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ENERGY POLICY DEVELOPMENT FOR MOROCCO

A Report on a Cooperative Project
Between the Government of the Kingdom of Morocco
and the
United States Agency for International Development

Energy Directorate
Ministry of Energy and Mines

Development Sciences Inc.,
Technical Assistance Contractor, with
Energy and Environmental Engineering, Inc.

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PREFACE

This document reports on the current status of a cooperative project between the Direction de l'Energie, Ministry of Energy and Mines (MEM) of the Kingdom of Morocco and the United States Agency for International Development (USAID) aimed at strengthening the Directorate's energy planning capabilities. This project has been underway for almost four years. Intermediate accomplishments, both institutional and technical, have been encouraging. As a result, USAID has gradually increased the effort level for the technical assistance contract that forms part of the project.

Institutionally, the past few years have seen the emergence of a national energy planning unit in the Ministry's Energy Directorate, soon to assume a separate organizational identity. Staff members of the technical assistance contractor, Development Sciences Inc. (with a subcontract to and Environmental Engineering, Inc.), have been working with the MEM personnel assigned to the project in a truly integrated fashion, with both sides contributing to design, development, data collection, analysis and interpretation. In addition, the project has significantly contributed to the emergence of an energy "planning network" tying together planners in the Ministry and in the specialized energy agencies, the sous-tutelles.

Technically, one useful accomplishment has been the formulation and implementation of the EnVest planning support system, a microcomputer-based system for energy project appraisal and policy development. This system, a joint product of the two partners, incorporates a detailed data base on possible energy investment projects and the current status of the energy sector, and programs for data base management, project appraisal (under conditions of uncertainty), economic and demographic forecasting, energy demand analysis and forecasting under alternative pricing assumptions, and the assessment of the overall performance of a particular energy investment portfolio formulated over a 20-year time horizon. This planning support system will facilitate the development of specific energy investment plans. At the same time, it provides the means for very quick "what-if" assessments of alternative policy options in response to new developments. The structure and implementation of this system have proved of sufficient interest to energy planners elsewhere. For example, the adaptation of the EnVest planning support system to the specific policy problems in Costa Rica is now underway.

This report reflects the cooperative nature of the project. The prime technical assistance contractor, Development Sciences Inc., has been in change of report preparation and retains final responsibility for its contents. However, all members of the planning project have directly and indirectly contributed to the report, through data collection and analysis, software development, or through the preparation of materials used in various sections of the report. The project approach has therefore resulted in a fairly lengthy list of authors and contributors:

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A. Bencheqroun, the Deputy Director of Energy, has been responsible for the overall supervision of the project on the part of MEM, in addition to his significant substantive contributions to the formulation of the basic structure of the EnVest approach. As USAID (Washington) project officer, P. Baldwin has guided the project from its inception. J. Bever, now with USAID, has contributed much as the project's first resident director.

The Minister of Energy and Mines, M. Saadi, and the Director of Energy, A. Bouhaouli, have provided direction for the planning group through their questions and requests for information. Among the people in the Moroccan energy sector who have provided assistance and support to the project, we would like to single out the following individuals for special thanks: Messrs. Barrakad, Afsahi and Saber in the Energy Directorate; Messrs. Kettani, Nejjar, Hajjani, El Ghorfi and Fadili in the Office National de l'Electricite; Messrs. Douieb, Bennis, Debbagh, Marcil, Berrada, Hood (Bechtel), Isfaoun, and Oudghiri in the Office National de la Recherche et d'Exploitation Petroliere; Messrs. Aouad and Boudraa in Sococharbo; Messrs. Es-Sdiqui (who also contributed significantly to the conceptual stage in his former role as Director of Energy), Bouzid and Bennani-Smires in SNPP; M. Houdaigi in Charbonnages du Maroc; Messrs. Fakihani, M'Zabi, Ghozlani, Himy (RTI), Fabre (RTI), and McWilliams (A.T. Kearney) of the Centre pour le Developpement des Energies Renouvelables; M. Kerman at SCP; and M. Tahiri at the Ministry of Commerce, Industry and Tourism.

The project has benefited greatly from discussions with the USAID evaluation team which visited Rabat in May 1983, under the direction of D. Kohler from the Rand Corporation. Similarly, the intensive review sessions and discussions with our colleagues, especially M. Fonseca, A. Umana and H. Hesse in Costa Rica have resulted in many modifications of the analysis system, improving its overall performance and (we hope) usefulness.

We would also like to acknowledge the contributions and support of

the USAID Mission in Rabat. Both the current Mission Director, R. Chase, and his predecessor, H. Fleming have helped clarify policy issues and approaches. G. Bricker and J. Akhaloun have monitored the project for the Mission and have provided much-needed assistance to the resident and visiting short-term experts working on the project.

Needless to say, these acknowledgments are in no way meant to shift blame (or credit) for opinions, errors, or shortcomings. The final responsibility for any of these rests with the prime contractor, Development Sciences Inc.

Guide to the Report

The main body of the report is organized into two parts. The first part examines the substantive issues and decisions in energy policy making in Morocco. It reviews the energy situation, places it within the broader economic context, and examines recent policy trends as a background for appraising the progress on the project to date. The second part is more concerned with methods of energy planning. Following a brief review of the energy planner's toolbox, both for project analysis and for policy assessment through macro-system modeling, this part presents the philosophy and technical choices incorporated in the EnVest planning support system. This discussion summarizes many of the salient points, without examining them in great detail. More detailed discussions of specific issues are presented in a series of EnVest Technical Memoranda which deal with both methods and data preparation.

PART I:

THE ENERGY POLICY PROJECT -- BACKGROUND AND PROGRESS

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1.0 INTRODUCTION AND OVERVIEW

1.1 Historical Background of the Project

The formal beginning of this cooperative undertaking dates back to 1978. In that year, the US Agency for International Development responded to a request of the Ministry of Energy and Mines (MEM) of the Kingdom of Morocco and sponsored a visit of energy experts to Morocco. The purpose of this mission, which included representatives of USAID and of Development Sciences Inc., the University of Florida and of C.T. Main, was to discuss a long-range program of technical cooperation and assistance. This program now comprises three major components:

- enhancing the government's capabilities in the areas of energy policy development and conservation;
- contributing to the search for and exploitation of Morocco's hydrocarbon resources through technical assistance in the area of conventional energy, principally oil and natural gas, to the Office National de Recherches et d'Exploitations Petrolieres (ONAREP);
- encouraging the adaptation and demonstration of renewable energy technologies through technical support to the Centre pour le Developpement des Energies Renouvelables (CDER).

The principal technical assistance contractors in these three areas are, respectively: Development Sciences Inc., Bechtel National, Inc., and Research Triangle Institute.

The energy policy development and conservation project pursues one principal goal: to strengthen the capabilities of the Ministry of Energy and Mines in the area of national energy policy planning, analysis and decision making. This overall goal builds on several specific objectives, stated in the original Project Grant Agreement and subsequent amendments, which can be paraphrased as follows:

- to compile a comprehensive information base necessary for energy policy formulation and appraisal;
- to assess overall energy supply and demand strategies in the energy sector, as well as specific interventions;
- to assist in training personnel in the techniques and process of evaluating specific energy investment projects, technological options, investment programs, pricing policies, and other policy alternatives under different asssumptions about the overall economic context.

Accomplishments on the project to date in terms of each of these objectives have demonstrated significant progress toward the central goal. While improvements continue as the achievements so far are put to the test in actual policy practice, the Ministry of Energy and Mines today possesses an effective national energy planning capability that has strengthened its leadership role in energy policy making. This capability also facilitates

communication and interaction with the specialized energy agencies, and with the other government agencies concerned with other aspects of economic and social advancement for the country.

The MEM planning group, working as an integrated unit of Ministry staff and personnel of the technical assistance contractor, has adapted energy project evaluation techniques and national energy planning methods to the specific needs and conditions of Morocco. It has assembled a comprehensive data base on current energy production and consumption. It has also developed the framework for describing energy investment options representing different energy technologies in concrete terms, and has used this framework to characterize and analyze specific projects. This information base forms the core of an interactive system for energy policy development and appraisal, implemented as the EnVest system on Apple II+ microcomputers equipped with 5-megabyte hard disks .

The EnVest system represents a deliberate departure from the traditional macro-level (optimizing or satisficing) energy planning models. Rather, it is designed as a collection of data and analysis programs in support of a specific approach to energy planning. The EnVest system integrates institutional and analytical elements. MEM first formulated the institutional and conceptual structure of energy planning. The analytical procedures and data collection efforts, as well as the more general institutional development efforts, responded to that structure. The philosophy and implementation of this approach are discussed in greater detail in Part II (Section 3).

In mid-1983, USAID decided to commit sufficient resources for a long-term support of the project. As a result, the effort level on the active contract was increased to permit the addition of a resident analyst and data base manager to the Rabat office of the technical assistance contractor. A new contract, covering the period beyond September 1984, is expected to be awarded to the successful bidder by the fall of 1984.

1.2 Highlights of the Moroccan Energy Situation

Morocco's energy situation presents a difficult challenge. For its commercial energy supplies, the country depends to over 85 percent on imported petroleum. The remainder is accounted for by domestic coal, hydroelectricity, and (so far) small amounts of domestic natural gas and imported coal. Sections 2.1 and 2.2 provide more detailed information on the current situation and its economic implications. The opportunities for improving this situation are rather limited. They can be grouped into six major policy options (which are clearly not mutually exclusive):

- replacing some of the imported oil by cheaper imported coal;
- reducing the energy intensity of selected economic activities through energy conservation programs;
- finding and exploiting domestic natural gas and petroleum reserves;
- exploiting the country's vast oil shale reserves;

- increasing the role of renewable energy through an aggressive development program;
- introducing nuclear energy as a key element of electricity generation.

Common to the last four options is their high initial cost relative to the principal current alternative, importing oil, and the often considerable degree of uncertainty surrounding their prospects for success.

Because of that, short-term policies have focused on replacing imported oil with imported coal. The state-owned coal marketing agency, Sococharbo, a subsidiary of Charbonnages du Maroc has proved effective in encouraging and supporting the substitution of coal for fuel oil in industry, especially in the cement industry. As a result of these activities, the switching over of part of the Roches Noires (Casablanca) power plant, and of the in-construction conversion of Units III and IV of the Mohammedia power plant to burn coal, prospects for the immediate and distant future suggest a much more important role for imported coal, provided the country can develop its ports to allow for the larger freighters required to realize the potential.

Oil and gas exploration has been continuing for some time, under the aegis of ONAREP since that agency's inception in 1981. While Morocco has long been a producer of relatively small quantities of natural gas, discoveries in the Meskala basin look more promising. Current estimates place recoverable reserves at some 4.4 billion cu-m, corresponding to 600,000 cu-m/day for a period of 20 years, or the equivalent of over 180,000 tonnes of imported petroleum per year. While these estimates must remain preliminary, they suggest a reasonable potential for replacing some of the current petroleum products consumed with natural gas; the estimated annual production would correspond to roughly 20 percent of the 1982 industry consumption of fuel oil. Several international oil companies have formed joint ventures with ONAREP to engage in (mostly offshore) oil exploration.

Morocco is rich in oil shale. Its proven resources place it among the top tier of countries in the world. However, the costs of exploiting this resource anywhere at a commercial scale have proven too high relative to those of available alternatives. As a result, the necessary research and development efforts have slowed to a crawl in most countries, with many of the more prominent projects abandoned. Morocco, which had been pursuing a policy of supporting a domestic research program building on research in other countries, notably the U.S., finds itself now in the role of a technology leader. Its research program continues, both in the laboratory and in the form of a pilot plant for the T3 process developed in Morocco. Barring any technological breakthroughs, though, the cost of shale oil retorting remains too high to count on this option to replace imported oil, at least in the foreseeable future.

At the same time, other options of using the shale resources demand some consideration. Direct combustion of oil shale for electricity generation may be competitive in certain situations and at a certain scale of operation. Thus, the shale option may offer an answer to specific problems and imbalances. Overall, though, it is unlikely to have a significant

impact on the problem associated with the country's dependence on imported oil for another generation or so.

As far as one can determine with available data, the potential of energy conservation and fuel substitution in Morocco is reasonably high. In the industrial sector, relatively few plants account for the lion's share of consumption. Thus, programs focusing on a single operation may yield significant overall savings. Several studies, including one conducted by the World Bank, have identified such opportunities; in a few instances, they have already been followed by action. Virtually the entire cement industry of Morocco has taken steps to reduce its energy consumption and to substitute cheaper fuels for imported oil, primarily imported coal. A recent seminar on energy conservation in Moroccan industry (23 and 24 January 1984) provided ample evidence for the efforts undertaken by various enterprises to increase the efficiency of energy use.

At the same time, the absence of required information precludes even broad estimates of the potential gain from energy conservation in sectors with many small energy consumers, such as households or transportation. The country's effective prices of petroleum products, especially for the clean liquid fuels, have been high enough to encourage prudent use of these forms of energy. The situation is different for electricity; more economic pricing here could yield better usage. Thus, while there are undoubtedly opportunities for improving the efficiency of energy use in transportation and the household sector, the cost of achieving these savings may well be quite high.

What is lacking at this point is a comprehensive assessment of the potential of energy conservation at the national level, based on solid information on energy consumption patterns at the microlevel.

Morocco appears to offer some potential for introducing renewable energy in several sectors and subsectors. Conditions for utilizing solar and wind energy are rather favorable. Development of this option is again hampered by its economics, sometimes exacerbated by certain policy decisions. Renewable energy, aside from the continuing consumption of traditional fuels in rural areas, currently plays a negligible role in the overall energy picture in Morocco. It is likely to continue to play a minor role at the national level for the remainder of this century. However, with the right policy incentives and a national commitment to this option, it could develop into a significant factor in several submarkets.

Morocco is committed to the introduction of nuclear power. Several options are still under consideration relative to scale and timing, but the basic decision appears to have been made. A Centre National des Etudes Scientifiques et Techniques de l'Energie Nucleaire (CNESTEN) has been formed and a feasibility study for a 600 MW plant is underway. Morocco is hoping to use uranium extracted from its phosphates in nuclear power plants that are now expected to be needed (and economically feasible) in the 1990's to meet projected electricity demand. Unfortunately, recent developments in the technology of nuclear power have increased the cost of this option substantially. The scale of planning, constructing and operating a nuclear power plant in itself presents a challenge given the financial and technical resources of the country.

This overview could do little more than provide an impression of the major energy problems and policy options for Morocco. Each one of these problems and options will be examined in some detail in Section 2.

1.3 Prospects: Some Preliminary Findings

The work of the planning group so far has focused on the examination of specific questions and the appraisal of specific projects. The emphasis in our work on close cooperation with our colleagues in the various "sous-tutelles" assures realism and feasibility of the options considered, but also makes surprises less likely. Even so, a number of tentative conclusions have emerged from the options analyzed so far. In the interest of stimulating discussion and further examination, they are stated as contentions -- sometimes more strongly than the evidence in fact allows:

- Pricing electricity to reflect its economic costs better could conceivably result in a slowdown in the growth of electricity demand such that current expansion programs for the country's generation system might change;

- given the current price structure, demand for coal from industry is likely to increase sufficiently to keep demand for petroleum products nearly constant over a 20-year period; however, without adequate development of the port infrastructure, this demand could not be met; failure to upgrade the country's transportation infrastructure to support the change could result in additional costs and delays;

- given appropriate pricing (which may require changes in taxes and import duties) and a public sector commitment similar to that encouraging the use of coal, solar collectors could capture a significant share of certain market segments, notably hot water preparation in commercial, public, and urban residential buildings;

- while shale oil retorting is likely to remain too expensive an option through the end of the millennium, smaller-scale power plants using direct combustion of oil shale could be deployed to meet demand in small regional markets not connected to the grid;

- a combination of an aggressive reforestation program and the provision of alternative fuels (notably LPG) to rural areas is required to stem the decline of Morocco's forests.

Again, these statements are at least partially assertions, rather than fully supported findings. More experimentation with more comprehensive and more reliable data is clearly needed.

2.0 THE MOROCCAN ENERGY SITUATION

2.1 Overview: Morocco's Energy Balance

Overall energy production and consumption patterns in Morocco -- at least for the commercial energy forms -- can best be illustrated in the form of a simple energy balance. Table 2-1 shows such a simplified energy balance for the year 1982. This summary information highlights the overwhelming importance of imported oil in the Moroccan energy picture; it accounts for over 85 percent of total commercial energy.

Virtually all of the domestic coal, mined primarily in the form of fines from a single deposit at Jerada (see map in Figure 2-11 below), is used in a power plant located at the mine. In 1981, hydroelectric power acccounted for about 20 percent of total electricity generated. As a result of a lasting drought that began in that year, this percentage had dropped to some 6 percent by late 1983 -- at a time when strong demand continued, fueled in part by the increased energy needs for irrigation pumping. According to available estimates, the existing dams exploit about 40 percent of the country's hydro-capacity. However, many of the remaining sites seem to represent marginal investment opportunities, justified primarily in terms of their irrigation and water supply benefits.

The product slate of the nation's two refineries (SAMIR and SCP) explains the fact that Morocco both imports and exports petroleum products. The refineries produce more of the higher-value light products than the economy consumes. As a result, Morocco exports some of these light products, especially naphtha, the fraction from which gasolines are made.

Table 2-2 shows the distribution of total final consumption of commercial energy across major sectors of the economy. In 1982, industry accounted for over half of all commercial energy consumed. Transportation consumed over one-fifth of the total, most of it in the form of the lighter petroleum products.

The two tables are combined in graphical form in Figure 2-1 which tends to convey a much more striking impression of the dominant patterns than is apparent from the numbers alone.

The focus on commercial energy glosses over one important aspect of Morocco's energy policy problem: the "other energy crisis" -- the growing shortage of traditional household fuels, especially fuelwood and charcoal -- is no stranger to Morocco. So far, appraising the magnitude of this crisis has proved difficult. Estimates of the harvesting and consumption of fuelwood vary widely, ranging from about 2 million cu-m to about 11 million cu-m per year, or from about 500,000 TOE to some 3 million TOE.[1] Most of the recent studies seem to accept the higher estimates as more

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[1] See Appendix A for a brief discussion of the methods and sources used in estimating consumption patterns for commercial and traditional energy. TOE stands for tonnes of oil equivalent. Conversions and equivalencies in energy analysis are notoriously difficult and often inconsistent. Throughout this report and our empirical work, we are using the conversion factors shown in Appendix B.

Table 2 - 1
Morocco's Energy Balance, 1982
(in 1,000 TOE)

Source/Use	Gas	Oil	Electricity	Coal	Total
Primary Production	64	15	147	403	629
Imports	-	4,311	-	39	4,350
Stock Changes (-)	-	125	-	-9	116
Total	64	4,451	147	433	5,095
Thermal Generation	-	-1,030	1367	-337	0
Exports	-	267	-	21	288
Losses	-	91	281	-	372
Final Consumption	64	3,063	1,233	75	4,435
Total	64	3,421	1,514	96	5,095

Note: Conversion factors: 1000m³ natural gas = .759 TOE; 1T Jerada fines = .5 TOE
1 Gwh = 247.5 TOE; 1T Jerada fines= .74 TOE
1T Imported coal= .59 TOE

Table 2 - 2
Consumption by Sector, 1982
(in 1,000 TOE)

Sector	Gas	Oil	Electricity	Coal	Total
Agriculture	-	291	61	-	352
Industry	64	1,086	782	67	1,999
Transport & Services	-	1,075	41	-	1,116
Residential	-	611	349	8	968
Total	64	3,063	1,233	75	4,435

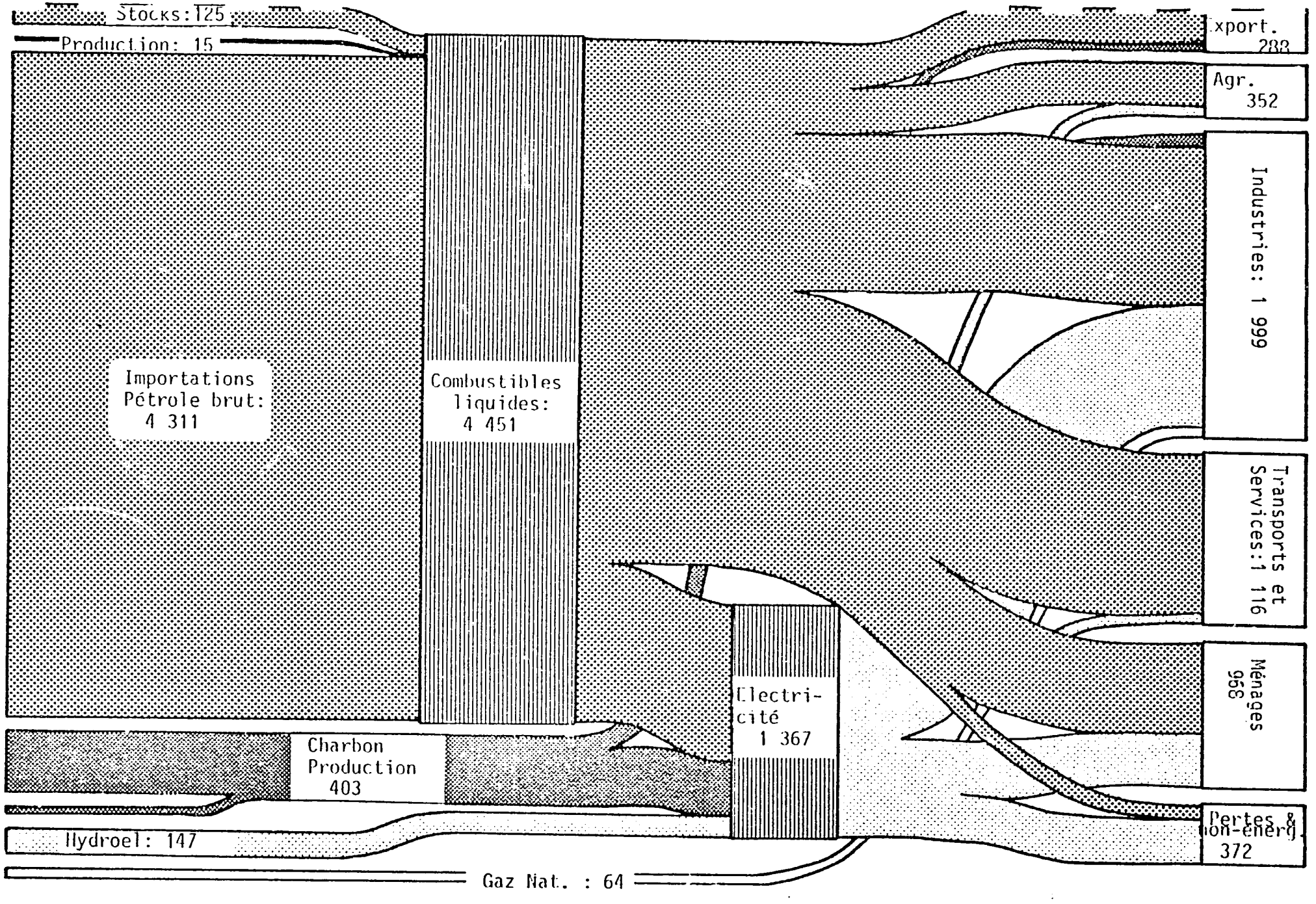

Figure 2-1: Energy Flows for Morocco, 1982 (in 1,000 TOE)

plausible, which are based on an assumed consumption of 0.8 cu-m per capita for the rural population, and 0.1 cu-m per capita for urban areas. At that level, traditional fuels would account for about three-fourths of the total energy consumed by households, or roughly one-third of the total energy used in Morocco. This pace of fuelwood consumption entails serious problems; it has been estimated to exceed the maximum allowable level -- to sustain existing forests -- by a factor of more than three. Figure 2-2 illustrates the composition of total energy consumption, including fuelwood and charcoal by major end user sectors.

Consumption of forestry resources for energy uses combines with other factors, such as overgrazing, to create significant long-term ecological problems. The "other energy crisis" thus by no means limits its worsening impacts to shortages in energy supplies. Moreover, coping with it requires approaches and policies different from those for commercial energy problems.

International comparisons show Morocco to be neither profligate nor particularly parsimonious with respect to energy consumption. A World Bank comparison places Morocco's energy consumption relative to GNP in the mid-range of countries with similar economic characteristics. The graphic illustration of the relationship between energy consumption per capita and per capita income in Figure 2-3 also shows Morocco in an about-average position.

2.2 Energy in the Economic Context

The level and patterns of energy use reflect economic and technological forces. Thus, Morocco's economic performance over the last decade or so establishes the background for the analysis of energy policy problems.

The fate of Morocco's economy over the last few years mirrors that of other oil-importing developing countries dependent on a few primary products for their export earnings. In 1982, the Gross Domestic Product (GDP) amounted to some 90 billion Dirhams, corresponding to a per capita figure of about US-$810.[2] Figure 2-4 shows the average annual growth rates of the GDP for four subperiods spanning the fifteen years between 1967 and 1982, together with the corresponding growth rates for total (commercial) energy consumption. In this analysis, GDP is measured in constant (1969) Dirhams.

Following a strong performance in the late 1960's and a relative slowdown in the first part of the 1970's, economic growth picked up again in the second half of the decade, with the economy growing at an average annual rate of 6.1 percent. (The total population grew at an average annual rate of 2.6 percent during the period 1971-1982.) Economic growth

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[2] Official estimates based on the 1982 Census place the population for that year at 20.4 million inhabitants. For a more detailed discussion of Moroccan population growth, the distribution of the population by economic region and type of residence, and the use of this information in demographic forecasting, see EnVest Technical Memorandum No. 4, "Economic and Demographic Forecasting in the EnVest System," December 15, 1983 (Working Draft).

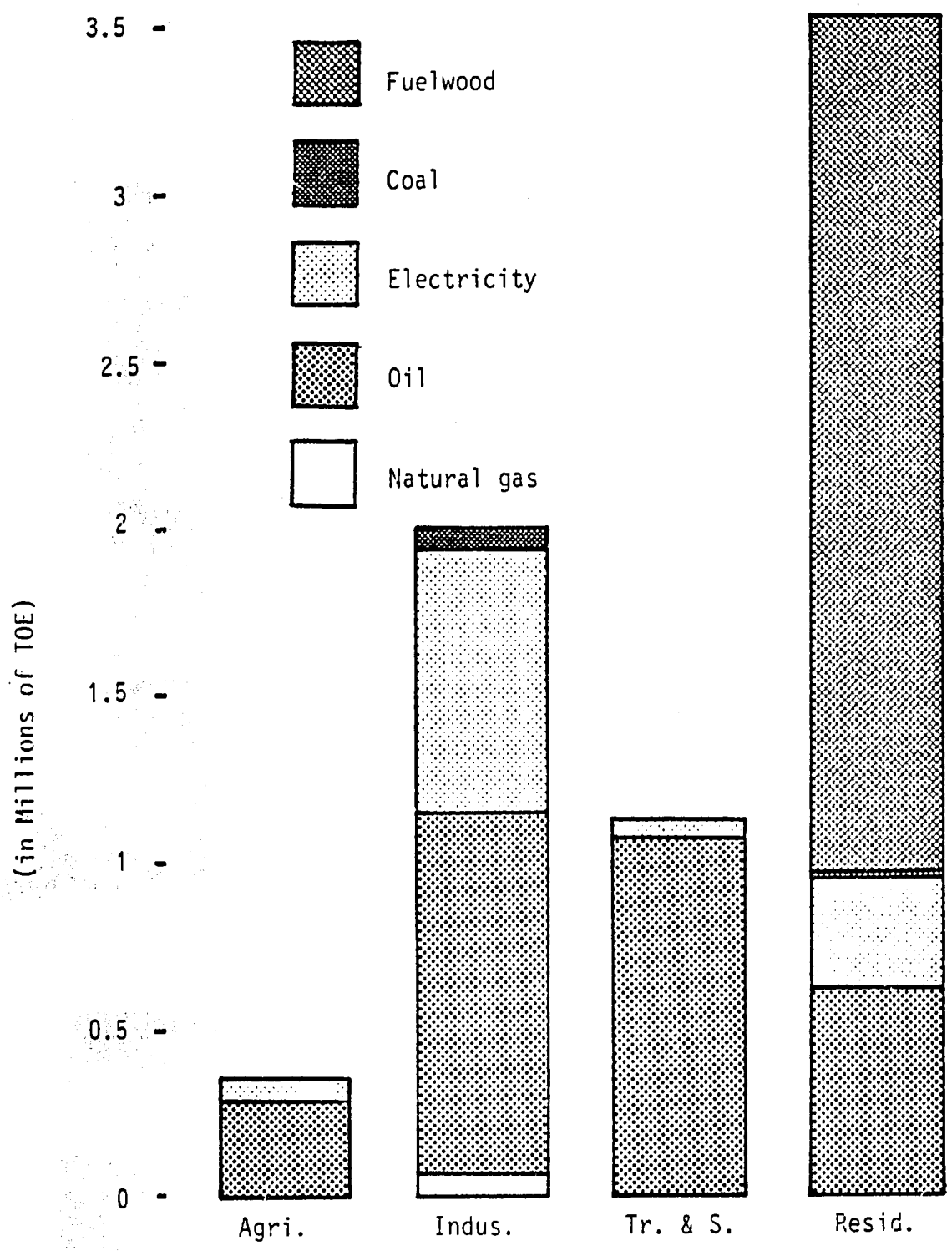

Figure 2-2:

Total Energy Consumption
by Major User Sector

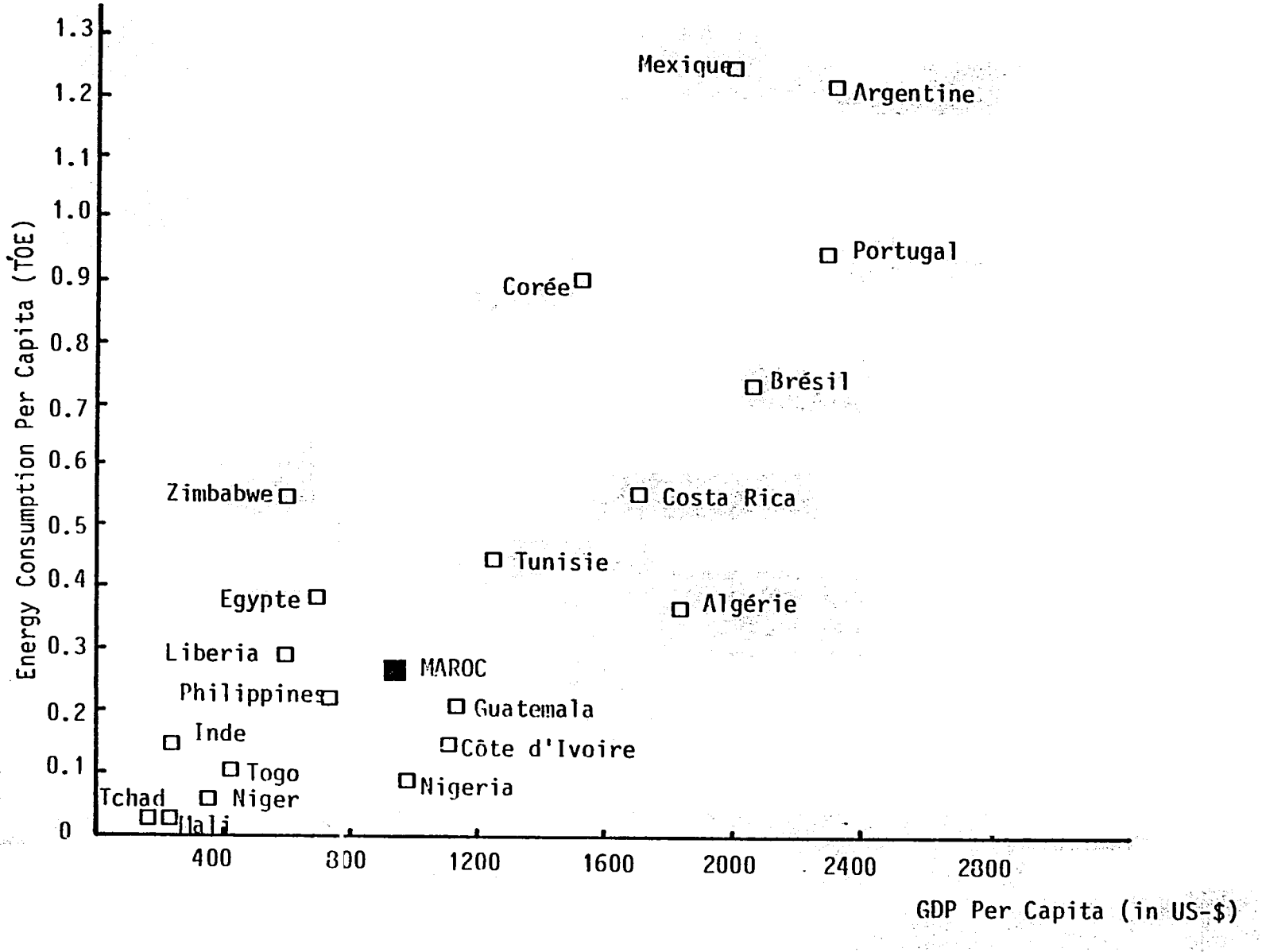

Figure 2 - 3: Energy Consumption Per Capita
vs GDP Per Capita (1980)

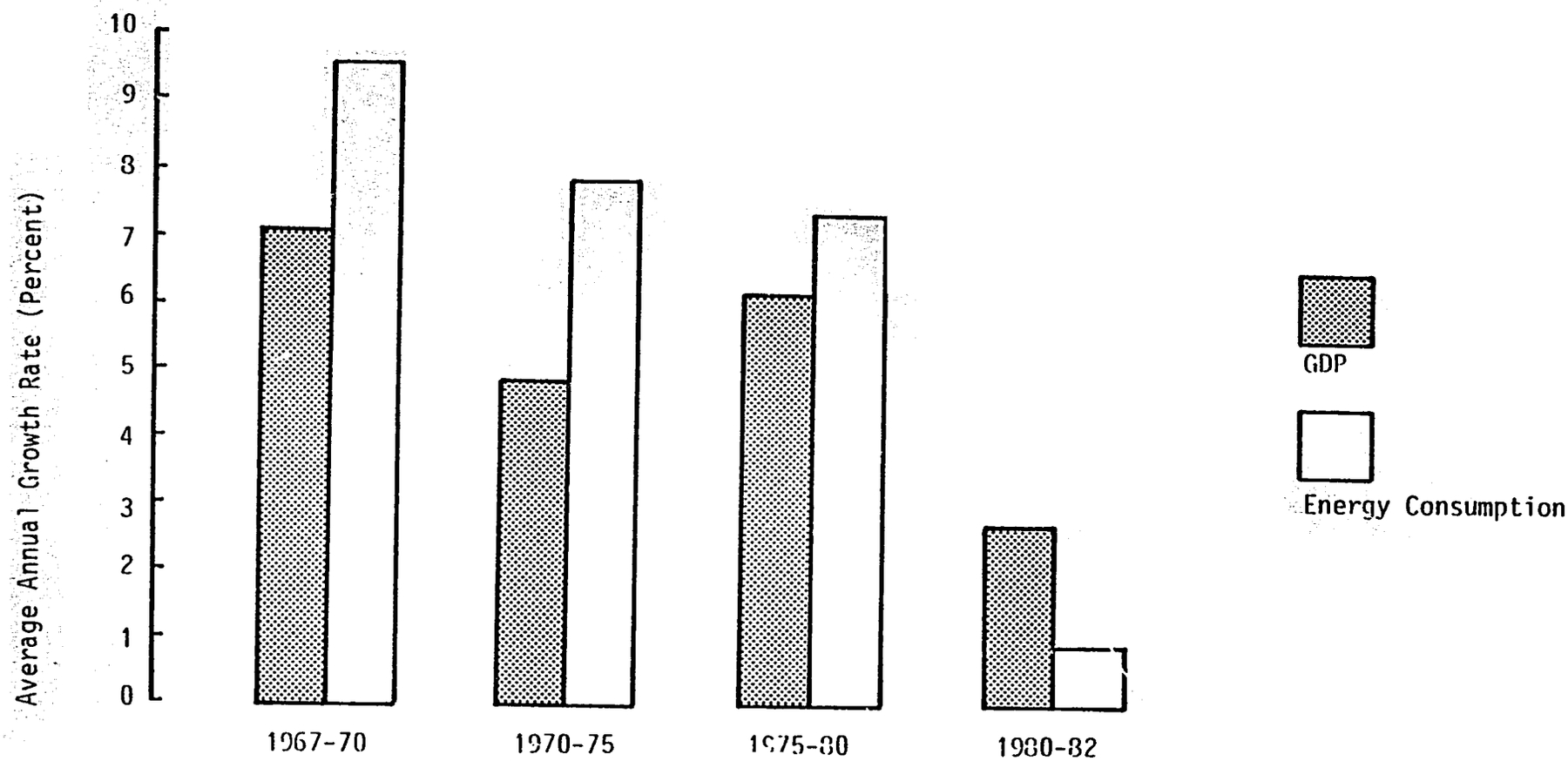

Figure 2 - 4: Growth Rates of Gross Domestic Product and Commercial Energy Consumption.

since 1980 has been curtailed by the worldwide recession and by a sustained drought affecting agriculture. Between 1980 and 1981, the Moroccan GDP actually fell by 1.3 percent. The partial recovery in 1982 was fueled primarily by agriculture, in spite of the drought, while stagnation continued in the industrial sector. Preliminary data for 1983 suggest somewhat of a reversal. Total GDP (in real terms) grew by only 0.6 percent, with agriculture registering a drop of 6 percent in its value added.

