Title
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Publication Date
1986-06-01

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

APPLIED SCIENCE DIVISION

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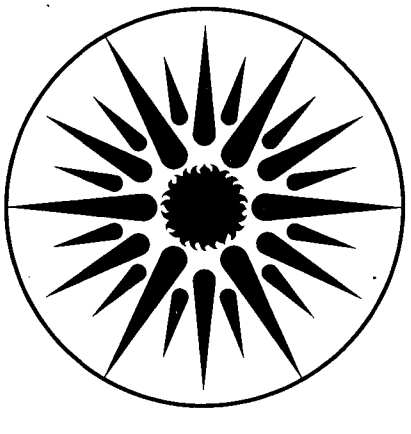
June 1986



APPLIED SCIENCE DIVISION

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

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This work was supported in part by the Office of Policy, Planning and Analysis, the Assistant Secretary for International Affairs and Energy Emergencies, Office of International Energy Analysis, the Assistant Secretary for Fossil Energy, Office of Planning and Environment, of the U.S. Department of Energy under Contract No. DE-AC03-76F00098; and in part by grants from British Petroleum Co., and Statoil.

LBL-21227

Substitution for Petroleum Products in Brasil: Urgent Issues

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Introduction

In response to the oil shocks of 1974 and 1979, which threatened the security of supply to the Brazilian economy and heavily increased the cost of the country's petroleum imports, Brazilian energy policy during the last decade has focused on the replacement of imported petroleum with domestic energy sources, combined with efforts at conservation. The substitution results, however, have been more spectacular by far.

The strategy of replacement is based on two elements. First, to increase domestic petroleum exploration and production. Second, to promote non-petroleum fuels as alternatives to the industrial and transportation sectors, for the substitution of fuel oil and gasoline, respectively.

The promotion of non-petroleum fuels was largely based on two instruments:

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i) disincentives to the use of petroleum products through increases in price or taxes -specially for gasoline - and the imposition of quotas : after the 79 oil shock and throughout 1980, fuel oil use was tightly rationed, generating uncertainty as to its availability to industrial users, and

ii) tax incentives and subsidies to the alternative energy forms. Namely, agreements and subsidies to use of steam coal in the cement, steel, and paper industries; subsidies to the use of hydroelectricity (available through the temporary existence of excess capacity) to raise steam in industry; and incentives and subsidies to the production and use of alcohol fuels as a substitute for gasoline in automobiles. The chief examples of programs offering such incentives are PROALCOOL, EGTD, and Protocolos do Papel, do Cimento e do Aço.

A combination of the substitution strategy, the country's petroleum refining structure, and the composition of demand, has resulted in large surpluses of both gasoline and fuel oil, while diesel has become the most used among petroleum products. The surpluses are not easily exportable because there is ample availability of fuel oil in the world market, and because the low octane number of the gasoline produced in Brasil is not compatible with the engines of cars elsewhere in the region and in the world. Furthermore, although gasoline might be upgraded, the question remains that prospects for the world market are not encouraging, and an export-based strategy does not seem justified in view of the growing surpluses.

In view of that, there appears to be no economic incentive for the continued subsidization of alternatives to gasoline and fuel oil, specially considering that such subsidies use funds that are badly needed in other areas. On the other hand, the existing subsidies cannot be removed without creating serious socio-economic imbalances, which would bring about heavy losses both for the energy market and other sectors of the economy.

The objective of this analysis is to review the mechanisms of the major petroleum-substitution programs currently in existence, identifying their past impact on the energy market and the possible consequences of changes in the goals and operating conditions of these programs, in the light of the new prospects for increased domestic oil production and self-sufficiency.

Overview of Recent History

The post-74 Brazilian Energy Policy was marked by an intense effort aimed at lessening reliance on imported oil, in two directions: 1) to increase significantly domestic oil production and 2) to replace oil by other domestic sources. Conservation per se did not attract the same attention, although some significant results were attained and mention must be made of programs like CONSERVE (discussed later). This policy was, by and large, successful. This success, however, was not attained without costs that must be (and are being) evaluated for a redefinition of the energy policy, both in the short and long run.

Although we have spoken of one energy policy, a closer look reveals several periods or phases, which are not entirely consistent with one another. Thus, the period 1974-1984 covers three distinct phases: i) the years 1974 to 1978 ; ii) 1979 to 1981; and iii) 1982 to 1984. As we shall see, the year 1985 may mark the beginning of yet another period, with significant inflections. Let us briefly review the main features of these phases.

i) 1974-1978: The Best of Worlds Between Two Shocks.

The basic lines of the overall policy regarding programs and institutions were laid during this period. The underlying assumptions, however, differed from those of the other periods, as did the international context. The "Brazilian Miracle" was still in the order of the day, petrodollars flowed obligingly at interest rates that were very low or even negative given the dollar inflation, and oil prices were stable (or declining in real terms). Assuming that international conditions would remain favorable for a long enough period, the Federal Government launched a series of projects aimed at reducing the country's vulnerability, not only in energy, but for the whole economy. The scale of many of these projects was such that the investments required heavy borrowing abroad which, given the assumptions, did not seem to pose a threat to the future of the economy. As we shall discuss later, the results were mixed; although the favorable conditions lasted less than assumed, and the high interest rates sent the debt snowballing before many projects could show results, in some cases one might argue that the projects were successful and gave the country an additional flexibility that more than compensated for their cost.* [1] In other cases, though, such as the Nuclear Program, the balance seems largely negative; in fact, the implicit assumptions of favorable conditions and continued high growth

* Some authors have recently reviewed the overall economic policy of the period, which coincided with the 2nd National Development Plan, noting some of these aspects; see for instance Castro & Pires de Souza [1].

rates, together with a high degree of centralization of political and economic decisions, tended to lead to waste.

The components of energy policy during this period were:

Oil: increased production, both at home (schemes for accelerated production at the Campos basin) and abroad (specially in Iraq, where Petrobrás discovered the giant Majnoon field; later on the activities of Petrobrás abroad turned to negotiating better conditions with the oil suppliers and acting as a import-export trading company); increased prospecting and specially the opening up of selected fields for exploration and development by transnational companies under risk contracts.

Oil Products: gasoline was perceived to be the critical product, and one that could easily be displaced within certain limits. Its price was therefore substantially raised and gas stations were closed during weekends; additionally the first phase of Proálcool (discussed below) was implemented. As to other oil products, during this period their prices had smaller increases; in the case of LPG, there was a price reduction after a raise immediately following the first oil shock (Figure 1). Even though diesel and fuel oil prices increased 40 to 50% compared to their average in 1973, gasoline prices went up by more than 120% between 1973 and 1977. In fact, not only were those products (diesel, fuel oil and LPG) seen as non-critical, but there was a preoccupation not to penalize their use, either because of their role in economic production, or due to the desire to expand their use, as was the case for LPG.

