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Report No. 4157-MOR

Morocco: Issues and Options in the Energy Sector

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March 1984

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ISSUES AND OPTIONS IN THE ENERGY SECTOR

March, 1984

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ABSTRACT

Morocco faces a complex set of choices in the energy sector. While it currently is 85% dependent on imported oil for its commercial energy needs, it has important oil shale, hydropower, oil and gas, and uranium resources. In each case, there are questions of cost and/or risk that make the key decisions that must be taken difficult ones, and the fact that many of the decisions are inter-linked only complicates them further. The country's continuing economic difficulties force a reevaluation of investment priorities in the energy sector as elsewhere and this underscores the need to strengthen energy planning both at the enterprise and central government levels. Demand management and energy efficiency are subjects that need increased attention in pricing and tariff setting and in the management of large energy producing and consuming public enterprises and, again, calls for improved sector coordination and planning.

Woodfuels are widely used in Morocco (accounting for about 35% of total energy consumption) and the rate at which wood is being harvested exceeds that at which it grows back by a ratio of about three to one. Deforestation, of course, can have very serious implications and dealing with it requires very long lead times.

The report provides an overview of Morocco's energy situation and prospects and a framework for understanding the relative magnitudes and interrelationships of the major decisions to be taken. It also makes a series of specific recommendations concerning investment priorities, pricing policies, and sector planning issues.

Abbreviations

BF	Boiler fuels (fuel oil, coal, natural gas, and oil shale burned directly)
BRPM	Bureau de Recherches et Participations Minieres (Bureau of Mineral Exploration and Participations)
CDER	Centre de Developpement des Energies Renouvelables (Renewable Energy Development Center)
Charbonnages	Charbonnages du Maroc (formerly Charbonnages Nord Africains) (Collieries of Morocco, formerly North African Collieries)
CLF	Clean liquid fuels (LPG, gasoline, kerosene, jet fuel, gas-oil)
DAE	Direction des Affaires Economiques (Economic Affairs Directorate)
FNF	Fonds National Forestier (National Forestry Fund)
FO	Fuel oil
IAEA	International Atomic Energy Agency
IBRD	International Bank for Reconstruction and Development (World Bank)
LPG	Liquified petroleum gases (butane and propane)
MARA	Ministere de l'Agriculture et de la Reforme Agraire (Ministry of Agriculture and Agrarian Reform)
MCIT	Ministere du Commerce, de l'Industrie, et du Tourisme (Ministry of Commerce, Industry, and Tourism)
MEM	Ministere de l'Energie et des Mines (Ministry of Energy and Mines)
MEM/DE	MEM/Direction de l'Energie (Energy Directorate)
MHUPE	Ministere de l'Habitat, de l'Urbanisme et de la Protection de l'Environment(Ministry of Housing, Urban Planning and Environmental Protection)
MI	Ministere de l'Interieur (Interior Ministry)
ONAREP	Office National de Recherches et Exploitation Petrolieres(National Office for Petroleum Exploration and Development Authority)
ONE	Office National de l'Electricite (National Electricity Authority)
Plan	Ministere du Plan, de la Formation des Cadres et de la Formation Professionnelle (Ministry of Planning and Executive and Professional Training)
SAMIR	S.A. Marocaine de l'Industrie du Raffinage (Moroccan Refining Industry Corporation)
SCP	Societe Cherifienne des Petroles (Royal Moroccan Petroleum Company)
SNPP	Societe Nationale de Produits Petroliers (National Oil Products Company)
SOCOCHARBO	Societe de Commercialisation du Charbon (Coal Marketing Company), a subsidiary of Charbonnages
Tpa	Ton per annum
UNICEF	United Nations Children's Fund
US-AID	United States Agency for International Development

Currency Equivalents

DH = dirham
MDH = million dirham

Quarter/Year	DH/US$	US$/DH
I/1978	4.31	.23
II/1978	4.27	.23
III/1978	4.12	.24
IV/1978	3.96	.25
I/1979	3.94	.25
II/1979	3.98	.25
III/1979	3.86	.26
IV/1979	3.82	.26
I/1980	3.83	.26
II/1980	3.89	.26
III/1980	3.84	.26
IV/1980	4.18	.24
I/1981	4.66	.21
II/1981	5.17	.19
III/1981	5.54	.18
IV/1981	5.32	.19
I/1982	5.65	.18
II/1982	5.92	.17
III/1982	6.19	.16
IV/1982	6.33	.16

PRICE INDICES (1980=100)

Year	DH (GDP Deflator)	US$ (MUV Index)	US$ (Crude Oil)
1970	47.4	30.8	5
1971	49.3	33.4	6
1972	51.1	36.7	7
1973	54.2	43.8	9
1974	67.1	54.3	34
1975	67.7	62.2	38
1976	71.1	63.2	40
1977	78.8	68.6	44
1978	85.4	81.3	45
1979	91.7	90.8	60
1980	100.0	100.0	100
1981	110.4	95.3	112

Notes: MUV Index measures the unit value of manufactured exports (SITC 5-8) from developed to developing countries on a cif basis. Crude oil price index based on average realized fob price of Arabian Light in US$ per barrel.

Weights, Measures, and Energy Conversion Factors

1 square kilometer (sq. km.) = 100 hectares (ha) = 0.3861 square miles
1 ton (T) = 1000 kilograms (kg) = 2,205 pounds (lb)
1 kilometer (km) = 1000 meters (m) = 0.6214 miles (mi)
1 inch (in) = 2.54 centimeters (cm)
1 barrel (bbl) = 42 US Gallons = 159.0 liters
1 kilocalorie (kcal) = 3.968 British thermal units (Btu) = 4,187 Joules
1 MBD = 1,000 barrels per day (approximately 50 Tpa)
1 MCF = 1,000 standard (i.e. at 60°F or 15.6°C) cubic feet (SCF) of gas
= 26.80 Normal (i.e. at 0°C) cubic meters (Nm^3) of gas
1 MMCF = 1 million SCF
1 MMCFD = 1 million SCF daily
1 BCF = 1 billion (thousand million) SCF
1 TCF = 1 trillion (thousand billion) SCF
1 Gigawatt-hour (GWh) = 1 million kilowatt-hours (kWh)
1 Megawatt (MW) = 1,000 kilowatts (kW)
1 ton of crude oil equivalent (toe) = 10.2 million kilocalories of lower heat value = 1,000 kilograms of oil equivalent (kgOE)
= 1.00 ton of crude oil (1.00 toe/T)
= 0.95 " " butane (1.05 toe/T)
= 0.93 " " propane (1.07 toe/T)
= 0.97 " " gasoline (1.03 toe/T) (0.76 toe/m^3)
= 0.99 " " kerosene (1.01 toe/T) (0.79 toe/m^3)
= 0.98 " " jet fuel (1.02 toe/T) (0.81 toe/m^3)
= 1.00 " " gas oil (1.0 toe/T) (0.83 toe/m^3)
= 1.06 " " fuel oil (0.94 toe/T)
= 50 MCF of natural gas from existing fields (0.75 toe/thousand Nm^3)
= 41 MCF of natural gas from new fields (8,900 toe annually per MMCFD)
= 2.00 tons of raw fines from Jerada anthracite mine (0.50 toe/T)
= 1.36 tons of washed Jerada anthracite (0.74 toe/T)
= 1.69 tons of imported steam coal (0.59 toe/T)
= 4160 kWh of electricity (245 toe/GWh) (2500 kcal/kWh)
= 119 g of Uranium (8,410 toe/T)
= 1.01 million Langley-m2
= 4.00 m^3 of fuelwood (0.25 toe/m^3)
= 1.45 tons of charcoal (0.69 toe/T)
= 2.50 tons of biomass residues at 20% moisture content (0.40 toe/T)
= 9.27 tons of Timhadit oil shale (0.11 toe/T)

Notes: Moroccan energy statistics are generally expressed in "TEP" (Tonnes Equivalents de Petrole), a measure which ranges in value from about 8.6 to 11.0 million kilocalories (0.84 to 1.08 toe) depending on the type of energy being measured. The aggregates and percentage breakdowns used in this report may therefore differ from similar figures based on unadjusted Moroccan statistics.

Electricity is converted to toe in this report at a rate based on fuel oil consumption per kWh output in Morocco's largest thermal-electric generating plants, which have a thermal efficiency of about 34.4%. The same conversion factor is applied to electricity consumption as to production, so the great bulk of the energy conversion losses involved in thermal generation (and equivalent notional amounts for hydro-generated electricity) are allocated to electricity consumers in the energy balances. This is consistent with Moroccan practice, and appears appropriate to the case.

This report is based on the findings of an energy assessment mission comprising Mr. D. Hughart (Energy Economist), Ms. J. Chassard (Consultant), and Messrs. C. Garrigues (Consultant), C. N. King (Research Assistant, UNDP), L. Maistre (Consultant), A. Malik (Renewable Energy Specialist) and S. Moussa (Petroleum engineer), who visited Morocco in January and February 1982 and on the World Bank's experience in Morocco with projects and prospective projects in hydro-electric development, rural electrification, petroleum exploration, oil shale engineering, coal mining, forestry, and industrial energy conservation. Messrs. U. Ernst (Consultant) and A. Sharma (Summer Intern) provided computer programming support and Ms. L. Toehl secretarial support in the report's preparation.

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SUMMARY AND RECOMMENDATIONS 1/

Energy and the Economy

1. The Moroccan economy faces serious balance-of-payments difficulties symbolized by a chronic current account deficit which reached $1.9 billion or 13% of GDP in 1981. The rising cost of energy has contributed markedly to this situation, and although recent gas discoveries hold out some prospect for alleviating the oil import burden in the long term, the extent of these is still quite uncertain, and investment requirements for development of indigenous energy supplies are very substantial. Given the country's constrained capital situation, the uncertainty surrounding future domestic gas availability, and the fact that some of its energy investment options have high costs and perhaps marginal to unattractive returns, an extremely careful selection of investment priorities is vital.

2. Morocco faces two serious energy problems simultaneously, one involving imported oil and the balance of payments and the other involving woodfuels (fuelwood and charcoal) and the energy needs of low-income households. The magnitude of these problems can be illustrated by a few statistics: 85% of the commercial energy consumed in Morocco is derived from imported oil whose cost (about $1 bn annually) consumes about 40% of export earnings. At the same time, wood, the principal non-commercial energy source for a substantial share of Morocco's population, and which is estimated to account for about 35% of total energy consumption, is being harvested at an estimated three times the rate at which it is growing back.

3. These problems are severe and cannot be solved in the short term. In the immediate future the energy balance can only be modified by measures to restrain the growth of energy demand through pricing of energy products and electricity and complementary measures to promote energy conservation. Improvement of the energy balance in the medium to longer term can only be achieved by the development of economically viable domestic energy resources. A short-term strategy should include the following priority actions: (i) expediting exploration, appraisal and, if viable, development of gas reserves; (ii) further and very careful evaluation of the technical/economic viability of those energy investment options for which the economic returns may be low (oil shale, domestic coal, certain hydro projects); (iii) emphasis on improving the efficiency of energy use in the industrial, transport, power, residential

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1/ While parts of this report reflect developments since the mission on which it was based, there has been no systematic effort to update figures or reflect minor changes that do not effect the principal conclusions. In particular, Morocco's continuing economic difficulties have led to lower energy demand growth rates than those indicated in the report and to the postponement of several of the investment projects discussed.

and commercial sectors, including a carefully balanced inter-fuel pricing strategy and inter-fuel substitution, (iv) increased attention to expanding reforestation efforts; and (v) measures to strengthen energy planning, particularly in the power sector, and strengthening of the key energy enterprises and coordination between them.

Energy Resources and Supply

4. Morocco has a number of energy resource development options, but each of these faces uncertainties and constraints and much work remains to be done to define an energy investment program that is based on acceptable economic returns and reflects the country's financial constraints. Options and priorities are as follows:

Natural Gas

5. The recently discovered gas reserve at Meskala have introduced the possibility that natural gas could be an energy source of major significance in Morocco, but the precise scale of this project is still beset by many uncertainties. Further drilling and analysis of the Meskala field is needed to clarify the amount of producible reserves. Current tentative estimates place recoverable reserves at between 10 and 50 million toe, implying that production from Meskala could fall in the range of 1 to 5 million toe/yr. 2/ These technical uncertainties are exacerbated by institutional constraints. While the top managment of the national oil company, ONAREP, which is responsible for work on the Meskala field, is competent, the company's middle management lacks experience in several important technical fields. Appropriate steps are therefore being taken to reinforce ONAREP's ability to carry out the exploration and appraisal of Essaouira, including: (i) creation of a working group composed of ONAREP staff and experienced expatriate explorationists, (ii) contracting a reservoir engineering firm and technical specialists from an international drilling contractor and (iii) simplification of financial control procedures to reduce delays. In addition, a management consulting firm is working with ONAREP to develop a longer term corporate action plan. All of these efforts are important to the success of this work.

6. It is estimated that gas could be produced and delivered to industry at about 20-50% of the cost of the oil it replaces. About one-half of that commercial energy demand is accounted for by large scale individual and power plants that, taking account of their location, can be economically converted to gas. On favorable assumptions, it is possible that natural gas from Meskala alone could replace up to 60% of current oil imports (mainly fuel oil) within 10 years.

7. There are other geologically promising areas of Morocco that have not been adequately explored and could contain additional oil and

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2/ Petroleum consumption is currently about 4 million toe/yr.

gas deposits. Three new exploration joint-venture agreements between the national oil company and foreign partners have been signed since the fall of 1981. This is a welcome development and should be further extended.

8. There is no doubt that the highest priority in the energy sector is expediting the exploration, appraisal and development work on natural gas, starting with Meskala, with a view to achieving rapid and sizeable relief on the balance of payments. This involves action on two fronts. The first, and most urgent need is to carry out the work described in paragraph 5 to reinforce ONAREP's technical staff, develop a long-term corporate plan, and streamline managerial and financial procedures in relation to expenditures at Meskala. The second is to improve the framework for increasing the participation of foreign companies in the exploration and development of gas in other promising areas.

Oil Shale

9. Morocco's oil shale resources are immense (several billion toe) and the technical problems involved in their development through either retorting to extract liquids or direct combustion in power plants, do not appear insurmountable. However, it should be recognized that the technology for the exploitation of oil shale is still not well established and there is considerable doubt whether the economic costs of such development would be less than the imported oil that it would replace. It is advisable that no major commitment be made to development of shale retorting prior to the satisfactory outcome of current engineering studies in early 1984. In addition, the plan to order an experimental power plant burning shale should be shelved until there is a better evaluation of the costs of oil shale development in relation to alternative energy sources.

Hydropower

10. Morocco's hydro-power resources offer additional opportunities for reducing dependence on oil imports, but not on the scale of possible gas or shale developments. Total hydro potential is estimated at 1.1 million toe/yr. Forty percent of this is already developed, and the Government plans to develop virtually all the rest over the next two decades.

11. The first group of planned investments in hydro power are multipurpose projects (including the Dchar el Oued multipurpose dam and a group of inter-related dams in the Sebou watershed) which rely heavily on agricultural and other benefits for their economic justification. A simplified and tentative cost-benefit analysis indicates that construction of the Sebou dams may not be economically justified in view of the low incremental benefits of the irrigation component, which appear to provide the largest share of net benefits. These results indicate that these projects should be carefully examined to establish their economic viability within the context of overall water resource and power system development priorities. Coordination with MARA is essential to establishing the optimal development schedule for these projects taking into

account the rate at which land can be put under irrigation and the "backlog" of land yet to be irrigated from existing dams. Thermal power alternatives to hydro development are discussed below under Demand Management.

Domestic Coal

12. Coal resources stand at 60 to 80 million toe, but mining conditions are difficult and substantial investments will be needed to maintain the current production of 730,000 tpa (7% of commercial energy supply). 3/ With some mechanization, it is expected that production could increase to 1.0 million tpa in a first stage and about 2.0 million Tpa in a second stage, but such a program will have to take into account such factors as (i) the need for increased coal prices and an improved financial situation for the coal mining company (significant but insufficient progress was made in this direction in 1982), (ii) the results of the pilot mechanization project (the first year's results are generally positive), (iii) market constraints (the market for the first million Tpa appears reasonably well assured, that for the second still needs to be established), and (iv) the facilities needed to substitute coal for oil in industrial plants. The possible utilization of imported coal is discussed under Demand Management below.

Fuelwood

13. Alongside the priorities for action in the commercial energy area is that of balancing the demand for fuelwood with the productivity of Morocco's forests. Currently, about 11 million m^3 of wood are harvested while only about 3 million m^3 grow back each year. Current reforestation efforts cover only about 10,000 ha of new land each year because of three main problems: the very limited amount of information available on the location, quality, and exploitable volumes of Moroccan forests; the lack of incentives for the private sector and local authorities to invest in reforestation, and the limited financial, managerial and technical resources of the Forestry Directorate of the Ministry of Agriculture. Consequently, the forest area is shrinking at about 20,000 ha/yr (i.e. 0.4% of the present natural forest area of 5.1 million ha). Reversing this decline is important not only to assure an adequate future supply of traditional fuels, but also in maintaining agriculturally important soil, water, and forage balances. Meeting the estimated fuelwood demand in the year 2000 would require reforestation at a rate of about 50,000 ha/yr, over twice the maximum achieved to date (20,000 ha/yr). Measures that are urgently needed to alleviate the constraints to accelerated reforestation include a reallocation of investment resources to the sector in areas where it is shown to be viable, and the introduction of appropriate incentives where necessary to stimulate investment. There should be better management of existing

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3/ 365,000 toe of domestic coal out of total consumption of about 5.3 million toe in 1982.

forests to improve production and control grazing which causes damage. In addition, the Renewable Energy Development Center (CDER) should devote a large share of its resources to work that can help with the woodfuel problem by leading to efficiency improvements and inter-fuel substitution in cooking and heating within the economic reach of low-income households, as well as by exploring the substitution of biomass for wood where appropriate.