Until the early 1980's, growth in energy consumption outstripped economic growth. In the first half of the 1970's, total commercial energy consumption increased almost 3 percentage points per year faster than GDP. Following the first oil shock, the difference between the two growth rates declined to a little over 1 percentage point per year for the period 1975-1980. Even so, the energy intensity of economic activity continued to increase. In the harsher economic climate of the beginning 1980's, following the second oil price shock, though, energy use grew at a slower pace than the GDP. Between 1980 and 1982, energy intensity actually declined at an annual rate of 1.7 percent.

As in the case of other oil-importing developing countries, Morocco's foreign debt has grown apace in the last few years, from US-$919 million in 1972 to US-$11.6 billion in 1983, from less than 18 percent of GDP to some 82 percent. Over the same time period, annual debt service payments have increased by a factor of 15, from US-$103.5 million in 1972 to US-$1,590 million in 1983. In 1983, the debt service amounted to about 42 percent of export earnings and private transfers from abroad. This ratio is projected to increase to over 50 percent, after the recent debt rescheduling agreements.

The need to finance oil imports accounts for a major portion of the accumulation of external debt. Much of it, though, is a direct result of the country's development effort, as reflected in the relative magnitude of gross fixed investment. Figure 2-5 shows GDP and gross fixed investment, both in constant 1969 Dirhams, over the period 1967 to 1982. Until 1975, gross fixed investment (formation brute de capitale fixe) accounted for less than 15 percent of GDP. Encouraged in part by the sharp increase in export earnings as a result of the increases in world market prices for phosphates, the investment percentage jumped to 23 percent in 1975, to peak at almost 29 percent in 1977, and to level off to about 21 percent in 1982. An increasing share of total investment is undertaken by the public sector, often with little return in the short run.

In conjunction with its international agreements on debt rescheduling and a standby credit from the International Monetary Fund, the government has taken action to address some of the key problems. The measures included a clampdown on imports in the spring of 1983, as well as a series of price increases for various goods, including energy products. In fact, energy price increases in January 1984 were a contributing factor to the unrest Morocco experienced earlier this year.

As part of the recent austerity program, public investment budgets have been slashed, along with less severe cutbacks for operating budgets. In mid-1983, the government revised the budget, reducing total planned expenditures by some 12.5 percent. Much of this reduction was accomplished by cutting the investment allocation by some 27 percent for the government

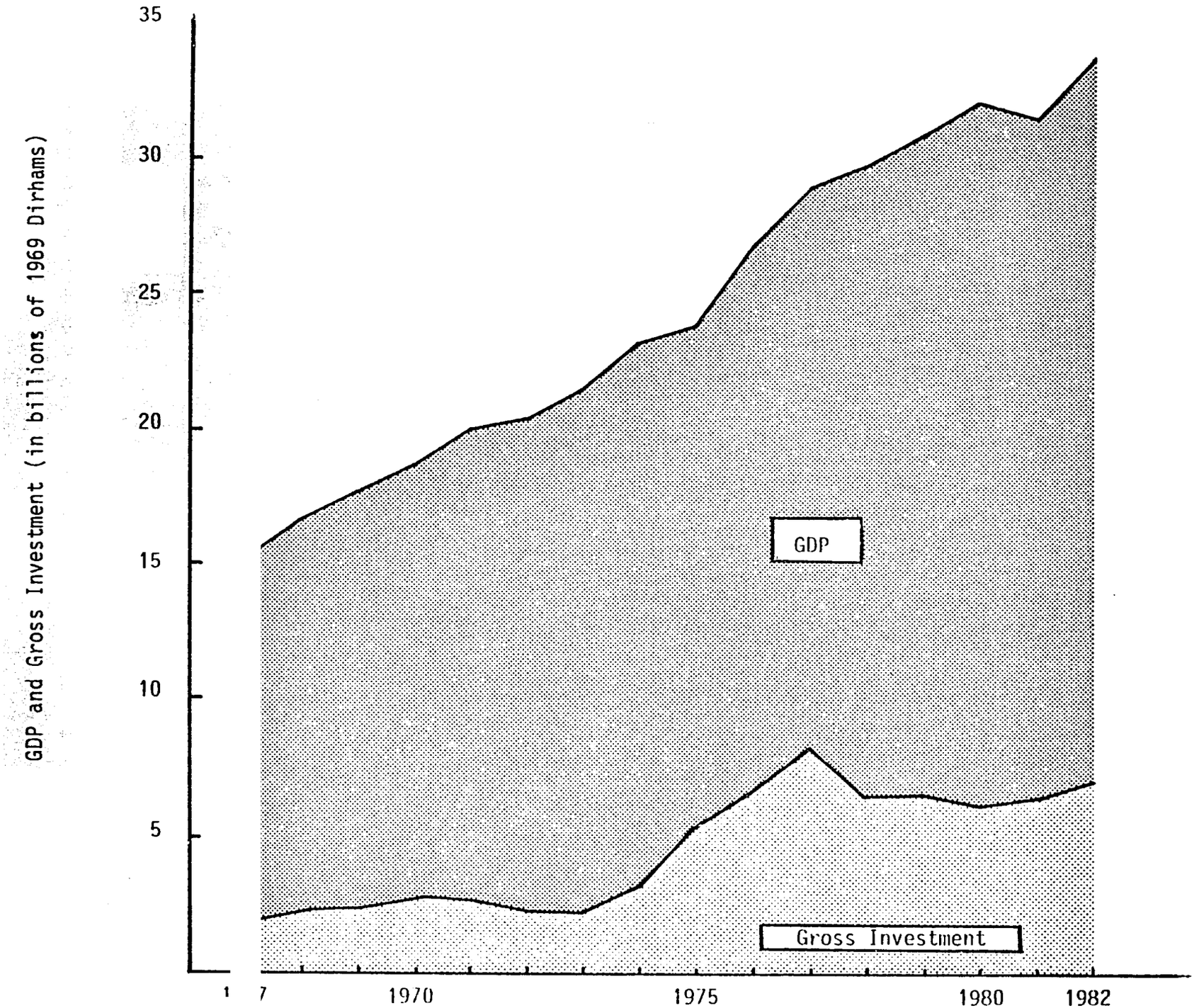

Figure 2 - 5 : GDP and Gross Investment

as a whole. MEM's investment budget fared reasonably well, with a below-average reduction of 18 percent. Reductions of about one-third are now contemplated for the investment program for the period 1984 and beyond. In the energy field, the Dchar el Oued dam may be affected.

Phosphates and phosphate-based products remain Morocco's most important foreign exchange earner. Morocco is the leading exporter, accounting for about one-third of the world market. However, worsening terms of trade have cut into receipts. Figure 2-6 compares export earnings from phosphates and other minerals (including products) and the cost of importing oil. For the first time, outlays for oil imports exceeded earnings from phosphates and minerals in 1982. This relationship has worsened as a result of the stronger dollar. Since mid-1982, the dollar has gained about 50 percent against the Dirham, exacerbating the burden of sustaining necessary imports and servicing existing debts. As late as 1978, a ton of phosphates purchased almost two barrels of oil. By now, the relationship is approaching an even trade -- a ton of phosphates for a barrel of oil.

Morocco has sought to address these problems in a number of ways. The strict import controls imposed in the spring of 1983 -- subsequently relaxed somewhat to prevent lasting damage to sectors of the economy dependent on imports -- improved the foreign trade situation. At the same time, efforts are underway to try and stem the continuing slide in the world market price of phosphates, possibly through commodity price agreements. However, even under fairly optimistic assumptions about Morocco's export performance, its financing requirements (the "residual gap") are projected to be in the order of US-$1.5 to US-$2.0 billion for the years 1985 to 1987.

Structural changes in the Moroccan economy have increased the importance of the industrial sector relative to agriculture, while the share of services has remained stable. Industrial growth has occurred primarily in agro-industry and the chemical industry. These structural changes have helped shape energy consumption patterns, given the differences among economic sectors in terms of energy intensity. Total energy consumption in 1982 for fourteen sectors defined on the basis of the 1975 input-output matrix for the Moroccan economy is shown in Figure 2-7.[3] Figure 2-8 illustrates energy consumption in TOE per Dirham of (estimated) value added for these fourteen sectors. Two sectors stand out: "Mineraux de carriere", which includes the energy-intensive cement factories, and "Transports". In the latter, energy consumption has been defined net of private transportation use, which has been allocated to households.

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[3] For a description of the procedure used to define these sectors, and a discussion of the underlying data, see EnVest Technical Memorandum No. 4, "Economic and Demographic Forecasting in the EnVest System," (Working Draft), December 15, 1983.

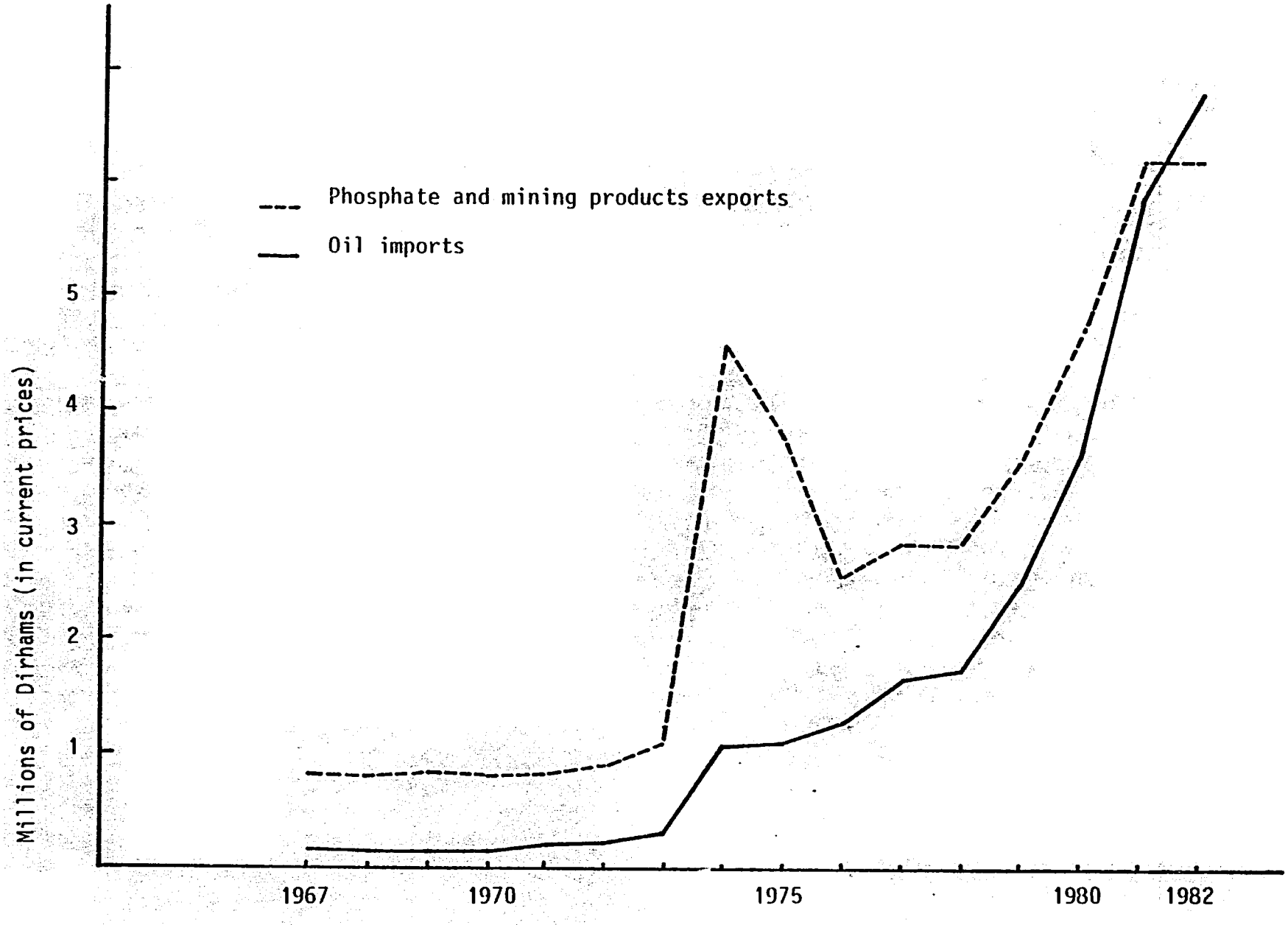
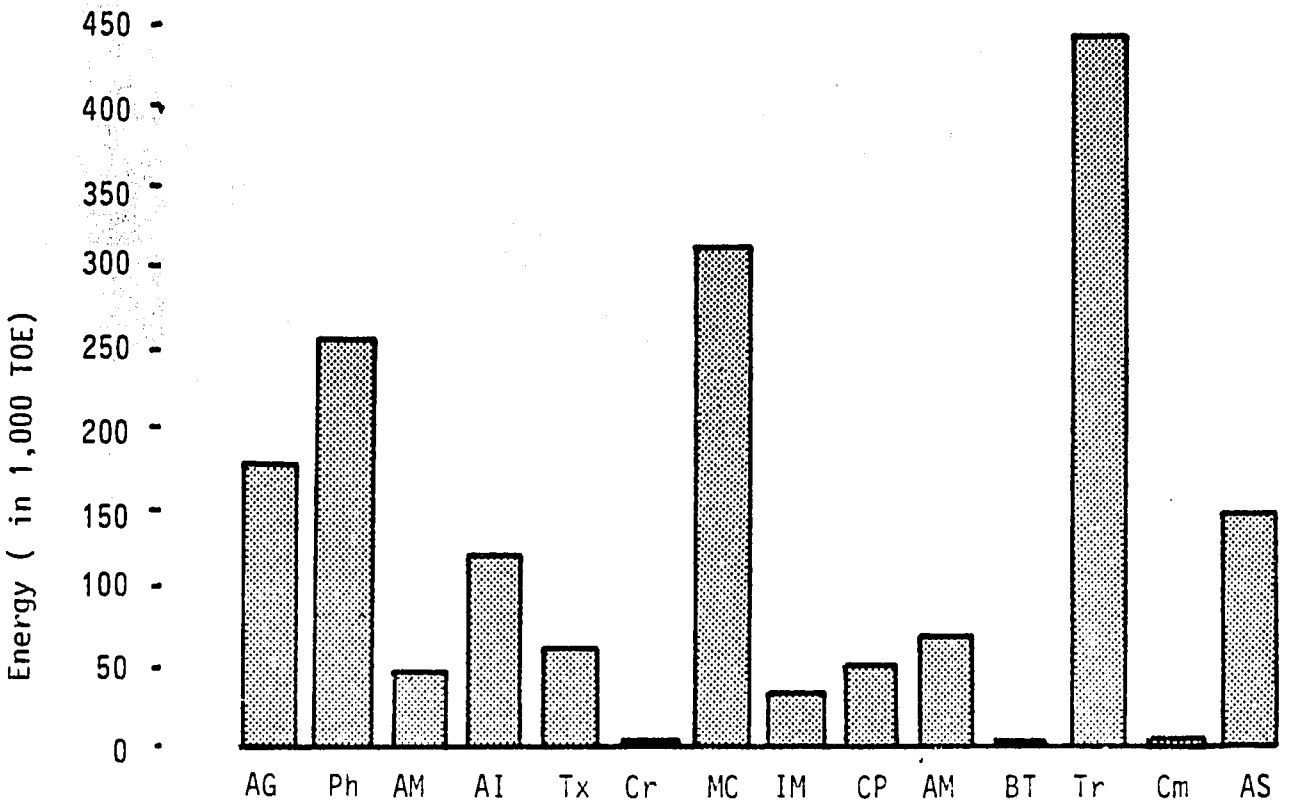


Figure 2-6: Export Earnings from Phosphate and Mining Products vs Cost of Imported Oil.

Figure 2-7:

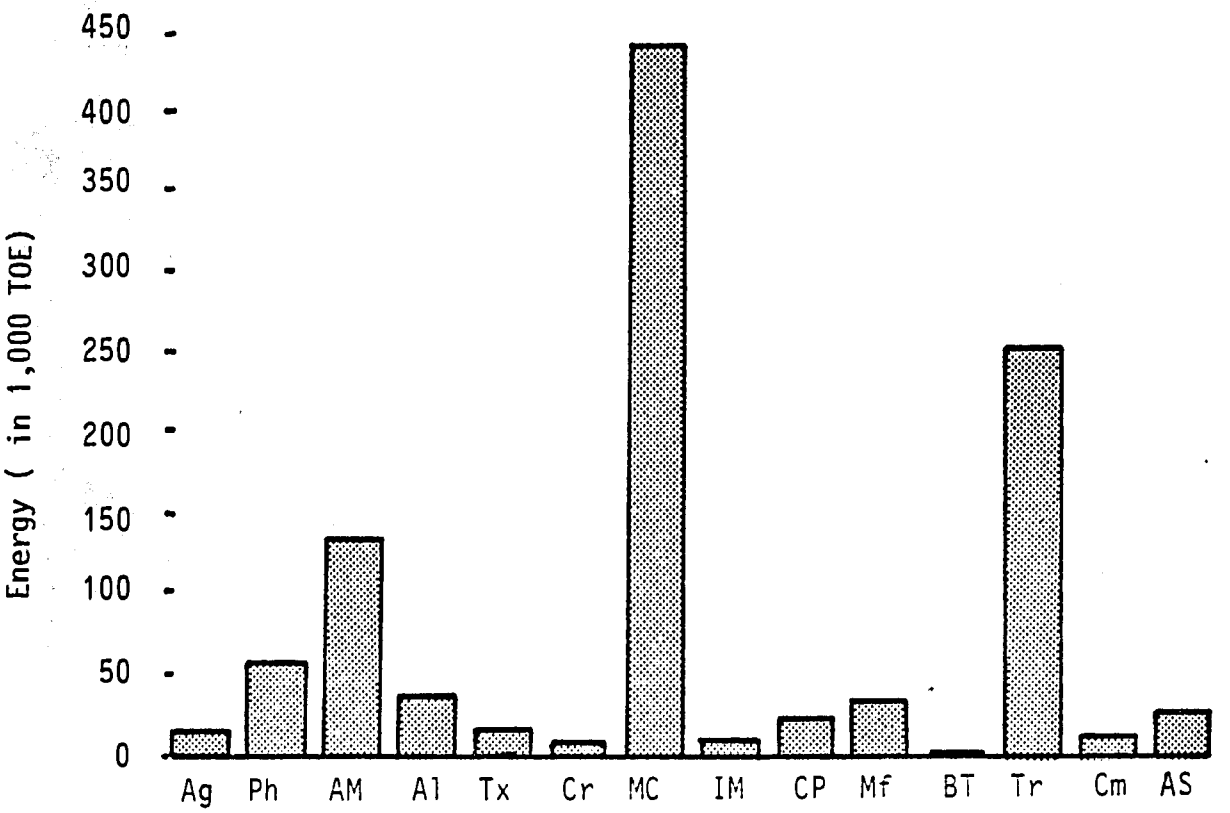
Total Energy Consumption
by Economic Sector,
1982



Ag: Agriculture
Ph: Phosphates
AM: Autres Minerais
AI: Agro-Industrie
Tx: Textiles
Cr: Cuir
MC: Minéraux de Carrière
IM: Industrie Mécanique et Electrique
CP: Chimie, Parachimie
Mf: Autres Manufactures
BT: Bâtiments et T.P.
Tr: Transports
Cm: Communications
AS: Autres Services Marchands

Figure 2-8:

Energy Consumption by Sector
per Billion DH Value Added



Ag: Agriculture
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Table 2-3
Characteristics of Thermal Power

Power Plant	Unit and Nominal Capacity	Fuel	Technical Minimum	Fuel Consumption at Nominal Capacity	TJ/GWh at Technical Minimum	Scheduled Maintenance (Days/Year)	Forced Outage Rate (%)
Jerada	3x55MW	C	40	11.640	12.980	40	15
Roches Noires II	1x60MW	C	40	10.426	11.724	30	15
Roches Noires III	1x60MW	F	10	10.342	11.933	21	15
Kénitra	4x75MW	F	25	10.478	11.933	21	15
Mohammedia I & II	2x150MW	F	45	9.002	10.258	21	15
Mohammedia III & IV	2x150MW	C	60	9.421	10.677	21	15
Turbines à Gaz							
Agadir I	20	F	-	13.482	-	12	20
Agadir II	20	F	-	13.859	-	12	20
Tanger I	20	F	-	13.482	-	12	20
Tanger II	20	F	-	13.854	-	12	20
Tétouan I	20	F	-	13.357	-	12	20
Tétouan II	20	F	-	14.068	-	12	20
Timhadite		S	80.100	12.770	11.724	?	?

2.3 Components of the Energy Sector

2.3.1 The Electricity Sector

Electricity accounts for a growing percentage of total final consumption of energy. In 1981, it represented some 24 percent of the total; for 1982, this percentage had grown to 28 percent, corresponding to a total of about 4,979 GWh. Most of this total, roughly 87 percent, is produced by the Office National de l'Electricite (ONE) and sold directly or through a network of local regies.

Thermal generation accounts for a growing proportion of total electricity production. The significance of hydropower has been shrinking. In 1950, hydroelectric installations generated 85 percent of Morocco's electricity. By 1980, this percentage had declined to 32 percent. The sustained drought further reduced the contribution of hydro power to about 10 percent in 1982 -- barely equalling the total system's transmission losses -- and even less in 1983. As the drought abates, the contribution of the 20 dams (with an installed capacity of 602 MW) to the country's electricity production will rise again. Over the long run, though, the role of hydropower will be limited, especially since more of the water will be used for irrigation purposes. Morocco's energy investment plans include the development of multipurpose dams, since existing installations exploit only an estimated 40 percent of the country's hydro capacity. However, concerns about their economic viability and tight budget constraints have delayed the realization of these plans.

As illustrated in the map in Figure 2-9, the majority of the thermal power stations is located along Morocco's Atlantic coast. The principal exception is the Jerada power plant, which is located at the mine whose coal it uses.

Table 2-3 summarizes the key characteristics of the country's existing thermal power plants, including units III and IV of Mohammedia expected to come on line in late 1984 and early 1985. With the completion of these two units and the re-conversion of the Casablanca plant (Roches Noires) to coal, the country's electricity sector is about to reduce its dependency on fuel oil significantly. Percentage figures are difficult to calculate, since they depend on the degree to which each type of plant is used. However, coal might account for as much as 50 percent of fuels used in electricity, from less than 20 percent now. Since domestic coal production at present is barely sufficient to satisfy the needs of the Jerada plant, the shift toward coal means substitution of imported coal for imported oil.[4] As discussed further below, this change portends increased demands on the country's transportation infrastructure, especially its ports. Massive coal shipments are planned to come through the new port of Jorf Lasfar, the completion of which has been delayed in part by the cuts of investment budgets. Consequently, Mohammedia III and IV will actually start out burning fuel oil. Other scenarios are under consideration to bring in sufficient coal through existing ports.

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[4] As discussed below, efforts are underway to develop additional coal deposits in the Jerada area, and to increase production from the existing mine.

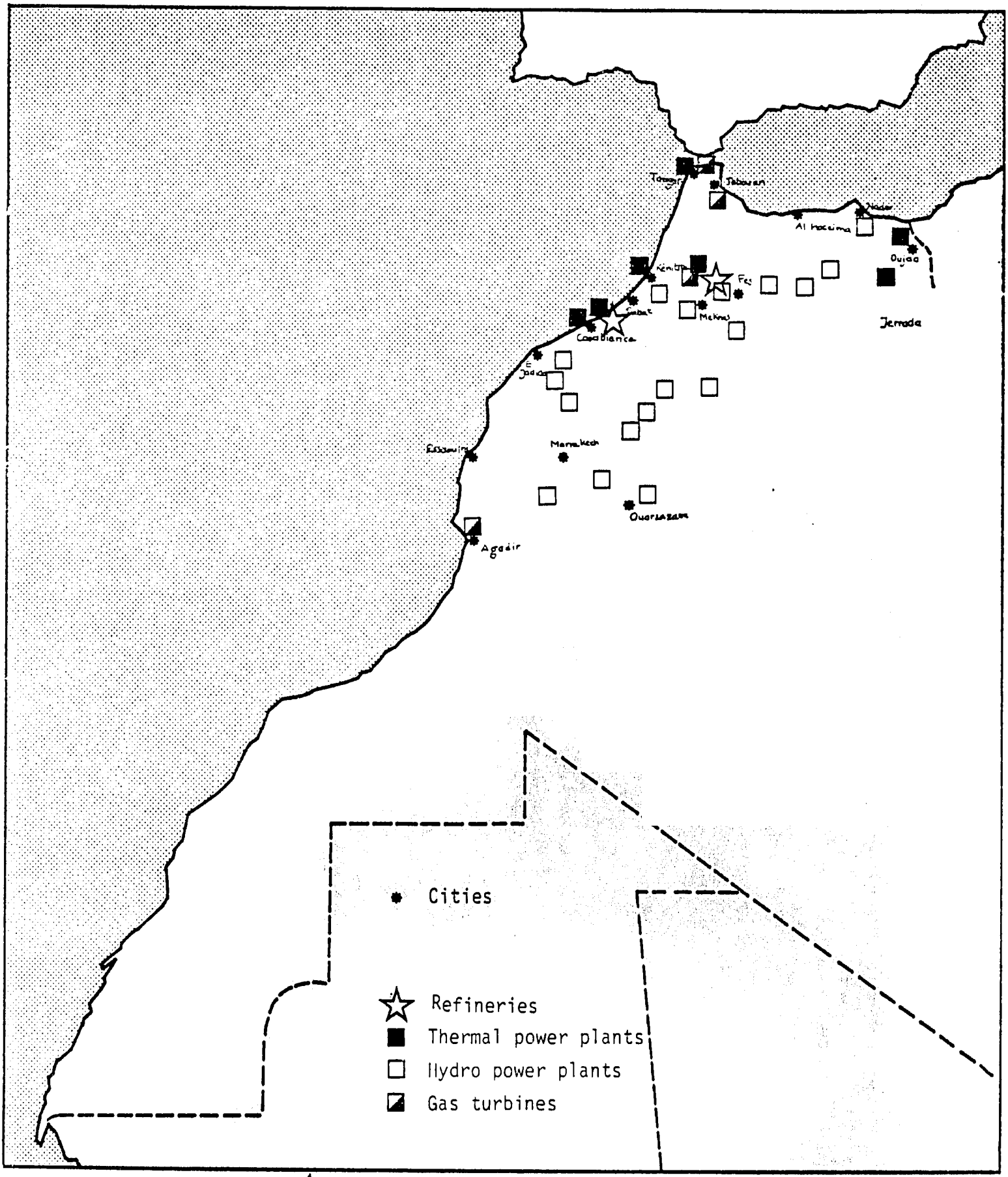

Figure 2-9: Morocco's Power Plants and Refineries.

Figure 2-10 shows the distribution of total electricity consumption across the sectors used in the energy consumption analysis and forecasting, along with energy consumption per sectoral unit (value added or persons). Among the industrial sectors, mining (Autres mineraux) and quarry products, especially cement, (Mineraux de carriere) show the highest intensity of electricity use per Dirham of value added. Urban households and Phosphates are the biggest consumers of electricity.

2.3.2 Petroleum Products

Figure 2-1 illustrates the overwhelming importance of oil in Morocco's energy system. Imported oil accounts for over 85 percent of total (commercial) energy consumption, mostly as liquid fuel, but also through its share of electricity production.

Morocco has been producing a small amount of crude from domestic sources. However, the known deposits are virtually exhausted, as reflected in the declining production. Annual production peaked in 1963, at 149,000 tonnes. Current production is slightly more than 10 percent of that -- 17,500 tonnes in 1981. Until recently, exploration for oil received little attention from outside organizations. A parastatal agency, the Bureau des Recherches et Participations Minieres (BRPM), continued exploration at a limited effort level. In the last few years, though, interest has grown. BRPM's successor organization in the field of oil and gas exploration, the Office National de Recherches et d'Exploitations Petrolieres (ONAREP) has signed joint venture agreements with several oil companies for continued exploration: Arco, and Mobil for off-shore Agadir, Amoco in the Mediterranean and the Rif area, and the Kuwait Foreign Petroleum Corporation (KFPC) for on-shore exploration. At the same time, on-shore hydrocarbon exploration continues, focusing primarily on natural gas, with financial support of USAID and the World Bank. The map in Figure 2-11 shows the geographical distribution of energy resources in Morocco, including the areas selected as promising for oil and gas exploration.

Imported (and the small quantity of domestic) crude is refined in the nation's two refineries. The larger installation, SAMIR, is located at Mohammedia with port facilities (which handle practically all the imports), and the smaller SCP refinery at Sidi Kacem. SAMIR can process up to 5,750,000 tonnes of crude per year, while SCP has a capacity of some 1 million tonnes. Figure 2-12 sketches their technical characteristics.

Thus, total refinery capacity in fact exceeds Morocco's needs. It reflects expectations of much higher growth rates in energy consumption, formulated in the 1970's. These expectations[5] led to a fairly aggressive program of capacity expansion in the second half of the 1970's, primarily focused on the SAMIR refinery.

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[5] In 1974, several organizations prepared estimates of the total 1981 refinery throughput; these estimates ranged from 6 to 7.8 million TOE. Actual throughput amounted to 4.2 million TOE.

