foreign competitors have strengthened their positions in the retail setting by providing effective visual accessories for point-of-sale product displays.

In visits to retail stations, we observed that retail operators use their most valuable display space for the presentation of foreign lubricants to retail buyers, often relegating Romanian lubricants to remote storage areas not even seen by customers. By their clear choices in product space allocation, service station operators seem to have virtually abandoned Romanian automotive lubricants and apparently have concluded that major import brands merit their strong support as retailers.

Based on these observations, we conclude that current Romanian lubricant producers and distributors cannot now compete effectively with foreign imports for the private vehicle segment. To compete effectively in the future would require large investments in manufacturing, packaging and distribution, brand-imaging, and channel management. We believe any effort to recapture this customer segment would be too costly, too slow, and highly risky, and hence do not recommend that such an effort be made. Revitalization of a tarnished image is exceedingly difficult and costly, and in our judgment is beyond the capability of the lubricants enterprises.

The attractive distribution margin structure described earlier strongly suggests that an opportunity exists in Romania to market imported automotive lubricants in competition with other importers. However, this distribution business cannot be sourced effectively by Romanian

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lubricant producers – importation of lubricant base stocks would be required. Skills in merchandising, brand management, and distribution management are obviously necessary. A new entrant wishing to capitalize on this opportunity could effectively distribute the new lubricant brand through PECO service stations, though not under PECO distribution management.

Thus, while an opportunity exists to serve growing demand within an attractive margin structure, this opportunity cannot be effectively sourced by Romanian producers acting alone, and PECO's contribution to the effort would be limited. We conclude that Romanian-manufactured lubricants are viable only within the industrial and commercial automotive segments, and, over the long run, these markets will also be threatened by competitors.

6.3.2 Manufacturing Viability

6.3.2.1 Astra and Petrotel

The assessment of the operational viability of the Romanian lubricant manufacturing operations has coupled a simple variable margin analysis for the two largest producers, Astra and Petrotel, with previous observations regarding Romania's ability to meet evolving market needs. This assessment has led to the conclusion that Astra and Petrotel, linked to Lubrifin's dewaxing capability, have potentially viable operations, at least in the near term. We recommend that the lubricant operations at Vega, Arpechem, and Steaua Romana be discontinued.

Table 6-4 presents variable costs for lubricant production at Petrotel based on costs for 1994. Market pricing was applied to both finished products and refinery feedstock. This analysis indicates roughly break-even performance on a variable-margin basis. A similar analysis for Astra leads to the same conclusion, with approximate break-even performance based on variable margins. Clearly, the addition of fixed costs, including staff costs, maintenance costs, and allocated overhead costs, would result in negative margins (operation at a financial loss) for both plants based on full cash costs. Furthermore, the closure of the Petrotel refinery would eliminate the local hydrogen source that currently provides hydrogen for lubricant hydrofinishing. The loss of this local hydrogen source would restrict the Petrotel lubricant operation to clay treatment, making more difficult the attainment of competitive cost performance.

Although full cash margins appear to be negative, both plants serve captive industrial and commercial operations, and both appear to be capable of cost improvement assuming continued customer purchases at roughly current volume. We recommend that the plant staffs adopt the market-based cost analysis presented here as a framework for monitoring cost results.

Table 6-4 Petrotel Economic Analysis

Item	Units per Tonne Feed	Price $/Unit	Propane Deasphalting	Furfural Extraction	MEK Dewaxing	Hydro Finishing
Utilities Consumption						
Power	kWh	0.045	22	8	147	41
Steam	kg	0.007	2417	750	2175	360
Fuel	kg fuel	0.076	19	90	0	71
Cold Water	m^3	0.021	0	8	2	5
Recycled Water	m^3	0.021	0	25	73	270
Chemicals Consumption						
Propane		0.076	2			
Furfural		0.250		3		
MEK		0.250			7	
Hydrogen		0.800				2
Feed (tpd, 1994)			400	700	473	247
Utilities ($/stream day)						
Power			$396	$262	$3,129	$456
Steam			$6,574	$3,570	$6,996	$605
Fuel			$574	$4,757	$0	$1,324
Cold Water			$0	$118	$20	$26
Recycled Water			$0	$368	$725	$1,400
Utilities Costs			$7,544	$9,073	$10,870	$3,811
Chemicals (10^6/year)						
Propane			$61	$0	$0	$0
Furfural			$0	$525	$0	$0
MEK			$0	$0	$828	$0
Hydrogen			$0	$0	$0	$395
Chemicals Costs			$61	$525	$828	$395
Stream Days/Year	250					
	tpd	**tpy**	**Price/Tonne**	**Value (10^6)**		
Inputs						
Vacuum Resid	400	100,000	$60	$6		
Vacuum Gas Oil	545	136,250	$125	$17		
Utilities				$8		
Chemicals				$0		
Total Inputs				$31		
Outputs						
Asphalt	245	61,250	$20	$1		
Aromatic Extract	227	56,750	$20	$1		
Slack Wax	226	56,500	$145	$8		
Gas Oil	10	2,500	$145	$0		
Lube Oil	239	59,750	$355	$21		
Total Outputs				$31		
Variable Margin (10^6)				$0		

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6.3.2.2 Vega

We recommend that lubricant manufacture at Vega be shut down because of Vega's small-scale and high-cost technology relative to both Petrotel and Astra. The high cost of Vega's lubricant operation is chiefly the result of excessive yield losses from its chemical refining process. Vega's lubricant production, less than 3 percent of total Romanian lubricant production in 1994, is an insignificant factor in relation to overall market requirements.

6.3.2.3 Arpechim

Were Arpechem to continue development of its hydrocracking capabilities, its goal clearly would be to produce a very high-viscosity index base stock to serve the private vehicle automotive market. To build this production capability, three significant investments would be required. First, Arpechim would have to purchase or develop a hydrocracking catalyst that would raise the viscosity index of the oils from 100 to 125. Second, Arpechim would have to purchase a dewaxing license and catalyst to inhibit the viscosity index reduction that is currently occurring in the current configuration. Third, Arpechim would have to invest to debottleneck the hydrogen compressor and increase utilization of the hydrocracker. Given Romania's inferior competitive positioning in the private vehicle automotive market, it would not be wise to make such large supporting investments. We recommend shutdown of the Arpechim lubricant operation.

6.3.2.4 Steaua Romana

Steaua Romana's lubricant operation was not assessed. However, it is improbable that Steaua Romana's small lubricant operation could be economically sustained following the refinery shutdown.

6.3.2.5 Viability Summary

Three of the producing sites – Petrotel, Astra, and Lubrifin – are operationally linked. This linkage positions them to continue service to state-owned industrial and commercial automotive customers. The process profiles presented earlier indicate that serious structural issues may limit their long-range success. Petrotel and Astra are state-owned; Lubrifin is privately owned.

Both Petrotel and Astra now operate at a loss. These lubricant plants operate on a break-even basis only before considering fixed costs. We have assumed that the costs of operating these facilities can be reduced through operational improvements. If operating costs cannot be reduced, even Petrotel and Astra should be closed.

6.4 STRATEGIC RECOMMENDATIONS

6.4.1 General

This section reviews the strategic position of the lubricant industry. Skills necessary to enhance relationships with industrial and commercial customers are outlined. Development of these skills is the most important requirement for the preservation of the long-term viability of Romanian lubricant manufacture. Complexities have been created by dividing industrial capabilities among these three sites and between two ownership structures, state and private. This division limits the ability of the manufacturing system at these sites to compete effectively. Capital investments at these sites should be delayed until meaningful skill growth has been demonstrated and until the problems created by site and ownership division have been resolved.

The assessment in Section 6.3 identifies the industrial and commercial automotive customer segments as areas of the Romanian lubricant market where the capabilities of the Romanian industry are potentially viable, at least in the near term. This assessment also includes a recommended rationalization of the manufacturing base. The recommended rationalization steps will lead to a more viable lubricant manufacturing system through the removal of the highest-cost production sites.

We recommend that the objective for the remaining sites be an intensified focus on lowering manufacturing costs through disciplined attention to process yields and to other factors which influence costs. Cost information presented in the assessment of manufacturing viability indicates only break-even cost performance at the largest two production sites. The variable cost format presented with this assessment provides a quantitative framework for monitoring cost results. We also recommend efforts to solve the major quality problems. For example, particulate contamination should be eliminated.

6.4.2 Strategic Threats

At present, an operational focus on cost-effective service to the industrial and commercial automotive segments constitutes a coherent and viable strategy for the Romanian lubricant industry. This strategy provides guidance in the near term for manufacturing and distribution decisions, but it is reasonable to expect important strategic threats resulting from Romania's continued transformation to a competitive, market-based economy.

Romanian lubricant manufacturers are currently capable of satisfying the product and service requirements of domestic industrial and commercial automotive customers. However, these segments of the lubricant market are likely to evolve in the direction of greater competitiveness, and this evolution will probably be accompanied by privatization. As privatization progresses within these customer industries, individual firms are likely to question traditional sourcing relationships and to reexamine suppliers, with the goal of enhancing their own competitive positions.

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The detailed analysis of the future lubricant requirements of industrial firms and of commercial automotive firms in Romania lies outside the scope of this study. Nonetheless, a general description of their probable future requirements can be inferred based on an understanding of lubricant sourcing by these customer groups in market-based economies. Table 6-5 lists general factors that are important in the marketing of lubricants to industrial and commercial automotive businesses under competitive conditions. Table 6-5 also provides a general and representative profile of the product and service capabilities that these customer groups in Romania are likely to demand of their lubricant vendors following the commercialization of these economic sectors.

Table 6-5 Marketing of Lubricants to Industrial and Commercial Automotive Customers

Key Success Factors	Rationale and Support
Technical sales support and quality	Commercial customers purchase lubricants through fact-based rather than perception-based decision processes, matching lubricants with applications requirements through technical specifications
Effective after-sales service	Lubricant performance is often evaluated through systematic testing programs, frequently conducted with vendor assistance in monitoring and follow-up
Extensive and varied product line lubricants	Commercial customers typically expect the vendor to supply a product line for a variety of application needs. The important role of additives necessitates a strong alliance with a capable additives supplier
Rapid and reliable delivery capability	The customer typically requires rapid turnaround on orders of multiple lubricant types. Strong inventory planning skills and an effective delivery network are required

As the Romanian economy continues to evolve, the success of the domestic lubricants industry in serving these customers will rest on the industry's ability to interpret customer requirements and to translate these requirements into appropriate products and services. Efforts directed at building these skills should take precedence over capital project investments that are not clearly demanded or valued by the market.

6.4.3 Restructuring

Operation of the three economically viable plants – Astra, Petrotel, and Lubrifin – is complicated by the operational and management divisions reviewed in the viability assessment. These divisions make the current manufacturing system complex and unstable. Integrative efforts are necessary to simplify and focus the system.

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Two scenarios are presented here to illustrate restructuring principles and approaches.

- *Scenario I.* Assume that a foreign entity based in lubricants seeks to form a lubricant business in Romania which is sourced from Romanian lubricant manufacturing
- *Scenario II.* Assume that no foreign entity emerges with interest in Romanian lubricant manufacturing

These two scenarios lead to different mechanisms for the acquisition of commercial skills and for the reorganization of the lubricant sector. A summary of these two scenarios and the restructuring issues associated with them is presented in Table 6-6.

We believe that the second scenario is far more likely than the first scenario. Therefore, the rapid development of skills in the marketing of lubricants to the industrial and commercial automotive segments and the streamlining of operations are essential steps if there is to be any reasonable possibility for economic viability within the Romanian lubricant industry.

Table 6-6 Lubricant Restructuring Scenarios

Scenario	Scenario Description	Restructuring Issues
I	A foreign entity intends to horizontally integrate the three sites in order to build a platform for effective lubricant manufacture in Romania	The foreign entity serves as the source of commercial skills and organizes the integration of processes and management between the three sites. We consider this scenario to be exceedingly improbable because the foreign entity envisioned is likely to regard lubricant distribution rather than lubricant manufacture as the source of added value. Hence, this entity would probably source Romanian distribution from imports and would not invest in Romanian manufacturing
II	No foreign party with interest in lubricant marketing emerges to partner with existing Romanian lubricant companies	Survival of the Romanian lubricant industry depends upon the rapid introduction of skills and the streamlining of operations. Integration of the existing sites into a focused entity is recommended to enhance skill development and to permit rapid optimization of production capabilities

Section 7

Distribution, Marketing, and Retail Assessment

7.1 INTRODUCTION

This section covers the distribution and marketing of petroleum products, including transportation. It includes facts, analysis, and recommendations on actions to create open-market conditions and to promote efficient operations in the sector.

7.2 STUDY APPROACH

The study of the distribution and marketing sector focuses on determining the value added or destroyed by the distribution and marketing processes and assessing the capabilities of existing enterprises to compete in a nonregulated environment.

The distribution and marketing sector has not been well defined in previous studies. The primary focus of those studies was to evaluate either the refining or the petrochemical segment. A balanced understanding of all of the sectors is necessary, and, we believe, achieved by broadening the current study.

