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TRENDS OF ENERGY USE IN BRASIL: IS SELF-SUFFICIENCY IN SIGHT?



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# Trends of Energy Use in Brasil: Is Self-Sufficiency in Sight?

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During the last five years there has been a significant decline in the overall growth of energy use in Brasil, as well as a marked trend of replacement of petroleum products with wood, coal, alcohol, and hydroelectricity. Inter-fuel substitution combined with increased domestic production of petroleum and slower growth in energy demand, has lowered the share of imports in total petroleum use from 85 percent in 1978 to about 65 percent in 1983 (Brasil, Ministerio de Minas e Energia, 1983).

The reduction of petroleum imports coincided with a severe economic recession. In sharp contrast with the period between 1968 and 1973, during which the economy grew at an average annual rate in excess of 11 percent, Brasil's GDP has declined since 1980. The energy trade balance is directly related to the performance of the Brasilian economy; petroleum is the country's largest import item in value and, in 1980, the value of petroleum imports amounted to half of the country's total export earnings. Curbing petroleum imports is, therefore, a necessary

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step for economic recovery.

To promote increased reliance on indigenous energy sources, the government enacted policies addressing both the supply and demand sides of the energy market. On the supply side, these policies encouraged the expanded domestic production of petroleum, as well as of alternative fuels such as coal, alcohol and,most importantly, hydroelectricity. On the demand side, prices, regulations, and fiscal incentives created an environment favorable to energy conservation and inter-fuel substitution.

Despite the improvements achieved in the energy trade balance, an important question remains unanswered: what would happen to the country's dependence on imported petroleum if the economy experienced another period of continued growth? To what extent could the domestic production of petroleum and the availability of substitute fuels match increasing demand?

This paper reviews of the trends in end-use of energy in the main sectors of the Brasilian economy, from 1970 to 1982. This analysis reveals that most of the reduction in the use of petroleum products has taken place in the industrial sector and that the transportation sector also shows evidence of successful implementation of conservation and substitution measures. On the other hand, it is clear that reduced economic activity has accounted for much of the decline in energy (and petroleum) use and that Brasil could once more experience a deterioration in its energy trade balance if rapid economic growth resumes.

## Aggregate Energy Use and Economic Profile

Between 1970 and 1982, there were two periods with distinct patterns of growth of energy use in Brasil. The first was from 1970 to 1978, when energy use increased at an average annual rate of 8.2 percent; the second was from 1978 to 1982 when, as a consequence of higher energy prices and reduced economic activity, energy use increased at a rate of 3.8 percent.

In the early 1970s, the economy was still experiencing a period of unusually growth, initiated in 1968. The favorable economic conditions were due to the positive trade balances that resulted from fiscal incentives to exports as well as from a gradual decline in the rate of inflation. The advantageous trade position earned the necessary foreign exchange to import the materials and capital goods required to expand productive capacity. Manufactured goods became an increasingly important component of the country's exports, which were traditionally made up of agricultural products and minerals. Accordingly, the share of energy used in industry increased with respect to that of other sectors (Figure 1).

While the economy was experiencing continued growth, there was no noticeable change in the average efficiency of energy use, as measured by the ratio of total energy use to gross domestic product (solid line in Figure 2). There was, however, between 1970 and 1978, an increase in the use of petroleum products relative to other energy forms (dashed line in Figure 2); during that period, the use of petroleum products grew at an average yearly rate of 10 percent, and the increasing demand was met primarily by imports, whose share of total petroleum supply went

*Figure 1*
*Brasil*
*Total Commercial Energy Use*

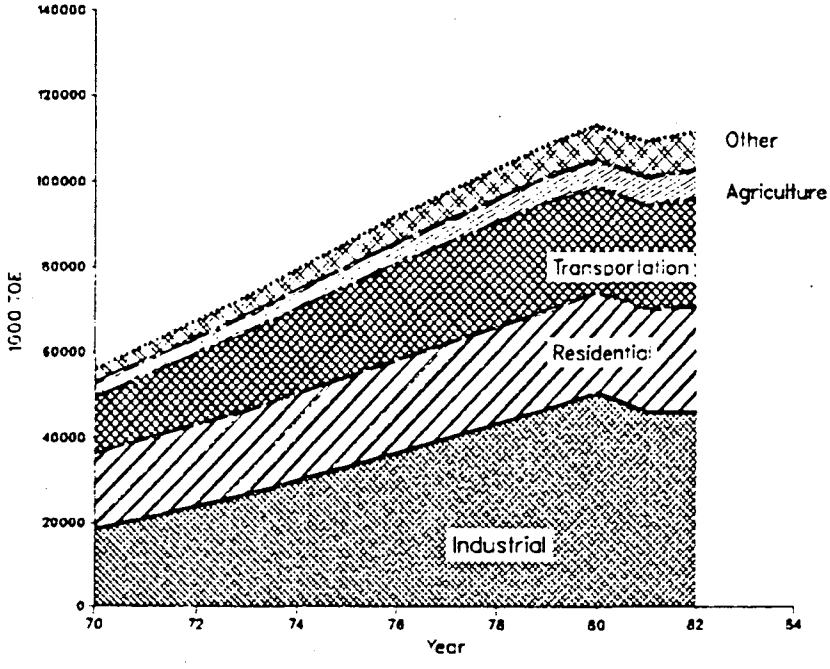
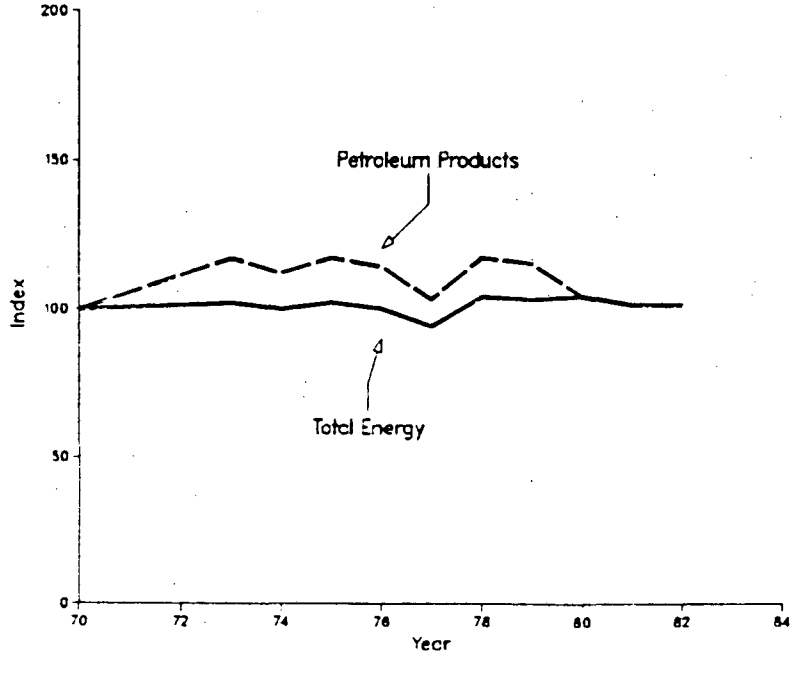



