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MOROCCO ENERGY STUDY

Office of Energy
Development Support Bureau
Agency for International Development

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PREFACE

This report is based on discussions held in Morocco 27 November - 13 December 1978. In two areas, shale oil development and decentralized hydropower, the Government of Morocco is holding negotiations which are relevant to this report. Morocco is negotiating currently a shale oil agreement with Occidental Petroleum Company. In hydropower, the World Bank is awaiting a Consultant's report on decentralized hydro photential in Morocco. Nevertheless, the energy team feels that developments in these two areas will not affect the substance of its recommendations.

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TABLE OF CONTENTS

		Page
i	Energy Team Members	
1.0	Overview and Conclusions	1
2.0	Oil Shale Development	8
3.0	Hydro Development	21
	3.1 Tarfaya Hydro Project	21
	3.2 Decentralized Hydro Power Plants	25
	3.3 Power Market and Systems Study	26
4.0	Non-Conventional Energy	28
	4.1 Solar Energy	28
	4.2 Bio Resource	37
5.0	Energy Investment and Economic Development	41
6.0	AID Project Recommendations	48
7.0	Appendix	61
	A. Officials Contacted	61
	B. Bibliography	62

1.0 Overview and Conclusions

A group of six energy specialists listed above visited Morocco from November 26 to December 13 to assist the Government of Morocco in evaluating three energy projects designed to produce economic development benefits and lessen Moroccan dependence on oil imports. This report discusses team findings on shale oil development, hydro electricity production at Tarfaya, and the creation of a solar energy institute. Additional comments suggest more generally closer linkages between economic development and energy investment.

This report is divided into several sections, the first is an overview of the conclusions of the team. The next sections deal with each of the separate project areas. In submitting the report in Washington, specific recommendations for AID assistance have been developed.

Investigations by the authors have resulted in various conclusions. On oil shale development, the recommendations focus on the need for a comparative analysis of alternative methods of exploiting the shale and the need to do an *in situ* test at some point. In the area of hydro development, the high costs for the Tarfaya project do not match stated benefits; a decentralized hydro program appears to have greater benefits. With reference to the GOM request for a center to develop solar energy, the recommendation endorses the concept and provided details on how it may be structured within the context of a renewable energy institute. Finally, the report comments on the preparation of energy investment programs.

Shale Development

Morocco has extensive deposites of shale oil. These deposits represent the long-term solution to Morocco's energy needs, but the costs of development and extraction are substantial. The risks of technological failures are difficult to assess, making financing especially difficult. Despite these difficulties, shale oil represents the largest potential indigenous source of energy to replace imported oil and fuel the economy. After lengthy discussions with the governments and private firms of the U.S.A., Germany, Rumania, and the Soviet Union, the GOM has decided to proceed with shale oil development.

There are three basic processes for producing oil from shale rock: direct combustion of the shale rock, above ground retorting or in situ (below ground) retorting. This report is mainly concerned with in situ retorting, the principal interest at present of the GOM. The actual technical and economic performance of in situ retorting of Moroccan shale needs to be determined. If current negotiations with Occidental Oil Company for a major feasibility study are not successful the next logical step in the development of oil shale is a pilot in situ retorting test under actual Moroccan field circumstances. This discrete, but sequentially important, step is one which will further the effort toward Moroccan shale production, and is the priority project for consideration in this area.

Moroccan shale oil researchers have performed resource economic analysis, but it was evident to the team members that current forms of project and cost analysis grossly understate or distort true costs for projects. Comparative trade-off analyses among shale exploitation alternatives have not been done. This makes it difficult to establish project priorities and to secure foreign support and financing for the program.

For this reason it would be very useful to develop procedures for the analysis and comparison of different shale oil projects and processes. It is also necessary to prepare a report which provides the international financial community with the data it will need to consider a request from Morocco for assistance in the construction of a commercial shale plant. Rendering judgments on how to proceed is now subject to error due to the difficulty of developing comparable and relevant data about different processes and projects. An energy management training program would be useful in shale, and would be generally useful to the Ministry of Energy and Mines. This would help establish priorities for a long-term strategy for shale development.

Thus, one of the recommendations in the area of shale development discussed in some detail below in the project reports indicate areas for assisting in the conduct of an *in situ* test under field conditions; design of a methodology for presentation of alternatives to energy managers, and the preparation of pre-financing documentation on the oil shale development program of Morocco.

Hydro: Tarfaya, Decentralized Power

The team investigated the proposed Tarfaya solar hydro project to generate power by piping water from the Atlantic Ocean to the Tarfaya depression. The 50 m water level difference between the ocean and the evaporation surface of 2.5 km^2 at the bottom of the depression would permit the installation of two or more turbines producing some 30 million KWh annually. The installed capacity of the plant would depend on the load demand

variation and was estimated at 10-11 MW. After analysis of the available meteorological and geological data, the team agreed that there are still some problems to be resolved. However, the scheme seemed feasible from the engineering point of view. Team also agreed with the Moroccan estimates of annual energy production by the Tarfaya hydroelectric scheme.

The energy generation economics were also investigated. The project and energy costs for 10-11 MW installed capacity hydroplant at Tarfaya were estimated by the Ministere de l'Energie et des Mines, by Office National de l'Electricite and by the USAID Energy Team. In the opinion of the U.S. team, the estimated project cost by the Ministere de l'Energie et des Mines is unrealistically low, making the energy cost also low.

Since the average cost of energy production in Morocco, according to ONE, is 0.14 DH/kwh and accepting the Ministere de l'Energie et des Mines estimate of thermal energy replacement of 0.25 - 0.30 DH/kwh to be realistic, the team estimated energy cost from the Tarfaya hydro scheme to be approximately 5 or 6 times the national average.

In view of the above, the project does not seem viable for electric generation or industrial exploitation of salt.

As an alternative, it is suggested that Moroccan authorities look into small decentralized hydro plant installation possibilities in the Atlas Mountain ranges and more economical industrial exploitation of salt. Small hydro plants most likely would be high head, small stream, flow installations with very small dams

and reservoirs. If built in reasonably accessible places, they could produce power at a fraction of the cost compared to that of Tarfaya hydroelectric scheme. If installed within reasonable distances from the existing thermal plants and population centers, the displaced fuel could be used for energy generation in localities where the hydro power is not feasible.

It is also recommended that system studies be made for better utilization of the existing plants and for implementation of a viable national power distribution network which would permit power generation centers at the most convenient locations with respect to the energy generation sources (hydro, coal, oil shale, etc.).

Non-Conventional Energy: Solar, Wind, Biomass

The GOM has set aside funds and a site for a solar center with the objective to increase the application of solar energy in the country. The team was asked to help outline the establishment of a center and suggest activities. In cooperation with Moroccan officials, the center was discussed and a preliminary proposal for a renewable energy institute developed. The GOM is currently seeking a director for the institute in Marrakech. Specific staffing needs are developed in this report.

The GOM has decided that the Center initially will house only solar energy projects but will gradually expand into all forms of renewable energy such as wind and biomass and decentralized hydro. Since there are few specialists available, the scope of the Center will be limited in the first few years, but the

team has identified immediate opportunities in solar including water and bio resources, that should not be delayed.

The center will begin with a training program to develop talent to meet the needs of an applied research center. Skills required will range from those of materials engineers who can measure the solar properties of materials, to lawyers and economists who can design incentive programs to encourage solar industries. Training in the United States would be made available until the institute has set up training facilities in Morocco.

The center will actively encourage solar energy use by developing information concerning the best geographic areas, uses and technologies for application and assisting industry to develop and market a Moroccan manufactured product. Since the center will be under the Ministry of Energy and Mines, it should receive needed attention within the Ministry. However, since project identification and implementation will often be the province of other ministries, such as agriculture, inter-ministerial and regional coordination will be essential.

Energy Investment and Economic Development

Moroccan commercial energy demand is met 80% by imported oil. The traditional sector utilizes very little commercial energy, is dependent on noncommercial energy, and requires a continuing energy supply for supporting economic development.

In proposing an energy investment budget for the next few years, annual energy investments were budgeted at U.S. $300

to $500 million. The larger figures, while not unrealistic from the point of view of what is needed to begin efforts at import substitution, place severe constraints on Morocco's budget. Investment projections which are realistic for resolving energy dependency are unrealistic from the point of view of economic distortions that might result from such expenditures.

To help resolve this dilemma, the Government of Morocco should consider emphasizing existing decentralized planning processes at the regional level. This will assist in the identification of decentralized energy sources closely matched to regional economic development investments. (Section 4) A planning and investment process which would identify decentralized applications would deal with the needs of the rural and urban economy and take pressure off higher quality energy sources to be used for more specialized and suitable applications. Thus, alternative and indigenous energy development could substitute for oil based centrally developed energy.

