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EMERGING ENERGY SECURITY ISSUES

Report Series No. 5

Projected Refined Product Balances in Key Latin American Countries:

A Preliminary Examination

Program on Resources: Energy and Minerals
East-West Center
Honolulu, Hawaii

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Introduction

Purpose of the Study

Over the years, the East-West Center has developed considerable expertise in refinery modeling, especially in the area of forecasting product balances for countries, given planned capacity changes, changes in product demand, changes in crude slates, and changes in product specifications. This expertise has been applied on an ongoing basis to the major refiners in the Middle East and the Asia-Pacific region, along with the US West Coast as a region in its own right. Refinery modeling in these three areas has been ongoing for nearly 15 years at the Center, and the tools and information sources are now well developed.

To date, the EWC has not applied these tools to Latin America. Although research on Latin America has been an ongoing area of concern at the Center in recent years, the information gathered to date is still not of the level of detail nor quality available for other areas. The modeling efforts undertaken in this report are of a "baseline" nature, designed to outline the major issues, attempt a first cut at emerging product balances, and, above all, to elicit commentary from those directly involved in the oil industry in the key countries modeled. Our experience in other regions has shown that it takes a few years of dialogue with refiners and government planners in individual countries to develop a reliable database, as well as the insights into operational constraints and practices that make accurate modeling possible. This report is no more than a first step down that road.

Tools and Methods

All serious refinery modeling is done with some sort of linear programming tool. Ideally, such modeling would move refinery-by-refinery, examining the situation that faces each refiner. It would also ideally move day-by-day, since annual average prices do not necessarily reflect the differentials prevailing at any given date. Neither one of these

approaches is practical. Combining the refineries in a country into a single "superrefinery" can open the door for what analysts call "overoptimization"—that is, a situation where, for example, intermediate feedstocks are available to be fed to unused capacity at a unit that is actually hundreds of miles away. On the other hand, using annual average prices tends to "underoptimize" refinery performance, since purchases of feedstock are undertaken at average prices rather than at the times that the best economics are offered.

Both of these difficulties are common, and are well understood; most of the pitfalls can be avoided by an experienced analyst. For instance, overoptimization tends to be a problem mainly in situations where upgrading and cracking capacity is very high relative to distillation—where too many units are chasing a limited amount of feedstock. This occurs frequently in a market such as the US West Coast; it is far less of a problem in countries where potential intermediates exceed the capacities of the upgrading units (as is the case in most of the Latin American countries.)

In our study of the Latin American refining situation, these problems are insignificant compared with the data deficiencies relative to the needs of a detailed LP model. The precise crude diets, exact product specifications (including number of different grades of a given product), and even basic demand figures are largely estimated. While product demand data is available from sources such as IEA, OLADE, the United Nations, and, for some countries from specialized sources (such as OPEC data on Venezuela), there are major inconsistencies between these sources. Moreover, widely used sources such as OLADE do not include precise information on materials such as naphtha (which are lumped with unlike materials such as asphalt and coke as "non-energy" products).

The interests of a modeler forecasting product balances are different from someone constructing a national energy balance (as in the case of the IEA), or examining final consumption of products. To someone constructing an energy balance, fuel oil produced in a refinery but burned in the refinery as fuel is fuel "produced" and then "transformed." From a refiner's perspective, it was not really produced—it didn't pass the refinery gate.

On the other hand, fuel oil produced in a refinery and delivered to a power plant in an energy balance is likewise accounted as "production" and "transformation," never reaching final consumption. From the refiner's perspective, the fuel oil in this case is produced—it passes the refinery gate—and it is also an element of demand; that is, it is sold to a customer in the domestic economy. Both viewpoints are valid, but the product balances as we employ them are far more useful for refinery analysis.

A difficulty that this produces is a further incompatibility between our data and other (already incompatible) data sources. On the other hand, product balances as used here have the advantage of being compatible with the records that a refiner would keep, and reflect actual sales and trade flows.

To clarify the entries found in our four-item balance sheet, it is best to offer specific definitions; in many cases apparent differences between our figures and other sources can be traced to these definitions:

Production: This is the final, salable output of the refinery or the refining sector. Material used as fuel within the refineries is deducted. Similarly, material produced but then rerouted as blendstock to another product pool is also deducted. (For example, kerosene downblended to fuel oil is recorded as fuel oil production, not kerosene production.) Insofar as possible, transactions between refiners are excluded; only those goods sold to non-refining buyers are part of Production.

Imports: Imports include final products brought into a country for sale. Insofar as possible, products imported but then used as blendstocks within a refinery are treated as feedstock rather than imports of finished products.

Exports: Exports include sales of finished products to other countries. They do not include bunkers (or international jet fuel), although these are often treated as exports for tax purposes by many countries. A country's bunker market is, from a refiner's perspective, part of the country's own market. This also eliminates the

problem of trying to distinguish between cargoes delivered to coastal navigation as opposed to international shipping (or apportioning to international and domestic the sales of jet fuel to a plane whose itinerary includes other domestic stops before flying on to a foreign destination).

Demand: Product demand, as used here, is the sum of domestic consumer demand, bunkering, and all sales to the non-refining energy sector. Thus, our demand numbers will typically be higher than "final consumption" numbers by bunkers plus product consumption in the power sector and other energy transformation sectors other than refining. In other words, demand is the total amount of product sold in the country, excluding transactions between refiners.

For our forecasts we have relied heavily on the economic and demand forecasts published by OLADE, as well as previous work at the East-West Center. (Graphs of historical trends in GDP are presented in Appendix 2 for reference.) The OLADE forecasts, which exclude certain volumes (and do not use quite as fine a product breakdown as employed here), were mainly used to compare growth trends on final consumption volumes; the absolute projections were not employed.

Product specifications and crude diets remain an area where considerable additional baseline data are needed. Most crude slates were estimated from anecdotal evidence (in the case of crude-surplus countries) and from production and trade data (in the case of crude-deficit countries.) Product specifications are based on fragmentary information. Octane and leading levels are provided in Octel's surveys, as well as covered for individual countries in occasional articles in the trade press. The quality assumptions for products heavier than gasoline are based on conversations, occasional articles, or, failing those, on external-market standards. Although much more detail would be desirable in this area for expanded modeling efforts, based on our calibration runs (usually on a 1993 basis), it appears that the assumptions about specifications must be fairly close to actuality.

An LP model of a refinery for "operations" purposes can run to thousands of equations; our models of countries where good information is available are usually in the range of 500-1,000 equations. On the other hand, some major firms model whole regions with as little as 100 equations. Our model here uses 200-350 equations (depending on the number of crudes processed). A more complex model would be desirable—but only if correspondingly detailed information were available.

Argentina

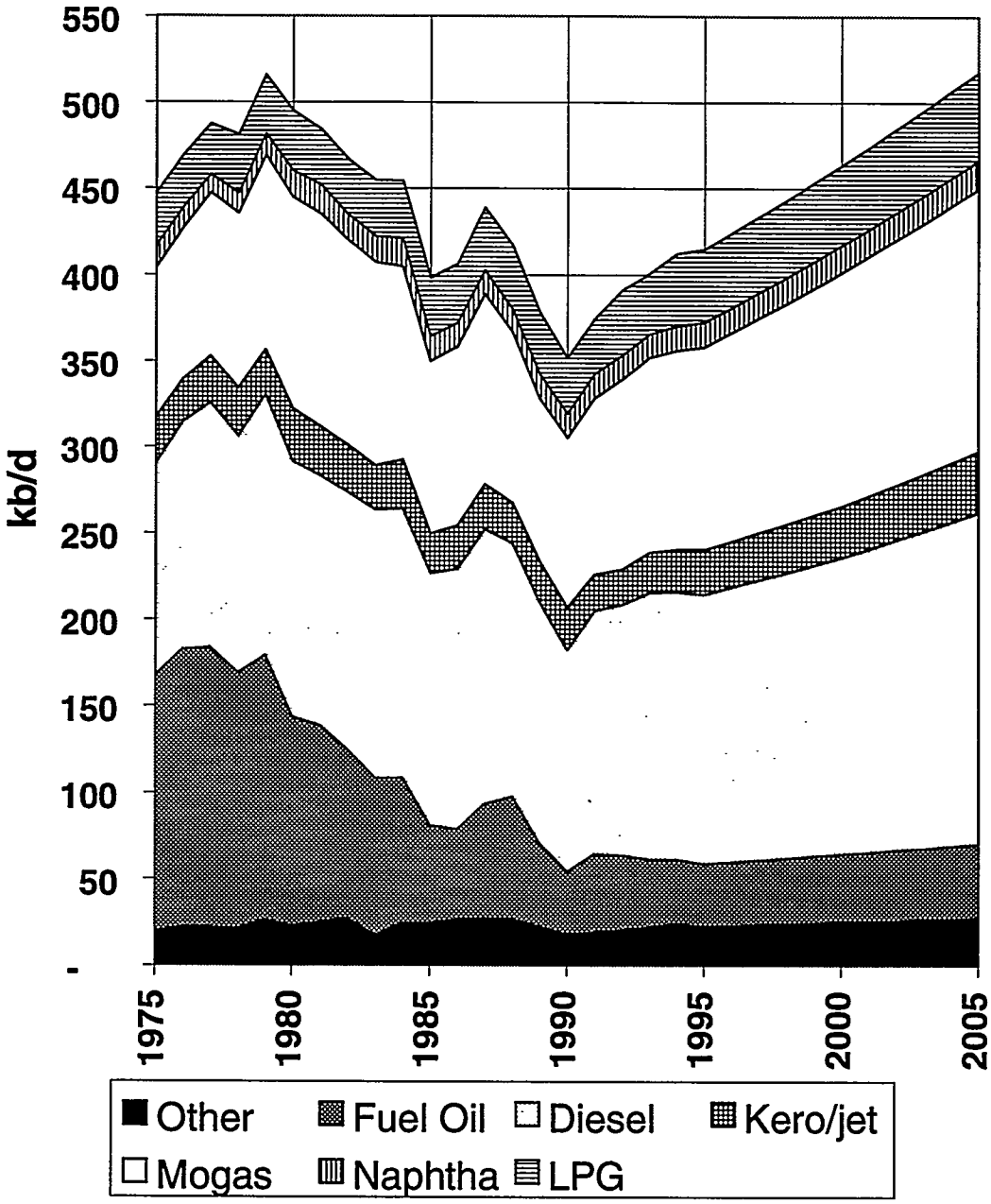
Product Demand

Oil demand in Argentina has until recently showed a pattern of long-term decline. In the late 1970s, overall oil demand growth was slow. Although light and middle distillate demand expanded in this period (at more than 7% per annum in the case of gasoline), steady substitution of other energy sources for fuel oil kept the overall growth rate down to about 2% per annum.

As Figure 1 shows, the decline in fuel oil demand continued throughout the 1980s at an average rate of 11.4% per annum. The steady drop in the amount of fuel oil consumed was not the result of any single new energy source coming into play; production and use of nuclear power, hydroelectricity, and natural gas all contributed to a shrinkage in fuel oil requirements. While fuel oil now plays a minor role in the Argentinian energy picture, the reliance on hydropower means that there will be episodic revivals in fuel oil demand in the power sector like that seen in the low-water years of 1986-88.

Higher prices in the early 1980s, coupled with economic and political turmoil throughout the decade, resulted in declines in demand for other cuts of the barrel as well. Higher prices dropped demand for kerosene (mainly in the residential sector) by 5.5% annually in the 1980-85 period. Gasoline demand declined by about 4 percent per annum, and diesel, naphtha, and LPG demand declined as well, though at more modest rates.

Figure 1. Argentina: Product Demand, 1975-94, & Forecast to 2005



Some revival of demand growth was seen by the late 1980s. By the early 1990s, demand increases were running at more than 3% per annum. The fastest-growing fuel was LPG, at nearly 5.3% annual increase, followed by diesel (4% per annum) and gasoline (3.7% per annum). Coupled with a leveling in fuel oil demand, the overall growth in the first half of the 1990s appears to be about 3.3% per year.

Some of the rapid growth appears to be "rebound" in fuels that have seen constriction rather than growth in the previous ten years. Although it is possible to envision accelerating growth in demand, as seen in many countries in Asia, our forecast sees a more stable, lower growth profile through the end of the forecast period, with a slight recovery in fuel oil demand (in industrial and bunker uses). The fastest growth will be seen in gasoline and in jet fuel, where jet use will come to dominate the kero/jet cut of the barrel. The actual pattern of demand is future years is unlikely to be as smooth as shown in the graph, of course, because the continued volatility in fuel oil demand is probably a permanent feature of the market.

Product Balances

Table 1 shows petroleum product balances for Argentina for the period 1990-93. Argentine refining capabilities are overbuilt relative to the needs of the country, so it is not surprising that exports are substantially higher than imports. There are no major product deficits, although there is a minor tendency to be a net importer of fuel oil. There is a considerable amount of trade for commercial and seasonal reasons, but overall the Argentinian refining system is well balanced.

Refinery Configuration

Table 2 shows Argentina's refinery configuration in 1995, as well as planned additions through 2000. At 660 kb/cd, current capacity is large relative to demands of about 400 kb/cd. The system has a sophisticated processing capability downstream of the distillation

Table 1. Argentina:
Petroleum Product Balances, kb/d

1990

	Output	Imports	Exports	Demand
LPG*	37.1	-	3.0	32.5
Naphtha	14.5	-	0.6	13.8
Mogas	130.1	0.6	29.4	98.3
Kerojet	25.0	-	-	24.5
Diesel	163.0	-	22.9	128.1
Fuel Oil	54.7	-	18.9	35.8
Other	26.8	0.5	6.9	18.5
Total	451.3	1.1	81.7	351.6

*Includes field output: 18.21

1991

	Output	Imports	Exports	Demand
LPG*	40.4	-	6.0	32.1
Naphtha	16.4	-	3.6	13.8
Mogas	141.9	-	39.1	102.2
Kerojet	22.0	0.9	0.3	21.4
Diesel	170.3	5.2	29.9	140.2
Fuel Oil	41.4	11.4	7.9	44.9
Other	28.0	0.8	7.1	19.8
Total	460.3	18.2	93.9	374.3

*Includes field output: 19.75

1992

	Output	Imports	Exports	Demand
LPG*	55.6	2.4	8.0	38.0
Naphtha	16.1	-	2.3	13.7
Mogas	146.7	2.4	33.1	110.7
Kerojet	25.1	0.4	0.4	20.3
Diesel	187.4	0.3	34.4	144.7
Fuel Oil	39.4	10.5	7.3	42.7
Other	34.8	0.6	9.5	21.0
Total	505.0	16.7	95.0	391.2

*Includes field output: 25.08

1993

	Output	Imports	Exports	Demand
LPG*	53.4	-	15.5	34.8
Naphtha	18.8	-	6.2	13.9
Mogas	150.1	2.9	26.9	113.2
Kerojet	24.9	1.1	0.6	23.1
Diesel	184.7	4.4	33.9	154.1
Fuel Oil	35.3	17.3	13.8	38.7
Other	37.6	1.0	12.7	22.6
Total	504.8	26.7	109.6	400.5

*Includes field output: 24.30

1994

	Output	Imports	Exports	Demand
LPG*	56.6	-	16.4	41.8
Naphtha	19.3	-	6.5	14.1
Mogas	153.5	2.9	27.6	115.8
Kerojet	25.7	1.1	0.6	24.5
Diesel	185.4	4.5	34.0	154.6
Fuel Oil	33.5	16.6	13.3	36.9
Other	39.4	1.1	13.1	24.5
Total	513.3	26.2	111.4	412.2

*Includes field output: 25.50

units, with large amounts of catalytic cracking and coking, as well as a single hydrocracker. At the levels of runs seen in recent years, it is clear why the output of fuel oil from the system is so low (about 7% of output).

There are no firm plans for expansion of primary capacity, but a revamp of coking capacity is under way at the La Plata refinery. Other additions are gasoline-oriented, with an alkylation unit and two new naphtha isomerizers scheduled to come onstream later in

the decade. This, coupled with about 2.5 kb/d of MTBE output from existing plants, will provide a substantial octane uplift for the system.

Table 2. Argentinian Refinery Configuration (kb/cd)

Argentina: 1995 Configuration

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes	Asphalt
Bahia Blanca	Isaura	25.2	14.5		8.8		4.4						
Buenos Aires	Shell	121.7	38.5		29.2		27.0	17.9	2.2		7.5	1.5	4.2
Campana	Esso	88.1	47.2	25.0	27.3						16.4		
Campo Duran	YPF	32.0											
Dock Sud	YPF	4.0	1.0										
Galvan	Esso	18.4					7.6						
L de Zamora	Dst. Argentina	8.0	1.3									0.9	0.6
La Plata	YPF	180.0	104.5	39.0	45.3			11.7			24.6	5.5	8.3
Luian de Cuyo	YPF	120.0	66.0	35.2	44.1	26.0		9.5			17.6		
Plaza Huincul	YPF	23.6					3.5	3.0					
S. Francisco Sc	Sol Petroleo	6.0											
San Lorenzo	YPF	37.6	16.1				12.5						
	Total	664.6	289.1	99.2	154.7	26.0	55.0	42.1	2.2		66.1	7.9	13.1

Argentina: Planned Additions by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes	Asphalt
La Plata	YPF									6.3			
Luian de Cuyo	YPF								2.7	3.5			
	Total			20.4					2.7	9.8			

Argentina: Planned Capacity by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes	Asphalt
Bahia Blanca	Isaura	25.2	14.5		8.8		4.4						
Buenos Aires	Shell	121.7	38.5		29.2		27.0	17.9	2.2		7.5	1.5	4.2
Campana	Esso	88.1	47.2	25.0	27.3						16.4		
Campo Duran	YPF	32.0											
Dock Sud	YPF	4.0	1.0										
Galvan	Esso	18.4					7.6						
L de Zamora	Dst. Argentina	8.0	1.3									0.9	0.6
La Plata	YPF	180.0	104.5	59.4	45.3			11.7		6.3	24.6	5.5	8.3
Luian de Cuyo	YPF	120.0	66.0	35.2	44.1	26.0		9.5	2.7	3.5	17.6		
Plaza Huincul	YPF	23.6					3.5	3.0					
S. Francisco Sc	Sol Petroleo	6.0											
San Lorenzo	YPF	37.6	16.1				12.5						
	Total	664.6	289.1	119.6	154.7	26.0	55.0	42.1	4.9	9.8	66.1	7.9	13.1

Projected Refinery Balances

Table 3 shows projected refinery balances in Argentina in 2000 based on current capacity plus announced projects. Despite growth in demand, the refining system is more than adequate to meet Argentina's needs while maintaining the country's export role in all of

the major products. Indeed, with the new facilities and higher crude throughput, gasoline output can be increased significantly.