*Figure 2*
*Brasil*
*Index of Energy Use per Unit Output*
*1970=100*



from 67 percent in 1970 to nearly 80 percent in 1973, and a high of 85 percent in 1977. As a consequence of the modernization of the industrial sector and of population migration to urban areas (see section on residential energy use), the share of fuelwood in primary energy supply declined from 33 percent in 1970 to 20 percent in 1982 (Brasil, Ministerio de Minas e Energia, 1983).

Since 1978, the trend of increasing use of petroleum products has given way to wider use of hydroelectricity, domestic and imported coal, wood, and alcohol fuels. Whereas hydroelectricity has always accounted for a large share of energy supply in Brasil, the more widespread use of coal and alcohol fuels are new elements in Brasilian energy policy. From 1978 to 1982, coal use increased at an average annual rate of 8.5 percent, and alcohol fuels at 20 percent, while the use of petroleum products declined at an average rate of 1.6 percent, and their relative share in primary energy supply was reduced from 43 percent in 1973 to 36 percent in 1982.

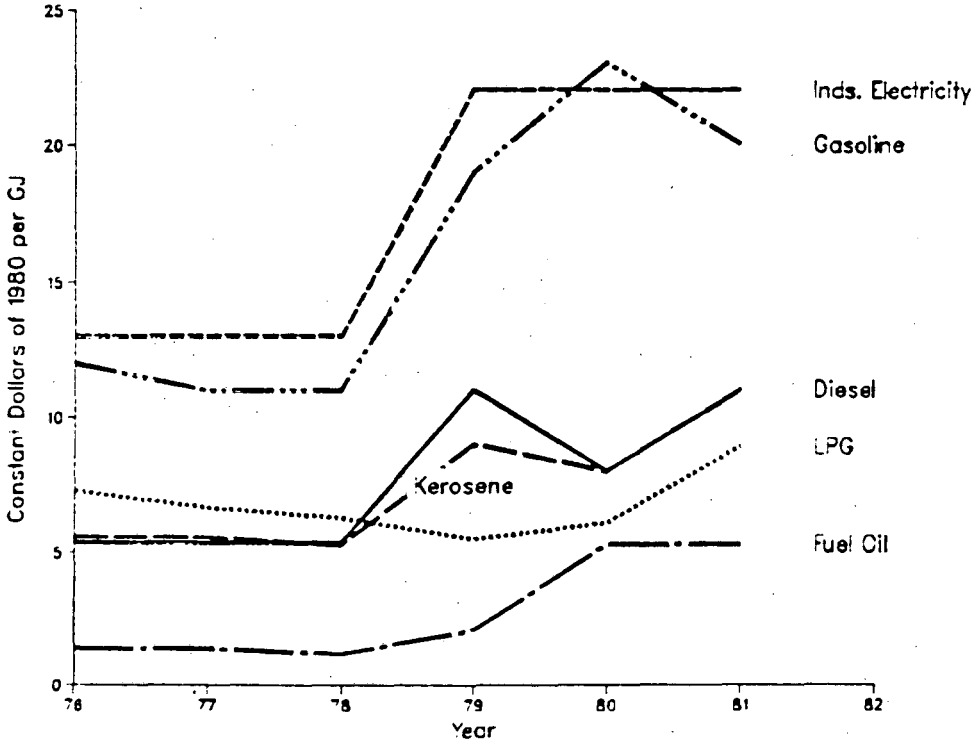
The drop in petroleum imports resulted from higher domestic production of crude oil as well as reduced demand. The domestic production of petroleum, on the strength of the newly developed offshore field of Campos, increased from 8 million TOE (tonnes of oil equivalent) in 1978 (15 percent of total consumption) to over 19 million TOE in 1983 (about 35 percent of total consumption). The total demand for petroleum, curbed by the economic recession, higher prices and substitution policies, declined from nearly 56 million TOE in 1979 to 52 million TOE in 1982.

At the same time, the trend of fast economic growth came to a halt, caused by a combination of a worldwide slowdown in economic activity, by the increased cost of oil imports and, most markedly, by the continuous increase in the service of the country's external debt. Most of the foreign exchange borrowed to finance growth in the early and mid-1970s is tied to the international interest rate (LIBOR). Between 1978 and 1980, LIBOR increased from 8.8 to 14 percent; at the same time, the service of Brasil's external debt reached $11.3 billion (or 56 percent of total exports), the value of petroleum imports went from $4.1 billion to $9.4 billion, and the external public debt totaled $53.8 billion, or 19 percent of the country's GDP (IDB, 1982, 1983).

In addition to high interest rates and generally deteriorated credit conditions, Brasil also had to adjust to the rising trend in the world oil market, which drove up the price of most energy forms in the country after 1978-79. Within a short period, the real prices of gasoline, diesel oil, and kerosene at least doubled, and the price of electricity for industrial users increased by 60 percent (Figure 3).

In the presence of such adverse conditions, Brasilian GDP experienced no growth from 1980 to 1981 and actually declined from 1981 to 1982. The stagnant economic conditions affected the use of petroleum through the reduced activity in some of the most energy-intensive industries such as cement and steel, whose output has declined for three consecutive years. That, plus the incentives offered for inter-fuel substitution, brought the total use of petroleum to its lowest level since 1977.