Solar and Wind Energy

14. Solar and wind resources are widely available sources of energy in Morocco, but are not likely to contribute significantly to national energy supplies in the short or medium term. However, the production of improved solar water heaters as well as the rehabilitation or replacement of windmills for water pumping or small-scale electricity generation should be explored, particularly for use in remote rural areas not connected to the national electricity grid.

Demand Management

15. Total demand for commercial energy is now about 4.8 million toe/yr and could rise to 7-8 million toe/yr by 1990. However, unless the natural gas prospects mentioned in paras v and vi are sufficiently large to replace large proportions of Morocco's energy imports, this increased energy demand would place untenable stress on Morocco's balance of payments. The rate of demand growth and the mix of fuels consumed in the various end-use sectors should be moderated by effective demand management measures.

Energy Efficiency and Fuel Substitution

16. Compared to other developing countries with similar economic structures, Morocco's commercial energy consumption per unit of GDP is below average overall as well as in the consumption of electricity and the lighter fuels generally used in transportation and by households and small businesses. Although Moroccan industry is reasonably efficient overall in its energy use, straightforward conservation measures based on European standards would save roughly 5% of the energy consumed by the industrial sector at lower cost than an equivalent increase in supply. Opportunities for efficiency improvements in the rest of the economy are difficult to estimate, but significant reductions may be possible in fuel requirements for inter-city trucking if licensing restrictions on large capacity trucks that discourage their effective utilization can be altered.

17. Periodic review of industrial and thermal power plant fuel supply plans at the national and regional levels will be essential to make the best use of possibilities for (a) substitution of fuel oil by coal (imported or domestic), natural gas or even oil shale, and (b) energy conservation and co-generation of electricity and process steam in major industrial plants. The 40% of Morocco's commercial energy consumption that is accounted for by fuel oil either directly or indirectly (via

thermal power plants) offers a variety of opportunities for inter-fuel substitution and for conservation. Importing coal in place of at least some of the oil imports is one approach to reducing the cost of energy imports. The major thermal power plant now under construction (Mohammedia III and IV) is being built with a view to firing with imported coal, and conversion of several cement plants to coal is under consideration. There is less scope for converting from oil to coal than from oil to gas, especially in existing plants: however, roughly 45% of incremental projected commercial energy demand could be met by imported coal as opposed to about 70% by gas. The savings that could be obtained through coal imports will depend largely on the capacity of Morocco's ports to handle large coal carriers: it now costs about as much to bring coal across the Atlantic to Morocco as it does to buy it f.o.b. the principal US export ports because of restrictions on the size of ships that can be received in Moroccan ports. The cost of port development to receive larger carriers, and other transportation and storage infrastructure, will need to be taken into account to determine the least cost coal supply option for comparison with other substitution alternatives. Further studies should also be carried out leading to investment and other measures so that viable efficiency-improvement opportunities are realized. This work should include the necessary energy audit and other preparatory studies to define energy-saving and fuel substitution measures in industry, power and transport. A coordinated set of decisions regarding individual industrial plants, transportation infrastructure, and the power system is needed to effect major changes. The close cooperation of several ministries is needed.

18. Determination of the best options for electric power supply also requires improved analysis of alternative power sources. The power system is projected to be short of capacity within five years, and alternative investment programs should be prepared and evaluated now for the medium and longer term. These investment programs should include not only the direct, separable costs involved in power generation but also the infrastructure investments (dam construction, in the case of hydropower and port storage and transportation infrastructure in the case of coal) whose costs do not appear to be taken into account in the selection of energy investments. With respect to hydro projects, a sub-commission on water projects has been established to develop a water resource development plan based on an analysis of the overall costs and benefits of proposed projects.

Pricing

19. Energy pricing is currently oriented principally toward the regulation of suppliers rather than the management of demand. A new industrial investment code providing incentives for energy conservation has been promulgated, but conservation should be further encouraged in the transport, household, commercial and small industrial sectors through appropriate pricing incentives applied to groups or classes of users. Improved coordination across ministerial jurisdiction is needed in this field to ensure that decisions on pricing regulations for each type of energy and other regulations and incentives that indirectly affect energy

use that are now generally made independently do not, taken together, produce undesired results. Three areas need attention:

(i) Electricity tariffs The average price at which electricity is sold to consumers in Morocco is only 60-70% of the estimated cost of meeting incremental demand for electricity and, as a result, the electric utility is unable to finance its agreed share of its investment program. The low price of electricity may also have contributed to rapid growth of consumption: electricity consumption accelerated in the second half of the 1970s, while consumption of other energy forms grew more slowly than in the first half. The electricity rate structure includes many extremely complex geographic variations that bear little or no relation to the cost of service, but is, conversely, too simplified in terms of time-of-day, seasonal, and peak-load pricing to large users. Electricity tariffs need to be generally increased and their structure rationalized, both to facilitate the financing of power investments, and to stimulate the more efficient use of electrical energy.

(ii) Coal prices Given the financial problems of the coal company mentioned earlier, it is necessary that a revised coal price be established not only to stimulate efficient coal/oil substitution, but also to facilitate the sound financing of future coal investments if they are shown to be economically viable.

(iii) Natural gas pricing The Meskala discovery and the prospect of gas becoming a major component of the national energy balance now requires that a gas pricing policy be developed. The uncertainty of the volume of future supplies from Meskala complicates the determination of such a policy, as the utilization options and related opportunity costs for gas are partly a function of the volume of supply. Nevertheless, the lack of an appropriate gas pricing policy could lead to delays in development of the Meskala discovery while negotiations with major consumers drag on and revenue uncertainties complicate financing. It may be appropriate to establish a policy of setting gas prices to the users at levels which, for the marginal gas user, would make production costs using gas equal to those using the most competitive fuel. Given that the Moroccan market for fuel oil as a boiler fuel is large, and much of it could be switched to gas, it would seem appropriate for the time being to link the gas price to that of fuel oil, with enough of a discount to justify conversion. If, later, reserves are found to be sufficiently large that it appears advantageous to encourage lower-value uses, prices would have to be adjusted accordingly.

Institutional Issues

20. Institutional issues involving coordination among public and semi-public enterprises need to be resolved in a number of subsectors. As regards petroleum refining and distribution, coordination among enterprises might be improved while at the same time reducing the need for MEM to be involved in their day-to-day operations. The generation and distribution of electricity is fragmented and hampered by problems of technical and economic coordination between ministries which need to be addressed at the highest levels.

I. ENERGY BALANCE AND PROSPECTS

1.1 Compared with many developing countries, Morocco is well endowed with natural resources. Morocco has the worlds largest and most easily recoverable phosphate reserves, which makes the phosphate sector a key export sector. Other minerals such as iron ore, manganese, lead and zinc are also exported but in much smaller amounts. Morocco also has a relatively good agricultural potential. In addition, Morocco's proximity to Europe has favored trade, tourism and labor migration with the EEC countries. Current population is 21.3 million, and is growing at 3.0% p.a. About 41% of the population is urban, predominantly concentrated along the northwestern coastal strip between Casablanca and Kenitra.

1.2 During the 1970s, substantial investments were undertaken by the Government to promote economic growth, while a growing concern for social development and equity also led to a considerable expansion of social programs. The results, however, have not been commensurate with the country's efforts and potential, reflecting, in part, the fact that both public and private investments have not always made the best use of resources. Growth has been erratic, and while relatively high on average, has been associated with severe financial imbalances. Domestic savings have been persistently low and their share in GDP has been declining. The Moroccan economy in the 1980s is faced with a severe external resource constraint and the urgent need to make more efficient use of resources, in order to achieve adjustment and growth and make progress towards its social goals with relatively less investment than in the past.

1.3 The Moroccan economy experienced a rapid rate of growth in the mid-1970s, with GDP increasing by 6 to 7% a year until 1977. This expansion was essentially based on a rapid increase in public spending and financed with large external borrowings. Public investment and consumption were both approximately doubled, in real terms, as the Government, seizing upon the promise of a short-lived phosphate export boom, launched a massive investment program and vastly increased the scope of its activities in the social sectors, while also increasing its defense expenditure. These strong domestic demand pressures quickly spilled over into the external sector, at a time when the petroleum import bill was rising rapidly and export performance was deteriorating as a result of a drop in phosphate prices and a stagnation in agricultural exports. The economy's resource gap rose to an unsustainable 20% of GDP in 1976-77. Public investment was cut back sharply in 1978, the growth of public consumption moderated somewhat and imports dropped in volume. Growth slowed down to less than 4% p.a. However, major fiscal and external payments disequilibria have persisted and, with exports and domestic savings stagnant and the oil import bill continuing to rise require continued large-scale external capital inflows. In 1981, with a severe drought adding to the existing difficulties, both the budget deficit and the current account deficit of the balance of payments rose to 13% of GDP, while the debt service ratio reached nearly 33% of exports of goods and services.

Current Balances

1.4 Morocco suffers from a drastic imbalance between domestic production and consumption of both commercial and traditional forms of energy. On the commercial side, primary production of about 690 thousand toe compares with total domestic demand of about 4.75 million toe (1981 figures). The deficit is made up almost entirely by oil imports, which constitute about 85% of supply and cost close to 30% of Morocco's total export earnings (including goods and services). Data on traditional energy (fuelwood, charcoal, agricultural residues, etc.) are less precise, but they do indicate that about 35% of Morocco's energy consumption falls into this category and that the rate at which wood is extracted from the country's forests at over three times the rate at which it grows back.

1.5 Morocco's overall energy balance is illustrated in Table 1.1. Domestic production of primary energy consists predominately of fuelwood; coal, hydropower and natural gas account for about 6%, 5%, and 2%, respectively, of commercial energy supply. Hydropower production in 1981 was affected by a drought and with normal rainfall would have supplied about 9% of total commercial energy.

1.6 Electricity and gas oil together account for over half of final demand for commercial energy, with 28% and 26% of the total respectively. The remainder is made up of fuel oil (about 19%) gasoline (9%), followed by LPG (7%), jet fuel (5%), coal (1.6%), natural gas (1.3%), and kerosene (1.2%).

1.7 Households and industry are the most important energy-consuming sectors, accounting for about 45 and 27%, respectively, of total consumption. Households consume primarily traditional energy, however; they consume only about 13% of commercial energy. A summary of energy consumption by sector and energy form is shown in Table 1.2.

1.8 A more detailed energy balance is presented in Annex I and it is worth noting several points which are not apparent from the figures in Table 1.1. One is that the imbalance between the product slate of its refineries and the proportions in which oil products are consumed gives it a surplus of the higher value light products and/or a deficit on the lower value heavy products. Morocco is unusual among developing countries in this respect. The oil exports shown in the table are thus primarily naphtha (the fraction from which gasolines are made), while the product imports are mostly fuel oil. Substantial quantities of butane ("butagaz") are also imported.

1.9 The single "coal" column in the table conceals some qualitative differences. The coal produced is anthracite, mostly fines but including some lumps. Most of the fines are transformed into electricity in a mine-mouth power plant, and most of the lumps are exported. Coal imports include both metallurgical coke and bituminous coal and are used primarily in the mineral processing and beet sugar industries.

Table 1.1: Overall Energy Balance, 1981
(thousand toe)

	Tradi-tional	Commercial Energy Gas	Oil	Elec.	Coal	Total	Total
Primary Production	2775	64	19	254	352	689	3414
Imports			4,698		27	4,725	4725
(of which: products)			(185)			(185)	(185)
(-) Stock changes			-226		50	-176	-176
Supply	2775	64	4,491	254	429	5,238	7963
Thermal Generation			-790	1,115	-345	-20	-20
Non-energy uses	125		225			225	350
Exports			216		30	246	246
Losses	-238	24	283	201		508	743
Final consumption	2362	40	2,978	1,171	52	4,240	6602
Demand	2725	64	3,701	1,372	82	5,239	7964

Notes: "Gas" includes natural gas, excludes LPG. "Coal" includes coke. "Non-energy uses" include pulp and paper and other wood-based industries and asphalts and lubricants.

1.10 Fuelwood and charcoal are the predominant traditional fuels used in Morocco. Total woodfuel consumption is estimated at about 0.8 m^3 (0.2 toe) per capita-year in rural areas (12 million population) and about 0.1 m^3 (0.025 toe) per capita-year among the urban population (8 million). Total consumption on this basis is about 10.4 million m^3 (2.6 million toe). Legally-manufactured charcoal (115,000 T or about 80 thousand toe) would account for about 12% of this if the average conversion efficiency is assumed to be 25%.

Recent Historical Evolution

1.11 A brief look at the recent evolution of Morocco's energy balance is useful as a means of establishing benchmarks against which to measure projections into the future and also to gain insight into the context within which policies and institutional structures have been developed. The important changes that have taken place over the last 15 years in the structure of the energy balance are linked to the shift in electricity supply from hydro (87% in 1965) to thermal (71% in 1980) sources.

Table 1.2: Energy Demand, 1981
(thousand toe)

Line	Sector	Non-commercial energy: Fuel-wood	Non-commercial energy: Char-coal	Non-commercial energy: Total	Coal	Natural Gas
1	Industry				49	40
2	(of which: phosphates					(30)
3	cement					
4	other)				(49)	(10)
5	Transportation & services					
6	Agriculture					
7	Households	2,283	79	2,362		
8	Losses			238	4	3
9	Total	2,283	79	2,600	53	43

Notes: "Industry" includes mining and "services" includes government and commerce. CLF (clean liquid fuels) include LPG, gasoline, kerosene, jet fuel, and gas-oil). FO is fuel oil. Coal, natural gas, and fuel oils exclusive of refinery fuels are included in the "boiler fuels" sub-total.

Line	Electricity	Oil Products: CLF	Oil Products: FO	Oil Products: Total	Boiler Fuels	Total Commercial	Total
1	679	144	866	1,010	955	1,778	1,778
2	(135)		(208)	(208)	(238)	(373)	(373)
3	(90)		(329)	(329)	(329)	(419)	(419)
4	(454)	(144)	(329)	(473)	(388)	(986)	(986)
5	171	1,425	35	1,460	35	1,673	1,673
6	61	134	9	143	9	204	204
7	260	349	17	366	21	630	2,992
8	209			304		516	754
9	1,379	2,052	926	3,282	1,019	4,758	7,358

1.12 From 1965 to 1980, commercial energy demand grew at about 7.4% p.a. on average. As Table 1.3 shows, the overall growth rate actually slowed somewhat through the period in spite of the fact that GDP growth was accelerating, so that by 1975-80, energy demand growth was within 1% p.a. of GDP growth. The table also shows some shifting of market shares among the three broad groups of commercial energy commodities: electricity; clean liquid fuels (CLF) (LPG, gasoline, kerosene, jet fuel, and gas oil or diesel fuel); and boiler fuels (fuel oil, coal, and natural gas). Within the overall demand, the share of electricity rose from 21% in 1965 to 26% in 1980, while that of boiler fuels (exclusive of electricity generation) fell from 32% to 26%.

Table 1.3: Evolution of Final Demand for Commercial Energy, 1965-80
(thousand toe and (%))

	1965	1970	1975	1980
Electricity	298 (21)	444 (21)	656 (22)	1,086 (26)
Clean Liquid Fuels	681 (47)	1,035 (49)	1,523 (50)	1,976 (48)
Boiler Fuels	464 (32)	630 (30)	840 (28)	1,083 (26)
Total	1,443	2,109	3,019	4,145
Annual Growth Rate	(7.9)	(7.4)	(6.5)	
Annual GDP Growth	(4.4)	(4.9)	(5.6)	

1.13 Table 1.4 compares growth over the 1970-75 and 1975-80 periods in the consumption of the three categories of energy with weighted GDP growth rates constructed by weighting sectoral GDP growth rates according to the share of each sector in consumption. It shows that since 1975 (1970 in the case of boiler fuels), the consumption of CLF and boiler fuels, has grown more slowly or only slightly faster than the corresponding sectors, while electricity consumption, encouraged by low tariffs, has grown much faster than the sectors that consume it.

Table 1.4: Energy Demand and Related GDP Growth By Energy Category, 1970-80

	Growth rates (% p.a.)		Sectoral Weights			
	1970-75	1975-80	Agr.	Ind.	S&T a/	Hsld b/
Electricity						
Weighted GDP	5.9	5.3	.052	.580	.146	.222
Consumption	8.1	10.6				
Clean Liquid Fuels						
Weighted GDP	4.7	6.4	.065	.070	.694	.170
consumption	8.0	5.3				
Boiler Fuels						
Weighted GDP	7.2	4.9	.009	.937	.034	.021
Consumption	5.9	5.2				

a/ Services and transportation.
b/ Households. Total GDP was used with these weights.

1.14 A dramatic shift took place in the pattern of electricity supply over the 1965-80 period. The share of hydro fell from 87% in 1965 to 29% in 1980 as demand grew to exceed the capacity as shown in Table 1.5. The corresponding increase in thermal generation pushed the total demand (including that of thermal power plants as well as the final demand discussed earlier) for boiler fuels up from 35% of commercial energy demand in 1965 to 48% in 1980 in spite of the fact that direct demand was declining in proportional terms.