In sum, energy investments can be brought more closely in line with particular locations and appropriate energy characteristics of economic development. A decision process which encourages the application of suitable energy and a technical capability to deliver the services is a major recommendation of this report.

2.0 Oil Shale Development

Preface

The evaluation, conclusions and recommendations contained in this report are based on meetings held with USAID Mission, U.S. Embassy and Moroccan Government officials. A list of persons interviewed is contained in Appendix A. Appendix B lists the major documents and reports reviewed during the visit.

The purpose of this report, in response to the verbal directions and terms of reference supplied to the team members is to (1) review the status of the current Moroccan oil shale development program, (2) assess the value of oil shale to Moroccan energy supply, and (3) develop conclusions and recommendations.

In addition to the AID energy team, the U.S. Department of Energy (DOE), Laramie Energy Technology Center, James R. Schlesinger, Secretary of Energy and Occidental Petroleum Company have recently been advising and assisting the Moroccan Government in shale oil development planning. Some of this assistance was provided following the completion of the AID energy team's visit to Morocco. The oil shale section of the AID report has been revised to incorporate the work of these other teams. The conclusions and recommendations reflect information received after the team left Morocco.

Background

The shale oil exploitation program in Morocco is the responsibility of the Ministry of Energy and Mines. The Bureau

of Research and Mining Participation (BRPM) is concerned with extraction (retorting) of oil from the shale and the National Office of Electricity (ONE) is concerned with direct combustion of shale to generate electricity. Both programs are still in the planning and testing stages; both are several years away from producing oil or electricity with the oil shale retorting program seemingly the closest to implementation.

Oil shale is found in the Timahdit deposits in the Atlas Mountains in central Morocco and in Tarfaya on the southeastern coast. Data taken from the current five-year plan (Ref 1) indicate that there are at least ten billion confirmed tons of 74 liters per ton oil shale reserves in Timahdit and at least one billion confirmed tons of 80 liters per ton oil shale reserves in Tarfaya. The potential total reserves for both areas are thought to be at least ten times larger than those now confirmed. In general the Tarfaya reserves contain lower grade oil shale.

Status of Oil Shale Retorting Program

Since 1974 the Ministry of Energy and Mines, BRPM, foreign governments and private companies have been analyzing and conducting pilot retorting tests of Moroccan oil shale. Tosco, Union Oil Company, Lurgi, and the U.S. Government (DOE) have all run above ground or simulated pilot *in situ* retort tests on Moroccan shale. These tests have shown that above ground retorting is technically feasible, and within the next 12 months an on site *in situ* retort pilot test may be conducted in Morocco to demonstrate the feasibility of this concept. Capital cost estimates

for various retorting schemes have been prepared. These estimates include an initial investment of US $1.7 billion (1976 dollars) for a 22 million barrel of oil per year above ground retort project using Tosco's technology and Timahdit shale (22 million barrels of oil is the approximate 1976 oil consumption in Morocco). A rough USDOE initial investment cost estimate for an *in situ* retorting plant to supply approximately 11 percent of the 1976 oil consumption (7,000 barrels per day from Timahdit shale) is U.S. $80-90 million (1978 dollars). At the present time there are three major and several minor commercial options being considered for retorting oil shale. The three major options include:

- Tosco built and GOM financed above ground retorting in Timahdit
- Occidental Oil Company built modified *in situ* retorting in Timahdit exchange for phosphate ore from GOM.
- Union Oil Company built and GOM financed modified *in situ* retort in Tarfaya

The minor projects (those not as far advanced) include joint work or contracts with the Soviet Union, Paraho and Lurgi.

Tosco has prepared preliminary cost estimates for its project. However, major feasibility studies including infrastructure and project engineering details have not been prepared. Cost estimates for other full or prototype scale projects have been prepared by the Ministry, but these are very preliminary and based only on project concept papers, not on detailed feasibility studies. Several problems such as definition of the ultimate use of the

oil, disposal of (ash) slag, provision of water, reducing the the excessively high sulfur content of the oil (6 percent), multi-purpose project uses, etc. have not been resolved. The Ministry is currently working on a large number of possible oil shale retorting projects which are in different stages of development. It is not clear whether these projects compete with one another, or how priorities will be set to advance one or more projects to the engineering design stage. There appears to be a large amount of duplication in planning and less than optimum coordination among the various groups in the Ministry considering various oil shale projects.

Evaluation of Oil Shale Retorting Needs

During the AID Energy Team's visit in Morocco, several areas of assistance for shale retorting were identified and discussed with the Ministry. Two specific areas for assistance were identified. The first related to technical assistance necessary to advance *in situ* retorting to the next stage of development. This area was emphasized by the Ministry and the Ministry specifically requested that AID cooperate in an *in situ* retorting pilot project in Timahdit. US DOE has offered to supply personnel to assist in the conduct of this test, and the Ministry asked AID to consider financing the technical assistance and the purchase of equipment necessary to conduct the test and monitor the results.

At the time of the Energy Team's visit, the Moroccan Government was negotiating with Occidental Oil Company on oil shale development in Morocco. The negotiations involved utilizing Occidental's

proprietary modified *in situ* oil shale process in Morocco; an arrangement to pay Occidental in phosphate ore for a commercial scale plant and a joint oil exploration agreement between Morocco and Occidental. Recently received reports from the U.S. Embassy in Morocco state that Occidental and the GOM have reached agreement on an interim step while leaving the larger oil shale-phosphate deal for further negotiation. Occidental and the GOM have agreed to do a $3 million detailed feasibility/preliminary design of a 10,000 and 50,000 bbl/day oil shale plant to be constructed in Morocco (Timahdit). This study, to be performed by Occidental Oil Company, will take 12 to 18 months to complete and will include the following general elements:

1. Rock (oil shale) fragmentation tests in Morocco.
2. Geological rock mechanic and other studies of the oil shale deposits in Morocco.
3. Small-scale simulated *in situ* retorting of Moroccan shale at Occidental's Colorado property.
4. Computer simulations and analyses to develop design parameters for the mining-retorting facility in Morocco.
5. Preliminary design and costing of a 10,000 and a 50,000 bbl/day mining/retoring preparation in Morocco.
6. Preparation of a report.

According to the agreement, the GOM will shoulder all costs associated with the feasibility study. The Minister of Energy and Mines has requested U.S. financial and technical assistance in conducting the feasibility study. The Occidental process is proprietary and it is not now clear which portions of the feasibility study would have to be kept secret to protect their proprietary process. United States Government assistance could be limited depending upon secrecy requirements.

The second assistance area identified during the visit was in project comparison and trade-off analysis. It appeared that more shale projects were being considered than the known economically exploitable reserves, near-term Moroccan financial capabilities and Ministry technical capability could support. The overall planning program in the Ministry has not developed a set of comparable data for each project. Several possibly conflicting oil shale retorting projects are now at the point where substantial investment of capital and/or Ministry technical capacity are about to be required. Thus assistance is needed to develop data in order to compare each project and to set priorities. This assistance would involve the loan of technical personnel experienced in assessment of shale technology, in project engineering, & in financing & infrastructure development

to work with Ministry personnel. This general need was also identified by several team members in other areas. However, personnel at the Ministry felt that individual project assistance was a more critical need at this time. Both areas of need are critical not only for internal GOM planning but also for the GOM to attract foreign private sector, governmental or lending agency capital to finance one or more of the projects. Detailed comparisons of technologies, projects and information on overall infrastructure needs are necessary if the GOM intends to seek outside funding from the World Bank or similar sources.

Status of Direct Oil Shale Combustion Program

The National Office of Electricity (ONE) in Casablanca is responsible for direct combustion of oil shale to produce electricity. Their current program includes contracts and joint studies with the following:

- Klockner-Ina (Germany): combustion analyses and studies,
- Deutsche-Babcock (Germany): large-scale combustion studies in Germany,
- Technopromexport (USSR): studies of combustion.

The current plan is to install a 200 to 250 MW prototype direct shale combustion electricity power generation station by 1984 in Timahbit. Following three years of testing, three or four more units of similar size are planned for installation to bring the shale burning central power station to 1000 MW's of installed capacity.

The studies conducted by ONE and their contractors have identified that shale can be combusted directly and that for a 1000 MW direct combustion plant, 10,000,000 tons of 7.5 percent shale must be mined per year. These studies have also shown that there will be substantial problems with pelletizing the shale prior to combustion; cementation of shale during combustion; corrosivity (silicon dioxide) and high sulfur content of combustion products; handling and disposal of ash or slag; supply of water for cooling and slag compaction; and the provision of infrastructure such as roads, power lines, skilled workers, housing, schools, medical facilities, equipment, etc. A feasibility study prepared by ONE indicates that with raw shale (70 to 100 liters of oil per ton of shale) costing 10 Dirham per ton to mine and deliver to the furnance, electricity can be produced for approximately 13 to 18 Dirhams per kilowatt hour of electricity. This range is for two different technologies. Doubling of oil shale price to 20 DH per ton increases the cost per Kwh of electricity approximately 8 percent. On the basis of this analysis, it seems that oil shale can compete with coal and oil as a direct fuel of power plants. However, from the available and the published data in the feasibility study, it is not clear whether the estimated overall costs for power production included the following:

- accurate mining cost estimate (even 20 DH/ton is low based on other current strip mining costs in Morocco)
- amortized costs for developing the shale mining process

- costs for pumping water
- costs for dealing with or eliminating problems of corrosion, ash cementation, air pollution
- disposal of the large quantities of ash from combustion
- cost of interest on borrowed money during construction
- foreign exchange cost for project

The existing feasibility study indicates that infrastructure costs are not included.