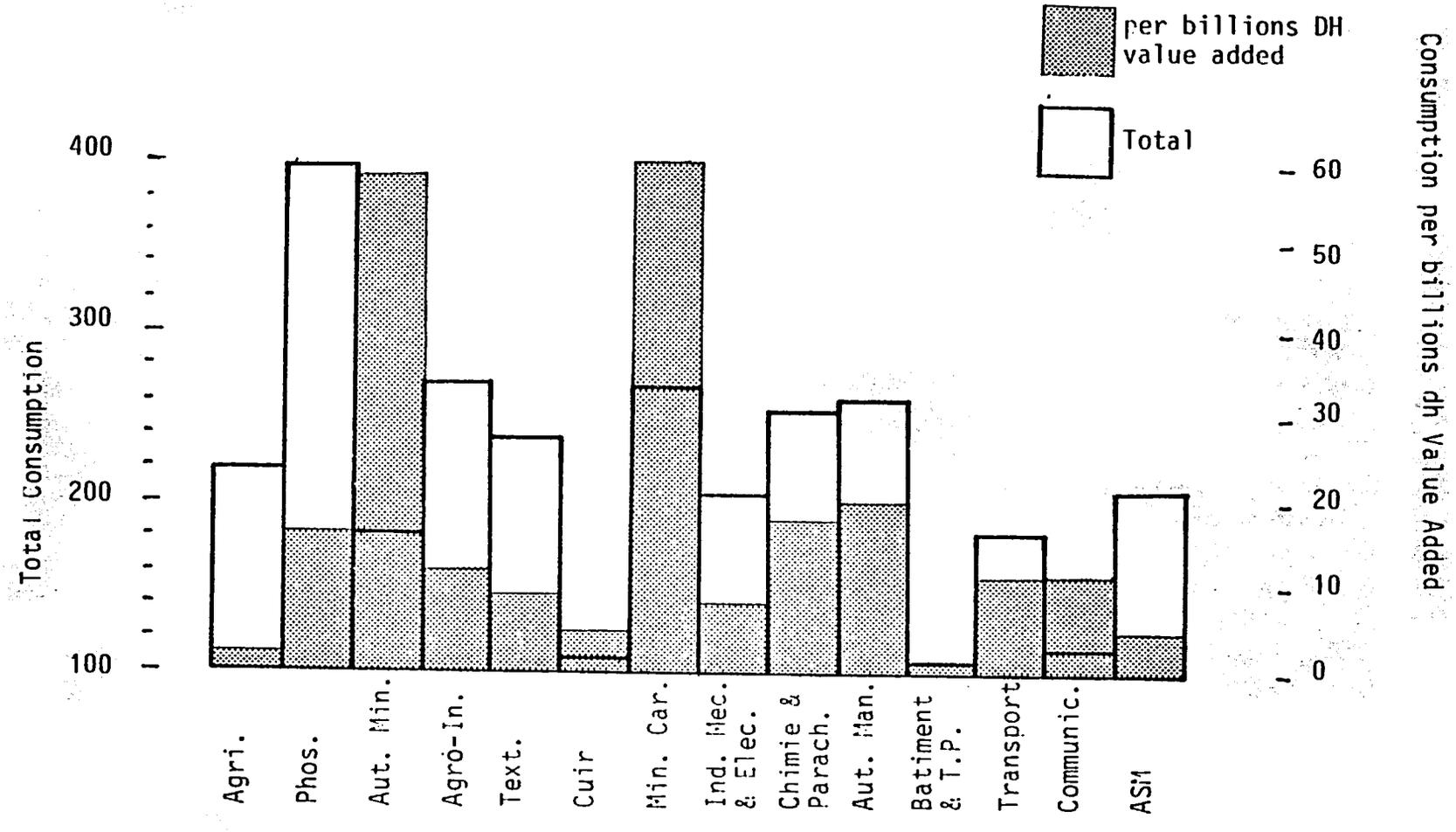


Figure 2-10: Electricity Consumption by Sector, 1982
(in 1,000 TOE)

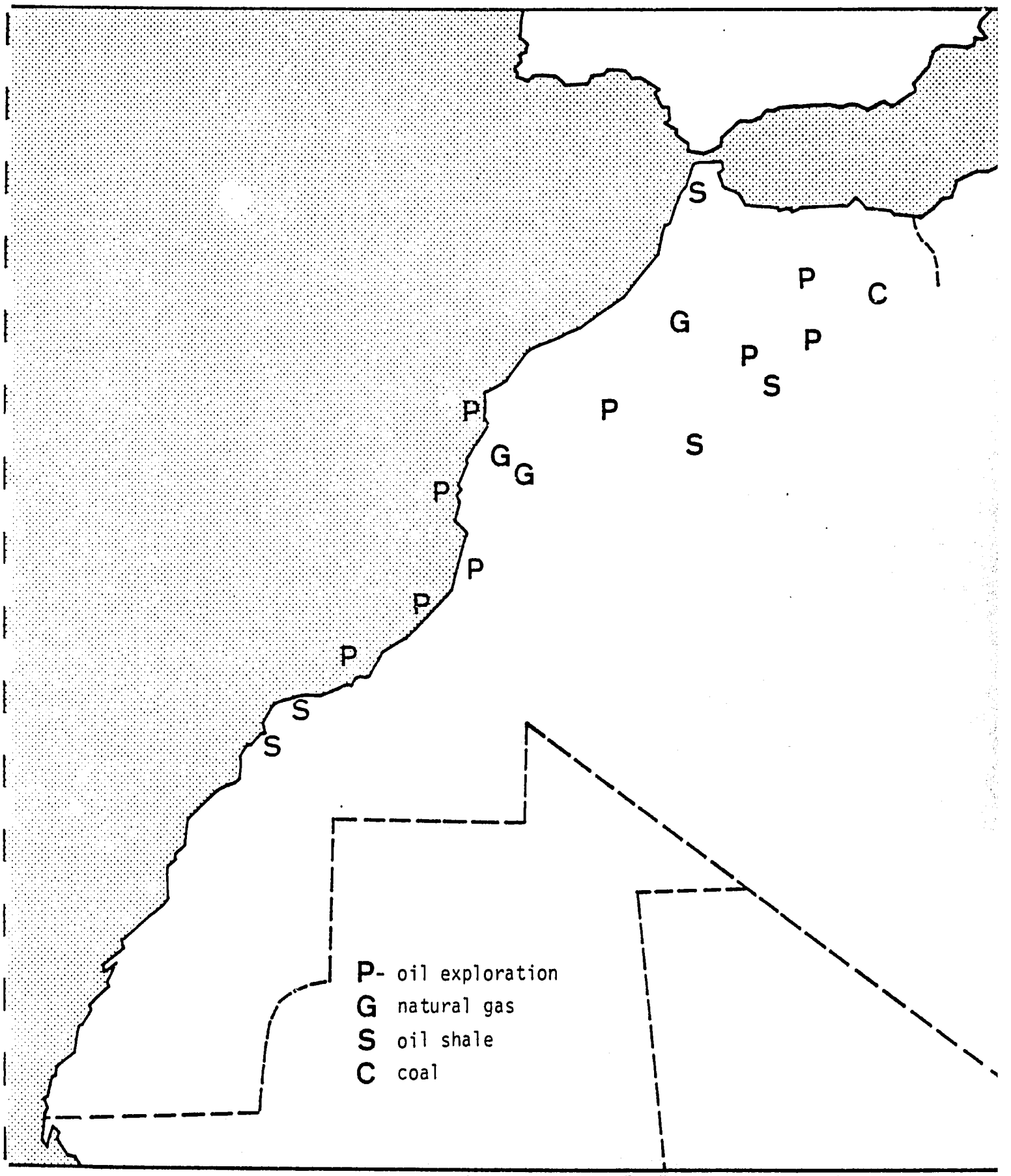
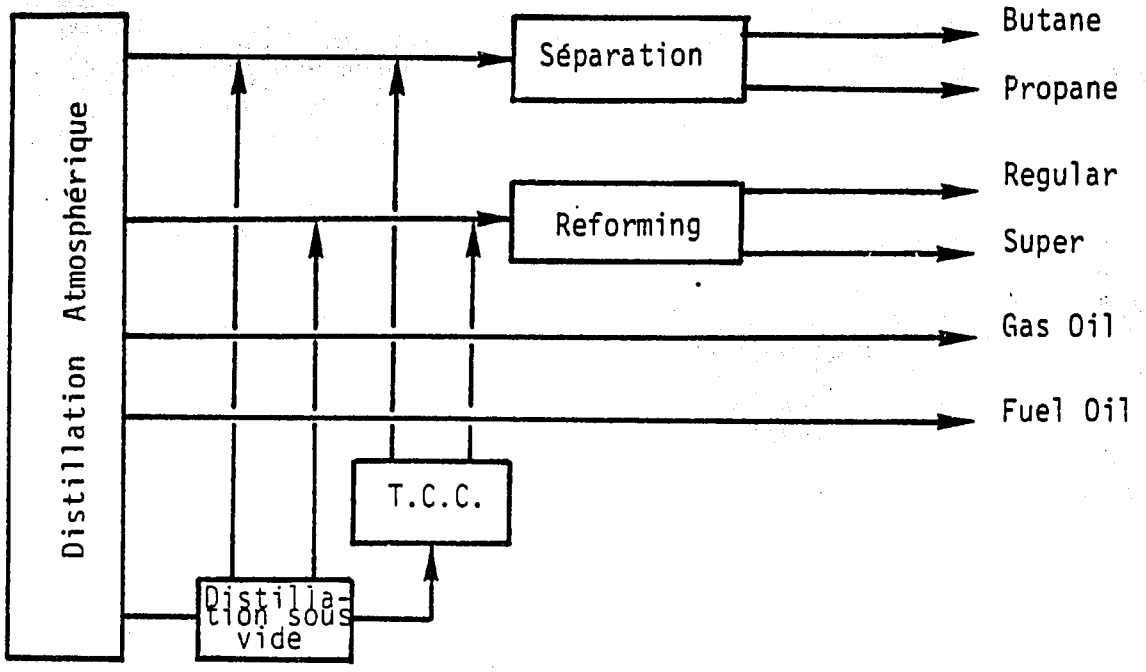


Figure 2-11: Morocco's Energy Resources

SCP



SAMIR

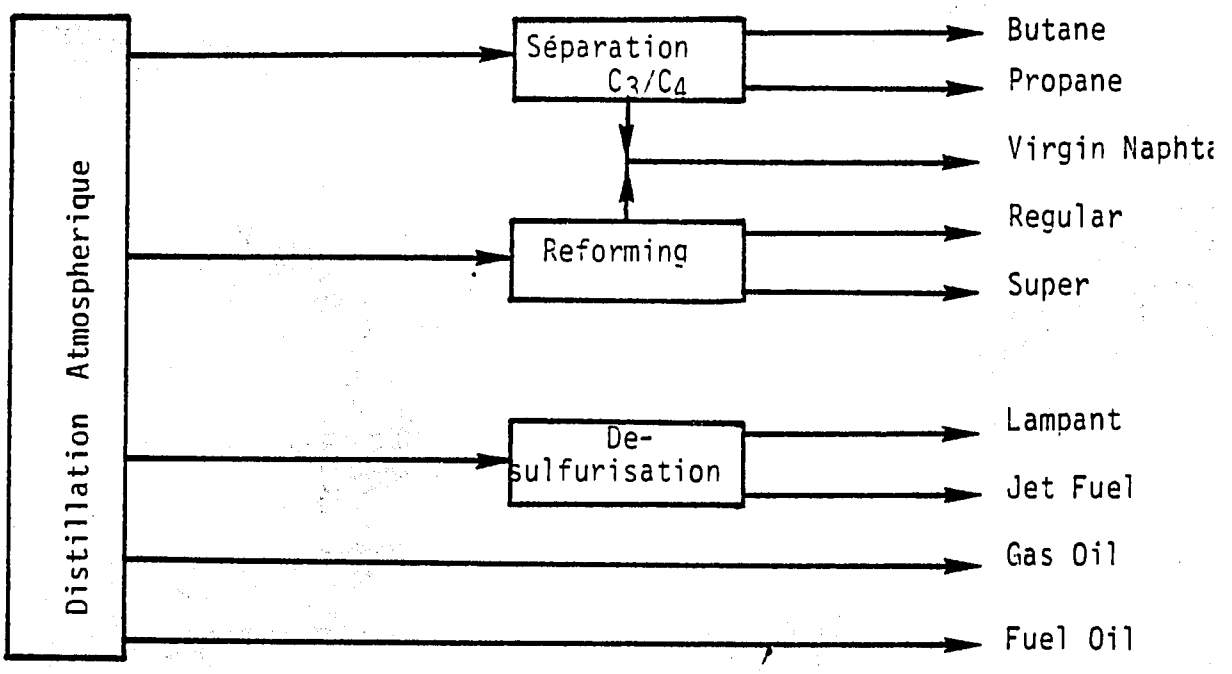


Figure 2-12 : Refinery Characteristics

Table 2-4 shows the product slate for the two refineries for the year 1981. Overall, fuel oil accounts for 44 percent of total production, corresponding closely to its share in total consumption. Even so, the share of the lighter products remains too high, resulting in the need to export some of it, primarily in the form of naphtha. As programs now underway designed to conserve energy in industry, and to replace fuel oil with imported coal begin to show results, the share of fuel oil in total petroleum product consumption will fall. At some point, it may necessitate technical changes in refinery processes to increase the share of clean liquid fuels, especially diesel (gas oil).

Figure 2-13 illustrates the importance of the transportation sector in total final demand for refined products. However, energy intensity is higher in "Mineraux de carriere" (cement plants). Figure 2-14 illustrates the composition of final demand for major refined-product categories; the total excludes fuel oil used in electricity generation.

2.3.3 Natural Gas

Natural gas is a potentially bright spot in the Moroccan energy picture. Morocco has been producing small quantities of natural gas at a reasonably steady rate, corresponding to about 64,000 TOE in both 1981 and 1982.

In addition, exploitation can begin in the Toukimt field with estimated recoverable reserves of some 200 million cu-m, allowing an annual production of about 30,000 TOE for a period of 7 to 8 years. Both well and surface installations are in place. Actual production is awaiting resolution of specific marketing issues; the most likely consumer is the Asmar cement plant, located close to Marrakesh, about 120 km from the gas field. Its annual energy consumption corresponds to the potential production of Toukimt. A pipeline could be constructed to furnish gas from the field to the cement plant. Unfortunately, in over a year of negotiations, no agreement has been reached on the price of the gas. Thus, other options are now considered, including the original plan of selling the gas to the Office Cherifien des Phosphates (OCP).[6]

Finally, exploration efforts succeeded in 1981 in locating a significant gas field in the Meskala basin (adjacent to Toukimt, but apparently geologically separate). While first estimates of reserves and production potential have proved to be somewhat optimistic, it still appears that the Meskala field could yield significant savings in imported petroleum. The most recent estimates -- which continue to be subject to considerable uncertainty -- place recoverable reserves at some 4.4 million cu-m, for an annual production of about 600,000 cu-m/day, the equivalent of roughly 180,000 TOE per year. Thus, the two fields, Toukimt and Meskala, together may be able to produce as much as 210,000 TOE per year, corresponding to just about 10 percent of the total consumption of fuel oil, or over 20

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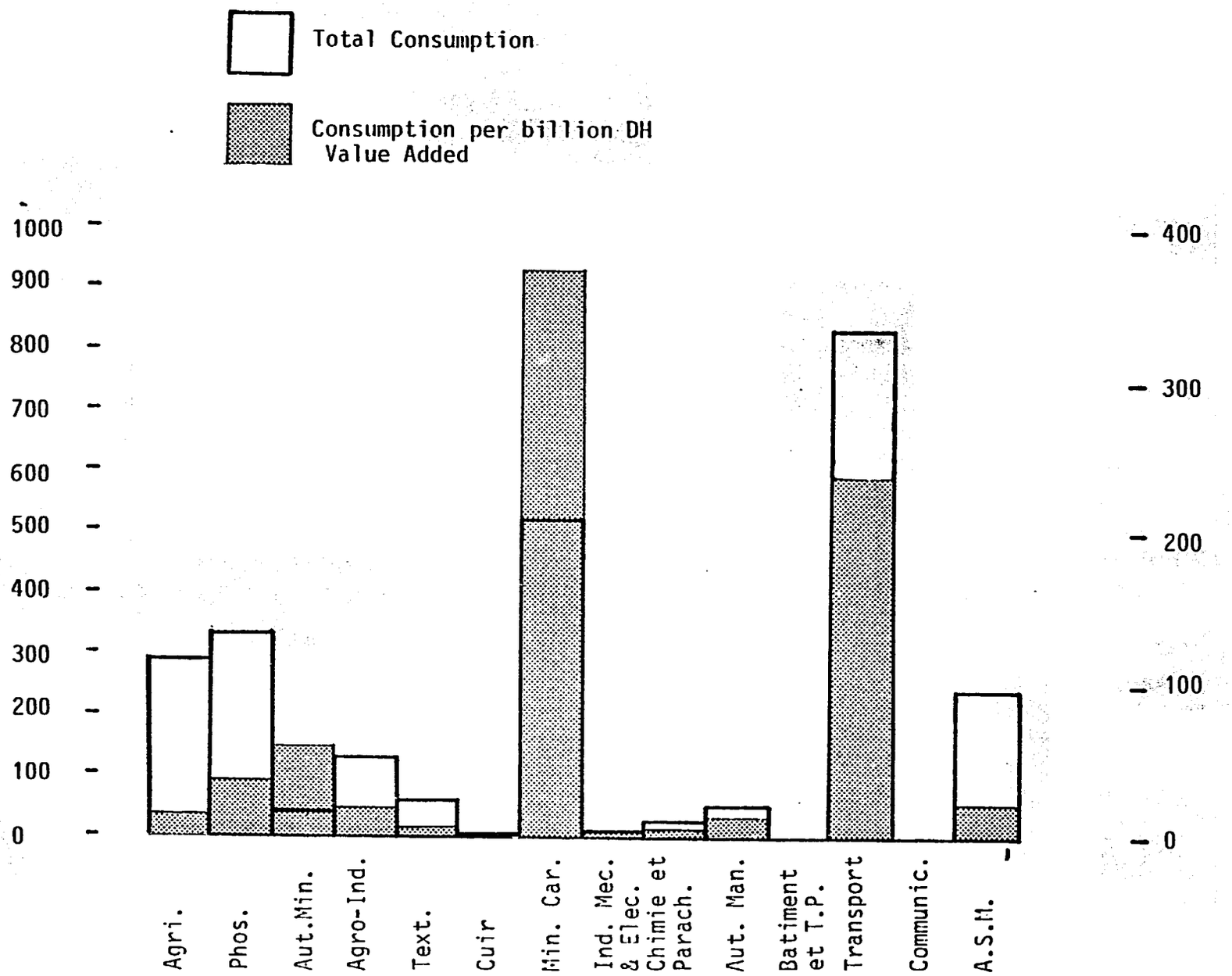
[6] Cf. EnVest Technical Memorandum No. 1, "Economic Analysis of the Toukimt-Asmar Pipeline Project," (August 11, 1983) and Addendum 1, September 20, 1983, for a more detailed discussion of the production and pricing options. See also the pricing discussion below.

Table 2 - 4

Product Slate for Moroccan Refineries, 1982
(in Percent of Total Output)

Product	SAMIR	SCP	Total
Propane	0.6	0.9	0.7
Butane	3.8	4.5	3.8
Gasoline	8.5	10.2	9.0
(-Normal)	(3.0)	(3.8)	(3.2)
(-Super)	(5.5)	(6.4)	(5.8)
Jet Fuel	5.8	0.0	4.5
Kerosene	0.8	3.5	1.4
Diesel/Gas Oil	28.7	36.5	30.5
Fuel Oil	45.1	44.3	45.0
Virgin Naphta	3.9	0.0	3.0
Bituminous	2.7	0.0	2.1
Total crude processed (t)	3,291,825	1,024,081	4,315,906

Figure 2-13: Petroleum Products Consumption by Sector, 1982 (in 1,000 TOE)



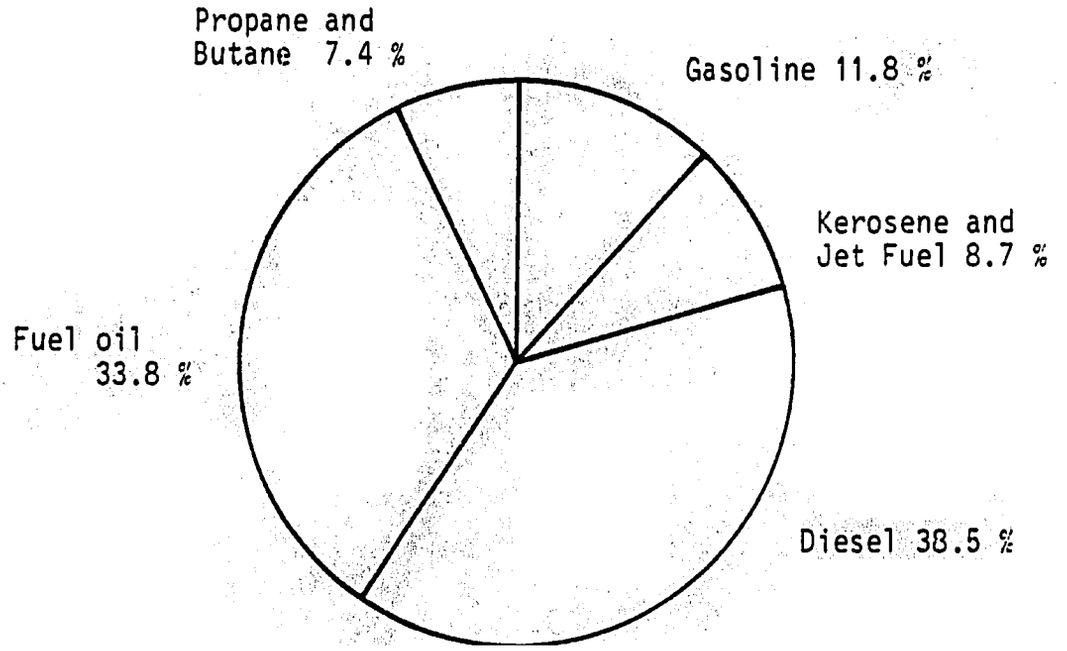


Figure 2-14 : Final Consumption of Petroleum Products

percent of industrial fuel oil consumption.

The gas in both fields is also rich in condensates, offering another opportunity for reducing Morocco's dependence on imported oil. Exactly in what manner these resources can and should be exploited remains a central problem of national energy policies for Morocco. The technical options are vast, including a shift toward LPG production, and an accelerated exploitation of condensates. Choosing among these options to design the most appropriate production path depends on economic prospects in various regional and sectoral user markets for these products. Determining these prospects is hampered, in turn, by the remaining uncertainties regarding the size and other characteristics of the Meskala field. At the lower end of potential production, transportation costs per unit become significant. These costs limit the geographic size of the effective market. Since there are only a few potential users within a "reasonable" radius of the Meskala and Toukimt fields, market conditions often resemble those of a monopsony, that is, with a single firm on the demand side. The practical problems of such a situation have been illustrated by the negotiations between ONAREP and the Asmar cement plant.

Until the exploration efforts have succeeded in assessing total reserves and possible annual production levels from the Meskala field, appraisals of policy alternatives incorporating natural gas in a key role must remain tentative. Yet, at the same time, continuing uncertainties by no means obviate the need for examining such alternatives along with more pessimistic scenarios.

2.3.4 Coal

Until recently, Morocco has imported little coal. It has relied on its one mine at Jerada to produce coal for the mine-mouth power plant. The power plant burns primarily fines, which account for some 80 percent of the anthracite produced by the mine. Larger granules have been exported. Up to 1975, these exports were handled through the Algerian port of Ghazaouet, located about 120 km from Jerada. Since then, exports had to be transported to the ports of Kenitra (570 km from Jerada) or Casablanca (700 km). Because of production problems, related to the difficult nature of the seams in the deposit, and export commitments, the Jerada mine has not always been able to meet all the fuel needs of the power plant, roughly 700,000 tons per year. Thus, domestic production has been supplemented by small amounts of imported coal. Coal use in industry has been negligible until recently.

Morocco is pursuing a two-pronged strategy to increase the market share of coal. First, efforts are underway to increase domestic production by stepping up the operation of the existing mine, as well as opening a new seam. Furthermore, exploration of other potentially significant deposits in the Jerada area and elsewhere continues. The national coal management organization, Charbonnages du Maroc (CDM), has recently awarded a US-$10 million contract to Oceaneering International for exploration work near the Jerada mine. Plans call for expanding the existing mine operations to step up production from some 700,000 tonnes per year to 1 million tonnes. Opening another seam (Siege VI), planned for the next decade, is expected to add another 1 million tonnes annually, once it reaches capacity. Thus,

total domestic production is projected to reach 2 million tonnes per year.[7] Achieving this target will require massive investments in the mines. Similarly, the transportation infrastructure would have to be expanded to assure the best use of the unexportable fines. The market for this coal exists. However, regulated coal prices do not allow CDM to finance any significant portion of any expansion investments internally. Moreover, the economics of these projects appear discouraging, even for more economic pricing schemes because the seams are thin, resulting in high mining costs.

In addition to these efforts to expand production, technology development projects seek to make better use of the country's coal resources. For example, current plans call for the construction of a 12 MW pilot power plant near Jerada using coal shale (schistes charbonneux, a heretofore unused by-product of the mine) in a fluidized-bed process. Similar plans are on the drawing board for the lignite deposits near Fes.

For the second leg of the coal strategy, Sococharbo, CDM's coal marketing subsidiary has embarked upon a fairly aggressive program to increase coal use in the industrial sector. Sococharbo has also worked with ONE to raise the share of (imported) coal in electricity production. These efforts have met with considerable success. The first (re)conversion of a thermal power plant from fuel oil to coal was Unit II of the Roches Noires (Casablanca) installation. Sococharbo received the first shipment destined for this plant in September 1982. Similarly, Units III and IV of the Mohammedia plant are nearing completion, having been converted to coal during the construction phase. Total consumption of imported coal by these two power plants would amount to some 850,000 tonnes per year.

Sococharbo has also succeeded in converting major energy consumers from fuel oil to coal, notably cement plants. The CADEM plant at Meknes is already using coal; the plant had originally been constructed to use coal, had been converted to fuel oil, and is now burning coal again. Similarly, the Lafarge (Casablanca), Tetouan and Temara cement plants are scheduled to switch to coal in the next few years. Between 1984 and 1987, coal use for currently known users thus is projected to increase from about 340,000 tonnes per year to 1.2 million tonnes, corresponding roughly to one-fourth of the total boiler fuel consumption in 1982. Figure 2-15 illustrates these projections. In addition, further conversions in industry, such as other cement factories or sugar refineries, are likely. For example, a contract for US-$3 million was recently awarded to Loesche of West Germany to convert another cement plant, the Cimenterie de l'Oriental (CIOR), from oil to coal.

Sococharbo has signed contracts with British suppliers at reasonably favorable prices to meet projected demand for imported coal. However, one key constraint on the use of coal in place of imported oil may be the transport infrastructure, especially ports. Moroccan ports currently are ill-equipped to handle the larger coal freighters (50,000 tonnes or more) needed to supply imported coal most advantageously at the level required for a large-scale substitution. The principal focus of development efforts

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[7] These targets appear to have been scaled back somewhat in more recent plans to about 1.1 million tonnes per year.

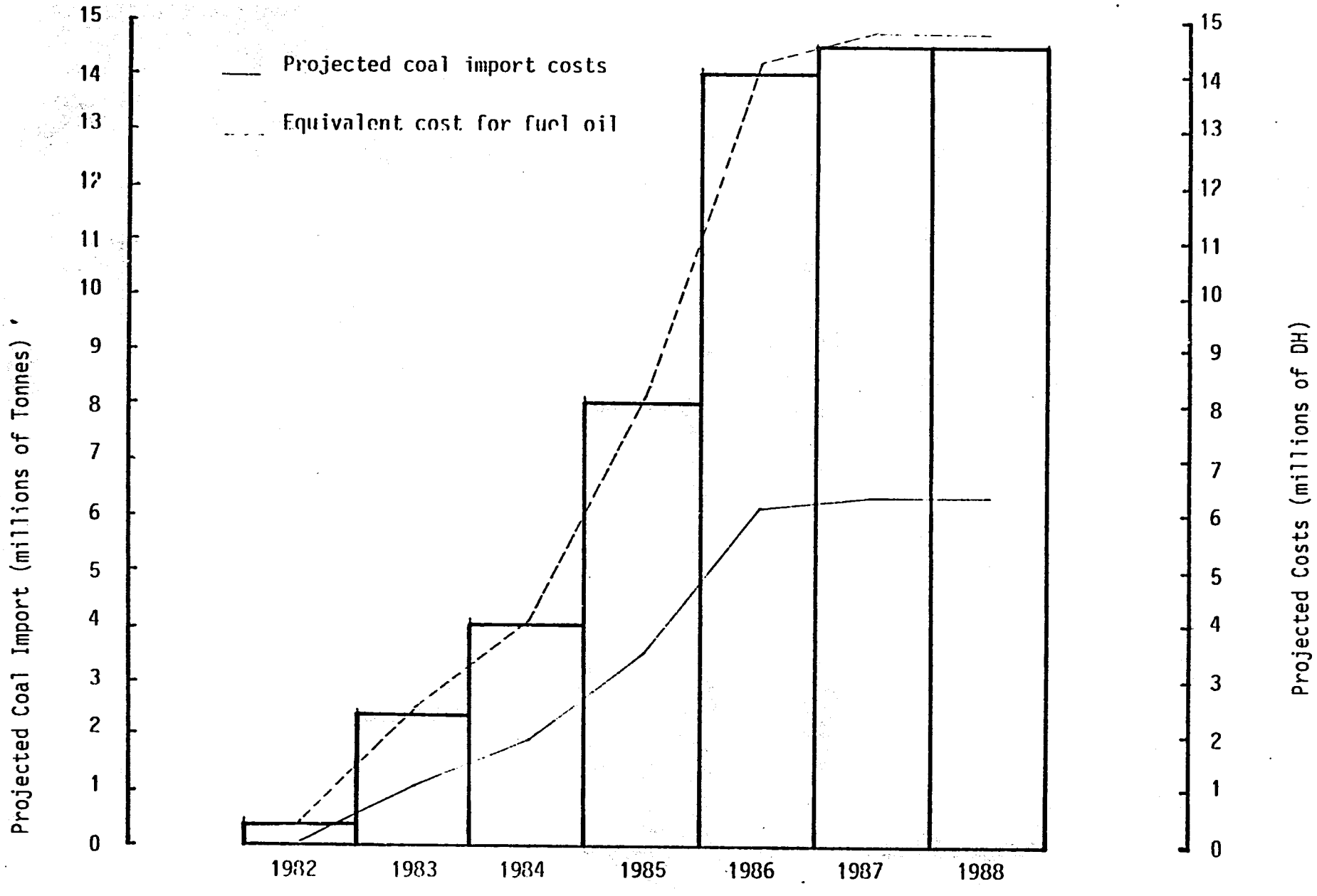

Figure 2-15: Projected Coal Imports (Source: Sococharbo)

is the new port of Jorf Lasfar (after plans to expand Mohammedia were scuttled). However, the coal pier of this new port, part of a phosphate-based chemical complex, is now scheduled to start operations in 1986 at the earliest. Sococharbo has proposed a contingency program involving changes in the management of existing port facilities (reassignment of piers, etc.) to allow for handling the quantities of imported coal needed to supply its customers. At the same time, ONE has formulated plans to start operations of Mohammedia III and IV using fuel oil if coal is not available in sufficient quantities.

2.3.5 Oil Shale

Morocco possesses vast reserves of oil shale in several deposits. The map in Figure 2-11 identifies the two major deposits at Timahdit and Tarfaya. Other deposits include one near Tangiers. Total shale reserves have been estimated at over 100 billion tonnes, containing some 6 billion tonnes of oil. The most promising site for any significant exploitation of oil shale is Timahdit where conditions would allow for open-pit mining. Total reserves in this deposit have been estimated at about 3.3 billion tonnes of shale, containing some 190 million tonnes of oil. While deposits near Tarfaya have been studied in less detail, they alone have been estimated to contain some 100 billion tonnes of shale with an oil content comparable to that of Timahdit, up to 6 billion TOE. But geological conditions would mean substantially higher mining costs than at Timahdit.

The actual exploitation of this resource has been impeded by the high cost of extracting oil from the shale. Some of the most recent estimates for various processes suggest that crude oil prices would have to double or so before shale crude could become economically competitive. With the stabilization of the world market price of oil, extraction of oil from shale with known processes is simply prohibitively expensive. As a result, virtually all large-scale developments have been abandoned, delaying the further development of technologies. Originally, Morocco had reason to hope that its own efforts could interact with technology developments abroad to bring the utilization of a major national resource within the realm of the economically feasible. It now finds itself in the somewhat precarious position of a technology leader, with work focusing on the Moroccan T3 (Timahdit-Tarfaya-Tangiers) process for oil extraction. This work is supported by the World Bank.

At the same time, efforts are continuing to use oil shale directly as a boiler fuel. In spite of the shale's rather low caloric value (1,100 kcal/kg vs. about 6,500 kcal/kg for imported coal) and high ash content, it could be used in a direct combustion power plant. A pilot plant is now under construction near Timahdit. In addition, there are also plans to construct additional pilot plants using the same fluidized-bed process as for coal shale and lignite.

2.3.6 Renewable Energy

Morocco offers a reasonable potential with respect to both wind and solar energy. The country's geographic location assures a high level of solar radiation, which has been measured at about 170 kilolangleys (475

kcal/sq-m) per year. Considerable work has been done on the development of more detailed and comprehensive information on solar radiation as a first step to the development of a more deliberate policy. One of the key actors in this field in Morocco is the Centre pour le Developpement des Energies Renouvelables (CDER) in Marrakesh, focusing on the adaptation and demonstration of renewable energy technologies in Morocco.

Unfortunately, the effective exploitation of Morocco's solar potential has been dealt a severe blow with the decision made by customs officials to levy a high import duty on parts required for solar collectors assembled in this country. A study concluded in early 1981 identified several (public and private) enterprises involved in developing the solar-collector market. With the imposition of the higher duty, only two are left (one of them Sococharbo), doing very little business in this field. According to officials, critical parts cannot be produced locally.