*Figure 3*
*Brasil*
*Energy Prices in US$ per GJ*



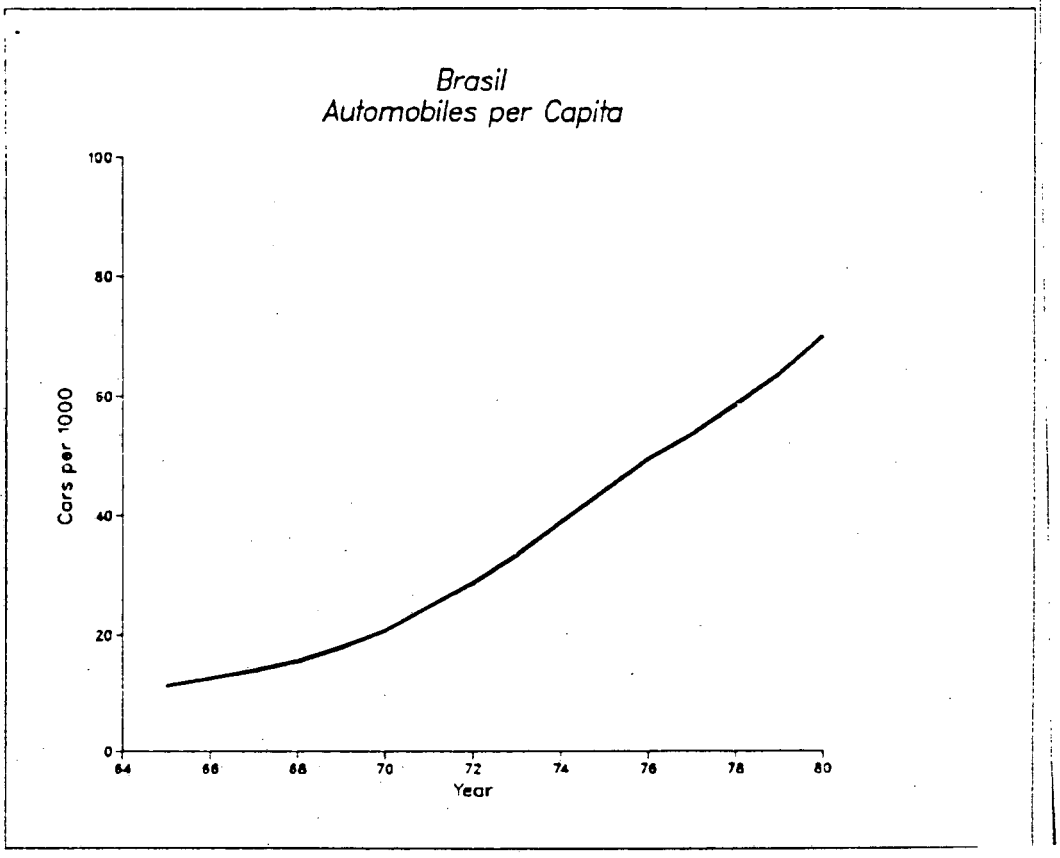
The attempts to restore economic stability have focused on improving the trade balance by increasing exports and reducing petroleum imports. Energy conservation measures, such as the ones adopted for the transportation sector, have been effective and could continue to curb petroleum demand throughout this decade. Special credit conditions have been made available to some of the larger users of petroleum products in order to promote use of alternative fuels. It is unclear, however, whether such incentives can continue to exist in the presence of a tight credit market and given the massive investments needed for the development of domestic energy sources, especially petroleum and hydroelectricity.

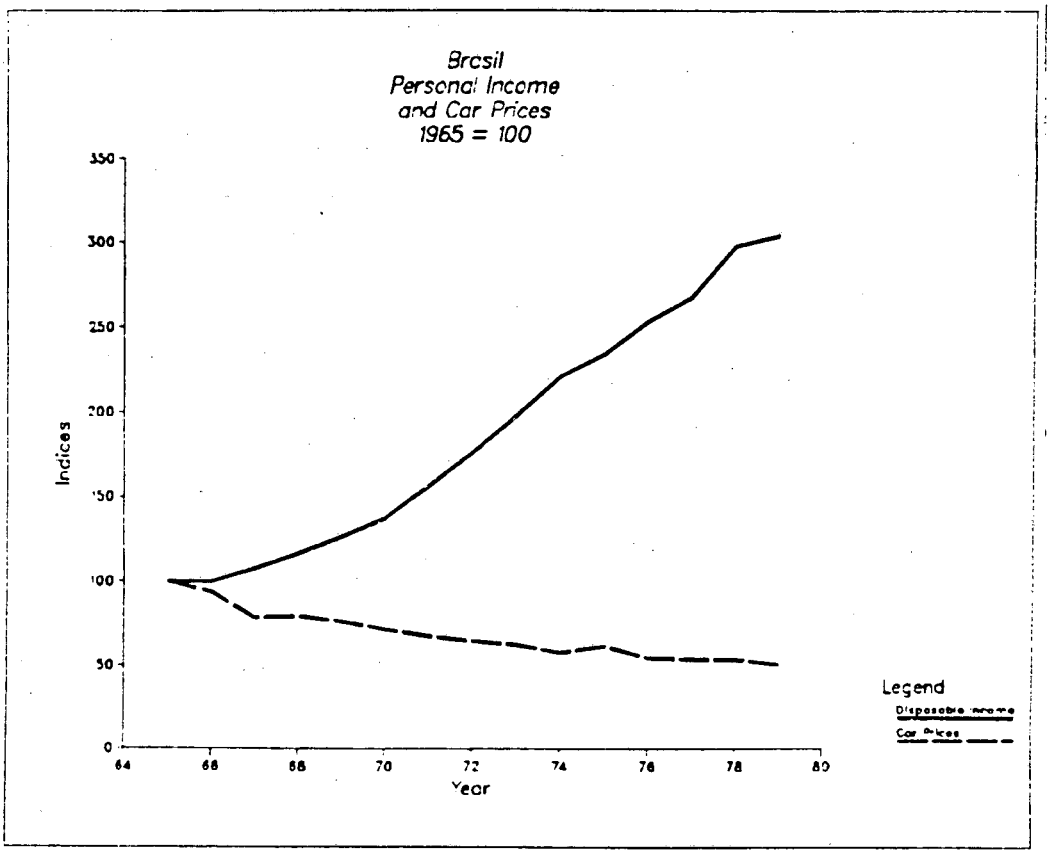
Transportation

Since the late 1960s, the demand for transportation services has grown steadily with the rest of the economy. The main reasons for the increased energy use in the sector are the growth in freight transport to support industrial activity, the growing demand for public transportation in urban areas, and the growth in the automobile fleet, caused by rising income and declining real prices of automobiles (Figure 4). Total energy use in transportation increased at an average yearly rate of 8 percent between 1970 and 1978, experienced a slight decline in 1979-81, and resumed growth in 1982.