Coal: the emphasis was, on the one hand, on the use of domestic production of steam coal that was a by-product of metalurgical-grade coal production, and, on the other hand, on increasing prospection and production. Nevertheless, during this period the actual increases in the use of coal were limited to the Steel and to the Cement Industries through formal formal agreements (protocols) with the government. Through these protocols a detailed agenda was set for the reduction of fuel oil use, both through increased efficiency of oil-burning equipment and through substitution with coal. Although some the actual improvements and substitution efforts fell somewhat short of what was agrred to, the protocols certainly played an important role in the reduction of fuel oil use in the cement and steel industries. Other, less successful, agreements were signed with other branches of industry (e.g. paper and pulp), in an attempt to increase their use of coal. Additionally, coal-fired power plants were planned near the mines, in order to use high-ash coal pre-treated on site.

Electricity: development of large hydro projects went on at an accelerated pace, and the Nuclear Program started with the Brazilian-German deal; the basic premise was that demand would grow at such a high rate that by 1990 the Southeast would be deficitary, and long-distance transmission from the North would be uneconomical. Nevertheless, even during this period, new studies showed the economic potential of hydropower to be substantially greater than previously assumed, while the opposite happened to nuclear power, whose costs increased by much. [2] This led to sharp reductions in the nuclear plan, from 65 GW to 18 by the end of the period, whereas hydro projects were unaffected; the best-known examples are Itaipu and Tucuruí.

Alcohol: The Programa Nacional do Alcool (Proálcool) was created in November 1975 with the dual purpose of displacing gasoline with alcohol fuels while, at the same time, lending some stability to the sugar industry.

Sugar has always been one of Brazil's main export commodities, and the stability of the sugar industry is important for the Brazilian economy. International sugar prices can vary greatly over periods of a few months, which often poses financial problems to sugar producers. The creation of Proálcool happened in response to a changing petroleum market, but was also an instrument to support the sugar industry at a time when it faced sharply declining value of its product, after a period of record-high prices in late 1974.

The success of Proálcool cannot be understood without referring to the long-standing tradition of alcohol fuel use in Brazil, mixed with gasoline in small quantities since 1934 as an instrument for regulating the sugar market. For this purpose, every sugar mill had an annex distillery, and much experience and research had been accumulated in the use of alcohol-gasoline mixtures.

Under Proálcool, however, both the scale and the purpose were new, and alcohol production did not increase substantially until 1976/77. It was not until sugar prices plummeted in 1975/76 that massive quantities of alcohol started being produced.

At its inception, Proálcool was based primarily on the use of idle capacity in annex distilleries and on increasing the mixing of anhydrous alcohol with gasoline by an order of magnitude (the plan did also stimulate the construction of new, autonomous distilleries and research on alcohol-fueled motors).

The basic incentive to producers was, and still is, that alcohol be bought by Petrobrás on a sugar-equivalent basis (with prices and quotas fixed by the IAA* on a cost basis, which means that producer prices vary among regions, although consumer prices

* The National Institute for Sugar and Alcohol, which regulates the entire sugar industry.

are equalized by CNP [**]. This causes a revenue transfer in favor of less cost-efficient regions), but additional incentives were established, mostly through credit subsidies to producers.

Other biomass: not much was done, besides the signing of protocols with a few industrial branches - Steel and Iron, Cement, Paper and Pulp - to increase their utilization of fuelwood or charcoal and reduce consumption of fuel oil. In fact, these were branches which already used these fuels and the protocols aimed basically at better efficiency and sustainability, by requiring an increasing commitment to fuel from planted forests. To be sure, there were a few investigations into alternatives to sugar cane ethanol as a motor fuel, such as ethanol from manioc or vegetable oils, but these never really got off the ground.

ii) 1979-1981: Consequences of the Second Shock.

The second oil-price shock shattered many premises of the former policy. The upheaval in international conditions came too early, too suddenly and too strongly to allow a graceful transition even in projects that were basically sound. For some, such as the Nuclear Program, the bill to pay was out of proportion with their expected revenues, and the waste that had formerly been tolerable now severely restricted the range of choices to be made. The economic policy changed its orientation several times (despite its centralization in the hands of one single decison-maker), although the leitmotiv remained the sudden charge imposed by steep raises in interest rates and oil prices. The borrowing, which had formerly been done to finance projects, now had to be done to finance the service of debt itself.

Energy policy responded frantically to this situation; reading the "Brazilian Energy Model" (BEM) [3] one finds not a model or a plan, but rather a statement of goals which essentially amounted to substituting as much imported oil as was deemed feasible, by exploring all possible avenues: explicit mention was made of oil shale, peat and a good number of other nonconventional fuels. High goals were set for coal and alcohol, and investments in oil exploration and production more than doubled in 1981 relative to 1978. Another example of this attitude was the fuel-oil quota imposed upon industries during 1980; this was discontinued but had the effect of making industrialists supply-counscious, starting a search for substitutes and greater efficiency. Thus, an energy conservation program [*] drew their attention, despite some complaints about its sluggish bureaucracy.

Let us review some features of this period:

1981, while the share of exploration and production went up from 54 to 90% of investments during that period. Drilling activity doubled, and both reserves and production increased.

Oil products: diesel oil was now perceived as the constraining product, and increasingly so, since practically all new commercial vehicles were now equipped with Diesel engines. However, it was deemed that refineries could accommodate a reasonable change in profile, and thus substitution efforts for gasoline and fuel oil would mean a net reduction in imported oil. At the same time, prices of most products were substantially raised, with two exceptions: naphta for the chemical industry, and LPG for the residential sector.

Substitution programs: the protocols for coal, charcoal and wood were revised and new goals were set. According to the BEM, total coal production should be raised from 5 million to 19.7 million tons per year by 1985 (revised version of BEM,1981); alternatives to diesel fuel also started being explored. Undoubtedly, Proálcool was the substitution program that was carried farthest, and deserves separate consideration.

Alcohol: A second phase of Proálcool began, in which the emphasis was on autonomous distilleries and vehicles running on pure alcohol. Until then, alcohol production was mostly based on existing capacity; on the other hand, the amount of ethanol mixed into gasoline could be varied freely (up to a limit of 20%) with little effect on vehicle performance, making ethanol an excellent regulator for policy purposes. Now, two elements of rigidity were introduced: there had to be substantial increases in capacity, and two different engine suited to distinct fuels; the program ceased to be a reversible policy mechanism, becoming an irreversible commitment. The automobile industry, which was reticent at first, was converted into an enthusiast by the dwindling sales of gasoline-powered vehicles.