In evaluating distribution and marketing, we conducted interviews at several territorial PECOs, which are the enterprises closest to the retail consumer. These interviews were designed to supplement the information obtained from interviews and data gathered from the headquarters offices of PECO, Rafirom, and PetroTrans. Current market information and previous restructuring studies were provided by Rafirom, PECO, and PetroTrans to our team prior to and during this project. The study conducted by Chem Systems in 1993 yielded certain base projections for the market environment and its growth prospects. Our own projections updated that previous work. In our study, markets and competitive forces were observed through site visits at (1) PECO's retail and terminal operations, (2) independent marketer operations, and, in some cases, (3) foreign marketer and joint venture operations. The mechanisms affecting supply and service levels were reviewed. The distortions in the marketplace, along with opportunities created by those distortions, were also examined.

7.3 VIABILITY ASSESSMENT

7.3.1 Sector Overview

Romania's downstream operations consist of 10 refineries; a product transportation and distribution system of pipelines, railcars and trucks, related storage, and terminals; and a marketing network of approximately 1,100 retail outlets (including 500 owned by PECO). Except for truck transportation and independent retailing, virtually all of the distribution and marketing sector's activities are owned and managed by state-owned enterprises. Facilities operated by the state-owned enterprises are in generally poor condition. In most cases, the assets are severely underutilized and are operated for a limited period every day. In addition to the downstream activities of the state-owned companies, there is an important and rapidly growing

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private sector in the retail gasoline market (including diesel fuels and LPG). Some 600 retail stations are now in private hands, and this number is growing rapidly. These privately owned outlets now account for over half of the total amount of motor fuels sold in the country, and their market share is growing rapidly.

Government-owned monopolies exercise almost total supply control over the manufacturing and bulk distribution of refined products, making this sector highly dependent on state policies. With prices controlled by the government, currency exchange strictly limited, and a system of import restrictions and tariffs, there is little opportunity to legally import refined products.

Bulk transportation is performed or managed by PetroTrans, the state-owned petroleum products transport company. PetroTrans uses its own pipelines to move about one-third of the products and state-owned railroads to move the other two-thirds. In addition, a small fraction of products is delivered to retailers by independent truckers and to very large industrial customers (e.g., RENEL) by local refinery pipelines. Most refined products are distributed by tank trucks managed by PECO. Independent companies do not constitute meaningful competition in bulk transportation or distribution because of entry barriers in the sector. For example, the independent hiring of railcars requires a receiving facility, a means of cleaning these railcars, and a large number of product storage facilities. When these costly requirements are coupled with the transaction cost of buying product, the resulting economic barrier limits effective access to rail transport to all but a few independents. Some independent retailers now pick up product directly from the refineries, but this is limited to direct purchase by individual retail owners as there are no independent wholesale jobbers in the country.

7.3.2 Sector Pricing

Among state-owned enterprises, product prices at both the refinery gate and customer levels are controlled, as are all pipeline and railcar transportation prices. Even though retail price controls theoretically apply only to state-owned entities, in practice the competing independent retailers find that their prices must conform owing to the dominant market presence of state-owned stations with which they compete. PECO pricing effectively places a ceiling on the prices independents can charge.

Controlled refinery-gate prices and transport costs severely depress the economic performance of the retail sector operated by PECO and inhibit the development and operation of the private sector. There is little opportunity to develop an independent wholesale distribution segment, the mainstay of a healthy competitive industry elsewhere in the world.

As discussed below, among state-owned enterprises, rigid flat-rate pricing also creates enormous marketplace distortions which, if unchanged, will ultimately lead to the bankruptcy of PECO and possibly PetroTrans. These distortions open up artificially induced niche opportunities for those willing and able to bypass the official systems.

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7.3.3 Competition

Product supply is nearly monopolistic since only state-owned refiners produce products locally, import tariffs are high, and imports are restricted. Only imported, packaged specialty products, such as high-quality automotive and machine lube oils, have meaningful competitive access to the Romanian market.

The substantial cost of infrastructure involved in bulk transportation of fuel products creates a high barrier which effectively limits the number of participants. Usually a small number of companies compete to provide bulk transportation, each having equal access to key strategic assets such as common carrier rail lines and pipelines. In Romania, no such competition exists. Rail transport of refined products is a de facto monopoly of PetroTrans, and distribution terminals are monopolies controlled by PECO.

Truck transportation and retail marketing are becoming competitive. Many small, independent station operations are emerging, some of which are joint ventures between Romanian citizens and foreign investors from Western Europe. Some large multinational oil companies, such as Shell, AGIP, and Amoco, have made preliminary investments in retail sites or have indicated modest intentions. Their investment programs are on a smaller scale than they would prefer since desired investments are discouraged by product price controls, high costs of transportation, and nontariff barriers, and by the lack of independent bulk transportation infrastructure.

7.3.4 Bulk Transportation

Bulk product transportation is the responsibility of PetroTrans, an organization expressly charged with product pipeline transportation as well as scheduling and logistics of product delivery by rail tank cars to state-owned enterprises. The government-owned distribution terminal and retail station operator must obtain products through PetroTrans and ship them via transportation managed by PetroTrans when available. The Romanian National Railroad (RNC) operates the rail lines, but RNC may not be used for petroleum product transport by government-owned refineries or PECO other than through PetroTrans. Independents could arrange their own bulk transportation but the lack of a private terminal infrastructure is a barrier that prevents this from occurring (local delivery to independent retailers does occur in small trucks).

The transportation infrastructure is in poor condition and badly managed. Equipment, procedures, and processes to properly measure, protect, or invoice products are not present. Inventories are contaminated and product losses are excessive. The pipeline assets, 60 percent of which are 40 years old or older, require considerable maintenance. In part, the need for much of this maintenance is caused by bandits who puncture pipelines in order to steal products and then leave the pipeline open to spill into the environment. Pumps are old and inefficient.

PetroTrans takes title to the products and is therefore the direct customer of the refineries. PetroTrans bundles products with transportation and sells delivered products to PECO, which

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may buy only from PetroTrans. This separates the customer from the supplier and eliminates choice in supplier selection or terms.

The transport charges applied by PetroTrans are fixed on a zone-by-zone basis. Within a zone, rates are the same regardless of distance, method of transport, or the type of liquid product. In a free market, pipeline transportation is normally priced much lower than rail transport, because pipelines move large volumes for lower cost. PetroTrans employs a high fixed-rate tariff, approved by the Ministry of Finance. Tariffs are based on PetroTrans's total costs and not on actual cost for delivery, other than for the modest interzone difference. The rate differences between zones are very modest, less than 20 percent from nearest to farthest. The result is distorted economics since shipping costs are disproportionately high for deliveries close to the refineries, but are subsidized at artificially low levels for deliveries to remote locations. This is the opposite of the way in which costs are incurred. The PetroTrans tariff structure was designed to result in equal transport prices and uniform pump prices to the public across Romania; however, it actually subsidizes poor operating practices since there is no penalty attached to high-cost customers. Meanwhile, low-cost customers are unfairly charged.

PetroTrans has no competitors in long-haul bulk transportation. Private trucking for short-haul transportation is allowed and is growing in markets closest to the refineries. PetroTrans's pipeline transportation tariffs are not separately regulated by any government agency, and the pipelines are not common carriers. As a result, PetroTrans has been able to use higher rail shipping rates as a price umbrella to raise pipeline rates to the same level as rail rates.

The market distortions caused by PetroTrans's monopoly on transport and flat, cost-based tariffs have been devastating for PECO, which is compelled to use PetroTrans to procure product. The impact of PetroTrans on independents is far less damaging because these competitors of PECO have begun to develop unofficial product channels which are not legally available to PECO. Because these independents are located close to refineries, they use their own lower cost tanker trucks (or, in some cases, rented rail tank cars) to ship products at a cost below PetroTrans's official price. The independent competitors are thus able to dominate some of PECO's best markets. Owing to high Romanian refinery gate prices, quantities of gasoline have also begun to enter from Hungary, Ukraine, the Mediterranean, and Austria. Independents are arranging transportation by barge, railcar, or truck, and circumventing import restrictions and tariffs.

Given its near monopoly over bulk transportation, PetroTrans's financial statements should indicate substantial income and cash flow. However, most of its available cash flow is currently directed toward maintenance and reconstruction of the current product pipelines, which are in poor condition. PetroTrans has no modern or accurate control system to measure product flows or energy consumption or to warn of environmental leaks. Storage capacity owned by PetroTrans is limited and is inadequate to support a multisupplier competitive environment with a wider range and larger number of possible products. Considerable product and quality losses are occurring from leaks, tank evaporation, and contamination. A business transaction system suitable for commercial operations does not exist in the current environment, and the manual methods used are inadequate and ineffective.

The product transportation flows are shown in Figure 7-1 and summarized as follows:

- PetroTrans takes delivery of product at the refinery gate using railcars and pipelines to move products to bulk terminals.
- Independent marketers bypass PetroTrans by providing their own transport from the refinery using trucks and, to a small degree, railcars.

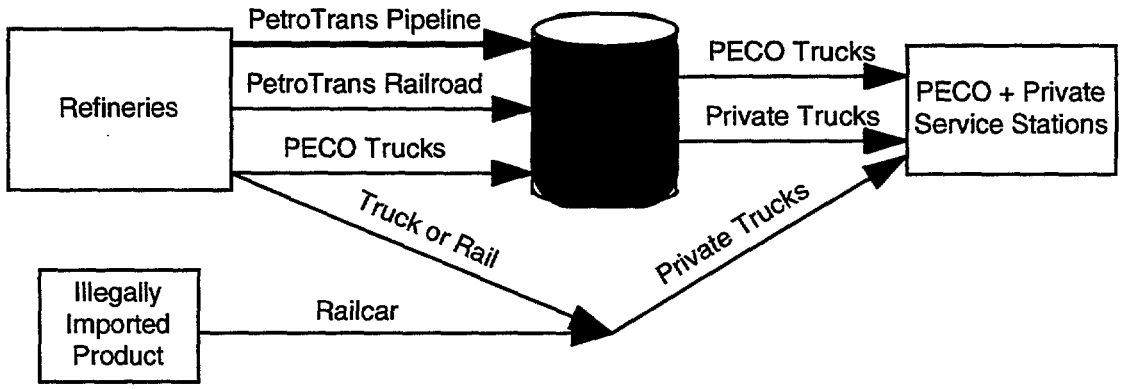

Figure 7-1 Product Paths

- Some independent marketers bypass both the high-priced Romanian refineries and PetroTrans by sourcing from foreign sources and providing their own rail, barge, and truck transportation.
- Some territorial PECO operators also circumvent the PetroTrans channel and avoid its high cost of terminaling by using trucks to pick up products directly from refineries.
- Pipeline damage, open rail tank cars, and poor operating procedures cause product loss and contamination.

Government policies of price controls, unreasonable transport tariffs and limited supply choice are therefore destroying the government marketing enterprises, keeping consumer prices higher than necessary, and promoting inefficiency, poor quality, and product losses.

7.3.5 Final Distribution and Marketing

Most refined products are distributed by PECO, and motor fuels are marketed at retail by PECO and independent retailers. PECO is not one entity but a group of entities, consisting of a central strategy organization (PECO-SO) and, 41 county organizations (territorial PECOs) which operate about 500 retail outlets, 154 bulk terminals, and a few local product pipelines. Territorial PECOs operate most product terminals and deliver local products to PECO stations and to many commercial and agricultural customers. Motor fuel marketing at PECO stations is also directed by the territorial PECOs.

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PECO-SO collects data and consolidates product orders from territorial PECOs, furnishes these data and orders to Rafirom and PetroTrans, and allocates supplies to territorial PECOs. PECO-SO, in effect, supports the central planning role of Rafirom as product orders are passed by territorial PECOs to PECO-SO and then to PetroTrans. However, some territorial PECOs order directly from PetroTrans. Territorial PECOs make payments directly to PetroTrans, and PECO-SO receives a small fee from PetroTrans for handling orders.

7.3.6 Territorial PECOs

There is one territorial PECO in each of Romania's 40 counties and a separate one for the municipal area of Bucharest. All are fully staffed and set up as independent companies. Each of these organizations operates at least one large bulk terminal and one or two smaller depots, served either by a PetroTrans pipeline or by a PetroTrans railcar unloading ramp, for a total of 154 bulk terminals in Romania. Some territorial PECOs have 70 or more retail gasoline outlets; others have just a few.

Refined products may be sourced through PetroTrans from any of the country's refineries. However, product origins are not well understood by the territorial PECOs because, from their perspective, PetroTrans acts as the single supplier.

All of the 154 product terminals are government-owned through the territorial PECO organizations. The large number of bulk terminals provide convenient access for the agricultural community and for remote commercial customers. Within each bulk terminal, there is sufficient tankage to store only a single grade of each product. In a competitive environment of multiple suppliers, bulk terminals would need to be able to handle several grades of each product. Eight of the terminals are on LPG pipelines and have LPG bottle-loading facilities, which serve most of the nation's bottled LPG customers. Trucks haul LPG bottles from these eight terminals to the other territorial PECOs. Large bulk terminals have top-fill trucks and loading racks, LPG filling facilities, LPG exchange tank delivery trucks, station construction and maintenance companies, lube oil packaging facilities, and warehouses for tires, batteries, and accessories. Storage tanks are usually owned by territorial PECOs, but in some cases may be leased. Some tankage is dedicated to specific large customers or government organizations.