Between 1970 and 1982, a major change occurred in the structure of energy demand for transportation. The use of diesel oil increased and surpassed that of gasoline, which had traditionally been the predominant fuel. In the early 1970s, gasoline accounted for nearly 60 percent of

FIGURE 4


Brasil
Automobiles per Capita
Cars per 1000
0
20
40
60
80
100
64
66
68
70
72
74
76
78
80
Year


Brasil
Personal Income
and Car Prices
1965 = 100
Indices
0
50
100
150
200
250
300
350
64
66
68
70
72
74
76
78
80
Year
Legend
Disposable income
Car prices

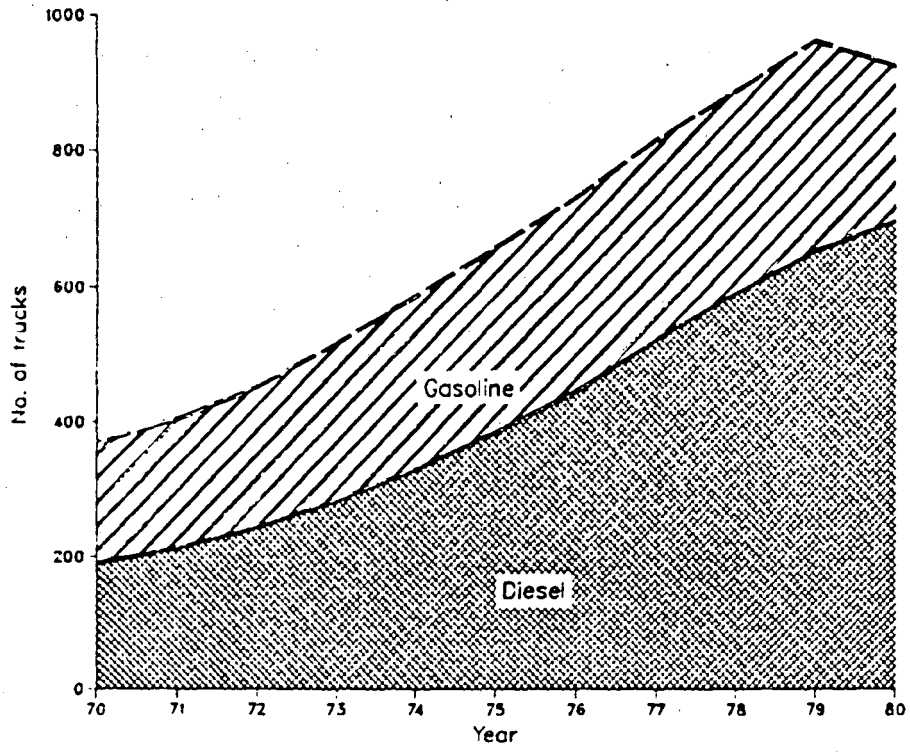
total demand; by 1982, the relative shares of diesel and gasoline use in transportation were 45 and 31 percent respectively. This change was caused mostly by a steady increase in the price of gasoline relative to that of diesel and, to a smaller extent, by the increased use of alcohol fuels as a substitute for gasoline.

Throughout the late 1960s and early 1970s, the price of gasoline had usually been 20 percent higher than the price of diesel(CNP, 1984). In 1974, in order to curb demand, a policy was adopted that placed a surtax on gasoline, raising its price beyond the increases in the price of crude oil (Homem de Melo, 1982). By 1982, gasoline cost 2.5 times more than diesel, with the surtax accounting for as much as 30 percent of the price of gasoline at the pump.

This change in the relative price of fuels prompted a steady increase of the diesel truck fleet. A study of the cost of truck freight (Pinheiro, 1983) determined that trucks were used at an average 1300 kilometers per month, and that, before 1974, the use of diesel trucks was advantageous in fleets with an average vehicle use of at least 3000 kilometers per month.[1] By 1980, as a consequence of the higher gasoline prices, diesel trucks became economical at a much lower average vehicle use (500 kilometers per month), which explains the extreme change in the composition of the truck fleet (Figure 5).

Besides the conversion of the truck fleet to diesel engines, conservation of gasoline was also promoted through measures such as:

*Figure 5*
*Brasil*
*Composition of Truck Fleet*
*by Fuel Use*



- limiting operation of gasoline stations from 6 a.m. to 9 p.m. Monday through Saturday. Gasoline stations do not operate on Sundays and holidays (thereby precluding long trips by private automobiles). On the other hand, alcohol fuel is made available throughout the weekend, and costs less than gasoline.

- providing tax and financial subsidies to buyers of cars equipped to run on pure alcohol fuels.

- stricter enforcement of speed limits on highways.

Expanded us of alcohol fuels has contributed to the reduction in the use of gasoline. Since 1975, Brasil has intensified the use of ethanol made from sugar cane as a substitute for gasoline. Ethanol has been used both in mixture with gasoline (up to 20 percent in volume), and also as a pure fuel in cars especially designed for that purpose. This strategy has proven successful in that production of alcohol has increased substantially, and its use as transportation fuel became more widespread. In 1982 alcohol fuels accounted for 10 percent of total energy use in transportation, up from less than 1 percent at the end of 1976 (Brasil, Ministerio de Minas e Energia, op.cit.). In 1983, an average of 14 million liters of alcohol were used daily as transportation fuel, compared to 24 million liters per day of gasoline. Through the National Alcohol Program, the government continues to provide incentives to expand the market for alcohol fuels, hoping that by the end of this decade alcohol will displace as much as 40 percent of the projected demand for gasoline. In 1983, 88 percent of all cars sold in Brasil were equipped to run on pure ethanol. Today there are more than one million pure-ethanol vehicles in circulation, corresponding to more than

10 percent of the total vehicle fleet (CNE, 1984).

