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ENERGY POLICY AND TECHNOLOGY IN EGYPT

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* The opinions expressed in this document are those of the authors and do not necessarily reflect the views of the United Nations Economic Commission for Western Asia.

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INTRODUCTION

This paper describes insights which have been generated following a joint U.S.-Egyptian project performed under USAID funding with support from the Government of Egypt by The MITRE Corporation and representatives selected by the Government of Egypt.* The objective of that project was to delineate areas for potential assistance initiatives by USAID in the development of renewable energy resources in Egypt.** During the course of the work, an extensive survey was made of Egypt's energy system and associated Government of Egypt policies.

The authors would like to acknowledge the contributions made by the Egyptian and American team members to the success of that project. Their names are given in Attachment 1. In particular, the participation of the highly qualified Egyptian personnel was indispensible in enabling an adequate understanding of the Egyptian political, economic and social context to be developed.

*The opinion expressed are solely those of the authors and should not be taken to represent official U.S. or Egyptian positions or views.
**Overall project guidance was provided by Ms. K. Keys McManus, Mr. James Riley, and Ms. Janice Weber of USAID.

In any consideration of energy matters, it is impossible to escape the ramifications of the dramatic increase in world oil prices since 1973. Both oil-importing and oil-exporting countries have experienced profound changes as a result. As far as its energy situation is concerned, Egypt represents a middle ground between the extremes experienced by oil-importing countries on the one hand and oil-exporting countries on the other.

Egypt has sufficient petroleum to supply its immediate needs and to leave a small net surplus for export. Therefore, Egypt has had the ability to insulate itself from the recent turbulence of the world petroleum markets. However, this situation will not last indefinitely and Egypt may be faced with the necessity of making a painful readjustment to prevailing world prices, perhaps within the next 10 years. Correct planning and policies are necessary now if the ill-effects of this transition are to be minimized.

Egypt is a country of about 1,000,000 square kilometers. In basic geographic terms, Egypt forms part of the wide belt of desert which stretches from the Atlantic coast of Africa into the Middle East. As such, the country is largely arid and only lightly populated, except for the Nile Valley and Delta, where 95 percent of the population is concentrated. These areas also contain virtually all the land which is at present irrigated. This contrast between the rich cultivated lands of the Nile Valley and the surrounding barren desert is extreme, particularly in Southern Egypt; cultivation extends exactly as far as the irrigation system reaches, and ends abruptly at that point.

The current population of Egypt is about 40 million, increasing at about 2.3 percent per year. It is expected to reach 60 million by 2000[1]. Some 50 to 60 percent of the population live in rural areas, and the population density in the fertile rural regions is extremely high; perhaps 1500-2000 persons per square kilometer on average. However, a strong trend towards urbanization is present. The two largest cities of Cairo and Alexandria together contain about one-third of the population.

In 1977, the Gross Domestic Product of Egypt was LE. 7.3 billion, or roughly LE. 180 per capita (about U.S. $460 at the then-prevailing exchange rates)[2]. The Government occupies a dominant position in the Egyptian economy, and can set internal prices for most goods and services. Agriculture is the major economic activity, although a well-developed industrial sector exists, accounting for nearly 30 percent of the GNP.

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[1] The World Bank, World Development Report, Washington, D.C., 1978.
[2] International Monetary Fund, International Financial Statistics, Washington, D.C., April 1979.

Following a brief description of Egyptian energy production and consumption we note some Egyptian government policies which impinge on energy matters, and the paper concludes with an analysis of possible future trends and their impacts on energy technology.

THE EGYPTIAN ENERGY SYSTEM

Table I provides an overview of the Egyptian energy system in 1975. Total gross production was about 890 QJ*, and consumption was about 650 QJ, or about 660 kilograms of coal equivalent per capita. The difference of 240 QJ between production and consumption is accounted for by net exports and imports and losses. The major components of this difference are oil exports (110 QJ) and flared or injected gas (120 QJ).

The table illustrates a country in transition. Traditional (or "non-commercial") energy sources, such as crop residues, animal wastes, and muscle power still occupy an important place in the energy economy and provide about one-third of energy consumption.** However, the new energy sources of oil (especially) and natural gas are assuming dominant roles as Egypt develops from a simple, largely self-sufficient rurally-based economy towards an urban, industrial and commercial economy.

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*1QJ = 10^{15} joules. Note that 10^{15} Btu (1 quad) is 1050 QJ; therefore Egypt's energy consumption in 1975 was about 0.62 quads.
**The figures for non-commercial energy production and consumption must be, perforce, rough estimates.