Some development work, primarily under the aegis of CDER, is underway in the area of photovoltaic systems. These systems may play an important role in rural electrification programs now being discussed.

Morocco also enjoys a good supply of wind energy, especially along the coast and in the mountains. The characteristics of wind conditions make this energy form suitable for water pumping and electricity generation. The potential had been well-used in the past. Some 10,000 windmills for water pumping had been installed through the mid-1960's, providing sufficient incentive for some local production of the equipment. The introduction of cheap diesel pumps offered a convenient substitute. In addition, lack of spare parts and technical knowhow hampered maintenance and repair of existing windmills. Even so, the experience indicates that a program of dissemination and development of a maintenance infrastructure could succeed in using a local energy resource more effectively.

CDER also has developed a pilot project demonstrating the potential of a biodigester in rural areas in Morocco. The project -- operating just outside of Marrakesh -- has received considerable attention. It has succeeded in demonstrating the technical feasibility of this technology; however, economic, social and management questions remain to be answered before biogas can be considered as a major alternative for supplying energy to rural areas.

Biomass represents a major energy resource for Morocco. As the inclusion of traditional energy forms in the analysis of energy consumption in Figure 2-2 illustrates, fuelwood and charcoal account for the lion's share of the total energy consumed by households. Forests cover about 5.1 million hectares in Morocco, with alfa grass growing on another 2.6 million hectares.[8] Less than half of that total can be considered as productive. Estimates of both the sustainable yield and the actual consumption vary, but most students of the problem agree that the latter exceeds the former by a significant margin. Consequently, Morocco is losing a valuable re-

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[8] Alfa grass, sometimes also called esparto grass, is a long fiber grass with a fairly high caloric content (comparable to Jerada anthracite); it is currently used for fodder and in the manufacture of ropes, paper and shoes.

source -- not only from an energy point of view, but also with respect to comprehensive environmental management.

In recognition of this problem, Morocco has developed a plan for reforestation. The execution of this plan has failed to reach its rather modest goals of planting 22,000 hectares per year, achieving an average of only 5,000 hectares per year. Renewed efforts in this direction are in preparation. However, the legal and administrative framework for any such initiatives is complex, necessitating the involvement of many agencies at the national, regional and local levels.

2.3.7 Nuclear Energy

Existing projections of electricity demand, based primarily on extrapolations of past growth trends and therefore likely to overstate future growth, suggest that the system load in the mid-1990's will reach levels that warrant the introduction of nuclear power plants. This option is of considerable interest to Morocco, given its reserves in uranium, contained in phosphate ore. These reserves have been estimated at some 7 billion tonnes. Several processes have been developed to extract uranium in the form of U O from the spent ore (after phosphates have been extracted). Under the direction of the Office Cherifien des Phosphates (OCP), work is underway to build an extraction plant using the Westinghouse process. Capacity of this plant will start at 220 tonnes per year, to reach some 2000 tonnes by the year 2000.

In preparation for the introduction of nuclear power, Morocco has also established the Centre National des Etudes Scientifiques et Techniques de l'Energie Nucleaire (CNESTEN). A US-$3.3 million contract has been awarded to Sofratome (France) for a feasibility study of a 600 MW nuclear power plant.

3.0 ENERGY POLICY MAKING IN MOROCCO

3.1 The Policy Framework

Morocco can best be characterized as a mixed economy. The government is encouraging and supporting the growth of the private sector, but finds itself often in a position of complementing private-sector activities and investments in certain critical areas. However, even in these cases, the public sector often attempts to involve private investors in a significant role. Thus, major investment projects and economic activities frequently bring together the semi-autonomous public sector organizations -- the sous-tutelles or para-statal agencies -- and private investors, in many instances foreign.

Consequently, energy policies involve the manipulation of a whole gamut of instruments affecting the sector both directly and indirectly. The possible policy interventions can be categorized into two groups: those aimed at increasing investment necessary to produce more energy domestically or to convert it more efficiently, and those seeking to modify market conditions. The investment-oriented policy instruments basically focus on lowering the cost and reducing the risk associated with a particular project for the private investor, through:

- concessionary arrangements, such as reduced taxes, special loan terms, or direct subsidies;
- joint ventures (risk sharing);
- related infrastructure investments, including training.

These measures may not be enough to attract private investment. Moreover, the existing legal framework in Morocco reserves certain key activities -- such as utilities -- for the public sector. These provisions turn the public sector into a key entrepreneur who has to weigh different project and financing options like any other investor, with the added mandate of treating social objectives at the same level as financial ones.

Market-oriented policy interventions seek to manage demand to make energy use more efficient, or to create favorable market conditions for new technologies or energy forms judged to be desirable:

- regulate prices of energy products or energy using devices directly;
- influence prices through taxes and subsidies to producers or consumers;
- create sheltered markets through government procurement policies (e.g., a requirement that public buildings use coal for heat and hot water);
- lower the cost of energy conservation or fuel substitution investments through tax subsidy schemes;
- provide fiscal or regulatory incentives to incorporate

"co-generation" of energy in industrial activity, including the utilization of by-products;

- modify consumer and producer preferences through public education and information campaigns;
- increase market areas through infrastructure investments designed to lower the cost of distributing certain types of energy;
- improve infrastructure management to increase the efficiency of energy use (especially transportation system management activities).

This list could be extended. It should suffice, though, to illustrate the range of options that need to be considered in designing energy policies and assessing their likely performance. It also demonstrates two other aspects that influence national energy planning. First, the very breadth of policy options makes it difficult to find the "best" one. Predicting the effects of certain policies, or -- even more importantly -- deriving the most appropriate choices from desired consequences, requires a solid understanding of behavioral responses that is, alas, lacking.

Second, the key policy instruments affect not only energy consumption and production. They influence a broader set of economic and social objectives, some of which simply are more critical than energy goals. The energy planner cannot assume that all potential instruments are equally manipulable. Rather, their choice and determination involves interaction and compromise among the various participants in the policy making process. To establish the background for an examination of specific policy concerns and developments, and the role of the project in these developments, a brief review of the major actors in the energy policy process seems therefore appropriate.

3.2 Key Agencies

Ministry of Energy and Mines: MEM, through its Direction de l'Energie, plays a central role in the formulation and implementation of energy policies. It is given specific responsibilities with regard to regulatory and budgetary matters. Its most important role grows out of its oversight responsibilities for the specialized energy agencies, the sous-tutelles. As the agency responsible for presenting and defending the energy portion of the Five-Year Plan to the Ministries of Plan and Finances, as well as the annual budget requests for the energy sous-tutelles, the Ministry performs a key function as leader and sometimes arbiter among its sous-tutelles.

The Energy Directorate comprises three functional divisions. The Division des Produits Petroliers

- oversees the operations of the nation's two refineries, SAMIR and SCP;
- assures adequate distribution of refined products through

two other organizations, the Societe Nationale des Produits Petroliers (SNPP) and the Association Marocaine pour les Activites Petrolieres (AMAP), and their retail companies, through monitoring and direct intervention;

- prepares studies and statistical material relating to the demand, supply and pricing of refined products.

The Division de l'Energie Electrique carries out similar functions in the area of electricity generation and distribution. Finally, the Division du Developpement des Ressources Energetiques is responsible for supervising the activities of the sous-tutelles dealing with the country's own energy resources (aside from hydropower), including Sococharbo's coal importing and marketing.

The discussion of the current energy situation has already identified many of the key energy agencies. Appendix C presents a complete list of the public and quasi-public organizations in the energy field, together with some background data and indications of their specific responsibilities. Thus, a brief summary suffices here.

Electricity Production and Distribution: The Office National de l'Electricite operates the country's principal power plants, as well as the distribution system for high, medium and low tension to the major industrial plants and cities. Within the cities, distribution and sales are the responsibility of local "regies." The financial position of many of these "regies" has worsened over the years, necessitating direct and indirect subsidies, e.g., by having ONE sell them electricity below the established price.

In rural areas, electricity production, distribution and management is handled by the "groupes electrogenes." In virtually all instances, the local "regies" and the "groupes electrogenes" fall under the administrative purview of the Ministry of the Interior. These oversight responsibilities give Interior a central role in rural electrification. However, under a fairly complex arrangement, MEM provides some funds for this purpose.

Oil, Gas, and Oil Shale: Imported oil, as well as the small amount of domestic production, is refined in the two major refineries, SAMIR and SCP. A third small refinery, SEBLIMA, handles only bituminous products and lubricants. The SCP's responsibilities include management of natural gas production from existing wells. It was also involved in some of the more experimental work with condensates from the Toukimt field, which is owned and will be operated by ONAREP.

The Societe Nationale des Produits Petroliers (SNPP) works through joint ventures with various private (foreign) oil companies which actually operate the service stations and other installations. SNPP holds 51 percent of the capital of these joint ventures. These companies account for some 70 to 80 percent of the total petroleum products sold in Morocco. The Association Marocaine pour les Activites Petrolieres (AMAP) represents Moroccan-owned distribution companies. MEM oversees and regulates the activities of both the SNPP and the AMAP companies.

The Office National de Recherches et d'Exploitations Petrolieres

(ONAREP) is relatively small by oil company standards. Its responsibilities include supervision and management of oil and gas exploration efforts, exploitation of any oil and gas actually found (such as the Toukimt and the Ndar'K fields), and research and technology development in the oil shale field.

Coal: Charbonnages du Maroc (CDM) operates the Jerada mine where most of its 6,000 employees are stationed. It is also responsible for coal exports, as well as for exploration efforts. Its subsidiary, Sococharbo, handles marketing and importing of foreign coal. Sococharbo also operates an assembly plant for solar collectors, whose business is negligible at present.

Renewable Energy: The Centre pour le Developpement des Energies Renouvelables (CDER) is primarily responsible for research and dissemination projects in the area of renewable energy. It is also involved in the preparation of the information necessary for the formulation and implementation of an effective strategy for exploiting the country's renewable energy potential. To some extent, CDER's role is still evolving.

Other Ministries: Formulating and implementing energy-related policies is complicated by the fact that energy touches so many other area of economic and governmental activity. Reforestation, for example, falls within the purview of the Ministry of Agriculture and Agrarian Reform, which is also involved in rural electrification efforts, along with the Ministry of the Interior. Similarly, several ministries are involved in questions of pricing policy. The case studies of pricing and energy conservation in Sections 3.3 and 3.4 provide some idea of the nature in which different agencies interact in specific energy-related policies.

To encourage and facilitate inter-ministerial cooperation, a National Energy Commission has been established in 1982, with subcommissions on finance and pricing policies, energy resources, hydro-electric dams, rural electrification and energy conservation. Through regular meetings, the Commission and its subcommissions have contributed to the development of comprehensive and consistent energy policies for Morocco, and in structuring and preparing annual budgets and budget revisions in a time of major adjustments, such as the current austerity program.

These commissions will be complemented by ad-hoc committees during the preparation of the next Five-Year Plan which will establish the framework for the preparation of specific annual budgets.

3.3 Energy Pricing

The Moroccan government relies on price regulation and price control as key instruments of social and economic policy. Multiple objectives and a decentralized administration have created a complex system. Overall, the country adheres to a market system. Thus, the market determines the price for many goods and services (accounting for indirect taxes and the effects of regulatory action). In other instances, though, the government sets prices and enforces them. The price setting mechanism can involve several layers of government. Generally, the Prime Minister's office or the Ministry in charge of the respective sector determines prices. At the

level of the province, the governor can add a surcharge to reflect the cost of access. The final price is set at the level of the commune by local administrators. The basis for deciding on a price varies. For certain basic products, prices are uniform. In other instances, the final prices are determined as a function of cost, with administrators fixing the markup of the wholesaler or retailer.

Energy, or at least petroleum products, are treated as part of the basic goods. The Caisse de Compensation, created in 1941 to facilitate imports of basic necessities, today subsidizes four key products: sugar, butter, cooking oil, and petroleum products. A form of cross-subsidization applies in the case of petroleum products. Prices for gasolines are set very high, which raises revenue to subsidize the prices of diesel and fuel oil. This policy reflects both social equity concerns (a tax on a luxury good, the automobile), and considerations of improving the competitive position of Moroccan industry (lower costs for a key input). Enforcement of the established price ceilings is strict, relying on some 1,200 "controleurs des brigades," and penalties ranging from the confiscation of stock, hefty fines (up to 200,000 Dirhams) and shop closings for five days to two weeks. These measures have recently been supported by an intensive publicity campaign.

Table 3-1 presents an overview of the price structure for energy products in 1982, the year for which we have consumption figures. It also shows some comparison figures for refinery products based on representative world market prices.[1]

Overall, the data shown illustrate the pricing policy pursued by the government. For the refinery products, gasoline is priced very high, both in terms of its relationship to other products and in terms of the comparator. LPG and kerosene, both used to a large extent by the residential consumer, are priced relatively low, at about parity with the estimated comparison price for importing the finished product.

These patterns become clearer in the data shown in Table 3-2: refinery product prices for January 1984 (after the last general price increase, which has been followed by another increase in gasoline prices in April 1984), and the receipts or subsidies per ton for the Caisse de Compensation for each product. The comparison indicates heavy taxes on gasoline, combined with significant subsidies for kerosene and LPG, especially LPG in smaller containers. Diesel fuel is "taxed" at a rate of less than 1 percent of the final price; in contrast, the subsidy to fuel oil consumers amounts to about 3.5 percent of the final price. Based on the composition of consumption in 1982, the cross-subsidization scheme would correspond to an average "tax" on each ton of refinery product sold in Morocco of about 60 Dirhams. This "tax" is in addition to import duties and normal taxes. The average "tax" has increased as a result of the most recent gasoline price increase in April 1984. Even so, price increases for petroleum products overall have not kept up with the increase in the ex-

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[1] Energy pricing policy in Morocco is the subject of a special study within the context of this project; the report on that study is projected for completion by early fall 1984.

Table 3-1

Domestic Energy Prices, November 1982
(6.10/$)

Product	DH/unit	$/TOE	% of Comparator*
Refined products (per ton)			
- Super	6,356	1,010	245
- Regular	6,233	991	250
- LPG	2,504	386	101
- Kerosene	2,841	462	99
- Gas oil	3,065	502	135
- Fuel oil (No.2)	1,420	247	120
Coal (per ton)			
- Domestic : raw fines	252	82	-
washed fines	364	81	-
- Imported steam coal	600	166	-
Electricity (per KWh)			
- Low voltage	.607	403	-
- Medium voltage	.600	398	-
- High voltage	.487	323	-

* comparator for refines products: mediterranean posted prices (average 1982), plus $20 freight and insurance, plus 5¢/liter handling for gasoline and gas oil, 10¢/liter of kerosene, $10/ton of fuel oil, and $75/ton of LPG.

Table 3-2

Prices and Net Subsidies, Refined Products
(January 1984, 8.10/$)

Product	DH/t Wholesale	DH/t Retail	$/TOE (Wholesale)	Subsidy (-) or "Tax" (+)/t*
Super	6,824	6,973	817	+ 1,218
Regular	6,560	6,702	786	+ 1,439
LPG				
- less than 5 Kg	2,820	3,050	327	- 262
- more than 5 Kg	2,813	2,958	326	- 176
Kerosene	3,527	3,616	413	- 475
Gas oil	3,687	3,772	455	+ 32
Fuel oil (No.2)	1,705	-	223	- 59

* Caisse de Compensation.

change rate, as indicated by lower dollar prices for 1984.

Prices for domestic coal appear to be set below economic levels. A resolution of this question is difficult, given the world market situation in which coal prices typically involve significant subsidies of some form or another. However, the low prices for domestic coal have strapped the financial capabilities of Charbonnages du Maroc. It is not earning enough money to finance any significant portion of contemplated expansion investments.

Electricity tariffs vary by voltage level as well as by region, but not (yet) by time of use -- peak vs. off-peak. In spite of some recent increases, they apparently continue to fall below long-run average costs, although the exact relationship would require a reassessment of the ONE's cost structure. In any case, these tariffs do not allow ONE to meet its goal of financing 20 percent of its investments internally, as agreed with the government and international financial institutions. The financing gap has widened more as a result of recent price increases for primary energy products. Before ONE's rates could be adjusted accordingly, events led the government to suspend any further price increases and to rescind some for basic necessities.

3.4 Energy Conservation

Our review of the energy situation in Morocco suggests some potential for energy conservation. Other countries with similar economic structures and at similar levels of economic development consume relatively less energy. In addition, energy use is concentrated in a few energy-intensive industries, notably transportation and cement production. Thus, focused efforts to reduce energy consumption or to shift to cheaper fuels could be effective.

Much of the attention has focused on the cement industry, which was the principal target for Sococharbo's drive to encourage the switch from fuel oil to cheaper (imported) coal. This drive has been quite successful. Virtually all of the major cement factories have converted or are committed to a conversion to coal, often in conjunction with an overall modernization of the plant.

Energy conservation policies have been less focused. A number of steps have been taken to encourage energy conservation measures by individual plants and industries. A recent national campaign for energy conservation culminated in a two-day seminar, sponsored jointly by the Ministry of Energy and Mines and the Ministry of Commerce, Industry and Tourism. This campaign included an extensive public education effort through posters, stickers and brochures, aimed at the individual consumer of energy in the home and in the private car. Figure 3-1 shows the cartoon character who figures prominently in the poster campaign, exhorting Moroccans to "do as I, give up the car and take the bicycle." Other posters focus on energy use in the household, such as cooking and lighting.

To encourage energy-saving investments in industry, the January 1983 investment code provides for a premium of 500 Dirhams for each TOE/year saved, with a minimum of 250 TOE, up to 20 percent of the total amount of

Figure 3-1: Energy Conservation Campaign Example.

the investment. After a lapse of several years, Morocco re-introduced daylight savings time in March 1984. Other measures are currently under evaluation, including tax incentives for fuel substitution, price incentives to reduce peak use of electricity, and even such fairly radical measures as continuous workdays. As part of this project, a preliminary study of the energy conservation potential in the transportation sector suggested several possible steps. An industrial energy conservation study conducted as part of the World Bank energy assessment also identified specific opportunities for reducing energy use or substituting cheaper forms of energy.

The assessment of energy conservation options in the transportation sector as part of this project also found that available data were simply insufficient to formulate more than general conclusions. Consequently, the study recommended a pilot project involving publicly owned vehicles to ascertain the potential of different energy conservation measures under Moroccan conditions.

The January 1984 energy conservation seminar showed that industrial and energy enterprises have taken varied measures to reduce the cost of energy, including the installation of monitoring and control devices, use of waste products, etc. However, the seminar also demonstrated the lack of an adequate data base for assessing the potential of energy conservation policies. Assembling such a data base, for industry, transportation and for households remains a high-priority task. A relatively small-scale study of industrial and energy establishments is being conducted by Trans Energ, a French organization. Similarly, a survey is scheduled for 1984 to obtain better data on household energy consumption.

The development of a better data base regarding the potential impact of energy conservation policies is especially important, given the fact that several ministries will have to share responsibilities for implementing any such program.

3.5 Private Sector Involvement and Competition

The Moroccan government and its parastatal agencies encourage and support private sector involvement in dealing with the country's energy problems, to the extent permitted by the country's legal system. In many instances, they are seeking a partnership with private-sector interests. As already noted, the distribution of refinery products is handled through a number of companies owned to 49 percent by international oil companies. Similarly, ONAREP has aggressively and (to some extent) successfully pursued private-sector partners for joint ventures for oil and gas exploration. The country's petroleum code appears to offer reasonably attractive terms. The Energy Directorate of MEM also searches out contacts with private investors. Until the imposition of the extra import duty placed their product at a competitive disadvantage, several private entrepreneurs were active in the solar industry.

Even so, the legal and institutional framework of the country reserves the key role in energy for the public sector. However, control of energy production and conversion by the government and parastatal agencies does not necessarily mean the absence of competition. Allocation of energy

resources, choice of technology, and choice of energy forms by some end user typically are not imposed by administrative fiat. Rather, these decisions are often the outcome of extended negotiations where price and other economic conditions can play a significant role.

3.6 MEM's Planning Unit

The institutional and legal framework of energy policy in Morocco outlines the most likely role that the Ministry's planning unit is to play. Its principal role will be to improve the flow of information among the diverse groups of public, parastatal and private decision makers and planners to clarify alternatives and their implications, thereby contributing to decisions made with a better understanding of their immediate and wider consequences.

The planning unit needs to perform a number of functions to achieve this overall goal. First of all, it establishes a common planning framework -- the kinds of actions that should be considered within this context and the policy consequences that provide the criteria. Such a framework cannot be imposed. Rather, it keeps evolving as the participants in the planning and policy process have a chance to work with.

Within that common planning framework, the planning unit can assist in the formulation of specific investment options, more realistic ones for the short term, and (perhaps) more speculative ones for the long term. By playing the role of a catalyst, the unit provides the leadership in exploring the full range of policy options, some of which may be complementary while others are competing with one another. In addition, the common framework makes it easier to ensure that different groups work with comparable assumptions about the economic and social context, and that they are formulating these assumptions following common groundrules. For example, exploring the impact of slower growth in demand requires that the analyst or decision maker identify the source of the slowdown -- slower economic and demographic growth, more efficient use of energy, fuel substitution, etc. Once the sources have been specified, it becomes possible for planners and analysts in other agencies to examine the impact of these assumptions on their (more detailed or differently oriented) plans. In short, a common frame of reference enables planners from different agencies and entities to compare their results and develop compromise solutions.

Detailed project appraisal should and does occur at the level of the individual sous-tutelles. However, the planning unit needs to assure that these appraisals employ internally consistent methods and assumptions. To meet this mandate, it must be able to carry out its own analysis of individual investment projects in or related to the energy sector, though typically not a the same level of detail as, say, ONAREP's short-term project planning. More importantly, the Ministry's planning unit is responsible for the analysis of the consequences of a particular combination of investment projects to be implemented over time -- a particular energy investment portfolio. The ability to examine specific plans within the context of the country's overall energy (and economic) policy allows the unit to provide the needed leadership in the process of developing a consensus on energy policy.

Finally, the unit also plays a central role as a data repository.

Data scarcity and fragmentation hamper the formulation and assessment of energy policy options. As a first step, compiling and reconciling available data establish a useful basis, also helping to identify major data gaps. The planning unit can perform this function effectively, although it has to rely largely on other agencies to conduct the actual collection of data.

The concluding section examines the progress this project has made toward establishing a planning unit capable of performing these functions.

4.0 TAKING STOCK: PROGRESS TO DATE AND OUTLOOK FOR THE FUTURE

4.1 Compiling the Information Base

The project has contributed measurably to the establishment of an information base for energy policy development and appraisal. At the macro-level, data collection and analysis have laid the foundations for a better understanding of energy use patterns, in particular for commercial energy. This work has proceeded in two directions. First, the project has worked with the respective sous-tutelles in analyzing sales data and allocating sales to a common set of sectors, which are also relevant to the analysis of economic growth patterns. The analysis involved further breakdowns of available statistics, and the allocation of certain aggregated sales data among the various sectors according to secondary information, as briefly described in Appendix A.

Second, the project assisted MEM staff in preparing a portion of the questionnaire used by the Ministry of Commerce, Industry and Tourism in its annual study of the manufacturing sector. This part of the questionnaire focuses on energy consumption by the industrial establishments in the country. The first results (for 1981) have just become available for further analysis and comparison with the estimates based on sales data for the various types of commercial energy.

These data form the core of a macro-level energy data base which combines information on energy consumption and production at the national level with aggregate and sectoral economic data. In parallel with the process of strengthening MEM's planning capabilities, the Direction de l'Energie is developing a system to facilitate updating of this data base periodically . In that way, the system ultimately can be used to generate reports on an annual or as-needed basis, which can then be integrated into the preparation of regular statistical publications on the energy sector. This particular element of developing the necessary infrastructure for national energy planning goes somewhat beyond the scope of the planning project. Even so, the project has directly contributed to improving the basis for such a system, both in terms of baseline data and in terms of the appropriate procedures.

With respect to specific investment options in the energy sector, the planning project has formulated a well-defined structure for project description across the various subsectors. It has used this structure to define and explore Morocco's principal options. Specifically, project staff have prepared engineering cost and performance estimates for some 50 investment projects. These project characterizations have allowed analysts to assess various alternatives, both at the project and at the portfolio level. Table 4-1 presents a list of the original projects in the inventory. Following the massive upgrading of the analytical software used for project appraisal and portfolio performance simulation, the project inventory is being completely revised.

A brief inspection of the original projects shown in Table 4-1 clarifies one of the reasons. Many of the projects, defined and estimated in 1981 and 1982 and continually updated, reflect assumptions about the country's resource endowment or about the state of technology that no

Table 4-1:

Original List of Projects in Inventory

(InVest Version No1)

Centrales Electriques

N° 1	Centrale à Gaz Naturel; 2 X 150 MW
N° 9	Centrale à Charbon, 2 X 250 MW
N° 10	Centrale à l'Alfa, 3 MW
N° 16	Centrale à Schiste, Lit Fluidisé, 200MW
N° 17	Centrale à Schiste, Conventionnel, 200 MW
N° 20	Centrale Nucléaire, 600 MW

Centrales Hydrauliques

N° 14	Huit Barrages, 1991 - 1995, Capacité 347 MW
N° 15	Six Barrages, 1981 - 1985, Capacité 839 MW

Changement de Fuel

N° 2	Utilisation du Gaz Naturel: Ciment Humide
N° 3	" " " " : Phosphates
N° 4	" " " " : Sucreries
N° 5	" " " " : Ciment Sec
N° 6	" " " " : Industries Alimentaires
N° 7	" " " " : Autres Mineraux
N° 8	" " " " : Services et Autres Secteurs
N° 11	Tranches 3 & 4 de Mohammedia, 2 X 150MW

Developpement de Gaz Naturel

N° 21	Exploitation du Gisement du Gaz Naturel de MESKALA
N° 24	Gazoduc de MESKALA à TANGER, 11,5 million m³/jour
N° 25	Oleoduc entre MESKALA et la Raffinerie SAMIR
N° 36	Gazoduc de 800 km, Capacité 1 million m³/jour
N° 37	Gazoduc de 800 km, Capacité 3 million m³/jour
N° 38	Gazoduc de 800 km, Capacité 6 million m³/jour

Exploitation du Charbon

N° 18	Expansion de Siege 5 à Jerrada, 300 000 tonnes/an
N° 19	Ouvrir siege 6 à Jerrada, Capacité 1 million tonnes/an
N° 26	Port à Charbon

Exploitation des Schistes Bitumineux et de l'Huile de Schiste

N° 12	Raffinerie pour l'Huile de Schiste, Capacité 10 000 bbls/j
N° 13	Raffinerie pour l'Huile de Schiste, Capacité 50 000 bbls/j
N° 27	Huile de Schiste/Pyrolyse: VMIS/T3
N° 28	" " " " : Paraho Circulaire
N° 29	" " " " : Paraho Rectangulaire
N° 30	" " " " : Lurgi/Runrgas
N° 31	" " " " : Union SGR
N° 34	Unité de Traitement, Capacité 50 000 bbls/jour
N° 35	Unité de Traitement, Capacité 10 000 bbls/jour
N° 40	Mine des Schistes, TIMAHDIT, Capacite 3 million tonnes/an

Recherche et Exploitation des Energies Renouvelables

N° 22	Plantation d'Arbres, Production 206 000 m³/an
N° 23	Plantation d'Eucalyptus sur 60 000 ha
N° 32	Pompage Photovoltaïque, 15 Unités de 3 kW
N° 33	Electrification Rurale de 10 Villages
N° 39	Recherche de Pétrole et de Gaz, 1981 - 1985

longer hold true. For example, most of the projects related to the development and exploitation of natural gas are based on original estimates of the size of reserves in the Meskala field that unfortunately have proved overoptimistic. Thus, 800-km pipelines, or the massive conversion of industry to natural gas are no longer realistic options (unless, of course, optimism should be rekindled by any new discoveries). Similarly, the various options for shale oil retorting are rapidly becoming obsolete. These projects can no longer be treated as active. The remaining projects form the core for the development of a new inventory of energy investment projects better reflecting Morocco's current options.

Another reason for a necessary revision refers to process. The persuasiveness of analysis results depends to a large extent on whether counterpart planners and decision makers in the sous-tutelles have confidence in the inputs to the analysis. That has been one of the major lessons of the initial work of the planning unit. Consequently, it becomes essential to rely heavily on planners and engineers in the specialized agencies in developing and characterizing specific investment projects. The formulation of the project-level data base has laid the foundations for this process. It has allowed the planning unit to structure the approach of planners and engineers, and to organize it around central concepts. As a consequence, information provided by the sous-tutelles can now be used directly to describe projects in sufficient detail for the analysis.

In fact, project development is becoming an integral part of the national energy planning process. It allows planners in the various agencies to explore options in consultation with each other, to identify constraints and complementary investment projects. In short, an apparently purely technical task has become a cornerstone of institutional development.

4.2 Strengthening the Institutional Infrastructure

The establishment of a permanent planning capability within the Ministry of Energy and Mines clearly calls for technical competence -- skill and experience in conducting the economic and engineering analysis of specific policy options. These options are not limited to specific investment projects and portfolios, but comprise other elements (such as pricing and regulatory initiatives) that make up the full spectrum of energy policies for Morocco. In some respects more important than technical expertise to conduct the analysis, though, is the ability to advise, to formulate or assist in the formulation of policy options, and to generate and argue results of the appraisal process that carry a weight commensurate with the responsibility of the Ministry. This ability is essential in providing overall guidance regarding the consequences of energy policy alternatives.

The planning unit is expected to advise not only decision makers within the Ministry, but also in the sous-tutelles. Achieving that objective requires more than technical competence; it hinges on the unit's stature and the respect it commands in the energy planning community. Measuring progress in this direction poses some difficulties, since the criteria tend to be vague and often subjective. Moreover, institutional change and development almost by definition proceeds slowly and gradually. Thus, impressions and anecdotal "evidence" necessarily carry much of the

argument in assessing what has been accomplished in terms of the emergence of the Ministry's planning unit as a key actor in policy development.

While much remains to be done, there are indications that appreciable impact has been achieved in this area. Within the Ministry of Energy and Mines, decision makers have not only accepted the overall approach as a reasonable way of assessing major policy alternatives, but have also begun to use the planning information generated in weighing their options. For example, in response to a cabinet-level request, the planning unit provided information on the implications of a significant slowdown in the growth of energy consumption over the next 20 years to help formulate the Ministry's energy conservation policies. The Ministry's planning capability also figured prominently in a presentation to potential private-sector investors on opportunities in Morocco (during a conference organized in early 1984 by the International Chamber of Commerce). The increasing acceptance of and reliance on planning information have stimulated and shaped the development of analytical and substantive capabilities. This process will continue.

Ultimately, though, acceptance within the Ministry is not enough. The planning unit must provide central decision makers with information regarded as both relevant and reliable by the sous-tutelles. Without this, partially subjective, confidence, the Ministry's arguments are likely to lack the strength to guide policy formulation at the level of the sous-tutelles. Planners and decision makers in the specialized agencies have begun to look toward MEM's planning unit as the central coordinator and information conduit. This development is evidenced by an increased willingness to share information on particular investment projects, to work with MEM in improving its planning tools, and to participate in a continuing debate of major options and opportunities for Morocco. The planning network exists and is growing stronger as planners work with each other.

4.3 Skill Enhancement

The development of a permanent planning capability within the Ministry requires both the formation of a core staff responsible for national energy planning on a continuing basis, and the training of other staff in the Ministry and in the sous-tutelles in the basic aproach and specific methods used.

With respect to the permanent core, the Direction de l'Energie has assigned several staff to its "Cellule de Planification." This Cellule is expected to be upgraded to a "Service" in the Division des Produits Petroliers. So far, four staff members have been assigned full time to the energy planning project. The head of the Cellule and a second engineer are both "contractuels," government employees with an 8-year contract which is subject to extension. The two other staff members are "civilistes" with a two-year time commitment. This commitment expires in the fall of 1984. Their status beyond that date is uncertain, given the hiring constraints associated with the government's austerity program. Plans also call for the assignment of personnel from the other Divisions (Energie Electrique and Developpement des Ressources Energetiques) to the project, initially on a part-time basis.

Both the head of the Cellule and one of the civilistes have partici-

pated in the Energy Management Training Program for Developing Countries at the State University of New York at Stony Brook. In addition, two other MEM staff members have also gone through this program. The integrated nature of the project -- all project staff are working at the office of the prime contractor for technical assistance -- has facilitated continuous on-the-job training in planning techniques, data collection and analysis procedures, interaction with planners in the sous-tutelles, and the use of microcomputers in the planning process. Considerable project resources are being devoted to this function. Finally, project staff have conducted a series of seminars and presentations for Ministry staff and that of the sous-tutelles and other Ministries.

One key element of the skill enhancement portion of the project has been the development of a microcomputer package for investment project appraisal and the assessment of alternative policies. The EnVest package, described in greater detail in Section 3 in Part II of this report, is structured around the process of planning for Morocco. This package is not, and was never intended to be, "a model" requiring certain data, using certain techniques, and yielding specific answers to energy policy questions. Instead, it is designed to help in exploring alternatives within a process that brings together national-level planners in the Ministry and their counterparts in the specialized energy agencies. The package is construed to allow planners to focus on the substantive issues, and the formulation of assumptions, guiding them through the process with minimal technical requirements. In the same way that commercial accounting software enables non-accountants to manage their financial affairs, EnVest seeks to enable planners with limited experience to manage the planning task. This approach has proved fruitful in structuring the planning debate and focusing it on the substantive questions, by offering an assurance that purely technical questions have been resolved.