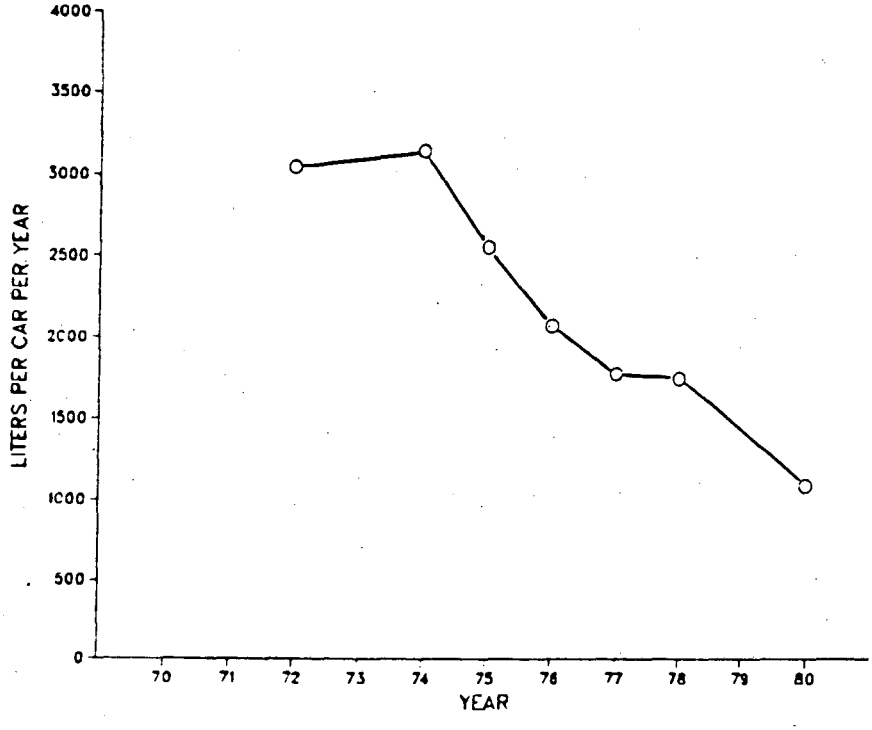
The higher gasoline prices, the conservation measures, and the use of alcohol fuels resulted in a sharp drop in total gasoline use, as well as in fuel consumption per vehicle (Figure 6). The rapid decline in gasoline use could not be immediately matched by an equivalent change in the refining structure, leading to the accumulation of gasoline surpluses and to the elimination of the surtax in 1981. Since 1976, Brasil has been a net exporter of gasoline (CNP, 1983).

Having succeeded in curbing gasoline use, the country now faces the problem of maintaining an adequate supply of diesel oil. PETROBRAS has invested in modifications in its refining structure to obtain a larger portion of diesel oil out of each barrel. As a result, the fraction of diesel in refining has increased from 27 percent in 1979 to 31 percent in 1983, and is expected to reach 60 percent by 1986 with the installation of refining units that will allow further cracking of residual oils.(CNE, 1984).

The use of energy in transportation should continue to grow; the extent of the increase will depend largely on the performance of the economy in general and of the industrial sector in particular. In the event of continued economic recession, there should be some growth in the use of gasoline: the elimination of the surtax on the price of that fuel is likely to result in higher use per vehicle and to enhance the competitiveness of gasoline trucks for light freight transport. Some growth in the use of diesel can also be expected because of continued migration to urban centers resulting in increased demand for public transport. Therefore, even in the absence of a strong economic

FIGURE 6

BRASIL
YEARLY USE OF GASOLINE PER CAR



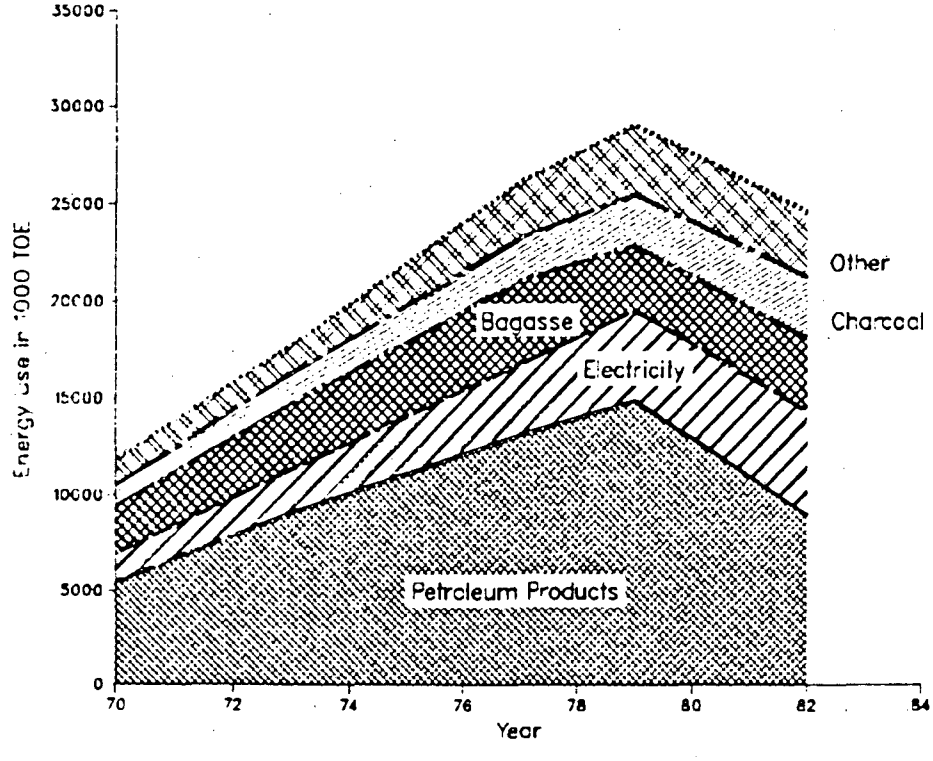
recovery, the use of energy in the transportation sector should continue to grow, probably at yearly rates between 3 and 4 percent, as during in the recent recession period of 1981-82. If economic growth resumes, there will be more demand for freight transport for industry, which will result in rapid growth of diesel oil use, as well as an increase in gasoline use resulting from higher personal income. In that case, the use of energy in transportation could well grow at the rates of 8 to 10 percent, as it did between 1970 and 1978.

## Industry

The industrial sector typically accounts for over 70 percent of all fuel oil use in Brasil. Over the years, consumption of fuel oil in industry has been encouraged by low prices and by the virtual nonexistence of coal as an alternative. Electricity has always been more expensive and unable to compete with fuel oil in all of its applications.

Throughout the 1970s, a large reduction in the use of fuel oil was achieved by expanding the use of hydroelectricity and, to a smaller extent, coal as energy sources for industry. From 1973 to 1982, the share of fuel oil in industrial energy use declined from 39 to 24 percent, while that of electricity increased from 11 to 18 percent.[2] (Figure 7)