Terminals normally operate only 10 hours a day and only 5 days a week, limiting the access to supply, especially on weekends and holidays. LPG bottle transport trucks line up at loading stations on Friday afternoon and wait until Monday morning to obtain their supply. Independent retailers fill their storage tanks and then their trucks for temporary, and hazardous, onsite storage of gasoline in order to ensure inventory over a weekend.

7.4 SECTOR DEFICIENCIES

7.4.1 Deficiencies in the Retail Marketing Sector

PECO is rapidly losing a great deal of retail market share to competing independents and majors, declining from 100 percent in 1989 to an average of less than 50 percent in July 1995. The design and operation of PECO's retail outlets are substandard, and the outlets are usually sited on narrow, inside lots rather than at high traffic corners or intersections. Poor pump placement is inconvenient to customers. Hours of operation are severely limited and inconvenient. The overall level of customer service is poor. Some sites are so small and badly configured that customers must back their automobiles up just to enter the facility. Motor fuel is frequently unavailable. Commercial customers are often forced to travel to the terminal office to pay their bills or obtain other services.

New investments and expansion of retail outlets are badly needed by PECO. However, there is an even greater need for retraining to improve operating practices, customer service, and site operations. The lack of customer focus is the single most important factor allowing independent retailers to gain market share. Customer defections are driven by the ability of independents to use their lower transportation cost to generate cash flows and use them to improve customer service.

The 41 territorial PECOs do not operate as a coordinated enterprise. Substantial potential synergistic benefits are not realized. No overall marketing leadership or promotional services are provided by PECO-SO. There is no common station design, image, or marketing strategy. No unique services or products are promoted. The only integration between the enterprises seems to be a common name, a common source of supply, and the price restrictions imposed by the government. However, even the common name is not as widespread as it once was as the Bucharest operation has changed its name to ComPetrol, avoiding any association with the PECO image. It is also apparent that product sourcing by the territorial PECOs sometimes circumvents the existing system.

Having 42 complete management staffs for PECO-SO and the territorial PECOs with only 500 stations and 154 bulk terminals leads to highly inefficient staffing levels, particularly in management and support functions. Inefficiency and poor management are aggravated by outdated business transaction systems that are not computer-driven, even for basic accounting. Sample data obtained indicated numerous errors, reporting delays of over a month, and frequent commingling of data from unsynchronized time periods. There is little direct cost accounting or profit center reporting, severely limiting the usefulness of the little information that is eventually compiled.

Some territorial PECO management teams have tried to respond to competitive threats, but they lack marketing and management skills, as well as the systems that support decision-making. The tiny margins available under price controls provide them with so little profitability that it is virtually impossible to fund improvements. Many of the territorial PECOs depend upon their

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control of product supply at the terminal to generate margins from captive governmental customers just to be able to survive.

7.4.2 Deficiencies in the Sector Pricing Structure

The price controls in the state-owned enterprises are intended to make products affordable to the general public. In fact, they result in higher prices, product shortages, and a highly inefficient refining and transportation sector.

Because accurate financial data are not available, it is difficult to determine financial results for the distribution and marketing sector. Figures 7-2, 7-3, and 7-4 show the Romanian and U.S. cost structures (July 1995 prices) and the differences between the two countries.

The charts show the value chain (before consumer taxes) for gasoline in Romania, and compare it to the same value chain in a market economy, the United States.

The U.S. example provides ultimate retail prices that are nearly the same as those in Romania. This comparison is similar to most market economies, including those in most of the European Union.

The value chain approach recognizes that each link in the chain of converting crude oil into gasoline and delivering it to consumers adds value to the process. The parties which perform each process in the chain receive this value for their contribution to the process of making products and services available to those that wish to buy them. To earn profits, the participants must add more value than their cost of adding that value. They do so by enhancing the value and by lowering the cost of delivering it.

In a market economy, the amount of value that each process adds is determined by customers and is expressed in the price they are willing to pay at each point in the process. Given a choice, customers will select the right products and service at the right quality, the right place, the right time and at the right price, all on a combined basis. This establishes the value added in each link in the chain.

As these figures show, Romania's refiners receive almost three times as much as their U.S. counterparts, the transporter (PetroTrans) receives 112 percent more, the oil producer (Petrom) receives 35 percent less, the distributor (PECO) receives 80 percent less, and the retailer (also PECO) receives 62 percent less. Under this system, (1) Petrom is deprived of the capital that it needs to discover and produce badly needed oil so that the growth of high-cost imports can be reduced and the balance of payments can be improved, (2) the refining sector is overpaid to support capacity levels that greatly exceed the needs of the nation, (3) an inefficient transport system is preserved and, (4) state-owned distributors and retailers are deprived of desperately needed capital to restore their systems. The figures do not reveal other important problems; in particular, they do not show that precious capital is wasted by all industry participants through overstaffing, inefficient and ineffective practices, and poor management.

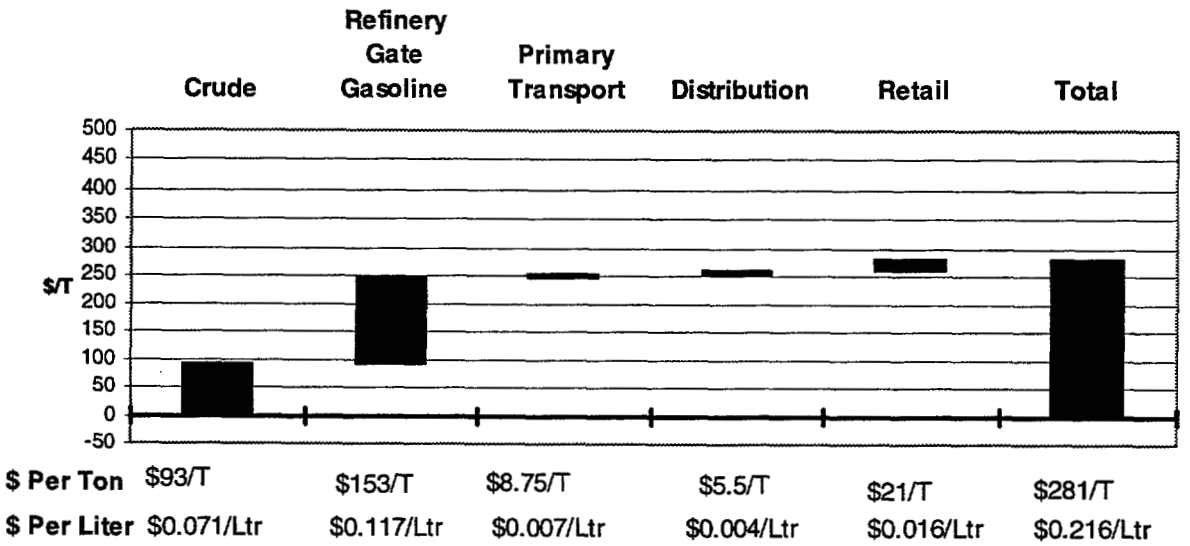

Figure 7-2 Gasoline Value Chain for Romania

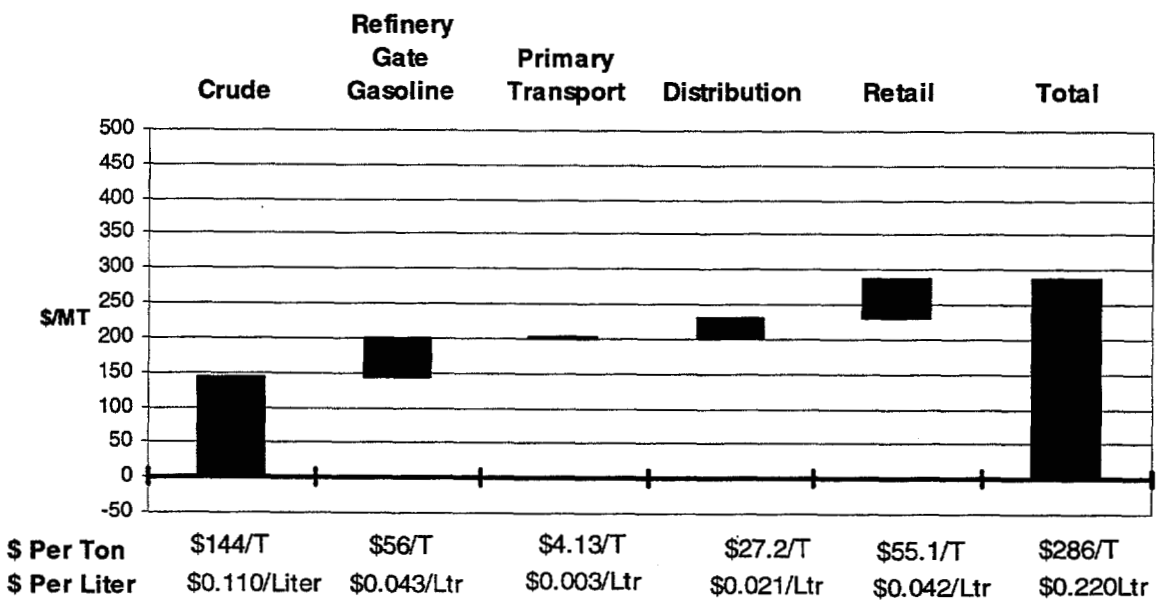

Figure 7-3 Gasoline Value Chain for the United States

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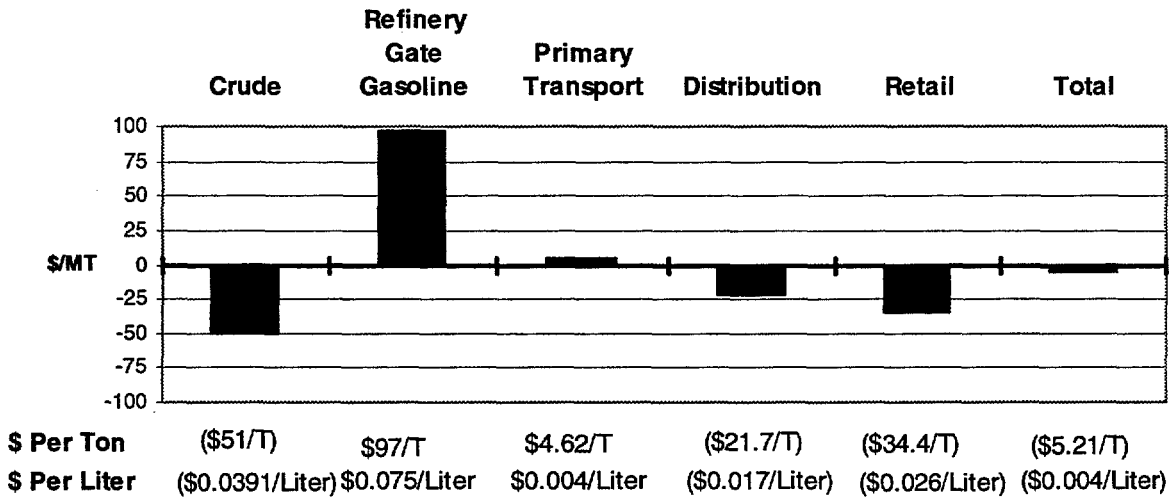

Figure 7-4 Value Chain Differences Between Romania and the United States

Figure 7-4 clearly shows that Romanian government policies cause a disproportionate share of the total value of the end product to be diverted to the refineries and primary transportation at the expense of oil producers, distributors, and retailers. As a result, taxes that could be available for public use are not generated. The government policies that subsidize refiners at the expense of others also cause the government to lose a major source of tax revenues, especially if final prices include taxes at the higher levels found in most European countries. Such tax revenues are often used to fund highway, road, and mass transit construction and maintenance and to meet other government priorities.

The systemic margin distortions in the distribution and retailing are depriving Romania of badly needed foreign investment that could be used to restore the sector to health and develop the retail sector. For example, the number of retail stations found in a market economy to serve equivalent consumer needs would total between 2,500 and 5,000 sites as opposed to 1,100 in Romania today. This represents an enormous potential source of jobs. It is possible to employ more Romanians in an expanded retail sector, at higher pay, and in a more pleasant atmosphere, than the total number of people now employed in the entire refining sector. This adds up to a compelling argument for eliminating price controls, rationalize capacity and employment, and increase private-sector participation.

7.4.3 Deficiencies in the Legal and Regulatory Environment

Significant barriers to a competitive distribution and marketing sector in Romania will persist until laws permitting open competition are enacted. Price controls and high costs of refining and transportation within the sector reduce the economic incentives for most activities and raise the overall costs to consumers without benefit to the overall economy. These controls make investing excessively risky and lower investor returns, preventing most international companies

from entering the marketplace. This is especially true in the transportation and distribution sector, where new investment might otherwise be well under way.

The legal and regulatory system causes other difficulties in doing business. Foreign individuals or companies are not allowed to own property, inhibiting their control and security over investments. Local bureaucratic licensing procedures, site approvals, and permits require unnecessary (and repeated) steps that consume time and waste money. Local politicians sometimes require special payments for access to prime property locations. Quality control and measurement practices are not standardized, regulated, or policed. Uneven application of other laws often results in the need for independent retailers to bribe law enforcers. Apart from the destructive social consequences, this corruption also thwarts preferred foreign investors.

7.4.4 Deficiencies in the Current Organization and Management

Many business processes and support functions required are missing in the marketing, distribution, and retail state-owned enterprises. For example:

- Marketing and merchandising is neither practiced nor understood.
- Logistics are designed not to meet customer needs but to implement centralized supply considerations with little attention to economic results.
- The central command system results in a very low level of customer service.
- Management processes do not function adequately, nor respond to the changing marketplace.