TABLE I

OVERVIEW OF EGYPTIAN ENERGY SYSTEM
1975 Figures in 10^{15} Joules

DEMAND SECTOR	ENERGY SOURCE: ELECTRICITY	OIL	CROP RESIDUES AND WOOD	ANIMAL WASTE	COAL	GAS	MUSCLE POWER	HYDRO	TOTAL
Rural Residential	0.9	29.9	173.5	43.0	-	-	-	-	247.3
Agriculture	-	15.4	-	-	-	-	6.6	-	22.0
Urban Residential	5.2	26.0	-	-	-	-	-	-	31.2
Industry (Iron and Steel)	17.4 (Industry: Iron and Steel, Feedstocks, Other)	60.9 (Industry: Iron and Steel, Feedstocks, Other)	-	-	30.0	0	0	0	122.0 (Industry: Iron and Steel, Feedstocks, Other)
Industry (Feedstocks)			-	-	-	8.2	-	-	
Industry (Other)			-	-	-	5.5	-	-	
Public Utilities	2.0	-	-	-	-	-	-	-	2.0
Transportation	0.7	64.8	-	-	-	-	-	-	65.5
Other	1.4	66.1	-	-	-	-	-	-	67.5
Electric Generation	-	46.9	-	-	-	-	-	78.0*	124.9
Exports (net)	-	114.5	-	-	-30.0	-	-	-	84.5
Losses	2.3	24.5	-	-	-	124.6**	-	-	151.4
Domestic Consumption	27.6	310.0	173.5	43.0	30.0	13.7	6.6	78.0	654.8***
Domestic Production	29.9	449.0	173.5	43.0	-	138.3	6.6	78.0	888.4

*Valued as equivalent energy input to fossil-fired stations
**Nearly all flared or reinjected
***Excluding electricity

Source: GOE/USDOE, Joint Egypt/United States Report on Egypt/United States Cooperative Energy Assessment, Vol. IV, 1979

As noted in the introduction, Egypt is fortunate in being self-sufficient in energy. Four major sources supply the bulk of domestic consumption. These are: oil (310 QJ); crop residues (176 QJ); hydropower (78 QJ*); and animal wastes (43 QJ). In addition, some 30 QJ of coal is imported for metallurgical purposes. Natural gas is used to only a small extent (14 QJ), despite its large actual supply (138 QJ).

In terms of demand sectors, rural residential consumption amounts to 247 QJ, with agriculture (a closely related area) consuming another 22 QJ. The bulk of this consumption is supplied by non-commercial fuels. Electric generation consumes 125 QJ (including hydro), and industry consumes 124 QJ (including public utilities). Transportation consumes 66 QJ, and urban residential uses consume 31 QJ, leaving about 68 QJ unaccounted for in other uses.

A number of comments can be made concerning Egypt's energy supply and demand structure. On the supply side, the lack of use of natural gas is due to lack of suitable infrastructure, such as pipelines. This deficiency is being remedied rapidly, and much

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*Evaluated as equivalent input energy to fossil-fueled generating plant.

greater use of natural gas is expected, primarily in industry. On the demand side, the very high rural residential use (compared to other factors) is due to the inefficiency of the ways in which crop residues and animal wastes are used; much of the consumption involves cooking over an open fire or in a traditional mud oven. The end-use efficiency of open-fire cooking is estimated at 5-10 percent.*

Egypt's relatively large industrial sector is illustrated by the level of energy consumption in this sector, amounting to 38 percent of domestic consumption, when electric generation is included. The composition of the "other" component in the table is not known, but may include non-energy uses outside industry, and commercial use.

Table II shows more recent estimates of the overall availability of energy resources. Egypt is, relative to many developing countries, quite well placed for oil and natural gas. However, proven reserves to permit the expansion of production as projected by the state oil and gas companies over the next twenty years are not fully identified.

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*Relatively simple and cheap designs are available for home-cooking stoves using traditional fuels which could double or triple this efficiency.

TABLE II

ENERGY RESOURCE AVAILABILITY IN EGYPT

OIL	1977 production: 20 million tonnes per year. 1977 reserves: 600 million tonnes approximately. Production increasing; adequacy of resources to meet production goals to 2000 highly uncertain.
GAS	1976 production: 400 million M^3 1976 reserves: 100 billion M^3 Production increasing; adequacy of resources to meet production goals to 2000 uncertain but potentially good.
COAL	Limited economically recoverable reserves; about 36 million tonnes in Sinai. (Best potential use: blend with imported coaking coal.)
HYDRO	Aswan High Dam: 2100 MWE Aswan Low Dam: 220 MWE Limited additional potential. Adequate sites for pumped storage appear to be available.
URANIUM/ THORIUM	No currently economic reserves. Geology appears favorable, although detailed explorations have not been conducted.
SOLAR	Excellent resource potential; daily insolation 4000 to 9000 kilocalory/M^2, depending on location and season. Good wind resource (12-18 mph average) along parts of coasts.
BIOMASS	High current non-commercial use (about 220 QJ/year).
GEOTHERMAL	Very small potential based on current data.