ONE has sent a summary report and a request for guidance on continuing effort in direct oil shale combustion to the Ministry. They are planning to prepare a detailed project engineering study for 200-250 MW prototype station over the next 12 months. They are also considering combining oil shale retorting and an on-site oil fired power plant in Timahdit. This combination in association with an Occidental Oil Co.-Moroccan oil-shale development program would produce 3 million tons of oil per year with 2 million going to electricity generation ad 1 million tons for other uses or export.

Needs in Direct Combustion of Shale for Electricity Production

Past ONE work in direct combustion of oil shale for power generation seems to have shown that although there are many problems to overcome, it is reasonable to continue studies and to plan a prototype direct combustion operation. In this regard it is also important to consider mixing coal and oil shale or lignite and oil shale as fuels and to prepare a more detailed

engineering study for a 250 MW direct fire oil shale power station. As with retorting of oil shale and with the Tarfaya hydro depression project, there is a need to consider more than the technical components of the project during the next studies. The next ONE study should consider all project costs (capital and operating) as well as foreign investment requirements and should be expanded to consider conditions and infrastructure requirements beyond the physical boundaries of the project site. Additionally, the Ministry of Energy and Mines should develop a standard methodology for projects. This methodology should specify common assumptions and units and define the types of indices and calculations to be made. The existence of a standard format for the shale projects would allow direct comparison of the advantages and disadvantages of all shale projects now under consideration by BRPM and ONE. Because any one project will demand a large amount of capital, technical skill and require outside financing, it is very important that priorities be set for shale projects only after comparing projects on a common and equal basis.

Conclusions and Recommendations

The feasibility of oil shale development and exploitation as a major energy resource for Morocco has been the principal subject of this evaluation. The results of the technical evaluation indicate that even under the most conservative assumptions as to quantity and quality of the oil shale reserves,

exploitation could substantially reduce oil importation. While several different technologies and development projects are under consideration, the existing project specific cost and infrastructure data are not developed to the point where an adequate technical trade-off analysis can be performed. It is also unlikely that favorable financial terms for one or more of the projects can be arranged from out of country/international lending sources without more complete analyses. On the basis of the existing project engineering and cost data, it is not evident which project is economically feasible or how one would select a project to fund. While the political feasibility of a project can very likely be decided using existing data, a comparative presentation of all projects could facilitate this determination.

The major conclusion of this evaluation is that the large and exciting potential for oil shale in Morocco can most directly be achieved by implementing a series of short-term recommendations. The following recommendations represent a package of actions which, when implemented, will allow oil shale to begin to supply power and substitute for imported oil in various sectors of the Moroccan economy.

(1) The first recommendation is that all shale project descriptions be coordinated in such a way that the advantages or disadvantages of projects for the use of shale can be directly compared whatever the site, technology, size, ultimate use of the resources, infrastructure need, etc. The first step in

implementing this recommendation is to develop a simple methodology for presenting all projects and the adoption of a set of minimum standard calculations and parameters for all projects.

(2) The second recommendation is that all shale exploitation projects now being seriously considered (above ground retorting, in situ retorting and direct combustion for power generation) be immediately compared using the above methodology. A comparative evaluation of all projects at this time using the best available data would be helpful in deciding which projects to emphasize, which projects require more study or new thinking and which projects to reject at this time.

The decision of the Moroccan Government to have Occidental Oil Company prepare a detailed feasibility study covering the use of their modified in situ technology in Morocco is only one step in a long journey towards commercialization. The next step likely will involve the search for out-of-country financing for a commercial scale pilot plant (probably the Occidental process). In order to acquire financing it will be necessary to justify the selection of one process over the others, and to prepare a detailed economic analysis (both project and macro cost implications). The economic analysis will be especially necessary before agencies such as the World Bank can be asked to consider financing a commercial scale plant. Thus it is important to start now to prepare the details for an oil shale development proposal to the financial community.

(3) The third recommendation involves conduct of the Timahdit in situ retorting test. It is very important that the

Timahdit on-site pilot *in situ* retorting test be conducted as soon as possible if the Occidental-Moroccan agreement is not consumated. If the Occidental feasibility study is not started the technical and economic feasibility of *in situ* retorting can be evaluated by conducting the test in Morocco. This testing program then should be given priority because it represents the last major piece of technical data necessary to make engineering and economic trade-off studies among oil shale projects.

As a conclusion to this report, it is important to consider that although oil shale development in the United States has, at times, been technically and/or economically feasible, we do not yet have even one commercial scale oil shale plant. This is in part due to economic or political constraints. In Morocco, while economic feasibility is not yet certain, a governmental commitment has been established in the most recent national development plan. The implementation of one or more large scale oil shale projects in Morocco could well affect oil shale development in the United States and act as a catalyst to United States applications. Therefore, active United States support and cooperation in the Morocco oil shale program could be extremely valuable to both Morocco and the United States.

3.0 Hydrodevelopment

3.1 Tarfaya Hydro Project

At the request of the Government of Morocco, the team investigated the use of a natural depression near the town of Tarfaya (known as Sebkhat Tah) as a source of hydro power. Water from the Atlantic Ocean would be conveyed to the Tah depression through a 12 km long system of underground galleries and penstocks. The hydro power plant in the depression would utilize the 50m gross head for generating power. The discharged water in the depression would evaporate so that the available power plant head could be maintained. The total area of the Tah depression is 350 km^2; however, only the part which is 50m below sea level could be utilized for evaporation. Thus the effective depression area is 216 km^2; all calculations were based on this area. Initially, the depression up to 50m below sea level would be filled with unsaturated ocean water. After several years the salt concentration in depression water would increase and the evaporation rate decrease. 30-32 million kWh energy could be produced annually to be used in a new chemical industry and for domestic purposes. This assumes that one third of the brine in the depression would be processed in the anticipated ocean salt extraction industry with fresh water replacing the processed brine.

The installed capacity of the proposed hydro power plant would depend on the nature of load/demand variation. Assuming a capacity factor 0.33, the installed capacity would be 11.6 KW.

The above figures, arrived at by an analysis of the available meteorological data, agreed closely with the estimates made by the Ministry of Energy and Mines and the Office Nationale de l'Electricite (ONE).

The AID team examined published reports, the results of the available geological exploration, available meteorological data (evaporation) and concluded that the project is feasible technically in the form as conceived by the Moroccan authorities. The team agreed with the Moroccan estimate of annual energy production by the Tarfaya hydro-electric scheme.

The energy generation economics were also investigated. The project and energy costs for 10-11 MW installed capacity hydro plant at Tarfaya as estimated by Ministere de l'Energie et des Mines, by Office National de l'Electricite and by the AID Energy team are given in the Table on page 23. While both Moroccan agencies investigated several schemes, the Table presents only the data of the most feasible project variation, i.e. 10-11 MW.

In the Moroccan cost estimates some items, such as engineering and construction supervision, and interest during construction, were not included, and therefore the estimates are too low. The project estimate by the Ministere de l'Energie et des Mines is unrealistically low. The energy team estimate, while preliminary in the nature, includes all the cost items missing in the Moroccan estimates. The cost estimate of DH 17,949 per kW installed is several times higher than that of normal, economically viable hydro projects.

Cost Comparison Table
(Cost in Dirhams)

	Ministere de l'Energie et des Mines	Office National de l'Electricite	AID Energy Team
1. Assumed installed capacity (MW)	11	9.6	11
2. Annual Energy Generated (kWh)	30.856×10^6	30.8×10^6	32.0×10^6
3. Estimated Total Project Cost (DH)	89,120,000*	179,000.000*	208,204,000
4. Estimated Cost per kW installed (DH)	8,102	18,646	17,949
5. Estimated Energy Cost (DH/kWh)	0.35	0.68**	0.78**
6. Estimated Cost of Thermal Energy (DH/kWh)	0.250.30	-	-

*Does not include the interest during construction or engineering and construction supervision.

