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INITIAL ENERGY RESOURCES ASSESSMENT

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SINAI DEVELOPMENT STUDY - PHASE I

PERFORMED FOR THE ADVISORY COMMITTEE FOR RECONSTRUCTION

OF THE MINISTRY OF DEVELOPMENT

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EXECUTIVE SUMMARY

The energy resources of Sinai are summarized on the basis of information obtained during January and February, 1981 in Cairo. Fossil fuel production rate, known reserves and projected future production is described to the extent the information was available. Renewable energy resources are discussed in terms of current technology and potential applications in the future development of Sinai.

Meetings were held with numerous representatives of Egyptian government organizations to obtain their cooperation and to establish a basis for future cooperation in the energy planning for Sinai. In general, the Egyptians seemed optimistic concerning the potential for utilizing solar energy in Sinai, and they were eagerly awaiting the results of the Sinai Resources Planning Study. It is hoped that this initial Sinai energy resources study will be useful in the overall Sinai resources planning, and that the final report on Sinai energy resources and energy requirements for Sinai development will be an accurate representation of the present and future energy picture for Sinai.

Oil production from the petroleum fields in the Suez Gulf area, including adjacent portions of Sinai, represents a major source of energy for Egypt and the primary source of capital for the nation's imports. Nearly two-thirds of the 1980 additions to the proven oil reserves for Egypt are located in the Sinai region of the Suez gulf, suggesting that Sinai oil will be an important contribution to the Egyptian economy for several decades at least.

Associated gas from oil production in the Sinai portion of the Suez gulf is presently flared except for small portions that are utilized for supporting the drilling operations. Although equivalent to only one percent of the total Egyptian oil production, the flared gas in Sinai has an energy equivalent to 6000 barrels of oil per day. Capture and utilization of this flared gas would be equivalent to LE 50 million of crude oil at world market prices.

Coal deposits at Maghara have a probable recoverable value of 35.6 million metric tonnes. There were indications that by February 1981 the Egyptian Geological Survey

had a technically feasible proposal for utilizing Maghara coal for electrical power production and for blending with imported coal for coke making.

Oil shale deposits and geothermal resources exist in limited amounts which are not considered to be economically recoverable. Geothermal springs at Hamman Fara'un, however, have some potential for development as a tourist attraction.

Renewable energy resources in the form of solar and wind power have a tremendous potential in Sinai, and existing technology as demonstrated in Egypt and elsewhere is available to utilize both sun and wind for the future growth and development of the region. Since a 10 kW diesel-electric plant consumes about one gallon of fuel per hour, the annual savings of an equivalent solar/wind powered replacement is in the order of 8760 gallons of diesel fuel.

Biogas units under test and development at the National Research Center in Dokki can potentially be utilized to produce gas for cooking and gas lighting. The digester units utilize "night soil", manure from farm animals and some biomass from farming operations. The spent sludge from the digester is useable as fertilizer and humus for the soil.

A number of project summaries have been identified which should be useful in facilitating a viable energy program for Sinai. It is expected that certain of these project summaries will be expanded into full project definitions such that funding can be established and plans can be implemented. Additional project summaries are expected to be written to cover all significant energy projects planned by the Canal Electrical Distribution Company or other organizations in Sinai.

Follow-on study activities are planned for the period from mid June to mid July, 1981 to upgrade the Sinai energy resources definition, to establish energy use recommendations for energy intensive development projects in Sinai, and to complete project definitions for those energy projects which are selected for implementation.

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INTRODUCTION

This report on Energy in Sinai was prepared as part of the Phase I study of Resources in Sinai. The Phase I study was conducted for the Egyptian Ministry of Development by a joint Egyptian-American team under the leadership of Dames and Moore. The report is based on information collected during an in-country investigation by the Solar Engineering Group, Princeton, New Jersey, from 16 January, 1981 to 15 February, 1981.

Annex 1 is a list of the principal contacts established during the initial data gathering visit to Cairo and Sinai during January and February 1981.

The primary energy study effort was organized under Task 8.0. Infrastructure, in the Phase 1 Statement of Work. Task 8.3, Energy Assessment, specified that the energy supply alternatives be evaluated with a view toward maximizing the economic benefits of using the region's indigenous energy resources. Task 8.4 requires the development of an inventory of the physical requirements for energy systems and supplies in Sinai that can be used in the overall assessment of regional development costs and priorities.