A new policy element was introduced: fiscal advantages for buyers of alcohol-powered vehicles (and credit advantages as well, during several years), and a government commitment to limit the price of hydrated alcohol to 65% of the price of gasoline. This introduced a certain decoupling between producer and consumer prices, resulting in additional temporary subsidies to alcohol (although there is not enough published evidence to say their net value was substantial), depending on the timing and amount of the readjustment for both prices.

Electricity: the nuclear program was repeatedly revised downwards although the nuclear lobby had partial victories, such as the commitments to two additional plants in São Paulo.

In hindsight, the most striking feature of the period was that financially sound enterprises such as Petrobrás and Eletrobrás were forced to borrow, not for any need of their own, but to supply the government with foreign exchange, thereby greatly weakening their financial position, specially that of the electric sector.

iii) 1982-1984 : Debt Crisis and Domestic Recession.

By 1981 the country had already suffered an economic recession; 1982 saw very small growth, but the external debt was such that, by September, Brazil had to follow the steps of other Latin-American countries and address itself to the IMF. The negotiations led to a policy of generating large surpluses at any cost, by a combination of export increases and import cuts, which brought about a recession in 1983. In the following two years the economy showed enough resilience to generate large trade surpluses and still grow at a reasonable average rate of 5 percent yearly, surprising most observers and planners as well.* (Although 1984 was led by agriculture, the 1985 growth was due to industry, and specially its modern sectors.)

In the energy area, the main characteristics were : investment cuts, with the electrical sector being particularly hard hit; the consolidation of the second phase of Proálcool, surmounting technical obstacles and becoming a strong interest group; the maturation of previous efforts in oil exploration; and the creation of EGTD (see below) providing hydroelectricity at low rate for use as boiler fuel, given the surplus in generating capacity created by recession.

Oil: Although investment cuts in 83 and 84 reduced total investment from a high mark of 3.1 billion US$ in 1982 to 1.7 billion in 1984 (1984 constant dollars), even this figure was higher than the investments of 1980; and drilling activity had only a moderate decline of 10 to 15%. Meanwhile, production more than doubled over 1981 figures, arriving in 1984 at 27 million cubic meters or 470 thousand barrels a day, while reserves increased 36% to approximately 2.6 billion barrels. [4]

Oil Products: The measures previously adopted led to a substantial increase of the share of diesel in refining and to an equally substantial drop in the shares of both gasoline and fuel oil; several schemes had to be adopted to avoid creating large, virtually unsaleable surpluses of these fuels, of which the predominant one was the mixing of a part of light naphta into diesel fuel, up to a level that would not be damaging to engines, although the fuel specifications were significantly changed. Additionally, the price ratio of gasoline to

* The National Petroleum Council, which officially defines consumer fuel prices.

[4] This was called CONSERVE, and managed by the Office for Industrial Technology (STI) of the Ministry of Industry and

diesel oil, which had reached a high of 2.3 in 1980, was lowered to 1.4 in 1984 (real gasoline prices themselves dropped 23% in the same period) and LPG prices had a slight increase, reverting the trend in an effort to discourage its clandestine use in cars.

Alcohol: The solution of technical problems, combined with a comprehensive set of incentives to consumers and a large production capacity, reversed the market decisively. In two years gasoline vehicles became marginal in new vehicle sales, thus creating a new problem: a structurally growing surplus of gasoline. The installed capacity of alcohol distilleries grew fast, so that from 1983 onwards alcohol stocks started being systematically greater than technical reasons would warrant, raising a new concern. It is true that overproduction stemmed partly from recession, which had not been foreseen in the goals and credits set for Proálcool. By 1984, the consumption of alcohol (in barrels of oil equivalent) had already surpassed that of gasoline, and in 1985 the goals set by the BEM were exceeded.

In this new situation, credits for production expansion started being drastically reduced and licensing of distilleries became stricter. Nevertheless, this did not prevent new capacity being contracted, with or without government funds. In effect, the alcohol industry had reached enough maturity to be able to do without subsidized loans, thereby showing that the prices received by producers were amply satisfying, notwithstanding the complaints of distillers.* [5,6]

Coal: Due to the existence of excess capacity, the cuts in investment in coal production did not have much of an effect. Despite the BEM goals of 19.7 million tons of total sellable production by 1985, in 1984 it was just 7.5 million tons, 50% above the 1979 figures. (Of this, steam coal production increased by 2/3, while that of metallurgical coal actually decreased due to recession). [7] Even so, data gathered for 1983 show that though effective production was on the average 23% less than planned production for steam coal, consumption was 8% below effective production and about equal to existing stocks at the end of the year. This reflected the limited market for coal, rather than production and transportation bottlenecks, although these do exist. In effect, coal-fired electricity generation and the cement industry answered in 1983 for three quarters of total steam coal

Trade (MIC); its purpose was mainly to assist industries which wanted to improve their energy efficiency with advice and incentives.

* Personal communication of an economist then working at the Ministry of Plan (SEPLAN).

In a well-documented paper, COOPERSUCAR's J.M. BORGES presented the evolution of production costs, government prices and prices expected by producers from 78/79 to 82/83 crops, showing a downward trend in costs of 4% per annum, and arguing that government prices in 82/83 were very close to costs and insufficient to adequately remunerate industry. In view of the dynamism shown by that industry and the fact that in no year government prices matched the producers' expectations, it is licit to wonder whether those expectations were more of a bargaining ploy than a realistic assessment. See Borges [5] in Oliveira&La Rovere [6].

consumption, half of the rest being split between the chemical and paper/pulp industries. [8]

In view of the restrictions and excess capacity, some subsidies were reduced or eliminated (see [7]). It is difficult to give precise figures, as costs are a well-kept secret of mining companies [8] and the market is strictly regulated, with 18 different prices according to the type and origin of coal, plus conditions specified in individual industrial contracts (which, we must recall, concentrate on a relatively small number of large users).

Electricity: several projects were delayed to comply with investment cuts; in view of the recession, this did not affect supply conditions in se. The market conditions were greatly changed, however, by the enactment of EGTD (Energia Garantida por Tempo Determinado). This was a program devised specifically to promote the replacement of fuel oil with hydroelectricity in industrial boilers. In early 1982 EGTD started offering electricity at very low rates (30 percent of regular price) 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 for the new equipment, prompting many users to switch to electricity for steam generation. The basic motivation for this policy was that, as a consequence of economic recession, there was an excess of firm capacity [*]. Additionally, there had been a deterioration of the regular tariffs themselves: the rate paid by an industrial consumer with 25 MW demand and 90% charge factor, which had reached a high of 26 mills/kwh in 1982, dropped to 18 mills/kwh by 1984 - and the fall continued in 1985. Other categories of consumer tariffs had the same behavior : a fall of 30 to 35% in two years, continuing into June 1985 (see Table 1 and Figure 2). [9]

Strictly speaking, as long as there was an excess of firm capacity, the EGTD tariff did not imply a subsidy, because the marginal cost of hydro-energy under these conditions was just the capitalized cost of additional transformers at the point of delivery (although this is debatable, and one might argue that tariffs should include all fixed costs, even with excess capacity). Although EGTD might make sense in the short run, its enactment and the deterioration of rates imposed upon the electrical sector had two serious effects: first, excess capacity was soon absorbed reducing the margin needed to respond to an economic recovery; second, the financial conditions of the sector were weakened by the reduced rates at a time when it had a heavy financial burden, thus making it more difficult for the sector to respond to the demands of recovery when it came.