**Estimated by AID Energy team assuming 10% interest on the investment with the capital recovery in 50 years.

The cost of energy is also several times higher than the power from economically viable hydro projects or from thermal steam power plant. Ministere de l'Energie et des Mines cost estimate of thermal energy at Tarfaya ranged from 0.25 to 0.30

DH/kWh. This energy cost is realistic for Tarfaya conditions. The Tarfaya hydro energy cost as estimated by the energy team would have the following foreign and local currency components:

Cost Component	Energy Cost DH/kWh
Local Currency	0.52
Foreign Currency	0.26
TOTAL	0.78

From the above it may be seen that the foreign currency component of Tarfaya would be even higher than that of the foreign currency cost component of energy production by thermal power plants operating on imported fuel. (ONE gave the average overall cost of energy produced in Morocco as 0.14 DH/kWh.)

In view of the above, it is recommended that some other, less expensive, energy source be sought if an ocean salt industry at Tarfaya is the only goal. Moroccan authorities should consider seriously small hydro plant installations in the Atlas Mountain ranges. These small plants most likely would be high head, small stream flow installations which would produce power at a fraction of the cost of Tarfaya hydroelectroc scheme. If hydroelectric stations were installed within reasonable distances of existing thermal plants and population centers, conventional fuel replaced by hydro power could be used for energy generation in localities where the hydro power is not feasible. Systems studies should be made for better utilization of the existing plants and implementation of a viable national power distribution net-

work which would permit power generation centers at the most convenient locations with respect to the energy generation sources (hydro, coal, oil shale, etc.).

3.2 Decentralized Hydro Power Plants

According to the "Activity Report, 1977" ("Rapport d'Activite") of the Office National de l'Electricite, the quantity of energy generated by small hydroelectric installations is minimal. In 1977, of 1,374 billion kWh produced by hydroelectric plants, only 45 million kWh, or 3 percent, was produced by small hydroelectric installations in the vicinity of Fes, Sefrou, Taza, Meknes, etc. The Atlas Mountain range extends virtually throughout the length of the country with most near-mountain regions receiving an average rainfall of 16-30 inches per year. It is probable that there are accessible locations where limited capacity, high head hydro plants could be constructed economically, even on small mountain streams. These plants would have small reservoirs, sufficient for daily or weekly regulation, with heads most likely in the range of hundreds of meters. With flows of a few hundred liters per second, the developed capacities could be measured in megawatts. The Atlantic side of the Atlas ranges have significant population centers, e.g., Tanger, Taza, Fes, Meknes, Marrakech, Agadir, etc. While all significant large-scale centralized hydro sites have been developed or are under development, small hydro plant development definitely should be investigated. The following measures are recommended:

(a) A survey of locations for installation of small hydro plants along the whole mountain range be made and classified as to the potential of their development;

(b) The hydrological and stream flow parameters for each site be evaluated on the basis of available meteorological or stream gauging data. Where such data are missing, the data should be collected.

(c) Preliminary geological appraisals of selected sites be made by site inspection or on the basis of available geological explorations made for other purposes (mining, etc.). Possibility of slides and other geological eventualities such as erosion, etc., also should be evaluated;

(d) Power market and transmission facilities for individual or groups of selected sites be studied;

(e) After completion of the above sites, the most viable sites be selected and prefeasibility studies performed which would narrow the field for feasibility studies and eventual final design and implementation of small hydro plants.

3.3 Power Market and System Studies

The Moroccan energy production statistics indicate that about 14 percent of energy is lost in the transmission and distribution network. This is a rather high loss and indicates that some improvement could be made in the transmission system. An effective transmission system would permit more efficient utilization of the existing plants and an easier planning of

new, small, thermal and hydro plants by connecting them to the national grid. The new power plants could be located convenient to the fuel or energy sources. Thus, the team recommends that power market and system studies be conducted to increase utilization of the existing generating facilities and to assist in the planning of future facilities.

4.0 Non-Conventional Energy

The Government of Morocco requested AID Energy team to investigate the feasibility of establishing a solar institute in Morocco. The solar report is in Section 4.1. The team also examined briefly other alternative, renewable energy resources such as biomass, wind and hydro. While additional data on renewable energy resources are needed, the potential for using these energy resources appears to be large. The energy team encouraged the Government of Morocco to consider establishing a Renewable Energy Institute of which the solar center would be part. This institute would be responsible for coordinating renewable energy activities and managing applied research. Sections 4.2 and 6.0 discuss further the team views on renewable energy potentional in Morocco.

4.1 Solar Energy

The Govermment of Morocco specifically requested the AID Energy team to examine the feasibility of establishing a solar center in Morocco. The limited data available to the team indicated that solar energy could contribute an important part of Morocco's energy demands. As the solar center is just a concept at the present time, this report concentrates on the organization of the center. It should be emphasized however that the team felt that the solar center should be part of a Renewable Energy Institute which would include such energy sources as wind, solar, biomass and hydro.

The solar center should study Morocco's energy problems and determine how solar energy could best be used in meeting energy demands. The center would plan projects which make technical, economic and social sense; analyze their probability of success and carry through the design, supervision of construction, implementation and final evaluation of the projects.

The following gives a discussion of a possible mission, structure and operation of the solar center, discussing also personnel requirements. Projects which seem to have good potential for success in Morocco are also discussed. It is important that the solar center be established properly, be supported at the appropriate Government levels, work efficiently and have some definite results toshow for its efforts within a reasonable time. The center thus could demonstrate the potential economic, technological, and social impact that solar energy could make in Morocco.

Solar Center

The solar center must be set up properly to be effective and must have a conceptual plan, a mission and objectives, an efficient structure, good personnel and excellent leadership, and worthwhile projects to promote.

Concept:

The solar center should include the following functions:

1. Develope an intergrated plan for solar energy research and utilization in Morocco.

2. Develop a data bank on solar energy and energy related subjects covering renewable energy resources. It should provide for dissemination of this information.

3. Develop a research facility to carry out basic and applied work, specifically applicable to Morocco.

4. Develop technical capabilities and provide technical assistance to architects, engineers and industry in the utilization of solar energy.

5. Set priorities of solar energy and other renewable energy projects in the light of national and/or local needs.

6. Develop capabilities to examine legal ramifications of the utilization of solar energy.

7. Set minimum performance standards for solar and renewable energy conversion equipment.

8. Help with or provide funding for projects in solar energy and energy conversion activities.

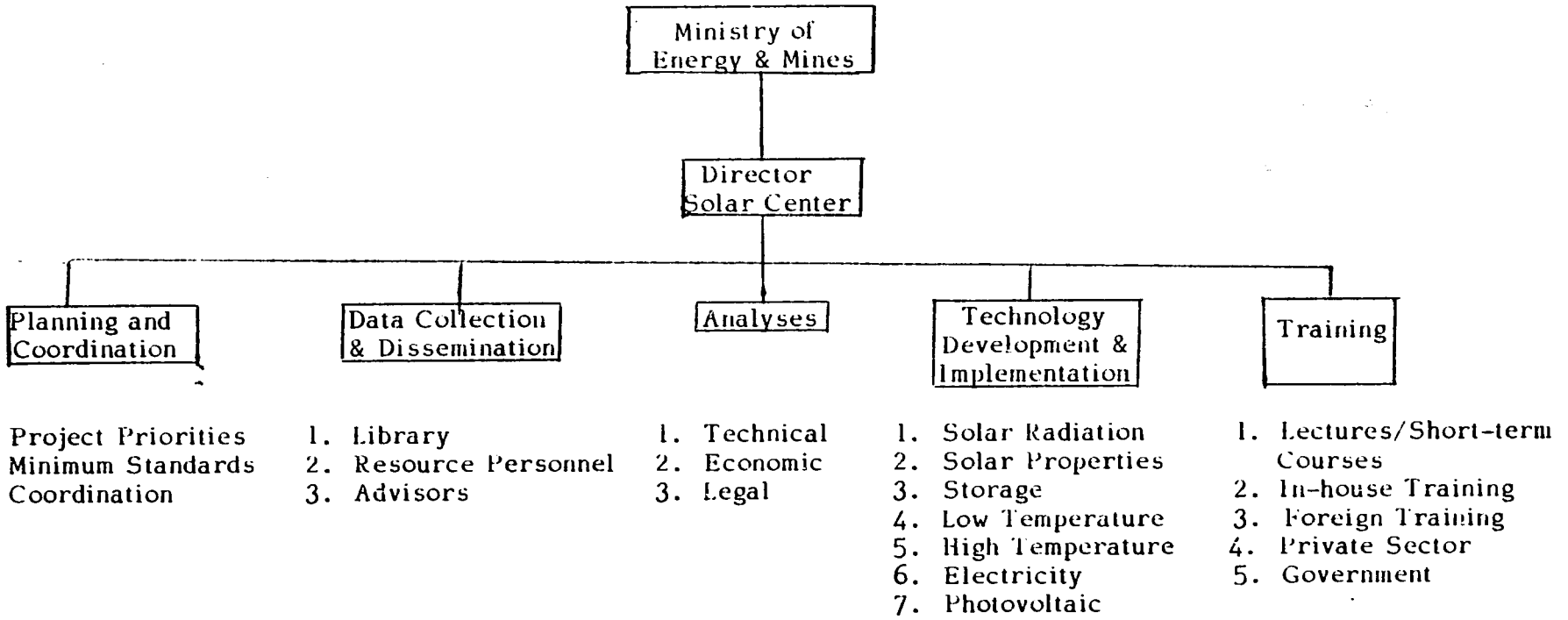
9. Coordinate activities in the solar energy field between government agencies, the private sector and universities.