The energy resource assessment, Task 8.3, was the principal effort during the January-February 1981 period. The following elements of the energy assessment task are extracted from the Terms of Reference:

1. Assess existing energy resource facilities, design capacities, conditions, and current loads.
2. Evaluate natural gas associated with crude oil production.
3. Review data on present and planned production of oil and gas and on costs of transportation and distribution to potential centers of demand.
4. Consider coal reserves.
5. Analyze a number of alternative energy forms for development- electric power generators, liquified natural gas, pipeline gas or oil, geothermal, salt-ponds, wind, solar, and various other systems.
6. Consider the cost of construction and operation, reliability of supply, technical and manpower requirements, and system flexibility and durability in evaluating energy forms.

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The evaluation of current and projected energy requirements under Task 8.4 will be the principal focus of the subsequent period of study, to be conducted during Spring-Summer 1981. Completion of Task 8.4 will require quantitative definition of development planning in other tasks of this project. However, current and probable demands for electricity have been analyzed in this first stage.

The following elements of the energy requirements task are extracted from the Terms of Reference:

1. Develop an inventory of the physical requirements for energy systems in Sinai to be used in the overall assessment of regional development costs and priorities.
2. Assess each existing and proposed urban settlement, economic, and industrial development in terms of its near-and long-term energy requirements.
3. Estimate amounts, forms and costs of energy required to meet immediate or near-term "threshold" levels of energy inputs and longer term increments of energy inputs.
4. Provide inputs to to Tasks 11 and 12, described in Appendix A of the Prime Contract.

Specific tasks identified for the first visit to Cairo, in addition to the requirements mentioned in task 8 were:

1. Identify projects (Tasks 1,2) appropriate for prefeasibility analyses for "detailed feasibility studies." Go ahead with prefeasibility analyses.
2. Investigate and comment on feasibility of the proposed 600-megawatt power plant for North Sinai.
3. Comment on feasibility of operating the Maghara coal mines.
4. Prepare working paper on energy in Sinai: present situation and development ideas and strategies.

This study of energy in Sinai is not to be taken as an isolated event, but as one important facet of infrastructure development that is essential for the long range growth and development of the region. The intelligent selection and efficient utilization of energy will be a major factor in the success of development programs for Sinai.

Concerning the specific tasks identified for the first visit to Cairo, the following represents a summary of the findings:

1. PREFEASIBILITY ANALYSIS

A total of thirteen project summary sheets were prepared to provide a basis for detailed feasibility studies and actual demonstration projects for Sinai. Annex 3 includes descriptions of the projects and recommendations. The titles for the initial group of project summaries are as follows:

- o Test Solar Desalination of water from Sinai sites.
- o Automatic Solar, Wind and Meteorological Monitoring Station.
- o Energy Audit for Sinai.
- o Evaluation of Potential Infrastructure Use of Abu Zenima Electrical Generation and Desalination Facilities after Rehabilitation.
- o Glass Factory.
- o Industrial Complex near Abu Rudeis to Utilize Flared Gas from Sinai Oil Wells.
- o Lake Bardawil Power & Ice Project.
- o Solar Demonstration Site
  Governorate of South Sinai
  El Tor, South Sinai.
- o Solar heating and hot water for motels, hotels, and multifamily dwellings.
- o Solar Domestic Water Heater Factory, El Arish.
- o Solar Cookers.
- o Quality Assurance Plan.
- o Sinai Transportation System.

2-3 FEASIBILITY OF THE PROPOSED 600-MW POWER PLANT FOR NORTH SINAI AND FOR OPERATING THE MAGHARA MINES

The Maghara Coal Mine was in initial stages of operation at the time of the 1967 War. A methane gas explosion occurred sometime after the ventilation system was turned off when a Bedouin struck a match inside the entry portal. The explosion closed off the portal, although an 85 meter lift nearby appears to be intact. Apparently, current Egyptian plans are to utilize the coal for producing electrical power and also for blending with imported coal for making coke.

No detailed evaluation of the economic feasibility was made because of the sensitive status of the ten proposals which were under evaluation by the Egyptian Geological Survey. During the occupation years, Maghara Coal was not extracted because it was considered to provide slightly sub marginal economic returns on a short term basis. Under the more favorable long term planning options for Egypt, and with current and projected high costs of energy, it is reasonable to assume that the project would be an economic undertaking. (See Sections 1.3 and 4.3 of this report)

1.0 ELECTRICITY

1.1 MINISTRY OF ELECTRICITY

Authority for governmental policy and planning for electrical power rests with the Ministry of Electricity, and the responsibility on a nationwide basis for electrical generation and transmission is delegated to the Egyptian Electrical Authority (EEA). The EEA generation facilities consist of two hydroelectric power stations at Aswan, with a total generating capacity of 2,445 megawatts (MW). An additional 1444 MW of steam generating units and 523 MW of gas turbine installations provide a total capacity of 4,412 MW. During 1979, the latest year for which statistics are available, the peak generated load was 2752 MW and total electricity generated was 16.338 terrawatt hours. Averaged over the period from 1975 to 1979, both peak load and total electricity generated have grown at a rate of 12% per year.