Table 3. Argentina:
Forecast Petroleum Product Balance, kb/d

2000	Output	Imports	Exports	Demand
LPG	62.7	-	16.4	46.3
Naphtha	28.9	-	13.4	15.5
Mogas	183.2	-	47.4	135.8
Kerojet	33.8	-	4.0	29.8
Diesel	209.2	-	37.9	171.3
Fuel Oil	53.0	-	14.0	39.0
Other	41.7	-	16.2	25.5
Total	**612.5**	**-**	**149.3**	**463.2**

There are no imports shown in the balance; on a net basis, none are needed. It is likely, however, that there will be continued two-way trade in most products for commercial reasons. One change of note is that Argentina's position as a net importer of fuel oil could easily change at higher crude throughput.

There are no firm plans beyond 2000 in Argentina, but the existing refining system with announced upgrades is sufficient to meet our projections of Argentinian demand until late in the first decade of the twenty-first century. Even if these demand projections prove much too low, and Argentina enters a major boom in consumption, it will be several years before Argentina's demand presses against its supply capabilities.

Brazil

Product Demand

Brazil's oil product demand has remained strong throughout the 1970s and 1980s, despite mixed economic fortunes and periods of high energy prices. As in many other developing countries, there was a major sag in overall oil consumption in the early 1980s; as Figure 2 shows, however, this was almost entirely attributable to the decline in the demand for fuel oil. Between 1975 and 1980, fuel oil demand expanded at about 4.2% per annum. In the next five years, through 1985, fuel oil demand plummeted by more than 11.5% annually.

Although some of the decrease in fuel oil demand was a result of price-induced conservation, the bulk of it can be accounted for by the substitution of other energy sources. This was most notable in the power sector, where fuel oil use was roughly halved between 1975 and 1985. The alternative power sources employed initially concentrated on hydropower (which tripled in the 1975-90 period) and coal, but by 1985 Brazil was also generating nuclear electricity.

Although the largest changes in fuel oil demand were in the power sector, the most aggressive fuel switching was in the industrial sector, where fuel oil demand was sharply curtailed. The largest switchovers in the industrial sector were in obvious target areas, such as cement manufacture and iron and steelmaking, but conversions to non-oil energy were widespread in industry. Even more important than the switching of existing demands was the expanded energy growth in non-oil fuels; energy demand in industry continued to expand rapidly at the same time that fuel oil demand was cut. The statistics for the period are astonishing. Direct use of coal in industry grew at more than 33% per annum in the 1975-85 period. Industrial consumption of natural gas, which was a minor fuel in the early 1970s, expanded at an annually rate of 120% across the same period, and this was supplemented by a large expansion in gas by-products from coking ovens.

Although alternative fuels have played their most important role in competition with fuel oil, it is Brazil's use of alcohol as a gasoline substitute–both as neat alcohol, and

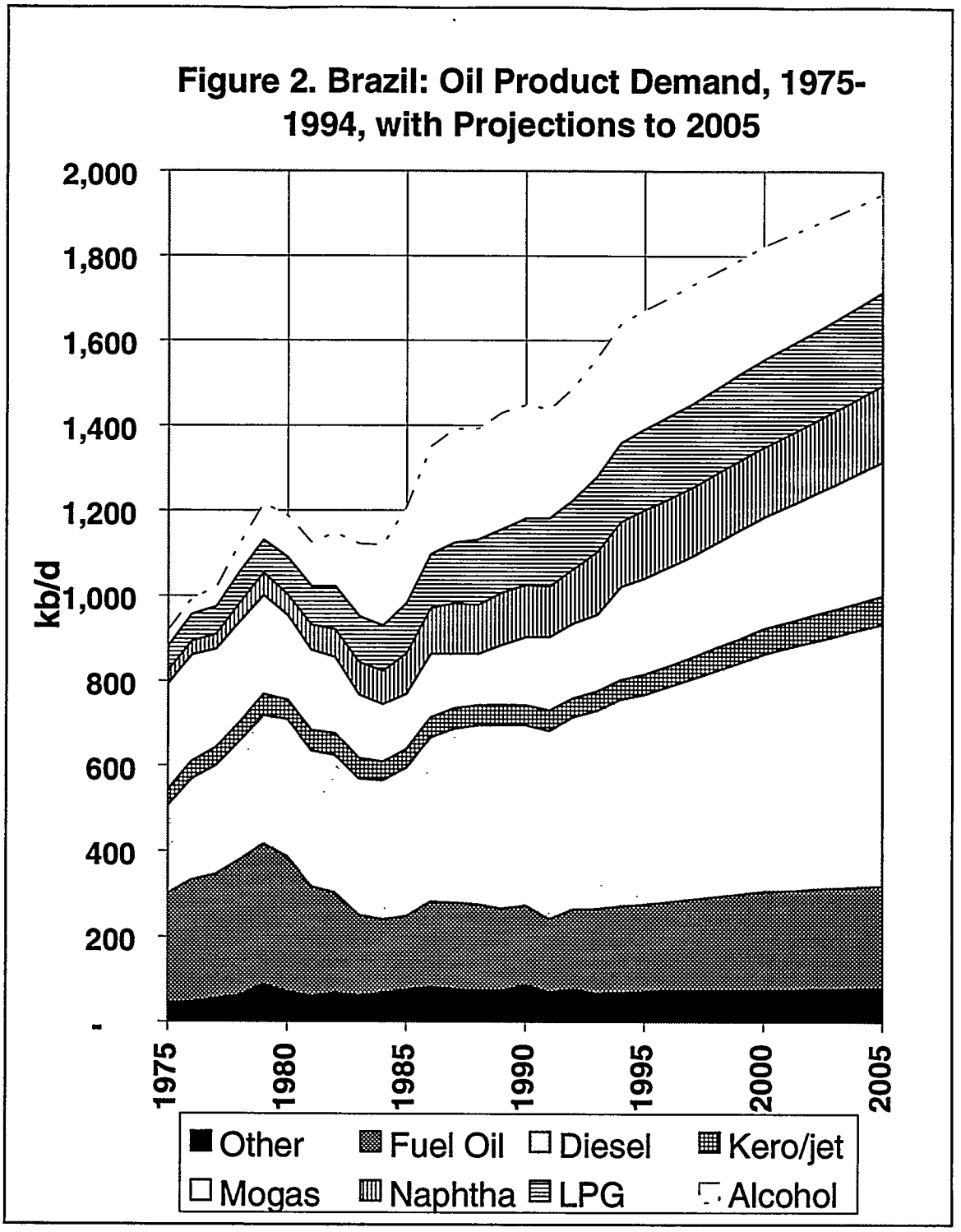


Figure 2. Brazil: Oil Product Demand, 1975-1994, with Projections to 2005
kb/d
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
1975
1980
1985
1990
1995
2000
2005
Other
Fuel Oil
Diesel
Kero/jet
Mogas
Naphtha
LPG
Alcohol

as a gasohol blend running up to 22% EtOH–that has been most widely noted. Gasoline demand appeared to fall in the 1975-85 period, declining at about 4.5% annually in 1975-80, and at more than 8% annually in 1980-85. This decline was more than compensated for by an the increases in use of alcohol motor fuels; together, alcohol and gasoline were essentially flat in 1975-80 (0.5% per annum growth), but grew at 3.8% annually in 1980-85, and have maintained similar rates of growth through the present. The composition of this growth varies widely, however; alcohol production plateaued by the late 1980s (resulting in shortages of alcohol fuel), and has grown only slowly in recent years.

Observers of Brazil's ethanol program tend to use it to confirm their own preconceptions about alcohol fuels. Those who claim that alternative fuels are uncompetitive (and those who advocate non-interference in energy markets) point to the higher costs and shortfalls in supply to prove their points. Alcohol enthusiasts, on the other hand, point to Brazil to demonstrate that the technical problems with alcohol fuels have been overemphasized, and use Brazil as an example of how large an impact alcohol can have on gasoline demand.

There are three main schools of thought on the future of Brazil's ethanol program. The optimists (a shrinking group) believe that the program will revive and continue to expand as in past years, possibly as the result of another crude-price increase. The pessimists claim that the program has been a fiasco, and that ethanol will rapidly be pushed out of the market by increased gasoline use. The third school, to which we belong, believes that, while ethanol is not an attractive option at today's energy prices, the significant investment in ethanol infrastructure (both consumer and supplier) means that ethanol use will gradually decline, but at a rate more connected with the aging of the automobile fleet. Of course, government policy created the ethanol industry in Brazil, and government policies could easily alter its future.

As a large, "frontier" country, Brazil uses substantial amounts of diesel fuel, not only for transport, but also for small-scale power generation in remote sites. At the end of the 1970s, growth rates for diesel were in the 9-10% per annum range. Increased prices

after 1979 sharply curtailed this growth, but by no means reversed it; even in 1980-85, diesel demand continued to grow at about 1.5% annually, and by the 1985-90 period it had recovered to an annual expansion of about 4% per annum. Some of this may have been "demand rebound," however, as diesel demand has slowed in recent years to about 3% annual growth–a rate that is likely to slow slightly in coming years as development of the frontier slows.

In the early 1970s, Brazil's kero/jet demand was split about evenly between jet fuel and other uses. The use of kerosene in households, restaurants, and industry set into a rapid decline after the first oil-price increases, and the use of kerosene has continued to fall in both absolute and relative terms. By the mid-90s, jet fuel accounted for about 92% of kero/jet consumption, and household demand was a mere 4% of the total. Jet traffic is therefore the key to kero/jet demand, and this end-use has seen relatively flat growth in recent years. Our forecast sees a recovery (largely as a result of tourism) in the late 1990s, and modest demand growth thereafter.

Brazil was one of the countries that suffered from major overcapacities in petrochemicals in the 1980s, so much of the continued growth in naphtha demand has been from increased utilization of existing facilities. Although Brazil's large chemicals industry will continue to expand, the emphasis in future years is likely to turn toward secondary and tertiary products, as well as more specialty products; therefore, the consumption of naphtha for basic chemicals is expected to grow more slowly than in past years.

Product Balance

Table 4 shows product balances for Brazil in the 1990-94 period. Brazil has moved from a position of large net exports in the 1980s to a growing deficit in the 1990s. In 1990, Brazil's only major deficits were in LPG and diesel; by 1994, Brazil was deficit in LPG, naphtha, gasoline, and diesel.

The emergence of a net deficit in gasoline in 1994 should be welcome news to the world market. The development of Brazil's ethanol market in the 1980s meant that Brazil had large gasoline surpluses for export, and these were often sold at such low cargo prices

Table 4. Brazil:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	116.8	39.4	0.1	156.1
Naphtha	119.3	3.9	-	123.3
Mogas	184.1	16.8	37.3	160.5
Kerojet	56.7	0.5	10.1	46.4
Diesel	416.3	11.7	4.4	422.9
Fuel Oil	216.5	11.3	44.5	184.1
Other	87.6	2.0	1.0	88.6
Total	1,197.3	85.7	97.5	1,181.9
*Includes field output:		23.2		

1991	Output	Imports	Exports	Demand
LPG*	111.7	46.6	-	158.3
Naphtha	108.4	11.3	0.1	119.6
Mogas	192.3	23.4	25.5	173.7
Kerojet	56.0	2.5	11.7	47.1
Diesel	410.9	31.4	3.2	440.8
Fuel Oil	206.5	4.1	41.7	169.5
Other	72.8	1.5	2.4	71.9
Total	1,158.6	120.8	84.6	1,181.0
*Includes field output:		19.4		

1992	Output	Imports	Exports	Demand
LPG*	115.8	46.7	0.1	162.4
Naphtha	104.6	23.7	0.8	127.5
Mogas	183.5	29.8	34.8	174.5
Kerojet	53.3	2.5	11.0	45.4
Diesel	418.7	38.9	5.1	450.6
Fuel Oil	218.2	9.3	42.4	185.8
Other	82.6	0.2	4.2	78.6
Total	1,176.8	151.1	98.3	1,224.9
*Includes field output:		20.0		

1993	Output	Imports	Exports	Demand
LPG*	125.2	51.7	0.2	176.7
Naphtha	103.0	44.8	-	147.8
Mogas	203.5	60.9	67.2	180.6
Kerojet	53.2	7.9	12.4	45.5
Diesel	404.1	75.5	13.6	465.2
Fuel Oil	212.2	88.1	46.2	196.0
Other	70.9	1.0	3.3	68.7
Total	1,172.0	329.9	142.9	1,280.4
*Includes field output:		19.1		

1994	Output	Imports	Exports	Demand
LPG*	133.8	52.3	0.1	186.0
Naphtha	102.0	49.0	-	151.0
Mogas	221.4	75.8	53.8	219.9
Kerojet	51.6	7.2	13.8	45.8
Diesel	452.6	56.1	18.4	486.1
Fuel Oil	216.0	49.7	56.2	199.8
Other	73.0	1.5	3.5	71.0
Total	1,250.4	291.7	145.9	1,359.7
*Includes field output:		20.3		

that they arrived at destinations as distant and unlikely as Singapore.

The slow fall into deficit over recent years would be expected to gradually eliminate Brazil's exports. Instead, however, both imports and exports have expanded. At present, Brazil's exports are still running at high levels despite the overall deficit; high blending rates of ethanol give Brazil considerable octane flexibility, and money can be made by placing cargoes at other nations' specs. (At one time, this was considered the easiest way of exporting ethanol to the US while ducking the high duty on chemical alcohol). Refiners elsewhere may find consolation in the fact that Brazil itself is now a substantial importer, but Brazil continues to put 50-60 kb/d of gasoline onto the market.

Overall, however, Brazil is now deeply in deficit at the light end of the barrel. Although the deficit of gasoline in 1994 was just over 20 kb/d, the combined naphtha/gasoline deficit was more than 70 kb/d, compared with a combined naphtha/gasoline surplus in 1990. Any increase in gasoline output could therefore easily be absorbed by the naphtha demand instead.

Brazil's diesel deficit has climbed fairly steadily, despite major increases in domestic output. As recently as 1990, the diesel situation was roughly in balance, but in the last few years deficits have climbed to 40 kb/d and more. Without additional cracking facilities, Brazil's incremental source of diesel is straight-run distillate; only more crude runs can rectify the problem in the near term, but, as the next section will describe, Brazil's crude system is operating near capacity already.

Refinery Configuration

Developments in Brazil's refinery configuration may not provide much relief for the market on the gasoline front. Table 5 shows Brazil's 1995 configuration, as well as planned expansions by 2000. Despite the steady strength of diesel demand in Brazil, no hydrocracking capacity has ever been completed (although there were dozens of hydrocracking projects planned and designed in the 1980s).

Table 5. Brazilian Refinery Configuration (kb/cd)

Brazil: 1995 Configuration

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	Naph. Treat	Dist. Treat	Lubes	Asphalt
Araucaria	Petrobras	159.2	62.6		45.7								27.5
Belim	Petrobras	136.5	62.6		33.1					11.3	27.7		
Canoas	Petrobras	68.2	30.7		14.0								
Capuava	Petrobras	38.1	11.9		11.6								
Cubatao	Petrobras			32.7	49.6			3.1	7.6	11.3			
Duque de Caxi	Petrobras	225.7	97.5	15.7	41.4					11.3	32.2	13.7	31.6
Fortaleza	Petrobras		6.2										4.5
Manaus	Petrobras	10.2	6.3		2.2								
Mataripe	Petrobras	118.0	57.9		24.8						2.1	2.6	4.7
Paulinia	Petrobras	272.9	125.1		50.3								
Rio de Janeiro	RdP Manguinh	10.0				9.2	3.0						
Rio Grande do	RdP Ipiranga	9.3	4.1		2.5								
Sao Jose dos C	Petrobras	204.7	91.0		57.9					17.6	57.8		
	Total	1,252.8	555.9	48.4	333.1	9.2	3.0	3.1	7.6	51.5	119.8	16.3	68.3

Brazil: Planned Additions by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	Naph. Treat	Dist. Treat	Lubes	Asphalt
Araucaria	Petrobras										31.5		
Canoas	Petrobras				15.0						31.5		
Cubatao	Petrobras										31.5		
Duque de Caxi	Petrobras	37.7		15.7	15.0						31.5		
Mataripe	Petrobras	170.0			37.7						18.9	1.3	
Paulinia	Petrobras										31.5		
	Total	207.7		15.7	67.7						176.4	1.3	

Brazil: Planned Capacity by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	Naph. Treat	Dist. Treat	Lubes	Asphalt
Araucaria	Petrobras	159.2	62.6		45.7						31.5		27.5
Belim	Petrobras	136.5	62.6		33.1					11.3	27.7		
Canoas	Petrobras	68.2	30.7		29.0						31.5		
Capuava	Petrobras	38.1	11.9		11.6								
Cubatao	Petrobras			32.7	49.6			3.1	7.6	11.3	31.5		
Duque de Caxi	Petrobras	263.4	97.5	31.4	56.4					11.3	63.7	13.7	31.6
Fortaleza	Petrobras		6.2										4.5
Manaus	Petrobras	10.2	6.3		2.2								
Mataripe	Petrobras	288.0	57.9		62.5						21.0	3.9	4.7
Paulinia	Petrobras	272.9	125.1		50.3						31.5		
Rio de Janeiro	RdP Manguinh	10.0				9.2	3.0						
Rio Grande do	RdP Ipiranga	9.3	4.1		2.5								
Sao Jose dos C	Petrobras	204.7	91.0		57.9					17.6	57.8		
	Total	1,460.5	555.9	64.1	400.8	9.2	3.0	3.1	7.6	51.5	296.2	17.6	68.3

Instead, Brazil is largely a system of distillation backed up by cat crackers; there is little other capacity, with the exception of lubes, asphalt, and two large cokers. Hydrotreating facilities are minimal, and even octane enhancing technologies, such as reforming and alkylation, are minor (perhaps to be expected given the relative abundance of octane from ethanol).