Sources: GOE/USDOE Joint Egypt/United States Report on Egypt/United States Cooperative Energy Assessment, 1979.

Large gas fields are being brought on line and will greatly expand industrial utilization of this resource over the next few years, particularly in fertilizer production. There are no plans at present to build gas distribution systems for residential and commercial use. In contrast, no large oil fields have been discovered in the past several years, although exploration is continuing. Therefore, further large expansions in oil production must rest on new discoveries, since known fields are nearly fully committed now.

Some uranium and thorium deposits exist in Egypt, but their economic potentials appear dubious at current world prices.

Egypt has interesting prospects in renewable energy sources. The success of hydro-electric generation along the Nile is well-known. Insolation is very good and solar thermal applications for industry and residential/commercial hot water are promising. (Space heating needs are limited by the warm climate and solar applications are unlikely in this area.) Solar crop drying may also be feasible. Good wind regimes exist along the North-West and Red Sea coasts. Potential applications include irrigation pumping on the North-West coast and remote (off grid) electricity generation. However, low cost technologies to exploit these resources are not fully developed and/or commercialized as yet.

In addition, Egypt has considerable biomass resources. Although these are already fully utilized, improvements in end-use efficiency are possible (e.g., by the use of improved rural stoves or biogas digesters). Such improvements would have the beneficial effect of releasing organic matter for soil conditioning. Soil quality is a matter of great concern in Egypt, with its limited arable land and overall food deficit, and any improvements would be very welcome, as well as potentially reducing demand on other energy sources for fertilizer production, or freeing fertilizers for export.

EGYPTIAN ENERGY POLICIES

Energy policies can basically be divided into supply-side policies and demand-side policies. Supply-side policies are government measures designed to control or influence energy production, or which indirectly have effects on energy production. Demand-side policies are those which control or influence the demand for energy in terms of either the type of energy used or the quantity.

We shall consider supply-side policies first. Egypt is committed to developing its indigenous energy resources as rapidly as possible, largely through the medium of the state-owned petroleum and gas production operations. This policy has had considerable success, as evidenced by Egypt's position as a modest energy exporter. Egypt's success in hydro-electric development is, of course, widely known. Conventional hydro resources are now nearly fully committed, and the Qattara project* will require many years before fruition. In addition, the Egyptian government has expressed interest in exploiting renewable resources other than hydro, and has recently

*The Quattara Depression lies about 100 miles south of the Mediterranean coast, 300 miles west of Cairo. It is approximately 400 feet below sea level, and the Qattara project would drive a series of canals and tunnels to allow the generation of hydro-electric power from the inflow of sea water to the Depression.

set up a coordinating council for this purpose. Some pilot and demonstration programs dealing with solar energy are under way, but large scale impacts have not yet been made. Egypt has recently contracted for the construction of a nuclear power plant; this is likely to reduce the growth of petroleum consumption in electricity generation.

Thus, the Egyptian supply-side policy appears basically to be one of concentrating attention on the development of oil and gas resources and, recently, nuclear. The development of other energy resources is also being promoted but with less emphasis at present.

The impacts of the de facto demand-side policies of the Government of Egypt are very significant. Because of the position which the Government of Egypt occupies in the economic life of the country, it is able to control prices for many materials, including basic foods and energy supplies. In general, the prices are set well below world market levels.

The extent to which Egyptian domestic prices differ from world prices for petroleum products is shown in Table III. Butane, kerosene and fuel oil sell in Egypt at less than one-eighth of their world prices. A similar pricing structure is found for electricity (Table IV), although the differences between world and domestic prices are not quite so great, domestic prices for electricity being about one-sixth of world prices.

TABLE III

FUEL PRICE LEVELS IN EGYPT (1979)

FUEL	WORLD PRICE L.E./10^9 J*	LOCAL PRICE L.E./10^9 J	RATIO OF WORLD PRICE TO EGYPTIAN PRICE	LOCAL PRICE EXPRESSED IN U.S. UNITS
Butagas	9.20	2.10	4:1	$1.30/Mcf
Kerosene	3.90	0.48	8:1	$0.10/Gal
Mazout (Residual fuel oil)	2.95	0.17	17:1	$0.03/Gal

*L.E. 1 = $1.40 U.S.