Table 1.5: Evolution of Electricity Supply, 1965-80
(thousand toe and (%))

	1965		1970		1975		1980
Hydro	304 (87)		335 (65)		252 (31)		374 (29)
Thermal	47 (13)		182 (35)		549 (69)		911 (71)
(-) Losses	-53		-72		145		-200
Total	298		444		656		1086
Annual Growth Rate		(8.3)		(8.1)		(10.6)	

1.15 Coal met about 30% of total boiler fuel demand (thermal power plant and final demand) until the late 1970s, when production at the Jerada mine could no longer keep up with the growth in demand. The result has been the increase in fuel oil's share from 70% to 80% shown in Table 1.6.

Table 1.6: Evolution of Boiler Fuel Supply, 1965-80
(thousand toe and (%))

	1965		1970		1975		1980
Fuel Oil	357 (70)		509 (63)		952 (64)		1,609 (81)
Coal	145 (28)		270 (33)		384 (28)		334 (17)
Natural Gas	9		33		53		51
Total	511		812		1389		1,994
Annual Growth Rate		(9.7)		(11.3)		(7.5)	
Share of Boiler Fuels in Total Final Demand	(35)		(39)		(46)		(48)

1.16 Oil in general and fuel oil in particular have increased their shares of total commercial energy demand. Table 1.7 shows that fuel oil accounted for 24% of commercial energy demand in 1970 and 38% in 1980. The rapidly expanding fuel oil market together with the slower growth in demand for clean liquid fuels has shifted the balance in the oil products market. In 1970, fuel oil was 33% of the oil market, a fraction which rose to 45% in 1980. Meanwhile, the share of fuel oil in refinery production (excluding non-energy products) rose from 30% in 1970 to 44% in 1980.

Table 1.7: Evolution of Refined Petroleum Product Demand, 1965-80
(thousand toe and (%))

	1965		1970		1975		1980
Clean Liquid Fuels	681 (66)		1,035 (67)		1,523 (62)		1,976 (55)
Fuel Oil	357 (34)		509 (33)		952 (38)		1,609 (45)
Total	1,038		1,544		2,475		3,585
Annual Growth Rate		(8.3)		(9.9)		(7.7)	
Fraction of total commercial energy demand							
Clean liquid fuels	(47)		(49)		(49)		(47)
Fuel Oil	(25)		(24)		(31)		(38)
Total	(71)		(73)		(80)		(85)

Note: Due to rounding errors, items do not always sum to totals.

International Comparisons

1.17 International comparisons are useful in discussing the relationship between economic growth and energy consumption. Table 1.8 compares the consumption (per unit of GNP) of commercial energy in Morocco with those of other countries with comparable economic structures. It shows that Morocco consumes somewhat less than proportional quantities of electricity and clean liquids but the direct demand for boiler fuels is relatively high. Overall, the energy intensity of Morocco's economy is less than the average of the comparators.

1.18 Table 1.9 compares the growth rates of per capita GNP and commercial energy consumption over the 1960-1979 and 1970-1979 periods in developing countries whose economic structure at the beginning of these periods was comparable to that of Morocco in 1979. Both tables indicate that the link between levels of economic development and energy consumption is one that allows for considerable flexibility, even over periods of one or two decades.

Table 1.8: International Comparisons of Energy Intensity, 1980
(toe of commercial energy consumption per million US$ of GNP)

Country (US$GNP/Capita)	Energy Intensity Total	Boiler Fuels	Clean Liquids	Electricity
Nigeria (1010)	95	13	68	14
Paraguay (1340)	123	8	72	43
Guatemala (1110)	177	7	109	62
Morocco (860)	238	62	113	62
Tunisia (1310)	334	90	162	83
Ghana (420)	385	18	140	227
Ecuador (1220)	351	33	242	76
Turkey (1460)	376	170	114	91
Bolivia (570)	447	47	283	116
Avg. (unweighted)	286	53	146	87

Note: Countries shown resemble Morocco in broad sectoral distribution (agriculture/industry/services) of the labor force (Nigeria, Paraguay, Guatemala, Ghana and Bolivia) and/or of GDP (Tunisia, Ecuador, Turkey, and Bolivia). Due to rounding errors, items do not always sum to totals.

1.19 Economic. Morocco's economic performance has been deteriorating in recent years. Annual GDP growth fell from 7% in 1973-77 to less than 4% on average in 1978-80. The same drought which reduced hydro production in 1981 also reduced agricultural output, and GDP as a whole is estimated to have fallen by 1.5%. Prospects for recovery are clouded by large external and fiscal imbalances. Since 1978, investment, has exceeded domestic savings by amounts fluctuating between 11% and 14% of GDP while government budget deficits have run between 10% and 13% of GDP. Foreign borrowing to fill these gaps has increased Morocco's external debt by about US$1 billion per year and debt service payments have been rising much faster than export earnings.

1.20 The economic and financial situation is likely to remain difficult for the next several years. The external economic environment (commodity prices, interest rates, exchange rates), which contributed to the existing imbalances, cannot be expected to improve markedly. The IBRD is currently projecting real GDP growth at 3.1% p.a. on average in the 1980-85 period and 5.0% p.a. thereafter. Agriculture, which was 18% of 1980 GDP, is projected to grow about 1.0% p.a. in the first half of the decade, and then accelerate to a 2.5% p.a. growth rate. Industrial GDP (32% of the 1980 total) will rise 3.6% p.a. over 1980-85 and 5.5% p.a. in later years according to these projections. The corresponding figures for transportation and services are 43%, 3.4% p.a., and 5.5% p.a. (The remaining 7% of GDP is accounted for by import taxes.)

Table 1.9: Economic and Commercial Energy Consumption Growth Rates in Selected Developing Countries, 1960-79 and 1970-79
(% p.a.)

Country a/ (1960 GNP/cap in 1980 $US)	1960-1979 Average Per Capita Growth Rates (A) GNP	(B) En. Cons	Difference (B-A)	Ratio (B/A)
Congo, P.R.(580)	0.9	2.8	1.9	3.1
Peru (580)	1.7	2.8	1.1	1.6
Colombia (630)	3.0	3.3	0.3	1.1
Syrian A.R.(530)	4.0	6.0	2.0	1.5
Ecuador (510)	4.3	6.2	1.4	1.4
Paraguay (690)	2.8	5.9	3.1	2.1
Tunisia (500)	4.8	6.9	2.1	1.4
Mexico (1080)	2.7	4.2	1.5	1.6
Costa Rica(1050)	3.4	5.3	1.9	1.6
Average (unweighted)			1.8	1.7
(weighted by population)			1.2	1.5

Country b/ (1970 GNP/Cap in 1980 $US)	1970-1979 Average Growth Rates (A) GNP	(B) En Cons	Difference (B) - (A)	Ratio (B)/(A)
Syrian A.R.(790)	9.0	14.2	5.2	1.6
Tunisia (800)	7.6	12.0	4.4	1.6
Bolivia (490)	5.2	7.9	2.7	1.5
Panama (1160)	3.4	4.0	0.6	1.2
Peru (680)	3.1	2.9	-0.2	0.9
Zimbabwe (480)	1.6	2.1	0.5	1.3
Ivory Coast(920)	6.7	3.3	-3.4	0.5
Egypt (390)	7.6	8.0	0.4	1.1
Thailand (430)	7.7	6.9	-0.8	0.9
Colombia (840)	6.0	5.7	-0.3	1.0
Costa Rica(1470)	6.0	6.1	0.1	1.0
Ecuador (780)	8.3	20.2	11.9	2.4
Nicaragua (620)	2.6	1.6	-1.0	0.6
Average (unweighted)			1.5	1.2
(weighted by population)			0.7	1.1

a/ Countries listed are those developing countries in which the distribution of the labor force by sector in 1960 resembled that of Morocco in 1979.
b/ Countries listed are those in which the distribution of GDP by sector in 1970 resembled that of Morocco in 1979.

Note: Based on IBRD World Development Report, IBRD World Tables, and UN Statistical Office data.

1.21 Demand. These economic growth projections are summarized in Table 1.10 in terms of the weighted GDPs discussed above. The table also shows the range of growth rates for final demand that are used to generate the projections. The projections, shown in Table 1.11 imply a continuation of the historical shift within final energy demand toward electricity but a reversal of the trend within final demand for fuels away from the boiler fuels and toward the clean liquids. This projected change reflects the relative growth rates of industry (high) and of transportation and services (low) in the underlying GDP projections.

1.22 Overall growth in energy demand in the low projection is essentially in line with GDP growth: 3% p.a. over the 1980-85 period, rising to about 5% in later years. Energy demand growth rates in the high projection are 3% p.a. higher. The Ministry of Energy and Mines is currently working with a considerably narrower and generally lower range or demand projections than those presented in the table. The Ministry's projections imply a commercial energy demand growth rate between 3.4 and 3.8% p.a. from 1980 to 1995. The difference is most pronounced with respect to electricity demand; the Ministry's estimates range from 5.3 to 7.1% p.a. growth from 1980 to 1995, levels 2 to 3% p.a. lower than those in the table.

Table 1.10: Projected Energy Demand and Related GDP Growth by Energy Category, 1980-1995
(% p.a.)

	1980-85	1985-90	1990-95
Electricity			
Weighted GDP	3.3	5.2	5.2
Consumption (Low)	7.0	7.5	7.5
" (High)	10.0	10.5	10.5
Clean Liquid Fuels			
Weighted GDP	3.2	5.3	5.3
Consumption (Low)	1.0	3.0	3.0
" (High)	4.0	6.0	6.0
Boiler Fuels			
Weighted GDP	3.5	5.5	5.5
Consumption (Low)	2.0	4.0	4.0
" (High)	5.0	7.0	7.0
GDP	3.1	5.0	5.0

Note: Sectoral weights same as in Table 1.4

Table 1.11: Commercial Energy Demand Projections, 1980-95
(thousand toe and (% p.a.))

	1980	1985	1990	1995
Final Demand	(Low Energy Demand)			
Electricity	1086	1523	2187	3139
CLF	1976	2077	2408	2791
Boiler Fuels	1083	1196	1455	1770
Losses	459	540	689	890
Total	4604	5336	6739	8590
Growth rate	(3.0)	(4.8)	(5.0)	
Final Demand	(High Energy Demand)			
Electricity	1086	1749	2881	4747
CLF	1976	2404	3217	4305
Boiler Fuels	1083	1382	1939	2719
Losses	459	623	915	1358
Total	4604	6158	8952	13129
Growth rate	(6.0)	(7.8)	(8.0)	

Note: Losses estimated as 15% of electricity and CLF final demand.

1.23 Consumption of traditional fuels is projected to decline very slowly in absolute values as consumers switch to commercial fuels (primarily butane) at a rate that compensates for population growth. Table 1.12 shows a projection of woodfuel consumption that implies a 5% decline over a 15 year period.

Table 1.12: Woodfuel Consumption Projections, 1980-95

	1980	1985	1990	1995
Rural Population (millions)	12.00	13.10	14.30	15.60
Per-capita rural consumption(kgoe)	0.20	0.18	0.16	0.14
Rural consumption (thousand toe)	2,400	2,358	2,288	2,184
Urban population (millions)	8.00	10.10	12.80	16.20
Per-capita urban consumption(kgoe)	0.025	0.023	0.020	0.017
Urban Consumption (thousand toe)	200	232	256	275
Total Consumption (")	2,600	2,590	2,544	2,459

Supply

1.24 The fact that fuel oil meets, directly or indirectly, about 35% of Morocco's commercial energy demand makes it easier than in most countries (developed or developing) to alter the pattern of energy supply. Imported coal, natural gas, and oil shale are all at least potentially available to substitute for oil on a large scale.

1.25 An investment program has been planned to increase domestic coal production from its current level of about 400,000 toe/yr to 500,000 toe/yr in 1986 and 1.0 million toe/yr in 1982. Coal is also available on the Atlantic coast of the United States for about US$55 per ton or $93/toe, compared to posted fuel oil prices of about $140/toe in the Caribbean and about $180/toe in the Persian/Arabian Gulf. The principal limits on utilization of imported coal are related to transportation infrastructure at the national and regional level, environmental considerations at the local level, and boiler and fuel handling characteristics at the plant level. The cost of imported coal delivered to Moroccan users will depend largely on the capacity of the country's ports to handle large vessels. Currently, the least expensive way to ship coal from the U.S. involves trans-shipment at a European port and when shipping, port and land transportation charges are considered, the delivered cost (excluding duties and taxes) of coal is about 85% to 90% of that of fuel oil per unit of energy content.

1.26 Assuming that the new port facilities recently built for phosphate exports could be used to handle coal imports in ships large enough to cross the Atlantic economically and/or that price developments increase coal's competitive margin sufficiently to compensate for the higher costs involved in using coal, the market for steam coal would still be restricted to large plants that are able to burn coal or could be converted to coal. New thermal power stations and the cement and phosphate industries would probably be the major markets; together, they represent about 45% of the projected 1990 total boiler fuel demand (including that for power generation) net of existing natural gas and coal uses.

1.27 The utilization of "new" natural gas depends first and foremost on supply. A recent discovery at Meskala may be able to provide several million toe annually, but it might also be much more limited. Potential demand for power generation can be estimated from the projections for electricity demand discussed above after adjustments for generation by hydro plants and thermal plants that could not conveniently be converted to gas. Potential direct demand can be estimated from the boiler fuels projections with (1) deductions for absorption of the excess of Jerada's antracite production over the amount that is utilizable in power production or exportable and for existing flows of imported coal and natural gas and (2) an assumption on the share of the remaining market that gas might capture. Pipelines from Meskala could economically reach provinces with about 70% of the final demand for boiler fuels, but not all fuel oil users in these provinces could or would convert to gas. Assuming that within this area there is complete conversion of the cement and phosphate industries and 60% conversion on other fuel-oil users, the overall (national) market penetration rate would be about 60%.

1.28 Table 1.13 shows projections of the potential markets for "new" natural gas and imported coal supplies made on the basis of the assumptions discussed above. The rapid growth in both markets, and especially that for coal, reflects the increasing importance over time of new power plants that are or can be designed to burn gas or coal.

1.29 The flexibility in primary energy supply allowed by these market constraints is illustrated in Table 1.14. It indicates the relative and absolute importance of the options as well as certain interrelationships among them, such as the potential effect of gas development on the market for coal or of shale development on the market for gas. Natural gas (and associated condensates) could substitute for about 60% of projected oil imports in 450 and 50% in 1995 if supplies are not limiting. The gas, gas/coal, and gas/shale case projections assume, however, a maximum gas production rate of 3.0 million toe/yr plus 1,140 thousand toe/yr of associated condensates. Coal would not be able to substitute for as much oil (11-16% in 1985, 18-27% in 1990, and 31-40% in 1995 depending on the rate of demand growth).

Imports

1.30 Projected energy import costs corresponding to the various supply and demand assumptions considered are shown in Table 1.15. In the base supply case and under the high demand assumptions, the energy import bill would more than double from its 1980 level of about 4.6% of GDP to 9.8% by 1995. The projected increase in real oil prices accounts for some of this increase (to 6.3% of GDP). The rest results from the gradually increasing energy intensity of the economy implicit in the demand projections. Switching to coal could hold the increase to about 7.9% of GDP, while holding demand growth to the lower level would keep it to about 5.9%. The two together would hold the energy import bill to 5.1%, about its current proportion of GDP. The savings obtainable from gas and shale development will obviously depend upon how much is available and the costs of these alternatives.

1.31 Macroeconomic projections indicate that the high demand projections would severely strain the balance of payments except in the cases that include natural gas development. This implies that the projected GDP growth is contingent on either successful hydrocarbons exploration, an energy conservation effort sufficient to hold the growth of demand down to a level appriximating the low demand projections, or some combination of the two.

Table 1.13: Projections of Potential Markets for Natural Gas and Coal Imports, 1980-95
(thousand toe except as noted)

Line		Actual 1980	Low Demand 1985	Low Demand 1990	Low Demand 1995	High Demand 1985	High Demand 1990	High Demand 1995
	Electricity Generation							
1.	Final Demand and Losses	1,195	1,675	2,406	3,453	1,924	3,169	5,222
2.	Hydro Production	371	480	791	1,046	480	791	1,046
3.	Jerada Coal (existing pit)	242	284	284	284	284	284	284
4.	Inflexible oil-fired thermal	172	160	92	0	160	210	0
5.	Potential Gas Market	410	751	1,121	2,123	1,284	1,884	3,892
6.	of which: not convertible to coal	410	751	1,029	1,029	1,029	1,029	1,029
7.	Potential Coal Market	242	284	376	1,378	539	1,139	3,147
	Direct Boiler Fuel Market							
8.	Final Demand	1,083	1,196	1,455	1,770	1,382	1,939	2,719
9.	Existing Gas	51	50	50	50	50	50	50
10.	Jerada Coal (existing pit)	29	79	129	175	79	129	175
11.	Existing Coal Imports	21	21	21	21	21	21	21
12.	Remaining Market	982	1,046	1,255	1,503	1,232	1,739	2,452
13.	Potential Gas Market (60%)	589	628	753	902	739	1,043	1,471
14.	Potential "New" Coal Market (45%)	442	471	565	676	554	783	1,103
	Totals							
15.	Potential Gas Market	996	1,379	1,874	3,025	1,739	2,928	5,363
16.	(in MMCFD)	(112)	(155)	(210)	(340)	(195)	(329)	(602)
17.	Potential "New" Coal Market	465	471	656	1,770	554	1,638	3,966
18.	(in thousand Tpa)	(785)	(795)	(1109)	(2992)	(937)	(2768)	(6703)

Notes: (line 2) Hydro: 410, 741, and 1006 thousand toe in 1985, 1990, and 1995, Jerada coal: 284 thousand toe throughout.
Oil-fired thermal: 160 thousand toe in 1985 and 210 thousand toe in 1990.