Over the next few years, the biggest change in Brazil will be the expansion of distillate hydrotreating. This will not only allow the average sulfur in the existing diesel pool to be reduced, but will also allow increased blending of cycle oils without resulting in major quality decreases.

In addition to the expansion of hydrotreating, Brazil will also expand distillation and coking, and will revamp and expand a number of existing cat crackers to run increased amounts of whole residuum. These expansions will enable Brazil to increase throughput and increase cracking as well, but they are only a small part of what has been proposed over the years; it is quite possible that additional capacity will be proposed and built before 2000. In particular, additional distillation capacity is likely; at many points in the early 1990s, Brazil has run its system well above nameplate capacity.

Projected Refinery Balances

Table 6 shows projected refinery balances in Brazil for 2000 based on current capacity plus planned additions. The planned expansions enable Brazil to hold roughly steady in terms of net imports and the general pattern of trade—but only at very high levels of capacity utilization.

This balance requires two caveats, however. First, as mentioned earlier, any surplus of gasoline could potentially be absorbed into naphtha demand, although our model results here suggest that there will continue to be enough octane surplus in the system to support gasoline exports.

Second, not too much emphasis should be given to the apparent surplus of fuel oil. Shifts in the crude slate or in levels of demand could increase this level, or easily shift the system into deficit. By 2000, Brazil will be consuming more than 1.5 million barrels/day of oil products under this scenario, so small changes in demand growth rates can have a large volumetric effect on product balances.

Table 6. Brazil:
Forecast Petroleum Product Balance, kb/d

2000				
	Output	Imports	Exports	Demand
LPG	138.5	66.8	-	205.3
Naphtha	104.8	60.0	-	164.8
Mogas	272.9	-	19.0	253.9
Kerojet	59.5	-	1.2	58.3
Diesel	498.1	60.9	-	559.0
Fuel Oil	259.1	-	30.8	228.3
Other	76.3	0.6	-	76.9
Total	**1,409.3**	**188.2**	**51.0**	**1,546.5**

Since there are no new projects planned past 2000, the balance that would be inferred is merely a continuation of the 2000 patterns against a background of higher demand. Unless new capacity is completed, by 2005 Brazil will experience deficits in all products other than fuel oil, and will face an overall product shortfall of around 300 kb/d. Thus, there is ample room for additions to the Brazilian refining industry in the fairly near term.

Colombia

Product Demand

Like many other Latin American nations, Colombia's total product demand was sharply curtailed by higher prices in the 1980-85 period. As in the other countries showing this pattern, the decline in demand was dominated by reductions in fuel oil demand through deployment of alternative resources.

Unlike its neighbors, however, in Colombia switchovers in power generation fuels had only minor effects on fuel oil demand. As early as 1970, Colombia already generated more than 70% of its electricity from hydropower; the remainder was split fairly evenly

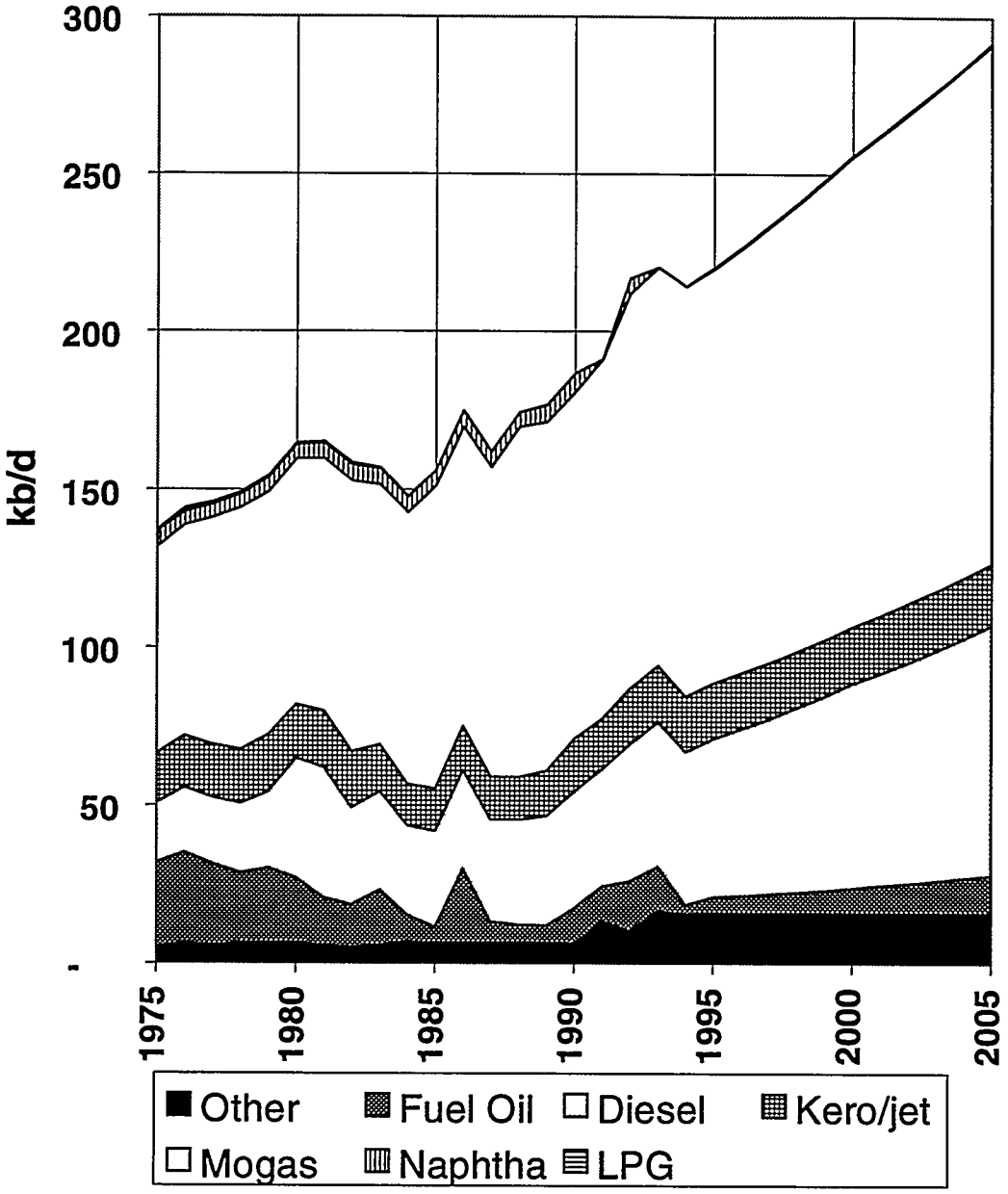
between natural gas, coal, and oil, with oil having a lead over the other fuels. As the 1970s progressed, however, coal and gas both expanded their shares of power generation, while oil held fairly constant and then declined in the 1980s. Even at its peak, however, fuel oil for power generation was less than 9 kb/d. In Colombia, the big user of fuel oil was the industrial sector, and, as natural gas and direct use of coal became more widespread in the 1980s, the use of fuel oil in industry was driven close to extinction. There was a minor revival in fuel oil use in the early 1990s to cover potential electricity shortfalls, but the bulk of Colombia's minor fuel oil is in bunkering.

Diesel and kero/jet demand also declined in the early 1980s, both falling by just under 4.5% per annum. In the case of kero/jet, this was the result of switchovers to natural gas in the residential and industrial sectors; for diesel, the main factor in the decline was a reduction in the use of gasoil for small-scale power generation.

Figure 3 shows Colombia's demand history, with our projections through 2005. The most striking feature of the figure is the dominance of gasoline in the demand barrel. This is an unusual pattern for a developing country; indeed, it is an unusual pattern for *any* country, industrial, developing, or OPEC. Even countries famous for their high levels of gasoline demand, such as the United States or Venezuela, tend to have less than half of their demand barrel as gasoline across time. Colombia's average share of gasoline in demand since 1985 has been 60%, and this has risen as high as 63% in some years.

This high level of growth in gasoline demand is not expected to continue indefinitely; indeed, there was a slowdown in gasoline demand growth rates after 1985. The most rapid growth of importance is in diesel, which has grown at more than 6% per annum in the early 1990s (compared with 2.8% annual growth for gasoline). Nonetheless, gasoline is growing from such a large base that even modest growth rates mean relatively large absolute additions to demand; thus, the rapid growth in diesel demand will still leave gasoline as 56% of the barrel in 2005. The three "transport fuels" (gasoline, kero/jet, and diesel) account for about 90% of the barrel today; this is not likely to change in the future, making Colombia one of the more transport-fuel-intensive countries in the world.

Figure 3. Colombia: Oil Product Demand, 1975-94, Forecast to 2005



Product Balances

Table 7 shows product balances for Colombia in the 1990-94 period. Even without any knowledge of the nation's refinery configuration, the balance is what might be expected on a very naïve basis: a shortage of gasoline, and a surplus at the bottom of the barrel (mainly in fuel oil, but also with a small surplus of diesel). Since LPG demand is vanishingly small, there is also a persistent exportable surplus of LPG.

Refinery Configuration

At first glance, Colombia's refinery configuration in Table 8 appears to be what might be expected from the pattern of demand: a system with a high ratio of cat cracking to distillation, along with auxiliary processes such as alkylation and feed desulfurization. A substantial amount of visbreaking is included, not for uplift, but to make marketable fuel oil from the vacuum bottoms after the VGO is stripped for FCC feed.

A closer look, however, presents something of a surprise: there are no catalytic reformers. This is not too unusual in a country with low gasoline requirements, but it is very odd for a country where gasoline is in perpetual deficit. Why is reforming not available to uplift the heavy naphtha fraction into gasoline blendstock? The answer is that the heavy naphtha is already used as gasoline blendstock; Colombian octane specifications run as low as 80 RON on some grades, with substantial amounts of TEL still allowed. Under these conditions, substantial amounts of heavy naphtha are used directly. If product quality is to be improved, as is currently under discussion, then these practices will have to change; but as Table 8 shows, current plans have been cut back to include only a small visbreaking expansion. There is a strong impetus for additions to capacity in Colombia, but there is presently great uncertainty about where and how capacity might be added.

Table 7. Colombia:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	13.3	-	13.3	0.0
Naphtha	5.8	-	-	5.8
Mogas	82.9	27.3	-	109.8
Kerojet	16.6	-	-	16.6
Diesel	41.3	-	3.7	37.1
Fuel Oil	68.1	-	56.4	11.1
Other	6.3	-	-	6.3
Total	**234.2**	**27.3**	**73.4**	**186.8**
*Includes field output:		2.4		

1991	Output	Imports	Exports	Demand
LPG*	14.0	-	13.9	0.1
Naphtha	-	-	-	-
Mogas	88.2	26.0	-	113.7
Kerojet	16.0	0.0	-	15.9
Diesel	44.6	0.0	6.8	37.3
Fuel Oil	74.7	-	64.3	10.9
Other	13.4	-	-	13.4
Total	**250.9**	**26.0**	**84.9**	**191.3**
*Includes field output:		-		

1992	Output	Imports	Exports	Demand
LPG*	16.1	0.6	16.7	-
Naphtha	4.7	-	-	4.7
Mogas	89.8	35.7	0.7	124.9
Kerojet	17.2	0.4	-	17.8
Diesel	47.2	0.3	4.8	43.6
Fuel Oil	66.0	0.1	49.7	15.5
Other	10.1	0.2	-	10.3
Total	**251.1**	**37.2**	**71.9**	**216.7**
*Includes field output:		4.4		

1993	Output	Imports	Exports	Demand
LPG*	15.4	2.3	17.7	0.0
Naphtha	-	-	-	-
Mogas	88.8	36.6	-	126.0
Kerojet	18.0	-	-	17.8
Diesel	52.9	0.3	8.6	46.0
Fuel Oil	62.3	0.1	48.0	14.0
Other	16.5	-	-	16.5
Total	**253.9**	**39.3**	**74.3**	**220.3**
*Includes field output:		4.2		

1994	Output	Imports	Exports	Demand
LPG*	15.5	0.5	16.0	-
Naphtha	-	-	-	-
Mogas	88.5	42.0	0.4	129.8
Kerojet	17.7	-	-	17.4
Diesel	55.5	0.0	11.0	48.7
Fuel Oil	54.5	0.1	55.2	2.6
Other	15.7	-	-	15.7
Total	**247.4**	**42.6**	**82.6**	**214.2**
*Includes field output:		3.5		

Projected Refinery Balances

Table 9 shows projected refinery balances in Colombia for 2000 based on current capacity plus the minor addition seen in Table 8. The result, unsurprisingly, is a continuation of the

trends seen in Table 7. Despite some minor increases in light product output from adjustments in the crude slate, the gasoline deficit increases.

Table 8. Colombian Refinery Configuration (kb/cd)

Colombia: 1995 Configuration

Site	Company	CDU	VDU	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	VGO Desulf	Lubes	Asphalt
Apiay	Ecopetrol	2.3									
Barrancaberme	Ecopetrol	173.0	101.0	64.0	33.0		2.1	1.6	19.8	1.4	1.5
Cartagena	Ecopetrol	70.0	40.0	26.0	19.0		2.1				
Orito	Ecopetrol	1.8									
Tibu	Ecopetrol	1.8									
	Total	248.9	141.0	90.0	52.0		4.2	1.6	19.8	1.4	1.5

Colombia: Planned Additions by 2000

Site	Company	CDU	VDU	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	VGO Desulf	Lubes	Asphalt
Cartagena	Ecopetrol				6.0						
	Total				6.0						

Colombia: Planned Capacity by 2000

Site	Company	CDU	VDU	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	BTX	VGO Desulf	Lubes	Asphalt
Apiay	Ecopetrol	2.3									
Barrancaberme	Ecopetrol	173.0	101.0	64.0	33.0		2.1	1.6	19.8	1.4	1.5
Cartagena	Ecopetrol	70.0	40.0	26.0	25.0		2.1				
Orito	Ecopetrol	1.8									
Tibu	Ecopetrol	1.8									
	Total	248.9	141.0	90.0	58.0		4.2	1.6	19.8	1.4	1.5

Increased demand for diesel turns Colombia into a diesel importer by the end of this decade, despite roughly constant diesel output. Surpluses of fuel oil and LPG remain at high levels.

Colombia's deficits require more than an increase in FCC capacity; almost all of the available VGO feed is already committed to FCCs or lubes. Some of the diesel shortfall could be made up by addition of severe gasoil hydrotreating, which could allow some of the cycle oils to be upblended; but closing the gasoline gap would require either revamping existing FCCs to RCCs, or building whole new cracking refineries–or both. As long as Colombian gasoline specifications remain so relaxed, the economic incentive for

expansion may not be very powerful; there is no shortage of low-spec gasoline on the market at reasonable prices. Nonetheless, the volumes of imports are growing large enough that some sort of refinery expansion seems inevitable, though not necessarily before the end of the decade.

Table 9. Colombia:
Forecast Petroleum Product Balance, kb/d

2000				
	Output	Imports	Exports	Demand
LPG	20.8	-	20.7	0.1
Naphtha	1.1	-	0.8	0.3
Mogas	92.5	56.4	-	148.9
Kerojet	17.9	-	-	17.9
Diesel	54.3	10.6	-	64.9
Fuel Oil	59.8	-	51.8	8.0
Other	13.7	2.1	0.0	15.8
Total	**260.1**	**69.1**	**73.3**	**255.9**

Ecuador

Product Demand

Until recently, when it resigned from the organization, Ecuador shared with Venezuela the distinction of being one of only two OPEC members in the Western Hemisphere. In the 1970s, Ecuador enjoyed booming revenues from oil, and, as in most OPEC nations, oil demand boomed along with the increased income. In 1975, Ecuador was consuming about a quarter of its own oil; by the mid-80s, despite substantial increases in production, Ecuador's runs of its own crude were approaching half of output.

Ecuador has never been a large producer; output until recently has typically been in the 200-250 kb/d range, making it, with Gabon, one of OPEC's minor producers.