[*] This is a concept linked to hydropower systems, and means the minimum power that can be supplied during several years with a fixed margin of risk given the known behavior of hydrological conditions, the reservoir and the installed turbines. If consumption falls below firm capacity, water will have to be thrown away; thus the marginal cost of generating this energy is zero since operational costs are fixed for hydroelectricity. If in addition there is excess capacity for transmission and distribution, the cost is but the cost of upgrades at point of delivery, if any.

The nuclear program suffered new delays as the Angra I plant continued to be beset with technical problems; cost estimates were raised further and conditions became generally less favorable. On the other hand, the commercial use of firewood and charcoal in substitution to fuel oil was straining forest resources, which were already under pressure from the expanding agricultural frontier, according to a study by CETEC (Center for Technology Studies of Minas Gerais State) [8].

Present Situation and Perspectives *

As we write (late January 1986), the international oil market is going through its largest adjustment since the 1979 shock, and uncertainties are greater than ever before **. [10] How does this situation affect Brazilian energy policy, and what are the long-term prospects? In trying to answer this, we must be aware of the fact that in 1985 there was already a considerable reorientation in Brazilian Energy Policy. Despite many elements of continuity, the "Nova República" differs from the preceding regime in two decisive aspects: the political accountability of decision-makers, and the larger space for expression of social demands. This led to an effective reorientation of economic policy towards growth of the internal market and social programs, and although there is no clearly defined energy policy as yet, we note an interest in reappraising existing programs.

This reappraisal is all the more important in view of the limited resources available to cover all the required investment, which means that an effort must made to revert or at least attenuate the past trend towards an increasing share of investments in energy in the total gross capital formation. Furthermore, the policy pursued over the last few years led to developments that have of themselves deep implications for the future energy policy. These are:

- Substantial Additions to Oil and Gas Resources

Between 1979 and 1985 Petrobrás increased oil production from 171 to 572 thousand barrels a day (from September 1985 the average exceeded 600 thousand bbl/day); gas production tripled over the same period, reaching almost 15 million m^3 per day last September. This increase was accompanied by a smaller increase in reserves, from 1.25 to

* This section draws heavily upon the findings of a workshop organized by AIE-COPPE, and co-sponsored by the CEC, FINEP, UNDP, and UNESCO, last November in Rio on energy prospects for Brazil in the medium and long terms; its proceedings will be forthcoming.

** Thus Prof. H.D. Jacoby [10] from MIT estimates as likely a price range between 15 and 25 dollars a barrel, but points to factors that might bring about movements outside this range.

2.0 billion barrels of oil and from 45 to 84 billion m^3 of gas, both between December 1979 and December 1984. [11] The increase of both production and reserves is coming from offshore fields at a depth of 400 meters, and Petrobrás estimates that exploration within this range will guarantee a sustained production of 800 thousand barrels of oil a day and double the present gas production. [12] However, the largest discoveries thus far lie in the 400-1000 meter range; although Petrobrás is understandably reluctant to give precise estimates of the size of these fields, it acknowledges that, assuming that technical problems are solved, the deep water discoveries made thus far will allow an additional production of 1 to 1.3 million bbl/day between 1995 and 2000, maintaining good reserves-to-production ratios, accompanied by a gas production from 25 to 30 million m^3 a day, or approximately between 170 and 200 thousand bbl/day in oil equivalent.[12] The technical problems involved are not to be slighted; but Petrobrás has joined in a pool with major transnational oil companies to develop deep water drilling technology, and is already developing a semi-automated scheme for an intermediate range of 400-600 meters. Assuming that such efforts are successful, capital requirements will tend to be larger; but the size of the newly-discovered fields makes it likely that cost per barrel will remain in the neighborhood of present costs (approximately 15 dollars/bbl offshore).* Of course, such a development will depend to a large extent on the efforts to develop the necessary technology, as well as on the reaction of the oil companies to the new international situation. The potential, however, is there not only for self-sufficiency in oil (in 1985, national production was greater than oil imports, with total consumption of oil products estimated at roughly 960 thousand bbl/day), but also for a more important role for oil than it has recently had.

- Structural Surpluses and Deficits in the Refining Profile

Between 1973 and 1984, the structure of demand for oil products changed substantially. LPG use increased from 6.6 to 10.9% of the total volume consumed, and diesel oil from 21.8 to 34.3%, while gasoline use in cars dropped from 30.6 to 14.2%, and fuel oil from 28.3 to 18.5%. [13] Such a change could not be easily accommodated by refineries, and as a result one-third of gasoline production, and one-fourth of fuel oil production, were exported in 1984 despite all the measures taken. If present substitution trends continue, the pressures on the refining structure will increase: demand scenarios in the November 85 workshop in Rio showed projections of gasoline consumption falling to less

* We thank Prof. A. Oliveira of COPPE/UFRJ for pointing this out.

than 1 million m^3 a year in the year 2000 due to the phasing out of gasoline vehicles, displaced by alcohol and diesel. In fact, if present fiscal and pricing policies are maintained, gasoline consumption should decline to negligible levels, within ten to fifteen years.

Projections also show the share of diesel oil increasing up to nearly half of all oil products consumed, and the share of LPG remaining around 12%. The fate of fuel oil depends to a large extent on how far and how long substitution will proceed.

In effect, as we shall discuss below, there is reason to argue that fuel oil substitution may soon decelerate, although there is still room for penetration by natural gas,charcoal and bagasse (which is closely linked to the expansion of alcohol); all have low costs - yet charcoal will eventually become more expensive as supply is gradually based upon planted wood, which will decrease its attractiveness.

By contrast, bagasse has evolved from a nuisance that had to be burned away (and inefficiency was therefore built into distillery design and operation) to a marketable good that has progressively been adopted by industries in the neighborhood of distilleries. This is a considerable market, since most of São Paulo food-processing industry is located in the area. Thus, in 1983, bagasse was already the second most used industrial fuel* in São Paulo [14] and, by the end of last year, it took the lead in energy supply for industry, surpassing fuel oil. [15] However, soil cover and cattle feed are other growing uses for bagasse; this and its light energy density will tend to limit its role as a fuel.