(line 4) Line 3 less 1029 thousand toe generated at Kenitra and Mohammedia I and II, which cannot burn coal.

(line 6) Existing gas and imported coal supplies: 71 thousand toe.

Jerada coal: 79, 129, and 246 thousand toe in 1985, 1990, and 1995.

Table 1.14: Alternative Primary Energy Supply Patterns, 1980-95
(thousand toe)

	Actual 1980	Low Demand 1985	Low Demand 1990	Low Demand 1995	High Demand 1985	High Demand 1990	High Demand 1995
	ALL CASES						
Hydro	374	480	791	1,046	480	791	1,046
Existing Natural Gas	51	50	50	50	50	50	50
Existing Coal Imports	21	21	21	21	21	21	21
	BASE CASE						
Net Oil Imports	3,833	4,346	5,355	6,836	5,157	7,533	11,294
Jerada Coal	271	363	413	480	363	413	480
	GAS CASE						
Net Oil Imports	0	(2,629)	3,028	3,093	(2,983)	3,871	7,632
New Natural Gas	0	(1,379)	1,874	3,000	(1,739)	2,928	3,000
Condensates	0	(414)	562	900	(522)	878	900
Jerada Coal	0	363	413	480	363	413	480
	COAL CASE						
Net Oil Imports	0	3,951	4,808	5,223	4,690	6,039	7,566
Coal (Jerada and New Imports)	0	834	1,069	2,250	917	2,051	4,446
	SHALE CASE						
Net Oil Imports	0	4,422	4,264	3,393	5,244	6,477	7,932
Shale-elec.	0	0	200	1,200	0	200	1,200
Shale Oil	0	0	1,000	2,400	0	1,000	2,400
Jerada Coal	0	363	413	480	363	413	480
	GAS/COAL CASE						
Net Oil Imports	0	(2,629)	3,028	3,068	(2,983)	3,871	5,269
New Natural Gas	0	(1,379)	1,874	3,000	(1,739)	2,928	3,000
Condensates	0	(414)	562	900	(522)	878	900
Coal (Jerada and New Imports)	0	363	413	505	(363)	413	2,843
	GAS/SHALE CASE						
Net Oil Imports	0	(2,629)	2,501	1,053	(2,983)	2,671	5,592
New Natural Gas	0	(1,379)	1,674	1,800	(1,739)	2,928	1,800
Condensates	0	(414)	502	540	(522)	878	540
Shale-elec.	0	0	200	1,200	0	200	1,200
Shale Oil	0	0	1,000	2,400	0	1,000	2,400
Jerada Coal	0	363	413	480	363	413	480
	ALL CASES						
Total	4,604	5,336	6,739	8,590	6,158	8,952	13,129

Table 1.15: Projected Energy Import Costs, 1980-95

Case	Actual 1980	Low Demand 1985	Low Demand 1990	Low Demand 1995	High Demand 1985	High Demand 1990	High Demand 1995
			% GDP				
Base	4.6	4.9	5.5	6.0	5.8	7.6	10.0
Gas	n.a.	(2.9)	3.0	2.6	(3.4)	3.7	6.6
Coal	(4.3)	4.7	5.1	5.2	5.5	6.8	8.1
Shale	n.a.	n.a.	4.3	2.9	n.a.	6.4	6.9
Gas/Coal	n.a.	n.a.	3.0	2.6	n.a.	3.8	5.5
Gas/Shale	n.a.	n.a.	2.6	0.9	n.a.	2.7	4.9
			1981$ millions				
Base	853	1,061	1,508	2,133	1,259	2,119	3,517
Gas	n.a.	(631)	836	943	(742)	1,052	2,328
Coal	(802)	1,008	1,414	1,841	1199	1,885	2,863
Shale	n.a.	n.a.	1,177	1,035	n.a.	1,788	2,419
Gas/Coal	n.a.	n.a.	836	939	n.a.	1,068	1,938
Gas/Shale	n.a.	n.a.	690	321	n.a.	737	1,706
			1981$/toe				
Oil Price	222	240	276	305	240	276	305
Coal Price	112	127	133	140	127	133	140

Notes: % GDP computed at 1980 prices (for both GDP and energy imports) and average 1980 exchange rate (3.935 DH/$).

Amortization and interest on the roughly $7,000 million estimated incremental investment required for shale development would cost roughly $1200 million/year. Gas development costs would imply amortization and interest charges of roughly $150 million/year.

Prices include $10/toe (oil) and $28/T or $45/toe (coal) margins above projected prices f.o.b. (OPEC average for oil, Hampton Roads, US, for coal). The coal transport cost estimate is based on assumed transshipment in Europe. Large-scale imports would utilize direct shipment (requiring some investment in port facilities) at lower unit cost.

Parentheses are for cases and years that are not feasible but where figures are useful for comparison and interpolation.

II. Resource Base and Existing Infrastructure

2.1 Morocco has a wide variety of energy resources. In terms of gross reserves, the largest is uranium: although no conventional deposits are known, the country's immense phosphate reserves (about 50 billion tons) contain some 7 to 10 million tons or 60 to 84 billion toe of uranium. Extraction is, however, far from economic with present technology and prices. Several billion of oil shale have been found. Although more promising than the uranium, the economics of their development have not yet been established either. Much smaller hydrocarbon and coal resources also exist. Oil reserves are very small, but a recent gas discovery at Meskala may eventually yield several hundred million toe. It may, on the other hand, yield only 5 to 10 million toe; it is likely to be at least mid-1983 before the magnitude of the discovery can be estimated much more closely. Coal reserves of above 8 million toe have been proven, and another 50 to 70 million toe are classified as probable and/or possible. Biomass production can be estimated at about 10 million toe per annum, but two-thirds of this is in the form of crop and animal wastes that are generally costly to collect and process into useful energy. Morocco's total hydro potential is estimated at about 1 million toe per annum. Map IBRD-16581 shows the locations of the principal mineral deposits and infrastructure installations referred to in this chapter.

Oil Shale

2.2 Moroccan oil shale reserves identified to date are estimated at well above 100 billion tons, containing more than 6 billion tons of oil. The two major deposits are located at Timhadit in the central plateau about 90 km south of Fes and at Sebkat-Tazgha, near Tarfaya. Other small deposits of lesser importance also exist.

2.3 The most favorable deposit for early development of an oil shale industry appears to be Timhadit, where proven reserves of about 3.3 billion tons of oil shale have been identified with an average oil content of 65 liters/ton of shale (above 5.7% by weight). Within this deposit, a 6 km^2 plateau has been identified containing some 135 million toe of oil in about 2.9 billion tons of shale with a favorable overburden ratio of 1.1 and hardly any inert rock layers within the oil shale bed. This plateau is suitable for open-pit mining, with mining costs likely to be below those for underground oil shale mines.

2.4 The Timhadit shale has been tested for retorting both in Morocco and abroad. About 19,500 samples have been subjected to laboratory analysis in Morocco and various experimental facilities have tested about 1800 tons. The tests and associated prefeasibility studies showed that extraction of oil from Timhadit shale is technically feasible with high recovery rates for all the retorting processes tested. While Timhadit shale is "leaner" than high grade Colorado shale (65 liters/ton compared to about 115 liters/ton), it has a high proportion of residual carbon, which may serve as fuel for the retorting process and thus substantially reduce the need for external energy. Although further testing of a wide range of samples covering the entire deposit is still needed, the quality of the shale analyzed to date and the geological characteristics of the Timhadit deposit appear suitable for industrial oil shale exploitation.

2.5 The studies undertaken to date do not however, provide sufficient data to allow conclusions as to the overall economic viability of a shale oil extraction project. An extensive program to assess the technical and economic viability of a commercial exploitation of the Timhadit deposit for producing oil is therefore presently being undertaken with the assistance of the Bank as well as of foreign petroleum companies who might be interested in participating in an oil shale project in that location. This work includes the construction of a test station, a testing program for the shale, and studies of various retorting processes, as well as mine development, environmental and overall feasibility studies.

2.6 The tests made to date also indicate that, notwithstanding the shale's low calorific value (1,100 kcal/kg) and its high ash content (60%), it could fuel a direct combustion power plant. The first such plant Morocco plans to build at Timhadit would be a prototype designed for two 100 MW boilers, of which one would be erected and would consume shale at an annual rate of 0.2-0.4 million tons during a trial period. In full operation, consumption would be about 1.0 million Tpa.

2.7 The other deposits have been far less studied than Timhadit even though they are even larger in terms of total volume of reserves. The geological studies of the Sebkat-Tazgha or Tarfaya deposit indicate that that deposit alone contains about 100 billion tons, with an oil shale grade varying between 60 and 90 liters/ton. The total oil content of the deposit is thus on the order of 5 billion toe. However, the overburden and seam thicknesses of this deposit are less favorable than those of the Timhadit deposit, so mining costs would be higher.

Coal

2.8 Morocco's currently known coal potential is limited to the Jerada anthracite deposit, which is presently being exploited. No other mineable coal deposits have been identified, although traces of coal have been found in four different basins (Tindouf, the Hauts Plateau, Er Rachidia, and Fquih Ben Salah). The Jerada basin contains about 16 million tons of proven, 60 million tons of probable (of which 20 million in the existing pit) and 40 to 80 million tons of possible reserves.

2.9 The Jerada mine entered production in 1938 and currently produces about 730,000 Tpa. The coal has a calorific value of 5,000 to 7,500 kcal/kg after cleaning and in lump form is ahigh quality product (anthractie burns with little or no smoke) suitable for household heating and specialized industrial uses. The mine is difficult to exploit because of its highly fragmented geological structure and very thin, steeply inclined and deep seams (there are three seams averaging 60, 70, and 50 cm respectively in thickness and at depths of up to 900 m). These conditions contribute to the very high proportion (85%) of fines in total production.

2.10 A program to partially mechanize the mine may bring production up to 1.0 million Tpa in a first phase. A pilot project to test the equipment is underway. Later on, there are plans to increase production to above 2.0 million Tpa by opening a new pit. This second expansion must still be viewed as most uncertain as sufficient reserves still have to be proven and the mineability of the coal still has to be assessed. The characteristics of the Jerada deposits are such that difficult technical problems can be expected in developing a new pit.

Hydrocarbons

2.11 Morocco has a number of structurally distinct sedimentary basins, which extend over a significant portion of the nation's area, both onshore and offshore. All of these basins have geological characteristics which make hydrocarbon generation and accumulation possible, but most have not been adequately assessed.

2.12 Exploration has been intermittent, and concentrated on only some of these basins. Prior to 1958, exploration was confined principally to the shallow depth horizons of the Rharb basin in northwest Morocco. Proved plus probable remaining reserves include about 1.6 million toe of natural gas, 0.10 million toe of gas liquids, and 0.15 million toe of oil. In the period between 1958 and 1972, exploration activity extended to other basins, first onshore and then offshore. However, due to the lack of any commercial discovery, this was followed by an almost complete withdrawal of foreign companies. Interest in Morocco's petroleum prospects did not revive until very recently. As a result, during the past decade, there was little further exploration offshore, and onshore explorations was carried out principally by the national petroleum and mineral firm, BRPM, with the exception of joint ventures with Apex (American Petrofina) and (since 1979), with Elf-Aquitaine in the Rharb Basin, and a joint venture with Phillips in the Hauts Plateaux.

2.13 In 1981, gas was discovered in the Triassic sandstones underlying Meskala, in the Essaouira basin. This discovery is potentially quite significant. The abnormally high formation pressures are indicative of a thick productive interval and/or long gas column, the gas is rich in liquid condensates, and other wells drilled previously in the area also encountered high formation pressures, so the possibility exists that there may be a large regional accumulation of gas. However, the reservoir rocks encountered to date give evidence of being heterogeneous with relatively poor reservoir characteristics that vary significantly with both depth and distance, due in part to their being compartmentalized by sealing faults. These factors could place significant limits on gas recoverability.

2.14 At the current stage of exploration, with the extent of the field still unknown and the lack of data on recoverability, it is not possible to establish estimates of recoverable reserves and corresponding production scenarios without their being subject to abrupt revision as new evidence is obtained from the ongoing drilling and reservoir engineering program. However, in light of currently available data, it is considered very likely that future drilling can establish recoverable reserves in the local Meskala area of 330 billion cubic feet of gas and 20 million barrels of condensate (together equivalent to 10.5 million toe). These and the other figures corresponding to high and low estimates for the Triassic with and without a downward extension of the gas accumulation into the Paleozoic are presented in Table 2.1.

Table 2.1: Alternative Assumptions on Meskala Reserves and Corresponding Production Scenarios

	Without Paleozoic		With Paleozoic	
	Low Triassic	High Triassic	Low Triassic	High Triassic
Recoverable Reserves				
gas (BCF)	330	1,250	1,000	1,900
liquids (million bbl)	20	70	64	100
Total (million toe)	11	39	32	60
Production				
gas (MMCFD)	90	250	300	460
liquids (MBD)	5.4	15.2	16.0	25.4
Total (million toe p.a.)	1.0	2.9	3.4	5.2

2.15 The Meskala discovery has coincided with a more general renewal of interest in Morocco's petroleum prospects. Recently, most interest has been shown by foreign companies in Morocco's offshore. Phillips, as operator for a group, is now drilling offshore Essaouira and ONAREP has signed three new exploration joint-venture agrements with foreign partners since the fall of 1981. These agreements with Arco (September 1981 offshore Agadir, Mobil (February 1982 offshore Agadir) and Amoco (June 1982 offsshore Mediterranean), commit the foreign partners (who will bear 100% of exploration cost) to exploration expenditures in the first four-year period toalling $77.5 million. Only KFPC (Kuwait Foreign Petroleum Corporation) appears to be giving serious consideration to several onshore blocks (Boudnib, Doukkala and the Essaouira extensions). Elf-Aquitaine, on the other hand, appears ready to relinquish its concession by October 1982. However, work on small fields in the Gharb by Petrofina, and in Essaouira by SCP, continues. Despite very marginal recent results in its own drilling on Gharb seismic bright spots, ONAREP is pursuing the joint venturing with Petrofina and SCP in that region in an effort aimed at a small gas development to supply Kenitra. It is also pursuing on its own the possibility of a small development of the Toukimt field.

2.16 The known oil fields are almost depleted now and domestic production is continuing to decline. Remaining gas reserves in the Rharb area approximate 1.3 billion cubic meters of which 0.7 are developed reserves currently producing (2 fields) and 0.6 are undeveloped (four fields). Toukimt, an ONAREP field in the Essaouira basin is believed to contain about 0.35 billion cubic meters of gas and 100,000 tons of liquids. Annual oil production peaked at about 149,000 tons in 1963, falling to 17,500 tons in 1981, mostly from SCP's field in Essaouira, with the rest from its wells in the Rharb basin. An average of 78.5 million cubic meters (0.06 million toe) of gas have been produced each year from 1975 to 1981, with production almost equally divided between the Rharb and Essaouira basins.

2.17 Morocco has two oil refineries, the larger SAMIR refinery (5.75 mn Tpa capacity) is located at Mohammedia and has port facilities. The SCP refinery (1.20 mn Tpa capacity) is at Sidi Kacem in the Rharb area. Capacity utilization is low (53% at SAMIR in 1981, 91% at SCP, 60% overall) because major expansions came on stream in the late 1970s in anticipation of demand which has not materialized (1981 crude throughput was estimated in late 1974 by the Department of Mines at 6.0 million toe, by the operator of the Sidi Kacem refinery at 6.2 million toe, and by an Interministerial Energy Committee at 7.8 million toe; the actual figure was only 4.2 million toe).

Hydropower and Electricity

2.18 Morocco's total hydro potential is estimated at about 4,600 GWh (1.1 million toe) per year, less than current electricity demand. About a third of the total is already developed, and current plans call for developing 85% by the early 1990s. Rainfall is both highly seasonal and variable from year to year. For example, while the hydro plants operating in 1981 could have produced about 1,500 GWh in an average hydrological year, they produced in fact only about 1,000 GWh because it was the second successive dry year. Many small hydro sites exist, but even cumulatively they are a minor resource. An estimated 150-200 sites with a total capacity of about 50 to 60 MW (About 35,000 toe/yr. at a 30% plant factor) exist in the Middle Atlas region.

2.19 The major elements of the power system include oil-fired power plants at Mohammedia, Kenitra, and Casablanca, a mine-mouth coal-fired plant at Jerada, a number of hydro plants, and a transmission grid linking all the major generating and consuming centers from Agadir to Tangier and Oujda. The capacities and 1981 operation of the principal power stations are shown in Table 2.2.

Biomass

2.20 Moroccan natural forests cover about 5.1 million ha. An additional 2.6 million ha are covered by esparto grass (Sometimes called "alfa", esparto grass is a long fiber grass, used mainly for manufacturing paper, rope and shoes, and for fodder). Of this area, only about 2.5 million ha of forests and 1 million ha of esparto grass areas have significant production potential. The remaining areas (54% of total), especially in the more arid south, have as prime function the protection of soils and water catchments.

2.21 The forests are extensively used for grazing and are estimated to produce the fodder equivalent of about 1.5 million tons of barley, or about 35,000 Tpa of meat. Pulpwood and other wood fiber industries also extract roughly 0.5 million m^3 annually. The maximum sustainable rate of fuelwood extraction is estimated at about 3.0 million m^3 per year (about 750,000 toe) or less than 30% of the estimated actual rate. The forest resource base is, consequently, shrinking at a rate of about 25,000 ha/year.