*Figure 7*
*Brasil*
*Energy Use in Industry*



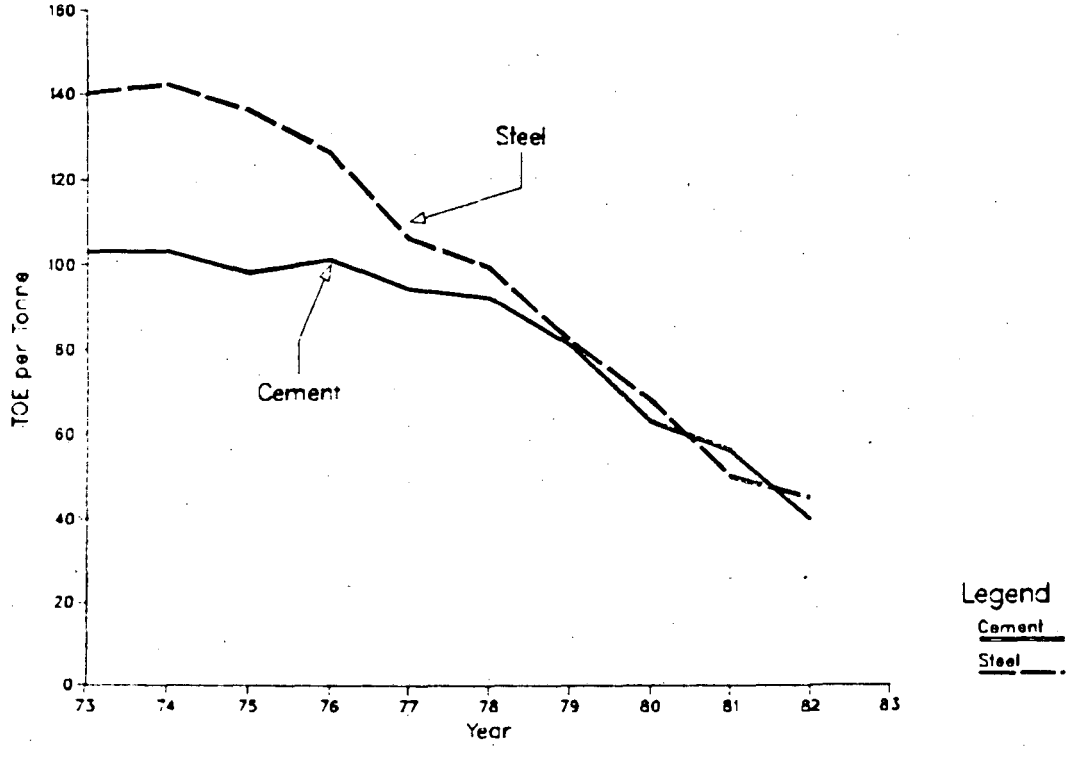
The industries that achieved the largest reduction in fuel oil use were cement (52 percent), food and beverages (47 percent) and chemicals (43 percent).

Most of the fuel substitution in cement production (the largest single user of fuel oil) and in the steel industry has been based on increased use of coal and, to a smaller extent, charcoal and hydroelectricity. Fuel oil use per tonne of output has been cut by 60 and 70 percent with respect to 1973 levels in the cement and steel industries respectively. (Figure 8)

Despite the greatly reduced dependence on petroleum, an analysis of the overall efficiency of energy use in cement and steel production shows little improvement. Since 1973, there has been only a 13 percent decrease in the total energy used per tonne of cement produced in Brasil[3] while there is no noticeable reduction in the energy content of steel. Furthermore, considering that 80 percent of the coal used by steel mills is imported (CNP, 1983) and that the low-energy coal available in Brasil may require the addition of some imported coal for cement production, it appears that the fuel-substitution strategy adopted by those industries reduces the country's deficit in energy trade but cannot eliminate the dependence on imported energy supplies.

Part of the decline in fuel oil use in steel and cement production can also be attributed to the economic recession that has prevailed over the last three years. As a consequence of lower demand, many plants had to cut production and, in some cases, to shut down. That being the case, it is likely that the least efficient plants were the first to be

*Figure 8*
*Fuel Oil Use for*
*Cement and Steel Production*
*Tons of Oil Equivalent per Tonne of Output*



shut down, therefore leading to an overall increase in the efficiency of energy use per ton of cement produced. As economic growth resumes, the less efficient plants would be reactivated, which might result in an increase in fuel oil use.

Industrial users have also benefited from subsidized rates in order to replace fuel oil with hydroelectricity for steam generation. As a consequence of the economic recession, the use of electricity in the early 1980s did not reach the levels previously anticipated, resulting in a surplus of generating capacity. In 1981, a policy instrument was enacted offering electricity at highly subsidized rates (30 percent of normal levels) to industries willing to replace fuel-oil-burning boilers with electrical ones. The price differential was such as to provide payback periods as short as 10 months (SEPLAN, 1984), prompting many users to switch to electricity for steam generation. The food processing industry, where fuel oil is used primarily as boiler fuel, is a perfect example of that pattern of substitution. The share of electricity in total energy use in food processing climbed to 27 percent in 1982, up from 20 percent in 1979, while the use of fuel oil declined from 19 to 9 percent over the same period(MME, op.cit.).

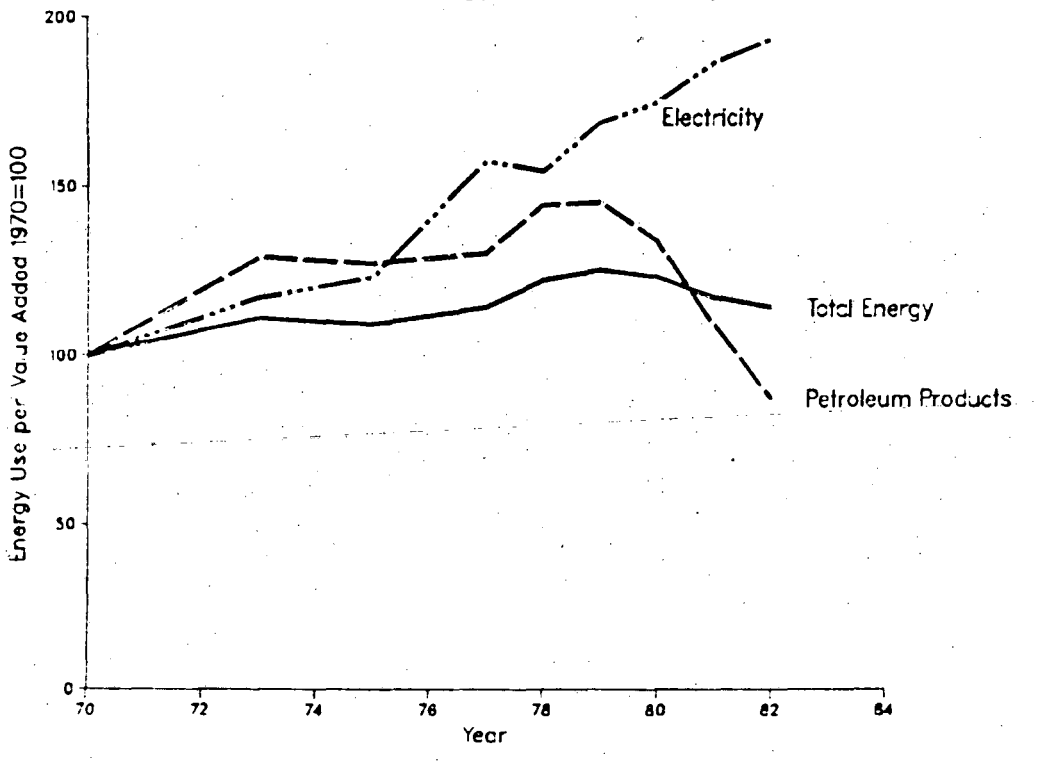
The subsidized electricity rates will be in effect through 1986 when all industries will again be charged the regular rate. This is not expected to cause a return to fuel oil because users will have recovered their investment, and will be aware that the supply of hydroelectricity is more reliable and its price more stable than that of fuel oil. Nevertheless, in the absence of the subsidy, the new industrial units entering the market after 1986 will have no economic incentive to use

electricity for steam generation, which could result in a rapid increase in the industrial use of fuel oil thereafter.