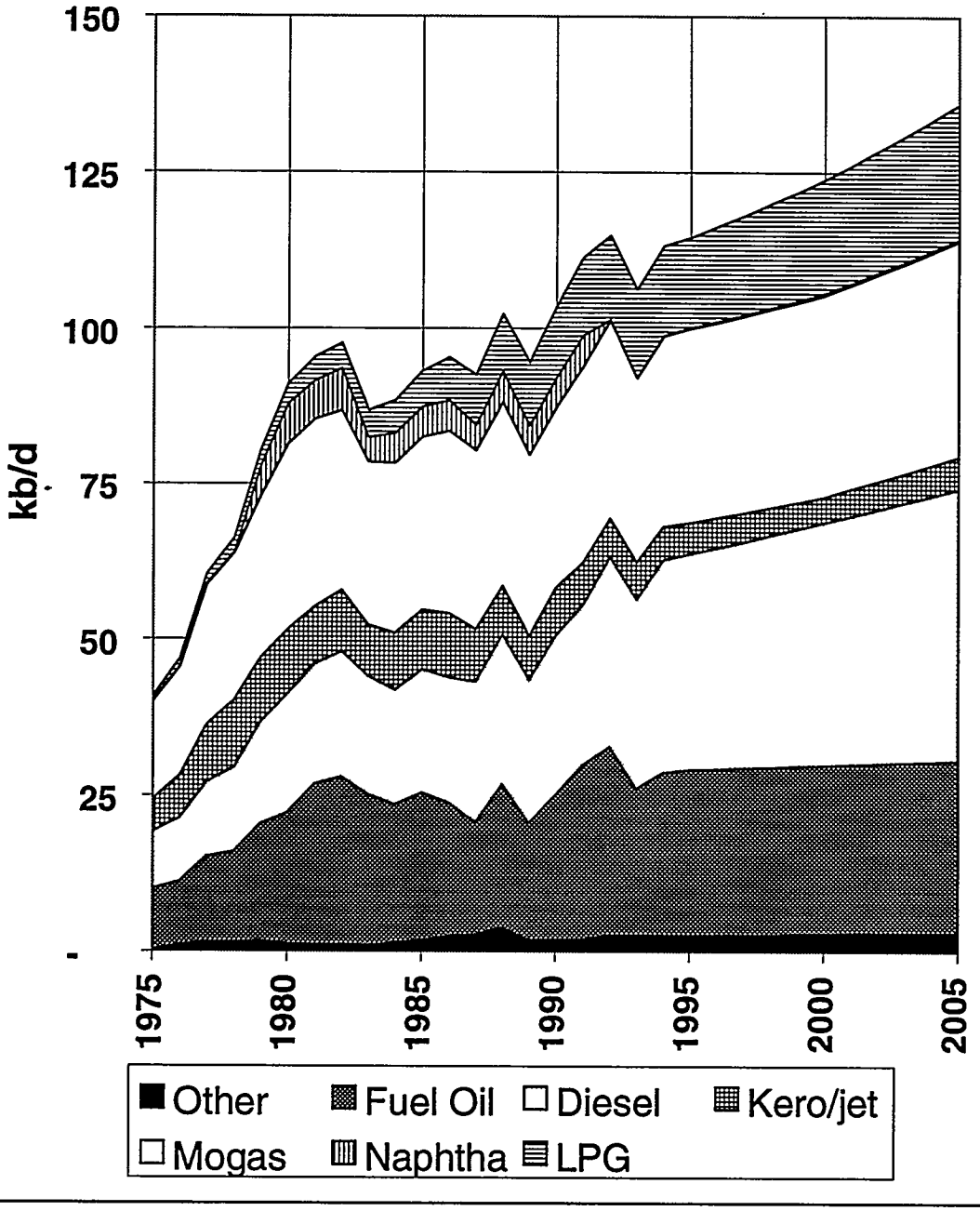
Although Ecuador benefited from the run-up in prices in the late 1970s, its own economy was damaged by inflation and a slowdown in the non-oil sector, leading to a serious slowdown in demand growth in the early 1980s. Since that time, growth in demand has resumed, but at a far lower rate of increase; in the 1975-80 period, oil product demand increased by almost 17.5% per annum; in 1980-90, this was reduced to about 1.3% per annum.

Ecuador's baseload electricity supply is from hydropower, and thus fluctuates from year to year; this is the key to the jagged appearance of Ecuador's demand profile, shown in Figure 4. Fuel oil demand is roughly flat, but departs substantially from this in times of low water and high power demand; this pattern is further exacerbated by variations in the bunkering trade. The fluctuation in fuel oil leads to a deceptive impression that product demand in Ecuador is unstable. In fact, after a sharp contraction of demand in the early 1980s, the growth in products other than fuel oil has been generally steady, albeit slow. Gasoline has increased at rates of 0.75-1.5% per annum since its low of 1983; diesel has increased at rates of 5.4-6.2% annually across the same period.

From a very low base in 1975, LPG use increased rapidly, maintaining 13-14% annual growth rates through the 1980s. Now that the consumer base is established, the 1990s have seen LPG demand settling down to a more sedate 4-5% annual growth. Much of the growth in LPG has been at the expense of household kerosene. Total kero/jet shows a steady decline from 1980 through the present. Although jet fuel has actually grown at annual rates of about 2.7% annually since 1980, this increase has been more than offset by declines in cooking and illuminating kerosene. This situation is likely to persist through the end of the decade, when growth in jet fuel will finally overtake the shrinking volume of kerosene demand.

Combining all of these independent factors together, the outlook for Ecuadorian demand is continued overall growth, but probably at rates of under 2% annually. The fastest growth in the near term will be in diesel and LPG; after 2000, kero/jet demand will increase quickly as well.

Figure 4. Ecuador: Oil Product Demand, 1975-94, Forecast to 2005



Product Balances

Table 10 shows Ecuador's product balances for the 1990-94 period. In general, the system is well balanced; although there is a significant surplus of fuel oil, deficits in the other products are small. There is a steady import of 6-7 kb/d of LPG, but no other consistent trend. Refinery runs have been expanded slowly to keep up with the modest level of demand growth; since diesel and gasoline have been needed in roughly equal proportions, matching runs to demand growth has not been too difficult to date.

Refinery Configuration

As Table 11 shows, Ecuador's refinery configuration is simple; only one refinery, the Esmeraldas plant, is equipped with upgrading. This is a standard cat cracking refinery where the vacuum bottoms are processed in a visbreaker. There is a small reformer to increase the gasoline make. Recently, it has been reported that the FCC is under revamp; the base unit is now fairly old.

Ecuador faces an increasingly heavy crude slate. There are two ways to produce the needed products as the feed slate gets heavier; the first is to add cracking, and the second is to increase throughpout and export the surplus fuel oil. On present plans, Ecuador anticipates doing both. Capacity is being increased at its four largest refineries. In addition, a 10 kb/d cat cracker is being added at Shushufindi, to help produce a useful slate from the heavy local crudes. This may not be the ideal approach to achieving balance in an engineer's view–and other plans were announced in the past–but these expansions offer a far cheaper means of following demand with a heavier feed slate than most of the grass-roots options that have been discussed in recent years.

Table 10. Ecuador:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	4.7	6.6	-	11.3
Naphtha	4.7	-	-	4.7
Mogas	29.3	0.3	-	29.0
Kerojet	7.6	0.1	-	7.7
Diesel	25.0	0.6	-	25.6
Fuel Oil	48.4	-	25.3	23.1
Other	2.0	-	-	2.0
Total	**121.7**	**7.6**	**25.3**	**103.4**
*Includes field output:		0.7		

1991	Output	Imports	Exports	Demand
LPG*	6.0	6.5	-	12.5
Naphtha	5.0	-	-	5.0
Mogas	30.8	0.8	-	31.6
Kerojet	6.7	0.1	-	6.8
Diesel	25.6	-	-	25.6
Fuel Oil	49.6	-	21.8	27.9
Other	2.0	-	-	2.0
Total	**125.8**	**7.3**	**21.8**	**111.4**
*Includes field output:		2.7		

1992	Output	Imports	Exports	Demand
LPG*	6.9	6.4	-	13.3
Naphtha	0.1	-	-	0.1
Mogas	31.1	1.1	0.4	32.0
Kerojet	6.1	0.1	-	6.2
Diesel	28.8	1.7	-	30.5
Fuel Oil	51.0	-	20.9	30.1
Other	2.7	-	-	2.7
Total	**126.7**	**9.2**	**21.3**	**114.8**
*Includes field output:		2.7		

1993	Output	Imports	Exports	Demand
LPG*	8.1	6.1	-	14.1
Naphtha	0.1	-	-	0.1
Mogas	29.7	-	-	29.7
Kerojet	5.9	0.1	-	6.0
Diesel	30.3	-	-	30.3
Fuel Oil	50.7	-	27.2	23.5
Other	2.7	-	-	2.7
Total	**127.4**	**6.2**	**27.2**	**106.3**
*Includes field output:		3.7		

1994	Output	Imports	Exports	Demand
LPG*	8.3	6.0	-	14.3
Naphtha	0.1	-	-	0.1
Mogas	30.5	0.1	-	30.6
Kerojet	5.4	0.1	-	5.4
Diesel	30.6	3.4	-	34.0
Fuel Oil	54.4	-	28.4	26.0
Other	2.7	-	-	2.7
Total	**132.0**	**9.6**	**28.4**	**113.2**
*Includes field output:		3.8		

Table 11. Ecuadorian Refinery Configuration (kb/cd)

Ecuador: 1995 Configuration

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Naph. Treat	Dist. Treat	Lubes	Asphalt
Amazonas	PetroEcuador	10.0									
Esmeraldas	PetroEcuador	90.0	43.5		16.1	25.2	2.8				
La Libertad	PetroEcuador	47.0									
Lago-Agrio	PetroEcuador	1.0									
Shushufindi	PetroEcuador	7.0									
	Total	155.0	43.5		16.1	25.2	2.8				

Ecuador: Planned Additions by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Naph. Treat	Dist. Treat	Lubes	Asphalt
Amazonas	PetroEcuador	10.0									
Esmeraldas	PetroEcuador	20.0									
La Libertad	PetroEcuador	10.0									
Shushufindi	PetroEcuador	20.0			10.0						
	Total	60.0			10.0						

Ecuador: Planned Capacity by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Naph. Treat	Dist. Treat	Lubes	Asphalt
Amazonas	PetroEcuador	20.0									
Esmeraldas	PetroEcuador	110.0	43.5		16.1	25.2	2.8				
La Libertad	PetroEcuador	57.0									
Lago-Agrio	PetroEcuador	1.0									
Shushufindi	PetroEcuador	27.0			10.0						
	Total	215.0	43.5		26.1	25.2	2.8				

Projected Refinery Balances

Table 12 shows projected refinery balances in Ecuador for 2000 based on current capacity plus planned expansions as shown in Table 11.

The new capacity will increase total throughput by about 50% above current levels. This should lead to short-lived surpluses in all the main products other than LPG; but only the fuel oil surplus, which will double from present levels, is significant.

There is ample room for additional cracking in the system, even without going to deep processing; the bulk of the system's 85 kb/d of fuel oil output is virgin whole resid. There is an estimated 30-45 kb/d of VGO available in the straight-run resid streams which

Table 12. Ecuador: Forecast Petroleum Product Balance, kb/d				
2000				
	Output	Imports	Exports	Demand
LPG	14.2	3.9	-	18.1
Naphtha	2.6	-	2.3	0.3
Mogas	37.6	-	5.1	32.5
Kerojet	8.2	-	4.1	4.1
Diesel	42.4	-	3.5	38.9
Fuel Oil	85.7	-	58.7	27.0
Other	2.9	0.0	-	2.9
Total	**193.6**	**3.9**	**73.7**	**123.8**

could be fed to crackers without the need to go to full-residuum processing. On the other hand, given the state of the market, there are a number of cracking refineries in the US that would be happy to contract for such large volumes of virgin material; the "crackability" of the international fuel oil pool has been declining steadily in recent years.

In any case, beyond the increases in fuel oil exports, it is not expected that Ecuador will have a major impact on the regional market in coming years. At present, it is a minor importer of light and middle products; the increase in capacity may allow this pattern to be reversed in a minor way for a few years. Unless more ambitious expansions are undertaken, the general effects will be small.

Mexico

Product Demand

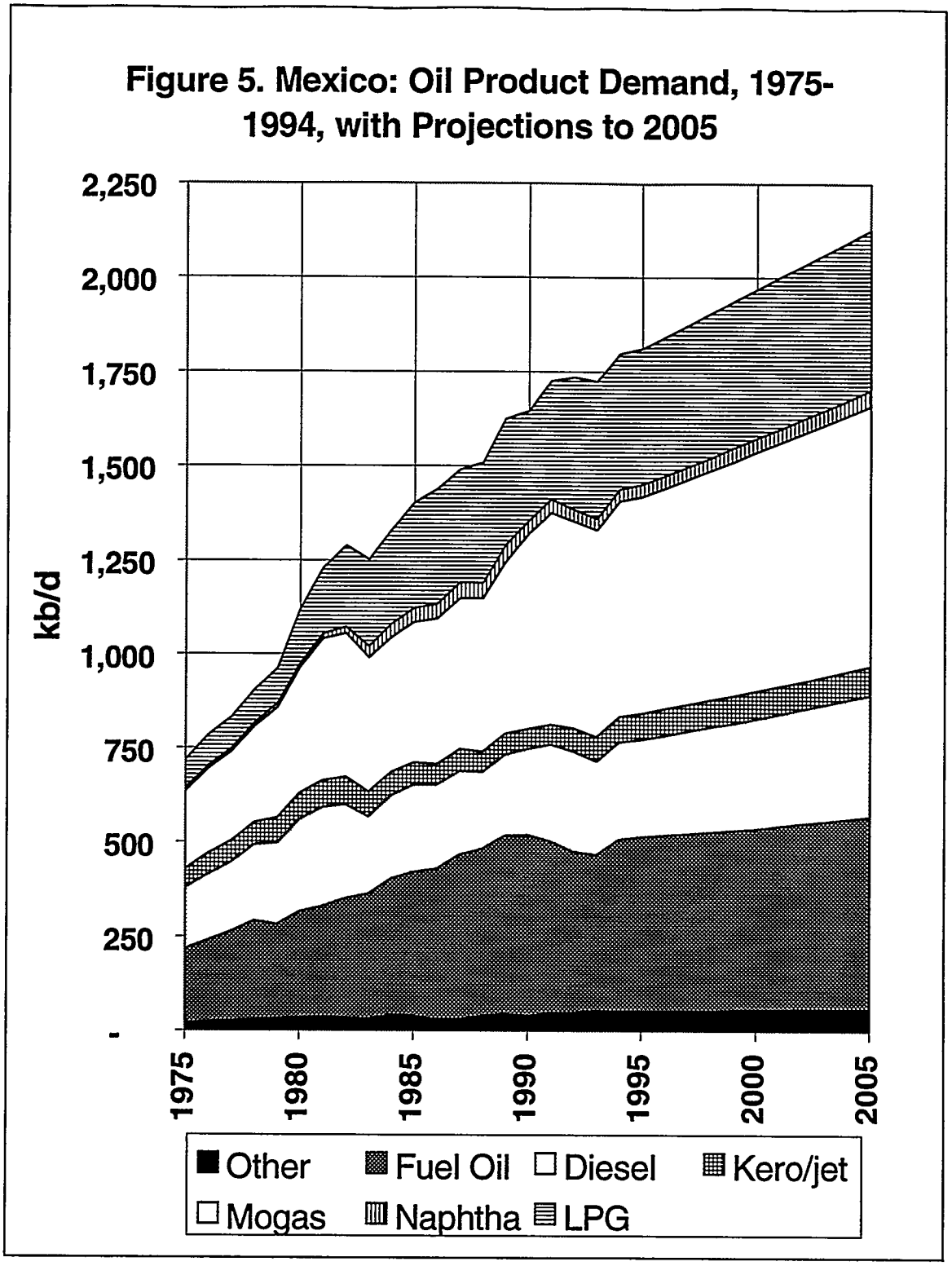
As if it were an OPEC nation, Mexico saw explosive demand growth in the 1970s, moving ahead at annual increases of 8-9%. This accelerated into even faster growth in the 1979-1982 period, when oil prices were at their peak; despite efforts to restrain growth (to maintain export volumes), Mexican oil demand in these years increased at over 10% per

annum. Like the majority of Latin American countries, Mexico's economic growth has been uneven over the years. In terms of real income per capita, Mexico's peak year was 1981; there have been a slight fall and then a slight recovery thereafter. In other words, Mexican economic growth has generally just kept pace with its population growth of around 2% per annum.

The linkage between oil demand growth and economic growth appears strong over the long term, but the relationship is not a firm one. In general, the oil/GDP ratio grew through the 1980s, but this trend was reversed in the 1990s as economic reform moved forward. Although many might argue that an increased oil dependence should occur at this point in Mexican economic growth, increased US investment in Mexican manufacturing is unlikely to be in energy-intensive industry; instead, light, labor-intensive manufacturing is likely to dominate. In this case, the main driver of Mexican oil demand will be the consumer side of the equation, rather than the inputs needed by industry. Indeed, Mexico's oil-demand structure is already heavily influenced by the consumer sector.

The largest single cut of the Mexican demand barrel is gasoline, at almost a third of total demand. This demand is highly responsive to both price and income effects; Mexico saw sharp drops in gasoline demand in both the early 1980s and the early 1990s. In past years, gasoline demand growth has often outpaced general economic growth, but recently it has slowed to a more sedate pace. As Figure 5 shows, our forecast expects gasoline to continue a rate of growth slower than the economy in coming years, increasing at slightly less than 2% per annum.

Fuel oil is the second-largest element of Mexican oil demand, at around a quarter of the barrel. As the figure shows, fuel oil showed vigorous and steady demand growth through the 1970s and 1980s, but fell in the early 1990s as economic reform took place. Use of fuel oil in power generation (which accounts for about half of fuel oil use) leveled off in the early 1990s, while fuel oil use in industry and other sectors actually declined. The current forecast sees only a slow growth in fuel oil demand in coming years, but this



is obviously an area where policies on utility fuel and other issues could have a dramatic effect.

The demand for middle-distillates in Mexico is relatively low; together diesel and kero/jet account for only 18% of the barrel. Stagnant kero/jet demand disguises many changes in demand at lower levels; jet fuel demand continues to grow, but the demand for kerosene in all non-transport sectors has fallen steadily. Diesel demand showed negative overall growth in the 1980s, but this changed in the 1990s, when diesel demand moved forward at about 2.4% per annum, outpacing demand for other main fuels with the exception of LPG.

LPG is the third-largest fuel in total demand, accounting for 20% of the barrel. Demand growth in LPG has been very rapid, at 13-14% in the 1975-1985 period. This growth slowed greatly in the late 1980s as per capita incomes sagged, but resumed rapid growth in the early 1990s, transforming Mexico from a net exporter of LPG into a net importer. Our forecast sees a slowing of this recent growth rate (partly as a consequence of the fact that leakage of LPG canisters is now seen as a major contributor to Mexico City's air pollution problem).

Air pollution has been a topic of serious concern in Mexico in recent years, and Mexico mandated a push into unleaded gasoline in the late 1980s. Between 1990 and 1993, unleaded jumped from 10% to 35% of the pool, and the target is a 50% unleaded pool in 1996. Thereafter, a gradual lead phaseout is scheduled for the entire country. The new standard also calls for mandatory oxygenation of the unleaded gasoline, at a level of 5.5% by volume of MTBE. Although Mexico has ambitious MTBE production plans, the volume of MTBE needed to oxygenate the total gasoline pool at this level far exceeds current production plans. This means that Mexico must either become a major importer of MTBE, or must relax the rate of phase-in of new gasoline grades. Unless some sort of international assistance is forthcoming, this latter prospect seems more likely.