Natural gas will also contribute to the displacement of fuel oil. The extent of that substitution is estimated to reach 50 thousand boe/day in the near future. [16] However, it does not seem likely that these fuels will keep increasing their share, if industrial recovery lasts. In 1985 industrial production had already reached the all-time high levels set in 1980, and future growth will require fuel characteristics that only fuel oil (and natural gas, although geographically more restricted) will have the necessary flexibility to satisfy.

Given the existing of fuel substitution, it is clear that, under the current refining structure, surpluses of gasoline (and fuel oil to a smaller extent) will continue to accumulate, unless immediate steps are taken to reshape the structure of the demand for petroleum products.

*Taking all fuels at their end-use equivalent

- Problems with Electricity Supply

The financial erosion of the electricity sector led to investment cuts; at the same time, reduced rates (specially those provided by EGTD) induced a growth in electricity demand despite the economic recession. Therefore, when recovery started, there was no slack capacity; a serious black-out occurred in the Southeast, exposing several weak spots in the system. Despite a thorough revision of investments, not only in generation but particularly in transmission and distribution, the prospects for the next ten years are not encouraging. Assuming a growth of electricity consumption from 18 GW-year in 1984 to 41 GW-yr in 1995, the latest version of Eletrobrás' "Plano 2000" estimates that the risk of power shortage will grow significantly throughout the period. That scenario of the Plan is conservative in that it assumes an average yearly growth rate of electricity consumtpion of 7.5 percent, compared to the 9.5 percent average rate observed from 1973 to 1983. Furthermore, this risk will be unevenly distributed: in the Southeast (the largest market) it will grow from the present 2% up to approximately 10% from 1992 through 1995, when it will start to decline; in the South figures are consistently higher, reaching 18% in 1982-83; in the North the critical years will be 1991-93, the risk exceeding 20% in 92; but perhaps the hardest situation will be found in the Northeast, where risk of power outage approaches 30% in 1993 before it starts to decline. The risk of substantial power loss (more than 10% of the market) is also significant, except for the North, where it barely reaches 2% during the critical years, while in other regions, it lies between 5 and 15% (Figure 3). [17]

Alcohol at the Crossroads

Proálcool is arguably the largest effort ever made to substitute biomass for petroleum fuels, and it has a record of significant success. Nevertheless, it also has liabilities that should not be lightly dismissed. The first, and perhaps most obvious one, is the fact that ethanol is costlier than gasoline: although most estimates vary between 40 and 65 US$/bbl of gasoline equivalent (bge) * (in the Southeast; for the Northeast, cost figures are closer to US$ 100/bge, the difference in costs being subsidized through the equalization mechanism discussed above), even a moderate figure of US$45-50 is significantly higher than the cost (or the international price before the recent debacle) of gasoline. This implies a transfer of revenue from other parts of the economy to the alcohol-

* One liter of hydrated alcohol is equivalent to 0.8 liter of gasoline in Brazil, the higher compression rates possible with alcohol partially offsetting its lesser heat content.

producing sector. As long as the transfer was from the higher-income households, through a steep gasoline tax, one could argue that the program not only saved badly needed dollars as it also had positive impacts on employment and production. However, as gasoline is being displaced in favor of alcohol, two perverse effects appear: on the one hand the tax revenues from gasoline are declining, thereby reducing the funds available to the government. On the other hand, as the individual car fleet is becoming increasingly alcohol-powered but the fuel cost differential persists, the existing subsidies will require more funds, not less; therefore, unless a firm stand is made to eliminate subsidies to alcohol, the higher-income consumer will turn into a net beneficiary of the revenue transfer, whose social and economic impacts will be greatly reduced if not downright negative since the difference will come increasingly either from productive sectors or from low-income households. The issue is further aggravated by the fact that light commercial vehicles are also turning to alcohol, which raises potential inflationary pressures when subsidies are finally dropped.

Furthermore, ethanol competes for land with other uses, particularly food crops. This has not been a serious problem in the Southeast, where the displacement affected mostly pastureland; but, as the area planted with sugar cane expands, the conflict will become more severe, especially with the possible displacement of crops needed both for the supply of food and to help control inflation in the process of recovery. [18] In the Northeast the situation is clearly worse. There, the best arable land lies on a narrow coastal strip and is dominated by sugar cane plantations, which have progressively taken over the area. If we add to this the fact that the Northeast is the region facing the most acute social problems - endemic malnutrition is particularly high in the sugar cane-producing areas of the region - showing a per capita income that is substantially below the national average as well as highly concentrated, the conflict seems evident: since sugar cane represents a large share of the regional economy (more than 30% for some states) and benefits from subsidies as we have noted above, this situation is not likely to change without a firm political action by federal as well as regional authorities. The need to avoid a serious breakdown of the regional economy, however, indicates that only a comprehensive strategy will succeed.

Meanwhile, the capacity under contract as of now guarantees for 1990 a production of 16 million m^3 of ethanol, which will require 4.8 million ha, plus 2.5 Mha for sugar, unless productivity increases significantly. While Proálcool sources estimate that demand will follow this capacity and will reach 32 Mm^3 by the year 2000, [19] this assumes that current trends continue.

What Is To Be Done?

Whatever vigor the Brazilian economy has shown and may continue to display in the future, the service of the external debt will continue to limit severely the availability of resources for investments, at least through the next decade. If economic and social development is to be pursued, substantial priority changes will be required. The pace of oil substitution must be revised, and programs reassessed, taking into account the new market conditions. While this does not imply repudiation of the accomplishments of the existing programs, it will require that new initiatives be extremely cost-conscious, as well as compatible with the overall goals of sustainable social and economic development of the country.

Among the existing energy policies, four major issues appear to us as deserving highest priority for reassessment: costs and productivity in ethanol production, electricity tariffs (in particular EGTD), motor fuel policy, and the role of fuel oil.

Alcohol Productivity and Costs.

According to both COOPERSUCAR and STI, there is a potential for 30 to 40% reduction in costs and a 50% productivity increase in alcohol fuels production until the end of the century (see [5, 19]). This would mean a reduction in the cost of ethanol down to the neighborhood of 25 US$/bbl (of gasoline equivalent) and would also allow meeting a demand of 24 million m^3 without increasing the cultivated area under contract. Such results, however, require a firm policy restricting producer prices as well as licensing of new production facilities.

As for the regulation of alcohol fuels production in the Northeast, deeper structural changes will be necessary, and will require ample political debate prior to their implementation, as they must be part of a coherent development project for the region.

In general, it seems clear that subsidies are no longer necessary in the Southeast, and should be terminated. The industry is sufficiently mature to operate on its own and achieve the necessary improvements in productivity and cost.