Substantial reduction in the use of fuel oil is also expected in the paper and pulp industry by expanding the use of firewood. This substitution has been accelerated since 1980 by replacing some fuel oil with the bark of trees processed for production of paper, in addition to the use of fuelwood from commercial forests. Fiscal incentives exist for the development of commercial forests, and are expected to be extended so that by 1985 fuelwood could supply 830 thousand TOE to paper production, a 27 percent increase over 1982 levels (O Estado de Sao Paulo, 1981).

After experiencing a continuous increase throughout the 1970s, the overall intensity of energy use in industry declined in the early 1980s, and is now at the same level as it was in 1973 (Figure 9). Considering the conditions that led to the remarkable reduction of petroleum use in Brasilian industry, it is not clear whether this pattern of fuel substitution can be maintained. The supply of alternative fuels may not be able to keep pace with growing demand, and industries such as cement and steel will be motivated to use coal if its price continues to be subsidized to stay below that of fuel oil. Electric boilers will likely continue to be adopted by industries only as long as rates are subsidized (1986); after that oil-fueled units should again be the more economic option for steam generation. In general, it seems clear that fiscal incentives and price subsidies have been essential to the process of fuel oil substitution in industry. If the real price of crude oil remains stable, such subsidies might become too costly and could be

*Figure 9*
*Brasil*
*Indices of Energy Use in Industry*



discontinued, causing many industries to revert to fuel oil use.

## Residential

The energy market in the residential sector consists of two groups with very distinct patterns of energy use. In rural areas, most of the household energy use goes into cooking, whereas in urban households, due to the higher degree of electrification and appliance saturation, cooking accounts for a smaller portion of the total energy used. Wood and charcoal are the predominant cooking fuel in rural areas, whereas in the cities cooking is fueled almost exclusively by LPG, except in Rio de Janeiro and Sao Paulo, where piped gas is also available (Barros and Boluda, 1983). Graca et al. confirm that the use of LPG and electricity is more widespread in urban areas, where over 80 percent of households use electricity and LPG, whereas those fuels are present in only one-fourth of rural households. (Table 1).

Table 1 - Energy Sources for Urban and Rural Households in Brasil (1979)

| Source | % Urban Homes | % Rural Homes |
|---|---|---|
| Electricity | 89 | 24 |
| LPG | 84 | 27 |
| Wood | 16 | 79 |
| Charcoal | 9 | 11 |
| Kerosene | 12 | 73 |

Source: Graca et al., 1984

Between 1970 and 1982, there was a continuous and intense migration of population towards urban areas in Brasil, causing the energy-use patterns to change accordingly. In 1970, 56 percent of the population lived in urban areas; by 1982 that fraction had climbed to 70 percent (IDB, 1983). As expected, that shift in the distribution of population was accompanied by a steady decline in the share of firewood relative to electricity and LPG (Figure 10)[2]. The use of firewood in the residential sector should continue to decrease both as a consequence of urbanization, as well as of the increased availability of LPG in rural areas.

A marked characteristic of the substitution of electricity and LPG for firewood is the increase in end-use efficiency, evidenced by the decline in total energy use per household (Figure 11). That is due to the use of electric and gas appliances, which are usually more efficient than the wood stoves found in rural households. The overall improvement in end-use efficiency caused the total energy use in the residential sector to increase at a slower rate than the other sectors (2.7 percent from 1970 to 1982, compared to an average 6.6 percent for all sectors, MME,1983).

Although smaller, the increase in energy use observed in the residential sector has shown little sensitivity to fluctuations in economic performance. While the growth of energy use in industry and transportation was affected by higher prices and the recession, the energy use in the residential sector advanced steadily throughout the 1970s and early 1980s, regardless of economic conditions. The regularity of the increase in energy use indicates that as a consequence of the urbanization process, households have to rely more on LPG and