The Mexican demand outlook given here is highly uncertain. As in the other Latin American countries considered here, the basic economic outlook for the country is a point of considerable controversy. In addition to this basic uncertainty, there are many other matters that amount to basic energy-policy issues. The two key ones are the future of

electric-power sources, and the future of residential energy supply. About half of Mexico's power supply is from oil, followed by hydropower at 21% of supply. Hydropower is of course quite limited in potential for expansion. Natural gas is the third largest supplier, at 12% of power output, but Mexico is short of natural gas supplies. Coal provides 8% of power, geothermal 5%, and nuclear (which entered the supply equation in 1989) 4%. Mexican coal supply is limited; good geothermal sites exist, but not always in appropriate locations. Nuclear power is always an option, but produces expensive power and is always subject to some degree of public opposition. There are many possible alternatives to expansion of the use of oil in the power sector, but it is not clear what final course will be chosen; although the free market is widely preached, nowhere is the utility industry a good example of a free market at work.

With respect to oil, the main issue in residential energy supply is the use of LPG. Beginning in the late 1970s, the use of LPG in homes and small businesses was encouraged because it was readily available and freed up oil for export. Although the expansion of LPG use forestalled (and even reversed) growth in kerosene usage, by the mid-80s Mexico was a substantial net importer of LPG. As a "clean fuel," continued growth in usage has been encouraged; but it now appears that evaporation of LPG into the atmosphere is a main source of pollution in at least some areas in Mexico. The only obvious alternative is to expand residential use of natural gas (which has indeed been growing at about 6% per annum in recent years); but gas supplies are limited, and there is significant competition for access.

Product Balances

Table 13 shows Mexico's product balances for the 1990-94 period. The system shows a steady pattern of shortages in LPG, gasoline, and fuel oil, with slight surpluses in the middle distillate range. The size of the net shortage in fuel oil is very sensitive to the total volume of distillation throughput; it would not require a great increase in distillation, all other things held equal, to eliminate net imports of fuel oil.

Table 13. Mexico:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	314.9	21.1	47.2	288.8
Naphtha	35.9	-	-	35.9
Mogas	491.5	36.3	8.4	517.8
Kerojet	66.8	-	14.8	53.2
Diesel	258.6	-	31.1	229.8
Fuel Oil	435.1	51.8	7.7	478.7
Other	40.4	-	-	40.4
Total	1,643.2	109.2	109.2	1,644.6
*Includes field output:	265.0			

1991	Output	Imports	Exports	Demand
LPG*	328.0	20.8	35.9	312.9
Naphtha	37.0	-	-	37.0
Mogas	508.7	74.5	15.5	563.3
Kerojet	71.4	-	16.6	53.0
Diesel	278.4	-	20.1	257.9
Fuel Oil	414.2	46.6	7.7	451.9
Other	49.7	-	-	49.7
Total	1,687.4	141.9	95.9	1,725.6
*Includes field output:	281.0			

1992	Output	Imports	Exports	Demand
LPG*	340.2	29.7	19.1	350.8
Naphtha	31.4	-	-	31.4
Mogas	480.8	88.8	22.4	549.8
Kerojet	76.5	-	15.2	62.0
Diesel	300.6	-	37.8	265.6
Fuel Oil	408.9	53.0	35.2	424.9
Other	50.9	-	-	50.9
Total	1,689.2	171.4	129.7	1,735.3
*Includes field output:	299.0			

1993	Output	Imports	Exports	Demand
LPG*	350.8	30.1	17.7	363.1
Naphtha	30.4	-	-	30.4
Mogas	489.2	90.0	36.0	549.1
Kerojet	83.6	-	16.8	66.9
Diesel	289.7	-	43.9	247.0
Fuel Oil	421.4	55.7	66.8	411.9
Other	55.8	-	-	55.8
Total	1,721.0	175.8	181.2	1,724.3
*Includes field output:	292.0			

1994	Output	Imports	Exports	Demand
LPG*	353.0	31.3	25.3	359.0
Naphtha	31.0	-	-	31.0
Mogas	509.3	66.3	-	572.2
Kerojet	84.9	-	15.8	69.1
Diesel	284.4	-	20.3	258.3
Fuel Oil	420.0	78.7	45.1	453.1
Other	55.0	-	-	55.0
Total	1,737.6	176.3	106.5	1,797.7
*Includes field output:	294.0			

Refinery Configuration

As Table 14 shows, Mexico's refinery configuration is relatively sophisticated; every refinery (with the exception of the tiny Reynosa plant) is equipped with an FCC unit of 40

kb/cd or more, and some refineries have coking facilities. The orientation of the system is obvious: In addition to FCC units, all the major refineries have catalytic reforming, and two have alkylation plants. This is a system designed to maximize gasoline output.

Table 14. Mexican Refinery Configuration (kb/cd)

Mexico: 1995 Configuration

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes
Cadereyta	Pemex	235.0	137.0		40.0		20.0			50.0	
Ciudad Madero	Pemex	195.0	81.5	18.0	43.0		15.0	3.4		40.0	
Minatitlan	Pemex	200.0	83.0		40.0		31.0	0.6		42.0	
Reynosa	Pemex	9.0									
Salamanca	Pemex	235.0	101.2	4.0	40.0	18.5	24.8			38.0	19.0
Salina Cruz	Pemex	330.0	155.0		40.0		50.0			100.0	
Tula	Pemex	320.0	155.0	41.0	40.0		30.0			50.0	
	Total	1,524.0	712.7	63.0	243.0	18.5	170.8	4.0		320.0	19.0

Mexico: Planned Additions by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes
Cadereyta	Pemex							6.0	15.0		
Ciudad Madero	Pemex						5.0				
Minatitlan	Pemex								15.0		
Salamanca	Pemex							3.4	10.3		
Salina Cruz	Pemex							14.1	13.5		
Tula	Pemex					50.0		7.7	13.7		
	Total					50.0	5.0	31.2	67.5		

Mexico: Planned Capacity by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	HDC	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Lubes
Cadereyta	Pemex	235.0	137.0		40.0		20.0	6.0	15.0	50.0	
Ciudad Madero	Pemex	195.0	81.5	18.0	43.0		20.0	3.4		40.0	
Minatitlan	Pemex	200.0	83.0		40.0		31.0	0.6	15.0	42.0	
Reynosa	Pemex	9.0									
Salamanca	Pemex	235.0	101.2	4.0	40.0	18.5	24.8	3.4	10.3	38.0	19.0
Salina Cruz	Pemex	330.0	155.0		40.0		50.0	14.1	13.5	100.0	
Tula	Pemex	320.0	155.0	41.0	40.0	50.0	30.0	7.7	13.7	50.0	
	Total	1,524.0	712.7	63.0	243.0	68.5	175.8	35.2	67.5	320.0	19.0

Planned additions to capacity include a second hydrocracker, as well as a number of units aimed at increasing gasoline output while simultaneously improving gasoline quality. Four new alkylation units are to be added, along with five new C5/C6 isomerizers and a small reformer expansion.

Projected Refinery Balances

Table 15 shows projected refinery balances in Mexico for 2000 based on current capacity plus planned expansions as shown in Table 14. In this scenario, crude runs remain essentially unaltered from present levels.

Table 15. Mexico:
Forecast Petroleum Product Balance, kb/d

2000				
	Output	Imports	Exports	Demand
LPG	408.2	-	12.2	396.0
Naphtha	52.0	0.0	0.0	52.0
Mogas	549.8	93.4	9.2	634.0
Kerojet	79.2	-	5.6	73.6
Diesel	350.7	-	57.7	293.0
Fuel Oil	406.8	72.2	-	479.0
Other	49.1	-	7.8	41.3
Total	**1,895.8**	**165.6**	**92.5**	**1,968.9**

The installation of additional cracking and various gasoline upgrading technologies allows output of gasoline to be increased significantly over current levels. Nonetheless, the pattern without installation of additional distillation capacity is essentially a "holding pattern;" the general trade situation remains roughly the same.

The installation of a hydrocracker would allow Mexico, if desired, to substantially upgrade its diesel and fuel-oil quality as well, by selecting the cleaner, high-cetane component for blending, and then cutting the lower-quality gasoil blendstocks down into the diesel pool. In this case, the diesel surplus here could be substantially reduced, but fuel oil import needs would be reduced by a like quantity.

Over the years, many refining expansion projects have been proposed in Mexico, including large grass-roots projects. The majority of these have ended up shelved for lack of funds (and in response to slower growth). Although it may be some time before a major grass-roots project is seen in Mexico again, some expansion of distillation capacity

at existing facilities is likely. With MTBE available to provide octane uplift, additional crude runs of 80-150 kb/d over those seen here could make inroads into import requirements without creating insupportable surpluses. If Mexican demand picks up to levels beyond those used in this scenario, expansion of distillation in the near future will become a must.

Peru

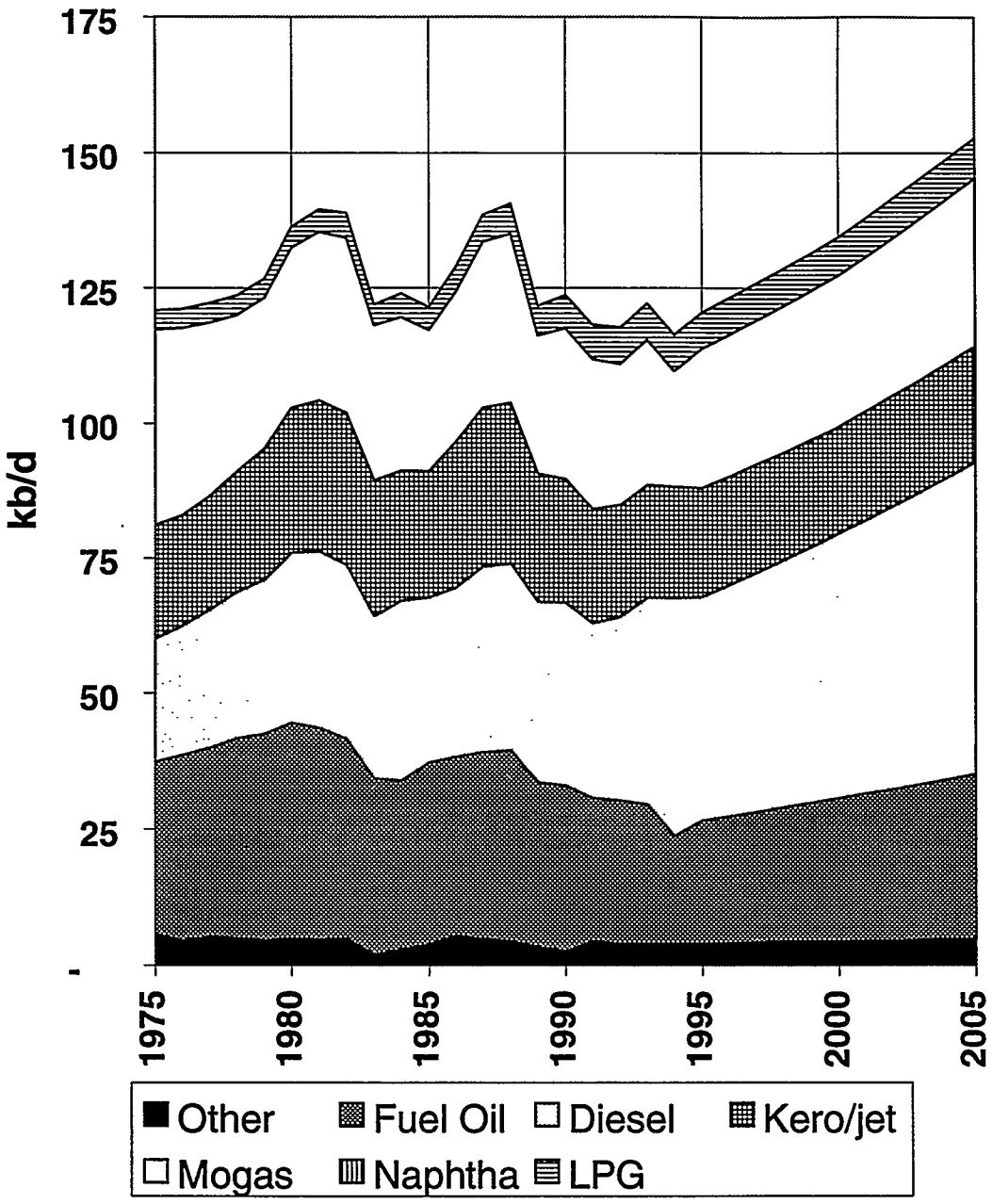
Product Demand

Peru's product demand has followed a rocky path over the last twenty years. This reflects the performance of the economy as a whole; Peru has experienced rapid economic expansion in some years, followed by dramatic drops in others. Overall, however, Peru's economy has generally been sluggish, and outpaced by growth in population: 1994 GDP per capita was about 20% lower than in 1975.

Although Peru nearly tripled its oil output between 1975 and the early 1980s, production since 1982 has generally declined. Both disappointing results in some prospective areas and a slowdown in exploration (often attributed to unsettled political conditions in frontier regions) has resulted in much lower output of crude than anticipated in the early 1980s.

Poor economic performance coupled with a declining availability of domestic oil has led to the establishment of a price regime that, while not punitive by any means, reflects the world market. With declining incomes and exposure to world market prices, by the late 1980s Peruvian demand entered a slump that has lasted through 1995.

Figure 6. Peru: Oil Product Demand, 1975-1994, with Projections to 2005



Our projections are more optimistic about economic conditions in the latter half of the decade; they are similar to the projections of OLADE. Our projection here shows an overall oil demand growth of 2.2% per annum in the 1995-2000 period, in comparison with the -0.5% growth in 1990-95. The most rapid growth is in diesel, at 3.5% per annum; this is a continuation of the 4.1% growth in the 1990-95 period. In the case of gasoline, the 1995-2000 growth just about cancels the 1990-95 decline; the recovery in fuel oil demand, on the other hand, leaves 2000 demand still below its 1990 level.

As in many other Latin American countries, kerosene and jet fuel show contrasting trajectories in recent years. Jet fuel, exposed to world prices and a dropoff in travel, fell in the mid-80s, and only recently began a recovery. Kerosene, on the other hand, showed considerable demand strength through the late 1980s, but has since entered a decline. As kerosene represents about 75% of kero/jet demand in Peru, netting out the two trends results in continued declines in total kero/jet demand even with a healthy recovery in jet fuel requirements.

The declines in kerosene consumption will generally be offset by increases in LPG demand in the residential sector. LPG is the only fuel that has seen steady growth since the 1970s; although it is not a large proportion of demand, it has not suffered absolute declines like other fuels in the Peruvian market.

Product Balances

Table 16 shows Peru's product balances for the 1990-94 period. With stagnant demand, Peru's refining sector has not been under a great deal of pressure. There is a consistent surplus of fuel oil, and a smaller but persistent shortage of middle distillates. With demand sliding down slightly during the period shown in the table, refinery output has fluctuated between 140 kb/d and 152 kb/d with no particular pattern, well below maximal throughput potential of the existing system.

Table 16. Peru:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	4.3	1.8	-	6.1
Naphtha	-	-	-	-
Mogas	28.8	0.8	1.6	27.9
Kerojet	21.2	1.5	-	22.8
Diesel	23.5	10.3	0.2	33.7
Fuel Oil	67.9	-	37.8	30.4
Other	1.3	1.3	-	2.7
Total	**147.0**	**15.7**	**39.7**	**123.7**
*Includes field output:		0.3		

1991	Output	Imports	Exports	Demand
LPG*	4.3	2.1	-	6.4
Naphtha	-	-	-	-
Mogas	28.2	0.7	1.1	27.9
Kerojet	20.9	0.6	-	21.2
Diesel	26.3	6.7	0.5	32.2
Fuel Oil	69.0	-	42.3	26.3
Other	1.9	2.5	0.0	4.4
Total	**150.5**	**12.6**	**43.8**	**118.3**
*Includes field output:		0.2		

1992	Output	Imports	Exports	Demand
LPG*	4.4	2.2	-	6.6
Naphtha	-	-	-	-
Mogas	26.0	0.2	-	26.2
Kerojet	20.6	0.5	-	20.7
Diesel	26.0	10.0	1.2	33.9
Fuel Oil	66.8	-	40.5	26.3
Other	1.3	2.6	-	3.9
Total	**145.1**	**15.5**	**41.7**	**117.7**
*Includes field output:		0.3		

1993	Output	Imports	Exports	Demand
LPG*	4.5	2.2	-	6.7
Naphtha	-	-	-	-
Mogas	26.9	0.4	0.3	27.0
Kerojet	21.0	-	-	20.9
Diesel	31.1	8.4	1.3	38.1
Fuel Oil	67.9	-	42.3	25.6
Other	1.3	2.6	-	3.9
Total	**152.6**	**13.6**	**44.0**	**122.2**
*Includes field output:		0.3		

1994	Output	Imports	Exports	Demand
LPG*	4.5	2.2	-	6.7
Naphtha	-	-	-	-
Mogas	24.0	0.9	3.5	21.4
Kerojet	21.7	-	0.2	20.7
Diesel	32.4	12.3	1.0	43.7
Fuel Oil	56.1	-	36.3	19.8
Other	1.3	2.6	-	4.0
Total	**140.1**	**18.1**	**41.0**	**116.3**
*Includes field output:		0.3		

Refinery Configuration

As Table 17 shows, Peru's refining system is relatively unsophisticated. Although there are two cat crackers in the country, there are essentially no upgrading units downstream (such as desulfurizers, cat reformers, isomerizers, or alkylation units). This reflects the

rather lax product specifications in the country, which enable the bulk of the gasoline to be sold at 80 RON on a leaded basis. Material that would elsewhere be naphtha is readily made into gasoline, and the LCO from the cat crackers is readily blended into the diesel pool.

Table 17. Peruvian Refinery Configuration (kb/cd)

Peru: 1995 Configuration

Site	Company	CDU	VDU	FCC/ RCC	ThC/ Visb.	Cat. Reform	Dist. Treat	Lubes	Asphalt
Conchan	PetroPeru	6.5	4.4						0.6
Iquitos	PetroPeru	10.5							
La Pampilla	PetroPeru	102.0	19.0	6.7					
Pucallpa	Maple Gas	3.3							
Talara	PetroPeru	62.0	24.0	16.6				1.2	0.6
	Total	184.3	47.4	23.3				1.2	1.2

There are presently no definitive expansion plans in Peru.