Motor Fuel Policy

The present motor fuel policy leads to a division of the market between diesel oil and ethanol, with gasoline being progressively eliminated. Attempts to deal with this growing imbalance have been supply-oriented, which is surprising, considering that this situation was brought about through a combination of supply and demand management measures.

At this time, most of the measures examined address the problem of how the structurally growing surplus of gasoline may be absorbed. Suggestions vary from gasoline with additives for use in Diesel motors to ethanol-gasoline-diesel oil mixtures.

Demand-oriented measures have not received attention, partly because of the instability of the vehicle market between the two Otto fuels: since ethanol-powered and gasoline- (or rather gasohol-) powered vehicles cost the same to produce, their market is essentially unstable, switching between them according to operational costs; but also because the emphasis was on stimulating alcohol-powered vehicles, which were favored not only by fuel prices but also by vehicle taxes.

Nevertheless, a segmentation of the vehicle market is in principle conceivable: though regulation might be difficult in view of the number of vehicles in existence for each fuel, one might restrict the alcohol market to residential users through changes in the existing taxation of vehicles and fuels. That would create a break-even point for alcohol and gasohol*, and provide an effective way to reduce the gasoline surplus problem. At the same time, it would slow the growth of alcohol demand and provide the necessary incentive to bring about the changes in cost and productivity**. [20]

Electricity Tariffs

The indebtedness of the electrical sector and the projections of demand require that rates be revised upwards. This is necessary to guarantee the resources for investment, and also to help regulate demand growth.

In fact, by June 1985 Brazilian electricity rates were the lowest among 22 countries* (not including EGTD). We must re-emphasize that the low rates stimulated electricity consumption in processes for which other fuels would be chosen under normal conditions.

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**We thank Dr. Alvim da Silva for pointing this out.

At the closing of this text, we read that studies are under way to end all alcohol subsidies and bring alcohol and gasohol prices to parity [20]; this agrees with our general thesis and shows the depth of reevaluations that are presently taking place in Brazil.

*Eletrobrás, C.I.C.T.E. 1973/1985. The countries are: Norway, Ghana, Chile, Canada, Israel, Argentina, U.S., Sweden, Uruguay, Ireland, Italy, U.K., Mexico, Austria, Germany, Spain, Japan, France, Switzerland, Brazil, Australia, and Belgium.

On the other hand, it should be pointed out that in the last few years, for the first time, the ratio of residential to industrial rates has been similar to international values (Table 1), which represents an improvement over a former situation where households were effectively penalized. Care must be taken not to revert this situation, particularly in view of the large number of low-income residential consumers.

As for EGTD, there is no excuse at all for extending the existing contracts. At the end of 1986 all of the contracts providing electricity at discount prices under EGTD are due to expire. The condition of excess capacity no longer exists. Instead, there is great concern regarding the reliability of power supply in the medium term, due to recent economic recession, which has halted investment in new generating capacity, as well as in transmission and distribution lines to match the new plants in place.

In all likelyhood, the termination of the EGTD contracts will meet with opposition from those who have been benefitting from the subsidized rates. Nevertheless, the subsidies provided were such that most all of the investment made in electrical boilers has been already paid off, so that there should be no loss associated with the switch away from electricity (probably to fuel oil).

The impending imbalance between supply and demand for electricity should provide motivation for more efficient management of demand. Especially important would be the establishment of a rate schedule that:

a) improves the load profile; the effective use of time-of-day rate schedule can continue to displace some of the industrial and residential users to off-peak hours; while this involves further investment in monitoring, a gradual substitution that gives priority to larger loads seems feasible;

b) reflects the marginal cost of investment for new generation and transmission capacity; over the last few years Brasil has offered electricity at rates that are insufficient both for meeting the financial obligations the sector has contracted in the domestic and foreign markets, and for responding to the need for new investments;

c) does not put a disproportionate burden on low-income residential users; this could be combined with demand management measures like higher tariffs for users with high demand peaks, discouraging wasteful behaviour and shifting the burden towards those households effectively responsible for added capacity; such a policy has been successfully implemented in countries like Ivory Coast at low cost.*

* Personal communication from a senior engineer at EDF.

The Role of Fuel Oil: An Upturn in Industrial Demand

During the last decade, fuel oil has been displaced both by conservation and by substitution. Its substitutes have been essentially coal (mostly for steel/iron, cement, paper/pulp), charcoal (mostly for steel/iron), fuelwood, electricity, and lately bagasse and natural gas.

There is no doubt that the conservation and substitution measures adopted in order to reduce fuel oil use in industry were successful. Fuel oil use in industry in 1984 was 5.6 million TOE, compared to 13 million TOE in 1980, and its relative share of industrial energy use was down to 11 percent, compared to 30 percent in 1976. [21] During the same period, the relative share of electricity underwent an increase as impresssive as the decline of fuel oil.

There is, however, reason to believe that this pattern of substitution is of a reversible nature, and that the conditions for a reversal are already having an effect. There are two main indicators of the reversibility of fuel oil substitution in the Brazilian industry. First, the lack of any incentive for the continued subsidization of non-petroleum alternatives. Second, the absence of an overall decline in the energy intensity of Brazilian industry since 1979 on account of greater participation of energy-intensive branches, despite the conservation that effectively took place.

When of the establishment of the oil conservation measures in industry, the following conditions prevailed in the energy market:

- Brazil imported 83 percent of its petroleum needs in 1980;
- the average cost of imported petroleum to Brasil was around $40 per barrel in 1980;
- In 1979, fuel oil was the most widely used petroleum product in Brasil, with its demand reaching 19 million m^3 (followed by diesel oil at 17.6 million); that also meant that fuel oil was the key to reducing petroleum imports.
- In 1980 Brazil was a net importer of fuel oil, having bought 1.1 million TOE of that fuel, in addition to domestic production.

By contrast, the conditions prevailing in the recent past and in the present are:

- Brazil imported 51 percent of its petroleum needs in 1984 and 40 percent in 1985;
- discovered oil and gas resources may accomodate a substantial expansion of domestic production through the next decade and beyond;
- the cost of petroleum in the world market is now under $20 per barrel;
- demand for fuel oil in 1984 was 9.9 million m^3, which is about half of that for diesel oil. Fuel oil has long ceased to be a factor limiting the reduction of petroleum imports;

• Since 1981 Brazil has been a net exporter of fuel oil. In 1984 net exports of that fuel were 2.9 million TOE.