Structure of Solar Center

The organization of the solar center will depend on its size and relationship to the Ministry of Energy and Mines. It should include the following divisions (see block diagram):

1. Directorate:

The Director is responsible for the administration of the center. He sets policy, in coordination with other appropriate officials, and coordinates with other agencies and


Ministry of Energy & Mines
Director Solar Center
Planning and Coordination
1. Project Priorities
2. Minimum Standards
3. Coordination
Data Collection & Dissemination
1. Library
2. Resource Personnel
3. Advisors
Analyses
1. Technical
2. Economic
3. Legal
Technology Development & Implementation
1. Solar Radiation
2. Solar Properties
3. Storage
4. Low Temperature
5. High Temperature
6. Electricity
7. Photovoltaic
Training
1. Lectures/Short-term Courses
2. In-house Training
3. Foreign Training
4. Private Sector
5. Government

utilization or solar energy. The work of this group could also be done by another division.

6. Technology Group:

Solar energy conversion and utilization is an important technical problem. For successful application of solar energy, technical information on solar energy must be available. This can be obtained through a solar radiation network. Solar properties of materials must also be determined.

Solar energy conversion should be divided into Low Temperature (non-concentrating - flatplate) applications and High Temperature (concentrating) systems. Electricity generation, if done by solid state rather than high temperature conversion, could form a separate group.

7. Training Group:

The solar center must be staffed by technically competent, knowledgeable personnel. It is not easy to find persons with technical background in solar energy. Thus the solar center will be responsible for the training of its personnel. Key officials of the Moroccan solar center should be sent for training to solar centers around the world. These solar energy centers should have a good technical program and working equipment which the Moroccans can train on. Upon their return, they can set up a Moroccan training program to train others in Morocco and neighboring countries. If necessary, foreign lecturers and professionals can be sent to Morocco to assist in developing the training program

organizations in the energy sector.

2. Planning Group:

This group is responsible for developing an intergrated solar research and utilization plan. It sets project priorities in conjunction with national and/or local needs. It sets policies on codes, ordinances, and minimum standards for solar equipment. It coordinates the various activities in the solar energy and energy conversion field to insure maximum efficiency and effectiveness.

3. Data Gathering and Information Dissemination Group:

This group collects information on energy resources in Morocco and in neighboring countries, particularly data relevant to solar applications. It provides advisers on solar energy who can answer questions or direct people to the correct source. The library collects international publications on solar energy and provides leaflets, pamphlets and possibly a newsletter to let people know what is going on in the solar energy field.

4. Analysis Group:

The objective of this group is to provide expert analyses of proposed plans and projects. It coordinates closely with other divisions of the center. Depending on the size of the solar center, this group could be part of the Planning and Coordinating Division or the Technology and Implementation Division.

5. Legal Group:

This group looks at legal ramifications, effects of codes, oridnances, laws, sun rights, etc. in connection with the

This training can be provided by lectures, short courses, special courses tailored to technical people (in special areas such as air-conditioning, distillation, irrigation, etc.). The training group is also responsible for the preparation of training manuals and other training materials, both for the solar center and the private sector.

8. Personnel:

The proper selection of personnel for the solar center is a most important factor in insuring the success of the organization.

The Director, as head of the solar center should have a good background in appropriate technology and solar energy (obtained by training after coming on board if necessary), be interested in practical applications and have a broad background in development activities. He should have the ability to inspire his co-workers and have enough stature to advise the Ministry of Energy and other high-level government officials of the necessary decisions that have to be made to promote the development of solar energy in Morocco. He should maintain contact with other professionals in the solar energy and alternate energy conversion field in other countries.

The Division Heads should have qualifications similar to that of the Director. International training at established solar energy centers probably would be desirable.

9. Solar Center Facilities:

The solar center should have a large enough site to house all personnel together. This promotes effective interaction between members of the center. The solar center should house the groups mentioned above and in addition a research facility, testing and evaluation facility, demonstration facility, training facility and visitors center.

To promote the coordination of all types of renewable energy resources sufficient property and facilities should be available to expand the solar center into a renewable energy center by adding wind, hydro and biomass components.

Suggested Projects for Solar Center

Solar energy has numerous applications. A brief investigation indicates that the following areas could use solar energy in Morocco.

1. Water Heating

Residential housing, hospitals, infirmaries, schools, hotels, restaurants, industry, laundries, etc.

2. Space Heating

Residential housing, government buildings, schools, hospitals, hotel restaurants, institutions, industry, etc.

3. Water Purification

(Sea water conversion, liquid waste recycling), residential housing, rural villages, schools, infirmaries, hospitals, restaurants, industry, etc.

4. Sewage Treatment

Heating of sewage digesters for higher production, drying of sludge, etc.

5. Solar Drying

Food preservation, agricultural crop drying, ore drying to reduce shipping weight, lumber drying, etc.

6. Solar Cooking

Rural community center cooking facilities with 24 hour cooking capability, domestic use, restaurants, schools, hospitals, etc.

7. Bulk Water Heating

Heating of any large vat, schools, hospitals, institutions, sports arenas, industry, etc.

8. Cooling and Refrigeration

Space conditioning in schools, hospitals, government buildings, cold storage installations, food preservation, etc.

9. Irrigation

Using solar pumps, rankine, stirling - hot air type engines, pumps, exotic engines, etc.

10. Electricity Generation

Small Scale (solar cells, etc.), domestic, village, remote sensing, transmitters, instrumentation, education, (radio, TV - send weather, agricultural information to remote villages as to when to plant crops, etc.)

Large Scale, solar cells arrays, thermoelectric conversion, power tower type conversion.

4.2 Bio-Resources

Today more than 50% of the total energy consumed by many of the developing nations is supplied by their bio-resources. The AID energy team has not had the opportunity to examine what part of Morocco's energy comes from its biomass but it can be expected that a very large measure of Moroccan energy comes from its biomass and animal waste.

This supply of energy principally goes to its rural and poor urban population and is used primarily for domestic purposes, i.e. cooking and hot water. In addition, some of this energy is used for small-scale industries such as tanning, soap making and food processing.

As in most developing countries, Morocco has not yet measured the availability of biomass nor studied seriously its potential uses as an energy source. Wood and other vegetation is currently used as a biomass energy source. However, it is consumed at a rate that probably far exceeds its normal replacement capacity. In some countries the rate of use is five times the rate of replacement; in Morocco it may be the same. Therefore, there is a real possibility that a serious shortage of this substantial energy supply will soon occur.

The idea of developing a renewable source of biomass to be used for energy purposes is beginning to take form and be accepted in some parts of the developing world. This idea has been fostered by scientists who have researched plants that are suitable for growth under harsh growing conditions, that produce

abundant mass (20-30 tons per acre), and that have fairly high BTU content or high gas or liquid conversion potential. Coupled with the research of vegetation suitable for energy production there has been a heightened interest in utilization of biomass for fuel either by direct combustion or by conversion to liquid or gas. Two medium-sized cities in the U.S., Burlington, Vermont and Eugene, Oregon, plan to generate their entire electric supply from wood combustion. The wood product industry of the U.S. is almost entirely independent of commercial electricity because of their use of wood as a fuel for electricity. Brazil is supplying as much as 18% of its liquid fuel from biomass.

In discussing the potential for development of biomass for fuel with experts of the Moroccan Ministry of Agriculture and Department of Waters and Forests, it seems that there are adequate areas in Morocco that would support the growing of biomass for fuel. There is keen interest in examining this sector in more detail and one could expect strong collaboration in pursuing the many phases of biomass development and utilization that are possible.

To pursue this sector of the energy field, it will be necessary to create a working organization capable of a) planning the mechanics of introducting biomass production for energy purposes, b) introducing the technology of biomass production and utilization, c) implementation and management at a scale large enough to be viable to both grower and user. This will take a serious effort to develop individual and institutional

capacity strong enough to support a permanent activity for bio resource energy purposes.

The first step will be to find a place for a bio resource organization in the Moroccan Energy and Agricultural hierarchies and to provide familiarization and specialized training to Moroccan scientists and technicians who are already developed in certain basic sciences. The proposed Moroccan Renewable Energy Institute might be the ideal location for this activity. As much of current technology is being developed in the U.S., it may be necessary to concentrate on developing some English-speaking skills to facilitate placing Moroccans in suitable U.S. specialized institutions. Once the organizational/personnel aspects of a bio resource effort have been established, programs and projects can be developed, i.e. examination and cataloguing of acceptable growing areas, investigation of areas where bio energy could be substituted for conventional energy.