There are discontinuities in the supplier/customer relationship within the distribution and marketing sector, apart from the obvious retail problems. Inefficiency, poor operating practices, product losses, measurement errors, and quality contamination are quite common. Some of the business enterprises and too many of the processes employed represent functions that do not add value at all. Some are value-destroying, existing only to provide political control or redundant employment. For example, consider the process of ordering refined products for sale at PECO sites. Orders flow from each individual retail site to the territorial PECOs, then to PECO-SO, from PECO-SO to PetroTrans, and from PetroTrans to the refineries. The territorial PECOs have no choice in supply options and no recourse in product quality disputes. The only functions PECO-SO performs are the consolidation of orders from PetroTrans, supply planning, and allocation control, thereby slowing down the order process and increasing the potential for errors. PetroTrans is a monopoly wholesaler buying from refiners and reselling to PECO retailers. The refineries are disconnected from their customers, receiving bulk orders from PetroTrans, which is also isolated from the real customers. PetroTrans delivers product to and collects payment directly from the territorial PECOs and pays PECO-SO a fee for consolidating orders.

In the system described in the example cited above, four companies are involved in this ordering and delivery process. This division of the ordering process adds many unnecessary steps, delays, and costs. It also separates the customer and producer, transferring too much control to

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PetroTrans. Because these enterprises interact as buyers, and sellers, sector-wide working capital requirements and inventory are increased and payment flows are slowed, reducing economic value to the entire sector.

Each of the 41 territorial PECOs and PECO-SO maintains marketing and management staff – a costly duplication of supporting functions. There is no repository of marketing information or historical market data. No central entity is responsible for the brand image or marketing process for all stations under the same brand. This has resulted in different station formats, operating hours, procedures, station colors, and signage across Romania. Contrast this with Shell or Agip stations, which can be readily identified with consistent and coordinated image marketing everywhere in the world.

7.5 CHALLENGES AND OPPORTUNITIES FOR PECO

To survive and prosper, businesses must excel at the core competencies that drive value creation in their business sector. Core competencies consist of those functions, skills, and knowledge that enable the business to identify customer needs and to meet them as well as or better than competitors, all the while earning profits that allow the business to flourish and grow. In addition to core competencies, a company also needs other strengths or advantages, some of which do exist in the Romanian petroleum distribution and marketing sector. Competitive advantages are built around these competency strengths. PECO has both strengths and weaknesses in these core competencies.

7.5.1 PECO's Strengths

- PECO is the only petroleum retailer with nation-wide coverage.
- PECO has an in-place infrastructure and operators with experience.
- The PECO brand name is widely recognized.
- PECO has a large market share.
- PECO has a good understanding of Romanian culture and some knowledge of customers.

7.5.2 PECO's Weaknesses

- PECO cannot control product supply, quality, or price.
- The marketing function and approach do not identify or address customer needs or satisfaction levels.
- Data on customers needs are not captured or maintained.
- Transaction processing and information systems are inadequate.
- The quality of service and merchandise is poor.

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- The facilities are poorly designed and normally found in unattractive locations.
- Staff members are poorly trained and lack a customer orientation.
- PECO does not generate sufficient funds for reinvestment or expansion.

7.5.3 Opportunities for PECO

- Consumer demand is strong and growing.
- PECO owns some prime sites that could be upgraded.
- PECO can organize a Romanian market campaign faster than most new entrants.
- A restructured PECO is an attractive partner for an experienced foreign marketer.

7.5.4 Threats to PECO

- Major oil company competitors are entering the Romanian market. They have considerable financial resources and excellent marketing skills.
- Prime highway locations are rapidly being captured by independents.
- Price controls continue to negatively impact profit margin.
- PECO's required reliance on PetroTrans inflates its cost structure and reduces its ability to respond to markets.

7.5.5 PECO's Key Success Factors

For PECO to survive growing competition and manage its strengths, weaknesses, opportunities, and threats, it must:

- Restructure into a flat organization with fewer, but more capable, managers and staff members
- Become market- and consumer-oriented
- Divest itself of its poorly designed, equipped, and low-volume retail sites and terminals
- Begin a comprehensive marketing program and consolidate its brand image
- Obtain access to least cost, high-quality products
- Obtain access to competitively priced, reliable transportation of products

7.6 CONCLUSIONS AND STRATEGIC RECOMMENDATIONS

The present distribution and marketing system in Romania, which is government-owned and subject to price controls, suffers from inadequate profit margins and does not meet customer-

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driven needs. The PetroTrans monopoly on bulk transportation distorts transportation costs and restricts product quality, availability, and delivery options. Relaxation of the import bans and price controls has not allowed PetroTrans to respond to outside forces, but has instead opened up informal and illegal secondary transportation systems. PetroTrans must be converted to a common carrier as rapidly as possible and make the critical investments necessary to take custody of product and ensure quality control. All prices should be adjusted to reflect specific costs. Ownership and operation of rail transportation of bulk and refined products should be completely separated from pipeline transportation to create competition between the sectors and allow for profit margins that attract new investment.

PECO has a tightly compressed profit margin due to controlled high product cost and low retail price. The result is a severe shortage of capital to upgrade and expand sites, minimal services provided to customers, and lack of new investment. As with PetroTrans, the easing of import and development restrictions is creating a substantial private sector retailing system which, if current trends continue, will completely replace the PECO system. At that time, the PECO system and assets will be worthless. The government must reform the permitting and approval process to eliminate corruption, lengthy delays, and complicated and duplicative bureaucracy. Once price controls have been lifted, PECO should continue selling the individual sites to independent buyers in the rural locations; and for the urban systems PECO should form a joint venture or sell as a unit to an international oil retailer offering the established sites and network in exchange for the capital, brands, and marketing expertise of the international oil company.

To successfully manage change in the distribution and marketing sector, both the Romanian government and industry management must radically change the mission of the state-owned companies as well as the mindsets of both management and employees. Laws, industry organization, and capital assets must be restructured to enable the enterprises to become as competitive as other participants in any market-driven economy; otherwise they will be destroyed by competition.

Section 8

Environmental Assessment and Critical Investments

8.1 INTRODUCTION

This section assesses the environmental aspects of the downstream petroleum sector in Romania and examines the environmental consequences of past and present operations. Throughout the world, the downstream petroleum sector generates various waste streams that pollute the environment, endanger the public, and contribute to operating costs. This section discusses Romanian environmental regulations, air emissions, wastewater discharges, solid waste discharge and storage issues, contamination of ground and groundwaters, and environmental remediation of plant shutdowns. The section concludes with an estimate of critical environmental investments.

8.2 OVERVIEW AND CURRENT STATUS

The environmental contamination caused by the Romanian state-owned industries is well documented. The fundamental issues that require addressing are:

- Remediation of pollution and contamination caused by past operations
- Reduction of current pollution streams by process modification, installation of new hardware, and upgrading of process and utility efficiencies
- Future upgrading of pollution control facilities and reduction at the source to permit compliance with tougher environmental regulations and European Union (EU) directives

The solutions to the environmental problems will be expensive and impossible to finance from internally generated funds, and will require outside technology. These solutions will improve operating efficiencies at the subject enterprises and create substantial, intangible benefits to the country as a whole. Environmental issues are national by nature and require joint efforts of local enterprises, the downstream sector, the government, and the funding sources.

The downstream Romanian petroleum industry consists of five large refineries, five smaller refineries, a large crude and product terminal on the Black Sea, a network of crude and product pipelines, and local terminals for product distribution. All of these facilities have environmental issues that will affect privatization. The major issues that must be addressed are:

- Air emissions
  - High sulfur content of refinery fuels
  - Significant hydrocarbon emissions from storage tanks
  - Uncontrolled emissions from fired heaters
- Wastewater
  - Excessive wastewater flow rates

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- Low quality of treated effluent
- High energy consumption in treating facilities

- Solid wastes
  - Large volumes of waste material not properly dewatered
  - Previously landfilled sludges that are hazardous and are not contained at secure sites

- Groundwater
  - Large areas of contaminated groundwater extending past refinery property limits

8.3 ENVIRONMENTAL REGULATIONS

8.3.1 Existing Romanian Regulations

The current Romanian regulations require that the various enterprises pay a fee for emissions and discharges. The fees currently apply to wastewater discharges and to solid wastes transported to landfills. The fees for air emissions have been waived because most Romanian enterprises do not have adequate instrumentation to measure air emissions. Some of the 1995 fees for wastewater discharges are presented in Table 8-1.

Table 8-1 Wastewater Discharge Fees
(in lei per tonne)

Constituent	Base Fees	Higher Limit Fees
BOD 5	16,989	29,550
Suspended Solids	6,580	–
Phenol	6,595,330	–
Oil	395,550	–

8.3.2 Proposed Romanian Regulations

The following is based on discussions and a review of portions of draft regulations now being considered by the Romanian Parliament. The law as passed by the Parliament may be modified. Since Romania intends to join the EU, it has proposed new legislation that will update environmental regulations according to EU directives. The proposed law will stipulate the following:

- All state-owned and private sector enterprises will perform an environmental impact assessment (EIA) to evaluate the current environmental condition of the facilities.
- Following the completion of the EIA, the enterprise will develop environmental action plans that present programs for complying with new regulations and remediation of past pollution problems.

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The current law permits all levels of discharge and imposes higher fees for higher discharges. The new law establishes a fee system, but adds a fining system and penalty system above certain thresholds. Fees will apply to normal, permitted discharges. Discharges above the limit established in the new law can result in penalties, legal action, and a shutdown of the offending facility. Owing to the capital constraints on the existing enterprises, a schedule will be established so that compliance with new environmental requirements can be achieved over time.

In general, the new law will not specify specific emission or discharge limits. These will be established by administrative order from the Ministry of Environment, and will be enforced on a local or county basis. This procedure is similar to those found in many Western countries, including the United States.

To meet the intent of EU directives, Romania must:

- Reduce air emissions, mainly sulfur dioxide and hydrocarbons
- Reduce wastewater discharges, mainly flow and dissolved constituents
- Reduce solid waste discharges and improve long-term storage facilities
- Eliminate contamination of the ground and groundwaters

8.4 AIR EMISSIONS

8.4.1 Sulfur Dioxide

Sulfur dioxide, which is a product of the combustion of fuel or process acid gases, is a significant environmental and health hazard. Certain refineries are processing crude oils with a higher sulfur content than the units were designed to handle, and are using processes or process catalysts that are not sufficiently efficient to meet fuel product sulfur specifications. Process changes required to reduce sulfur dioxide emissions are discussed in Section 4.

To establish a sulfur dioxide reduction program for EU countries, a baseline yearly emissions level for each country was established. Each country was then allowed to develop its own programs to reduce these emission levels over time. Gradual implementation policies in different countries were developed with initial goals of 60 to 70 percent reduction, then subsequent reductions to 80 percent or more over time.

It is assumed that Romania will establish a similar program calling for reductions from all industries, a phase-in period, and enforcement of penalties or shutdowns for violators.

For the purpose of this analysis, the following program is recommended for the downstream petroleum industry:

- To reduce the sulfur content of refinery fuel gases, acid gas streams, etc., refineries will initially install facilities such as amine treating, sour water stripping, and sulfur recovery units.

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- The sulfur content of refinery fuel gases will be reduced to the acceptable parts per million level, and the efficiencies of the sulfur recovery units will be 98 to 98.5 percent.

During the second phase of sulfur emission reduction, the refineries will need to reduce fuel oil sulfur levels to a maximum of 1 percent. It is assumed that refinery modernization programs to produce lower sulfur products will also include the capacity to meet this requirement. Longer term goals to reduce fuel sulfur levels to the range of 0.05 to 0.3 percent will also need to be established.

8.4.2 Hydrocarbon Emissions

8.4.2.1 Reduction of Emissions

In 1995, the EU passed Directive 94/63/EU, "Control of Volatile Organic Compounds (VOC) Emissions Resulting from Storage of Petrol and Its Distribution from Terminals." The target of this regulation is to reduce VOC emissions from terminals and other storage facilities to less than 0.01 wt% of the throughput. This regulation affects all segments of the downstream petroleum sector in Romania.

Compliance will have to be phased in 3, 6, or 9 years from the effective date, depending on the size of the facilities, as shown in Table 8-2.

Table 8-2 EU Directive 94/63/EU Stipulations for Reduction of VOC Emissions

No. of Years for Compliance	Size of Facility
3 Years	
if storage volume is	> 50,000 tpy
if tanker loading is	> 150,000 tpy
if service stations throughput is	> 1,000 m^3/yr or the station is in a community
6 Years	
if storage volume is	> 25,000 tpy
if tanker loading is	> 25,000 tpy
if service stations throughput is	> 500 m^3/yr or the station is in a community
9 Years	
if storage volume is	< 25,000 tpy
if tanker loading is	< 25,000 tpy
if service stations throughput is	> 100 m^3/yr or the station is in a community

The regulation also specifies that external floating roof tanks have primary and secondary seals and that internal floating roofs have a single seal using one of the more advanced technology designs.

8.4.2.2 Storage Tanks

The Romanian petroleum industry uses floating roof tanks to store lighter hydrocarbon products, but these tanks use the older seal designs. In general, all floating roof tanks will need to have their roof seals modified to meet new regulations.