10^9 J = 0.95 x 10^6 Btu

Source: Egyptian Ministry of Petroleum

TABLE IV

EGYPTIAN ELECTRICITY GENERATION COSTS
(1979)

Total marginal grid production costs including primary distribution (MMS)*

SEASON & DAY	WORLD PRICES		EGYPTIAN PRICES	
	PEAK	SLACK	PEAK	SLACK
Winter Weekday	33.3	24.1	16.4	6.3
Winter Friday**	24.1	24.1	6.3	6.3
Summer Weekday	47.2	16.1	30.3	2.4
Summer Friday	18.1	13.1	2.7	2.0

*1MM = L.E. 0.001 = $0.0014 = 1.4 Mills

**Friday is the Moslem Sabbath

Source: Egyptian Electricity Authority

The effect of these low prices is to introduce many distortions into the economy. Firstly, they encourage profligate use of non-renewable fuels, and thus less petroleum is available for export. This has a negative effect on Egypt's balance of payments. The longer-term implications are also negative because of Egypt's limited known petroleum resources.

Secondly, the economy is distorted by making energy artificially cheap relative to labor and capital. While this may benefit some aspect of development, it has the parodoxical effect of discouraging employment and investment in favor of energy-intensive activities.

Thirdly, specifically in the energy market, cheap fossil energy forces a low value on other energy products. In order to compete, alternate energy sources must also be priced artifically low. The introduction of new energy sources, such as solar energy, is discouraged because they simply cannot compete; indeed, the only way new energy sources can compete economically is if they are given countervailing subsidies. Additionally, the inefficient and wasteful use of organic materials for open-fire cooking is propagated, robbing the soil of valuable conditioners.

Despite these negative aspects of a heavily subsidized energy price structure in Egypt, it has proven very difficult for the government to readjust prices up to world levels. Considerable unrest among the population resulted in the middle 1970s when an attempt to introduce a new price structure was announced. However, private communications with Egyptian government officials have indicated to us their awareness of the long-term desirability and importance of bringing domestic prices into line with world levels.

Another government policy which bears upon energy consumption is the New Cities Program. Under this program, a number of totally new settlements are being constructed in sparsely-settled regions in an arc around Cairo. The objective is to divert growth away from the immediate Cairo area and away from the very valuable fertile land of the Nile valley. Loss of agricultural land to urban growth is a major concern to Egypt.

The design and layout of these new cities will have a strong bearing on the energy consumption patterns of their citizens over the coming decades. At least two major impacts can be delineated:

- The extended nature of the new cities will probably lead to increased transportation needs.
- The housing designs used will affect energy needs for domestic purposes.

On the latter point, the housing designs and materials being used do not appear to be particularly well adapted to desert conditions. As the population becomes more affluent, this may lead to increased energy demands for space conditioning and refrigeration.

FUTURE TRENDS AND IMPACTS ON TECHNOLOGY UTILIZATION

The overall effect of the present energy supply and demand policies of the Government of Egypt is to encourage heavy reliance upon artificially cheap supplies of oil and gas. These policies will not be sustainable over the long term (in the absence of currently-unexpected major oil and gas discoveries) for several interrelated reasons:

- The demand for oil and gas will grow rapidly in Egypt as a result of both economic growth and population growth.
- Egypt's resources of oil and gas are adequate at present, but by no means very large.
- Egypt's underlying balance of payments deficit makes large-scale importation of petroleum undesirable.

It is by no means possible to predict the exact point in time at which these trends will collide. For instance, the level of committment to nuclear power will affect petroleum use in electricity generation. However, it is clear that the situation could become serious within a decade or so. The most likely form that a crisis would take is a gradual diminishing of net petroleum and gas production available for export, causing a worsening of the balance of payments situation. Attempts to balance imports and exports would most likely take the form of an internal austerity program designed both to reduce economic demand for imports and to free up resources for export. Such a situation would at least reduce economic growth, perhaps to negative values, and, at worst, could lead to severe social and political instability.

When considering energy technology policies for Egypt, two separate but essential aspects must be balanced; firstly, an overall climate favorable to solving the country's long-term energy problems must be created; and, secondly, policies should be introduced to assist specific and carefully selected energy technologies towards this end.

Present policies have a strongly negative influence upon the introduction of new technologies and upon conservation. This negative influence is due mainly to the extremely low domestic price of petroleum-based fuels. New technologies simply cannot compete economically without assistance, and the idea of conservation gains little support.