5.0 Energy Investment and Economic Development

Based on documentation given the team and conversations with Moroccan officials, especially Energy Minister, Moussa Saadi; the Director of Energy, Mohammed Sdiqui; and the Chief of the Division of Energy Resource Development, Houmad Houdaigui, the team investigated a number of projects. As these and other energy projects require a very large investment, calculations were done to estimate the financial implications of the growth of the energy sector.

Given the limited data and the time available to develop necessary information, a simple method was used to make gross estimates. [1] In the 1973-77 Five Year plan, the mean annual investment in energy was reported at $160 million. (All cost in this section are in U.S. dollars unless otherwise noted.) Using the 1977 GNP of $9,555 million as a base figure, energy investment comprised 1.6% of the GNP. The energy investment includes construction of refineries, electric plants, capital equipment, research studies in exploration. Energy consumption costs, mainly oil, are not included.

A roughly comparable investment program for the proposed 1978-1982 Five Year energy plan showed a very large projected growth for energy investment. Using 1978 estimated GNP of $11,300 million as a base and the forecast mean annual energy investments of $515 million, the proposed 1978-1982 energy plan would require energy investments equal to 4.6% of GNP. Such

[1] See Appendix A

a large increase from 1.6% to 4.6% of GNP is worthy of note. The implementation of such an energy investment plan probably would cause economic dislocations at different points.

Upon further discussion it was found that an internal GOM review of the proposed Five Year plan has resulted in a similar conclusion and on June 4, 1978 King Hassan II cancelled the Five Year plan and requested that a more modest Three Year plan be drafted. During the visit of the AID team, that plan was under discussion in the government and the parliament and no final plan had been prepared as of this writing.

However, officials in the Ministry of Energy showed us a draft of their proposed Three Year energy plan. Once again using 1978 estimated GNP as a base year, the new energy investment program was projected at 2.9% of GNP, down from the 1978-1982 Five Year plan requiring 4.6%, but up from the 1973-1977 Five Year plan requiring 1.6%. Thus, a more modest allocation was made. The reductions occured primarily in postponing oil shale investments and the projected capacity to produce electricity.

Without more extensive investigation, the team could not comment on the reasonableness of the new plan, given Moroccan development objectives. However, the Five Year plan projected to 1982 seemed consonant with the goal of reducing dependency on oil imports (which now provide 80% of Moroccan commercial energy requirements.) A shale oil plant capable of meeting 10% of current oil demand would require a capital investment of $80 to $90 million.

Current oil imports average 50,000 barrels a day. By the time a 7,000 barrels/day shale oil plant is built, the oil consumption probably would be higher.

In response to this dilemma, the team felt that energy planning should be considered on a different plane. Current projections of need are based on extrapolating past consumption figures. The implication is that the capital intensive economic development programs of the past will characterize the future. However, energy projects illustrate that this form of economic development cannot continue without major investment shifts into the energy sector, at the expense of other sectors. This dilemma has implications for both energy and economic development investors.

Rather than planning energy investments from an extrapolation of past growth matched against known domestic or imported energy resources, energy planning should be made in an economic development context. This requires analysis of economic development and projects at the regional level and a search for a broader range of economically viable energy alternatives for particular regions and projects. At the regional level, it is much more likely to discover energy sources suitable to economic development needs (e.g. crop drying as part of an agricultural export program requiring reduction of spoilage or small decentralized hydropower sites or other decentralized energy sources in a region which is slated for decentralized light manufacturing.)

Current energy planning has concentrated on large scale projects. On site hydropower generation or thermal energy

potential from the sun or biomass are considered minor contributors to national energy production. Investments in major electric or oil shale facilities appear to offer the only significant opportunities. As a result, the highest forms of energy are considered where specific projects might be able to use lesser forms of energy, thermal or mechanical energy rather than electricity from oil.

The benefits of different forms of energy can be brought to regional scale projects. Hydropower from small streams may not contribute significantly to the national electric grid, but manufacturing in regions near mountain streams can eventually contribute to the total national economic productivity. However, if economic development planning is centered on the cities, then energy planning must also be, and the result is the dilemma posed earlier: no more energy is possible without major investment, so the ability to invest in urban industry is lessened.

Since Morocco favors decentralization of its economic development, it could now make the investment decision to decentralize energy production as well. That coordination of investments could result in greater national results aggregated from the regions near diverse energy sources, than would arise from an entirely centralized capital intensive investment program. Without considerable effort in planning for investment coordination in this fashion it is difficult to quantify the likely opportunities to be found by decentralizing both economic development and energy investments together.

This kind of coordination of investments does not alter the need for centralized energy and economic development but it does encourage that 1) new energy sources be applied and 2) sources suited to particular forms of work be better matched. Decentralized energy investment is required for these benefits and close work with economic development programs is needed.

This conclusion reinforces the team's technological evaluation in the first parts of this report. In hydropower, the more expensive centralized station was shown to have unfavorable economic return compared to other alternatives; small decentralized hydropower and biomass was suggested for serious consideration. Likewise the Renewable Energy Institute will concentrate on favorable applications. The shale project is very expensive and the resulting electricity or oil should not be used where less expensive alternatives can do the same work.

The team suggests that the Government of Morocco select some areas for coordination of regional economic and energy planning, especially in regions where there is potential for small hydropower, biomass or solar energy and quantify the expected benefits. If successful, this approach could be expanded to include more regions. This approach is consistent with this team's technical recommendations, especially the Renewable Energy Institute, for that institution would be most likely to encourage and recognize opportunity for non-conventional applications.

In order to do this type of energy management planning some training will be required. Thus, it is recommended that training, either in the U.S. or in-country, be given to a Moroccan group to accomplish this linking of decentralized economic development and multiple source energy management.

According to the Prime Minister's Office of Planning, the national plan is discussed at the regional level. If the Ministry of Energy has people trained to recognize and introduce new energy sources, there will be communications mechanisms to see that opportunities are identified. While regional development programs are logical places to identify energy efficient applications, the energy skills are currently concentrated at the central government level. Thus, the introduction of energy innovation will require the initiative of the Energy Minister who will work at the interministerial level and send his staff to assist regional officials in choosing appropriate technologies. The existence of this process can be especially important to the success of the Renewable Energy Institute.

ENERGY INVESTMENT RATIOS

Plan of 1973 - 1977 (Actual)

5 year expenditure
3,246,409 DH
(in millions)

1977 GNP $9,555 (Million US $)
Mean annual energy investment
$160
% of GNP 1.6%

Proposed Plan of 1978-1982

Projected 5 year expenditure
10,412,000 DH
(in millions)

1978 GNP $11,300 (Million US $)
Projected mean annual energy
investment $515
% of GNP 4.6%

Modified Proposed Plan 1978-1980

Projected 3 year expenditure
3,711,400 DH
(in millions
includes Sahara region

1978 GNP $11,300 (Million US $)
Projected mean annual energy
investment $330
% of GNP 2.9%

4 Dirhams = US $1.00

References:

GNP estimates
Key Economic Indicators 1976-1978
AID Country Summary

5 Year Proposal -
Preparation du Plan de Developpement Economic et Social 1978-1982
Rapport du Groupe Energie - Energies Nouvelles Ministere de l/Energie et des Mines Octobre 1977

3 Year proposal - Draft Internal Report

6.0 AID Project Recommendations

The Energy Team concluded that there are basically two energy sources that can minimize and possibly eliminate for the foreseeable future, any need for Morocco to turn to nuclear energy. These are renewable energy sources (solar, biomass, hydro and wind) and shale oil. Use of these energy sources will benefit people living in rural areas by providing reliable energy sources for improved agriculture and social services.

AID could help Morocco develop these new sources. The recommendations listed below outline the form the assistance could take. The recommendations must, of course, be reviewed further by AID/Washington and USAID/Morocco before any project documentation can be prepared. The costs associated with each recommendation are preliminary estimates. Nevertheless, the following projects could form the basis for a viable AID energy assistance program in Morocco.