Although refinery expansions (and even new grass-roots facilities) have been discussed for Peru over the years, all of the plans appear to be in limbo at present. Given the fact that distillation capacity exceeds demand by a comfortable margin, the only project that could make any sense is the addition of further cracking to move material from the fuel oil pool into lighter products, notably diesel. At present, the economics of such an addition are not compelling; the limited refining capabilities of the country are still adequate to meet the country's limited needs.

Projected Refinery Balances

Table 18 shows projected refinery balances in Peru for 2000 based on current capacity alone. Simply by running more crude and making slight adjustments to the crude slate, Peru can essentially maintain its present balance across the barrel, with slight increases in both fuel oil exports and middle distillate exports. Although middle distillates are likely to be at a premium on the market around 2000, while the market for fuel oil is likely to be somewhat slack, the volumes involved are not large enough to justify major investments in cracking unless concessionary financing is used. If these trends continue, however, an

expansion of upgrading and cracking could be needed after 2000—especially if product specs are increased toward world levels.

Table 18. Peru:
Forecast Petroleum Product Balance, kb/d

2000				
	Output	Imports	Exports	Demand
LPG	7.9	-	0.8	7.1
Naphtha	-	-	-	-
Mogas	29.5	-	0.2	28.0
Kerojet	20.7	-	1.0	19.7
Diesel	37.1	11.8	-	48.9
Fuel Oil	65.9	-	39.6	26.3
Other	2.8	1.6	-	4.4
Total	**163.9**	**13.4**	**41.6**	**134.4**

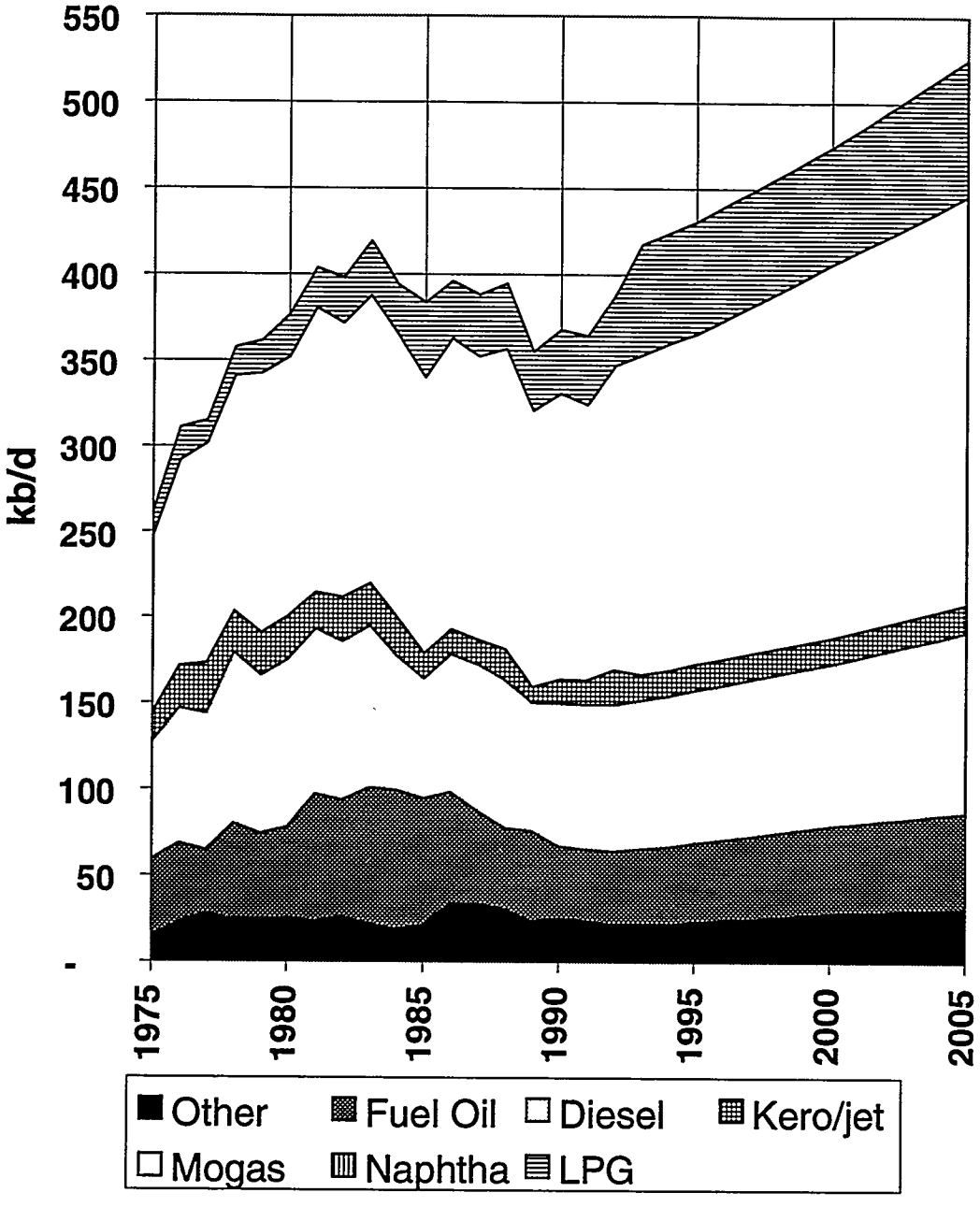
Venezuela

Product Demand

Venezuela is one of the key OPEC members, and, by some reckonings, vies with Saudi Arabia for the world's largest oil resource (depending on how the Orinoco superheavies and tars are counted). Unsurprisingly, the Venezuelan economy is dominated by oil. Although Venezuela's population (22 million) gives it a larger economic base than many of the major producers in the Mideast, it is still small relative to the amount of oil available.

Venezuela was hit hard by the oil price declines in the early 1980s, as Figure 7 shows. An era of rapid demand growth peaked in 1983, and demand declined through the 1980s, only recovering after 1993. To a great extent, this parallels Venezuela's recovery of its position in crude exports; but it also reflects diversification. Venezuela is not in a position to diversify away from an energy-resource base, but major increases in the

Figure 7. Venezuela: Oil Product Demand, 1975-1994, with Projections to 2005



production of coal and natural gas, as well as major investments in refining and petrochemicals, have allowed the country to become somewhat less exposed to the vagaries of the crude market.

In the boom years of the early 1980s, fuel oil demand increased rapidly, following the need for electric power. After the economy tightened, fuel oil substitution became rapid, with fuel oil being displaced both by natural gas and by output from Venezuela's burgeoning hydropower system.

During the same period, industrial diesel use was likewise displaced by increased use of natural gas. Although diesel demand in transport continued to grow steadily, total diesel demand fell at about 7% per annum in the 1980-85 period, and then resumed overall growth. Kero/jet showed an even more dramatic decline in the 1980s, as both LPG and gas became more widely available in the residential sector.

Venezuela is famous for the political importance of gasoline in the economy. The effective price in US currency has varied, but its maximum level was $0.65/gallon, and recent prices have averaged $0.13-0.20/gallon. Increases in price have resulted in widespread unrest and even riots. Despite this, however, Venezuelan demand for gasoline does not show rapid growth—largely because the demand is saturated. Although there is more potential for transport demand in the country, most of the vehicles on the roads already drive as much as they would even if gasoline were free. Thus, gasoline demand grew at only 1% per annum in the 1980s, despite low prices. Our projections see this rate increasing to 2.7% in the 1990s as incomes increase.

LPG has grown rapidly across the historic period shown in Figure 7, and took a major leap in the 1994-95 period as petrochemical projects using LPG feed came onstream. Depending on the additions of capacity in coming years, this fuel could be subject to similar sharp increases in demand in the future.

Product Balances

Refining in Venezuela has a long history; even in 1960, capacity was nearly 1 million b/cd. With this large capacity, and many years of operational experience, Venezuela has no import needs. Table 19 shows Venezuela's product balances for the 1990-94 period. (The data for 1994 is preliminary; there is considerable dispute between sources regarding the production of gasoline. Indeed, OPEC statistics on Venezuela always report Venezuelan gasoline production and demand at almost the same levels—implying that Venezuela, a major mogas supplier to the world market, has no gasoline exports.) Increases in cat cracking and C5/C6 isomerization in the early 1990s allowed Venezuelan gasoline output to rise after 1993. The general output pattern fluctuates primarily as a result of changes in the crude slate.

Refinery Configuration

Venezuela has long had a relatively sophisticated refining system—largely because of the low quality of the bulk of Venezuelan crudes in terms of gravity and sulfur content. Cracking has therefore always been a key element in Venezuelan refining; with Venezuela's own high gasoline demand, and the US as a traditional export destination, the cracking has concentrated on FCCs (Table 20).

Other facilities are equally gasoline-oriented. There is a large alkylation capacity in place, and in the early 1990s this was joined by a number of C5/C6 isomerizers. Current plans call for construction of a large coker (to handle vacuum bottoms), middle-distillate desulfurizing, a large cat reformer, and additional C5/C6 isomerizing. This will lower the average output of fuel oil, increase the output and quality of middle distillates, and increase gasoline output by about 50 kb/d. With these new facilities, as well as major MTBE plants now operating in the country, Venezuela can meet many of the increasingly stringent gasoline specifications around the world.

Table 19. Venezuela:
Petroleum Product Balances, kb/d

1990	Output	Imports	Exports	Demand
LPG*	56.9	-	20.1	36.8
Naphtha	-	-	-	-
Mogas	310.8	-	143.4	167.5
Kerojet	74.8	-	76.8	13.5
Diesel	242.8	-	158.1	83.1
Fuel Oil	254.1	-	215.2	41.6
Other	55.1	-	29.7	25.3
Total	994.4	-	643.3	367.8
*Includes field output:			54.3	

1991	Output	Imports	Exports	Demand
LPG*	69.0	-	29.0	40.0
Naphtha	-	-	-	-
Mogas	291.6	-	130.9	160.8
Kerojet	88.3	-	77.5	14.1
Diesel	303.1	-	219.0	84.1
Fuel Oil	264.8	-	223.6	41.3
Other	63.0	-	28.0	24.0
Total	1,079.8	-	707.9	364.2
*Includes field output:			61.6	

1992	Output	Imports	Exports	Demand
LPG*	70.2	-	29.7	40.5
Naphtha	-	-	-	-
Mogas	296.0	-	118.3	177.7
Kerojet	85.6	-	57.8	20.0
Diesel	262.3	-	177.1	85.2
Fuel Oil	248.5	-	206.3	42.1
Other	60.2	-	21.0	22.0
Total	1,022.8	-	610.3	387.5
*Includes field output:			62.1	

1993	Output	Imports	Exports	Demand
LPG*	90.5	1.6	28.2	64.0
Naphtha	-	-	-	-
Mogas	334.3	-	147.2	187.0
Kerojet	83.5	-	58.0	14.7
Diesel	235.5	-	149.3	86.2
Fuel Oil	254.8	-	211.0	43.8
Other	60.4	-	38.6	21.8
Total	1,059.0	1.6	632.4	417.5
*Includes field output:			81.7	

1994	Output	Imports	Exports	Demand
LPG*	92.2	-	28.0	64.2
Naphtha	-	-	-	-
Mogas	342.0	-	151.0	191.0
Kerojet	81.5	-	58.2	14.7
Diesel	211.4	-	125.8	87.3
Fuel Oil	261.2	-	216.3	44.9
Other	60.0	-	38.0	22.0
Total	1,048.3	-	617.4	424.1
*Includes field output:			83.0	

Projected Refinery Balances

Table 21 shows projected refinery balances in Venezuela for 2000 based on current capacity plus the additions shown in Table 20. The overall effect is an increase in exports, as well as an increase in the value of the export slate. Fuel oil exports increase only slightly relative to their 1994 level, while exports of gasoline increase by 35 kb/d, diesel

exports increase by 25 kb/d, and kero/jet exports increase by about 18 kb/d. This can be achieved even with a slight increase in the gravity of the crude diet.

Table 20. Venezuelan Refinery Configuration (kb/cd)

Venezuela: 1995 Configuration

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	VGO Desulf	Asphalt
Amuay	Lagoven	571.0	336.0	52.1	97.2			17.8	9.8	63.0	149.0	39.8
El Palito	Corpoven	105.0	63.0		50.4		8.9	20.0				
El Toreno	Corpoven	4.8										
Puerto La Cruz	Corpoven	195.0			13.6			4.1				
Punta Cardon	Maraven	286.0	147.6		72.7	82.0		22.8	9.5	32.3	31.1	
San Roque	Corpoven	5.2	1.8									
	Total	1,167.0	548.4	52.1	233.9	82.0	8.9	64.7	19.3	95.3	180.1	39.8

Venezuela: Planned Addition by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	VGO Desulf	Asphalt
Amuay	Lagoven								14.0			
El Palito	Corpoven											
El Toreno	Corpoven											
Puerto La Cruz	Corpoven								17.5	66.0		
Punta Cardon	Maraven			60.0			45.0		15.0			
San Roque	Corpoven											
	Total			60.0			45.0		46.5	66.0		

Venezuela: Planned Capacity by 2000

Site	Company	CDU	VDU	Coking	FCC/ RCC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	VGO Desulf	Asphalt
Amuay	Lagoven	571.0	336.0	52.1	97.2			17.8	23.8	63.0	149.0	39.8
El Palito	Corpoven	105.0	63.0		50.4		8.9	20.0				
El Toreno	Corpoven	4.8										
Puerto La Cruz	Corpoven	195.0			13.6			4.1	17.5	66.0		
Punta Cardon	Maraven	286.0	147.6	60.0	72.7	82.0	45.0	22.8	24.5	32.3	31.1	
San Roque	Corpoven	5.2	1.8									
	Total	1,167.0	548.4	112.1	233.9	82.0	53.9	64.7	65.8	161.3	180.1	39.8

In future years, it is likely that Venezuela will require further investment in distillate treating; although Venezuela can now meet fairly stringent specifications for its gasoline exports, the diesel sulfur content of its gasoil exports still lag the market frontier by a considerable margin. Beyond this change, any further investments in Venezuelan refining in the next ten years will be a matter of market strategy and export-refining economics.

Table 21. Venezuela:
Forecast Petroleum Product Balance, kb/d

2000				
	Output	Imports	Exports	Demand
LPG	108.3	-	40.4	67.9
Naphtha*	15.6	-	12.9	2.7
Mogas	404.2	-	186.2	218.0
Kerojet	91.6	-	76.3	15.3
Diesel	244.8	-	150.7	94.1
Fuel Oil	273.9	-	223.6	50.3
Other	68.2	-	39.6	28.6
Total	**1,206.6**	**-**	**729.7**	**476.9**

*Exports are BTX.

Conclusions

Table 22 shows Latin American refining capacity in 1995, along with projected capacity in 2000 given current plans. Firmly planned refinery construction is at a low as of this writing, and most of the activity that is planned is for additions of upgrading facilities to existing capacity. This situation is unlikely to persist; there are always new plans under development, and there is serious talk of, for example, grassroots refining additions in Colombia under private-sector ownership.

Table 22. Key Latin American Countries: Refinery Configuration (kb/cd)

Key Countries: 1995 Configuration

Country	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Asphalt
Argentina	665	289	99	155	26	55	42	2		66	13
Brazil	1,253	556	48	333		9	3	3		120	68
Colombia	249	141		90		52		4			2
Ecuador	155	44		16		25	3				
Mexico	1,524	713	63	243	19		171	4		320	15
Peru	184	47		23							1
Venezuela	1,167	548	52	234		82	9	65	19	95	40
Total	5,197	2,338	263	1,094	45	223	228	78	19	601	139

Key Countries: Planned Additions by 2000

Company	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Asphalt
Argentina			20					3	10		
Brazil	208		16	68						176	
Colombia						6					
Ecuador	60			10							
Mexico					50		5	31	68		
Peru											
Venezuela			60				45		47	66	
Total	268		96	78	50	6	50	34	124	242	

Key Countries: Planned Capacity by 2000

Company	CDU	VDU	Coking	FCC/ RCC	HDC	ThC/ Visb.	Cat. Reform	Alky/ Poly	C5/C6 Isom	Dist. Treat	Asphalt
Argentina	665	289	120	155	26	55	42	5	10	66	13
Brazil	1,461	556	64	401		9	3	3		296	68
Colombia	249	141		90		58		4			2
Ecuador	215	44		26		25	3				
Mexico	1,524	713	63	243	69		176	35	68	320	15
Peru	184	47		23							1
Venezuela	1,167	548	112	234		82	54	65	66	161	40
Total	5,464	2,338	359	1,172	95	229	278	112	143	844	139

As Table 23 shows, however, while there may be incentives for expansion in certain countries, for the key countries as a group there is little immediate need to expand beyond current plans. As a group, these countries have a large export surplus; the group as a whole has been deficit only in naphtha and LPG in recent years (almost entirely owing to Brazil's import requirements). Additions already planned will increase the net exports

Table 23. Key Latin American Countries:
Petroleum Product Balances, kb/d (1990-94 with forecast 2000)

1990	Output	Imports	Exports	Demand
LPG*	548	69	84	532
Naphtha	180	4	1	184
Mogas	1,257	82	220	1,111
Kerojet	269	2	102	185
Diesel	1,170	23	221	960
Fuel Oil	1,145	63	406	805
Other	219	4	38	184
Total	**4,789**	**247**	**1,070**	**3,960**
*Includes field output:		364		

1991	Output	Imports	Exports	Demand
LPG*	573	76	85	562
Naphtha	167	11	4	175
Mogas	1,282	125	212	1,173
Kerojet	281	4	106	179
Diesel	1,259	43	279	1,018
Fuel Oil	1,120	62	409	773
Other	231	5	38	185
Total	**4,913**	**327**	**1,133**	**4,066**
*Includes field output:		385		

1992	Output	Imports	Exports	Demand
LPG*	609	88	74	611
Naphtha	157	24	3	177
Mogas	1,254	158	210	1,196
Kerojet	284	4	84	192
Diesel	1,271	51	260	1,054
Fuel Oil	1,099	73	402	767
Other	243	4	35	190
Total	**4,917**	**401**	**1,068**	**4,188**
*Includes field output:		413		

1993	Output	Imports	Exports	Demand
LPG*	648	94	79	659
Naphtha	152	45	6	192
Mogas	1,322	191	278	1,213
Kerojet	290	9	88	195
Diesel	1,228	89	251	1,067
Fuel Oil	1,105	161	455	753
Other	245	5	55	192
Total	**4,991**	**593**	**1,212**	**4,271**
*Includes field output:		425		

1994	Output	Imports	Exports	Demand
LPG*	664	92	86	672
Naphtha	152	49	7	196
Mogas	1,369	188	236	1,281
Kerojet	288	8	89	198
Diesel	1,252	76	211	1,113
Fuel Oil	1,096	145	451	783
Other	247	5	55	195
Total	**5,069**	**564**	**1,133**	**4,437**
*Includes field output:		430		

2000	Output	Imports	Exports	Demand
LPG*	761	71	91	741
Naphtha	205	60	29	236
Mogas	1,570	150	267	1,451
Kerojet	311	-	92	219
Diesel	1,437	83	250	1,270
Fuel Oil	1,204	72	419	858
Other	255	4	64	195
Total	**5,742**	**440**	**1,211**	**4,970**
*Includes field output:		480		

of LPG, gasoline, kero/jet, and diesel; fuel oil exports alone will fall, and net imports of naphtha will decline as well. There is thus little need for urgent action in the region's refining sector, unless there is a surge in demand, or product specifications change dramatically.