*Figure 10*
*Brasil*
*Residential Sector*
*Breakdown of Final Energy Use*

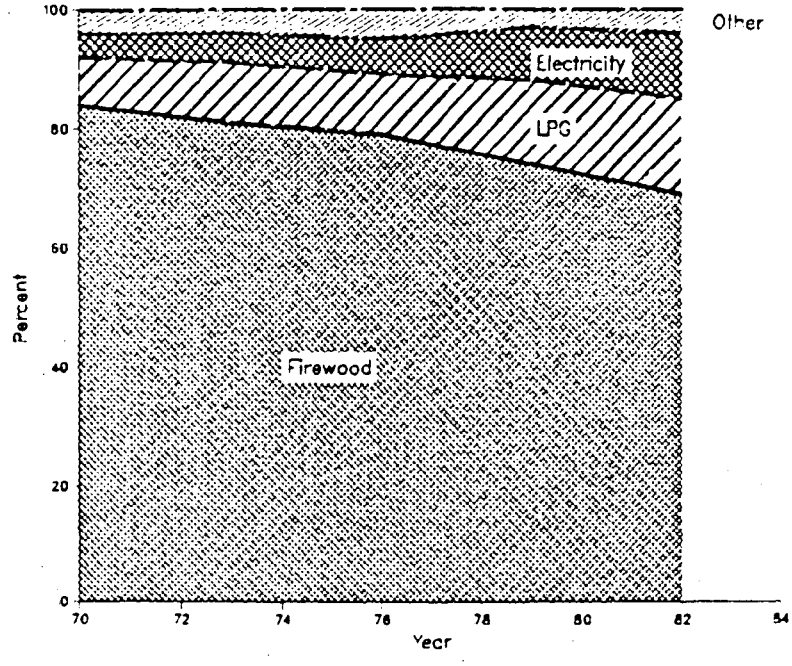
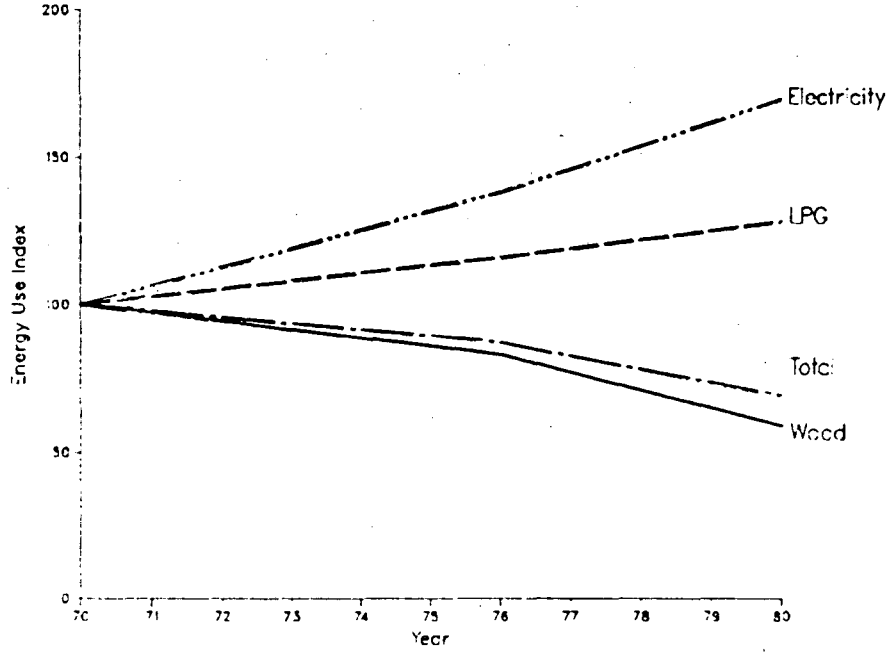



*Figure 11*
*Brasil*
*Residential Sector*
*Index of Energy Use per Household*
*1970=100*



electricity, regardless of their prices. While the real price of LPG has been kept constant for several years, electricity rates for residential users doubled from 1978 to 1981, and yet there was a 9 percent increase in the use of electricity in the residential sector during that period (Brasil, MME, 1983).

Even though the residential sector accounts for 90 percent of total demand for LPG, the energy use in households is less of a concern than that in industry and transportation from the standpoint of petroleum imports. During most of the period between 1970 and 1982, domestic production of LPG has kept pace with increasing demand. The volume of LPG produced in the refineries is largely determined by the refining structure or cut-of-the-barrel; currently, about 7 percent of each barrel of oil refined is made into LPG (CNP, 1983). Assuming that the use of LPG in the residential sector will grow at the steady rate observed over the last decade, and considering that enough oil will have to be refined to meet the demand for diesel oil and gasoline,it is unlikely that LPG use will become an obstacle to the overall reduction in petroleum imports.

## Conclusions

Over the last 10 years, the main thrust of energy policy in Brasil has been the reduction of the country's dependence on imported petroleum. That has been achieved by increasing and diversifying the production of domestic energy sources, as well as by promoting conservation and inter-fuel substitution in the various sectors of the economy.

The implementation of new energy policies, combined with the severe economic recession that beset the economy since 1980, has reduced Brasil's dependence on foreign petroleum supplies. Petroleum imports now account for 65 percent of total oil supply, compared to 85 percent in 1977.

On the side of supply, the most important achievement has been the expansion of domestic oil reserves and production. Current reserves are at 1.9 billion barrels, while production has recently exceeded 500,000 barrels per day or three times the average during 1979. This improvement in domestic oil production, however, is almost entirely due to the discovery and development of the Campos field off the coast of Rio de Janeiro in the mid-1970s. Since then there have been no new discoveries of comparable magnitude.

Most of the reduction in the demand for petroleum products has occurred in industry, where fuel oil continues to be replaced with hydroelectricity, coal, and biomass fuels. In transportation, the use of gasoline has declined more than 30 percent since 1979, in response to higher prices, mandated conservation and increased use of alcohol fuels. Some of the reduction in the use of petroleum products, especially in the industrial sector, has to be attributed to a deep recession that has caused the GDP to decline for three consecutive years.

One of the most important changes in the pattern of petroleum use has been the emergence of diesel oil as the most used liquid fuel. Its demand was boosted by a surtax in the price of gasoline which caused a disproportional increase in the fleet of diesel trucks. PETROBRAS has responded by changing its refining structure to produce more diesel oil

at the expense of gasoline and residual oil.

Since 1979, in Brasil has successfully reduced its dependence on imported oil. Nevertheless, the substitution of petroleum fuels has been achieved under conditions that may no longer exist between now and the end of the decade. First, the reduction in petroleum use was achieved during a period of economic recession, when inefficient industrial units could be shut down, and when the demand for energy-intensive services (such as freight transport) was slack. Considering that there has been no reduction in the overall use of energy for the economy as a whole, and that the energy intensity of industrial production has increased considerably, it is likely that a new surge in the demand for petroleum products would occur if economic growth resumes.

Second, in the presence of the country's staggering external debt and very tight credit conditions it is unlikely that subsidies such as the ones available to industrial users of coal and electricity and to owners of alcohol-powered automobiles can be maintained for very long. The move away from fuel oil in industry was backed by a number of subsidies and fiscal incentives, which enhanced the competitiveness of alternative sources such as hydroelectricity, coal, and biomass. Such subsidies are competing for the financial resources badly needed for the expansion of domestic oil production and for the creation of adequate infrastructure for the distribution of alternative energy sources such as power lines for electricity and ports and railroads for coal transport.

Brasil has unquestionably been one of the leaders among oil-importing developing countries in the formulation and implementation of policies to increase reliance on domestic energy sources. Witness to that is the Alcohol Program, a pioneer effort in the large-scale use of biomass fuels in transportation. Nevertheless, the small size of domestic petroleum reserves, and the scarcity of capital needed to promote the use of non-petroleum fuels could again cause the deterioration of the country's energy-trade balance before the end of the decade.

FOOTNOTES

1. Diesel trucks have a higher initial cost and lower operating cost than gasoline trucks; therefore, diesel trucks become more economical with high vehicle use.

2. The percentage use of fuels was calculated by converting electricity at the end-use equivalent of 3413 BTU/kWh, therefore showing a smaller share for electricity than that estimated in Brasil's National Energy Balance, where electricity is evaluated at a primary-substitution value of 13,000 BTU/kWh.

3. Over the same period, the cement industry in Argentina has managed to reduce the total energy content of its product by 23 percent.

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