Romania has approximately 5 million m^3 of petroleum product storage at the refineries and oil terminals. (Products stored throughout the country for local distribution are not included in the above total.) Of this amount, 65 percent (3.23 million m^3 of storage) is affected by this proposed regulation or other regulations on the control of VOCs. Table 8-3 lists the storage space for each type of storage tank.

Table 8-3 Storage Tanks at Refineries and Oil Terminals

Type of Tank	m^3 of Storage
Fixed Roof Tanks	
Crude Oil	210,000
Gasoline	470,000
Other Light Products	120,000
Total	800,000
Floating Roof Tanks	
Crude Oil	1,800,000
Gasoline	425,000
Other Light Products	205,000
Total	2,430,000

8.4.2.3 Hydrocarbon Losses

The refineries control other hydrocarbon losses by the use of vapor recovery compressors to recover gases lost to flare systems. These gases are collected and reused as refinery fuel. Many of the existing compressors have been in service past normal operating periods and require maintenance or replacement. The older Romanian compressors have a low design operating efficiency, and replacement with high-efficiency compressors would result in considerable savings in operating power costs in addition to a reduction in hydrocarbon emissions.

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The refineries have only recently started to implement proper preventive maintenance and repair programs. For this reason, fugitive emissions from existing valves, pumps, etc., are high. Upgrading of the refineries should include proper budgeting and implementation of fugitive emissions reduction programs.

8.4.3 Other Air Emissions

Other air emissions result from combustion of fuels in heaters, FCC offgases, and delayed coker and coke handling. Reducing sulfur levels in the fuels will eliminate most of these emission problems. Heater fuel efficiency is currently between 75 and 80 percent. Efficiencies could be increased to 85 or 90 percent by the use of air preheat, waste heat recovery, process heating, or proper combustion controls. Large numbers of heaters are employed in the refinery process, and improved efficiencies would result in quick economic paybacks and corresponding reductions in emissions.

8.5 WASTEWATER DISCHARGES

8.5.1 Flow

The major problem with the refinery wastewater systems is far too much flow. The average flow observed for the industry is 4.20 m^3 of wastewater per tonne of crude processed. This flow rate is four to eight times higher than what has been observed in comparably designed Western refineries. When allowances are made for the added complexity of petrochemical plants or power and steam generation, the net flow of wastewater should be 1 to at most 1.5 m^3 of wastewater per tonne of crude. For the Romanian refineries, 2.0 m^3 of water per tonne of crude should be a target or goal to be achieved within the rationalization period.

As a rule, the high flows are from clean utility water streams that are lost to the sewers. These include cooling water and condensates that could be returned to boilers. As an example, one refinery, working with USAID funding, installed facilities to significantly improve the amount of steam condensate returned to the adjacent power station. This program reduced the flow of wastewater and the cost of steam generated by the power station. Several refineries are piloting the use of imported proprietary chemicals for use in cooling water systems. These chemicals allow higher reuse of water in cooling water systems, thereby decreasing water losses.

Recovery of condensates and reduction in losses from cooling water systems will help to further balance wastewater flows. The effect of these reductions will be significant as refineries increase production to meet growing demand. If these recovery methods are implemented, the increase in production should result in no corresponding increase in flow of wastewater.

As a result of the USAID study in 1993, the five larger refineries have been successful in reducing the volume of wastewater. However, without design changes, equipment modifications, instrumentation, and chemical additives, it will not be possible for the refineries to

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further reduce the volume of wastewater significantly. Table 8-4 summarizes the more commonly found areas of high water wastage.

Table 8-4 Sources of Wastewater

Source of Water	Reasons for High Water Loss
Cooling Water	System leaks, oil contamination; barometric condensers in vacuum units; ineffective chemical inhibitors
Condensate from Steam System	Contamination in condensate; inadequate analyzers to detect contamination; no inhibitors for controlling oxygen or carbon dioxide in system
Desalter Water	No flow measuring capabilities
FCCU Process Waters	No flow measuring capabilities; improper unit processing equipment to recover oil
Delayed Coker Unit	
Cutting Water	Too small a maze for coke fine settling; improper clarification for reuse as cutting water
Process Water	Improper oil-water separation facilities; improper degasing facilities

8.5.2 Recommended Upgrades

Each refinery has a similar design for the wastewater treating system: oil-water separators, homogenization (equalization), chemical addition, air flotation, and biological treating. While each refinery has individual needs for new or modified facilities, all refineries have three common needs:

- The biological treating system must be upgraded to improve performance and reduce energy consumption.
- Inorganic chemicals (ferric compounds and calcium hydroxide) must be replaced with organic polyelectrolytes.
- Oil-water separators must be covered to reduce VOC emissions to the atmosphere.

8.5.2.1 Upgrade Biological Treating Units

All biological treating units in the refineries are based on the use of older technology, low-speed aerators. These aerators are energy-inefficient and do not adequately mix the aeration basins. The biological treating units at the refineries usually do not function properly. Astra has contracted to purchase a modern technology fine bubble air diffusion system which includes

high-efficiency air blowers. This system is scheduled to start up in the last quarter of 1995 and should help the industry determine the effectiveness of the newer technologies available.

Each refinery has several trains of biological treating facilities. To improve performance and reduce energy, one train of equipment should be modified to include:

- Modern technology of aeration facilities
- Weir/level adjustments to maximize water depth in aeration basins
- Concrete repair as required
- Western-design air blowers, specifically designed for wastewater service
- Modified clarifiers to include baffled weir overflow design for containment of floating materials

8.5.2.2 Replace Inorganic Chemicals with Polyelectrolytes

Chemicals are added to wastewater for pH control and conditioning of the water for removal of residual oils in the air flotation process. These chemicals form inorganic by-products that are removed with the sludge that is formed in the flotation processes. The compounds increase the volume of by-product sludge formation by a factor of 2 or 3. Replacement of the inorganic chemicals with polyelectrolytes will reduce:

- The volume of by-product sludge
- The size of the dewatering facilities
- The amount of material that must be landfilled
- Overall daily operating costs of the wastewater treating plant
- Corrosion in flotation and biological treating systems
- Maintenance in flotation systems
- Contaminants to be removed in the biological treating system

8.5.2.3 Covering of Oil-Water Separators to Reduce VOC Emissions

All refineries have several oil-water separators that use a top-mounted traveling bridge for collection and recovery of oils and removal of oily sludges. Such separators are not compatible with retrofitting covers for reducing VOC emissions. The basins will require modification to a submerged mechanisms with a rotating flight separator mechanism so that covers can be placed on top of the separators.

Separators in Romanian refineries recover considerable amounts of oil. This is due to high oil losses from the process units, especially delayed cokers and FCC, and from oil-contaminated

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cooling water and condensates. Process modifications should be made to reduce water and oil losses, and then to cover oil-water separators.

8.5.2.4 Other Wastewater Treating System Requirements

Other problems were observed at individual refineries which reflect site-specific conditions. Commonly found maintenance and operating problems are:

- High maintenance and operating cost for turbine aerators
- Inoperative sludge dewatering systems
- High disposal quantities of waste oily and biological sludges
- Inadequate flow instrumentation and controls
- Inadequate laboratory facilities

Problems found at individual locations are:

- Leaking homogenization/equalization basins
- Air flotation units not working or missing
- Inoperable biological treating unit
- Acidic and nonacidic oily sludges accessible to the public
- Lack of groundwater monitoring wells for the refinery or the oily sludge lagoons
- High suspended solids content in the wastewater

Table 8-5 summarizes the refinery capacities and flow rates.

8.5.3 Technology Upgrades

One of the problems identified with the Romanian wastewater treating systems in the 1993 USAID study was obsolete technology and poor maintenance. Since that study, some of the refineries have undertaken extensive maintenance repair programs to replace or repair equipment. However, the petroleum industry's effluent discharge water qualities have not significantly improved, primarily because of the older technology used in the biological treating unit. The refineries will need to replace the existing technology to improve biological unit performance.

Petrolsub and Steaua Romania do not have working or partially working biological treating systems. Both of these refineries will need new facilities to meet the new environmental requirements. Improvements to the wastewater treating facilities will be required to meet the newer regulations expected from the Ministry of Environment in 1996. Many of these improvements will result in an outright economic benefit – either more oil will be recovered or significantly less energy will be required to treat the wastewaters.

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MODIFICATIONS TO IMPROVE ENVIRONMENTAL PERFORMANCE													
LOCATION	ARPECHIM	ASTRA	DARMANESTI	LUBRIFIN	PETRO BRAZI	PETRO MIDIA	PETROSLUB SUPLACU	PETROTEL	RAFO	STEAUA ROMANA	VEGA	OIL TERMINAL	TOTAL
REFINERY CAPACITY; T/D	8212	1818	1400	—	11345	8867	1335	15130	6478	715	1102	—	56402
WASTEWATER													
FLOW RATES; M3/H, DESIGN	2600	500	570	—	4200	4500	40	2000	1350	1150	500		17410
FLOW RATES; M3/H, ACTUAL	1650	500	370	—	2300	1340	50	2000	800	350	383		9743
1995 M3 WTR/TON FEED	4.82	6.60	6.34		4.87	3.63	0.90	3.17	2.96	11.75	8.34		4.15
TARGET FLOW; M3 WTR/TON	2.00	2.00	2.00		2.00	2.00	2.00	2.00	2.00	2.00	2.00		2.00
AS M3/H	684	152	117		945	739	111	1261	540	60	92		4700
BIOLOGICAL UNITS	13860	2400	1420	NR	29640	7240	276	7730	3070	1680	1840		69156
KG/DAY BOD REMOVED (ACT)													
BIOLOGICAL SOLIDS													
M3/YR									35000				35000
% SOLIDS													
M3 SLUDGE LAGOONS			10000		45000		80000		76000				211000
OILY SLUDGES													
M3/YR	2000		150		35000	8400		22000	35000		200	2000	104750
% OIL	2		2		15	5			5				
M3 SLUDGE LAGOONS													
SLOP OIL													
T/MONTH	1200		400		10400	4200	1500		2500		2000		22200
% OF CRUDE	0.49		0.95		3.06	1.58	3.75		1.29		6.05		
STORAGE TANKS M3													
CRUDE STORAGE													
IN FIXED ROOF TANKS			40000		62500		5475		81900		22500		212375
IN FLOATING ROOF TANKS	368560				90000	400000		290000	165000			480000	1793560
LIGHT PRODUCT STORAGE													
IN FIXED ROOF TANKS	99805		27000		206000		4150	23000	136830		35000	583000	1114785
IN FLOATING ROOF TANKS	133995				112000	54000		97000	69750			629000	1095745
MEDIUM/HEAVY PRODUCTS STORAGE													
IN FIXED ROOF TANKS	400510		83000		266500	163000	7330	256000	211320		55000	240000	1682660
IN FLOATING ROOF TANKS													
TOTAL STORAGE VOLUME	1002870		150000		737000	617000	16955	666000	664800		112500	1932000	5899125
FUELS													
PURCHASE GAS; T/YR	31400		8000		2845	26500	11300	68000	4600		10000		
REFINERY FUEL GAS; T/Y	131500		31000		150000	131916		45000	129000				
% S	0.15		1.14		0.7	1.15		0.03	1				
FUEL OIL; T/Y	103000		17700		61800	0	8000	316000	12000		40500		
% S	3.5		0.5		2		0.5	2	1.78		0.5		
KG/YR SO2	3802.25		441.90		2286.00	1517.03	40.00	6333.50	1503.60	0.00	202.50		
KG SO2/TONNE CRUDE	2.65		1.80		1.15	0.98	0.17	2.39	1.33	0.00	1.05		

The technology required to upgrade the wastewater treating facilities are as follows:

- New aeration facilities, including diffusers and air blower
- Sludge dewatering facilities for biological sludge
- Sludge dewatering facilities for oily sludge
- Use of polyelectrolytes, including automatic feeding facilities, replacing existing lime and ferric feed system
- New oil-water separation systems that can be covered to meet potential new regulations for reduction in hydrocarbon losses
- On-line field technology and laboratory analyzers
- Completely new biological treating systems at Petrolsub and Steaua
- Completely new air flotation systems at one refinery and one terminal

8.6 SOLID WASTE DISCHARGE AND LONG-TERM STORAGE ISSUES

Disposal of solid waste materials, both oily sludges and biological sludges, is a major problem for all of the refineries. In general, the petroleum industry does not have adequate solids/sludge dewatering facilities, and the individual enterprises are disposing of 5 to 10 times more volume of waste materials than would be generated it proper dewatering facilities were in place.

Three factors causing the high sludge production associated with the Romanian refineries must be corrected. They are:

- Clay sludges from lube oil production
- Use of inorganic chemicals, lime, and ferric compounds in wastewater treating
- Inadequate or inoperative dewatering facilities

8.6.1 Clay Sludges from Lube Oil Production

The refineries that have lube production facilities have additional problems associated with the disposal of by-product oily clay materials. Some of the clays, especially from past operations, also contain waste acids. Western refineries have generally made process modifications by employing technologies that do not require clays and, therefore, eliminate the by-product clay disposal problem. The Romanian refineries that produce lubrication products should also consider use of these newer non-clay treatment technologies to minimize future environmental problems.