6.1 Non-Conventional Energy

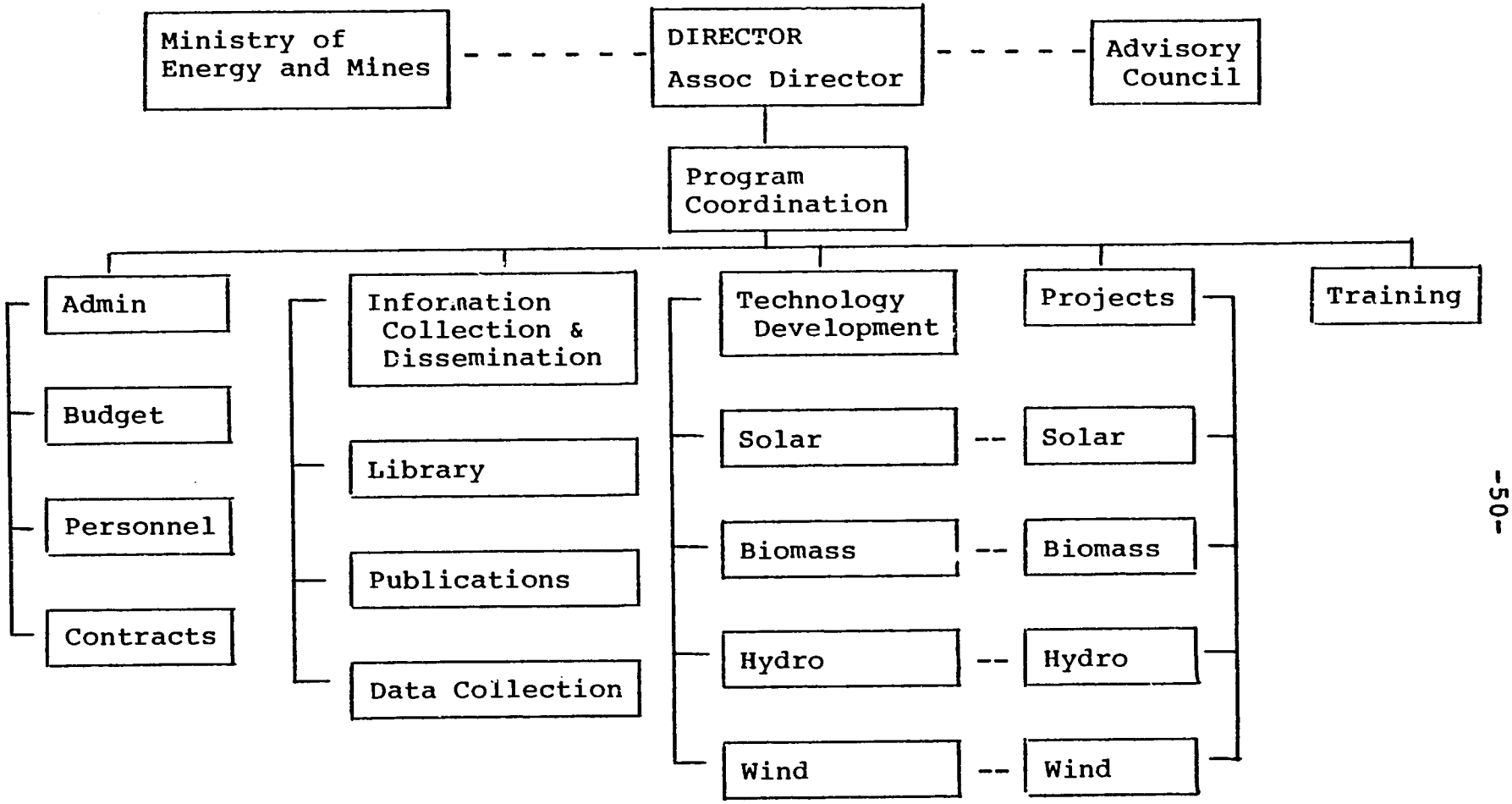
We recommend that AID assist the GOM in establishing a Renewable Energy Institute (REI). The initial idea of the GOM was to create a separate institute for direct solar applications. However, a Renewable Energy Institute encompassing solar wind, biomass and decentralized hydropower would increase greatly the Moroccan effort in the non-conventional energy field. As wind, biomass, solar and even hydropower are all influenced by similar factors, it is reasonable that one organization be responsible for developing their potential in Morocco.

The Ministry of Energy of Mines has set aside a one hectare site next to the School of Mines in Marrakech for the solar center. According to Energy Ministry Officials, land adjacent to the site is available for expansion. If the REI were established with its center in Marrakech, there could be sub-centers in other parts of Morocco. For example, the biomass program might be connected with reforestation activities in the Zaer region. The decentralized hydro program may be most effectively implemented out of ONE office in Casablanca.

While the REI would be connected directly with the Ministry of Mines, an Advisory Council should be created for the institute. This Council, composed of representatives of all agencies involved in energy activities (i.e. Agriculture, Waters and Forests, Industry, Energy and Mines, ONE, Universities, etc.) would meet periodically to review the institute program and suggest areas for adaptive research. The Advisory Council would also be a good forum in which to coordinate the renewable energy activities of various government agencies and the private sector.

The structure of the renewable energy institute must be designed to fit in to Moroccan political, social and cultural institutions. A suggested organization chart, which can be the basis for further discussion, is diagrammed on next page.

Direct AID support for the Institute would involve technical training in the United States and equipment. A three-year, $1,740,000 program is proposed. The exact phasing for training


Ministry of Energy and Mines
DIRECTOR
Assoc Director
Advisory Council
Program Coordination
Admin
Budget
Personnel
Contracts
Information Collection & Dissemination
Library
Publications
Data Collection
Technology Development
Solar
Biomass
Hydro
Wind
Projects
Solar
Biomass
Hydro
Wind
Training

and equipment would depend partly on Morocco's schedule for establishing and staffing the center.

A. Training:

Director	3 months	$ 10,000
Planner	3 months	10,000
Information and Data Collecting Specialist	6 months	20,000
Engineering Technologist	12 months	40,000
Training Specialist	6 months	10,000
Additional Personnel (12 persons @ 6 months each)		240,000
Resident US advisor (1 year)		80,000
Visiting US advisor (short-term)		70,000
		$ 480,000

B. Equipment:

12 Pyrheliometers @ 3,000	36,000
24 Radiation Measuring Instruments @ 1,000	24,000
21 Solar Calorimeter and Black Box	100,000
1 Hot Box/Cold Box	50,000
1 Data Acquisition System	150,000
1 Remote Data Acquisition System	100,000
1 Standard Instrument Set	100,000
Test Stands and Instrumentation	100,000
Demonstration Hardware	600,000
	$1,260,000

6.2 Oil Shale

In order to assist the GOM in implementing shale oil projects and to benefit the United States through large-scale demonstration of the economic viability of shale oil retorting and direct combustion, AID should take the following steps:

1. Provide funding for personnel and equipment to assist in conducting the Timahdit *in situ* oil shale retorting test if the Occidental-Moroccan feasibility study is not performed.

It is estimated that a small vertical *in situ* retorting test could be performed in Morocco (at Timahdit) with the aid of DOE personnel for approximately $500,000. The pilot retort could be very small in comparison to eventual commercial retort size but it would test the basic concepts of vertical *in situ* retorting and permit scale up to commercial size at a later date. Basically, this test would require a design study, site development including excavation/mining, rubbelization, bulkhead placement and sealing the retort, placement of oil and gas removal piping, placement of a combustion initiation and maintenance system, retort operation, and monitoring equipment, and a post retorting evaluation study including testing and data analysis. It is recommended that AID fund the design study, assist in the purchase of monitoring and control equipment and fund the post retorting study. It is estimated that this would required approximately $300,000 of U.S. funds.

2. Provide the GOM with up to three specialists for six months each to work with the Ministry of Energy and Mines

to develop a project comparison methodology and help in the preparation of an oil shale project trade-off analysis. This analysis would be designed to be the basic document used by GOM to secure financing for the selected oil shale development project. One specialist should have an understanding of shale mining and processing technologies; another should have a background in large-scale chemical engineering project implementation and the third should be experienced in preparing documentation for use in securing investment capital from major private and public sector financial institutions. This assistance will cost approximately $200,000.

6.3 Hydropower

To date, the Government of Morocco has concentrated on large-scale hydroelectric projects, without investigating fully the possibilities for smaller, decentralized hydro applications. The energy team concluded, on the basis of available information, that the potential for decentralized hydro projects was large enough to warrant serious examination.

The office National de l'Electricite (ONE) and the energy team discussed in detail a decentralized hydro project. The plan proposes to develop small, high head installations in the Atlas mountain ranges for the electrification of the mountain valley and rural population along the foothills of the mountain range. If any higher capacity installation locations were found in the mountain range, the power can be transmitted economically even to the larger population centers such as Agadir, Marrakech, Beni Mellal, Midelt, Fes, Meknes, Tetouan, etc.

The installations should be simple with minimum maintenance service. The service, when required, would be provided from centralized pools. The pilot installations could be used as training centers for future developments. ONE staff noted that the mountain population is familiar with hydraulic installations as there are many small stone dams in existence for irrigation canal intakes. The new hydro installations would be something with which they are already partly familiar and would be easily accepted. Besides, they would not deprive the population of the irrigation water. The power installations would create

better conditions for small industry development, better utilization of the available resources. ONE estimated that some 15-20 percent of the country's population could be reached by these small installations.

Detailed estimates are below. It is expected that the installed capacities of such small hydro plants would reach from 500 to 5000 kW, and the produced annual energy from 1-10 million kWh per year.