Electricity is sold by EEA to major industries, governmental authorities and electrical distribution companies for distribution and resale to individual consumers. The Governorates of North Sinai and South Sinai are served by the Canal Electricity Distribution Company (CEDC; see Exhibit 1.1). Currently, no electricity is transmitted from the national grid to either of the Sinai Governorates, but the impending completion of an 11 kilovolt (kV) transmission line through the new Suez Canal Tunnel will make this a possibility.

A feature of the Ministry of Electricity organization shown in Exhibit 1.1 that is especially relevant for Sinai energy planning is the Qattara Hydro and Renewable Energy Projects Authority. In addition to its oversight duties for major hydro projects, authority for renewable energy projects, including solar, wind and mini-hydro, is delegated to this agency.

1.2 CANAL ELECTRICITY DISTRIBUTION COMPANY

The Canal Electricity Distribution Company (CEDC) is responsible for providing electricity in the Governorates of Port Said, Ismailia, Suez, Sharkia, Red Sea, Northern Sinai and Southern Sinai. In 1979, it sold 556.2 million kWh with a value of LE 6.8 million, or 1.04 piasters/kWh.

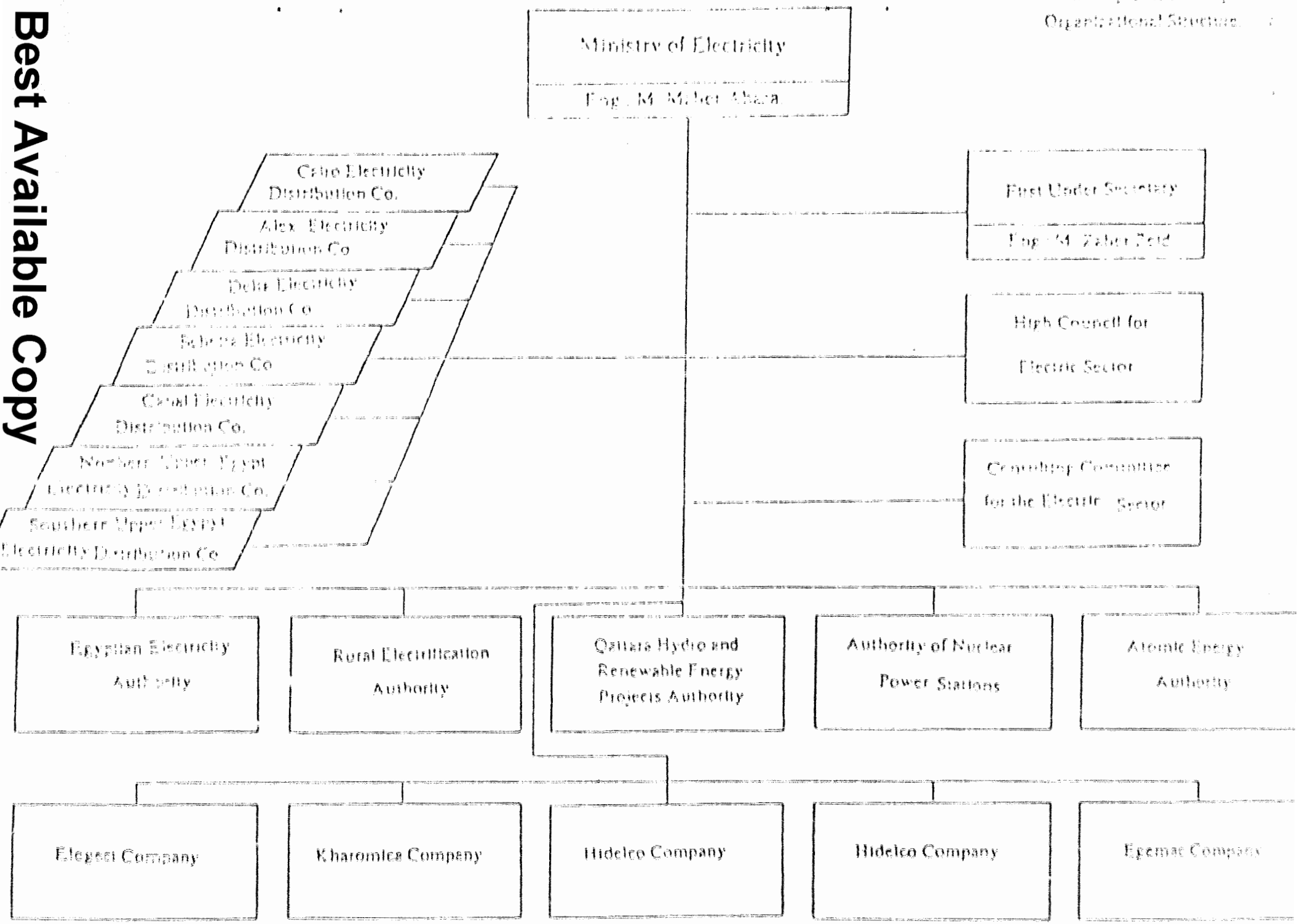
When Egyptian control returned to Sinai following the period of occupation, the CEDC was faced with the task of reinstituting electrical service to the area in the shortest possible time. During the Israeli occupation, El Arish had been connected to the electrical network of Beersheeba. Within eight days after regaining control, CEDC erected two 3.2 MW combustion gas turbines, changed the distribution network voltage from 3 kV to 11 kV, replaced major transformers and restored power to El Arish. Similarly, two 515 kW diesel-electric units were installed within four days at El Tor, even before return of this town to Egyptian control. Similar prompt and efficient effort was given to systems in Nakhl, Hasana, St. Catherine's, Sudr and Feiran. Except at El Arish, sufficient capacity now exists to meet current demand in all localities where electrical power is available. A major effort is underway to add generating capacity to the El Arish system.