Table 2.2: Principal Power Stations

	Installed Capacity (MW)	Nominal Generating Capability (thou toe/yr)	1981p Production (thou toe)	1981p Fuel-consumption (thou toe)	
Thermal a/					
Mohammedia	300	27 e/	27	23	Fuel Oil
Kenitra	300	515	447	429	Fuel Oil
Roches Noires b/	120	206	168	168	Fuel Oil
Jerada	165	283	286	350	Coal
Smaller ONE plants c/	150	185	71	93	Fuel Oil,
				3	gas oil
Independent producers & isolated centers f/	182	178	116	87	Fuel Oil
Subtotal	1,217	1,394	1,115		
		(Normal Year)	(Dry Year)		
Hydro					
Bine el Ouidane	135	65	45		
Afourer	94	129	105		
Im Fout	31	47	17		
Sidi Cheho	128	81	30		
Smaller ONE plants d/	225	156	117		
Independent Producers	10	4	2	3	
Subtotal	623	482	316	254	
Total	1,840	1,876	1,710	1,369	

a/ Excludes a total of 62 MW cold reserve at Roches Noires (Unit I), Oujda, and Sidi Kacem (diesel plant), and Tangier (diesel plant).

b/ Located in Casablanca, Unit II (60 MW) is able to burn some coal and is being re-converted to coal.

c/ Three gas turbine stations of 40MW each at Agadir, Tangier, and Tetouan, a 16 MW gas turbine at Sidi Kacem (to be placed on cold reserve as of end 1981) and 14 MW of isolated diesel plants.

d/ About 15 plants

e/ To build up to 515 thousand toe by 1983 and doubling to 1030 thousand toe as Units III and IV (designed to burn coal) enter service 1984-1986.

f/ These figures are Bank estimates.

2.22 Agricultural residues appear to be a much larger resource but also much less easily collected and used, especially for large-scale applications. A very rough estimate of 6.3 million toe/yr is constructed in Table 2.3, but with a 50% margin for error attributable primarily to uncertainty about the residue coefficients.

Table 2.3: Agricultural Residue Resource Estimates

	Resource Base (thousand tons p.a. production)	Residue Coefficient (T/T)	Energy Content (thousand toe/yr)
Major Crops			
Grains	4,400	0.9	1,600
Sugar beets	2,400	1.2	1,150
Sugar cane	340	0.4 b/	50
Sub-Total			2,800 +/- 50%
Livestock	(million head)	(Tpa/head)	
Cattle	3.0	0.9	1,100
Horses, mules	1.2	0.5	350
Sheep, goats	22	0.2	1,750
Poultry	55	0.005	300
Sub-Total			3,500 +/- 50%
Total			6,300 +/- 50%

a/ Primarily barley and wheat, some maize.
b/ Of which, roughly half bagasse and half field residue.

2.23 Municipal solid waste is estimated to be about 30% (by weight) organic material, and hence can be classified as a biomass resource. Extrapolation from an estimate made for Marrakech yields an estimate of 0.5 million dry tons (200,000 toe) of organic solid wastes on a national basis. Sewerage wastes are estimated at an additional 0.4 million dry tons (160,000 toe), but are not currently used for energy production.

Wind and Solar

2.24 Morocco is endowed with an unusually good wind regime technically well suited for both pumping water and generating electricity. Average wind velocities exceed 19 km/hr over 90% of the land area and winds in many areas average 20-30 km/hr, with the strongest winds in the southwestern coastal regions.

2.25 Average solar radiation in Morocco is high, around 0.16 toe/m^2-year in the north to an average of 0.18 toe/m^2-year in the south. Seasonal variations reach up to 50% of the annual average in the north as opposed to only 30% in the south.

III. INSTITUTIONS, PRICING AND PLANNING

3.1 The commercial energy sector is characterized institutionally by a large number of public and semi-public enterprises and a smaller number of private firms operating under detailed regulation of prices, operations and investments, mostly by the Ministry of Energy and Mines. The Ministry of Agriculture and Agrarian Reform is generally responsible for forestry. Other ministries are also involved, however. The Ministry of Interior, through its oversight of local governments, plays a key role in both electricity distribution and fuelwood. The Ministry of Industry, Commerce and Tourism, among others, regulates enterprises that account for much of energy consumption. The importance of energy issues in recent years has also led to ad hoc arrangements superimposed on the division of responsibilities among ministries, including special studies of energy problems by the Prime Minister's office and (in 1974) an inter-ministerial committee on energy.

Oil, Gas, and Shale

3.2 Prior to 1956, hydrocarbon exploration was the monopoly of the SCP, an oil company owned 50% by the Government and 50% by a French group led by Elf-Acquitaine. Hydrocarbon (and shale) exploration and production in Morocco are carried out under a contracting system under which companies negotiate with the Government for rights covering specific areas. SCP still holds contracts for exploration and production in some areas and has some gas and oil production, as well as the smaller of Morocco's two refineries and LPG distribution facilities. The larger of the oil refineries belongs to another state-owned enterprise, SAMIR. A state company, ONAREP, holds the contracts for several areas itself and is in most cases the partner of foreign oil companies in areas for which they obtain contracts.

3.3 ONAREP was created in mid-1981 by splitting off the petroleum and oil shale staff and assets of BRPM, a state holding company in the mining sector which has been active in hydrocarbon exploration since the late 1950's. The Essaouirra gas discovery was made by ONAREP in one of its areas.

3.4 ONAREP is a small company by international petroleum industry standars and is very thinly staffed at key technical and managerial levels. BRPM had been carrying out exploratory drilling for petroleum since 1958, but from 1970 to 1980 drilled an average of only five wells per year. The principal discoveries made prior to Meskala were at Toukimt and N'Dark, each with about 0.4 million toe recoverable reserves. Meskala could be several orders of magnitude larger than this and hence requires appraisal and development efforts on a scale unprecedented in ONAREP's history. The company is currently engaged in a program for appraisal for the area that requires keeping several drilling rigs operating simultaneously and testing wells under unusually high pressure conditions. The program is essential to providing the proven reserves and estimates of well productivities that are needed to cost and justify a commercial development program, and unnecessary delays carry a high (but implicit) cost. A number of useful steps have been taken to reinforce ONAREP's capabilities in implementing the Essaouira appraisal and exploration program:

(a) establishment of a task force comprising ONAREP personnel and highly qualified expatriate explorationists and engineers from an international oil company (Elf Aquitaine) to manage and supervise the Essaouira program;

(b) employment of a firm of reservoir engineers (Core Laboratories) to assist ONAREP in the assessment of reserves and well productivity:

(c) contracting of a number of skilled technicians from an international drilling contractor (FORASOL-FRAMER) to help man two of ONAREP's rigs; and,

(d) streamlining financial control procedures in several areas (procurement and purchasing, staffing, and timing of approvals of payments and budgetary appropriations) in order to help prevent costly delays in the program.

Further, longer term strengthening of ONAREP is being pursued through an on-going institutional study by a firm of international management consultants (Arthur D. Little Inc) that will (i) help the Government and ONAREP assess ONAREP's present institutional setting, objectives, and capabilities and formulate a plan of action for the company's future transformation and development; and (ii) assist ONAREP in the implementation of this plan. It is important that every effort be made to ensure successful completion of this work.

3.5 A decision on the possible involvement of foreign companies (either as investor/partners or as contractors for specific tasks such as drilling wells) will need to be made if and when development of Meskala is decided upon. ONAREP could either work with a company on development of the entire field or work in parallel after subdividing the permit area.

3.6 Morocco's Petroleum Code dates from 1958 but is for the most part well written. By today's standards, its fiscal terms are liberal (12.5% royalty on oil, 5% on gas; 55% income tax and 25% depletion allowance).

3.7 Petroleum product distribution is handled by 27 companies, most of them owned 51% by SNPP, a state enterprise, and 49% by foreign companies. The remaining distributors are owned by private Moroccan interests. Separate public enterprises operate an underground butane storage facility, ocean shipping of oil and oil products (three enterprises), and petroleum product storage terminals.

3.8 The apparent institutional fragmentation in the "downstream" petroleum sub-sector (refining and product distribution) together with a system of regulation that requires Ministry attention not only to major policy and investment issues but also to such details as the location of individual gas stations and finding truckloads of products for towns whose regular supplies are late or missing may (a) keep Ministry staff so busy with day-to-day problems that medium and long-term planning and policy issues do not get as much analysis as they should, and (b) in effect shift much of the operational management burden from the state enterprise sector to the Ministry, where it is more difficult to pay adequate compensation to attract and hold staff.

Coal

3.9 Morocco has one coal mine, one coal-producing institution, and a single power plant accounts for over 85% of consumption. Charbonnages du Maroc is a Government corporation responsible for coal production trading and exploration. Its present structure results from a reorganization of all coal related activities in Morocco which took place in 1980-81. Charbonnages employs more than 6000 people, virtually all of them at the Jerada mine. It is managed by a team of competent and experienced Moroccan mining engineers most of whom have worked with the company, in particular at the Jerada mine, for many years. This represents a distinct improvement over the situation in the late 1970s when the company had fewer than ten engineers, no geological staff, and had undertaken virtually no exploration in 20 years. While the Board of the company groups representatives of four ministries and two government agencies, the management of Charbonnages reports primarily to the Ministry of Energy and Mines. Charbonnages is also directly in charge of export marketing. Sales to the electric utility are handled at the Ministry level, while those to other local consumers (cement plants and other industries) of imported as well as domestic coal are handled by a fully-owned subsidiary company, Sococharbo.

Electric Power

3.10 Morocco's power subsector includes about ten regies (utilities for distribution of electricity and water owned by a municipality, commune, or group of neighboring communes) as well as an autonomous Government-owned entity, the Office National de l'Electricite (ONE), which is responsible for producing and transporting electricity for public use and distributing it in areas which are not served by the regies. ONE, created in 1963, produces about 90% of the electricity used in the country. About 54% of its production is sold through the regies and 46% directly to final consumers. Responsibility for the subsector is divided at the Government level between the Ministry of Energy and Mines (MEM), which has oversight over ONE, and the Ministry of Interior (MI), which supervises local government activities, including the regies.

3.11 The role of the regies is still evolving. Until 1976, the Regies had been able to finance their power system expansion from connection charges and retained earnings. More recently, as tariff increases have lagged behind cost increases, the regies have become dependent on Government contributions and loans for their investment programs and some are so financially weak that ONE is forced to sell them bulk power at reduced rates. At the same time, MI is implementing the Government's policy of decentralization of services by forming new Regies, which take over ONE assets in their service areas but not the corresponding liabilities. Rural electrification projects are selected and financed by MI, implemented and maintained by ONE, and operated by local municipalities.

3.12 Retention of the fragmented power subsector organization for distribution as it has developed historically has not been conductive to rational planning, investment or operation. Local forecasting by some regies is poor, duplicate facilities are built near regie area boundaries, and distribution equipment is neither standardized nor purchased in bulk. Central to this state of affairs is the division of jurisdiction for the subsector between the two ministries, MEM and MI, which sometimes have conflicting interests resulting from the different nature of their mandates. The Government is aware of the structural problem facing the subsector and after rejecting a consultant's recommendation to centralize distribution responsibilities under ONE, assigned the task of studying the problem to an ad hoc interministerial committee in 1978. Only a preliminary report has thus far been submitted to the Government and the basic problems remain. Viable solutions could range from complete centralization under ONE to complete decentralization of low and medium voltage distribution functions to local authorities, leaving ONE as a generation and transmission enterprise, as long as investment planning and operations are coordinated and the financial viability of each unit is compatible with adequate tariff levels.

Renewables

3.13 The Ministry of Agriculture and Agrarian Reform (MARA) plays a key role in the subsector which it exercises mainly through the Directorate of Water, Forests, and Soil Conservation (DEFCS). DEFCS is responsible for forestry planning, including protection and management of the forests, plantation programs and supervision of all forestry exploitation. While it has a staff of 2,500, it suffers from lack of funds and weak management. The Ministry of Interior also has an important role in the development of the forestry subsector since the Provincial Governors, who represent MI, have overall responsibility for development activities in their Provinces, and are responsible for coordinating the operations of the technical services including DEFCS. The Governors also review and approve the decisions of local authorities, including the communal budget; moreover, MI, through the Directorate of Local Collectivities, has the trusteeship of collective lands.

3.14 The paucity of reliable data on forest resources and their use severely constrains rational planning. Presently, only very limited information is available on the location, quality and exploitable volumes of Moroccan forests. The National Forest Inventory, launched in 1976, aimed at providing recurrent stocktaking of the country's forests over 10 year periods. As of 1980, only 1,100,000 ha (approximately 20% of total forest areas) has been subjected to detailed inventory and only 700,000 ha (13%) have management plans. This leads to suboptimal use of existing resources and investment decisions. Comprehensive coverage of Morocco's forests is a high priority. In the meantime, less detailed but useful information will be obtained rapidly through an IBRD-financed forest resource study based on satellite imagery, which will be completed by 1984.

3.15 Inadequate resource investment is another major problem in the sector and it is related in part to the institutional arrangements used to finance it. Reforestation activities are financed from several sources, including the Government general budget (62% of the 367,000 ha reforested to date), soil conservation programs (17%) and the National Forestry Fund (FNF) (15%). The FNF in turn is financed by a 10% tax added to the auction price of standing timber (virtually all forests in Morocco are either natural forests and hence state-owned by law or plantations established by the Government on private or collective land; standing trees in both categories are sold at DEFCS auctions) and by recovering (without interest) the FNF's investment in reforestation on private/collective land when the trees are sold. The bulk of auction revenues, however, go to the land owner or, in the case of state forests, to the commune. The communes are expected to put at least 20% of their proceeds from these auctions back into forest-related investments. Most, however, have not put enough into reforestation to replace the resources extracted. Options to systematically expand re-investment include,

(a) increasing the FNF tax on timber auction revenues,

(b) raising the fraction of communal revenue that must be re-invested,

(c) including interest in recovering FNF's investment, and

(d) recovering FNF's investment in reforestation on state as well as private and collective land.

The feasibility and financial, legal and social obligations of these options and of that of establishing a new source of revenue such as an import tax on wood products are the subject of an IBRD-financed study being undertaken by DEFCS and to be completed by the end of 1983. An effort also needs to be made to improve the economic use of stumps which become available from the on-going reforestation program. Rough figures of the wood that will be made available from stumps are that with 5,000 ha of forest being replanted every year and each hectare containing 1,000 stumps, some 35,000 toe of energy could be produced from stumps each year in the form of charcoal.

3.16 In 1976, Forestry Councils were established at national, provincial and local levels. The National Forestry Council is chaired by the Minister of Agriculture and consists of the ministers or representatives of the Ministries of Interior, Finance, Public Works, Commerce, Transport and Justice, as well as the Governors of several provinces with large forest areas and representatives of provincial and local authorities. The National Council is mainly concerned with financing and with defining Government's policy and reviewing legislation in the field. The Provincial Forestry councils are involved in matters dealing with the implementation of provincial forestry programs including forest exploitation and sylvo-pastoral development. At the local level, the Communal Councils play an advisory role, and participate in the organization of forest related programs within their communal boundaries such as the auctioning of forest woodlots, the organization of forest grazing and the collection of dead wood. Although it is still too early to measure the effectiveness of these councils, the existing Provincial and Communal Forestry Councils could certainly play a key role in helping design practical and adequate legislative and administrative instruments for the development of the forestry subsector including pastoral development.

3.17 MEM is involved in renewable energy development, and has established the Center for Renewable Energy Development (CDER) at Marrakech to coordinate and participate in renewable R & D, demonstration, and commercialization. MEM has also planned a number of demonstration projects in the solar, wind, biomass, and small hydro areas.

3.18 By developing country standards, the Moroccan program is large. It is new, however, and could be strengthened. Given the progress so far on CDER, and the planning that remains to be done with regard to infrastructure and manpower, the Center may not be functioning effectively before 1984. In the meanwhile, the renewable energy unit at MEM is the main policy formulations body in Morocco.

3.19 Renewable energy program planning and implementation is currently proceeding without any clear plan of action which is resulting in delays and dissipation of funds. To provide the basis for such a plan, a renewable energy planning study should be commissioned to evaluate various possible renewable energy programs in terms of technical and economic feasibility in the Moroccan context and their potential in the national energy picture. The solar, wind and biomass resource assessment needed as part of such a study is planned to be undertaken with USAID assistance. This information is of vital importance for planning purposes and this effort should be accelerated. The biomass resource and rural energy survey components relevant to possible fuelwood plantation should be given special priority. The planning study could be used to improve the choice of demonstration projects by MEM and the use of funds from bilateral and multilateral agencies. It would be especially useful if completed early enough to be used in reviewing the proposed organizational structure and manpower allocation of CDER before it is fully staffed. It seems likely that more resources will have to be allocated to fuelwood effort than is currently envisaged.

3.20 The winds have in fact been used extensively for water pumping in the past; some 10,000 windmills were installed through the mid-1960s for this purpose and a major U.S. manufacturer produced windmills locally. However, the windmills gave way to cheap diesel systems in the 1960s and most have fallen into disuse. As part of a larger water supply project, UNICEF plans to install about 100 windmills in the 1 kW range to pump water for livestock and human consumption in four southwestern provinces.

3.21 The winds might also be used to generate electricity, either with large turbines tied into the national power grid or with small units meeting the needs of isolated locations, but the economic viability of such projects is very site-specific and would have to be studied carefully. Average windspeeds of 20 km/hr will often, however, permit electricity to be generated at about 10¢ US/kWh.