The basic orientation of EnVest also means that the package may not remain in its present form. As planning skills and needs change, the various modules of the package may change. As better energy demand and use information becomes available, modules may be replaced or added to examine specific policy issues. Some of these extensions are already anticipated in the current structure of the program. Others may require additional software development. We expect that the EnVest package will be useful in the national energy planning process for Morocco for some time to come. In some respects, it institutionalizes a planning approach and a related capability. However, even if the current version of EnVest were to be phased out completely, it would have served an important function in developing the planning structure and training planners. Already, the development of the second version reflects the growing sophistication of planners and decision makers with respect to the role of planning support systems.

4.4 Policy Interaction

The long-term orientation of the project entails a somewhat limited role with respect to influencing decisions in the short term. In the short run, other pressures tend to carry more weight in forcing certain kinds of decisions -- especially the lack of investable funds. Even so, the project has not proceeded in isolation from the on-going policy process. Without the slightest intention to claim any responsibility, it may be instructive

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to review some of the major energy policy decisions taken over the last few years for Morocco, relating them to information generated by the project, before turning to some of the policy prospects mentioned in Section 1.3.

The 1981-85 Energy Plan for Morocco identified eight principal areas of concern:

- continued development of the country's hydroelectric potential;
- increased utilization of coal;
- intensified search for oil and gas;
- exploitation of the country's oil shale reserves;
- (preparation for the) introduction of nuclear power;
- policies to encourage energy conservation;
- development of renewable energy;
- expansion of rural electrification.

Virtually all of the more capital-intensive options have been postponed. For example, the development of the country's hydroelectric potential has been limited to preparatory work. Studies conducted as part of the planning project suggested that such a delay of actual construction need not be critical (from an energy point of view, at least), given that thermal power expansion projects are scheduled to come on-line and that the growth of electricity demand may slow down as a consequence of intended changes in the energy price structure. These conclusions still hold, although the continuing drought has lowered the output from existing hydropower plants drastically, necessitating some load shedding during peak hours.

Similarly, projects to exploit the country's vast oil shale resources have been pushed into the far future; current efforts in this direction are limited to research and development, including the startup of a pilot plant using a domestically developed retorting process. Aside from the high initial capital requirements for synthetic fuel projects, the leveling off of the world market price of oil has rendered these options economically very unattractive. For MEM's planning work, we obtained data from a detailed study on various technological options. The project appraisal suggested that the processes characterized at that time would break even at an oil price in the upper $40's (in 1978 dollars). In addition, combining these options with other energy investments in some sample portfolios indicated that the required funds would vastly exceed the country's financing/borrowing capacity.

Much of the current policy efforts concentrate on intensifying the search for oil and gas. ONAREP has sought very actively to involve private partners in this process, conducting the preliminary exploration work, and preparing and giving presentations to oil company executives. At this level, the planning project is not involved. However, once the policy debate moves to the question of exploiting national resources, the central

planning unit can perform a critical function as catalyst and coordinator. In fact, the problem of developing a policy for using and pricing the natural gas at ONAREP's Toukimt field provided an opportunity for rehearsing such a role.

In this case, the planning unit became involved through the mechanism of an economic analysis of the viability of distributing and selling the gas under different pricing options. (The results of this analysis are described in EnVest Technical Memorandum No. 1, "Economic Analysis of the Toukimt-Asmar Pipeline Project," August 11, 1983.) The study concluded that delaying exploitation, subsequently combining the Toukimt gas with that from the nearby Meskala field at some point in the future might be preferable to coming to an agreement at a lower than economic price. Conceivably, this conclusion contributed to ONAREP's policy (which now seems to favor combining the gas from the two fields) -- along with a host of other factors, including the intransigence of the Asmar cement plant as the prospective consumer of the gas.

Initial planning work also illustrated quite graphically (literally, given the heavy emphasis on graphics in the EnVest planning support system) the financial burden associated with some of the larger projects under consideration. Again, it clearly does not take computer simulation to appreciate the financial needs vis-a-vis the country's financing and borrowing capacity. Even so, to be able to visualize the "bottom line" of these expenses, in relation to the cost of continued oil imports, and in relation to average investment levels for the economy as a whole helps demonstrate the dimensions of the problem in a more striking manner.

MEM's policy now focuses on relatively small projects, with the hope that the intensified search for oil and gas will pay off, easing the energy situation and providing some capital for pursuing other options. The planning project is responding to this emphasis by developing means to explore the potential impact of a policy of small projects (such as small-scale power plants) on Morocco's energy situation.

This process of adaptation and response is critical to the continued functioning of the planning unit. No single agency or office will make decisions regarding energy policies for the country, given the distribution of responsibilities and the style of policy formulation through developing a consensus. The key role of MEM's planning unit is to assist in finding consensus solutions, given the myriad of needs and constraints. Indications are that we have made and are continuing to make progress in that direction.

APPENDIX A

DATA SOURCES

A NOTE ON DATA SOURCES

For the most part, this report has drawn on published or publicly available data. For the general background information on the Moroccan economy and its prospects, we have used the following information sources:

Maroc en Chiffres, various years, published by the Direction de la Statistique

Quarterly Economic Review of Morocco, various issues and supplements, prepared by the Economist Intelligence Unit

World Bank, Morocco: Basic Economic Report, (in two volumes), December 30, 1980

World Bank, World Debt Tables, 1982-83 edition

CEDIES Informations, various issues, a weekly newsletter published by the Centre d'Etudes de Documentation et d'Informations Economiques et Sociales, which is the standard source for all official statistics on the economy

Data from these sources have been complemented by newspaper accounts; we have also perused the macroeconomic Country Development Strategy Statement (CDSS) prepared by the USAID Mission in Rabat for information on the debt rescheduling negotiations.

To estimate commercial energy consumption, the project has worked closely with the sous-tutelles in question. Both ONE and SNPP statisticians were very helpful in trying to break available data down by sectors, to allocate remainders among sectors, and to determine where their sectoral definitions differed from ours. The sectoral energy consumption figures reported here are therefore based on distributing and available sales data across user sectors, and adjusting for underreporting etc. With the available information, all consistency checks have been performed. Even so, the data must remain somewhat tentative. After work on this report had been completed, first results of the energy consumption portion of the annual survey of manufacturing conducted by the Ministry of Commerce, Industry and Tourism became available. These data allow for additional cross-checking and verification. This process is now underway.

Data for agricultural energy consumption were adjusted on an ad-hoc basis. SNPP seems to include all diesel fuel sold for tractors in its "transportation" category. We compared the estimated agricultural consumption of "gas oil" to preliminary estimates of consumption by tractors and combines, prepared by the technical assistance contractor for CDER. This comparison resulted in the shift of some 200,000 TOE of diesel fuel from transportation into agriculture. (This amount accounts for some 60 percent of the resulting estimated energy consumption in agriculture.)

Translating these consumption estimates into energy use coefficients required data on the value added for each of the economic sectors distinguished. This information is not available. We therefore estimated value-

added figures using the 1975 base and estimated growth rates of the different categories of final demand, as well as historical data on import substitution. These value-added estimates were then compared to the available GDP data and adjusted accordingly. Given this process, we cannot vouch for the reliability of data for each of the sectors. However, for the major energy consumers, the baseyear data reported here should represent the actual situation within a reasonable margin of error.

As noted in the text, estimates of the consumption of traditional fuels, notably fuelwood and charcoal are subject to considerable uncertainty. The available empirical data are obsolete, and were suspect even then. Much work in this area has been done by the FAO and the World Bank; their consultants seems to be most comfortable with estimates of 0.8 cu-m of fuelwood (in the form of wood or charcoal) per rural inhabitant and 0.1 cu-m per urban resident. Recent data collection efforts by the Direction des Eaux et Forets for a sample of areas suggest higher consumption levels. The preliminary data suggest such a high consumption level, however, that their reliability has been questioned.

APPENDIX B

CONVERSION FACTORS

Energy Conversion Factors

equals

	Tonnes of oil equivalent (TOE)	Gigajoules (10^9 joules)
1 Tonne of		
Coal	.70	29.3
Charcoal, briquettes	.69	28.9
Firewood (air dried)		
Pine	.32	13.6
Hardwood	.22	9.3
LPG	1.08	45.2
Gasoline	1.05	44.0
Kerosene/Jet Fuel	1.03	43.1
Gas oil/ diesel	1.02	42.7
Fuel oil	.96	41.0
1 barrel of		
LPG	.09	3.9
Gasoline	.12	5.2
Kerosene/Jet Fuel	.13	5.6
Gas Oil/ Diesel	.14	5.7
Fuel Oil	.15	6.1
1000m³		
Natural gas (existing)	.75	31.40
Natural gas (new sources)	.91	38.10
1 GWh	245	3,600
1 Kcal		4.187×10^{-6}

APPENDIX C

ENERGY COMPANIES IN MOROCCO

ACTIVITES DES SOCIETES DU SECTEUR ENERGETIQUE (1987)

	Capital Social (1 000 DM)	Effectif	Chiffre d'Affaire (1 000 000 DM)	Recherche, Exploitation de Pétrole	Surfinage de Gaz	Fabrication de Bitumes	Importation de Produits Pétroliers	Stockage des Produits Pétroliers	Distribution des Produits Pétroliers	Transport Maritime des Produits Pétroliers	Importation G.P.L.	Stockage G.P.L.	Distribution G.P.L.	Commercialisation de Bouteilles de Bouteilles	Fabrication de Bouteilles	Blending Plant	Fabrication de Lubrifiants	Importation et Distribution des Huiles	Commercialisation des Huiles Lubrifiantes	Regénération des Huiles Usagées	Distribution des Huiles	Raffinage	Production de Charbon	Distribution de Charbon	Importation de Charbon	Production de l'Energie Electrique	Transport de l'Energie Electrique	Distribution de l'Energie Electrique	Fabrication de Panneaux Solaires	Etudes Energies Renouvelables
- SAMIP	363 000	761	4873				◆	◆			◆	◆																		
- SCP	78 500	820	2156	◆	◆		◆	◆																						
- SEDLIMA	8 200	79	109			◆																								
- SNPP	40 000	57	271				◆		◆																					
- OME																														
- ONAREP		929		◆																						◆	◆	◆		
- CDM																														
- SOCOCHARBO																						◆	◆	◆						
- COEB																														
- SONAS	13 000	15	19								◆	◆																◆	◆	
- CEC	26 000	16	53					◆																						
- PETROCAB	17 715	120	35							◆																				
- PETRAMAR	32 000		81							◆																				
- SHELL	60 000	546	1979								◆		◆	◆		◆	◆	◆	◆	◆	◆									
- MOBIL	33 000	194	1321				◆	◆	◆							◆						◆								
- MOBY	52 000	360					◆	◆	◆				◆			◆				◆	◆									
- TERACO	11 000	163	870				◆	◆	◆				◆	◆		◆				◆	◆									
- TOTAL	52 000	360					◆	◆	◆				◆	◆		◆				◆	◆									
- CMM	33 344	170	758				◆	◆	◆				◆	◆		◆				◆	◆									
- PETROM	15 638	129	417				◆	◆	◆				◆	◆		◆				◆	◆									
- AFRIQUIA	15 000	263	891					◆	◆				◆	◆		◆				◆	◆									
- SOMEPI	8 000	141	163					◆	◆				◆	◆																
- SONAP	1 500	42	63						◆				◆	◆																
- ZIZ	60 000	85	219										◆	◆																
- ATLAS SAHARA	2 000	67																												
- SODIPI	12 000	422	166				◆	◆	◆																					
- MAGHREB GAZ	5 000	96	160				◆					◆		◆																
- GAZ AFRIQUE	2 500																													
- DIMAGAZ	50		1.82										◆	◆																
- MADIGAZ	650	7	2.96										◆																	
- TADLAGAZ	3 000	30	34										◆																	
- SONOMAC	150	4											◆	◆																
- SOMASUD	100		8.40										◆	◆																
- LEMI	220	11	2.50																											
- SAFRACHIM	100	10	0.07													◆														
- ETMM		24																												
- IPC	820	17															◆													
- ACAP	600	32															◆													
- DRAGON GAZ	350	7	1.20										◆																	
- SODIPIT	2 000	41	24										◆																	
- BUTSIR	500	15	9.50										◆																	
- Sté Nat GAZ	480	37	19.60										◆																	
- BERLIET	1 600	15	15.11																											
- SALUB	1 030	28	22.50																											
- SADEA																														

Best Available Document

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PART II:

THE EnVest PLANNING SUPPORT SYSTEM

May 1984

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1.0 INTRODUCTION

Simplifying things a little, one could distinguish two basic approaches to the task of national energy planning -- optimization and consequences analysis. The first focuses on establishing certain performance criteria or objectives, defining constraints, and deriving the policy that will yield the best performance. This approach often uses mathematical programming techniques, such as linear or dynamic programming, to determine an optimal course of action. Sometimes, the analyst/planner may eschew optimization, seeking instead for solutions that meet certain minimum standards, thus replacing the search for the optimum with a "satisficing" approach. But the basic structure remains -- to derive the appropriate course of action from given objectives.

The second approach employs what Medawar [1979, p. 74] has referred to as a Kantian experiment: "Let's see what would happen if..." This approach has recently gained some prominence in financial and related planning using spreadsheet analysis (a la VisiCalc) on microcomputers. It proceeds in three steps which can be repeated many times over, until the planner or policy maker is satisfied with the results:

- formulating alternative actions and assumptions, the "if";
- analyzing or predicting the consequences of these choices under the given assumptions;
- interpreting and evaluating the predicted outcomes as to their desirability and their implications for modifying the original choice of actions.

The first and the last step depend critically on judgment and political wisdom. The intermediate analysis step depends more on technical expertise to represent the energy system and predict its responses in the broader economic and social context.

The initial discussions structuring the process of national energy planning at the level of the Ministry of Energy and Mines suggested that the second approach was more appropriate for Morocco, given the emphasis on developing a policy consensus. The Ministry's mandate requires the comparative appraisal of projects proposed by the specialized agencies in charge of energy subsectors, such as the electricity sector. It also must be able to examine the performance of a set or portfolio of projects scheduled over time.

To facilitate the performance of these tasks, Ministry and project staff decided early on to develop an analytical planning support system. The plan was to standardize analysis procedures as much as possible, to enhance existing analysis skills, thereby enabling planners and analysts to concentrate on substantive elements of the planning task, the formulation of particular options and the interpretation of their projected performance. The structure of the process of energy policy development itself therefore served as the point of departure for assessing the suitability of existing analysis tools, and their adaptation to the needs of Morocco. The planning support system reflects this process structure, guiding the analyst through the various steps and providing the analysis tools needed.

These decisions already implied certain design choices for the final planning support system -- interactive, proceeding in stages, accessible to users with limited policy analysis or computer skills, etc. Project staff also decided to take advantage of the potential of microcomputers as a low-cost and flexible option to provide the desired analytical support to MEM's planning unit.

Part II of this report provides a guide to this analysis support system, the EnVest system. The EnVest system has evolved into a comprehensive microcomputer software package that can be used with minimal training. It is structured to guide the analyst and decision maker in making policy choices and assumptions explicit to evaluate major options. The discussion in some respects replicates the process that has led to the current configuration of the EnVest system. It starts by examining the energy plannner's toolbox -- methods and options for project appraisal and for evaluating policy alternatives at the level of the economy. This review provides the background for a fairly brief overview of the EnVest system.

2.0 THE TOOLS OF PLANNING

2.1 Introduction and Overview

National energy planning directly contributes to the formulation of economic development policies. Cutting across all sectors, energy policy decisions affect virtually every economic and social activity. It incorporates the traditional and well-established planning efforts for energy subsectors -- electricity, coal, or oil products. But its mandate differs from that of subsector planning. The national planner seeks to develop a comprehensive policy program that strikes a balance between demand and supply management, between the needs of economic and social development and available resources, and among the different energy forms. This process uses information from subsector planning efforts and provides the overall guidance based on an assessment of opportunities and tradeoffs.

While interest in national energy planning has grown, subsector planning has continued and has often expanded in scope and depth. Consequently, coordination and frequently arbitration among the subsectors' plans, within the overall economic context, become the national planner's most important task. The need for such coordination in the energy sector has been stressed by many observers; for example, in drawing the main conclusions from energy assessments in twelve African countries, World Bank experts noted:

> ... Meme lorsque le cadre institutionnel formel est bon, la coordination est insuffisante quant a la prise de decision dans d'importants sous-secteurs de l'energie.[1]

This emphasis on coordination among the energy subsectors outlines a particular role for the national energy planner. If the legal and institutional framework assigns budget authority to the central agency -- in the case of Morocco the Ministry of Energy and Mines , the decision maker often functions in the same manner as an investment banker. He chooses among the projects and programs competing for funds to yield an <u>investment portfolio</u> that is somehow judged best. As an aide to the decision maker, the planner must then provide information on the performance of alternative investment portfolios, or identify the optimal one for a given set of criteria.

The planner's task is twofold: (1) to appraise and compare individual projects or programs proposed either by the subsector agencies or by some other public or private sector organization according to common criteria; and (2) to assess the performance of a <u>sequence</u> of policy actions -- a particular combination of investment projects, introduction of special tax/subsidy schemes, or other measures -- as a comprehensive whole. This distinction between micro and macro-analysis is common in the energy planning literature (cf. Meier [1982])

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[1] "Le secteur de l'energie dans des pays d'Afrique selectionnes", Paper prepared for the ICC Symposium on the Development of Energy in the Countries of Africa, Mohammedia, Morocco, February 1-3, 1984

This section presents a rather sketchy survey of some of the analytical options that exist for the planner's micro and macro-analytical tasks. This survey is primarily intended to establishs a reference point for the description of the actual choices that went into the analytical support system for national energy planning for Morocco, the EnVest system. As such, the survey is neither unbiased nor comprehensive, focusing instead on few critical issues and their possible resolutions.

2.2 The Planning Paradigm

Policy planning at the national level can assume many forms, employing a variety of techniques and procedures for determining the best alternative. However, the policy framework remains the same, irrespective of the specific approach chosen (or adopted by default). The literature on quantitative economic planning has examined this framework in some detail, both the philosophical and methodological underpinnings, and its deployment in practice. Tinbergen [1952] was among the first to structure the general planning paradigm, as sketched in Figure 2-1. This approach views the world of the policy maker in terms of four sets of variables, two exogenous, determined as input into the energy/economy system, and two endogenous, determined through the interaction of the components of this system:

- policy instruments -- the set of measures controlled by the government; in the case of energy policy, instruments would include budgetary allocations among investment alternatives to augment supply or improve the distribution and use infrastructure, taxes and subsidies (including tariffs and duties), regulatory action, or public education;

- non-controllable factors -- exogenous variables that affect the outcomes of energy policies, but lie outside the control of the decision maker; the key example in the energy sector is of course the world market price of oil;

- target variables -- those outcomes of the system of concern to the policy maker; the degree to which the country's energy needs are satisfied, the cost of meeting these needs, development of technical knowledge and skills, national security, etc.; these variables (and their relative weights) make up the policy maker's objective function;

- irrelevant outcomes -- results that are of little interest to the decision maker.

These variables are linked by the structure of the system itself, represented for planning purposes by some model. This model need not be explicitly defined; it may simply be the policy maker's general notion of what actions yield what outcomes. Alternatively, it may be a highly sophisticated mathematical representation of the relationships among the four sets of variables -- where sophistication does not necessarily mean greater reliability. No matter what form the model may take, no policy formulation can proceed without one.

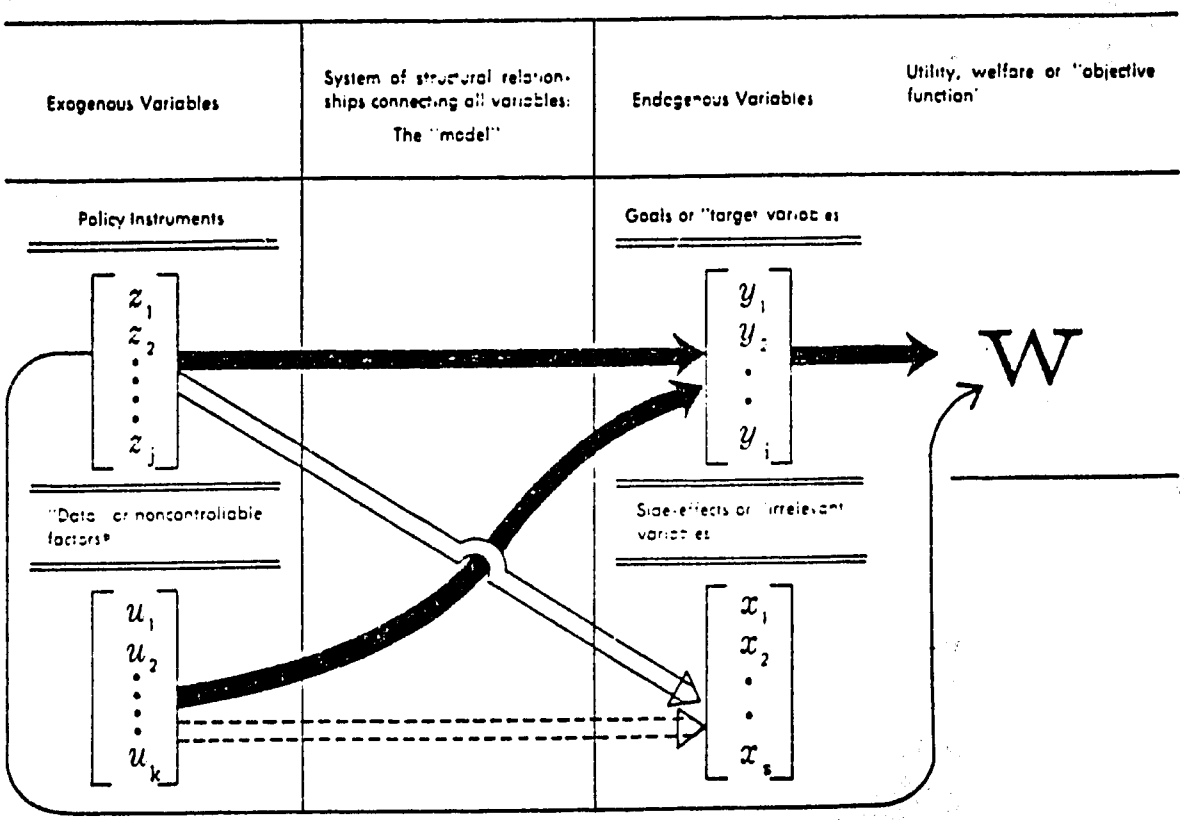

Figure 2-1: The General Planning Paradigm

Source: K.A. Fox and E. Thorbecke, "Specification of Structures and Data Requirements in Economic Policy Models," in: Hickman (1965), p. 44

This general policy or planning model has been further developed and extended by several authors, notably Theil [1961] who introduced the notion that the policy instruments themselves may not be value-free, but may well be part of the objective function. Spulber and Horowitz [1976] rephrased this conceptual framework in information-theoretic terms, facilitating its application to planning over time: as results of particular actions become apparent, policy makers revise not only their choices regarding instruments, but also their interpretation of the structure (their model). This particular modification of the basic paradigm succeeds in focusing attention on the ultimate role of (non-coersive) planning, namely to improve the flow of information on the outcomes of policy alternatives.

Any adequate representation of the structure in this basic conceptual framework must account for both its micro and its macro aspects. Micro-level analysis employs a partial-equilibrium framework, focusing on specific investment projects. These projects may be in the nature of social overhead capital (infrastructure) or, more rarely, directly productive investments. The appraisal and selection of investment projects becomes a key element in policy formulation. The discussion here therefore focuses first on project appraisal techniques before going on to the macro-analytical issues involved in national energy planning.

2.3 Project Appraisal

2.3.1 Principal Issues

Project appraisal seeks to determine whether a particular investment project (or sometimes policy program) generates more in benefits to society than it costs. It is designed to develop indicators of performance that allow for a comparison of different (types of) projects. This task requires the resolution of three major issues:

- enumerating and valuing costs and benefits,[2] i.e., deciding which effects of a particular project should be taken into consideration, either as costs (negative effects) or as benefits (positive effects), and how they should be measured;
- summarizing the information on cost and benefit streams over time to permit comparisons of projects with different cost and benefit patterns over time, or with different time horizons;
- controlling for differences in risk and uncertainty across projects; all other things being equal, the performance of a project involving a greater risk would normally be rated lower.

Every single one of these issues has produced a vast literature. Fortunate-

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[2] "Costs" and "benefits" are used here as convenient terms for referring to the negative and positive impacts of a project. However, project appraisal is not synonymous with cost-benefit analysis, which represents one particular method.

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ly, for the first two, several standard guidelines have emerged. Thus, the discussion in the first parts of this section can refer to reasonably well-established procedures -- although the actual application of these procedures still requires judgment and experience. The discussion does not attempt to pursue all technical details. Instead, it focuses on possible choices, relevant criteria, and the implications for analysis.

2.3.2 Enumerating Costs and Benefits

What impacts are to be included in the cost and benefit stream estimations depends on the type of project appraisal, and also on the scale of the project relative to its economic and social environment. In a strictly financial analysis, the analyst focuses on actual money costs and revenues in calculating a cashflow for the project. The costs and "benefits" to be included are determined by the legal and institutional context of the project -- market organization, taxes in all forms, and similar factors. The analyst can disregard any non-market impacts.

For virtually any public investment project, limiting the appraisal to the financial measures (or market impacts) may yield misleading results. Non-market impacts may occur in the form of externalities or distributional effects. The enumeration (and valuation) of such impacts presents some formidable problems. Some of it has been incorporated into the project appraisal process in developing countries as "social soundness analysis" (U.S. Agency for International Development [1975, pp. 5A-1 - 5A-12]). Similarly, newer techniques of shadow pricing tend to include adjustments for distributional impacts. Even so, many of the types of non-market impacts analyzed in the context of Environmental Impact Statements in the U.S. (as outlined in Rau and Wooten [1980]) are given short shrift in project appraisals for developing countrie -- even though they may be significant. For example, visual impacts or some projects become quite important in areas frequented by tourists.[3]

The types of costs and benefits, or, more neutrally, of inputs and outputs that should be included in the project appraisal process depend largely on the nature of the project itself. In the case of an infrastructure project, for example, the new facility may change conditions for a broad spectrum of activities. In that case, the project analyst may have to examine all of these activities to identify the benefits and costs generated by the project. As a rule, enumerating (and valuing) inputs is easier than identifying and measuring project outputs.

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[3] The port of Mohammedia provides one example for the crucial importance of this kind of impact which had not been adequately treated in the project appraisal process. Expansion plans for the port included the installation of facilities to handle larger ships for coal imports to supply coal to the Mohammedia power plant (units III and IV, converted to coal during construction). These plans were scuttled because of adverse visual impacts which were feared to affect Mohammedia's attractiveness to tourists. Consequently, Mohammedia III and IV now have to be supplied through the yet-to-be completed port of Jorf Lasfar, and through an overland railroad link.

On the output side, certain types of projects may also require the inclusion of the consumer surplus. Generally, if the project results in lower prices for its outputs, and if these outputs are already consumed by some group at the current (higher) price, this group will receive a benefit equivalent to the total "savings". For example, a new coal port may yield significant economies in handling imported coal, thereby reducing the price of all imported coal. If these savings are passed on to existing consumers in the form of lower prices, they in fact receive a "benefit" equal to the price difference times the amount consumed. In many instances, this benefit is small enough to be neglected in the analysis. But in special cases, it may in fact dominate the output side. The same holds for any producer's surplus generated by the project.

While the omission of non-market impacts may bias the results of the analysis at times, the most comprehensive analysis need not be the most useful one. In general, the decision on the inclusion or exclusion of various impacts should be made on a pragmatic basis:

> Economic project appraisal should determine whether a project is acceptable and, if it is, whether it is the best alternative; the purpose is not to quantify with great accuracy the myriad of direct and indirect effects it may have on the economy. Only those that may significantly affect the final conclusion should be considered. (Hansen [1978, p. 6]).

In most cases, conclusions about a particular project are more sensitive to the results of the technical (engineering) analysis than to efforts to trace secondary effects. Technical choices -- scale and timing of production, combination of technical alternatives, and management and organization -- tend to produce greater variations in the performance of projects than refined economic analysis of all possible impacts and their valuation.

2.3.3 Valuing Costs and Benefits

Procedures for valuing costs and benefits of a particular project vary according to the purpose of the analysis. To determine the viability of a project under purely financial criteria, the analyst typically focuses on marketed inputs and outputs. However, in certain instances, such as social overhead investments, markets for outputs do not exist. In this case, the analyst must develop surrogate values for the relevant variables. Whether markets exist or not, market (official) prices are used in the financial analysis to evaluate inputs and outputs. Even in the case of imputed values, market prices provide the guidance for establishing such estimates.

The financial analysis uses standard accounting practices to prepare income statements, cashflow projections, and balance sheets.[4] In this

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[4] Much of the material presented here draws quite openly on the UNIDO approach to project appraisal, UNIDO [1972], as presented succinctly by Hansen [1978]. Mercifully short on theoretical niceties, Hansen's small volume represents one of the most useful guides for any practicing project appraiser. Many of the points made in this discussion

case, the analyst acts like a private investor, including direct and indirect taxes and subsidies in the calculation. Well-established procedures can subsequently be used to obtain commonly accepted measures of project performance, such as the net present value or the internal rate of return. Section 2.3.4 examines the estimation and use of these measures under different conditions in greater detail.

The use of market prices for project inputs and outputs may lead to inappropriate investment decisions, if any distortions exist. Under a number of fairly stringent assumptions regarding competition and information, the price mechanism would yield an optimal allocation of society's resources. The price of any good or service would be equal to its marginal social value and its marginal social cost. Under these conditions, the analyst could use existing prices to determine the "true value" of any given project. Unfortunately, few market prices anywhere are established in perfect markets, reflecting the free interplay of demand and supply. Instead, some goods or services may be priced below their "true value" to allow for their consumption by low-income groups, or to guarantee lower costs of production in activities using these goods. In other instances, market prices are higher to discourage consumption or to protect marginal producers.

Using such distorted prices in project appraisal may yield misleading results. If the price of the output is artificially kept low, a financial analysis may erroneously conclude that it does not offer an attractive investment opportunity. Alternatively, output prices above the marginal social value would result in the financial analysis justifying investments that do not represent the best use of available funds. To avoid such misjudgments, the project analyst tries to control for existing price distortions by estimating the shadow prices of inputs and outputs, that is, their prices in the absence of protective tariffs, subsidies, price ceilings, etc. In principle, these shadow prices would in fact indicate the true value of some good to the economy.[5]

To provide guidance to the project appraisal process, two key questions need to be answered:

- When to shadow price?
- How to shadow price?

Most practitioners, including the UNIDO Guidelines and Hansen [1978], emphasize pragmatic criteria for responding to the first question. Shadow pricing is needed for all inputs and outputs where distortions are significant enough to influence the conclusion of project appraisal. In other words, the criterion is the sensitivity of the summary measure or project performance actually used to the difference between market and shadow apply to any method of economic project appraisal, though.

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[5] Using shadow prices in project analysis represents somewhat of a piecemeal approach. After all, distortions in the economy persist. A respectable literature has grown around this issue of "second-best optimization." See especially Little and Mirrlees [1974, pp. 367-373].

Table 2-1.

A Guide to Shadow Pricing

• Type of Impact	Type of Good or Service: Input	Type of Good or Service: Output	Valuation
• Domestic (non-traded)			
Production (supply)	More from local producers	Less by other local producers	Cost of production
Consumption (demand)	Less to other local users	More to other local users	Value to consumers
• Foreign (traded)			
Exports (supply)	Less export	More export	Value of export (f.o.b.)
Imports (demand)	More import	Less import	Cost of import (c.i.f.)

Hansen (1978), p. 24

prices. Hansen [1978] sketches an approach to calculating net present values and internal rates of return that allows for a quick assessment of the impact of any changes in the valuation of a particular input or output on the conclusion of the analysis. This approach becomes even simpler through the reliance on graphical interpretation.

The question of how to shadow price seems to be more difficult to answer. Texts and authors tend to disagree on the exact methods of determining the shadow prices of the relevant inputs and outputs of a given project. Again, it seems reasonable to go with the procedures adopted in the UNIDO Guidelines which distinguishes three types of situations as a basis for shadow pricing some particular element (Hansen [1978, p. 23]). For any given input or output, a project may change the

- supply available to the rest of the economy -- increasing it for its outputs, decreasing it for its inputs;
- level of its production in the rest of the economy -- discouraging production of its output elsewhere, or encouraging production of its input;
- level of its imports or exports -- decreasing imports (or increasing exports) of its outputs, or increasing imports (or decreasing exports) of its inputs.

These potential impacts can clearly occur together. How any one is best shadow-priced depends on the patterns of foreign trade, or, more precisely, on the tradability of the input or output in question.

Tradability is determined by the domestic cost of production plus the international cost of transport relative to the world market price. A tradable good would be imported or exported in the absence of trade restrictions or tariffs. Tradable goods may be either traded or non-traded. In the case of non-traded goods, changes in trade policies may change their status. Non-tradable goods are characterized by domestic costs of production plus international transport that are too high to make exports feasible, and too low to make imports attractive; that is, their costs lie between c.i.f. and f.o.b. prices.

With these definitions, rules for shadow pricing project inputs and outputs can be summarized as shown in Table 2-1. In the case of non-traded goods, shadow prices should reflect either the domestic cost of production, or the value to the consumer of the input or output. For production impacts, taxes are excluded in calculating the cost of production. In determining the value to the consumer, taxes should be included as part of the amount the consumer is willing to pay. Generally, if non-traded goods make up a significant portion of a project's inputs or outputs, decomposition becomes advisable: to describe their "contents" in terms of traded and non-traded goods and labor.