A major change in product specifications would pose considerable problems for the region, however. Table 24 shows our estimates of octane requirements and market shares for gasolines in the key countries circa 1994, estimated from information provided by Octel and other industry sources. Although the information is not precise, it demonstrates two important points. First, gasoline in these countries is leaded (though leading levels allowed differ widely); only Brazil and Mexico provide significant exceptions to this generalization, and even in Mexico the proportion of leaded gasoline is still high.

Table 24: Estimated Octane Levels and Market Shares for Gasoline

	Leaded Premium			Leaded Regular		
	RON	(R+M)/2	% share	RON	(R+M)/2	% share
Argentina	94	89.5	60	85	81.5	40
Brazil						
Colombia	92	na	65	80	na	35
Ecuador				80	na	85
Mexico				81	79.5	55
Peru	95	na	16	80-84	na	84
Venezuela	95	91	65	83	81.5	35

	Unleaded Premium			Unleaded Regular		
	RON	(R+M)/2	% share	RON	(R+M)/2	% share
Argentina						
Brazil	109*	99.5	62	97**	88.5	48
Colombia						
Ecuador	89	na	15	60	na	<1
Mexico				92	88	45
Peru						
Venezuela						

*fuel alcohol
**gasohol

Second, octane levels are generally low. Although the leaded premium grades in most countries have an octane level comparable with US grades, the leaded regular grades generally have very low octanes, even with existing leading. In the absence of lead, the gasoline pool in these countries (with the exception of Brazil) would have a low octane potential. Considerable investment in catalytic reforming, alkylation, and isomerization would be needed to bring gasoline production to the quality standards seen in the US or Europe, even with continued use of tetraethyl lead; in the absence of lead, the investment requirements become even larger.

Comprehensive information on grades of diesel and fuel oil is even harder to assemble, but the information available shows that sulfur specifications in the region are far more relaxed than in the US or Europe, and any tightening of these standards would require significant investment in desulfurization as well as changes in the crude slate.

For most of the countries, there is ample feedstock for units upgrading octane of blendstocks; there are large volumes of heavy naphtha in excess of reforming capacity, and large volumes of pentanes and hexanes in excess of isomerizing capacity. In many countries, however, the bulk of the vacuum gasoil is already committed to existing crackers; a large expansion in cat cracking might require conversion from FCC to RCC for some refiners. Thus, while there may be no urgent need for refinery investment beyond current plans based on volumetric demand requirements, improvements in the quality of products could require a major building campaign.

Appendix 1. Product Demand History and Forecast by Country, 1975-2005								
Oil Product Demand in Argentina, with Base Case Projections								
	Other	Fuel Oil	Diesel	Kero/jet	Mogas	Naphtha	LPG	Total
1975	20	148	123	27	87	13	30	447.1
1976	23	160	132	25	88	12	30	469.5
1977	23	161	142	27	95	11	29	487.3
1978	21	148	138	27	102	12	33	480.8
1979	27	152	151	26	113	12	35	516.1
1980	23	120	148	31	123	15	34	494.7
1981	25	113	145	29	123	17	33	484.5
1982	28	97	149	27	119	15	32	466.9
1983	18	90	155	26	118	15	32	454.7
1984	25	84	156	29	112	16	33	454.3
1985	25	56	146	23	100	15	34	398.2
1986	27	52	150	25	104	14	34	406.2
1987	28	66	159	26	111	14	36	439.0
1988	27	70	146	23	100	13	37	417.0
1989	23	48	139	23	95	14	36	378.3
1990	18	36	128	25	98	14	33	351.6
1991	20	45	140	21	102	14	32	374.3
1992	21	43	145	20	111	14	38	391.2
1993	23	39	154	23	113	14	35	400.5
1994	25	37	155	24	116	14	42	412.2
1995	23	36	156	26	118	14	42	414.6
1996	23	37	159	26	121	15	43	423.9
1997	24	37	162	27	125	15	44	433.4
1998	24	38	165	28	128	15	45	443.1
1999	25	38	168	29	132	15	45	453.0
2000	26	39	171	30	136	16	46	463.2
2001	26	40	175	31	139	16	47	473.6
2002	26	40	179	32	142	16	48	484.2
2003	27	41	183	33	145	16	49	495.1
2004	27	42	187	34	149	16	50	506.2
2005	28	43	191	36	152	17	51	517.6
2006	29	44	196	37	158	18	52	531.9
2007	29	44	201	38	163	19	53	546.8
2008	30	45	206	39	169	20	53	562.0
2009	31	46	211	40	175	22	54	577.8
2010	31	47	216	41	181	23	55	594.1
AAG 75-80	2.97%	-4.06%	3.85%	2.78%	7.14%	4.02%	2.57%	2.04%
AAG 80-85	1.21%	-14.12%	-0.31%	-5.53%	-4.01%	-0.95%	-0.37%	-4.25%
AAG 85-90	-5.66%	-8.60%	-2.55%	1.25%	-0.33%	-1.29%	-0.72%	-2.46%
AAG 90-95	4.47%	0.10%	3.98%	0.87%	3.69%	0.67%	5.28%	3.35%
AAG 95-00	2.09%	1.61%	1.93%	3.08%	2.87%	1.62%	1.92%	2.24%
AAG 00-05	1.82%	1.88%	2.23%	3.62%	2.32%	1.26%	2.03%	2.25%
AAG 05-10	2.33%	1.76%	2.42%	2.96%	3.55%	7.24%	1.29%	2.80%
AAG 80-90	-2.29%	-11.41%	-1.44%	-2.20%	-2.19%	-1.12%	-0.54%	-3.36%
AAG 90-00	3.27%	0.85%	2.95%	1.97%	3.28%	1.14%	3.59%	2.79%
AAG 00-10	2.07%	1.82%	2.33%	3.29%	2.93%	4.20%	1.66%	2.52%

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)								
Oil Product Demand in Brazil, with Base Case Projections								
1976	47	284	238	41	251	33	63	956.5
1977	56	290	255	42	233	34	64	973.8
1978	63	315	279	44	237	45	73	1,056.6
1979	89	327	303	49	232	53	77	1,130.5
1980	**72**	**314**	**323**	**46**	**199**	**48**	**87**	**1,089.4**
1981	62	254	318	50	189	59	91	1,022.5
1982	70	232	324	51	180	65	101	1,021.8
1983	63	187	318	49	150	76	108	951.9
1984	70	170	326	43	135	78	106	928.6
1985	**77**	**170**	**348**	**44**	**130**	**95**	**118**	**982.2**
1986	83	198	386	48	149	108	126	1,097.1
1987	78	200	408	49	129	118	142	1,124.6
1988	76	198	421	47	121	116	153	1,131.9
1989	75	190	431	49	141	122	149	1,155.9
1990	**89**	**184**	**423**	**46**	**161**	**123**	**156**	**1,181.9**
1991	72	169	441	47	174	120	158	1,181.0
1992	79	186	451	45	175	128	162	1,224.9
1993	69	196	465	46	181	148	177	1,280.4
1994	71	200	486	46	220	151	186	1,359.7
1995	**74**	**202**	**493**	**47**	**227**	**159**	**191**	**1,391.7**
1996	74	207	505	49	232	160	194	1,421.2
1997	75	212	518	51	237	161	197	1,451.4
1998	76	217	531	53	246	162	199	1,486.1
1999	76	223	545	56	255	164	202	1,520.8
2000	**77**	**228**	**559**	**58**	**262**	**165**	**205**	**1,554.8**
2001	77	230	570	60	272	167	208	1,585.1
2002	78	232	581	62	282	170	211	1,616.2
2003	79	234	592	63	293	173	213	1,648.0
2004	79	237	604	65	304	176	216	1,680.6
2005	**80**	**239**	**616**	**67**	**315**	**179**	**219**	**1,714.0**
2006	80	240	623	68	325	182	221	1,739.4
2007	81	242	630	69	335	185	224	1,765.3
2008	81	244	637	70	345	189	226	1,791.7
2009	82	245	644	71	355	192	229	1,818.6
2010	**82**	**247**	**652**	**72**	**366**	**196**	**232**	**1,846.0**
AAG 75-80	10.25%	4.24%	9.35%	4.43%	-4.48%	9.24%	9.11%	4.35%
AAG 80-85	1.40%	-11.54%	1.47%	-1.01%	-8.08%	14.61%	6.14%	-2.05%
AAG 85-90	2.77%	1.61%	4.00%	1.14%	4.24%	5.24%	5.83%	3.77%
AAG 90-95	-3.66%	1.88%	3.09%	0.16%	7.16%	5.23%	4.12%	3.32%
AAG 95-00	0.91%	2.47%	2.57%	4.49%	2.94%	0.72%	1.45%	2.24%
AAG 00-05	0.74%	0.89%	1.96%	2.79%	3.76%	1.61%	1.29%	1.97%
AAG 05-10	0.62%	0.68%	1.14%	1.37%	3.05%	1.85%	1.13%	1.50%
AAG 80-90	**2.08%**	**-5.19%**	**2.73%**	**0.06%**	**-2.11%**	**9.82%**	**5.98%**	**0.82%**
AAG 90-00	**-1.40%**	**2.18%**	**2.83%**	**2.31%**	**5.03%**	**2.95%**	**2.78%**	**2.78%**
AAG 00-10	**0.68%**	**0.79%**	**1.55%**	**2.08%**	**3.40%**	**1.73%**	**1.21%**	**1.73%**

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)								
Oil Product Demand in Colombia, with Base Case Projections								
	Other	Fuel Oil	Diesel	Kero/Jet	Mogas	Naphtha	LPG	Total
1975	**5**	**27**	**19**	**16**	**65**	**5**	**1**	**137.4**
1976	6	28	21	16	67	4	1	144.1
1977	6	26	21	17	72	4	1	146.1
1978	6	22	22	17	77	4	1	149.3
1979	6	24	24	18	77	5	1	154.6
1980	**7**	**20**	**38**	**17**	**78**	**5**	**1**	**164.8**
1981	6	15	42	18	80	5	0	165.1
1982	5	13	31	18	86	5	0	158.4
1983	6	17	31	15	82	5	0	156.9
1984	7	8	28	13	86	5	0	147.8
1985	**6**	**5**	**30**	**14**	**96**	**5**	**0**	**156.1**
1986	6	23	31	14	95	5	0	174.9
1987	7	6	32	13	98	5	-	162.1
1988	7	5	33	14	111	4	-	174.4
1989	7	5	35	14	111	5	0	177.0
1990	**6**	**11**	**37**	**17**	**110**	**6**	**0**	**186.8**
1991	13	11	37	16	114	-	0	191.3
1992	10	15	44	18	125	5	-	216.7
1993	17	14	46	18	126	-	0	220.3
1994	16	3	49	17	130	-	-	214.2
1995	**16**	**5**	**50**	**18**	**131**	**0**	**0**	**220.1**
1996	16	5	53	18	134	0	0	226.7
1997	16	6	56	18	138	0	0	233.5
1998	16	7	59	18	141	0	0	240.7
1999	16	7	62	18	145	0	0	248.1
2000	**16**	**8**	**65**	**18**	**149**	**0**	**0**	**255.9**
2001	16	9	68	18	152	0	0	262.6
2002	16	9	70	19	155	0	0	269.4
2003	16	10	73	19	158	0	0	276.6
2004	16	11	76	19	161	0	0	284.0
2005	**16**	**12**	**79**	**20**	**165**	**0**	**0**	**291.6**
2006	22	13	82	20	167	0	0	304.0
2007	31	13	84	21	170	0	0	318.9
2008	43	14	86	21	173	0	0	337.4
2009	59	14	89	22	176	0	0	360.6
2010	**82**	**15**	**91**	**22**	**179**	**0**	**0**	**390.5**
AAG 75-80	5.18%	-5.37%	14.93%	1.88%	3.54%	-1.94%	-2.33%	3.71%
AAG 80-85	-0.35%	-24.43%	-4.44%	-4.45%	4.24%	1.60%	-42.57%	-1.09%
AAG 85-90	-0.43%	17.30%	4.17%	3.95%	2.76%	3.55%	0.00%	3.65%
AAG 90-95	20.44%	-14.73%	6.21%	1.18%	3.60%	-44.78%	25.77%	3.34%
AAG 95-00	-0.13%	9.86%	5.27%	0.34%	2.59%	0.00%	0.00%	3.06%
AAG 00-05	0.13%	8.45%	4.09%	1.73%	2.01%	0.00%	0.00%	2.65%
AAG 05-10	38.93%	4.56%	2.84%	2.72%	1.74%	0.00%	0.00%	6.01%
AAG 80-90	**-0.39%**	**-5.85%**	**-0.23%**	**-0.34%**	**3.50%**	**2.57%**	**-24.21%**	**1.26%**
AAG 90-00	**9.68%**	**-3.22%**	**5.74%**	**0.76%**	**3.10%**	**-25.69%**	**12.15%**	**3.20%**
AAG 00-10	**17.94%**	**6.49%**	**3.46%**	**2.22%**	**1.88%**	**0.00%**	**0.00%**	**4.32%**

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)

Oil Product Demand in Ecuador, with Base Case Projections

	Other	Fuel Oil	Diesel	Kero/Jet	Mogas	Naphtha	LPG	Total
1975	**0**	**10**	**9**	**5**	**16**	**0**	**1**	**40.8**
1976	1	10	10	7	17	0	1	46.8
1977	2	14	12	9	23	0	2	60.5
1978	1	15	13	11	24	0	2	66.2
1979	2	19	16	10	26	5	2	80.3
1980	**1**	**21**	**19**	**10**	**30**	**7**	**3**	**91.1**
1981	1	26	19	9	30	6	4	95.4
1982	1	27	20	10	29	7	4	97.7
1983	1	24	19	8	26	4	4	86.9
1984	1	22	18	9	27	5	5	88.4
1985	**2**	**24**	**20**	**10**	**28**	**5**	**6**	**93.2**
1986	3	21	20	10	29	5	7	95.3
1987	3	18	22	8	29	4	8	92.6
1988	4	23	24	8	30	5	9	102.4
1989	2	19	23	7	29	5	10	94.6
1990	**2**	**23**	**26**	**8**	**29**	**5**	**11**	**103.4**
1991	2	28	26	7	32	5	12	111.4
1992	3	30	31	6	32	0	13	114.8
1993	3	23	30	6	30	0	14	106.3
1994	3	26	34	5	31	0	14	113.2
1995	**3**	**27**	**35**	**5**	**31**	**0**	**14**	**114.5**
1996	3	27	35	5	32	0	15	116.2
1997	3	27	36	5	32	0	16	118.0
1998	3	27	37	4	32	0	17	119.9
1999	3	27	38	4	32	0	17	121.8
2000	**3**	**27**	**39**	**4**	**33**	**0**	**18**	**123.8**
2001	3	27	40	4	33	0	19	126.1
2002	3	27	41	5	33	0	19	128.4
2003	3	27	42	5	34	0	20	130.9
2004	3	27	43	5	34	0	21	133.3
2005	**3**	**28**	**44**	**5**	**35**	**0**	**22**	**135.9**
2006	3	28	44	5	35	0	22	138.4
2007	3	28	45	6	35	0	23	141.0
2008	3	28	46	6	36	0	24	143.7
2009	3	29	47	6	36	0	25	146.3
2010	**3**	**29**	**48**	**6**	**37**	**0**	**25**	**149.1**
AAG 75-80	28.59%	16.72%	15.72%	14.72%	13.85%	168.87%	31.69%	17.41%
AAG 80-85	8.15%	2.39%	0.65%	-1.27%	-1.41%	-5.66%	13.07%	0.47%
AAG 85-90	1.81%	-0.42%	5.42%	-4.58%	0.89%	-0.68%	14.24%	2.09%
AAG 90-95	6.57%	2.75%	6.15%	-8.18%	1.53%	-53.79%	4.94%	2.06%
AAG 95-00	1.44%	0.37%	2.43%	-3.89%	0.76%	24.57%	4.68%	1.57%
AAG 00-05	1.34%	0.37%	2.31%	5.27%	1.20%	0.00%	3.60%	1.88%
AAG 05-10	1.86%	1.07%	1.98%	2.85%	1.35%	0.00%	3.21%	1.87%
AAG 80-90	**4.93%**	**0.97%**	**3.01%**	**-2.94%**	**-0.27%**	**-3.20%**	**13.65%**	**1.28%**
AAG 90-00	**3.97%**	**1.56%**	**4.28%**	**-6.06%**	**1.14%**	**-24.13%**	**4.81%**	**1.81%**
AAG 00-10	**1.60%**	**0.72%**	**2.15%**	**4.05%**	**1.28%**	**0.00%**	**3.41%**	**1.88%**
	3%	25%	14%	4%	32%	2%	20%	

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)