3.22 The Moroccan solar industry is in the early stages of development. About a dozen companies currently produce solar water heaters and a few others import them from Europe. However, the total collector area deployed remains under 2,000 m^2 p.a. The locally built collectors are of poor design and quality, while the imported ones are not the best designs available abroad, in addition to costing as high as $\$400/m^2$. Most of the solar water heaters are now being used in the residential sector, with only a few commercial applications.

3.23 The Government could assist in the development and rationalization of the solar water heater industry in a number of ways. CDER could establish test facilities and channel technical assistance to assist manufacturers and purchasers in materials and design selection, quality control, and making contact with lower-cost suppliers abroad. A demonstration program could be used to subsidize initial installations in industrial, institutional, and commercial markets whose performance could be monitored for comparison with the lab test results. A useful first step would be a survey of Moroccan and possible export markets.

Energy Pricing

3.24 Table 3.1 summarizes the commercial energy price structure and the relationship between Moroccan internal prices and comparators constructed by adding an allowance for internal transportation and distribution costs to the c.i.f. price of imports. Oil product prices appear to be at our above their comparators, with the lowest margins applying to the popular household fuels, LPG and kerosene, and the highest to gasoline. This is done as an income redistribution measure.

3.25 Electricity tariffs vary by voltage level, geographic area and other criteria but appear to average only 60-70% of corresponding economic costs. They also fall considerably short of the level that would allow ONE to finance 20% of its investment program internally as had been agreed.

3.26 There are also a number of issues involving the structure of electricity tariffs. The high voltage tariffs applied to bulk sales to the regies and large industries are generally a bit above the corresponding energy costs but only 7-23% of capacity costs. Medium voltage tariffs are even more skewed: they cover 130-140% of energy costs but only 10% of capacity costs. A tariff structure more in line with costs could be expected to lead large users to reduce their peak demands and hence ONE's need to invest in new capacity. Differences in tariffs geographically and across consumer categories in many cases do not correspond to variations in costs.

3.27 A tariff study based on an analysis of ONE's costs was completed four years ago. This study provided the basis on which the principles were established that orient the work of an interministerial commission set up to study tariffs and introduce reforms and simplifications each time a tariff increase is proposed. However, given the changes that have taken place since the study was completed in 1978 and the fact that it was based on ONE's development plans rather than a least cost program, the Government should proceed with an updating of this study. A detailed discussion of power tariffs is included in the World Bank's Report 4135-MOR, "Morocco: Power Subsector Study".

3.28 Natural gas pricing will become important if the quantities found at Meskala turn out to be sufficient to justify a major field development and pipeline project. Pricing policy would then become a key element in establishing the market as well as financing the necessary investments. A delivered price discounted slightly from that of fuel oil could be expected to encourage a shift from oil to gas but leave coal a more economical option for some users, while a lower price would undercut that of coal as well and a still lower price would reflect the balance that is desired between reserving gas for only those users in which it generates the greatest savings and developing the resource as rapidly as possible.

3.29 The role of price incentives might be increased in several parts of the energy sector without either giving up Government control over critical points in the economy or allowing unregulated monopolies to develop. The potential benefits are an improvement in economic performance as price incentives and market forces replace administrative controls and a reduction in the use of scarce Government staff resources in the administration of regulations. Specifically, price incentives might be given a greater role in petroleum refining and product distribution, coal importation, and electricity generation.

3.30 The case for deregulation is probably strongest in petroleum product distribution. Competition among independently operated filling stations and chains operating under safety and land-use regulations might be used to establish profit margins and standards of service. In an initial phase, filling stations in one or more urban areas might be allowed to reduce their margins and to improve service. Road haulage and delivery of fuel to filling stations might also be opened to more competition.

3.31 The Moroccan market for petroleum products is too small to make competition (both between the two refineries and with imports) compatible with security for the domestic refining industry. In today's market, with larger and more efficient refineries being shut down in Europe and the Caribbean and tanker rates low, it is possible that without subsidies the Moroccan refinery industry would fail to survive competition with imports or would be saved only by the fact that the country's port facilities are not equipped to handle refined products in quantities equivalent to the crude oil they now handle. A measured dose of competition might, however, be used to encourage better cooperation between SAMIR and

SCP's refinery operations and allow useful rationalizations in the utilization of plant, personnel, and feedstock. Natural gas and oil shale development are likely to require many technicians and skilled workers with qualifications similar to those in refinery operation, so personnel savings in refining could assist in gas and shale development.

3.32 Finally, it may be worthwhile to consider using price incentives to encourage industries to generate electricity for sale to ONE where this can be efficiently combined with the production of process heat or steam. Cogeneration can add complexity to the operation and management of both the power grid and the industrial plants involved, and it would be extremely difficult to spell out regulations and criteria that would sort out cases in which cogeneration is practical and economic from those in which it is not. An appropriate tariff structure would, however, give industry an incentive to find and implement economic opportunities for cogeneration. A flat rate based on the value of fuel savings in ONE's large oil-fired plants might be an appropriate first approximation that could later be refined with adjustment for transmission losses and, where appropriate, contributions to meeting peak demands and to system reliability.

Coordination and Overall Planning

3.33 The 1981-85 Five Year Plan reveals several apparent structural problems in Moroccan energy planning. The Plan treats subsectors more independently than would be desirable. In part, this can be traced to the inability, for lack of staff, on the part of the Ministry to evaluate independently the major investments planned in some subsectors, such as electric power. The timetable and preparation process for the plan also seem to allow too little time for effective integration of subsector plans. While related to more than the energy sector, it is also worth noting that there is apparently no systematic effort to compile evaluations of the various types of benefits expected from proposed dams, compare them with total cost, and formulate a water resource development plan accordingly. A Subcommission on Water Projects with representatives of the National Water Supply Authority, MARA, the Water Projects Directorate of the Public Works Ministry, and ONE has, however, been established to face this task.

Table 3.1: Commercial Energy Prices, Inclusive of Taxes
(November 1982; 6.30 DH/$)

Product	Unit	DH/Unit	Units/toe	DH/toe	$/toe	% of Comparator
Refined Products: a/						
Super	liter	4.70	1315	6180	981	236
Regular	liter	4.50	1315	5920	939	237
Kerosene	liter	2.25	1265	2845	452	109
Gas oil	liter	2.55	1205	3075	488	139
Fuel oil	kg	1.42	1060	1505	239	128
LPG	kg	2.55	950	2425	385	87 e/
Domestic Coal: b/						
Raw fines	kg	0.280	2000	560	89	89
Washed fines	kg	0.404	1360	550	87	87
Imported Coal:						
Steam Coal c/	kg	0.869	1690	1470	233	142
Electricity: d/						
Low Voltage	kWh	0.548	4050	2220	352	48
Medium Voltage	kWh	0.561	4050	2272	361	67
High Voltage	kWh	0.417	4050	1689	268	77

a/ Comparators are end-June 1982 import parity prices (Caribbean posted prices plus $20/toe estimated freight and insurance to Mohammedia plus handling costs of 5¢/liter of gasoline and gas oil, 10¢/liter of kerosene, 10$/ton of fuel oil, and 115$/ton of LPG.

b/ Examine. Fines account for 80-85% of production.

c/ Steam coal imports at $77/T cif plus $20/T for port costs and transportation to consumers.

d/ Low and medium voltage tariffs are estimated averages for Casablanca, high voltage tariff is for ONE sales to industrial clients. Comparators are corresponding long-run average incremental cost estimates based on Report 4235-MOR, Power Subsector Study.

e/ Comparator is average 1981 import price plus $115/T handling.

Source: Bank staff estimates.

3.34 Energy is of prime importance to its suppliers but only of secondary importance to its consumers, and this is reflected in the organization of the Energy Directorate. MEM/DE is organized into three divisions responsible for dealing with energy supply issues and institutions:

(a) petroleum products (SAMIR, SCP refinery, SNPP, distributors)

(b) electricity (ONE), and

(c) energy resource development (ONAREP, charbonages, CDER).

3.35 This is probably an appropriate organization for an Energy Directorate whose principal responsibilities are in the administration of laws and regulations pertaining to public and private energy supply institutions. Planning and policy formulation often require making links that cut across this type of organization. This is currently handled within MEM/DE among the director and division chiefs. Development of a more ambitious energy planning capability will probably require establishment of a new division for that purpose.

3.36 Regardless of internal organization, however, energy planning within MEM/DE is not likely to be effective in dealing with issues such as energy conservation or reforestation that depend primarily on the actions of institutions in other sectors for whom energy is only a secondary concern unless links are established with the ministries that have broad responsibilities in these sectors. MEM/DE can play an important role in these fields, but it is difficult, for example, to see how an industrial energy conservation program could be effectively planned and executed without being based largely on MCIT's knowledge of problems, opportunities and constraints in specific industries and making use of MCIT's administrative mechanisms.

3.37 Table 3.2 outlines three important fields of energy planning in which a "user-oriented" approach would seem useful. By "user-oriented" is meant both an analytical approach in which energy concerns are not assumed to predominate (the less energy-efficient process may be more reliable, give higher yields and be more profitable in some cases) and an organizational approach in which ministries and agencies whose principal concerns are not energy have important and perhaps even leading roles.

3.38 The set of problems that appears in most urgent need of this type of approach involves planning for industrial fuel supplies. This requires coordinated planning over a 5-10 year horizon of efforts to (i) develop domestic natural gas resources, (ii) put in place the infrastructure needed to handle large-volume coal imports, and/or (iii) equip industries and ONE to use one or both of these fuels, fuel oil, and/or electricity more efficiently than they do now.

3.39 The second "user-oriented" field identified includes energy consuming sectors characterized by numerous units each using relatively small quantities of energy but that, taken together, are important in energy demand management. Transportation, urban households, commerce, and small-scale industry generally use a different set of energy forms from large industries, they correspond to a different group of ministries, and the types of policy measures that could be used to promote energy conservation in these sectors is also distinct.

3.40 The third suggested focus of "user-oriented" energy planning is rural areas. Fuelwood and other traditional fuels are important in this context, as are distribution systems to deliver commercial fuels and electricity in rural areas and, at least potentially, a wider variety of renewable energy sources than elsewhere. Energy programs in a rural development context may justify being given more government support in the form of demonstration programs and direct and indirect subsidies than is appropriate or feasible in the wealthier urban context and their effective execution may rely more heavily on the cooperation of authorities within local communities.

3.41 Organizing the coordination among ministries and agencies that appears needed in these three fields is a problem that can be dealt with in a variety of ways ranging from ad hoc meetings of directors and division chiefs concerned with a problem to formal interministerial commissions. Leadership could come from MEM, from Plan, or from one or more of the key ministries related to a particular group of issues, or each of the three groups could be handled in a different way.

Table 3.2: Fields Requiring User-Oriented Approach to Energy Planning

General Issues Specific Topics	Industrial Energy Supply Planning	Urban and Transportation Energy Conservation	Rural Energy Development and Conservation
A. Energy Forms (Pricing, regulation, and development of ....)	Coal, coke, natural gas, fuel oil, shale, high and medium voltage electricity	LPG, gasoline, kerosene, gas oil, low voltage electricity, and solar water heating in urban areas	Wood, charcoal, "urban and transport" fuels in rural areas, solar drying, wind
B. Consuming Sectors (Consumption forecasting, conservation and fuel-switching potential in....)	Large industries Power plants	Transportation Urban households, services, and small-scale industry	Rural households, services, and small-scale industry
C. Related Issues	Port and railway planning Industrial and mineral development	Street and highway planning Traffic engineering Vehicle and appliance performance standards Trucking regulation	General rural development Agriculture and livestock development Land use
D. Principal Policy Instruments	Public sector investments, Incentives and negotiations with large consumers Pricing	Pricing Widely-applied regulations and incentives Media campaigns	Local authorities Direct and cross-subsidies R&D and demonstration projects Media campaigns
Related Ministries and Agencies (MEM, Plan, DAE, ONE involved in all three fields)	MCIT (Industry Directorate) Public Works (Ports Directorate) MCIT (Foreign Trade Directorate)	Transport MHUPE Public Works (Highways Directorate) Transport ? ONCF OCP	MI MARA CDER

IV. INVESTMENT PROGRAM

4.1 The current Five-Year Plan calls for a total investment of 9,156 MDH in the "energy sector" over the 1981-85 period. This figure excludes, however, investments in coal or reforestation as well as any contribution to the joint costs of multi-purpose hydro projects. Reclassification of these and other investments in projects appearing in the Plan under different headings brings the total to about 11,642 MDH, or about 10% of the total investments foreseen under the Plan.

4.2 The breakdown of this investment program is shown in Table 4.1. Electricity is the sector with the largest investment program, even excluding an experimental shale-burning plant discussed under the oil shale heading. About 4,394 MDH or 38% of the sector total is to be invested in the power system. Planned investment in oil and gas is almost as high at 4,276 MDH or 37%, and this does not include any provision for development of the Meskala discovery. It does, however, include 924 MDH for port and tanker investments classified by the Plan under transportation headings. Oil shale is the third major investment category, with a 2,168 MDH (19%) allocation in the Plan. Reforestation and coal make up most of the remaining 7%.

4.3 The central government's budget is expected to finance directly 6536 MDH or 56% of the total investment financing. Government budget contributions are mainly to finance all or virtually all investment in some infrastructure and high-risk categories (joint costs of multi-purpose hydro, ONAREP's exploration program, improvements at the oil port, the oil shale pyrolysis test station and reforestation) but not some others (foreign oil companies' exploration programs) or commercial activities (oil refining and product distribution).

Electricity

4.4 Generating plant, even excluding the experimental shale-burning plant, accounts for over 60% of the investment program. Most of this investment is in hydro, where the "adjusted" figures include a somewhat arbitrary 50% allocation of joint costs in multi-purpose water projects.

4.5 The investment program of Morocco's electric utility, ONE, calls for substantial investments in both hydro and thermal generation over the next two decades. Most of the country's remaining hydro potential would be developed between 1985 and 1995, with the remainder of the system's requirements met by thermal plants. The thermal units now under construction are being built to burn coal, oil, or gas. A series of five units of a shale-burning plant was originally planned (mostly coming on stream in the early 1990s), followed by nuclear plants. These plans are illustrated in Table 4.2.

Table 4.1: Energy Sector Investments Included In 1981-85 Five-Year Plan
(MDH)

	As Classified in Plan Documents		Adjusted Classification	
	Total Investment	Gov't Budget Contribution	Total Investment	Gov't Budget Contribution
ELECTRICITY				
(Incl. Rural Electrification)	4,491	1,756	4,394	2,143
Hydro generation	888	222	1753 a/	1,087 a/
Thermal generation	1,952	918	984	434
Transmission	575	144	575	144
Distribution and Rural Electrification	650	288	650	288
Nuclear center	0	0	6	6
Other	426	184	426	184
OIL AND GAS	3,352	2,500	4,276	2,070
Exploration	2,000	1,500	2,000	1,500
Refining	798	0	798	0
LPG facilities	305	0	304	0
Distribution	250	0	250	0
Oil port and tankers	n.a.	n.a.	924	570 b/
OIL SHALE	1,200	1,200	2,168	1,684
Test Station (liquids extraction)	1,100	1,100	1,100	1,100
Experimental unit (direct combustion)	n.a.	n.a.	968	484
Studies	100	100	100	100
COAL	n.a.	n.a.	250	113
Jerada modernization	n.a.	n.a.	250	113
RENEWABLES	93	65	539	511
CDER	31	15	31	15
Pilot renewable projects	62	50	62	50
Forestry	n.a.	n.a.	446 c/	446 c/
OTHER	21	21	15	15
Nuclear center	6	6	0	0
MEM/DE Studies	15	15	15	15
TOTAL	9,156	4,542	11,642	6,536

a/ Includes, for lack of a reasonable estimate, an arbitrary 50% of multi-purpose projects with large hydro components and one-third of general water-resource studies, etc. An analysis of the separable costs and benefits associated with each use of each of the major projects would be needed to construct an estimate.

b/ Estimate.

c/ 50% of DEFCS investment budget.

Table 4.2: Planned Additions to One Generation Capacity

Project (service date)	MW Capacity	thousand toe/yr Capability Hydro	Oil	Coal	Shale	Nuclear
Mohammedia III-IV (81-83)	300			515		
Roches Noires II (83-84)	-		-103	88		
6 Hydro projects (86-91)	629	328				
Timhadit I-V (90-94)	1,000				1,225	
7 Hydro projects (90-94)	218	168				
Nuclear I-V (94-04)	3,000					4,778

Notes: The first of the service dates is the first year the project is scheduled to operate, the second is the first year in which it is scheduled to be able to generate its full capability. Capacity figures are for dry winter conditions; capability figures are for average year conditions. Roches Noires II is to be converted from oil to coal. The six hydro projects are Amougguez, Dechra el Oued, M'Jara, M'Dez, Matmata, and El Menzel. The seven are Merija, Imezdilfane, Taskdert, Tajemout, Tanafnit, El Borj, and Tillougguit. An additional 11 hydro projects totalling 546 MW and 184 thousand toe/yr are to be studied.

4.6 These investments are scheduled so as to meet the projected growth in demand (averaging 9% p.a.) under dry-year (at the 20%-ile) conditions. A substantial reserve generating capability appears in the mid-1980s for several years after Mohammedia III and IV are put in service, but to delay the hydro projects which follow Mohammedia in the schedule would risk capacity shortages during peak demand periods in the event of a dry year. The program already has in fact a nominal (0.3%) projected shortage in available capacity to meet the 1987-88 winter peak under dry-year conditions.