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8.6.2 Use of Inorganic Chemicals, Lime, and Ferric Compounds in Wastewater Treating

The volume of oily and biological sludge from the refinery wastewater treating systems could be reduced by 30 to 50 percent if newer technology organic polyelectrolytes, rather than lime or ferric compounds, were used in the flotation and other processes. Currently, polyelectrolytes are not manufactured in Romania and must be imported. Several of the refineries have performed economic evaluations and have determined that they can reduce sludge disposal costs by replacing inorganic chemicals with imported polyelectrolytes. These refineries are also piloting the use of these chemicals, and it is recommended that they adopt full-scale use in the future.

8.6.3 Inadequate or Inoperative Dewatering Facilities

Only one refinery has a working dewatering system. This refinery has less than 2 percent of oily sludge to dispose of than the other refineries. The use of polyelectrolytes is expected to reduce this volume even further.

A second refinery has oily sludges with a heat content high enough to make incineration a reasonable approach. However, this refinery has such large process losses of both oil and coke that elimination of these process losses would be economically beneficial to this refinery, but would then require dewatering and disposal of the oily sludge as opposed to incineration.

Several refineries have installed dewatering facilities that use vacuum filtration. This technology is obsolete, difficult, and expensive to keep in operation. Vacuum filter technology has for the most part been replaced by twin-belt filter presses, plate and frame pressure presses, or centrifuges. Twin belt filter presses are most commonly used for biological sludges, and all three technologies are used for oily sludge dewatering.

8.6.4 Impounded Sludges

All enterprises have permanent landfill areas that contain large quantities of sludges mixtures. In certain locations, the sludges are segregated.

Since the early 1990s, sludge disposal landfills have been constructed with concrete, clays, or flexible membrane lining materials to prevent contamination of the local environment. These newer landfills are located either at the edge of the local townships or in their vicinity.

Landfills used by the various enterprises prior to 1990 represent serious environmental or health hazards. These landfills may contain only refinery sludges, or may be a mixture of highly contaminated sludges from various enterprises (chemicals, petrochemicals, municipalities, etc.).

Many of the older landfills are located within city or township limits and are not properly protected from the public. Local residents from time to time skim oil from the surface waters, and children play along and around the landfills. Many of the older landfills do not have impervious bottoms or local monitoring wells; local groundwater contamination is virtually certain. The newer landfills are better protected and have more security. Area monitoring varies

from adequate to needing more improvement. Since the enterprises do not have adequate dewatering facilities, the reserve capacity of these impoundments does not suffice for long-term needs.

In general, problems with the landfills can be solved by:

- Improving security measures to keep out the general public
- Upgrading area monitoring, especially in older impoundment areas
- Providing sludge dewatering facilities at individual locations to reduce the moisture and therefore lower the volume of sludge
- Providing dewatering facilities for older landfills, especially ones within city limits or ones that can potentially contaminate groundwater

Landfill dewatering will also recover considerable amounts of oils since in many landfills the oil content of the sludge is 3 to 10 percent of total volume. A heated centrifuge process will recover the maximum amount of oil and produce a dry sludge suitable for general landfill use. Other processes do not produce as dry a solid material or require more chemicals for process operation. Mobile or trailer-mounted processes are available so that once one site has been cleaned, the equipment can be moved to another site. The wastewaters from the dewater/oil recovery process may require treating, depending upon the pH or residual organics in the water.

8.7 CONTAMINATION OF THE GROUND AND GROUNDWATERS

Contamination of groundwater is a widespread problem and affects the entire downstream petroleum industry. At most refinery locations, the extent of the problem is known; at other locations, notably portions of the pipeline systems, the local terminal, and individual retail outlet, the extent of the problems is not well defined.

Romania has a system of lakes and other sources that provide water for the large cities. Fresh water generally originates from sources outside of areas with industrial development, which helps ensure that contaminated groundwaters are not used for drinking. All use of groundwater is regulated. In areas where the first level of water is contaminated, only lower water aquifers may be used. In these areas, shallow water wells have been bricked in or abandoned. However, during water shortages or prolonged outages, some local wells contaminated with hydrocarbons are used for both agricultural and drinking purposes.

In many areas, the groundwater contamination from oils has migrated outside the property line of the refinery. Some of these contaminated waters are only 5 to 15 meters below grade, and hydrocarbons are being recovered by local peasants and farmers. Pollution in Ploiesti is extensive, and will require a joint effort between the petroleum industry and the government. Given the considerable amount of oil in this area, it is probable that the amount of oil to be recovered can offset most of the recovery costs.

At present, multiple reports and some field data detail the extent of groundwater contamination at refineries and in the general area around these facilities. Some of these reports are no longer current and need to be updated to more accurately assess the amount of oil and the spread of the oil plumes. One of the refineries has data that show that once the source of contamination is eliminated, the area around the original source will naturally become clean over time, but that the original plume will continue to spread with the flow of the underground water aquifer.

As mentioned above, in some areas it appears there is sufficient oil such that the value of the recovered oil will offset the cost of collection. However, the data also suggest that there are other areas where recovery is required and recovered product value will not offset costs. The most likely scenario is that recovery costs will be offset initially by recovered product values. As the product recovery rates decline but costs do not, cash flow will became negative. However, remediation needs will continue for quite some time.

The magnitude of the groundwater contamination problem is immense; therefore, a combined donor/government/private enterprise effort will be required to solve the problem. In general, the following steps are necessary:

- Establish the legal framework under which hydrocarbons can be recovered and the ground/groundwaters treated on properties owned by private individuals, private corporations, and public sector properties. This framework should include the ownership rights to the recovered oil, temporary land use rights, aquifer water rights, etc. The government will need to clarify legal liability for the cause of the problems, and definition and protection of current or new enterprises from past operational practices.
- Provide an environmental impact assessment (EIA) of the problem. This will include geological assessments, estimates of quantities of oils that are in the ground and the percentage that can be recovered, methods of recovery to be employed that have the least effect on the environment, and reinjection/disposal of excess waters from recovery operations. The EIA should cover all aspects of the downstream petroleum industry, including refineries, terminals, pipelines, and retail sites.
- Install facilities to recover oil products and stop the spread of the oil plume. This will include installation of a series of single well (oil recovery only) or double well systems (small-volume oil recovery wells located near high-volume water pumping wells). Excess waters will then need to be treated and reinjected for plume control or used for local purposes. In some critical areas, geotechnical barriers may be required to contain oil products or to slow and redirect the spread of the oil plume.
- Continue operation of the recovery/treating systems as required to restore the aquifer for general purposes such as industrial or agricultural.

8.8 ENVIRONMENTAL REMEDIATION OF PLANT SHUTDOWNS

If it is determined that certain refineries are redundant or not economically attractive for privatization, environmental liabilities will be associated with decommissioning. There are two categories of facilities to be considered:

- Those located within city limits, including Astra and Vega in Ploiesti, Steaua Romania in Campinia, and Oil Tank Areas 1 and 2 located within Constanta
- Those located outside city limits, including Petrobrazi and Petrotel at Ploiesti, Arpechim at Pietisti, Rafo at Onesti, Petromidia at Midia, and Petrolsub at Suplaco du Bacco

The refineries and the two tank storage areas located within city limits have two issues in common: the facilities are adjacent to public housing and the land could be valuable for local population use, and the land under these facilities is heavily contaminated with oils.

Oil has seeped into the ground and the underlying water aquifer. After shutdown, the aboveground structures will need to be completely removed from the site, and equipment will have to be cleaned to obtain maximum salvage value. Concrete crushing facilities are recommended so that concrete buildings and other structures can be recycled and not create another disposal issue. Underground storage tanks will also require cleaning and removal or be filled in to prevent future environmental concerns.

At certain sites, the ground is relatively permeable. Once these sites have been remediated, the existing oil contamination can be eliminated over time, making the sites safe for residential or commercial use. However, depending on the specifics of the site and the extent of the contamination, oil recovery, removal, or farming of the topsoil all may be required.

Facilities located outside cities can be shut down and equipment can be removed, as required, and sold for salvage value. Alternatively, the equipment can be cleaned of oils to prevent further ground contamination and left in place. Underground tanks and sewers will also require cleaning and fill-in. The facilities will require fencing and safety patrols.

8.9 CONCLUSIONS AND ESTIMATE OF CRITICAL ENVIRONMENTAL INVESTMENTS

The downstream petroleum sector in Romania has operated in an unacceptable manner with regard to public safety, environmental economics, and the standards established by the European Community. The problems are caused by high flows, uncontrolled emissions, and improper operating and maintenance procedures. The solutions include equipment and technology upgrades, revisions to operations and maintenance procedures, and legal standards and practices that place a high priority on reduction and remediation of environmental pollution.

With the exception of the groundwater pollution in Ploiesti, the environmental situation is manageable and there is reason for optimism. As the refineries have instituted proper preventive maintenance programs and upgrades of treatment technologies, pollution rates have declined.

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The critical investments itemized in Tables 8-6 and 8-7 will bring operations in line with Western standards and raise the quality of the environment to proper levels. Remediation of past pollution will be a long-term, multiparty program. If the investments recommended here are made, the status of the physical environment in Romania will eventually be on a par with that of advanced and environmentally conscious nations.

Table 8-6 Environmental Upgrade Tasks Recommended

MODIFICATIONS TO IMPROVE ENVIRONMENTAL PERFORMANCE															
UNITS/LOCATION	ENVIRONMENTAL PROBLEM	SOLUTION	ARPECHIM	ASTRA	DARMANESTI	LUBRIFIN	PETRO BRAZI	PETRO MIDIA	PETROSLUB SUPLACU	PETROTEL	RAFO	STEAUA ROMANA	VEGA	OIL TERMINAL	COST
CRUDE UNITS			yes	yes	yes		yes	yes	yes	yes	yes	yes	yes		
DESALTER	High water flow rates	Water flow meter													
	Too high of oil content	New thermconductivity controls													
FLUID CATALYTIC CRACKER															
Process Waters	High water flow rate	Water flow meter	yes				yes	yes		yes	yes				
	High of oil content	Redesign process separation	yes				yes	yes		yes	yes				
		vessel													
DELAYED COKER UNIT															
Process Waters	High water flow rate	Water flow meter	yes		yes		yes	yes		yes	yes				
	High of oil content	Redesign process separation	yes		yes		yes	yes		yes	yes				
		vessel													
Cutting Water	High water flow rates	Redesign water mase or	yes		yes		yes	yes		yes	yes				
	High solids content	provided new clarification facilities													
		for improved water recycle													
SOUR WATER STRIPPER															
Overhead Vapors	Currently routed to flare	Route to Sulfur Recovery Unit	yes	yes	yes		yes	yes		yes	yes				
Live steam injection	adds to flow of wastewater	Add feed/effluent heat exchanger	yes	yes	yes		yes	yes		yes	yes				
SULFUR RECOVERY UNITS															
(Low recovery efficiency)	Currently less than 60 % efficient	Use more active western catalyst	yes	yes	yes		yes	yes		yes	yes				
	Do not meet newer EC Directives	Convert from 2 stage to	yes	yes	yes		yes	yes		yes	yes				
		3 or more stages (Super Claus)													
GENERAL PROCESS NEEDS															
Fired Heater Efficiency	Average heater efficiency 75 %	Add air preheat, add waste heat	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
		recovery; product/product or						(started)							
		steam generation													
		(only largest heaters)													
		Provide flue gas O2 analyzers	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
Low reactor catalyst activity	Lower specification products;	Replace existing catalyst	yes	yes	yes		yes	yes	yes	yes	yes	yes	yes		
	(ie higher sulfur levels in products)														
Reduced solvent activity	higher sulfur levels in products	Provide new MEA; or evaluate if	yes	yes	yes		yes	yes	yes	yes	yes	yes	yes		
	(ie MEA contaminated with heat	newer solvents, MDEA are													
	stabilized salts or COS by products)	better suited													
Pumps, compressors, valves	Fugitive emissions	New Western types of seals for	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	Product losses to sewers from leaks	pumps and compressors	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	Hi energy consumption	valve testing and repair	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
		Use more efficient western types													
		of pumps and compressors													
Product sampling	Product losses and air emissions	add on-line analyzers	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
INSTRUMENTATION	Older technology; not suitable for	Provide new spectrometers,	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	on line analysis	liquid/gas chromatograph etc.													
Air emissions monitoring	None existing at this time	Provide new monitoring facilities	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	Not possible to quantify emissions or	including multiple stack analysis													
	if there is an upset etc.	with one analyzer system													
Wastewater system and	Short term upsets not detectable	Provide new monitoring systems	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
discharge monitoring	and can lead to long periods of	Provide on-line controls for specific	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	off spec effluents	activities; ie chemical feed, etc.													
Cooling water	Too high of blowdown rates	Automated chemical feed systems	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
	Too much oil in water	Use newer western proprietary	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
	high exchanger corrosion rates	chemicals													
		Automatic pH control/acid feed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
		Side stream filters	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
		Flow control blowdown	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		