For traded goods, project inputs or outputs that affect exports are valued in terms of their f.o.b. prices, while those affecting imports are valued by their c.i.f. prices. In both cases, the analyst should examine likely changes in relative world market prices over the life of the project and adjust valuations accordingly.

Finally, the shadow pricing exercise also requires the choice of an appropriate numeraire, which may be either foreign exchange -- typically the US-dollar -- or the domestic currency, both exclusive of inflation. Either one should lead to the same conclusions. The difference lies in the standardization of prices. If foreign exchange is used as the numeraire, as in the Little-Mirrlees [1974] approach, the prices of non-traded goods are deflated to border prices. If the domestic currency is used, as in the UNIDO [1972] approach, the prices of traded goods are inflated to domestic price levels. Neither procedure changes the relative price structure.

In the conversion of domestic currency to foreign exchange, the analyst must account for the fact that controls on international trade imply distortions of the exchange rate. The official exchange rate may not correspond to the rate that would obtain under free international trade. Thus, foreign exchange needs to be shadow-priced. A reasonably simple formula for the shadow exchange rate is given by:

$$(2.1) \quad SER = OER\,[(M + T_M + X + S_x)/(M + X),$$

where OER - the official exchange rate;
M - total imports (c.i.f.);
T_M - import tax revenues;
X - total exports (f.o.b.);
S_x - export subsidies.

A study of Moroccan industry completed in February 1983 by the Ministry of Commerce, Industry and Tourism [1983], for example, concluded that the shadow exchange rate was some 10 to 20 percent higher than the official exchange rate.

This brief sketch of the principles of shadow pricing makes the task appear simpler than it often is. However, the emphasis on practicability, and the concentration on those inputs or outputs where shadow pricing (even in rough form) may alter the conclusions about the project's performance at least reduce the problem to more manageable proportions. In many instances, the analyst can draw on adjustment factors established by international agencies, such as the World Bank, to obtain some initial measures. Table 2-2 presents the results of a (by now somewhat outdated) World Bank study of the ratio of shadow to official prices for selected goods in Morocco. With the exception of that for phosphates, the shadow prices of all goods lie below their market prices.

The above-mentioned study of Moroccan industry also provides useful quantitative information on adjustments to input and output prices to account for market distortions. Unfortunately, little of this information is directly applicable to the appraisal of energy investment projects.

These shadow pricing principles refer to efficiency prices. Their application assumes that all the impacts of a particular project are equally valuable, irrespective of the uses or population groups affected. Typically, though, the government also considers the distribution of project impacts. For example, a project benefiting primarily the poorest population groups would be preferable to another one generating the same level of net benefits, but affecting primarily middle-income groups. The analyst

Table 2-2.

Illustrative Ratios: Shadow Prices to Market Prices

A. Principal Inputs	
Standard rate of conversion for internationally traded goods	0.59
Standard rate of conversion for nontraded goods	0.51
Transportation (general)	0.54
Wholesale and retail trade	0.42
Construction	0.51
Electricité et Eau	0.68
Gasoline	0.29
Kerosene	0.77
Fuel oil	1.10
Machinery	0.65
Imported machinery/ Investment Code	0.83
B. Intermediate Goods	Range 0.56 - 0.76
Iron and Steel	0.69
Cement	0.66
Chemical Products	0.64
Electrical Equipment	0.62
C. Local Industrial Products	Range 0.41 - 1.17
Cotton yarn and textiles	0.60
Automobiles	0.55
Agricultural Machinery	0.51
Phosphate Fertilizers	1.17
D. Raw Materials and Foodstuffs	Range 0.56 - 0.86
Cotton and Wool	0.72
Cereals	0.84
Bread	0.56
Urban Foods	0.76
Rural Foods	0.80
E. Miscellaneous Consumer Goods	Range 0.21 - 0.76
Miscellaneous fabrics and textiles	0.72
Clothing	0.58
Urban Consumer Goods	0.66
Rural Consumer Goods	0.71

Source: World Bank, 1980, pp. 116, 117.

can account for such concerns by applying distribution weights to the efficiency prices. The most thorough discussion of the principles and practical problems of such modifications is provided by Squire and van der Tak [1975]. These principles have been incorporated into the stepwise refinement of project appraisal outlined by Hansen [1978]. The result of these modifications is a set of projected economic cashflows which are adjusted for existing market distortions and which incorporate political judgments on the relative importance of different types of inputs and outputs.

2.3.4 Project Performance Measures

Several measures have been proposed to summarize the (expected) performance of a given project. The two most common ones are the net present value (NPV) of the economic or financial cashflows generated by the project, and the internal rate of return (IRR). The same expression defines both measures:

$$(2.2) \quad NPV = \sum_{t=0}^{T} \frac{A_t}{(1+r)^t}$$

where A_t - the cashflow for period t;
r - the discount rate (or the internal rate of return);
T - the project life.

To calculate the net present value of the project, the analyst chooses a value for the discount rate r. Alternatively, the analyst may determine the value of r that yields an NPV of zero, i.e., that equates the net present values of negative and positive cashflows. This value is the internal rate of return. Decision makers tend to prefer the internal rate of return as the criterion, since it resembles the interest rate that determines the earnings from a particular investment. This resemblance is somewhat superficial, though. In addition, the calculation of the internal rate of return in project appraisal and comparison may run into some problems. Generally, the net present value is a more reliable summary measure of expected project performance. Its major drawback, that it is measured in absolute terms rather than relative to the investment required, can be neutralized by using it in conjunction with a profitability index (indice de rentabilite), defined as the ratio of the net present values of positive and negative cashflows over the life of the project.

The determination of an appropriate discount rate for the calculation of the net present value faces several problems. If the main concern of the government is the improvement of consumption for the population, the appropriate rate is the consumption rate of interest (CRI) which is defined by the following expression:

$$(2.3) \quad CRI = ng + p;$$

where n - the elasticity of the marginal utility of consumption with respect to changes in per capita income;

g - the annual growth rate of per capita income;

p - the rate of pure time preference.

This definition renders the CRI a somewhat unwieldy concept, because neither the n nor the p are generally known or even knowable. Thus, quantitative estimates of the discount rate for Equation (2.2) must be derived on some other basis. One option is to use the opportunity cost of capital which may yield acceptable results for overall appraisal and comparison. Alternatively, several approaches (including the UNIDO method) do not attempt to fix a value for the discount rate a priori. Instead, net present values are calculated for a range of values and the critical value determined on the basis of the decisions of the policy maker in accepting or rejecting a particular project.[6]

2.3.5 Uncertainty and Risk

Project appraisal is based on projected cashflows. By definition, these projections are subject to uncertainty. Consequently, the overall performance of a project cannot be known with certainty. In accepting or rejecting a particular project, the decision maker therefore incurs a certain risk of making the wrong choice. Several methods have been described in the literature to deal with this problem.

First of all, it is of course possible to incorporate a risk premium into the discount rate used. Such an approach further complicates the choice of a value for this parameter.

Another fairly straightforward approach is the certainty equivalence technique, as described in Robicheck and Myers [1965]. In this case, the basic equation for determining the net present value is modified to account for the impact of risk:

$$(2.4) \quad NPV' = \sum_{t=0}^{T} \alpha_t A_t (1+r)^{-t}$$

where - the certainty equivalency coefficient which translates a given amount expected with some probability into its equivalent known with certainty; for positive cashflows, $0 \leq \alpha_t \leq 1$.

Another approach involves the assumption that projected cashflows follow some probability distribution which can be characterized by its mean and variance. The functional form of the distribution is of secondary importance. If the mean and variance of projected cashflows is known for each year of the project life, the analyst can obtain the expected value and the variance of the distribution of the net present value as well as that of the profitability index. If cashflows are independent of one another, we obtain for the mathematical expectation for the net present value:

$$(2.5) \quad E(NPV) = \sum_{t=0}^{T} E(A_t) \cdot (1+r)^{-t}$$

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[6] See Hansen [1978, p. 42] for a discussion of this "switching value." See also EnVest Technical Memorandum No. 1, "Economic Analysis of the Toukimt-Asmar Pipeline," August 15, 1983, for a more detailed examination of net present value and internal rate of return concepts, and of the issues surrounding the choice of a discount rate.

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and for the variance

$$(2.6) \quad Var(NPV) = \frac{1}{T} \sum_{t=0}^{T} \sigma_t \, (1+r)^{-t}$$

If cashflows are perfectly correlated, i.e., if A_t deviates by the same fraction of its standard deviation from its mean as A_{t-s} for all s, then the variance of the net present value becomes

$$(2.6') \quad Var(NPV) = \sum_{t=0}^{T} \sigma_t \cdot (1+r)^{-t}$$

The variance for the case of independence establishes a lower, that for the case of perfect correlation an upper limit on the actual variance of the net present value. Given these estimates, the analyst can determine the limits within which the actual net present value is likely to fall. Under the assumption of a normal distribution for the annual cashflow projections, for example, one could be about 68 percent certain that the actual NPV will fall in the interval E(NPV) $\pm$ Var(NPV). If the functional form of the distribution is unknown, Chebyshev's inequality would establish some outer limits for a given confidence level.[7]

To deal with these problems, Hertz [1964] developed a technique of developing distributions of the annual cashflow projections on the basis of a priori descriptions of the uncertainties associated with their constituent elements. This technique looks at the factors that determine annual cashflows, such as market size, price, market growth, market share, necessary investment, residual value of the installation, annual costs, fixed costs, project life, etc. For each one of these determinants, the decision maker or the analyst can establish estimates of their distribution based on experience or available data. Some illustrative distributions are shown in Figure 2-2. Subsequently, the distributions of the annual cashflows and their associated summary measures are obtained by means of a Monte Carlo approach using a model which expresses cashflows as a function of these variables.

The Monte Carlo method involves quantitative experimentation with different estimates of the key parameters and variables that are subject to random variations. This numerical experiment is repeated a certain number of times: using a random number generator and the specified probability distributions of the parameters or variables, values for each are chosen. Each particular combination of values yields a certain series of cashflows. The resulting values of the annual cashflows are subsequently summarized in the form of the net present value or the internal rate of return for this

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[7] The problem with this approach is its dependence on a priori knowledge or estimates of each year's cashflow mean and variance. While several simplifying short-cuts are possible, the need to estimate each of these elements separately places a considerable burden on the analyst or the decision maker.

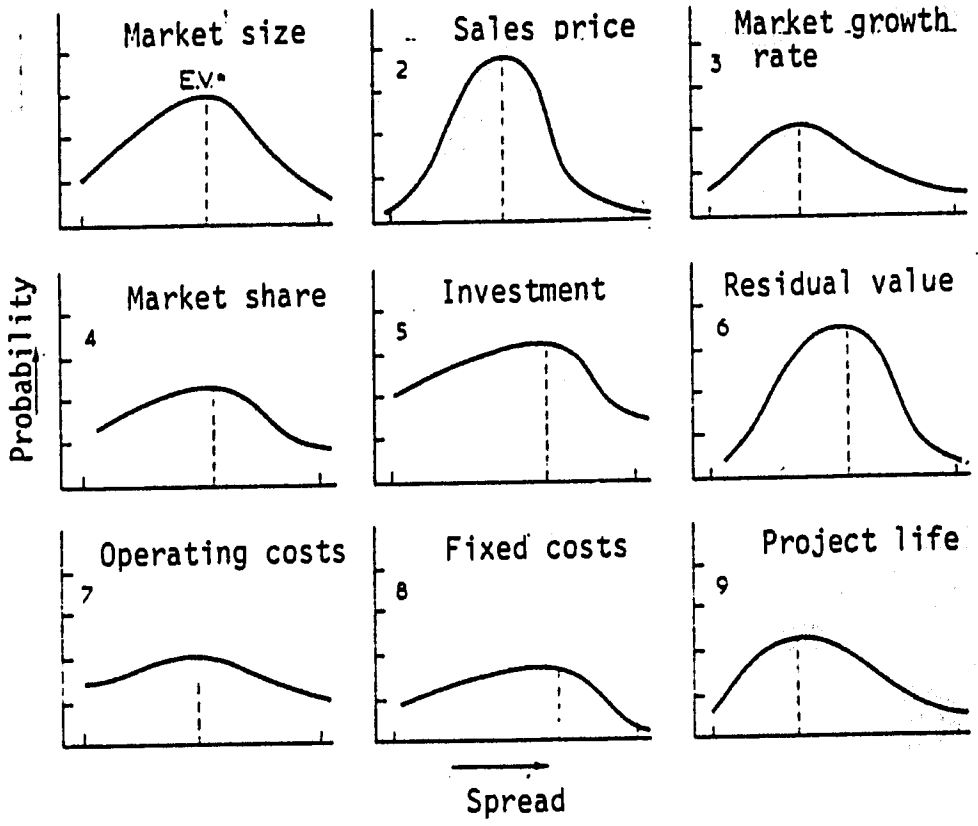

Figure 2-2: Distributions of Performance Determinants

Source: Hertz (1964), p. 102

particular combination of values. How many repetitions are needed depends on the purpose of the analysis. To develop a reasonable distribution of the summary performance measure, a minimum of 30 is advisable. Hertz [1964] developed this approach for capital-budgeting problems of private investors. Reutlinger [1970] has extended it to the appraisal of public investment projects. His illustration of the technique for a road construction project provides useful guidelines for its application in other settings.

2.3.6 Project Comparison and Choice

In general, the decision maker is likely to examine a range of projects, either as alternatives (i.e., mutually exclusive) or as possible combinations. In the case of alternatives, the decision is fairly straightforward: the project with the highest net present value will be chosen.

Putting together a portfolio of projects is also fairly simple for a fixed capital budget. In general, one would choose projects for implementation from a list which ranks possible projects by their profitability index until the available investment capital is spent. Horne [1972, pp. 42-46] illustrates some potential variations of this process of "capital rationing" with the following example. Let the total investment budget be limited to $300,000, and the investment options are given by:

Project	Profitability Index	Initial Investment
3	1.15	$200,000
1	1.13	125,000
2	1.11	175,000
4	1.08	150,000

In this case, investing in the best option (Project No. 3) would leave $100,000 unused. The investor can maximize the net present value of the "investment portfolio" by choosing projects 1 and 2 instead. In this case, the net present value of the investment would be $35,500, $125,000 x 0.13 + $175,000 x 0.11; investing in the best option would yield only $30,000.

Projects may depend on one another. For example, if project 1 could only be implemented in conjunction with project 4, they must be treated as one project in the choice of a portfolio. The decision criterion would be the (weighted) average of their respective profitability indexes.

The choice of an investment portfolio becomes even more complex, once uncertainty and risk are admitted as decision factors. Fairly sophisticated methods have been developed for the selection of an optimal investment portfolio incorporating risk, based on Markowitz [1959]. These methods require a specification of risk-return tradeoffs by the decision maker, as well as adequate information on the interdependence and correlation among investment options. In general, the requirements of analytical tractability imply some fairly significant simplifications for such an optimization approach. It is for this reason, that simulation techniques provide a better means for appraising the consequences of particular in-

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vestment portfolios. The decision maker can examine these consequences and make a choice among discrete options based on a subjective assessment of the desirability of the simulated consequences.

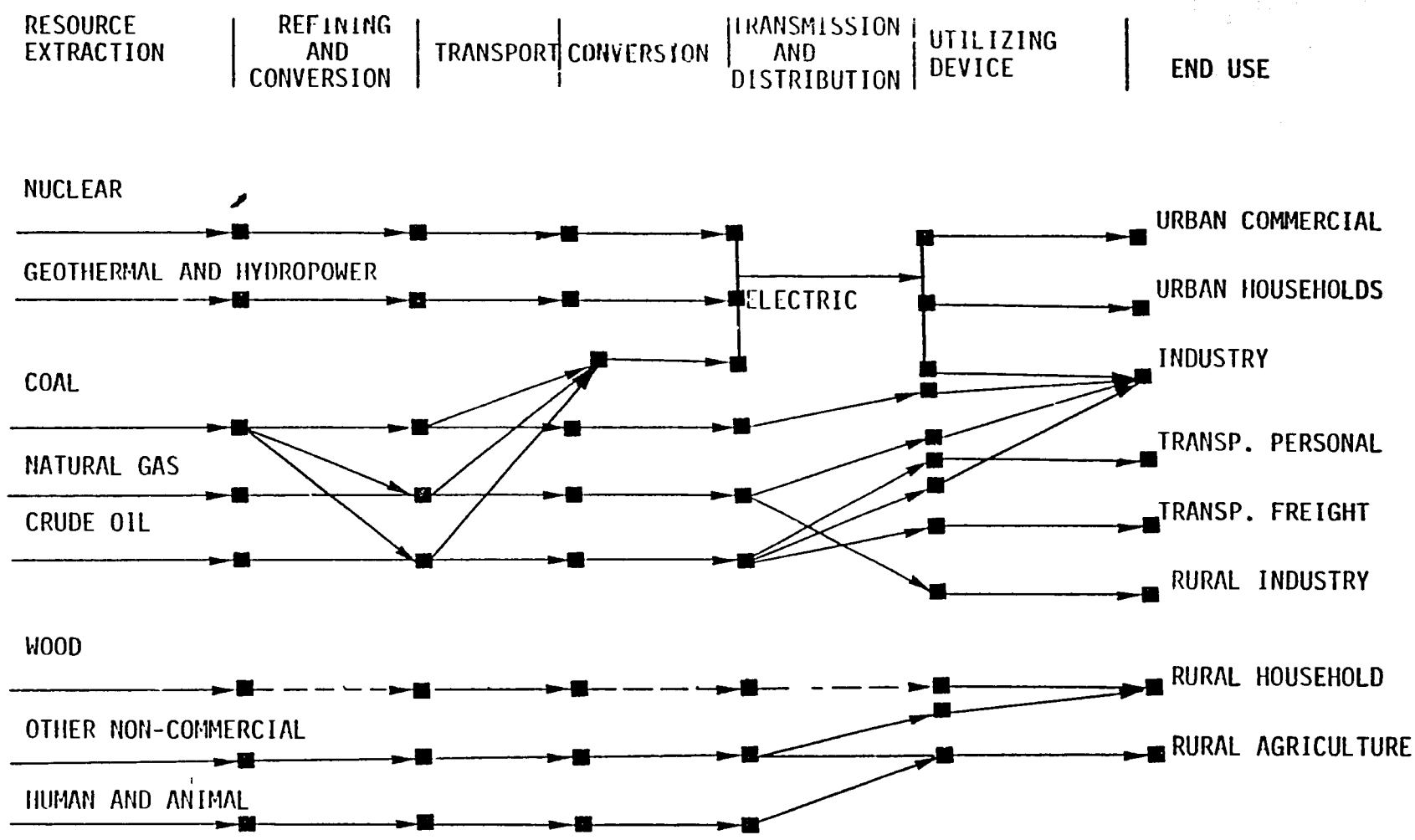
In the case of energy, the projects that can be chosen interact with one another through the technical and economic structure as sketched in Figure 2-1. Whether one seeks to identify projects through an optimization procedure, or to simulate the consequences of a particular portfolio, this structure must be specified. As noted at the outset, what makes this a challenging task is the mix of technical and economic relationships that need to be considered. These aspects are examined in the following subsections. Specifically, we will first look at some of the comprehensive planning models extant. The discussion of specific problems is organized into three topic areas -- demand analysis and forecasting, power sector planning, and planning for other energy subsectors.

2.4 Comprehensive Energy Planning Models

The first oil shock of the early 1970's spawned a slew of energy planning efforts, often involving the development of some comprehensive planning model. Since then, more work has been done. Existing models have been refined and new ones have been added. Any attempt at creating a representative inventory -- let alone any systematic evaluation -- goes beyond the scope of this report. An extensive literature has grown around this subject has reached Key evaluations of energy policy and planning models include Hogan and Parikh [1977], Hoffman and Jorgenson [1977], Brock and Nesbitt [1977], Kuh and Wood [1979], and Charles River Associates [1978]. Similarly, Julius et al. [1981, pp. 54-58] present a very concise review of some key energy policy models developed in the U.S. Instead of trying to summarize the results of these comparisons and evaluations, a perhaps somewhat cursory examination of the characteristics of some of these models may suffice to illustrate different approaches and methods.

One family of energy policy assessment and planning models has grown around the work started in the early 1970's (preceding the first oil shock, in fact) at the Brookhaven National Laboratory (BNL). This work produced the Reference Energy System (RES) approach, described in a number of publications, such as Beller [1975] or Malone and Reisman [1978]. This work rests on the specification of a linear system describing the energy flows in the economy, as illustrated in Figure 2-3. Basically, the system starts with the primary energy resources on the left, and follows them through the stages of extraction, refining and conversion, and distribution through to final use. At each stage, total resource consumption is determined together with the relative effectiveness of the process.

Once the data for quantifying the parameters of this system have been collected, it can be expressed in matrix form as a linear system. For planning purposes, the Reference Energy System is driven by forecasts of demand. Demand is determined on the basis of projected activity levels in the various consuming activities on the right-hand side of the graph. Each activity (such as total number of households, or tons produced in some industrial sector) is associated with a number of energy-consuming activities -- such as cooking, heating, steam generation, etc. For these



NOTES:
1. Flows in 10^{15} joules
2. Solid line indicates real process
3. Conversion efficiencies shown in parenthesis

Figure 2.3: LDC Reference Energy System (Illustrative).

Source: Meier (1982, p. 64)

energy-consuming activities, the empirical data together with assessments of emerging technologies and relative costs yield information on the likely fuel-mix.

By tracing the necessary energy flows from the right to the left through matrix manipulation, the planner can then determine the required activity levels in the various energy extraction, conversion and distribution activities. This information can subsequently be compared to the existing and projected capacities of the energy sector to identify system expansion and modification needs. The system expansion and modification needs in turn can be translated into specific investment projects, for example, by using the Energy Supply Planning Model (ESPM) developed by the Bechtel corporation as an adjoint to the RES in the mid-1970's and since developed further. Several policy options can be explored by varying the parameters of the basic forecast, the reference case.

The RES has been adapted to energy planning work in developing countries (Malone and Reisman [1978]). It can be deployed in an input-output framework to develop optimal approaches to structuring the energy system under specific assumptions about demand patterns. Thus, it represents a potentially powerful tool for national energy planning in a developing country.

However, several factors must come together to realize this potential. First, the necessary detailed data must be collected. While the authors of the system and its users have provided many aids to estimating certain system parameters, considerable work in the country itself is required to meet the system's data needs. That in itself can be a very useful activity, as the various RES applications in developing countries have demonstrated. Even so, it represents a costly first step.

Second, and perhaps more importantly, the RES tends to approach the energy policy problem in a normative manner. Its structure lends itself to the interpretation that the required policies can be derived from given demand targets (which may vary in response to certain assumptions). Such an approach abstracts from the actual planning process which characterizes many developing countries -- a more or less cooperative effort of several agencies and institutions. Typically, the central planning group only plays a role of primus inter pares in this process. In this situation, it may find it difficult to develop some optimal system expansion and modification program and make it palatable to the other institutions of the energy sector. However, the normative orientation is not inherent to the RES, as demonstrated by the fact that it has been used in different modes.

MARKAL (for MARKet ALlocation) represents on of the models developed on the basis of the Reference Energy System specifically for developing an optimal energy policy program. The model was developed jointly by the Brookhaven National Laboratory and the Kernforschungsanlage Julich (Germany) under the sponsorship of the International Energy Agency. It focuses on the determination of an optimal supply structure, taking demand forecasts as given. The model uses a dynamic linear programming approach to find the optimal solution, by minimizing the cost of meeting the given demand. The MARKAL model allows for a fairly detailed treatment of the energy sector. Some versions of the model contain some 3,000 constraints and 4,000 variables.

In his doctoral thesis, Abbad [1983] recently applied the model to the case of Morocco. Data constraints limited him to a relatively simple model specification. The results, for given demand levels, offer few surprises, given the underlying price assumptions -- replacement of fuel oil by imported coal, introduction of shale-burning (direct-combustion) power plants, nuclear power plants, etc. The model does not allow for any significant feedback from supply to demand. Nor does it take into consideration infrastructure requirements, an important element given the projected reliance on imported coal.

The application of the MARKAL model to Morocco illustrates some of the difficulties of an optimizing approach in a situation characterized by a complex system structure, and a relative dearth of relevant data. Both analytical tractability and data limitations force the analyst to simplify the model specification to a point where the results may be instructive, but provide little guidance for actual policy formulation.

Another example of a large-scale energy planning model is the Mid-Range Energy Forecasting System (MEFS), the reborn Project Independence Evaluation System (PIES). It represents a consistency, rather than an optimization, model, i.e., it is designed to predict the consequences of certain policy actions instead of trying to identify the actions required to reach certain goals. To our knowledge, it has so far only been applied to the case of the U.S.

The model structure can be represented schematically as shown in Figure 2-4. MEFS is a set of demand and supply models, the results of which are then integrated to determine market clearing conditions. The integration model represents the key element of the system. Working with demand and supply curves rather than single-point estimates, it determines prices and quantities through an iterative optimization procedure.

On the supply side, the MEFS focuses on three types of primary fuels, natural gas, coal, and oil. For each of these resources supply conditions are described in terms of both behavioral (economic) and technical relationships. The models for the two conversion subsystems, refineries and the electricity sector, use optimizing procedures to find the least-cost means of meeting a particular demand level. By defining an appropriate range of prices and the corresponding demand levels, the system determines supply curves for the conversion sectors as well.

The demand analysis in the MEFS proceeds in a two-stage process. In the first stage, the demand model predicts total energy demand by sector, based on sectoral activity levels and energy prices. In a second stage, this total energy demand is broken down into demand for each type of fuel on the basis of past relationships and relative prices. In private transportation, vehicle miles traveled is predicted on the basis of income measures and the cost of travel. The latter in turn depends on the fuel efficiency of the automobile fleet, determined as a function of the age composition of cars in use.

The MEFS thus comprises several highly sophisticated models that taken together describe the energy sector in sufficient detail for the assessment of different government policies in an essentially competitive

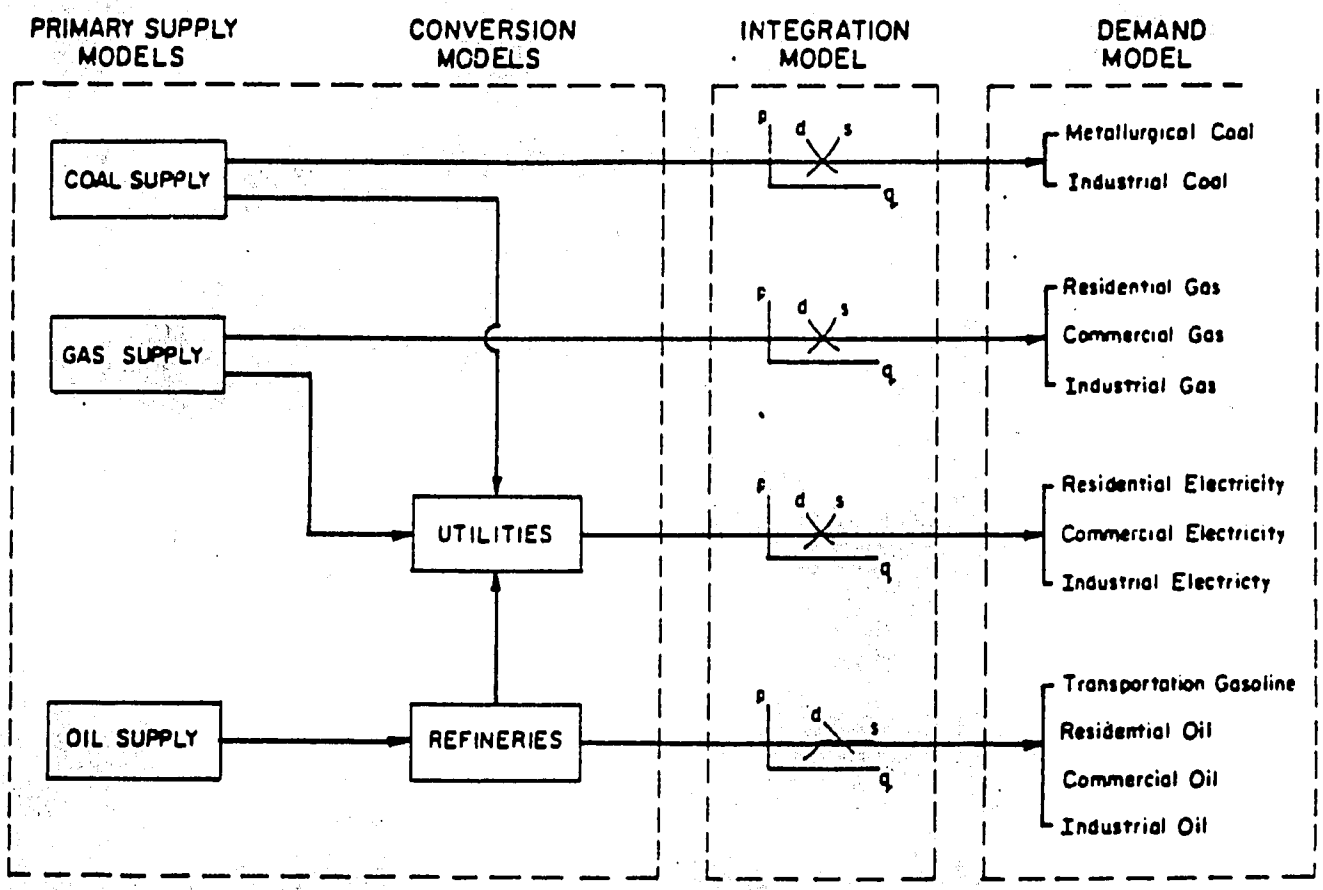


Figure 2-4: Structure of the MEFS Model

Source: DeSouza (1981), p. 167

economy. The level of sophistication and the accompanying data requirements tend to make this system unsuitable for use in a developing country. However, its overall structure provides useful guidance for thinking about the energy policy context. Even if the full range of data for the econometric specifications of behavioral responses is not available, some preliminary "guesstimates" can be introduced to assess policy consequences at least in rough form.

In fact, even in the full version of the MEFS, judgmental estimates of key parameters have played a significant role. In his review of the model, DeSouza [1981] notes:

> ... MEFS contains a vast number of parameters, the great majority of which are judgmental. Because of this proliferation of essentially subjective parameters, the possibilities for significant errors in MEFS are impossible to isolate and the mechanism by which errors are propagated is a complete unknown. ...one does not even have an empirical guide to the reliability of MEFS forecasts. (p. 176)

This comment raises some interesting methodological issues. It also suggests that data availability may not be the boon it is often made out to be. If a policy model for a country like the US depends critically on judgmental inputs, how much does a developing country gain in its energy planning efforts by devoting a major part of its available resources to data gathering and analysis? Unfortunately, this question has received scant attention. The experience with the MEFS suggests that detailed data collection and analysis may not suffice to obviate the need for informed judgment and imagination on the part of the analyst or decision maker.

The brief examination of a few comprehensive energy planning models here has served to illustrate two aspects that are important for national energy planning in developing countries in general, and in Morocco in particular. First, modeling the energy system is difficult. It is a very complex system. Its course depends on a myriad of economic, technical and behavioral factors which are often poorly understood. The work that has gone into the development of optimizing models (which require the explicit treatment of all structural characteristics, along with the specification of values attached to outcomes) has advanced our understanding of energy policy problems. However, it has also vividly demonstrated the technical complexity and extensive data and analysis needs of this type of model. Similar reservations apply to consistency models of the MEFS type which attempt a comprehensive representation of the energy system.

Second, the emphasis on improving the empirical foundations of energy planning may hold only up to some threshold. Beyond that threshold, gains may be limited. Many of the phenomena that determine the outcomes of different policies are inherently complex. More and better data on the past do not necessarily lead to better predictions. In any case, better empirical information certainly does not appear to substitute for the analyst's and policy maker's judgment. These points pertain directly to the choice of procedures and tools for energy planning in developing countries.

2.5 Demand Analysis and Forecasting

Demand for energy in various forms reflects technical as well as economic factors. It is a derived demand: for the firm, energy represents a factor of production, like labor, capital equipment, technology, or land. For the consumer, energy is required to produce certain services that have inherent value (food, warmth) or to contribute indirectly to the production of such services (transportation). Lancaster [1966] has developed the concept of the household production function which allows for treating the derived-demand problem on the consumer side within the same framework as that for the firm.

Two distinct, but by no means mutually exclusive, approaches have characterized the analysis and prediction of energy demand patterns. The first has more of an engineering orientation, examining the functional uses of energy in each sector considered, identifying the energy-using processes and the related capital equipment (or energy-using devices). Based on this analysis and an appraisal of technological and economic trends, changes in (capital-embodied) energy-use technology are forecast to obtain an assessment of aggregate energy needs by sector and for the economy as a whole. The basic RES approach illustrates this method. For example, Kernforschungsanlage Julich [1980] and Brookhaven National Laboratory [1979] document the results of a joint project to develop comprehensive data for current and future energy-use technologies for IEA member countries.

The second approach relies primarily on statistical methods to determine the role of energy in the general production function of a given sector. This type of work focuses primarily on the energy price structure as the key determinant of use patterns. Julius et al. [1981] represents an excellent and exhaustive review of the literature on energy pricing and demand patterns. A brief sketch of some of the major findings reported in this literature, with particular reference to developing countries, provides a useful background for the discussion of the demand forecasting approach adopted in the EnVest analytical support system. This sketch draws on the review of Julius et al. [1981].

Berndt and Wood [1977] and [1979] have developed the conceptual framework needed to summarize and compare several studies of the aggregate relationships between energy and economic growth. By treating capital and energy as a composite -- through their "utilized capital" concept -- they were able to determine the substitutability of energy for labor from a number of studies. Virtually all the studies examined by them show at least some energy-labor substitutability. In several instances, this relationship is statistically significant.