4.7 The earliest projects in the program are of course the most firmly decided and are also generally those for which economic viability is best established. The Mohammedia plant will have cost about $420 million, of which some $154 million ($513/kW) is attributed to a design change from oil-fired to coal-fired. Even allowing for recovery of this additional capital cost, the switch to a coal-fired design is likely to save 1.5 to 2.0 ¢/kWh.

4.8 The hydro program in the Five-Year Plan includes five approved projects and one project which is subject to the availability of external finance. A commitment has already been made for the construction of one of these plants: Amougguez (at the Ait Chouarit dam). It is part of a multi-purpose project which will also provide water to Marrakech. A second hydro project, Dechar el Oued, has been appraised in late 1982 and has been found economic. It, too, is a multi-purpose project with substantial irrigation and industrial water supply benefits.

4.9 The remaining four hydro projects that are scheduled to be begun in the 1981-85 Plan period are the M'Jara project on the Sebou and the El Menzel, M'Dez, and Matmata projects upstream from it. Three of the four projects are multi-purpose: El Menzel is solely for power generation, while M'Dez and Matmata are for power generation and irrigation, and M'Jara is for flood control as well. Generation in a normal year would be 1700 kWh/yr per kW of firm capacity, so the plants would largely be used for meeting peak loads. The Sebou projects thus complement the shale-fired plants that follow them in the expansion plan.

4.10 Appraisal of these projects in any detail is beyond the scope of this report. Even a comparison of separable benefits and costs (i.e., justification for installing power plants in dams justified by other purposes) requires a series of complex calculations to determine the least-cost program of investments to meet projected demand under various hypotheses and standards of reliability. ONE uses a sophisticated computer model adapted from one developed by the IAEA for this purpose. Because most of these projects are multi-purpose in nature, a more comprehensive approach taking into account factors such as the speed with which irrigation can be extended to new areas.

4.11 A simplified, preliminary analysis suggests the following conclusions:

(a) The multi-purpose projects are not either clearly viable or clearly non-viable economically. All should be analyzed carefully.

(b) Irrigation may provide the largest share of net benefits in each case (treating the Haut Sebou projects as a group) and be the dominant beneficiary of the Amougguez (also known as Ait Chouarit) and M'Jara projects. All of the projects, and particularly Amougguez and M'Jara, depend on agricultural priorities. Under these circumstances, it will be essential to coordinate closely with the Ministry of Agriculture when deciding the optimal time-table for constructing the dams, in order to take into account the expected pace of implementation of the corresponding land development programs and the backlog of land already under system command still awaiting development.

(c) To the extent that low-cost natural gas becomes available at Meskala, the dam construction program will need to be reviewed in the light of the estimated size of the gas reserves.

4.12 The cost and reliability of the shale and nuclear plants planned for the 1990s are not easily predictable, and ONE should test the sensitivity of the decisions that need to be made in the short term to a reasonable range of variations in these variables, as well as to the availability of combined-cycle thermal plants, a type not represented in its investment program, should natural gas become available in substantial quantities.

Oil and Gas: Upstream

4.13 Petroleum exploration is allocated 2000 MDH under the Plan, of which 1500 MDH would be provided by the Government budget and spent by ONAREP and 500 MDH would come from outside sources including foreign oil companies. The latter figure may prove to be under-estimated if the recent interest in Morocco by international companies is sustained, but the immediate macro-economic effects of any under-estimation are minimal since their investments are largely spent on imported goods and services and are entirely at their own risk.

4.14 The Meskala discovery was of course not foreseen in preparation of the Plan, and no allowance was included for petroleum development. Depending on the overall size of the field and the average productivity of the wells that will be needed to develop it, this cost could range from roughly $450 million to $1450 million. Table 4.3 shows discounted present value estimates for gas and condensate production and exploration and development costs (including pipeline) under representative assumptions. The resulting rough estimates of the net present value of a development program range from about $450 million to about $2.8 billion depending on the assumptions made.

4.15 The economic viability of developing Meskala appears to depend much more on average well characteristics than overall field size. This is partly because two small-diameter pipelines already connect the area to phosphate processing facilities and a point on the transmission grid where a small gas-fired power plant could be added. One of these pipelines carries (at partial capacity) gas discovered earlier in the same area at shallower depths. The other carries oil and could probably be converted to gas. The existence of these pipelines helps make a small development feasible. Another factor is the high contribution of condensates to the overall value of production. Because they can economically be carried by road and rail, they are much less subject to economies of scale than is gas. Table 4.4 indicates that, assuming wells and associated surface facilities cost about $7 million apiece, development becomes feasible with average recoverable reserves per well of about 2 to 3 BCF.

Table 4.3: MESKALA: Alternative Estimates of Net Present Value
(US$ millions at 1981 prices and discounted to 1981 at 10% p.a.)

	Without Paleozoic		With Paleozoic	
	Low Triassic	High Triassic	Low Triassic	High Triassic
Gas produced (at $4/MCF)	550	1,685	1,605	2,765
Liquids produced (at $35/bbl)	310	830	880	1400
Total output	860	2,515	2,485	4,165
Exploration	40	40	40	40
Development wells	140	345	370	455
Field facilities and pipeline	70	140	130	185
Total costs	250	525	540	680
Net present value	610	1,990	1,945	3,485

Table 4.4: Minimum Average Well and Field Production Levels Needed To Justify Meskala Development

	Field output (MMCFD)					
	10	20	50	100	200	300
Pipeline size (inches)	none a/	none a/	10	14	18	22
Pipeline cost ($ millions) b/	0	0	57	67	87	106
Pipeline cost ($/toe) c/	41 a/	41 a/	19	11	7	6
Sales price ($/toe)	131 a/	131 a/	170 d/	170 d/	170 d/	170 d/
Netback on gas ($/toe)	91	91	151	159	163	164
Netback on gas ($MCF)	2.22	2.22	3.68	3.88	3.98	4.00
Netback/condensate ($/MCF) e/	(2.10)	(2.10)	(2.10)	(2.10)	(2.10)	(2.10)
Total netback ($/MCF)	(4.32)	(4.32)	(5.78)	(5.98)	(6.08)	(6.10)
Min. reserves/well (BCF) f/	(2.0)	(2.0)	(1.5)	(1.5)	(1.4)	(1.4)

a/ Gas sold to ONE through existing pipelines at $3.20/MCF (yields electricity at 4.0¢/kWh). Arbitrary pipeline toll of $1/MCF.
b/ Cost of pipeline to Mohammedia (235 miles including 20% circuity).
c/ 15% annual charge. 41 MCF/toe.
d/ $4.15/MCF or 85% of fuel oil parity ($189/ton or $28/barrel).
e/ 30 bbl/MMCF. Sold at $35/barrel.
f/ Assuming average well and surface facilities cost $7 million, and present value equal to 80% of undiscounted total. This corresponds to a 4 to 5 year well life.

Source: Bank staff estimates.

Oil and Gas: Downstream

4.16 Large scale natural gas and condensate production from Meskala could displace fuel oil in the market for boiler fuels and provide raw materials for gasoline production other than the distillation of crude oil as well as substantial quantities of LPG. The middle distillates, primarily gas oil in the Moroccan context, would however be relatively unaffected. Shale oil development, on the other hand, would probably have the opposite effect as shale oil typically yields a high percentage of middle distillates. In either case, the result would be a structural change in the demand for refining services. There would be three basic alternatives:

(a) reduce refining operations and import deficit products,

(b) maintain self-sufficiency in all major products and export surpluses, and

(c) in the gas case, invest in "cracking" units to convert fuel oil into gas oil.

4.17 The usefulness of additional distillation capacity will also of course depend in part on gas and shale oil production. Table 4.5 shows alternative projections of the crude oil distillation and fuel oil yields operations that will be required by 1995. Depending on the growth rate of demand and on the case considered, there would be a market for (a) incremental distillation capacity, (b) new cracking units, or (c) neither. These demands can be met either by constructing new refining plant in Morocco or by importing refining services, either explicitly through "toll" refining contracts (in essence, leasing a share in a foreign refinery) or implicitly through the markets in crude oil and refined products. The analysis in Annex III indicates that, in recent years, the refinery industry has been a net foreign exchange loser for the Moroccan economy, and new investment proposals should be carefully examined even if it becomes clear that a market will develop. In cases where new distillation capacity is not required but new cracking capacity is, the investment would almost necessarily be at Mohammedia.

4.18 Studies of alternative types and scales of cracking facilities that could be installed at Mohammedia should proceed approximately in parallel with studies of the gas pipeline, since the possible market for cracking is clearly related to development of a market for gas and the investments have similar lead times. Given the long lead times available before investment in additional distillation capacity is likely to be necessary, detailed study is not needed for several years.

Table 4.5: Alternative Refining Requirements: Projections, 1980-95
(Crude oil distillation in millions of tons and fuel oil yields, parenthesized, in percent)

	Actual	Low Demand			High Demand		
	1980	1985	1990	1995	1985	1990	1995
Base Case	3.8 (41)	4.3 (45)	5.3 (48)	6.8 (53)	5.2 (46)	7.5 (51)	11.3 (56)
Gas Case		2.8 a/ (21)	3.2 (22)	3.4 (18)	3.2 a/ (21)	4.2 (22)	7.8 (43)
Coal Case		3.9 (38)	4.7 (41)	5.1 (37)	4.6 (40)	5.9 (37)	7.3 (32)
Shale Case		4.3 (45)	4.2 (57)	3.2 (64)	5.2 (46)	6.3 (59)	7.7 (67)
Gas/Coal Case		2.8 a/ (21)	3.2 (22)	3.4. (18)	3.2 a/ (21)	4.2 (22)	5.5 (18)
Gas/Shale Case		2.8 a/ (21)	2.2 (24)	1.2 (17)	3.2 a/ (21)	2.9 (29)	5.6 (59)

a/ Full-scale gas development is not considered feasible before 1987. Market-based estimate for 1985 is shown for reference.

4.19 Current LPG shortages can be reduced by using a 70:30 (volumetric) butane/propane mix instead of the LPG now marketed (85:15 max.). Propane should be recovered from the refineries and delivered in large containers (35-50 kgs) for restaurants and hotels.

4.20 Morocco imported 800,000 tons of sulphur in 1981 for sulphuric acid manufacturing to produce phosphoric acid, and these imports will increase significantly. With the availability of hydrodesulphurisers in both refineries sulphur production would be feasible, particularly on Mohammedia. Sulphur plants are not expensive and the process yields low pressure steam which can be used in process units.

4.21 The production of lubricants after 1983 will be governed by the local consumption which, at the best, is not more than 50% of plant capacity. Lubricants can be exported if Morocco negotiates an acceptable agreement with an internationally reputable marketing company to blend the products under a brand name for successful marketing in neighboring countries.

Oil Shale

4.22 Morocco is investing about 150 MDH ($26 million, 50% more than listed in the Plan) in a variety of studies and tests aimed at establishing the feasibility of developing its massive oil shale reserves. An extensive program to assess the technical and economic viability of a commercial exploitation of the Timhadit and other deposits for the production of liquid fuels is being undertaken with IBRD assistance and that of foreign petroleum companies potentially interested in participating in a Moroccan oil shale project. This program comprises construction of a test station and a testing program for the shale, studies of various retorting process as well as mine development and overall feasibility studies, including comparisons between liquids extraction and the use of pulverized oil shale itself as a fuel without first passing through the retorting step needed to extract the liquids.

4.23 The results of these studies (the last of which is scheduled for completion in early 1986) as well as the environmental studies (especially those on water pollution and mine surface rehabilitation) should be awaited before any major commitment is made to shale development. This would require a delay in the National Electricity Authority's (ONE) plans to burn shale at Timhadit in an experimental unit of 200 MW with two 100 MW boilers, one of which would be ordered in late 1983 and in service by 1987. If the experimental unit proves viable, ONE would consider the possibility of installing several of these units to bring oil shale fired capacity to about 1,000 MW during the 1990s.

4.24 The results of tests done with Timhadit shale indicate that notwithstanding the low calorific value of the shale (1.100 kcal/kg) and its high ash content (60%), the use of the shale as a power plant fuel is probably feasible, although the conventional combustion technology which ONE plans to use at Timhadit is currently being used in relatively large scale plants only in Estonia, and the experience gained there may not be transferable to Morocco because of differences in the characteristics of the shale. The alternative fluidized bed combustion technology is still at its early stage of development and restricted to small size plants. At this point it appears too early to make a definite commitment to either of the two technologies, or, given the gas prospects, to direct combustion in principle.

4.25 Since experience in the utilization of oil shale for power generation is fairly limited worldwide and the construction of a commercial size plant as planned by ONE using either technology would involve substantial financial risk (the cost of the first 200 MW unit is estimated at almost $350-400 million.), installation of a smaller unit as part of a stepwise development strategy would have clear advantages. In any case, deferral of any major commitment until the completion of the shale retorting studies now underway, further study on the technical and economic viability of direct combustion of shale and clarification of the magnitude of the Meskala gas discovery (mid-1983) appears advisable.

4.26 Positive results from both the shale retorting and direct combustion studies could open the door to liquid fuels production as well as electricity generation on a commercial scale. The development whose feasibility is being studied would produce 0.6 to 1.2 million toe/yr if both the liquids and electricity components go ahead. Estimated shale reserves at Timhadit are sufficient to support an even larger complex producing roughly 3.6 million toe/yr over at least a 25-year period. Table 4.6 shows the magnitudes of these possible developments and very rough and probably optimistic estimates of what they might cost. While liquids extraction and electricity production are shown as growing in parallel, they are basically independent projects, sharing only the mine and basic infrastructure.

4.27 These estimates make neither liquids extraction no direct combustion appear particularly attractive. Shale oil would cost about \$300/toe (\$350/toe in the first stage), or about the projected price of imported crude oil (\$276/toe in 1990 and \$305 in 1995). Electricity would also cost \$300/toe (\$350 in the first stage with higher unit investment cost and lower plant utilization rate), compared to about \$220/toe for a coal-fired plant (based on \$900/kW, 15% p.a. interest, amortization, and operating costs, 7000 hr/yr operation, and \$140/toe projected 1995 fuel cost).

Coal

4.28 Production at Jerada will decline in future years if additional investments are not made. The national coal enterprise, Charbonnages du Maroc, is financially unable to make the necessary investments because prices on its domestic sales are controlled at a level that meets only operating costs. A pilot project to test a system of partial mechanization of the mine is, however, being carried out. If it is successful, expansion to the rest of the mine is planned over a three-year period. Total planned investment in the pit is about \$60 million. The resulting production level would depend on geological factors, but could reach 1.0 mn Tpa with average unit production costs lowered slightly (from about \$45/T to \$40/T or \$80/toe) if reserves now classified as probable are confirmed.

4.29 Plans for a second pit to double production from 1.0 to 2.0 million Tpa at a cost of about \$180 million are highly uncertain. They depend not only on the results of the mechanization efforts at the existing mine and on proving sufficient mineable reserves, but also on marketing considerations, since costs would be about the same as at the first pit and the very limited availability of cooling water may prevent the establishment of a second power plant.

4.30 New markets for the unexportable fines will have to be developed in conjunction with an increase in production. The mine-mouth power plant, running at capacity (7000 hr/yr), consumes about 700,000 tons of fines per year. Fines produced beyond this level must be shipped to a power plant in Casablanca that can use about 180,000 Tpa of Jerada coal, and not all of it fines. Allowing \$25/T for transport to

Casablanca, fines sold at $35/T at Jerada would cost $120/toe delivered, approximately the ex-tax cost of imported coal. The principal fuel oil consumer in northeast Morocco is the CIOR cement plant at Oujda, about 50 km from Jerada. Conversion of this plant to coal could provide a market for about 110,000 Tpa of Jerada fines at current cement production levels and about 170,000 Tpa when the plant's production capacity is reached in the mid-1980s. Together, the two power plants and the CIOR plant would dispose of about 1.0 mn Tpa of fines, which corresponds closely to the production of 1.0 mn Tpa. Consumption of a second million Tpa of production from a new pit would require construction of a new power plant in the eastern region, either at Jerada (where a new source of cooling water would have to be found) along the shore (about 85 km away). The geological exploration and market studies needed to assess the proposed second pit should be pursued in parallel.

Table 4.6: Timhadit Oil Shale Development: Scale and Approximate Costs

	Studies & Demonstration	First Commercial	Eventual Commercial
Scale of components (usual units)			
Shale mining (mnTpa)	ca 1	10-20	ca 60
Liquids production (MBD)	0.2-2.0	10-20	ca 50
Electricity (MW)	0	125-250	ca 1,000
Scale of components (mn toe/yr)			
Shale Mining	?	1.1-2.2	ca 6.5
Liquid production	0.0-0.1	0.5-1.0	ca 2.4
Electricity production	0	0.1-0.2	ca 1.2
Net output	0.0-0.1	0.6-1.2	ca 3.6
Investment costs ($ millions)			
Shale mining	ca 50	200-400	ca 1,000
Liquids production	ca 150	600-1,200	ca 1,200
Electricity		200-400	ca 1,400
Total	ca 200	1,000-2,000	ca 5,000
Unit Costs			
Liquids ($/toe)		ca 350	ca 300
Electricity ($/toe)		ca 325	ca 300
" (¢/kWh)		ca 9	ca 7

Note: Unit costs estimated at 25% p.a. on investment cost in the mine and liquids plant and 15% p.a. on the power plant investment.

Energy Conservation and Fuel Switching in Industry

4.31 Substantial energy and energy cost savings appear feasible in Moroccan industry through energy conservation and fuel-switching. Table 4.7 summarizes potential energy savings from conservation and fuel switching projects in Moroccan industry, along with the associated investment costs. The major industries involved are cement, textiles, pulp and paper, and sugar. The very limited data available on phosphate processing facilities indicate that they can be considered efficient in their use of energy.