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MODIFICATIONS TO IMPROVE ENVIRONMENTAL PERFORMANCE			ARPECHIM	ASTRA	DARMANESTI	LUBRIFIN	PETRO BRAZI	PETRO MIDIA	PETROSLUB SUPLACU	PETROTEL	RAFO	STEAUA ROMANA	VEGA	OIL TERMINAL	COST
UNITS/LOCATION	ENVIRONMENTAL PROBLEM	SOLUTION													
		Eliminate use of barometric condensers	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
Steam/condensate systems	Too high of condensate loss	Improve deaerator efficiency	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
	High oil content in condensate	Use newer western proprietary chemicals	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
	Corrosion in steam system	Hydrocarbon analyzer for condensate return systems	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
		Condensate filters/coalescers	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
Product loading systems	VOC losses from gasoline/light product loading	Add vapor collection & recovery system	yes	yes	yes	yes	yes	yes	no	yes	yes	yes	yes	yes	
Storage Tanks	Product leaks	Scheduled maintenance program	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
		Repair/replace leaking tanks	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
		Modify tank roof seal design	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
		Add vapor recovery to cone roof tanks storing light products or convert tanks to floating roof type	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
Flares	Air emissions, SOx, NOx, Particulates	Maintain relief valves													
	Visible flames for extended periods	Improve operation of vapor recovery	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
		compressors	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		
WASTEWATER TREATING															
Oil water separators	Air emissions; VOC's	Cover separators	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
		Replace top mounted mechanisms	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
Equalization/homogenization	Air Emissions														
	Leakage into ground water						yes							?	
Chemical additions	Inorganic chemicals create	Use Western supplied	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
	excessive amounts of oily sludge	polyelectrolites; flow proportional	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
	corrosion of concrete basins	feed systems, improved mixing systems	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
Dissolved air flotation (DAF) systems	Overflow of sludges to biological	Improve overflow baffling	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
	systems, do not remove emulsions	Improve air water mixing	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
	efficiently	Improve/replace mechanisms	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr	yes	
Biological treating	Do not remove BOD, phenols, etc. effectively	Provide new Western Type aeration system	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr		
	overflow of suspended solids in effluent	provide baffled overflow protection	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr		
	High consumption of energy	provide Western air blowers	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr		
Biological sludge	Not properly dewatered	Provide Twin Belt Filter Press	yes	yes	yes	nr	yes	yes	yes	yes	yes	yes	nr		
	large volumes for disposal	with polymer conditioning system													
Oily sludge	Not properly dewatered	Provide new dewatering facilities	yes	yes	yes	?	yes	yes	yes	yes	yes	yes	yes	?	
	large volumes for disposal	belt presses, centrifuges, or plate presses													
Existing landfills	large volumes in existing landfills	Portable dewatering and oil recovery systems	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	Landfills require isolation & ground water monitoring	add monitoring wells	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	significant oil content	add fencing	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	
	oily sludges with acid														
Contamination of groundwater	Contaminated groundwater	Identify extent of contamination	no	yes	yes	nr	yes	nr	yes	yes	yes	yes	yes	yes	
	oil products in ground & water	Provide oil recovery systems	no	yes	yes	nr	yes	inc	yes	yes	yes	yes	yes	yes	
	local water wells are not useable	including water reclamation													
	local residence recovering oil														
SPECIAL PROBLEMS															
Clean up of contaminated lake												yes			
New biological treating units									yes			yes			

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Table 8-6 (Cont'd)

MODIFICATIONS TO IMPROVE ENVIRONMENTAL PERFORMANCE																		
UNITS/LOCATION	ENVIRONMENTAL PROBLEM	SOLUTION	ARPECHIM	ASTRA	DARMANESTI	LUBRIFIN	PETRO BRAZI	PETRO MIDIA	PETROSLUB SUPLACU	PETROTEL	RAFO	STEAUA ROMANA	VEGA	OIL TERMINAL	COST
Acid tar clean up				yes		yes				yes		yes	yes		
Process unit vapor controls				yes		yes			yes	yes		yes	yes		
New types of processing to eliminate oily waste sludges				yes		yes				yes		yes	yes		
High water content of crude														yes	
High solids content in crude									yes						

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MODIFICATIONS TO IMPROVE ENVIRONMENTAL PERFORMANCE																
UNITS/LOCATION	ENVIRONMENTAL PROBLEM	SOLUTION	ARPECHIM	ASTRA	DARMANESTI	LUBRIFIN	PETRO BRAZI	PETRO MIDIA	PETROSLUB SUPLACU	PETROTEL	RAFO	STEAUA ROMANA	VEGA	OIL TERMINAL	TOTAL COST
CRUDE UNITS			20000	10000	10000		20000	20000	10000	20000	20000	10000	10000		150000
DESALTER	High water flow rates	Water flow meter													
	Too high of oil content	New thermconductivity controls													
FLUID CATALYTIC CRACKER															
Process Waters	High water flow rate	Water flow meter	10000				10000	10000		10000	10000				50000
	High of oil content	Redesign process separation vessel	150000				150000	150000		150000	150000				750000
DELAYED COKER UNIT															
Process Waters	High water flow rate	Water flow meter	10000		10000		10000	10000		10000	10000				60000
	High of oil content	Redesign process separation vessel	150000		75000		150000	150000		150000	150000				825000
Cutting Water	High water flow rates	Redesign water mase or	350000		20000		350000	350000		350000	350000				1770000
	High solids content	provided new clarification facilities for improved water recycle													
SOUR WATER STRIPPER															
Overhead Vapors	Currently routed to flare	Route to Sulfur Recovery Unit	5000	5000	5000		5000	5000		5000	5000				35000
Live steam injection	adds to flow of wastewater	Add feed/effluent heat exchanger	15000	15000	15000		15000	15000		15000	15000				105000
SULFUR RECOVERY UNITS															
(Low recovery efficiency)	Currently less than 60 % efficient	Use more active western catalyst	*	*	*		*	*		*	*				*
	Do not meet newer EC Directives	Convert from 2 stage to 3 or more stages (Super Claus)	*	*	*		*	*		*	*				*
GENERAL PROCESS NEEDS															
Fired Heater Efficiency	Average heater efficiency 75 %	Add air preheat, add waste heat recovery; product/product or steam generation (only largest heaters)	*	*	*	*	*	* (started)	*	*	*	*	*		*
		Provide flue gas O2 analyzers	50000	30000	30000	10000	50000	20000 (started)	20000	50000	50000	20000	20000		350000
Low reactor catalyst activity	Lower specification products; (ie higher sulfur levels in products)	Replace existing catalyst	*	*	*		*	*	*	*	*	*	*		*
Reduced solvent activity	higher sulfur levels in products (ie MEA contaminated with heat stabilized salts or COS by products)	Provide new MEA; or evaluate if newer solvents, MDEA are better suited	*	*	*		*	*	*	*	*	*	*		*
Pumps, compressors, valves	Fugitive emissions	New Western types of seals for	*	*	*	*	*	*	*	*	*	*	*	*	*
	Product losses to sewers from leaks	pumps and compressors	*	*	*	*	*	*	*	*	*	*	*	*	*
	Hi energy consumption	valve testing and repair	*	*	*	*	*	*	*	*	*	*	*	*	*
		Use more efficient western types of pumps and compressors													
Product sampling	Product losses and air emissions	add on-line analyzers	*	*	*	*	*	*	*	*	*	*	*	*	*
INSTRUMENTATION	Older technology; not suitable for on line analysis	Provide new spectrometers, liquid/gas chromatograph etc.	*	*	*	*	*	*	*	*	*	*	*	*	*
Air emissions monitoring	None existing at this time	Provide new monitoring facilities	150000	150000	150000	*	150000	150000	150000	150000	150000	150000	150000	150000	1650000
	Not possible to quantify emissions or if there is an upset etc.	including multiple stack analysis with one analyzer system													
Wastewater system and discharge monitoring	Short term upsets not detectable and can lead to long periods of off spec effluents	Provide new monitoring systems	100000	100000	100000	30000	100000	100000	100000	100000	100000	100000	50000	100000	1080000
		Provide on-line controls for specific activities; ie chemical feed, etc.	30000	30000	30000	10000	30000	30000	20000	30000	30000	30000	20000	20000	310000
Cooling water	Too high of blowdown rates	Automated chemical feed systems	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000		220000
	Too much oil in water	Use newer western proprietary chemicals	*	*	*	*	*	*	*	*	*	*	*		*
	high exchanger corrosion rates	Automatic pH control/acid feed	15000	15000	15000	5000	15000	15000	5000	15000	15000	5000	5000		125000
		Side stream filters	150000	100000	75000	30000	75000	75000	40000	75000	75000	40000	40000		775000
		Flow control blowdown	10000	10000	10000	2000	10000	10000	4000	10000	10000	4000	4000		84000

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Section 9

Labor Force Reduction and Redeployment Analysis

9.1 OVERVIEW AND CURRENT STATUS

The downstream sector labor force of 57,700 managerial, technical, and operations employees is divided between the manufacturing subsector, which accounts for 37,700 employees, and the distribution and marketing subsector, which accounts for 20,000 employees. The manufacturing subsector workforce far exceeds the staffing level required to effectively operate the refining, petrochemical, and lubricant manufacturing facilities. This workforce must be sharply reduced to decrease the level of fixed costs. Overstaffing is also apparent in the distribution and marketing subsector, but the problem is not as acute as in the manufacturing subsector, and the anticipated growth of the retail sector will result in expanded labor requirements.

Large-scale labor force reductions are always difficult to implement, for the variety of political, economic, and humanitarian reasons. In addition, large-scale worker displacements are expensive when one takes into account the cost of severance, retraining, and unemployment compensation schemes. However, the cost of not reducing the refinery workforce is greater and ultimately less fair to the workers involved than an aggressive reduction program. The downstream sector currently receives large direct and indirect subsidies which, on a per-worker basis, are much greater than the worker's wages. Moreover, a majority of the workers do not contribute any economic value to offset the subsidy. Thus, it would be more beneficial to the overall Romanian economy to shrink the industry and pay the workers an equivalent amount in severance than to maintain the status quo.

The downstream sector has dealt with the reduced operating capacity by shutting down refinery trains, but has kept all refineries operating and fully staffed. The resulting high overhead costs are one of the main contributors to sector unprofitability. As shown in the optimization analysis, the most profitable approach would be to shut down the least efficient refineries, furlough the workers affected, and operate the remaining refineries at high capacities.

Romanian state-owned plants generally operate in a self-sufficient manner with regard to labor services, and this philosophy of self-sufficiency has led to low staff utilization, inefficient use of resources, and no incentive to reduce internal costs due to a lack of lower cost, outsourced alternatives. Each of the major refineries has over 1,000 workers assigned full time to maintenance, and Petrobrazi and Arpechim have over 2,000 maintenance workers apiece. The standard operating procedure in the refinery sector outside of Romania is to contract out for essentially all maintenance services. Based on international standards and adjusted upwards for the specifics in Romania, an independent workforce of under 2,000 should easily be able to provide maintenance for the entire refinery industry in Romania. A summary of the characteristics of the refinery subsector workforce is presented in Table 9-1.

Table 9-1 Romania Refinery Sector Labor Force Characterization

Site	Total Workers	Average Wage $/Worker	Classified as Maintenance	Workers Over 50 Years Old	% Over 50
Large Refineries					
Petrobrazi	7,800	$2,800	2,000	732	9.8%
Petrotel	6,490	2,700	1,868	565	8.7%
Petromidia	4,754	4,790	450	217	4.6%
Arpechim	8,056	2,900	2,000	730	9.1%
Rafo	3,804	2,510	735	185	4.9%
Small Refineries					
Astra	2,587	2,800[1]	774	204	7.9%
Petrolsub	486	2,800[1]	82	60	12.3%
Darmanesti	836	2,800[1]	322	57	6.8%
Steaua Romana	948	2,800[1]	224[2]	66	7.0%
Vega	1,977	2,800[1]	434	102	5.2%
Total	37,738		8,689	2,918	7.7%

1. Assumed, not reported
2. Calculated based on average of 23.6% at small refineries, not reported

In summary, the high level of redundancy has resulted from several overlapping staffing practices:

- *Staffing Levels Are Not Adjusted to Production Rates.* Throughput of the refining sector has fallen by 50 percent since 1989, yet the number of workers employed in the sector has remained constant. In some cases, specific units in the refineries have been shut down or decommissioned, but are still fully staffed.
- *A Government Policy of Full Employment.* The former government policy of full and guaranteed employment, despite the lack of demand for many of the workers, discouraged productivity-related investments and automation. Because wage rates were very low and continue to be in this environment, productivity investments were hard to justify. This lack of automation has had negative production and quality control consequences, as well as other economic costs.
- *The Operating Philosophy of Self-Sufficiency.* In Romania, the refineries are geographically dispersed, the workers have low mobility, and an independent service and maintenance sector has not been created. Thus, the refineries developed a staffing program of complete self-sufficiency in all operating, maintenance, and auxiliary service areas.

9.2 WORKFORCE POTENTIAL DISPLACEMENT

9.2.1 Refinery Sector

The refineries have a combined workforce of about 37,700 employees, with roughly 40 percent allocated to operations, 30 percent to maintenance, and the 30 percent balance to auxiliary activities. Most of these workers are not required for the proper operation of the sector, and present levels are very high, by a factor of 10 or more, on an international benchmark basis. For efficiency, productivity, and cost competitive reasons, a majority of these workers need to be removed from the refinery subsector.