A number of studies have focused on the correlation between aggregate economic activity and energy consumption in developing countries. Dunkerley et al. [1980] present a comparative assessment of various energy demand projections for this group. Some of the work, such as that of Leigh, Strasser and Trehan [1980], suggests that the strength of the correlation between energy consumption and economic activity, measured by the Gross National Product, depends on the level of development. Less developed countries (LDC's) with a low per capita income show little relationship between (commercial) energy consumption and GDP, while those with higher incomes have a more pronounced relationship between energy and GDP.

That observation is likely to reflect differences in market structure for energy products as well as differences in use patterns. In a comparison between two groups of countries, one emphasizing import substitution, the other export promotion, Dunkerley et al. [1981, p. 109] fail to demonstrate a relationship between development strategy and energy consumption.

Several studies have attempted to calculate income and price elasticities of aggregate energy consumption. Table 2-3, taken from Julius et al. [1981], shows a comparison of the results of these studies. These results suggest a range that may be useful in assessing the acceptability of specific energy demand forecasts relative to forecasts of total economic activity.

Pyndick [1979] presents one of the most comprehensive studies of energy consumption and demand by sector for a number of countries. Taking prices (rather than quantities) as exogenous, he uses a trans-log cost function to examine relationships among output, prices, and inputs, including energy. The results are shown in Table 2-4. Julius et al. [1981] comment:

> ...Perhaps the most important result is that the own-price elasticity of aggregate industrial energy demand appears to be significantly larger than had been thought previously and energy and capital appear to be substitute rather than complementary factors of production. (p. 63)

Given the typical data situation for developing countries, relatively little work has been done on sectoral energy demand and consumption in LDCs. A major exception is India whose industry has been studied by several authors. Among these studies is that of Williams and Laumas [1980], which concludes that factors other than labor appear to be reasonable substitutes for energy, and that the price elasticity of demand for energy is higher than that for other factors. The practical significance of these results may be limited by the peculiarities of the Indian economic situation compared to that of other LDCs. Moreover, as in the case of studies of energy demand conditions and responses for industries in the industrialized countries, questions of methods and data remain. Thus, the subjective reliability of specific numerical results may well be insufficient for any detailed planning applications.

Similar reservations apply to the findings of studies on the characteristics of residential demand for energy. On the basis of studies such as Fernandez [1980], Cody [1980] or Strout [1978] for LDCs, it appears that the income elasticity of residential energy demand tends to lie below unity (typically in the range of 0.6 to 0.8). Limited evidence is also available to show that price elasticities are in fact negative and below unity in absolute terms. However, the empirical evidence is far from reassuring to the planner.

This brief review highlights some of the problems ragrding the empirical information on energy demand. The numerical estimates clearly are insufficient to replace the planner's or decision maker's judgment. They may guide or support any judgmental specifications of key parameters. Such judgmental specifications may be suspect if the planner is trying to develop an optimal policy through mathematical techniques. However, if the

Table 2-3

Estimates of Income and Price Elasticities

of Energy in Developing Countries

	Income Elasticities		Price Elasticities	
	Short-Run	Long-Run	Short-Run	Long-Run
Choe (1978)				
- Upper Middle Income	.509	1.361	-.122	-.326
- Intermediate Middle Income	.398	1.305	-.085	-.279
- Lower Middle Income	.680	1.937	-.134	-.382
- Low Income	.621	1.146	-.152	-.280
Hoffman (1978) 1/				
- High & Upper Middle Income		1.34 to 1.73		
- Lower Middle & Intermediate		1.03 to 1.13		
- Low Income		0.90 to 1.38		
Choe (1979)				
- All developing countries (36)		1.36		
- Net Oil Importing developing countries (26)		1.35		
- Net Oil Exporting developing countries (10)				
Ezzati and Pinto (1979)				
- Intermediate Income Group		1.30		-0.279 to
- Lower Middle Income Group		1.94		-0.382

1/ Hoffman's study includes structural variables defined as share of various sectors (agriculture, manufacturing, etc.) in GDP.

Note: All coefficients are significant at 95 percent or higher, confidence limits.

Source: Julius et al. (1981, p. 52)

Table 2-4

Summary of Elasticity Estimates for Industrial Demand for Energy

Elasticity	Estimates
Factor inputs: elasticities of substitution	σ_{KL} = 0.77 to 0.82 σ_{KE} = 0.61 to 0.86 σ_{LE} = 0.93 to 0.97
Factor inputs: price elasticities	η_{KK} =-0.33 to -0.56 η_{LL} =-0.26 to -0.52 η_{EE} =-0.75 to -0.84 η_{KE} = 0.02 to 0.06 η_{LE} = 0.03 to 0.08
Energy demand: output elasticity	η_{EQ} = 0.62 to 0.86
Fuels: own-price elasticities, partial	electricity: -0.07 to -0.16 oil:-0.81 to -1.10 for U.S. and Canada -0.11 to -0.34 for Europe and Japan gas:-0.33 to -0.52 for U.S. and Canada -1.30 to -2.31 for Europe and Japan coal:-1.80 to -2.17 for U.S. a,d Canada -1.04 to -2.08 for Europe and Japan
Fuels: own-price elasticities, total	electricity: -0.54 to -0.63 oil:-1.03 to -1.117 for U.S. and Canada -0.06 to -0.56 for Europe and Japan gas:-0.41 to -0.67 for U.S. and Canada -1.37 to -2.34 for Europe and Japan coal:-1.89 to -2.24 for U.S. and Canada -1.29 to -2.15 for Europe and Japan

Note: K= Capital, L= Labor, E=Energy

Source: Pindyck (1979d), p. 222

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from: Julius *et al*. (1981, p. 64)

purpose of the planning exercise is to obtain some idea of the range of likely responses to policy alternatives under consideration, fairly crude estimates may well be sufficient. Thus, in spite of all the remaining uncertainties, the available empirical information can be quite useful in establishing some guideposts for parameter specification -- as long as the tentative nature of these estimates is clearly understood and acknowledged in the planning process. As discussed in Section 3, the EnVest analytical system allows for the use some of the numerical estimates available to explore the responses of the economy to alternative pricing policies.

2.6 Power System Planning

Planning for and managing electric power system presents a complex task. While many useful techniques have emerged for dealing with these problems, they offer no panacea. The basic problem is of course that electricity cannot be stored in any significant manner. It is consumed virtually the same instant as it is produced. Moreover, consumption fluctuates in a pronounced manner by time of day and season. Thus, to avoid deterioration of service to customers, the capacity of a power system must be sufficient to meet demand at its peak.

In addition, the capacity of the system at any given point is not known with certainty. Power plants are subject to unpredictable interruptions of service as a result of technical problems. Thus, the power system planner must not only plan for the peak -- rather than total demand over some period of time -- but also with respect to minimizing the chance of insufficient capacity at any given time because of system failures.

Consequently, planning the expansion of the electricity generation system is an exercise in dealing explicitly with uncertainty. The power system planning process starts with the forecast of the total system load and its distributional characteristics. Typically, the total consumption of energy (load) over some period of time can be described in terms of the load duration curve, as sketched in Figure 2-5. The load duration curve shows the total number of time units, normally hours, for which a certain system capacity is required. The point at which this curve intersects the y-axis represents the peak load, the point corresponding to the total number of time units in the period (e.g., number of hours per year) the base load.

Forecasting total system load thus is a two-step process. First, the planner needs to estimate the peak load (or the total demand), and subsequently the distribution of the load over the time period used in the analysis. A recent report by the U.S. General Accounting Office [1983] illustrates the wide range of techniques used for this purpose by utilities in the U.S. For some of its long-term planning efforts, the Office National de l'Electricite in Morocco uses methods incorporated into the Wien Automated System Planning Package (WASP), originally developed for assessing the prospects for nuclear power, and described in Jenkins and Joy [1974]. This procedure involves the estimation of a functional specification of the load duration curve (a fifth-degree polynomial) which is subsequently updated every five years into the future.

The next step consists of determining the ways in which this demand

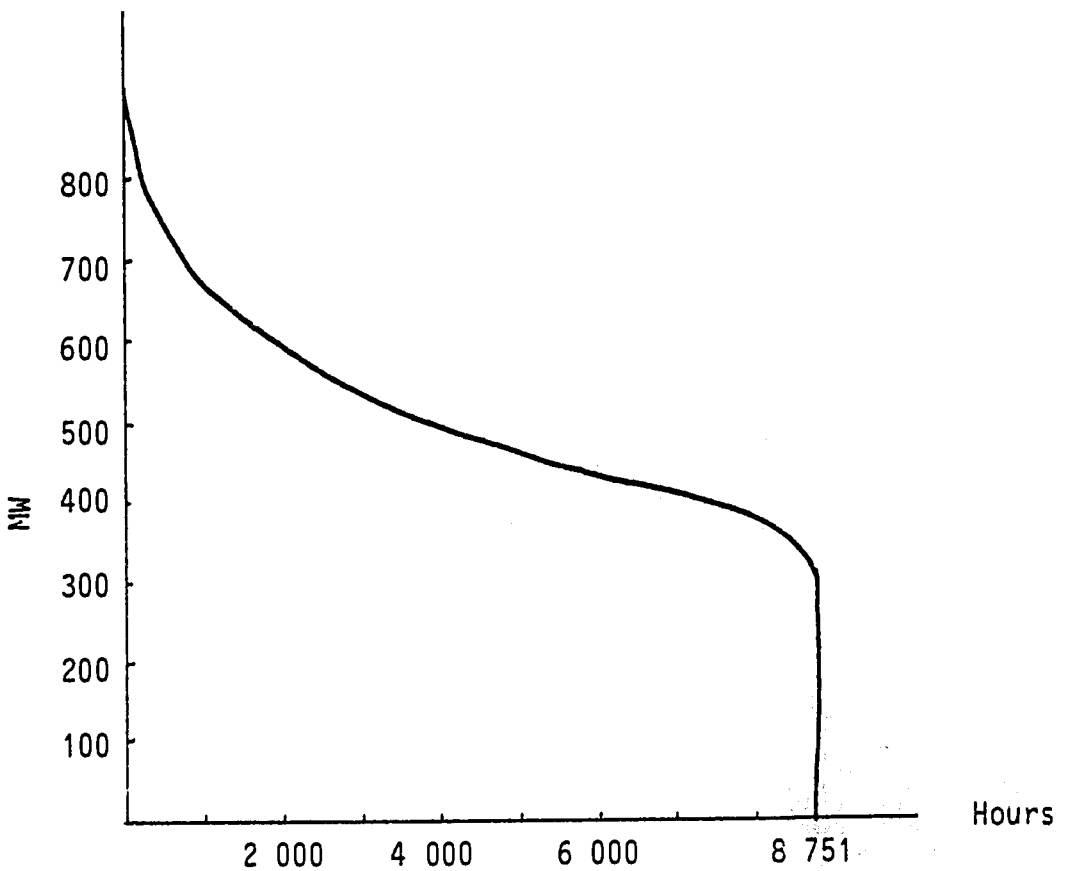

Figure 2-5:
Annual Load Duration Curve for Morocco, 1982

will be met by existing and to-be-constructed power plants. Dechamps [1983b] suggests a two-step process. In the first step, the generation expansion options are examined by means of relatively simple, and typically deterministic, models. In the second step, medium-term power system expansion is analyzed using stochastic simulation techniques. The WASP model represents one approach; see Jenkins and Joy [1974]. Baleriaux et al. [1967] describe a similar model, called PROCOS. Both approaches use the concept of an equivalent load duration curve which incorporates the effects of forced (unpredictable) outages by the system's thermal power plants. The approach is discussed in some detail in EnVest Technical Memorandum No. 2, "The Electricity Sector in the EnVest System," (Draft -- November 1, 1983).

A relatively simple model based on these concepts can be used to examine the performance of the system under different assumptions. Stochastic simulation yields information on total system performance, including the probability of not meeting demand (loss-of-load probability) for a given generation system configuration, system costs, etc.

Finally, power system planning also must include the transmission system. Both optimization and interactive simulation models have been developed for that purpose. Many texts on power system planning, such as Knight [1972], discuss these techniques. For the non-specialized national energy planner, the level of detail involved in these approaches may well go beyond the needs for comprehensive planning.

2.7 Planning for Other Energy Subsectors

Several specialized models have been developed for other subsectors of the energy system. Meier [1982, pp. 323-352], for example, discusses planning models for the refinery sector in considerable detail. Such models are of interest to the national energy planner. Yet, they also offer a level of detail that goes far beyond the responsibilities and therefore the needs of the central energy planning unit.

Another important area is that of renewable energy, especially in conjunction with the transitional forms of agriculture that characterize most developing countries. Part of the complexity of this problem derives from the fact that agriculture is both a consumer and a producer of energy. Moreover, many of the questions regarding energy and non-energy uses of various resources (agricultural residues, water) come up in conjunction with agriculture and renewable energy. In the context of the Bangladesh Energy Study, Gavan and Tyers [1982] and deLucia and Tabors [1982] explore some of these issues. In general, while several approaches to the question of renewable energy and energy in agriculture have been developed for national energy planning,[8] any claims of consensus or established procedures appear premature.

Similar reservations hold for the other subsectors, such as coal or

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[8] The EnVest planning support system incorporates an explicit treatment of the renewable energy subsector; work on this issue is continuing as part of this project, especially focusing on energy and agriculture.

natural gas. In general, the task of national energy planner lies in finding ways to interface with the planners in the specialized agencies or organizations to avoid involvement in operational detail and day-to-day decision making, but to assure adequate influence on strategic decisions. For example, specialized planning models can assist planners in the natural gas agency to examine the relative advantages of different technical configurations. The central planning unit's responsibility is to place these options within the context of the overall energy demand and supply situation. The choice of the appropriate level of detail in the planning and policy making process is difficult to decide on a general basis.

2.8 Energy Policies: Goals and Instruments

To conclude this section, we should return to the policy framework sketched in Section 2.2. Against the background of the planning methods and models available, how should the national energy planner approach the problem of policy formulation? The structuring of the discussion in this section reflects the notion that the government in an economy with significant economic controls and significant public sector activity can deploy three major sets of instruments:

- direct investments in social overhead capital or directly productive activities, e.g., in hydrocarbon exploration and exploitation, expansion of the power generation system, the improvement of the transportation system, research and development in new technologies, or human resource development;

- pricing policies modifying the effective cost of energy to steer demand into preferred directions; this set of instruments includes direct price setting, tax and subsidy schemes affecting the actual market price of energy products, or the ultimate cost to the user;

- leadership, a hard-to-define but nevertheless powerful element in the energy policy spectrum; public education campaigns to change attitudes only describe one dimension; this set of policy instruments also covers modifications in government procurement policies, regulations to change energy consumption through non-market means, changes in infrastructure management, or modifications of the legal and institutional framework, such as working hours, etc.

Planning methods have yet to reach the point where they can identify the most effective combination of the various policy instruments. Our understanding of market responses to changes in the price structure, for example, make it all but impossible to compare costs and benefits for a particular pricing program. Similarly, whether the creation of a sheltered market (e.g., the insistence on solar hot water systems in all new public buildings) establishes a critical minimum or whether it simply discourages efforts to make solar hot water heaters more competitive cannot be answered with confidence. Our understanding of the demand and supply responses is too rudimentary to allow for any firm conclusions.

As noted above, this state of affairs is not simply a matter of lacking empirical information. The problem is also that the past is usually a somewhat suspect guide to the future. To take an example from a sector with significant government involvement even in free market economies -- public transit. In spite of extensive research and data collection, transit operators can only count on ridership decreasing when fares go up, and more riders when fares go down (other things being equal, of course). But they cannot predict by how much. In the same manner, energy planners can only make qualitative judgments about the effects of market interventions. Quantification tends to be spurious.

As a result, market interventions (price setting, tax/subsidy schemes, or regulatory policies) are often judged by different criteria than public sector investments. Much of the literature on policy assessment has in fact focused on investments. As the discussion in Section 2.3 shows, project appraisal for public-sector investments has reached an impressive level of sophistication. By contrast, guidance on market-oriented policies is generally rather tentative. This situation requires an exploratory posture in formulating and appraising policies. It is this notion that forms the basis of the approach chosen for national energy planning in Morocco. In its project appraisal component, the EnVest planning support system uses relatively standard techniques. Its major emphasis, though, lies on the macroanalytical aspects, providing the means for updating and modifying the structure as understanding improves.

3.0 THE EnVest ANALYSIS SYSTEM

3.1 Introduction

The EnVest analysis system comprises an energy and economic data base together with a series of analytical programs on a microcomputer designed to support a process-oriented approach to national energy planning. Its characteristics are explained by its origin: design efforts first focused on the planning process, its structure, opportunities and constraints. The development of the analytical support system followed. This approach also means that the EnVest package is designed to continue to grow and adapt to emerging needs. As the national energy planning process evolves in the interaction of the various actors and agencies, new information and analysis requirements may suggest modifications and additions to the original system. The EnVest planning support package is set up to facilitate this process.

The basic structure of the planning process in Morocco steered the fundamental decisions regarding the nature of the analysis. Given the distribution of management and policy responsibilities in the Moroccan energy sector, the Ministry of Energy and Mines acts as a coordinator and sometimes arbiter among the plans of its "sous-tutelles," the specialized energy agencies. The broad outlines of national energy policy established in national policy statements reflect economic necessities as well as the opportunities offered and constraints imposed by the country's energy resource endowment and the relevant technology. Within these broad outlines, the planners in the specialized agencies develop both long-range and short-term investment and operating plans. The Ministry's principal task is to assure that the individual plans are not only compatible with one another, but also that the actions under consideration complement each other in an optimal fashion and that the overall portfolio of investments makes the best use of available funds. In other words, the actual planning process in Morocco does not aim at deriving and implementing some more or less theoretical optimum. Rather, it seeks to develop the best course of action by building on the plans of the sous-tutelles.

This approach implies an almost iterative nature for the actual planning process. Planners and decision makers continually examine specific combinations of investments and policy actions. Based on the evaluation of the consequences of the particular combination, modifications, deletions or additions are then negotiated among the participants in the policy process.

The data and analysis support system at the national level should therefore be geared toward the rapid appraisal of policy alternatives, even if the analysis methods are less than polished, and toward the more detailed analysis of the consequences of policies (such as pricing) that fall primarily into the domain of the national decision maker. These two functions imply a need for two components of the support system, one focusing on the macro-level decisions -- the national energy investment portfolio under a particular policy scenario -- and the other allowing for a comparative analysis of individual investment projects under different national policies. Each one of these two basic components of the system has its own data and analysis requirements, as discussed in this section.

3.2 The Planning Approach

3.2.1 Overview

The overall structure of the energy policy development process in Morocco, and of its associated analysis system, is shown in Figure 3-1. This structure has evolved out of the initial discussions with officials in the Ministry of Energy and Mines and the sous-tutelles, and out of the first experiences with planning in this context.

The basic planning cycle involves a series of activities which can be organized into the following steps:

- the formulation of the overall policy scenario regarding the starting conditions, the development of exogenous variables, and policy choices aside from actual investments;
- the development and maintenance of an inventory of energy investment projects, describing the major technological and resource options;
- the appraisal, comparison and selection of energy investment projects under different assumptions;
- the formulation of an investment portfolio in terms of the projects selected and the schedule of their implementation;
- the simulation of portfolio performance over time under particular policy scenarios; and
- the basic feedback loop or iteration which results in modifications of any of the steps of the planning process as planners and decision makers learn about the likley consequences of their actions.

This basic planning loop, emphasized in the schema in Figure 3-1 by the heavier lines and larger boxes, illustrates the fundamental nature of the planning process in an operating environment -- planning is an ongoing, continuous process. Broad policy directions emerge gradually, while the specific actions to be taken will change constantly as new information becomes available, as conditions change, and as new goals emerge.

3.2.2 The Energy Policy Scenario

The choice of the energy policy scenario involves a broad range of considerations, as illustrated in Figure 3-1. First, the policy maker or planner must assess the prospective economic environment for energy policies. Economic growth is taken as a given; at a later point, the planner may come back to this assumption to examine the economic growth impacts energy constraints might have. Treating economic growth as exogenous does not mean that the energy planner simply accepts economic growth forecasts from somewhere as given. Instead, the planning analysis must examine policy performance in different economic environments. That means different sce-

SYSTEME ANALYTIQUE DES INVESTISSEMENTS ENERGETIQUES AU MAROC

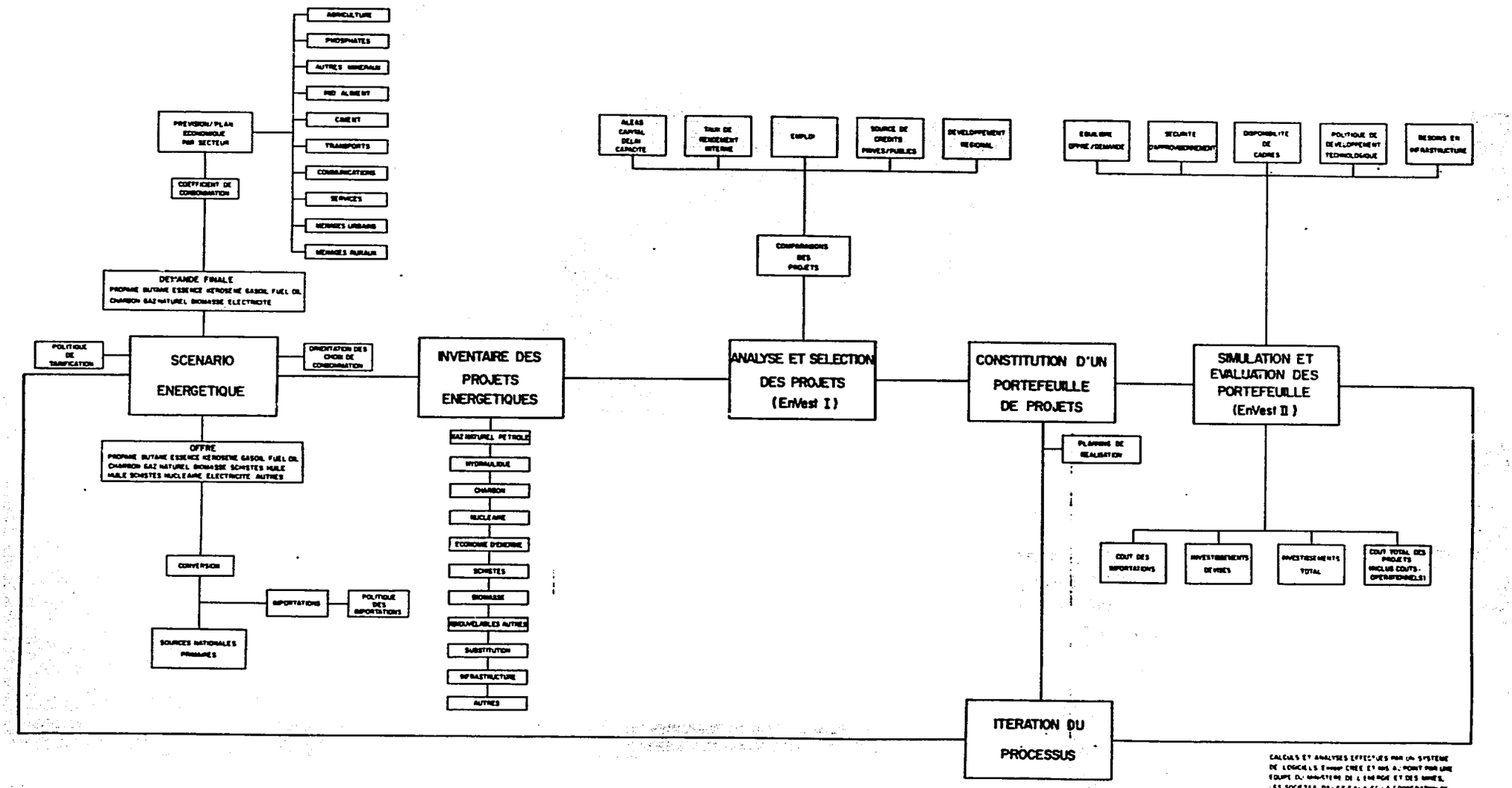

Figure 3-1: Schematic Overview of the Planning Approach.

narios -- bracketing the most likely growth paths for the economy with "extreme" cases.

Under the assumption that energy demand (or consumption) is derived demand, measures of economic activity provide the basis for assessing fundamental energy demand patterns. These demand patterns in turn reflect effective production and consumption technologies in the economic sectors and in the households, as discussed in Section 2.5. National energy policies can affect these patterns by developing new technologies or facilitating their adoption, changing the effective price structure, or by influencing consumption and use choices through regulatory action.

The policy scenario also includes the initial energy supply structure, determined by the characteristics of the current supply system -- the national energy resource endowment -- both known and suspected, national technological knowhow and skills, the effectiveness of the resource extraction and conversion system, the age of the supply system's capital stock, and the energy transportation and distribution system, as well as national policies with respect to energy imports. In addition, assumptions about the world market prices of energy products also contribute to the overall policy scenario.

This policy scenario is by no means a static concept. It changes in the course of the macroanalytic simulation of the performance of a particular investment portfolio. For example, specific demand-side fuel substitution projects will alter fundamental demand patterns. Similarly, if the investment portfolio includes infrastructure projects, energy import policies may change, etc. Even so, the most significant modification of the original policy scenario will be due to the changes of the energy supply (extraction, conversion, distribution) system resulting from the implementation of supply-side projects included in the investment portfolio.

3.2.3 Inventory of Investment Projects

Similarly, the inventory of energy investment projects is not a static concept. At any given point in time, this inventory should adequately and exhaustively describe the projects or investment options contemplated by the Ministry, its sous-tutelles, or other public or private entities. Keeping the inventory up to date means frequent change. New projects are constantly added, others are pushed into the background, if not completely eliminated, yet others are modified to reflect new information, or changing technologies. The inventory should be comprehensive, that is, it should cover all key investment opportunities in all energy subsectors, as illustrated by the list of energy categories in Figure 3-1.

Project definitions and descriptions, the entries into the inventory, are furnished by a wide variety of sources. Typically, the principal contributors are the sous-tutelles, but outside sources as well as the staff of the Ministry itself may provide new options or modify existing ones. The source of the information ultimately matters little, as long as most participants in the national energy planning process accept this information as suitable and reliable. This condition means that the contents of the project inventory are subject to continuous review and critical examination.

3.2.4 Project Appraisal

The project appraisal and selection step at the national level is concerned with two key aspects: (1) to assure consistency of the appraisal criteria and methods across the different energy sectors and specialized agencies, and (2) to allow for the assessment of the impact of specific national policies, such as pricing, on the economic and financial viability of specific projects. In addition, project appraisal also deals with one major element of formulating energy policies over the long run -- the careful weighing of the risks involved in "betting the country's future" on new and untested technologies, or on technologies with significant resource requirements, such as a large-scale energy extraction or conversion projects.

The inherent risk of any given investment project therefore plays a key role in project appraisal. The analysis in the EnVest system focuses on three major sources of risk -- total investment needed, construction time, and annual production or effective capacity. Thus, the assessment of risk forms a major part of the actual project appraisal, which is supported by the data and analysis procedures that make up the microanalytical portion of the planning support system, EnVest I.

Economic summary measures play a key role in appraising project performance: the internal rate of return for the project, its net present value, and its profitability index. However, project appraisal also takes into consideration the employment effects of the project, its impact on regional development, and it relative dependence on various sources of financing. These project performance measures determine the acceptability of any given project under particular specifications. They can thought of as a series of filters through which a project has to pass to be considered for implementation. These filters can be used to identify projects that simply do not offer the necessary return on their investment or violate other minimum conditions, at least in their present form.

In many instances, the projects describe specific options for developing existing energy resources of the country. While a particular approach may not be satisfactory, the potential of any existing resource makes it difficult to reject any such project forever. As a result, the filtering process becomes a mechanism to spot poor (expected) performance and possibly to identify specific problem areas requiring additional work or modification, or to identify particular conditions under which the type of project may be acceptable.

Similarly, the project appraisal step also identifies interdependencies among projects to establish constraints on portfolio selection and to determine areas in which combinations of projects can yield acceptable performance characteristics -- even if one of the projects individually may not measure up to standards.

3.2.5 Portfolio Choice and Appraisal

The choice of a particular investment portfolio involves two elements: selecting the investment projects, and scheduling their implementa-

tion. In principle, several approaches are possible for making these choices, including optimizing techniques. In practice, though, the investment portfolio will be the result of negotiations among the various actors in the energy sector.

The "degrees of freedom" increase as the planning process looks further into the future. In the short and medium term, specific needs and constraints are already well established. Here the emphasis in portfolio formulation will be primarily on schedule modifications, or variations in financing arrangements. The nature of energy investments, and the intended role of the Ministry's planning unit favors a focus on the long run. Even so, energy planning is just as critical for the short and medium term. Such a planning horizon requires more detail than may be suitable or acceptable for projects scheduled for implementation at a more distant point in the future.

For the long term, decision makers and planners have more opportunities to examine the implications of major (re)directions for the country's energy investment program. Qualitative shifts in policy, such as a strategic commitment to a particular technology or resource, or the adoption of new principles in pricing policies, rarely show their full impact over a short time horizon. Here the planner looks at the long run, abstracting from more detailed information to assess the broad implications of particular alternatives.

The simulation of the performance of a given energy investment portfolio under the conditions of some energy policy scenario is the task of the programs and data that make up the macroanalytical portion of the planning support system, EnVest II. The appraisal step takes the simulated performance of the portfolio and examines it with respect to a series of criteria: supply-demand imbalances, security of energy supplies, availability of skilled manpower to operate the facilities contemplated, impact on the technological development of the country, and general infrastructure investment needs. The appraisal also looks at the financial (or economic) cost implications of the portfolio, including total investment costs, foreign exchange needs, and imports of energy products. The projected costs can subsequently be arrayed against the country's projected debt situation, its total available investment resources over the planning period, and other benchmark values. These comparisons provide a feasibility check.

3.2.6 Feedback and Iteration

A key element in the EnVest planning approach is the continuous nature of the planning process. The portfolio appraisal provides indications of shortcomings as well as additional opportunities. Based on these indications, the planner then goes back to modify specific assumptions in the energy policy scenario, to add projects to the inventory, to change the characteristics of other projects in the inventory or to vary the composition or schedule of the portfolio. Modern planning theory and practice, as outlined in Spulber and Horowitz [1976], for example, places considerable emphasis on such a feedback relationship, both at a given point in time -- during the initial planning exercise -- and over time, as new information becomes available.

In actual planning practice, this approach places a premium on effective communication among the various participants in the process. If the results are to be taken seriously and to be integrated into the more detailed planning by the specialized agencies, the feedback loop must be well organized, building on a consensus about the role of the national planning effort, acceptance of the methods used, and confidence in the judgment of the national planner. These are the requirements that have shaped and continue to shape the development of the EnVest analytical support system. The following subsections explore some of the issues related to this system in more detail. This discussion provides sufficient information for the interested reader on the structure of the software that makes up the EnVest planning support system, the overall approach used in setting up the analysis, the data base provided as part of the system, the analyst's (or decision maker's) choices describing the policy scenario, and related elements. However, thge discussion here is not intended as a full system documentation which is in preparation, together with detailed user manual.

3.3 EnVest: System Design Overview

The EnVest planning support system comprises two major analytical components, one for project appraisal, the other for investment portfolio evaluation, the required data files, and several programs to enter and manipulate data and specifications of user choices. It is written in Apple Pascal and runs under the Apple Pascal Operating System (based on and largely compatible with the UCSD p-system) on an Apple II+ microcomputer with 64K bytes of memory, and a Corvus hard disk with 5 megabytes of storage.

The overall structure of the EnVest system is sketched in Figure 3-2 which groups data files and programs by major functions. The schematic presentation shows the names of each of the programs and files that make up the system.[1] Their functions and contents are described in more detail below, following the overview. The sketch in Figure 3-2 appears to imply a logic flow from the right to the left, as does the discussion in the following paragraphs. In actual practice, the process may well be less linear and sequential, as should become clearer in the course of the discussion.

The EnVest planning support system for Morocco uses three major sets of data in its two principal analysis components, project appraisal (Program NPVIRR) and portfolio performance simulation (Program Balance):

- baseline data on the economy and the energy sector, including information on current energy consumtpion, economic activity

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[1] Some of the programs shown are actually sets of programs. The Apple Pascal system allows for chaining programs, i.e., linking a series a series of separately compiled programs through the operating system. This option enables the programmer to set up very complex and lengthy programs that make very efficient use of the memory capacity of the Apple II+. For the user, any such program set behaves just like an individual program.