4.32 The cement industry accounted for almost 25% of the total energy consumption in the industrial sector (1,778 thousand toe) in 1981. Conservation measures at three of the older plants, Marrakech, Meknes, and Tetouan, would reduce their fuel oil consumption by 5.5 thousand toe p.a. at an investment cost of $2.8 mn. The textile industry consumes less than 10% of the energy used in Moroccan industry, but conservation measures in all textile plants would create fuel oil and power savings of 4.8 thousand toe p.a. for a $2.6 mn investment.

4.33 In the pulp and paper industry, Cellulose du Maroc is already well advanced in its own energy conservation program. Having completed a first phase of plant improvements, it has a program of two more phases: phase 2, conservation measures to save 11 thousand toe p.a. in fuel oil for an investment of $7.7 mn, and phase 3, substituting biomass for fuel oil to reduce fuel oil consumption by another 14 thousand toe p.a., given an investment of $5.5 mn.

4.34 The sugar industry consists of nine plants using sugar beets as feedstock, one (SUNACAS) using cane, and a refinery (CONSUMAR). Conservation in the two beet sugar plants that run on coal would save 3.7 thousand toe p.a. for an investment of $1.4 mn, while conservation in the other seven beet sugar factories, which use fuel oil, would save 31.0 thousand toe of fuel oil p.a. for $15.0 mn. SUNACAS could generate 2.5 thousand toe worth of power every year by burning its own bagasse. According to the official data, the COSUMAR refinery has a low energy savings potential, only 5%, which translates into 2.0 thousand toe of fuel oil p.a. for an investment of $1.0 mn. However, an inspection of the plant seems to point to possibly more substantial savings, hence the need for a more detailed study at an estimated cost of $30,000 and lasting three months.

4.35 Extrapolating the energy savings identified in this study to the rest of the industrial sector, excluding the phosphate industry, gives an additional savings of 5.0 thousand toe p.a. in fuel oil and power. Taking all the possible conservation measures cited above together would save Morocco 81.6 thousand toe p.a. for a total investment cost of about $39.4 mn. This amounts to about 5% of the industrial sector's (including phosphates) total energy consumption in 1981, and breaks down into about 9%, 1%, and 6% of the sector's total fuel oil, power, and coal consumption, respectively.

Table 4.7: Industrial Energy Conservation Projects

	Changes in Annual Fuel Consumption					Annual Fuel Savings				
	Fuel Oil ('000 tonnes)	Elec. (GWh)	Coal ('000 tonnes)		Gas (MMCFD)	Domestic Prices c/		Int'l Prices d/		Investment Cost
						------------(US$ million)------------				
A. Conservation										
Cement	-5.8					1.3		1.1		2.8
Textiles	-4.3	-.32				1.2		1.1		2.6
Pulp and Paper	-27.0					6.5		5.1		13.2
Sugar	-35.2	-10.0	-6.3			9.5		8.1		17.4
Other Industries a/	-4.7	-2.5				1.2		1.1		2.5
Subtotal Conservation	-77.0	-15.7	-6.3			19.3		16.5		38.5
B. Fuel Switching in Cement Plants						coal d/	gas e/	coal d/	gas e/	coal f/
Oujda	-56.0		+89.8		+6.0	8.2	n.a.	6.1	n.a.	17.6
Agadir, Tangier, Tetouan	-55.7		+89.3	or	+5.7	0.3	12.6	1.9	10.0	27.2
Marrakech, Meknes, Temara, Bouzkoura	-166.8		+266.9		+17.5	1.0	37.9	5.6	30.1	69.6
Subtotal Fuel Switching	-278.5		+446.0		+29.2	9.5	50.5	13.6	40.1	114.4
Total	-355.5	-15.7	+439.7	or	+29.2	28.8	69.8	30.1	56.6	152.9

a/ Extrapolation, based on 1981 Industrial Census (MICT/Industry Directorate).
b/ Fuel oil: 1320 DH/T = $227/T; coal: 804 DH/T = $138/T; electricity: DH = 0.317/kWh = $54,500/GWh.
c/ CIF prices plus internal transportation and handling but excluding duties and taxes. Fuel oil: $189/T; coal: $97/T, electricity: $78,900/GWh
d/ In the case of coal substitution. Coal price for Oujda cement plant assumed $50/T.
e/ Fuel oil savings: upper limit on savings in gas cases. The market in and near Oujda is unlikely to justify a gas pipeline.
f/ These figures are for coal substitution and do not include any investments in port improvements that may be necessary. Except for $3.3 mn for gas burners, the investment cost of conversion to gas is almost entirely in pipeline costs.

4.36 In terms of fuel switching prospects, the cement plants can be considered in three groups: Oujda (near Jerada as well as far from Meskala); Agadir, Tangier, and Tetouan (distant from Jerada as well as from the major potential gas markets); and Marrakech, Meknes, Temara, and Bouzkoura (most likely to be served with gas). In each group, the option exists to switch from fuel oil to coal, or, depending on the magnitude of the Meskala discovery, the natural gas. The case is clearest for conversion of the Oujda plant to coal because of the availability of inexpensive coal fines from the Jerada mine and the low likelihood of a gas pipeline extending to this area. An estimated $18 mn investment would save about $6 mn annually in fuel costs. Given the port facilities available, the Agadir, Tangier, and Tetouan plants could also switch to coal, at a total investment cost of about $27 mn, but the estimated savings at current price levels ($2 mn annually) would not justify the investment. Conversion to coal in the remaining four plants may depend on substantial investments in port facilities.

4.37 All of the cement plants except Oujda could switch to gas, should it become available in sufficient quantities. Except for an estimated total of $3.3 mn for gas burners for all the cement plants, the investment cost of conversion to gas would be almost entirely in the extension of the pipeline system.

4.38 Only a few of these investments (notably those at Cellulose du Maroc) have been studied in detail. The principal need now appears to be for a program of energy audits and feasibility studies to identify and evaluate the potential in sufficient detail to permit investment decisions to be made.

Table A1.1: National Energy Commodity Balances, 1981

Line	Item	Wood	Charcoal	Coal	Coke	Natural Gas	Electricity	Crude Oil	Butane	Propane	Gasoline	Kerosene	Jet fuels	Gas Oil	Fuel Oil	Bitumen & Lubes	Line
		(000 m^3)	(........tons.......)			mn Nm^3)	(GWh)	(...........................000 tons								...................................)	
	PRIMARY ENERGY BALANCE																
1	Domestic Production	10,900d		703a		85e	1,037ph	19									1
2	(+) Imports			15b	30			4,513									2
3	(-) Exports			-61a													3
4	(+/-) Stock changes			100aw				-188e									4
5	(=) Domestic Utilization	10,900		757	30	85	1,037ph	4,344									5
	TRANSFORMATION AND SECONDARY ENERGY BALANCE																
6	(+/-) Petroleum Refining					-28e		-4,167	144	24	537	49	208	1,123	1,880r		6
7	(+) Imports								134							45	7
8	(-) Exports									-9	-201						8
9	(+/-) ONE Thermal Power Plants			-690a			4,076p							-3	-745		9
10	(-) Plant use and losses					-4e	-807p										10
11	(+/-) Other Thermal Power Plants						474sp								-92		11
12	(+/-) Charcoal Production	-1,270g	115p														12
13	(-) Non-Energy Demand	- 500						-177								-51	13
14	(+/-) Stock Changes								-8i	1w	25w		14w	-14i	-58i	6w	14
15	(=) Final Domestic Demand	9.130	115	67	30c	53	4,780p	0	270	17	351	50	222	1,106	985	0	15
	FINAL DEMAND BY SECTOR																
16	Industry			60	30	53e	2,772p		1	9		5		128	921		16
17	(of which: Phosphates			(1)		(40)e	(550)p								(221)		17
18	Cement						(367)p								(350)		18
19	Others)			(59)	(30)	(13)e	(1,855)p		(1)	(9)		(5)		(128)	(349)		19
20	Transportation & Services						697p				351		222	837	37		20
21	Agriculture						249p							134	9		21
22	Households	9,130	115	8			1,062p		269	7		45		7	18		22
23	Total	9,130	115	67	30	53	4,780p		270	17	351	50	222	1,106	985		23

Sources: MEM, ONE, ONAREP, SNPP, SCR data except as noted

Note: Sectoral distribution of demand for oil products other than fuel oil based on rough estimates by SNPP.

a. Anthracite
b. Bituminous steam coal
c. Consumption assumed to equal imports
d. of which, about 3.5 million tons is sustainable yeild
e. Estimate based on inccomplete and/or conflicting data
f. Legal production. Actual may be considerably higher.
g. Based on 25% conversion efficiency.
h. Hydro
i. Net increase in stocks, computed as residual
p. Preliminary estimate
r. Includes 76 thousand tons classifed as residues
s. Includes 147 GWh from sulfur by Maroc-phosphore
w. Net withdrawals from stocks computed as residual
x. Imported from asphalt and lubricant production.

Relationships Used In Projecting Energy Balance

*	=	Given or estimated exogenously
	(1)	Electricity Demand
*	(2)	CLF Demand
*	(3)	Direct BF Demand
	(4)	Losses = 0.15 [(1) + (2)]
	(5)	Total Commercial Demand = (1) + (2) + (3) + (4)
	(6)	Elec. Gen. = 1.15 x (1)
*	(7)	Hydro
*	(8)	Jerada elec
*	(9)	Fixed oil-fired thermal
	(10)	Hydro and inflexible thermal = (7) + (8) + (9)
	(11)	Gas-Elec Market = Max. of zero and (6) - (10)
	(12)	Mohammedia-Kenitra Gen.
	(13)	Coal-Electricity Market = Max. of zero and (11) - (12)
*	(14)	Existing Gas and Imported Coal
*	(15)	Jerada production less exports
	(16)	Jerada non-electricity = (15) - (8)
	(17)	Existing non-oil direct BF = (14) + (16)
	(18)	Remaining direct BF = (3) - (17)
	(19)	Gas-direct market = 0.60 x (18)
	(20)	Coal-direct market = 0.45 x (18)
	(21)	Total gas market = (11) + (19)
	(22)	(in MMCFD) = (41/365) x (21)
	(23)	Total coal market = (13) + (20) = new coal (coal)
	(24)	(in thousand Tpa) = 1.69 x (23)
	(25)	Elec. BF demand = (6) - (7)
	(26)	Total BF demand = (3) + (25)
	(27)	New Gas (gas and gas/coal) = Max. of 0 and Min. of (21) and (68)
	(28)	New Coal (gas/coal) = Max. of 0 and Min. of (23) and (21) - (27)
*	(29)	Shale-elec. (shale and shale/gas)
*	(30)	Shale oil (shale and shale/gas)
	(31)	New gas (shale/gas) = Max. of 0 and Min. of (27) - (29) and (68)
	(32)	Fuel oil (base) = (26) - (14) - (15)
	(33)	Fuel oil (gas/coal) = (32) - (27) - (28)
	(34)	Fuel oil (coal) = (32) - (23)
	(35)	Fuel oil (shale) = (32) - (29)
	(36)	Fuel oil (gas/shale) = (35) - (31)
	(37)	Condensates (gas and gas/coal) = 0.30 x (27)
	(38)	Condensates (shale/gas) = 0.30 x (31)
	(39)	CLF exports (gas and gas/coal) = Max. of zero and (37) - (2)/3
	(40)	CLF exports (shale) = Max. of zero and (30) - 2 x (2)/3
	(41)	CLF exports (gas/shale) = (39) + (40)
	(42)	CLF demand and refinery losses = 1.15 x (2)
	(43)	Net oil imports (base) = (32) + (42)
	(44)	Net oil imports (gas/coal) = (33) + (42) - (37)

(45) Net oil imports (coal) = (34) + (42)
(46) Net oil imports (shale) = (35) + (42) - (30)
(47) Net oil imports (gas/shale) = (36) + (42) - (30) - (38)
* (48) Oil price
* (49) Coal Price
(50) Fuel oil (gas) = (32) - (27)
(51) Net oil imports (gas) = (44) + (28)
(52) Fuel oil yield (gas) = (50)/[(51) + (39)]
(53) Net import cost (gas) = (51) x (48) + (49) x 20
(54) Not used
(55) Fuel oil yield (base) = (32)/(43)
(56) Fuel oil yield (gas/coal) = (33)/ [(44) + (39)]
(57) Fuel oil yield (coal) = (34)/(45)
(58) Fuel oil yield (shale) = (35)/ [(46) + (40)]
(59) Fuel oil yield (gas/shale) = (36) [(47) + (41)]
(60) Net import cost (base) = (43) x (48) + (49) x 20
(61) Net import cost (gas/coal) = (44) x (48) + (49) x [20 + ((28)]
(62) Net import cost (coal) = (45) x (48) + (49) x [20 + (23)]
(63) Net import cost (shale) = (46) x (48) + (49) x 20
(64) Net import cost (gas/shale) = (47) x (48) + (49) x 20
(65) Not used
(66) Not used
(67) Not used
* (68) Maximum new gas production rate
(69) Used internally
(00) Used internally

Table A2.1: Input Data Used In Energy Balance Projections

Variable	Actual 1980	Low Demand 1985	Low Demand 1990	Low Demand 1995	High Demand 1985	High Demand 1990	High Demand 1995
(1)	1086	1523	2187	3139	1749	2881	4747
(2)	1976	2077	2408	2791	2404	3217	4305
(3)	1083	1196	1455	1770	1382	1939	2719
(7)	371	480	791	1046	480	791	1046
(8)	242	284	284	284	284	284	284
(9)	172	160	210	0	160	210	0
(12)	384	1029	1029	1029	1029	1029	1029
(14)	72	71	71	71	71	71	71
(15)	271	363	413	480	363	413	480
(29)	0	0	200	1200	0	200	1200
(30)	0	0	1000	2400	0	1000	2400
(48)	222	240	276	305	240	276	305
(49)	112	127	133	140	127	133	140
(68)	3000	3000	3000	3000	3000	3000	3000

Table A3.1: Estimated Refining Margins at International Prices
($/Ton)

Notes		1978 QI	1978 QII	1978 QIII	1978 QIV	1979 QI	1979 QII	1979 QIII	1979 QIV	1980 QI	1980 QIII	1980 QIV	1980 QIV	1981 QI	1981 QII	1981 QIII	1981 QIV
							A. CONTRACT MARKET										
(a,f)	Crude Oil	114.8	107.0	106.6	106.4	132.0	143.6	168.0	196.7	246.2	241.8	247.3	255.3	289.3	276.0	267.3	274.3
(b,c,f)	Gasoline	160.2	161.8	161.6	185.8	190.0	240.3	281.6	281.6	356.5	376.2	372.4	355.8	375.9	378.3	373.0	373.0
(b,d,f)	Gas Oil	128.9	130.4	130.2	134.9	144.0	175.7	231.3	231.3	299.8	317.1	313.3	297.7	310.8	313.2	301.7	307.9
(b,e,f)	Fuel Oil	84.9	86.4	86.2	83.4	87.3	122.7	133.8	159.8	169.3	161.5	161.8	211.5	235.0	237.4	181.8	182.7
(g)	Margin	-7.8	1.4	1.6	6.1	-14.0	8.9	14.8	-2.3	-12.5	-2.6	-9.9	-3.6	-19.5	-3.9	-24.7	-29.2
							B. SPOT MARKET										
(h)	Crude Oil	114.5	107.0	107.3	110.1	176.4	283.1	266.5	311.2	310.3	265.2	259.1	312.4	322.1	265.2	261.2	276.1
(i,l)	Gasoline	141.5	151.4	181.9	220.8	322.4	368.7	357.0	392.1	386.4	376.1	326.6	387.1	370.5	351.4	384.5	375.4
(j,l)	Gas Oil	119.6	122.6	122.7	155.5	289.2	319.9	316.9	362.4	307.2	321.0	272.4	321.4	303.7	271.4	294.0	322.3
(k,l)	Fuel Oil	76.2	74.1	72.2	83.9	103.5	128.6	138.5	174.9	145.0	161.3	152.6	232.2	212.3	181.5	161.1	176.4
(g)	Margin	-17.5	-8.4	-4.5	15.2	18.9	-58.8	-40.7	-48.3	-80.1	-24.8	-46.9	-38.5	-65.7	-36.4	-28.6	-28.6

Notes:
a/ Average (weighted by export volumes) of official selling prices of Arabian/Persian Gulf crude oils plus estimated freight (in 70 to 90 thousand ton vessels) and insurance to Mohammedia.
b/ Curacao posted prices plus estimated freight (in 35 to 40 thousand ton vessels) and insurance to Mohammedia.
c/ 95 Ron, 8.6 bbl/T.
d/ 48-52 diesel index, 7.4 bbl/T.
e/ Heavy, high sulfur, 6.7 bbl/T.
f/ As of mid-month or middle month of each quarter.
g/ Based on SAMIR 1981 yields (16.2% light products, 33.5% middle distillates, 44.6% heavy products, 5.7% losses) and assumption that average product value in each category is equal to estimated values shown of gasoline, gas oil, and fuel oil, respectively.
h/ Contract market price plus or minus average spot-official price differential for Middle Eastern light crudes in middle month of quarter.
i/ 98-99 octane.
j/ 53 diesel index.
k/ 3.5% sulfur.
l/ Rotterdam barge-lot prices quoted in $/T. Average of high and low prices for middle month of each quarter.

IBRD 16581

OCTOBER 1982