The second indicator is that, notwithstanding the sharp replacement of fuel oil, there has been no overall decline in the energy intensity of Brazilian industry, despite significant achievements in energy conservation in individual sectors. The reduced energy intensity of many activities was offset by a change in the structure of the sector, with the energy-intensive products corresponding to an increasingly large share of sectoral output. The net effect of those changes is that the overall energy intensity of Brazilian industry has remained virtually constant in terms of final energy use per unit of value added. [22,23] Even though the process of recovery will modify the industrial structure, diminishing the relative importance of the food industry, in the short and medium terms it will mean increased production of steel, cement, aluminum, chemicals and paper, besides mining, all of which are energy-intensive activities; therefore, even though energy efficiency is likely to continue improving, the overall intensity may show little or no progress in the years to come. This indicates that, given a sustained economic growth and in the absence of subsidies to alternatives, the use of fuel oil could rapidly return to the levels observed in the late 1970s. Although there are some permanent elements in the process of substitution (e.g., the use of coal and natural gas in the iron and steel industry, and to some extent steam coal for cement as also wood for paper and pulp or bagasse in the neighbourhood of distilleries), fuel oil is likely to appear as the most economic alternative for most other energy-intensive activities.

What will be the role of the alternative fuels in the future? Electricity use, for one, is likely to revert to its pre-EGTD patterns. Its growth should happen in activities that have traditionally relied on electricity. Bagasse and natural gas will increase their penetration in several important markets, but this will be limited by their availability. Fuelwood (and charcoal), as well as coal, pose the most difficult questions. Expanded use of fuelwood and charcoal carries the threat of deforestation: unless strong measures are taken, commercial forests will not be developed in time to avoid destruction of a significant fraction of the existing native forests. Even more serious is the possibility that a continued decline of fuel oil prices (which may occur if its surplus increases) will induce a reconversion of industries to oil before development of planted forests and after deforestation has proceeded further.

The case of coal is more clear-cut: it has failed to penetrate markets without the support of several subsidies. This has become evident since most subsidies have been removed, bringing about the stagnation of production and consumption. It does not seem advisable to boost coal production again through artificial measures. Rather, what seems

appropriate is the establishment of a strategy for the rationalization of its production and use, while keeping a long-term perspective for its potential.

It seems clear that the role of fuel oil in industry will tend to increase over the next decade, after its near-elimination from the industrial market. However, it is neither likely nor wise to allow fuel oil to regain its pre-1979 share of industrial energy use. The most advisable strategy seems to be the diversification of the industrial energy sources, with bagasse and gas, as well as fuel oil, increasing somewhat their shares and a relative retreat of electricity, coal, charcoal and fuelwood. In the longer term, of course, electricity will increase in importance through the trend towards automation and computerization; but in the near future it will lose some ground.

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TABLE 1

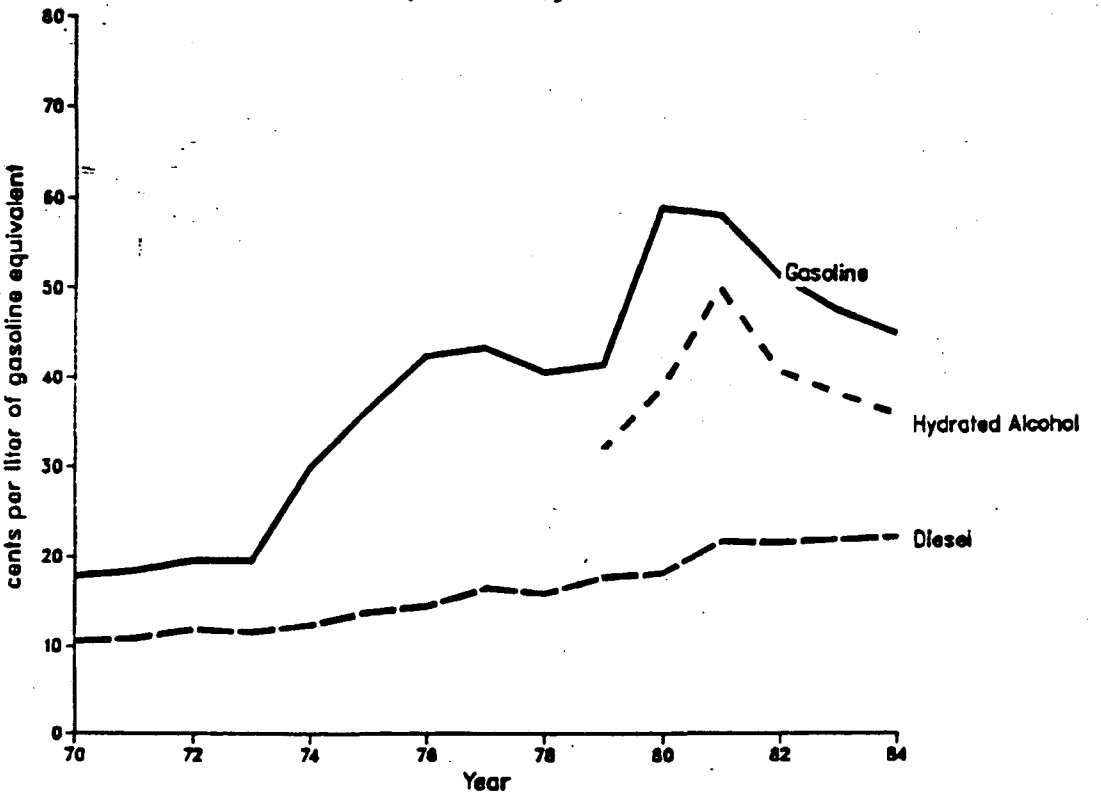
Year	Electricity Tariffs on June 1st (current US$ mills/kwh)					Ranking
	Residential	Industrial				
	200 kwh/month	1 MW, 30% LF	1 MW, 60% LF	25 MW, 60% LF	25 MW, 90% LF	Tariff Ratio (a)
1973	54.59	29.34	17.70	14.92	11.48	22
1979	58.43	34.61	21.24	17.35	13.49	23
1980	50.17	38.34	23.56	19.94	15.51	20
1981	52.20	47.96	30.72	25.69	20.51	16
1982	54.90	54.69	36.36	30.59	26.12	11
1983	38.94	38.16	25.86	22.06	19.04	11
1984	36.55	36.76	24.91	21.25	18.34	14
1985	25.14	27.79	18.83	16.06	13.86	11

Source: Eletrobras, **Comp. Intern. de Tar. de En. Elet. 1973/1985**

(a) This column gives the ranking of Brazil among 23 countries concerning the ratio between Residential and Industrial (25 MW, 90% Load Factor) electricity tariffs (1 is lowest ratio).

The ranking for 1973 covered only 22 countries, as the sample did not include Portugal that year; the total sample covered the following countries:Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Federal German Republic, France, Ghana, Ireland, Israel, Italy, Japan, Mexico, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America, and Uruguay.