There is a clear need for long-term policies designed to put in place the components which will allow Egypt to make the transition from a cheap-energy economy to an expensive-energy economy as painlessly as possible. This transition cannot be long delayed unless unforeseen factors enter in, such as large new oil discoveries. To base policy, either by decision or by default, upon such unforeseen factors coming to pass would perhaps be unwise.

If future problems are to be minimized, some means must be found of encouraging both development of new energy resources and conservation of old on a wide scale. The price mechanism is one effective tool to accomplish these ends (as the United States is finding out), but political and social forces may make such an approach difficult in Egypt. However, an integrated approach of public education coupled with a gradual raising of prices to world levels is a prossible strategy. Basic free-market economic theory would appear to indicate, moreover, that the removal of the distortions caused by unrealistic prices would, in the long run, help to provide overall benefits to the Egyptian economy in many areas.* Long-term policies must stimulate not only the introduction of new energy technologies including perhaps renewable energy, but also the implementation of serious efforts towards increasing the efficiency of energy usage (or conservation).

Egypt is fortunate in having an industrial base which is capable of undertaking significant efforts in energy technologies. Clearly, this capability does not extend to the highest-technology items, for example, nuclear power plants, but does encompass a wide range of low

*For instance, higher prices for food should stimulate production and reduce the need for food imports.

and medium technology construction and fabrication. Egypt is fortunate also in having a large cadre of exceptionally able and well-educated scientists and engineers whose talents, if effectively applied to these problems, would undoubtedly be of great value. Attempts should be made to involve these industrial and technical capabilities in solving the nation's energy problems.

Turning to policies which are specific to individual technologies, the major factors which must be considered are:

- Energy resource base
- Relative cost
- Market potential
- Social impacts
- Environmental impacts
- Infrastructure availability and needs
- Critical resource usage
- Balance of payments effects.

The first factor says that the available resource base must be large enought to support usage on a "big enough" scale; i.e., a scale which can economically recapture research and development effort and provide a net benefit to society. The second factor deals with the economic competitiveness of the new source and, the third, with the likely overall degree of acceptance and use throughout the country.

Social impacts must be considered for two reasons:

(1) New technologies requiring changes in habits may meet with severe resistance.

(2) New technologies may have strong negative effects on certain specific groups in society, while still having an overall beneficial effect.*

Equally, the environmental impacts of new technologies must be considered. This is indicated by some of the unexpected side effects of the High Dam at Aswan, such as waterlogging of fields and spread of bilharzia.**

The ability of the country to introduce, support and maintain technologies (infrastructure) must be taken into account, and areas of weakness noted for improvement. In considering energy

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*For example, biogas digesters, by increasing the value (and cost) of dung may penalize the poorest families who own no animals and must scavenge or trade for dung for fuel.

**This water-borne parasitic disease thrives in the slow-moving waters of Egypt's many irrigation canals. Prior to the completion of the High Dam , the annual flood of the Nile "flushed out" the system and controlled the disease. Since the completion, the Nile no longer floods and the disease has spread widely.

technologies which may be suitable for Egypt, it is important to note that maximum benefits can be reaped only from technologies which can be fully integrated into the economic and social structure of the country. In other words, the use of technologies which can be made in Egyptian factories employing Egyptian workers is more beneficial, other things being equal, than those which must be imported.

Any usage of critical resources (such as, in Egypt, arable land or fresh water) must be examined. Critical resources can also be construed to include capital and technically-trained manpower. Preference should be given to well-commercialized technolgies, since careful use of Egypt's limited research and development resources is also critical.

Finally, the overall Balance of Payments effects must be determined. This determination must not only take into account primary effects (such as imports of capital items), but also secondary impacts (such as release of petroleum fuel for export).

CONCLUSION

The main points made in this paper can be summarized:

1) Egypt is at present self-sufficient in energy, and domestic energy prices have been held at levels well below world prices.

2) The policy of holding energy prices low stimulates demand and reduces the potential for new sources to compete economically.

3) Egypt's energy resources (as at present understood) and projected energy consumption make it unlikely that Egypt can continue to be self-sufficient in energy for more than another decade at most.

4) Therefore, there is a need for policies which will encourage more effective use of energy and stimulate new sources of supply. The authors feel that the price mechanism is an effective tool in this respect.

5) New energy technologies may, however, need initial assistance even if effective price competition is arrived. When choosing energy technologies which are appropriate for development, factors which should be bourne in mind include resource base, costs, potential markets, environmental and social impacts, suitability of infrastructure requirements, usage of critical resources, and the balance of payments impact.

ATTACHMENT I

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