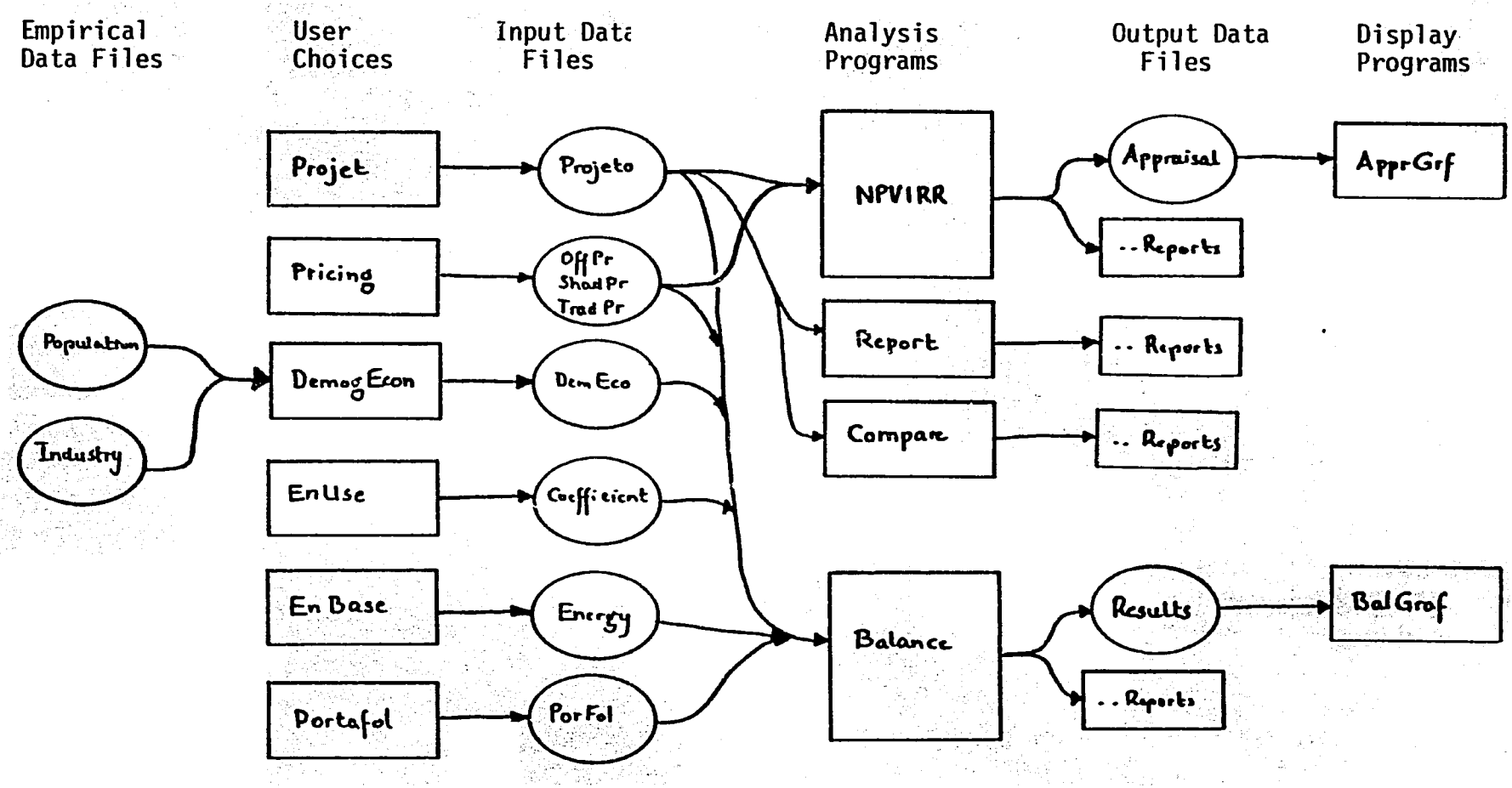

Figure 3-1: Summary View of EnVest System.

levels and interindustry relationships, energy production and conversion capacities, and energy imports; these data are in principle based on empirical investigations;

- project descriptions that are sufficiently detailed to allow for the preparation of cashflow projections for project appraisal as well as for the modification of the structure of energy consumption and production patterns for the portfolio performance simulation;

- user choices that define the policy scenario (pricing, economic and demographic growth, and changes in energy use technology), and the actual energy investment portfolio.

A key design decision separates the two functions of input preparation and analysis. In general, the analyst specifies the data in these three data sets and saves these choices in some file. One series of programs is designed to provide the necessary guidance and support for these functions of data entry, review and modification. Only two of the data files, the ones containing the baseline data for the economy, the final demand vectors and the coefficients of the Leontief inverse of the input-output matrix (the Economy file) and for the population by economic region and type of residence (the Population file) are not accessible to the analyst through the EnVest system itself. A copy of the program used to enter these data -- more laboriously than for the other data files -- is available, though.

Six programs serve the purpose of entering, reviewing and modifying the contents of files describing either baseline conditions or scenario/portfolio choices:

- Program Projet is used to inspect the contents of the project inventory file, the Projeto file, to enter information on new projects, or to change the information regarding existing investment projects;

- Program Pricing, which works with three data files, is used to help the analyst prepare projections or forecasts of the prices of energy products, of the exchange rate, and of the labor costs; projections/forecasts of official or market prices are stored in the OffPr file, shadow price estimates for these categories in the ShadPr file, and projections of the prices of tradable energy products in the TradPr file;

- Program DemogEcon assist the analyst in preparing economic and demographic projections; using baseyear data, the program allows the analyst simply to specify projected growth rates for the population, and for the four major components of final demand for the Moroccan economy, and prepares projections of the total population by type of residence, and of value added by economic sector; the results of these projections are stored in the DemEco file;

- Program EnUse helps the analyst define and modify information regarding energy consumption by households and economic sectors,

that is, the energy use coefficients, and the estimates of short and long-term own-price elasticities; these specifications are stored in the Coefficient file;

- Program EnBase is used to enter, review and modify the baseline data on the energy supply system in the Energy file;

- Program Portafol assists the user in choosing a portfolio of projects and saves the results in the PorFol file.

The extent to which the various programs in this series are used depends on the nature of the data, and on the intensity of the analysis. For example, baseline data are likely to be entered only once. While certain modifications are possible as any errors are discovered or as new information becomes available, the baseline data generally represent the more static element of the EnVest data base.

The project inventory file will experience more activity. Additions, modifications and elimination form a key part of the planning process at the level of the Ministry of Energy and Mines. The project inventory constitutes the central data file for the EnVest planning support system. Accordingly, the program used in managing this data base has received close scrutiny to provide as much support to any given user as possible. Errors in this data base could invalidate the results of a lengthy analysis process.

For the user choice files, the design approach has structured the system to allow the user to formulate several alternatives, for example, several economic/demographic growth scenarios, or a whole series of portfolios, at one point in time, and to select from those alternatives at the time that the actual analysis is being conducted. Thus, the system now no longer requires that the same or similar information be entered several times to carry out different analysis runs. This particular design feature reflects our experience with Version 1.0 of the EnVest planning support system. This experience suggests also that the portfolio selection program is the one used most frequently and, most of the time, publicly. Program Portafol has therefore been subjected to intensive testing to assure the reliability of its performance.

Figure 3-2 shows four analysis programs, three in the EnVest I category: Program NPVIRR performs the economic analysis of a selected project, using the specified pricing scenario as well as other user choices and stores the results, i.e., the distributions of the economic performance measures in the form of frequency distributions, in the Appraisal file, and prepares a printed report of the results of this Monte Carlo analysis. Program Report simply provides printed descriptions for any selected project in the project inventory; Program Compare, finally, prints out a ranked list of existing projects according to user-specified criteria.[2]

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[2] At present, the ranking criteria are limited to investment per (unskilled) job generated by the project. Other options are under consideration.

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In EnVest II, Program Balance performs the simulation of a particular portfolio under user-selected scenarios regarding economic/demographic growth, pricing, energy-use technology, and imports. The results of the simulation are stored in the Results file.

Finally, two programs in the EnVest system are designed to display the results of the analysis in graphical form. Program ApprGrf presents the histograms for the frequency distributions of the project performance measures, calculated by Program NPVIRR, while Program BalGraf is used to generate graphics describing the results of the portfolio performance simulation.

As a complete system, the functional programs just briefly identified are combined with a series of "driver programs," which offer the user a list or menu of function choices, and then transfer control to the respective program. The hierarchy of this system with the driver programs is shown in Figure 3-3. Basically, when the user turns on the machine, the Program Driver assumes control, offering the analyst a menu of seven choices:

- inspecting, adding to or modifying the project inventory; if the user elects this option, the program transfers control to the Program Projet;

- inspecting, adding to or modifying the elements of the scenarios or portfolios; if the user chooses this option, the Program Driver transfers control to the Program PortScen which in turn acts as a driver progam for a series of programs used to create or modify the contents of the data files regarding prices, economic/demographic projections, energy use technology parameters, or portfolios;

- analyzing or comparing individual projects; under this option, program control is transfered to the Program Exam, a driver program for three programs concerned with the preparation of reports for individual projects, project comparisons, and the economic appraisal of projects;

- simulating the performance of the energy sector over a 20-year period, a choice involving the transfer of control to the Program Balance which comprises several modules needed for the simulation;

- displaying the results of any of the project appraisals or of the simulation runs, for which control is transfered to the driver Program Graphs which in turn controls the two types of display programs;

- backing up data files on floppy disks;

- leaving EnVest to enter the Apple Pascal Operating System for any other function or program contained in that system.

This brief overview provides the background for the discussion of the functions performed by the EnVest planning support system.

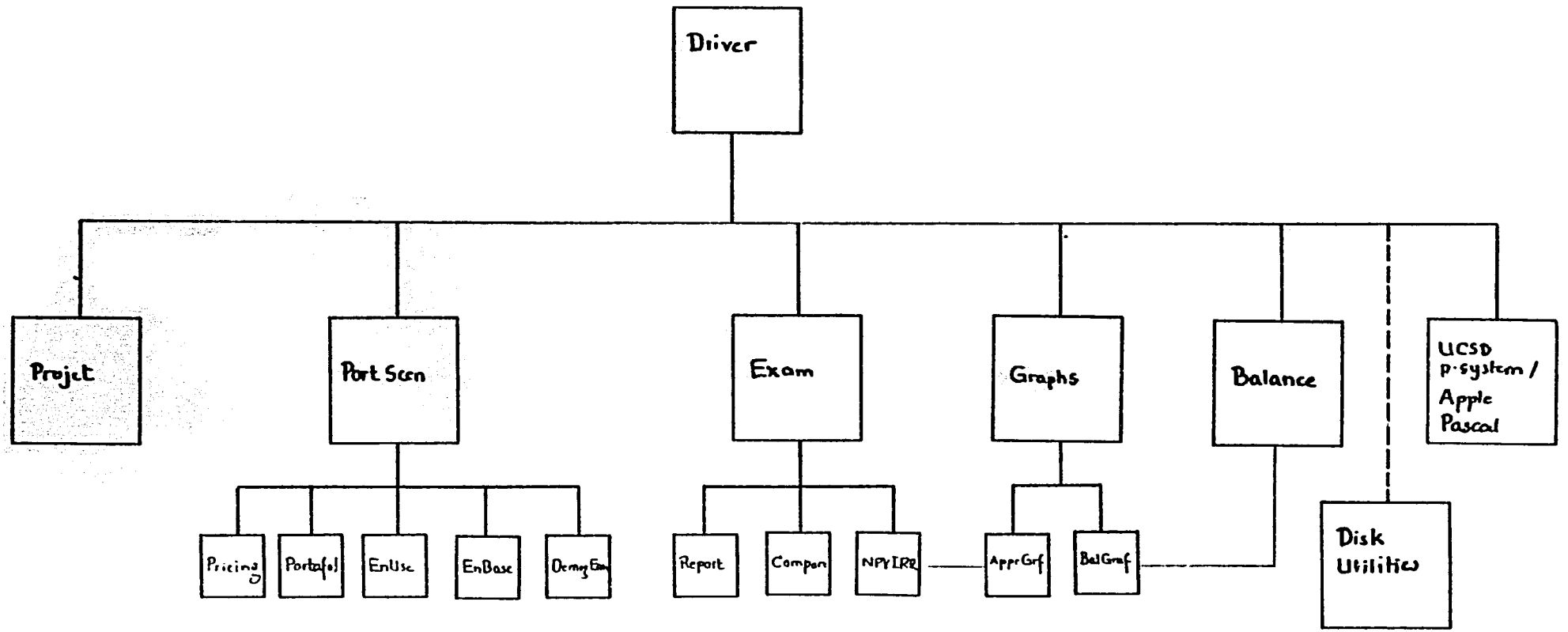

Figure 3-3: EnVest Program Hierarchy

3.4 Scenario and Portfolio Preparation

3.4.1 Pricing

Forecasts of pricing are needed in both project appraisal and the portfolio performance simulation, where official prices may be used to modify projected energy consumption by the economic sectors and households. As briefly discussed below, provisions have been made to allow for experimentation with user estimates of own-price elasticities in predicting demand. In addition, the portfolio performance simulation also requires data on the prices of internationally traded energy products to develop estimates of the energy import bill.

For project appraisal, the analyst is concerned with a full range of price information to update both cost and revenue projections incorporating changes in relative prices. The purely financial analysis using market prices must be complemented by an economic analysis using shadow prices. Ideally, one would look for means to update costs and revenues across a broad spectrum of project inputs and outputs. Accomplishing that on the input side is difficult, since too many goods and services would have to be considered. The EnVest system, Program Pricing, therefore works with separate prices for three sets of items:

- foreign exchange;
- labor, broken down by category -- unskilled, skilled, professional and technical, and office support;
- energy products:

  1 - Electricity
  2 - Propane
  3 - Butane
  4 - Gasoline
  5 - Kerosene
  6 - Gas oil (diesel)
  7 - Fuel oil
  9 - Natural gas
  10 - Biomass
  11 - Nuclear fuel
  12 - Shale ore
  13 - Shale crude
  14 - Regular crude
  15 - Condensate;

  the option of adding fuelwood and charcoal prices is kept open at this point.

All prices are to be specified per GJ to facilitate manipulation and conversion. A time horizon of 60 years has been chosen for these price projections to allow for the use of this information in evaluating projects with a long life expectancy scheduled to come on line late in the 20-year

planning period. This provision may be somewhat excessive, since only a few project types (notably hydroelectric projects and some infrastructure investments) tend to have a life expectancy exceeding 20 years. Even in those cases, variations in relative prices for labor and selected energy are likely to become fairly insignificant as they are discounted back to the present.

The analyst's or decision maker's projections of official market prices are stored in the OffPr file, shadow price estimates in the ShadPr file. The current system allows up to 10 different pricing scenarios for the official prices, giving the analyst sufficient leeway to experiment with various tax/subsidy schemes, and up to 3 alternative scenarios for shadow prices.[3]

The TradPr file contains the analyst's projections of world market prices for tradable energy products. The following products are treated as tradables:

1 - Propane
2 - Butane
3 - Gasoline
4 - Kerosene
5 - Gas oil
6 - Fuel oil
7 - Coal
8 - Regular crude

For each of these categories, prices are projected over the 20-year planning horizon. The file allows for a maximum of 3 different scenarios to be available for analysis at any given time.

3.4.2 Economic and Demographic Growth

Economic forecasts over a 20-year time horizon are extremely tentative at best. The planning support system therefore does not attempt to generate reliable forecasts. Rather, it provides a tool for the user to explore the implications of particular aggregate growth assumptions by distributing overall growth among the economic sectors on the basis of existing interindustry relationships. Instead of asking the user to specify separate growth rates for each individual sector, which requires a detailed understanding of the structural interrelationships in the economy, the Program DemogEcon prompts the user for broader assumptions about the behavior of the factors that are assumed to drive economic growth.

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[3] EnVest works with static file sizes, i.e., a certain number of records for each file is prespecified. The programs putting information into these files, such as the user choice inputs or the analysis programs, in effect simply replace information already in the files, either the blank/zero entries of the initialization programs, or information that is no longer needed. We have chosen this approach on pragmatic grounds, primarily to avoid clutter on the disk volume containing all the data files. If this proves unreasonable in actual practice, the system could switch to dynamic data files.

Specifically, in its economic portion, Program DemogEcon uses a consolidated version of the 1975 input-output matrix for the Moroccan economy. Total production in year t, y_t, is then calculated by means of the following expression:

$$(3.1) \quad y_t = [I - A]^{-1} x_t,$$

where y_t - the vector of total production by sector;

A - the matrix of technical coefficients of the input-output matrix;

I - the identity matrix;

$[I - A]^{-1}$ - the Leontief inverse of the input-output matrix;

x_t - a vector of final demand for each sector in period t.

Under the (admittedly heroic) assumption that the A-matrix is constant, we can then determine sectoral production levels and value-added figures on the basis of independent projections of final demand.

The EnVest system distinguishes four components of final demand: households, government, fixed capital formation, and exports. The Program DemogEcon asks the user for estimates of average annual growth rates for each of these four categories, for each of the four 5-year categories that make up the planning period. These growth rates are then applied to baseyear estimates of final demand by category, and subsequently translated into production and then value-added figures. The focus on value added as the key measure of economic activity is based on the premise of a systematic relationship between this variable and energy consumption by sector. Value-added projections are generated for the following 14 energy-consuming sectors:

1 - Agriculture
2 - Phosphates
3 - Autres minerais
4 - Agro-industrie
5 - Textiles
6 - Cuirs
7 - Mineraux de carriere
8 - Industrie metallique et electrique
9 - Industrie chimique et parachimique
10 - Autres manufactures
11 - Batiments et travaux publics
12 - Transports
13 - Communications
14 - Autres services (marchands)

For the demographic projections, the user specifies the annual averages for aggregate national growth rates for the four 5-year subperiods of the total planning period. Program DemogEcon uses baseyear population estimates by region and by type of residence, along with regional adjustment factors for the estimated national growth rates to produce population

forecasts by type of residence, urban and rural. This approach could easily be adapted at a later point to generate population forecasts for each of the country's seven economic regions.

The results of the demographic/economic projections are stored in the DemEco file which provides room for up to 5 scenario alternatives.

3.4.3 Energy System Characteristics

Energy demand and supply characteristics form a central part of the policy scenario. Given the structure of the portfolio performance simulation program (Balance), the characteristics of the supply system at any given point in time are determined by the initial situation and the changes resulting from the actions contained in the portfolio. The initial situation is described by the analyst using the Program EnBase. This program creates the Energy file which contains the following information:

- characteristics of existing thermal power plants, pretty much as shown in Table 2-3 in Part I of this report;
- characteristics of the country's hydropower system;
- refinery characteristics;
- domestic primary energy production projected for the planning period in the absence of any additional investments (crude, natural gas, coal, fuelwood, and charcoal);
- baseyear imports for tradable energy products.

Since the analyst is unlikely to consider major alternatives in this data base -- after all, these are largely empirical data -- the Energy file contains a single record.

The major portion of the Coefficient file also involves empirical information. The analyst creates entries in this file by using Program EnUse. The empirical portion of this file focuses on the energy use coefficients: the estimated consumption of each of the 12 final-demand energy products (electricity through biomass, plus fuelwood and charcoal) per Dirham of value added in each of the 14 economic sectors, and per person in the two household sectors, urban and rural.

In addition, the Coefficient file also contains information on the assumed or projected autonomous changes in energy use coefficients, expressed as an average annual rate of change for each element sector-by-product matrix. For example, suppose that the analyst has information showing that the share of irrigated agriculture in total agricultural production is projected to rise at some rate; since irrigated agriculture consumes more electricity per Dirham of value added, its increasing share means an increase in the amount of electricity consumed per Dirham of agricultural value added. In this case, we would enter a positive annual rate of change in the Coefficient file. Increased energy efficiency as a result of regular, replacement of capital equipment would result in a negative rate of change.

These changes are treated as "autonomous," since they are assumed to be only marginally influenced by energy policies. Of course, if the projected electricity demand in agriculture cannot be met, the assumption of an increasing share of irrigated agriculture may no longer apply. But for that given scenario, energy intensity would in fact increase irrespective of what is happening in the energy policies. In addition to these autonomous changes which reflect structural or technical trends in the end user sectors, energy use coefficients can change as a result of specific energy conservation or fuel substitution projects.[4]

Finally, the Coefficient file also provides the option to experiment with energy demand elasticity estimates. For each energy use coefficient, the analyst can specify a non-zero short and long-term (3-year lag) demand elasticity estimate. Given the dearth of relevant data -- and the remaining uncertainties even for cases for which data are available -- such specifications clearly are experimental in nature. However, they would appear to offer a means for assessing at least the potential range of impacts of alternative pricing policies.

The Coefficient file currently offers room for 5 alternative specifications of the energy use coefficients, the rates of change, and the demand elasticities.

3.4.4 Portfolio Selection

The specification of a particular portfolio is simple. The user specifies the project number from the list of projects and the year that the the project should come on line, i.e., begin production. The program determines whether the project is a "demand-side" project, modifying the energy use coefficients of some sector, or whether it augments or alters supply capacities. It also sorts the projects in the portfolio by type (demand/supply) and by year of implementation.

Since Program Portafol is likely to be used frequently and often in a public setting, it offers much support and extensive safeguards against user errors. The resulting PorFol file has room for 30 portfolios.

3.5 The Project Inventory

At the level of individual investment projects, the planner faces two major tasks: to maintain an up-to-date inventory of the possible projects, and to prepare financial and economic project appraisals. The components of EnVest I have been designed to assist with these tasks. Program Projet helps the analyst to enter, review, and modify information on possible investment projects easily. Since we expect that these func-

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[4] The format of the energy conservation/fuel substitution project can also be used to introduce changes in average energy consumption patterns in a particular sector resulting from a new mjor plant' such as a new steel mill.

tions will be performed not only by MEM analysts, but also by planners and others from the sous-tutelles, the program is designed to be used after a very brief training session. As in the case of other programs, extensive testing has been carried out to spot likely problems and modify the program accordingly.

Program Projet can best be characterized as a specialized data base management program. The project data base distinguishes 13 types of projects:

- thermal power plants;
- hydro power plants;
- refineries or refinery modifications;
- shale oil retorting;
- upgrading of shale crude;
- coal or shale mines;
- natural gas development;
- fuelwood;
- renewable/non-conventional energy;
- small-scale power plants (mini-hydro and photovoltaic);
- energy conservation and fuel substitution;
- infrastructure investment;
- research and development.

Each of these thirteen types of projects is described in terms of two sets of variables. The first set, shown in Table 3-1, is common to all projects. It refers primarily to investment and operating costs. The second of variables used for project description is specific to each type; the various sets are listed in Table 3-2. These variables list expected production and related performance measures.

The estimation of these measures represents a continuing process. The estimates are based on available engineering studies, historical information and special analyses. Part of the task of the national planner is to maintain the contacts to the specialized agencies, universities, and engineering firms to be aware of new projects to be added, and existing ones to be modified. Program Projet has been designed as a data base management system applying professional data base management system standards to facilitate this task. The project inventory must be continually updated.

The explicit consideration of risk in project evaluation determines the way in which projects are described. In the development of the EnVest

Table 3-1:

Project Descriptors: Common Variables

Variable Name	Description
ProjNo	Project number
TypeNo	Project type (1-13)
Projet	Project name (up to 40 characters)
ProjId	Brief project identifier (up to 5 characters)
InvImp	Part of total investment required in foreign exchange (in Dirhams at Exchange rate)
InvDom1	Domestic investment purchases of purely domestic goods (in Dirhams)
InvDom2	Domestic investment purchases (primarily imported goods -- in Dirhams)
InvEmp(1..4)	Construction labor by four labor categories (in person-hours)
ExDate	Date for which Exchange rate holds
Exchange	Exchange rate used in calculating InvImp and InvDom
InvPerc(1..2)	High and low limits for total investment as percent of most likely value
ConDelai(1..3)	Low, most likely and high estimates of construction time (in months)
CovTInv	Covariance, construction time/ investment
ConTAns	Most likely construction time estimate in years
Credit	Total investment financed by foreign loans
Interet	Average interest rate for loan
Profile(1..12)	Percentage of total investment planned for each year of the construction period
PLife	Project life in years
COpFix	Fixed operating costs
COpVar	Variable operating costs

Table 3-1: (Cont'd)

COpFxDev	Percentage of total operating costs in foreign exchange
COpVrDev	Percentage of total variable costs in foreign exchange
COpEnerg	Energy-related operating costs at full capacity operation
COpOeuvr(1..4	Total employment by labor category during typical project year

Note: COpFix and COpVar exclude costs for energy and labor

Table 3-2:

Project-Specific Variables (Subfiles)

1. Thermal Power Plants *

Nouv1	power plant modification indicator, = 1 if modification of existing power plant, = 0 or blank for a new power plant;
CentrNo	number of power plant to be modified; blank, if Nouv1 = 0/blank
NombUnits	number of units in the power plants;
NominCap	nominal capacity of each unit;
MinTech	minimum technique, the level at which the unit must be run;
Heatrate	overall heatrate for the unit (total consumption of fuel of type combustible per unit output at nominal capacity);
MinHtrate	heatrate for the minimum technique;
Combustible	type of fuel used: F - fuel oil G - natural gas N - nuclear S - oil shale B - biomass (alfa) C - coal;
OptCombust	optional fuel (same codes) -- switchover possible without significant investments;
TauxDefaiΠ(1..3)	forced outage rate (high, medium, low);
Indispon	no. of days in year unit is to be closed down for planned maintenance;
Increment(1..3)	low, medium and high usage at which plant will be run (percentage of time);
Buildup(1..10)	percentage of final capacity achieved in years 1..10;

2. Hydro Power Plants

FilEauAv	run-of-the-river capacity, average years;
FilEauSec	run-of-the-river capacity, (average) dry years;
LibreAv	additional capacity, average years,

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* All subproject files include project type and number.

Project-Specific Variables (Subfiles) (Cont'd)

LibreSec	additional capacity, dry years;
SecChance	probability that any given year is a dry year;
Liblotti(1..3)	low, medim, and high range on additional capacity;

3. Refineries and Their Modifications

OldCap	refinery capacity in Unite3 per year before modification (if 0, then we have a new refinery);
RefNo	No. of the refinery to be modified (blank if OldCap is zero);
refCap	capacity of the refinery after construction/modification
Unite3	unit in which refinery capacity is measured;
BrutType	type of crude processed: 'S' - shale crude 'P' - regular crude;
RcapLim(1..2)	low and high limits on capacity, as percentage of RefCap;
OldCoeff(1..6)	production coefficients by type of product before modification in percent; (0's in the case of a new refinery);
NewCoeff(1..6)	production coefficients by type of product after modification in percent;
CoalPerTon	coal use per Unite3 (also measured in Unite3 to simplify things)

4. Shale Retorting

SchProd(1..10)	production in years 1...10;
Unite4	unitT/bbl/Tj
SchLim(1..2)	upper/lower annual limit (%)
ElectrSch	electricity consumption in GWh per Unite4 produced;
GasoilSch	diesel consumption per Unite4 produced (also measured in Unite4);

4. Shale Oil Upgrading

SynCap(1..10)	output for years 1...10;
Unite5	unit T/BBLS/TJ

Project-Specific Variables (Cont'd)

SynLim(1..2)	upper/lower limit (%) on annual product;
SchBrut	consumption of shale crude in Unite5 per Unite5 produced;
CoalSyn	consumption of coal in Unite5 per Unite5 produced.

6. Mines

MinType	type of mine C - coal S - shale
MinProd(1..20)	planned production for year 1..20;
Unite6	tonnes/TJ
MinLim(1..2)	upper/lower (%) on annual production
ElMines	electricity consumption in GWh/Unite6
GOMines	diesel consumption in Unite6/Unite6
EssMines	gasoline consumption in Unite6/Unite6
FOMines	fuel oil consumption in Unite6/nite6

7. Natural Gas

GazProd(1..20)	production of gas for years 1..20
Unite7G	$1000m^3$ - M tonnes - T bbls - B $mmft^3$ - F for the gas production
GazCal	caloric value of gas (Kgcal/Unite7G)
GazLim(1..2)	upper/lower limit (%)
CondProd(1..20)	production of condensate for years 1...20
Unite7C	unit of CondProd
Densite	density of condensate
CondLim(1..2)	upper/lower limit
PegPrice	assumed ratio between price of LPG and that of butane

Project-Specific Variables (Cont'd)

8. Fuelwood

BoisProd(1..20)	planned production for years 1..20	
Unite8	unit of BoisProd:	T - tonnes J - terajoules M - m^3
BoisCal	Caloric value of wood (Kgcal/Unite8)	
BoisLim(1..2)	upper/lower limit (%)	

9. Renewable Energy

RenType	type of reneable energy	S - solaire E - eolienne A - alcool O - autre
SecRemp(1..16)	sector where energy is replaced	
EnRemp(1..12)	energy product replaced	
RenProd(1..20)	annual production of renewable energy for years 1..20	
Unite9	unit of RenProd	T - Tonnes M - m^3 L - litres J - terajoules
RenCal	oric value per unit.	

10. Small-scale power plants

MicType	type of small power plant/	H - hydro P - photovoltaïque
MicProd	annual production per plant	
MicLim(1..2)	upper/lower limit on MicProd	
Unite10	unit of MicProd	G - Gwhrs J - terajoules
MicNo(1..20)	number of plants coming on-line for years 1...20	
MicLim2(1..2)	upper/lower limit for MicNo (%)	

Project-Specific Variables (Cont'd)

Secteur	sector number(1...16)
CoeffUt(1..12)	new coefficients of energy consumption (in terajoule per unit of level activity)
ElShort(1..12)	short-term demand elasticity
ElLong(1..12)	long-term demand elasticity

12. Infrastructure Investment

EnType	energy product affected
InfType	infrastructure type (pipeline, port...)
InfCap	annual capacity
Unite12	unit of capacity (InfCap)
InfLim(1..2)	upper/lower annual limits on capacity (%)

13. Research and Development

RdType	type of research and development project.

system, three major sources of uncertainty in project performance were considered: total investment, construction time, and annual production. Instead of using single-point estimates for these three key variables. the project appraisal procedure works with probabilistic measures, based on engineering estimates of the most likely as well as the optimistic and pessimistic values for each measure. These estimates are subsequently transformed into probability distributions which are used to generate the frequency distributions of the net present values, of the internal rates of return and the "indices de rentabilite" through Monte Carlo simulations. The specific techniques and assumptions are described in EnVest Technical Memorandum No. 3, "Interdependent Risk Factors in Project Evaluation: The Approach in the EnVest System," December 15, 1984 (Working Draft).

The file containing the project information, Projeto, is set up to hold a total of up to 100 projects in the common data file, and varying numbers in the subfiles for the specific information for each project type.

3.6 Project Appraisal and Comparison

The principal analysis program of EnVest I, NPVIRR, is used for the Monte Carlo analysis of the net present value of a project, its internal rate of return, and the "indice de rentabilite." The program, actually a set of several linked programs, develops cashflow projections for the selected project on the basis of certain user choices, such as the appropriate price scenario, any modifications of analysis parameters, such as the autoregression coefficient used in estimating maximum production levels over time, calculates the internal rate of return, and the net present value figures for a user-specified discount rate, repeats this process a number of times, prepares a summary report, and saves the results in the Appraisal file.

For the analyst, using the Monte Carlo approach to project appraisal is fairly simple: for any given run, the program first asks for the specific choices, the number of "experiments" to be executed, the desired discount rate, the pricing scenario, the year in which the project is to start, and the values of other parameters. The program then takes a considerable amount of time to perform the calculations and estimate the summary performance measures. Once the analysis is completed, the analyst has the choice of displaying the results of this particular run in graphical form, or to compare it graphically to other project appraisals. The program used for this purpose, Program ApprGrf can also be accessed directly from the driver Program Exam.

Program Report is used to prepare project summaries for the current set of project descriptors; the format of these summaries is essentially a mirror image of the screens used for reviewing and entering project information. Here the analyst simply specifies the desired project. Program Compare is intended to allow for quick project comparisons on such measures as number of jobs created per Dirham invested.[5]

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[5] That is currently the only ranking criterion. Others will be developed as the system expands.

3.7 Portfolio Performance Simulation

The separation of the functions of entering user choices and other inputs from the actual analysis task facilitates the simulation of the performance of some portfolio under particular scenario assumptions. For this task, the user now only has to select the desired portfolio, the scenario elements (pricing, economic/demographic growth, and autonomous changes of energy use technology), and the import policies to run a particular simulation. As Program NPVIRR, Program Balance also comprises several linked program modules that perform specific functions. In essence, the program set simulates the performance of the energy sector over a 20-year time period, starting with energy demand projections which reflect autonomous as well as induced changes in energy use technology, and progressing to the prediction of output and (net) import levels for the different energy products. The program also keeps track of the financial implications of the particular portfolio under the given scenario, both in terms of investment and operating funds requirements and in terms of the cost of any energy imports.

The demand module examines for each year of the planning period whether any modifications in the energy use coefficients are required in response to autonomous changes, current or past price changes, or because of energy conservation or fuel substitution projects in the portfolio. It makes those modifications, and then multiplies the resulting energy use coefficients by the value added and population figures for the chosen economic/demographic scenario.

The update module subsequently checks for each year whether any supply-side projects are scheduled for implementation. If they are, it calls the finance and system modification modules to keep track of the financial implications, and to change the characteristics of the energy supply and conversion system to reflect the particular project. Once the system has been brought up to date for the current year, separate modules for electricity, renewable energy, hydrocarbons (oil, gas, and shale), and coal are executed to estimate production and import levels for each energy product, i.e., the quantity supplied.

Once the program has cycled through the entire planning period, a report module is called to print out the results of the simulation, and to store these results in the Results file for any subsequent graphical displays and comparisons using the Program BalGraf.

The Results file allows for keeping the results of up to 30 portfolio performance simulations on the hard disk.

Assumptions and specifications for the individual components of the portfolio performance simulation program set will be discussed in greater detail in a series of EnVest Technical Memoranda now in preparation and available together with the user documentation in mid-summer 1984.

3.8 Preliminary Appraisal and Outlook

The EnVest data and analysis support system forms part of a particular approach to national energy planning which focuses on the institutional dimension of this process. As such, it incorporates several useful techniques for project appraisal and energy system simulation, without striving for theoretical elegance. Its basic simplicity (as well as its reliance on graphics) makes effective use of the potential of microcomputers for energy planning.

At the same time, it potential lies in part in complementing more detailed planning efforts at the level of the specialized agencies. It does not seek to replace this more detailed planning which often requires more complex models and data.

The EnVest approach has proven effective in strengthening the interactions of planners in the various agencies. As its use becomes better established and as its empirical base improves, quicker responses with more reliable information will become possible.

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