Workforce reduction in the manufacturing subsector should be accomplished primarily through the closure of the four refineries, the outsourcing of major maintenance functions to new private-sector companies, and further workforce reductions at the complexes that remain in service. We estimate that these steps will result in the dislocation of approximately 27,300 employees. Labor redeployment costs will include severance payments, unemployment compensation, retraining costs, extended benefits, relocation costs, and startup costs to provide working capital for the new private-sector maintenance firms. Critical investments of about $166 million over a 3-year period will be required to fund these redeployment programs. The resulting savings through reduced wage costs of about $76 million per year (or $228 million over the 3-year expenditure period) will more than offset the cost of the redeployment assistance program.

9.2.2 Transportation and Retail Sector

The 20,000 workers in the transportation and marketing sector also have significant redundancy, but the problem is not as severe as in the refinery subsector. Even with major reductions in the production sector, the total worker count in the industry should be stable and could very likely increase as new retail sites are developed. The establishment of 1,000 new retail sites would create 10,000 new jobs to absorb many of the excess workers in the existing system. Because of the wide dispersion and small individual scale of the retail operations, no significant dislocations or concentrations of unemployed workers are anticipated.

Table 9-2 summarizes the causes of displacement due to refinery sector rationalization, the estimated number of workers displaced at each refinery, and the resulting savings in direct labor costs.

Table 9-2 Causes of Displacement Through Refinery Sector Rationalization

Site	Current Staff	Decomis-sionings	Maintenance Spinout[1]	Productivity/ Automation[2]	Total Displaced	Total Remaining	Annual Dir. Labor Saving ($1,000)
Petrobrazi	7,800	7,800	–	–	7,800	–	$21,840
Petrotel	6,490	6,490	–	–	6,490	–	19,963
Petromidia	4,754	–	250	1,722	1,972	2,782	9,446
Arpechim	8,056	–	1,800	2,502	4,302	3,754	13,233
Rafo	3,804	–	535	1,228	1,763	2,041	4,425
Subtotal	30,904	14,290	2,585	5,452	22,327	8,577	$64,482
Astra	2,587	–	674	765	1439	1,148	4,029
Petrolsub	486	–	32	182	214	272	599
Darmanesti	836	–	222	246	468	368	1,310
Steaua	948	948	–	–	948	–	2,654
Vega	1,977	1,977	–	–	1,977	–	5,536
Total	37,738	17,215	3,513	6,645	27,373	10,365	$78,610

1. 200 permanent maintenance workers remain at each operating refinery
2. 40% reduction in remaining staff after maintenance spinout

9.3 IMPLEMENTATION OF A LABOR REDUCTION PROGRAM

The recommended staff reductions will reduce the manufacturing sector workforce by two-thirds, from 37,700 employees to approximately 10,400 employees at the manufacturing complexes, plus 2,500 employees at contract maintenance firms. Although this staffing reduction is large as a proportion of current staffing, benchmarking against manufacturing operations of comparable size and complexity indicates that the residual staffing level will still be high by international standards. Thus, the reduced staffing level will be fully adequate for effective operation of the rationalized refining sector in Romania, and further reductions are feasible in the long run.

9.3.1 Reduction Steps

Figure 9-1 shows the refinery labor reduction steps, indicating the number of workers displaced in each step.

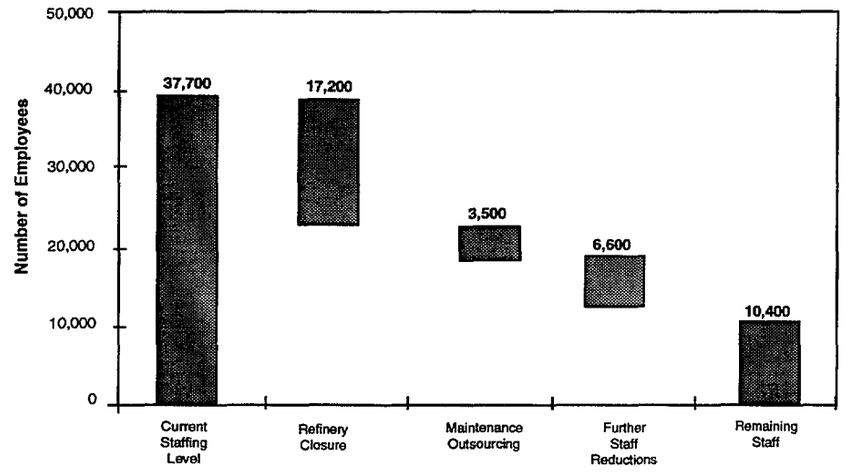

Figure 9-1 Manufacturing Labor Reduction

Labor savings are estimated at $76 million per year once the reduction steps have been completed, assuming wage and benefit costs of $3,076 per employee.

The total staff reduction of 27,300 results from three major initiatives:

- The closure and decommissioning of two large refineries, Petrobrazi and Petrotel, and two small refineries, Steaua Romana and Vega, account for 17,200 employees.
- Outsourcing of central maintenance work accounts for 2,500 employees who will be moved to another company, but are considered displaced for severance compensation purposes. This reduction level assumes that 200 permanent maintenance workers remain at each operating refinery. Note that these workers will become employees of the new private-sector contract maintenance firms. Accordingly, the costs of contract maintenance will continue to be borne by the manufacturing complexes through contractual payments.
- The further reduction of refinery staffs accounts for 7,600 employees. This decrease in staffing is based on a 40 percent reduction in the staff level after maintenance outsourcing.

The rationalization program described earlier in this report, which includes the decommissioning of two refineries, would take approximately 18 months to implement. The numbers of workers that would be displaced during the time line of this rationalization process is presented in Table 9-3.

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Table 9-3 Newly Unemployed Workers from Initiation to Completion of Rationalization

Site	0-6 Months	6-12 Months	12-18 Months	Total
Petrobrazi	2,000	5,800		7,800
Petrotel	2,000	4,490		6,490
Petromidia	250		1,722	1,972
Arpechim	1,800		2,502	4,302
Rafo	535		1,228	1,763
Smaller Refineries	928	2,925	1,193	5,046
Total	7,513	13,215	6,645	27,373

9.3.2 Redeployment of Excess Labor

Reducing the labor redundancy in the refinery sector will result in large numbers of unemployed workers. These workers will have minimal opportunities for immediate reemployment and will be concentrated in specific areas. A certain percentage of these displaced workers will be reabsorbed through various methods already in place. Of the refinery decommissionings, a significant number of workers will be retained to deal with the decommissioning process, which could take as long as 5 years, and the environmental remediation, which could last indefinitely. The estimates of worker requirements at each of these decommissioned sites is 500 long-term staff at the bigger refineries and 250 at the smaller ones. Another significant group of displaced workers would be picked up by the outsourced service providers. Rough estimates indicate that as many as 500 workers from the larger refineries could be absorbed by the independent maintenance services provider.

A redundancy elimination program normally takes 18 months to implement. During this time, a tranche of workers will be removed from the refinery workforce by attrition, an early retirement program, and normal redeployment in the economy. Analyzing the current age and turnover distribution shows that this number will be relatively small, comprising no more than 500 workers from attrition, 1,250 workers due to a special early retirement scheme (offering special incentives to all workers over 55 years of age), and up to 3,000 workers to be redeployed through the expected expansion of the national workforce. This leaves 15,000 displaced workers that will not be absorbed through any traditional means and are thus classified as structurally unemployed. Table 9-4 shows the reabsorption of the displaced workers by refinery site and by category.

Table 9-4 Reabsorption by Category Over a 18-Month Duration

Site	Total Displaced	Decomis-sionings/ Remediation	Attrition[1]	Early Retirement[2]	Maintenance Spinout	General Reabsorption[3]	Structural Unemploy-ment
Petrobrazi	7,800	500	117	387	500	780	5,016
Petrotel	6,490	500	97	305	500	354	4,734
Petromidia	1,972	–	71	112	500	493	796
Arpechim	4,302	500	121	369	500	806	2,506
Rafo	1,763	–	57	94	500	441	671
Small Refineries	5,046	500	103	244		1,270	2,929
Total	27,373	1,500	566	1,510	2,500	4,144	16,652

1. Calculated at 1% per year
2. Over age 55
3. Calculated at 25% of Rafo and Petromidia, 10% at Petrobrazi and Arpechim

9.3.3 Classification of Displaced Workers

For the purposes of estimating the costs and time line involved with the reabsorption, the displaced workers can be segregated into four groups:

- *Group 1.* These workers, accounting for 8 percent of the total, will leave the refinery workforce through normal attrition or early retirement during the 18-month implementation period and will need no redeployment assistance.
- *Group 2.* This group, comprising 30 percent of the total, will find new employment and be reabsorbed into the economy of Romania. The new private-sector maintenance company will absorb a portion of these workers. Redeployment assistance will be provided through traditional or existing programs.
- *Group 3.* The largest group of displaced workers, accounting for 52 percent, will find alternate employment after a period of 3 years, following extensive retraining and other social assistance. Redeployment assistance needs will be significant.
- *Group 4.* This group, approximately 10 percent of the workforce, will be unable to find alternate work and will remain permanently unemployed.

9.3.3.1 Group 1

A relatively small number of workers, classified as Group 1, will leave the workforce by normal attrition and by early retirement. Analysis of the current worker age distribution and turnover rate indicates that voluntary attrition will account for only about 600 workers, or about 2 percent of the total number displaced. About 1,500 workers are expected to accept early retirement

under a program offering special incentives to workers over 55 years of age. Thus, Group 1 accounts for only 2,100 workers, about 8 percent of the displaced workforce.

9.3.3.2 Group 2

Group 2 consists of workers who find alternate employment within the 18-month period required to implement the staffing reduction program. About 4,100 workers are expected to find employment in other sectors of the economy. It is assumed that the new companies formed to offer outsourced maintenance services will absorb 2,500 workers. In addition, 1,500 workers need to be retained to carry out decommissioning and environmental remediation activities at the refineries that are to be closed. The two large refineries, Petrobrazi and Petrotel, will each require 500 workers; the two small refineries, Steaua Romana and Vega, will each require 250. These staffs will be reduced gradually over a 2-year period as this work is completed, and we assume that these workers will find alternate employment without retraining assistance.

9.3.3.3 Group 3

The workers of Group 3 will become structurally unemployed upon termination of employment at the refinery sites. For these workers, extended benefits and social protection are necessary.

Group 3 workers are considered capable of taking advantage of the retraining opportunities to find new jobs outside of the refining sector. Extensive retraining will be essential because these workers (1) currently have narrow industrial skills and little or no alternate work experience, and (2) will face strong competition for industrial employment from terminated employees from Romania's heavy industry.

Many Group 3 workers will have to relocate from Ploeisti to other population centers. As Romania's economy is transformed, the service sector is expected to grow and will account for a growing proportion of employment. Net job growth will occur most rapidly in trading, business, and tourist centers, including Brasov, Bucharest, Constanta, and Timisoara. Since many displaced refinery workers will be forced to seek work in these cities, mobility assistance will be essential for the structurally unemployed, and this assistance should include housing assistance, resettlement allowances, and full transfer of social assistance benefits to new employment locations.

It is commonly assumed that the agricultural sector can absorb a significant proportion of excess industrial workers. However, employment levels in Romanian agriculture are already excessive. Current agricultural operations involve minimal mechanization, and increased mechanization is expected to reduce labor requirements. Therefore, workers displaced from heavy industries are unlikely to find employment in agriculture.

9.3.3.4 Group 4

Group 4 consists of workers who are assumed to be incapable of effective participation in retraining and relocation programs. This group includes approximately one-half of the workers who are above 40 years of age and who have received no education beyond high school. These workers have severely limited skills, and many will be incapable of successful relocation. Most of them are expected to remain unemployed for an extended period, and it is possible that many of them will remain permanently unemployed. They may find marginal employment in low-skill service jobs or drop out of the workforce altogether.

9.4 CRITICAL INVESTMENTS

The elimination of excess refinery labor will lead to a significant and permanent reduction in refining labor costs. These savings will be offset in the first 3 years by the critical investments that are necessary for successful labor redeployment. These costs include severance payments, unemployment compensation, retraining expenditures, and other special expenditures such as relocation assistance and funding to support the startup of the new private-sector maintenance firm. Table 9-5 presents an estimate of critical investments required during a period of 3 years after the termination of feedstock supply to the designated refineries. The wages in the table are based on an average annual wage of $3,076.

Table 9-5 Redeployment Costs for a 3-Year Duration ($1000)

Group	Number of Workers	Percent of Total	Severance Payments[1]	Unemployment Compensation[2]	Retraining Costs[3]	Special Costs[4]	Total Costs
Group 1	2,100	8%	$ 3,230	$ 2,411			$ 5,641
Group 2	8,100	30%	12,493	10,277			22,770
Group 3	14,608	52%	22,467	24,985	$44,934	$28,467	120,853
Group 4	2,734	10%	4,215	4,695		8,410	17,320
Total	27,342[5]	100%	$42,405	$42,368	$44,934	$36,877	$166,584

1. Six months' wages
2. Average of 55% of wages for 270 days, 60% of approximately 250,000 lei per month for an additional 270 days
3. One year's wages
4. Consists of extended benefits/relocation assistance/social protection fund, 6 months' wages for Group 3, 1 year's wages for Group 4
5. Includes 2,500 workers in contract maintenance firms

The table indicates total critical investments of approximately $166 million for labor redeployment. Reduction of the refinery labor force decreases fixed costs by approximately $76 million per year; thus a net savings of $62 million is expected to be realized during the 3-year redeployment period, with a permanent annual reduction in operating costs of the $76 million identified above.