Oil Product Demand in Mexico, with Base Case Projections

	Other	Fuel Oil	Diesel	Kero/Jet	Mogas	Naphtha	LPG	Total
1975	**22**	**195**	**161**	**51**	**205**	**7**	**77**	**718.4**
1976	25	215	176	55	225	8	82	784.7
1977	27	237	183	56	237	9	83	832.4
1978	30	262	201	59	254	10	88	903.9
1979	33	249	215	66	294	11	93	961.5
1980	**35**	**281**	**244**	**70**	**335**	**12**	**142**	**1,118.7**
1981	37	294	261	71	377	12	177	1,229.4
1982	36	315	248	74	383	16	216	1,287.2
1983	32	332	203	65	359	29	231	1,250.4
1984	42	361	220	62	360	36	249	1,330.6
1985	**40**	**381**	**230**	**60**	**374**	**37**	**279**	**1,402.1**
1986	31	400	221	57	387	40	303	1,437.5
1987	32	435	221	59	402	41	301	1,491.0
1988	41	443	203	54	407	41	319	1,507.8
1989	48	470	216	56	456	45	334	1,623.7
1990	**40**	**479**	**230**	**53**	**518**	**36**	**289**	**1,644.6**
1991	50	452	258	53	563	37	313	1,725.6
1992	51	425	266	62	550	31	351	1,735.3
1993	56	412	247	67	549	30	363	1,724.3
1994	55	453	258	69	572	31	359	1,797.7
1995	**56**	**459**	**259**	**70**	**575**	**32**	**361**	**1,812.2**
1996	56	463	265	71	586	33	368	1,842.4
1997	56	467	272	72	598	34	375	1,873.1
1998	57	471	279	72	610	34	382	1,904.4
1999	57	475	286	73	622	35	389	1,936.4
2000	**57**	**479**	**293**	**74**	**634**	**36**	**396**	**1,968.9**
2001	58	485	299	74	645	37	402	1,999.8
2002	58	491	305	75	656	38	408	2,031.2
2003	59	497	312	75	668	39	414	2,063.1
2004	59	503	318	75	679	41	420	2,095.6
2005	**60**	**509**	**325**	**76**	**691**	**42**	**426**	**2,128.6**
2006	60	511	330	77	702	44	432	2,155.8
2007	60	514	336	78	712	46	437	2,183.5
2008	61	516	341	78	723	48	443	2,211.6
2009	61	519	347	79	735	51	449	2,240.2
2010	**62**	**521**	**352**	**80**	**746**	**53**	**455**	**2,269.3**
AAG 75-80	10.04%	7.57%	8.59%	6.72%	10.26%	10.02%	13.09%	9.26%
AAG 80-85	3.04%	6.28%	-1.16%	-3.09%	2.26%	25.59%	14.44%	4.62%
AAG 85-90	-0.04%	4.66%	0.01%	-2.33%	6.70%	-0.59%	0.66%	3.24%
AAG 90-95	6.73%	-0.84%	2.42%	5.74%	2.12%	-2.30%	4.57%	1.96%
AAG 95-00	0.50%	0.86%	2.50%	0.92%	1.97%	2.38%	1.87%	1.67%
AAG 00-05	0.79%	1.22%	2.10%	0.62%	1.74%	3.13%	1.47%	1.57%
AAG 05-10	0.73%	0.47%	1.62%	1.11%	1.54%	4.76%	1.33%	1.29%
AAG 80-90	**1.49%**	**5.47%**	**-0.58%**	**-2.71%**	**4.46%**	**11.74%**	**7.33%**	**3.93%**
AAG 90-00	**3.56%**	**0.01%**	**2.46%**	**3.30%**	**2.04%**	**0.02%**	**3.21%**	**1.82%**
AAG 00-10	**0.76%**	**0.84%**	**1.86%**	**0.86%**	**1.64%**	**3.94%**	**1.40%**	**1.43%**

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)

Oil Product Demand in Peru, with Base Case Projections

	Other	Fuel Oil	Diesel	Kero/Jet	Mogas	Naphtha	LPG	Total
1975	6	32	23	21	36	-	3	120.9
1976	5	34	24	21	35	-	3	121.1
1977	5	35	26	21	32	-	4	122.2
1978	5	37	27	22	29	-	3	123.6
1979	5	38	28	24	28	-	4	126.7
1980	5	40	31	27	30	-	4	136.3
1981	5	39	33	28	31	-	4	139.6
1982	5	37	32	28	32	-	4	138.8
1983	2	32	30	25	29	-	4	121.9
1984	3	31	33	24	29	-	4	124.0
1985	4	33	30	23	26	-	4	121.5
1986	5	33	31	27	28	-	5	128.9
1987	5	34	34	30	31	-	5	138.5
1988	4	35	35	30	31	-	6	140.6
1989	3	30	33	24	26	-	5	121.7
1990	3	30	34	23	28	-	6	123.7
1991	4	26	32	21	28	-	6	118.3
1992	4	26	34	21	26	-	7	117.7
1993	4	26	38	21	27	-	7	122.2
1994	4	20	44	21	21	-	7	116.3
1995	4	23	41	20	26	-	7	120.5
1996	4	23	43	20	26	-	7	123.1
1997	4	24	44	20	27	-	7	125.8
1998	4	25	46	20	27	-	7	128.6
1999	4	26	47	20	28	-	7	131.4
2000	4	26	49	20	28	-	7	134.4
2001	4	27	51	20	29	-	7	137.9
2002	5	28	52	20	29	-	7	141.5
2003	5	29	54	21	30	-	7	145.1
2004	5	29	56	21	30	-	7	148.9
2005	5	30	58	22	31	-	8	152.8
2006	5	31	59	22	32	-	8	156.8
2007	5	32	61	22	33	-	8	161.0
2008	5	33	63	23	33	-	8	165.2
2009	5	34	65	23	34	-	9	169.6
2010	5	35	67	24	35	-	9	174.1
AAG 75-80	-3.22%	4.67%	6.59%	5.08%	-3.93%	na	1.59%	2.43%
AAG 80-85	-4.17%	-3.46%	-0.64%	-2.67%	-2.52%	na	2.25%	-2.28%
AAG 85-90	-7.26%	-1.86%	2.12%	-0.55%	1.36%	na	7.62%	0.36%
AAG 90-95	8.48%	-5.75%	4.08%	-2.52%	-1.50%	na	1.89%	-0.52%
AAG 95-00	1.92%	3.08%	3.49%	-0.40%	1.57%	na	1.17%	2.21%
AAG 00-05	1.76%	2.87%	3.33%	1.86%	2.06%	na	1.10%	2.60%
AAG 05-10	1.22%	2.63%	3.01%	1.96%	2.46%	na	3.48%	2.64%
AAG 80-90	-5.73%	-2.66%	0.73%	-1.62%	-0.60%	na	4.90%	-0.97%
AAG 90-00	5.15%	-1.44%	3.78%	-1.46%	0.02%	na	1.53%	0.84%
AAG 00-10	1.49%	2.75%	3.17%	1.91%	2.26%	na	2.29%	2.62%

Appendix 1. Product Demand History and Forecast by Country, 1975-2005 (continued)

Oil Product Demand in Venezuela, with Base Case Projections

	Other	Fuel Oil	Diesel	Kero/jet	Mogas	Naphtha	LPG	Total
1975	**15**	**44**	**68**	**17**	**104**	**-**	**14**	**261.7**
1976	22	46	78	24	121	-	19	310.7
1977	28	37	79	29	128	-	13	315.0
1978	24	55	99	24	138	-	17	357.7
1979	24	50	92	25	152	-	19	361.5
1980	**25**	**53**	**97**	**25**	**151**	**-**	**24**	**375.9**
1981	24	74	96	21	166	-	23	403.4
1982	26	67	92	26	160	-	26	397.8
1983	22	78	94	25	168	-	32	419.4
1984	19	80	78	22	166	-	29	393.9
1985	**22**	**73**	**69**	**15**	**161**	**-**	**44**	**383.5**
1986	34	64	80	15	170	-	33	396.0
1987	34	54	85	14	166	-	36	388.2
1988	31	46	86	18	176	-	38	394.6
1989	24	52	75	9	161	-	34	355.2
1990	**25**	**42**	**83**	**14**	**167**	**-**	**37**	**367.8**
1991	24	41	84	14	161	-	40	364.2
1992	22	42	85	20	178	-	40	387.5
1993	22	44	86	15	187	-	64	417.5
1994	22	45	87	15	191	-	64	424.1
1995	**23**	**46**	**89**	**15**	**193**	**-**	**65**	**430.8**
1996	24	47	90	15	198	-	66	439.1
1997	25	48	91	15	203	-	66	447.6
1998	26	48	92	15	208	-	67	456.2
1999	27	49	93	15	213	-	67	465.1
2000	**29**	**50**	**94**	**15**	**218**	**-**	**68**	**474.2**
2001	29	51	96	15	222	-	70	484.0
2002	30	52	98	16	226	-	72	494.0
2003	30	53	101	16	230	-	75	504.3
2004	31	54	103	16	234	-	77	514.7
2005	**32**	**55**	**105**	**16**	**238**	**-**	**79**	**525.4**
2006	32	56	109	16	241	-	80	535.2
2007	33	57	113	17	244	-	81	545.3
2008	34	58	118	17	247	-	82	555.6
2009	35	58	122	17	251	-	83	566.2
2010	**36**	**59**	**127**	**17**	**254**	**-**	**84**	**577.0**
AAG 75-80	10.55%	3.58%	7.50%	8.60%	7.80%	na	11.73%	7.51%
AAG 80-85	-3.09%	6.81%	-6.59%	-10.41%	1.33%	na	12.36%	0.40%
AAG 85-90	3.19%	-10.67%	3.71%	-1.59%	0.75%	na	-3.32%	-0.83%
AAG 90-95	-1.66%	1.95%	1.30%	1.99%	2.88%	na	12.10%	3.21%
AAG 95-00	4.18%	1.89%	1.21%	0.53%	2.47%	na	0.81%	1.94%
AAG 00-05	1.95%	1.88%	2.27%	1.02%	1.77%	na	3.15%	2.07%
AAG 05-10	2.65%	1.44%	3.80%	1.57%	1.31%	na	1.04%	1.89%
AAG 80-90	**0.00%**	**-2.32%**	**-1.58%**	**-6.10%**	**1.04%**	**na**	**4.23%**	**-0.22%**
AAG 90-00	**1.22%**	**1.92%**	**1.25%**	**1.26%**	**2.67%**	**na**	**6.31%**	**2.57%**
AAG 00-10	**2.30%**	**1.66%**	**3.04%**	**1.29%**	**1.54%**	**na**	**2.09%**	**1.98%**

Appendix 2

Figure A1. Real GDP for Key Countries

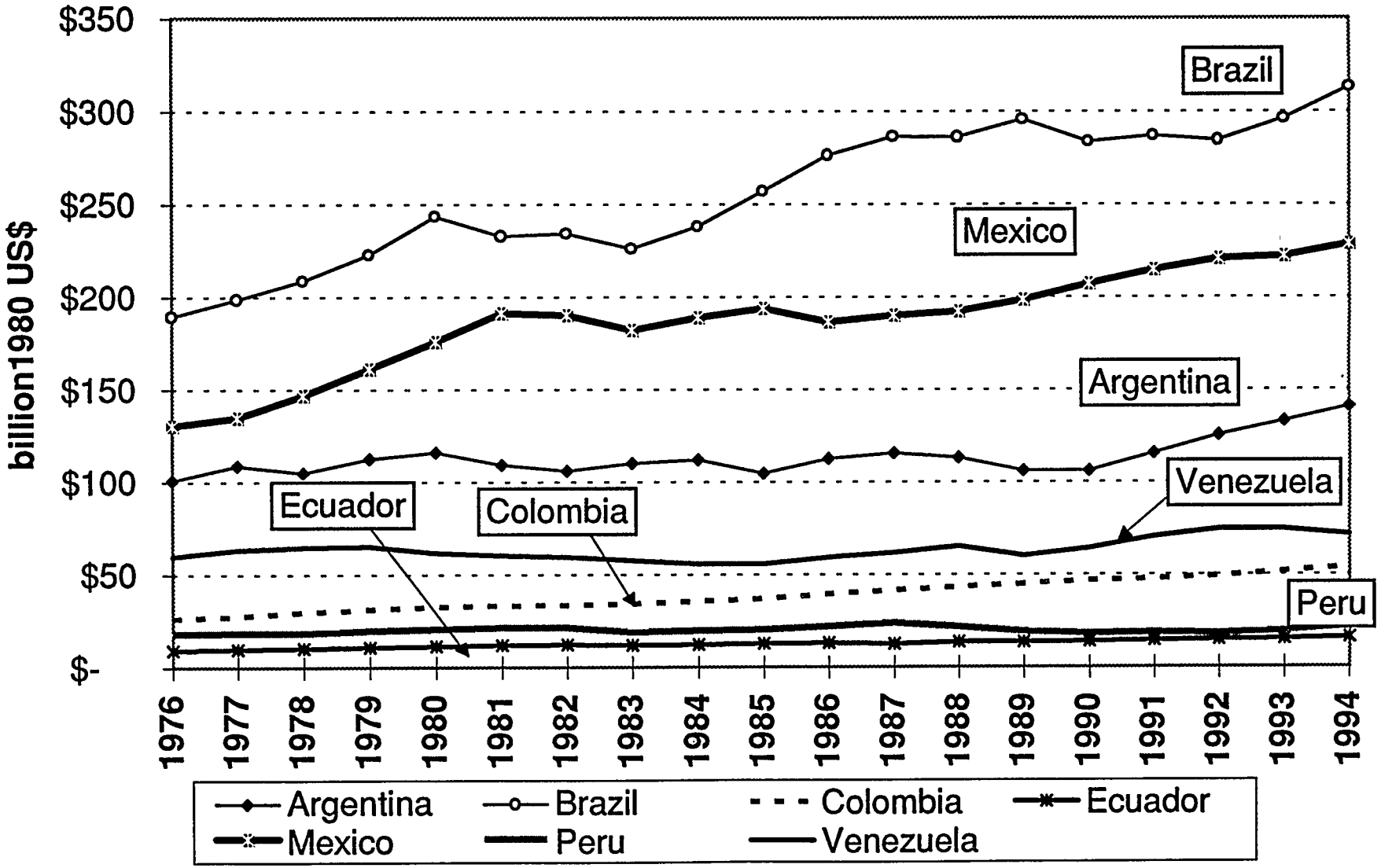
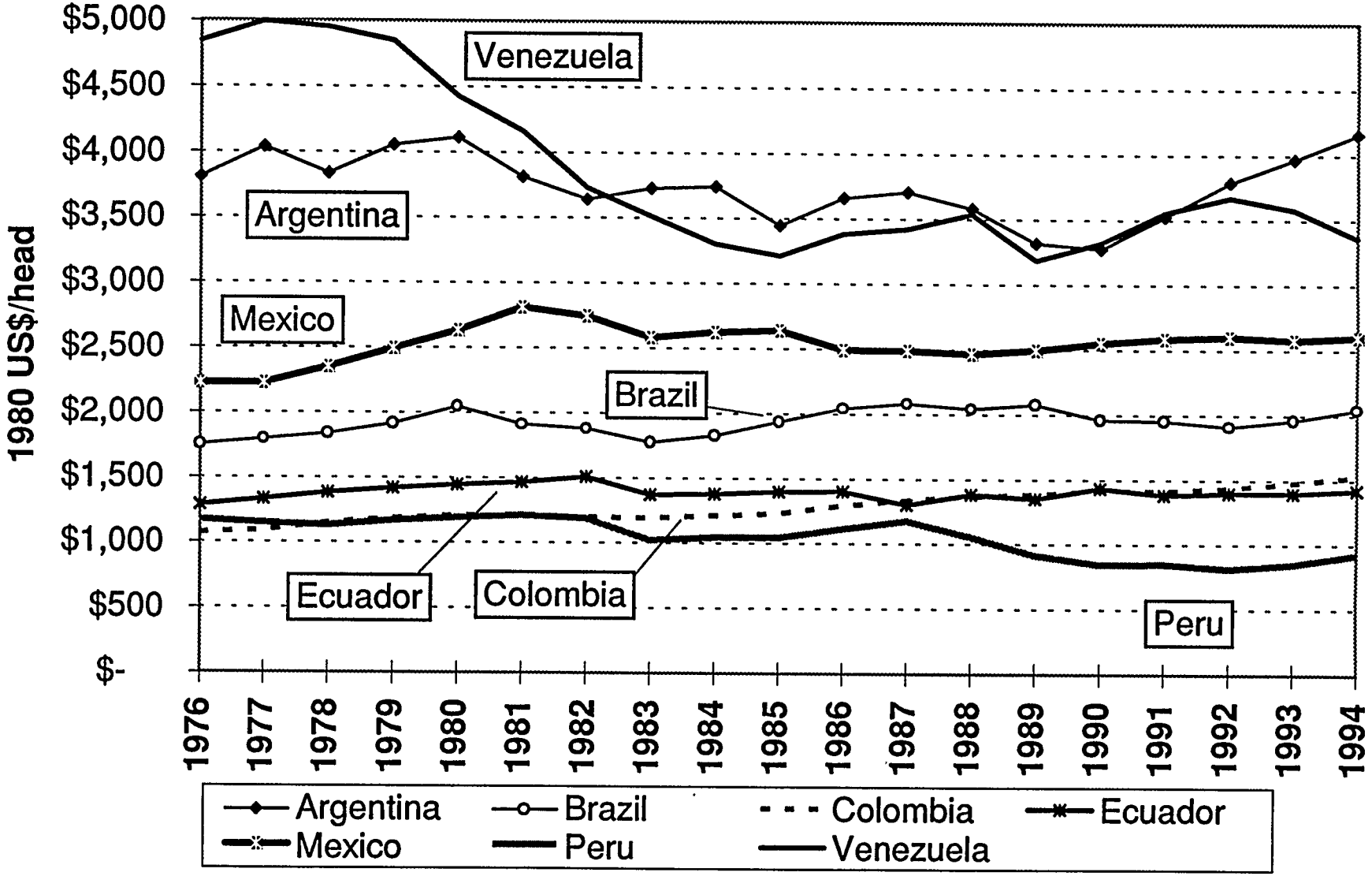


Figure A2. Real GDP Per Capita for Key Countries



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