ONE staff though that ONE should establish a special department for small decentralized hydro development. The initial survey work and prefeasibility study for individual sites would be done by the local consultants with the assistance of foreign consultants. A central office would be established in Rabat and Casablanca for processing the field information and the report preparation. Considering that some 600-700 km of mountain range has to be covered, the actual field work would be carried out from some five regional offices established along the mountain range. The suggested regions were as follows: Marrakech, Beni Mellal, Midelt, Meknes and Tetouan. The assigned hydro engineer and survey crews from these regional offices would traverse the mountain ranges and select in each area some 20-25 sites suitable for small hydro development. They would work in close cooperation with province governors and their staffs.

It was estimated that it would take some three months to organize and to launch the program and some 15 months to complete. The completed work would consist of preliminary drawings (1 or

2 per site), project description, power market and distribution line description, hydrologic and geotechnical conditions, capacity and energy estimations, cost estimates. It is visualized that the appropriate Moroccan authorities would then continue the work on the socio-economic side, i.e., the best energy applications for the benefit of the hydro installation in each community served.

In order to obtain the order of the cost of such a program, a preliminary estimate was developed during the meeting. The necessary funds were subdivided in local and foreign currency categories. The salaries for the foreign and local consultants and supporting staff include fringe benefits, overhead and fees.

Thus, expressing the estimate in U.S. dollars (4 Dirhams = 1 U.S. dollar) and rounding off, the following study cost was obtained:

Local Currency		$1,812,000
Foreign Currency		1,470,000
	Total	$3,282,000

PRELIMINARY ENGINEERING COST ESTIMATE
SMALL HYDRO INSTALLATION - PREFEASIBILITY STUDIES

All costs in Dirhams (1 US $ = 4 DH).
Foreign Staff 25% overseas allowances included.

Item	Est. Man-Months	Monthly Cost DH	Estimated Cost (DH) Local Currency	Estimated Cost (DH) Foreign Currency
CENTRAL OFFICE				
Foreign Proj. Mgr.	9	32,000 x 1.25	---	360,000
Local Proj. Mgr	9	20,000	180,000	---
Electrical Engineer	3	28,000 x 1.25	---	105,000
Mechanical Engineer	3	28,000 x 1.25	---	105,000
Foreign Cost. Eng.	3	25,000 x 1.25	---	93,750
Local Cost Eng.	3	20,000 x 1.25	60,000	---
Transmission Eng.	4	28,000 x 1.25	140,000	---
Draftsman	15	15,000	225,000	---
Typists	18	10,000	180,000	---
5 REGIONAL TEAMS				
5 Field Office Supv.'s	5 x 15	15,000	1,125,000	---
5 Surveyors	5 x 15	15,000	1,125,000	---
5 Draftsmen	5 x 15	12,000	900,000	---
20 Field Men	20 x 15	4,000	1,200,000	---
5 Hydro Engineers	5 x 15	30,000 x 1.25	---	2,812,500
1 Geologist (pt.t.)	15	25,000 x 1.25	---	468,750
1 Hydrologist (pt.t.)	15	30,000 x 1.25	---	562,500
5 Drivers	5 x 15	5,000	375,000	---
Totals	2,227		5,730,000	4,646,900
Expenses 15% Lab.			859,500	697,035
			6,589,500	5,343,935
Total Cost, including 10% contingency			7,248,450	5,878,328

6.4 Energy Management Training

The discussion team members had with various Moroccan officials indicated the need for energy management training. The five and three year energy plans do not appear to have been coordinated with or reflect general economic development plans. Energy needs have been projected based on past growth in energy demand without taking into account alternative energy sources or alternative development strategies. Thus, it would be useful if responsible Ministry of Energy and Mines officials could receive energy management training in the U.S. This training should cover the following areas: (a) regional economic development which would analyse investment in agriculture, commerce and industry, infrastructure and social services. The energy components of these investments and alternative ways of meeting them would be studied; (b) energy technologies appropriate to meeting energy demand would be studied. This would involve trade-off analysis between various technologies; (c) specific applications of various technologies would be examined. Ex: concentrating solar versus flat plate collectors; (d) finally, national energy planning in general would be covered. This topic is purposely left for the end of the course to emphasize the necessity of analysing energy demand from the user end. To attract responsible Ministry officials (who have limited time to travel and study abroad) the course should not last more than four weeks. It is possible that this training can be accomplished by incorporating it into the current Energy Management Training program conducted by AID/W.

6.5 General Energy Cooperation

In addition to the specific projects outlined above, it was suggested to the Energy Team that a more formal structure might be created for an annual energy review by the USG and GOM. This might be one way to respond to Moroccan ideas for a three-way relationship among the two governments and the private sector in energy matters. While a specific recommendation regarding the structure of energy relations between Morocco and the United States is beyond the scope of the Team's mandate, it is clear that there are sufficient energy activities to give substance to bilateral energy relations. There is much material for discussion and review: viz., technical assistance in solar, hydro and oil shale projects; energy planning and management; and the coordination of the distribution of risk for large new energy technologies involving the private sector.

7.0 Appendix

A. Officials contacted by Energy Team

Ministry of Energy and Mines

Moussa Saadi	- Minister
Taieb Skalli	- Secretary General
Mohamed Sdiqui	- Director, Direction de l'Energie
Mohamed Karbid	- Director, Direction des Mines
Rabah Bouchta	- Director, Division de l'Exploration Miniere
Abdellali Benchekroun	- Direction de l'Energie
Houmad Houdaigui	- Direction de l'Energie
Abderrafih Guessous	- Director General, Bureau de Recherches et de Participations Minieres (BRPM)
Mohamed Diouri	- Secretary General, BRPM
Sandor Szuts	- BRPM

Office National de l'Electricite (ONE)

Ahmed Tazi	- Director General, ONE
Mohamed Bekkali	- Directein de l'Equipment
Andre Fougerolles	- Ingenieur en Chef de l'Equipment
Daniel Murat	- Inqenieur en Chef de Mission Hydraulique
Mekki Berrada	- ONE

Ministry of Agriculture

Abderrahman Zaki	- Director, Department of Water and Forests
Abdelouahab Karmouri	- Chief of Economics Division, Department of Forestry

Ministry of Planning

M. Bijaad	- Secretariat au Plan et an Developpement Regional

USAID/Morocco

Harold Fleming
Eric Griffel
Mark Ward
Susan Gibson
Les Hall
Donald Walls

American Embassy/Rabat

Ambassador Richard Parker
John Brayton Redecker
Edgar Sourati

B. Resource Materials

I. Oil Shale

"Preparation du Plan de Developpement Economique et Social 1978-1982: Rapport du Groupe Energie IV - Energies Nouvelles," Ministere de l'Energie et des Mines, Rabat, Octobre 1977.

"Electrical Energy: Morocco's Estimated Requirements through 1995, and a Review of GOM's Investment Options for New Power Generating Facilities During the Latter 1980's," Airgram from the U.S. Embassy/Rabat to Department of State, July 10, 1978.

U.S. Department of Energy, Foreign Travel Trip Report - Morocco, June 24-July 2, 1978, "Potential of Oil Shale Deposits," Laramie Energy Technology Center.

"Timahdit Oil Shale Feasibility Study, Phase III Report, Preliminary Capital and Operating Costs for Oil Shale Production, Timahdit, Morocco," Tosco Corporation, June 1972.

"Schistes Bitumex de Timahdit," (DSE/ETN 99 132-78) Le Directeur de l'Office Nationale de l'Electricite a Monsieur le Ministre de l'Energie et des Mines, 6 Fevrier 1978.

"Schistes Bitumex de Timahdit," (DSE/ETN 99 270-78) Le Directeur de l'Office Nationale de l'Electricite a Monsieur le Ministre de l'Energie et des Mines, 23 Mars 1978.

"Etude Technico-Economique et Planning de Realisation du Project Centrale Hydro-Electrique a Sebkhat Tah," Rapport M.E.H. No. 1, Rabat, Octobre 1977, Ministere de l'Energie et des Mines.

"Rapport d'Activite 1977," Office National de l'Electricite.

II. Hydro

"Amenagement Hydro-Electrique de Sebkhat Tah," Office National de l'Electricite, January 1978.

"Etude Technico-Economique et Planning de Realisation du Projet Centrale Hydro-Electrique a Sebkhat Tah," Rapport M.E.M. No. 1, Ministere de l'Energie et des Mines, October 1977.

"Project d'Etude pour la Realisation de Complexes Energetiques, Hydrauliques, Siderurgiques et Petro-Chimiques dans les Provinces Sahariennes," Note Technique SE No. 4 (M.S.), Ministere du Commerce, de l"Industrie, des Mines et de la Marine Marchande, December 1975.

"Rapport d'Activite, 1977", Office National de l'Electricite.