Figure 1
Average Motor Fuel Prices to Consumers
(1984 US$)



Average Fuel Prices to
Industrial and Residential Consumers
(1984 US$)

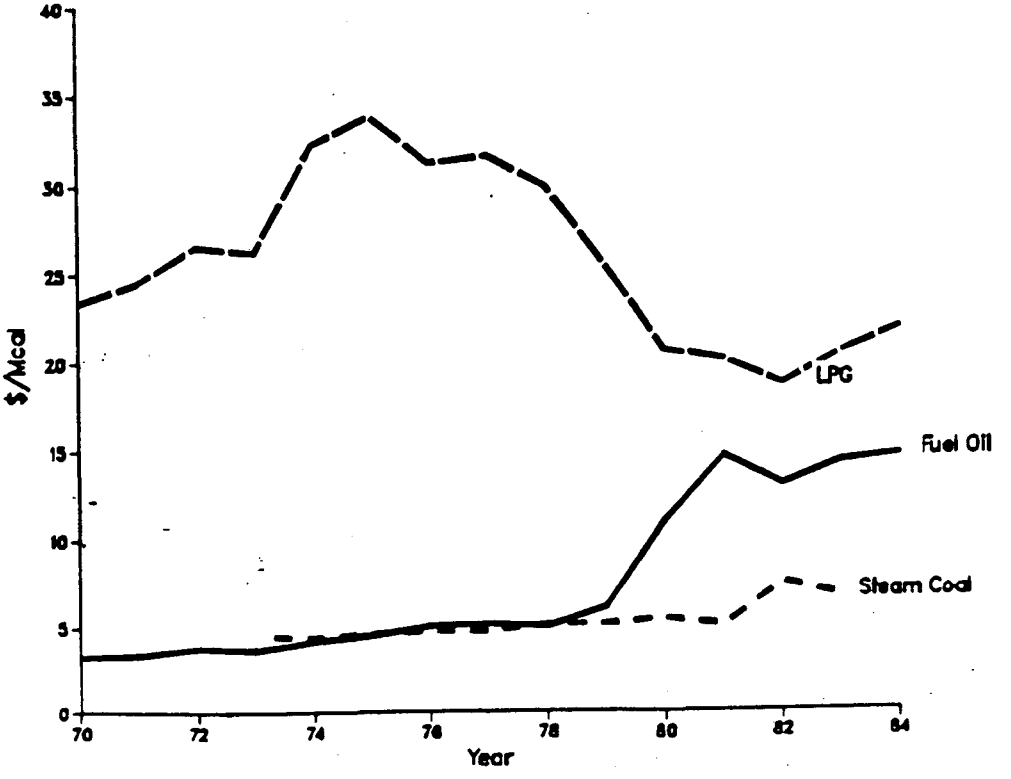
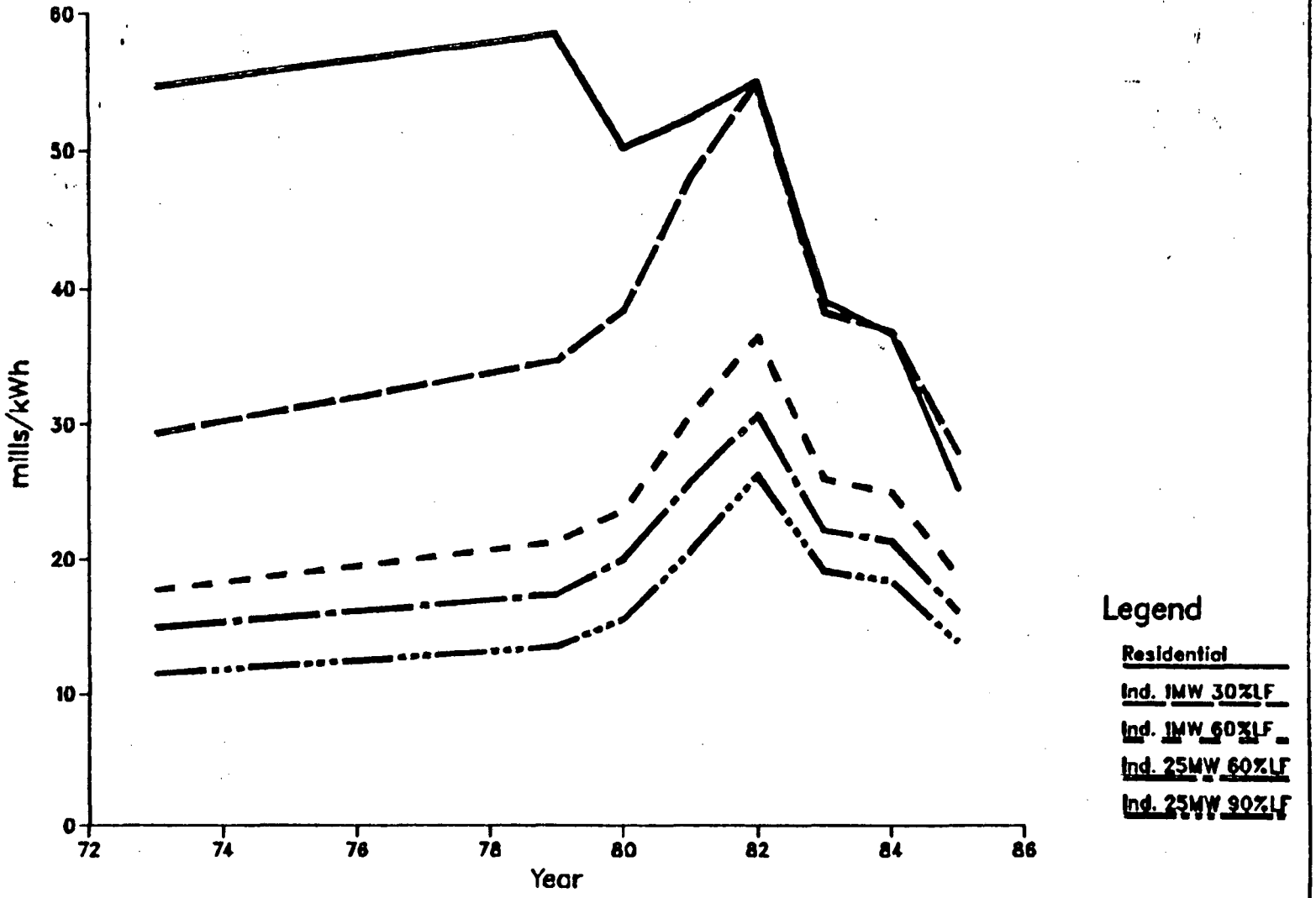


Figure 2
Electricity Rates on June 1st
(current US$ mills/kWh)



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