EXHIBIT 1.1

ORGANIZATIONAL STRUCTURE OF

THE MINISTRY OF ELECTRICITY

Ministry of Electricity
Organizational Structure



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The CEDC has not had sufficient operating experience in Sinai to estimate the influence of price on demand. Generally, CEDC purchases power from EEA at 9 millemes, and adds a distribution and management cost of 6 to 7 millemes per kWh. Power is sold on a sliding scale to residential consumers for 16 millemes (to 80 kWh), 17 millemes (80-250 kWh) and 18 millemes (more than 250 kWh). Larger consumers are subject to time-of-day pricing and a power factor charge. Since Sinai is not connected to the national power grid, CEDC has the responsibility for generation, distribution and power management in Sinai. It is believed that the Sinai Governorates pay the difference between the CEDC costs and the revenues collected from users in Sinai.

1.3 ELECTRICITY PLANNING FOR SINAI

The principal generation facility planned for Sinai in the near-term is a thermal generating station to burn coal from the Maghara complex. At this time, the facility is slated to contain two 300 MW generators, and the estimated total investment is U.S. $80 million local currency equivalent and $300 million foreign currency (source: "Strategy of the Ministry of Electricity and Energy for The Period 1980-2000", dated February 3, 1981). Depending on revised estimates of the total Maghara reserves, it is possible that only a single 300 MW unit will be installed. Facility location has not been established, and locations at mine mouth, El Arish and along the Canal are being considered. Also, the decision to utilize Maghara coal both for coking and for electrical generation could dictate that only the smaller plant be constructed. (see Section 4).

Limited information is available with which to estimate potential electricity demand in Sinai. However, recognizing that rapid development of this region will require per-capita energy consumption in excess of that for Egypt as a whole, one may assume that the national goals of the Ministry of Electricity are lower bounds. In 1980, the per capita annual electrical consumption in Egypt was 400 kWh, and this is projected to increase to 700 kWh in 1985, 1000 kWh in 1990, and 1600 kWh in 2000 (Source: "Strategy of the Ministry of Electricity and Energy for the Period 1980-2000").

The CEDC has projected Sinai power requirements by querying both the Northern and Southern Governorates as to their anticipated demands in 1981, 1985, and 1990. Based on this survey, a total demand of 18,650 kW is projected in 1981, 56,450 kW in 1985, and 169,550 kW in 1990. Additionally, a 20,000 kW demand is projected in 1985 and 1990 for the Sinai Ferromanganese facility at Abu Zenima, if the facility is reopened.

A breakdown of demand by load category is given for Northern Sinai in Exhibit 1.2 and for Southern Sinai in Exhibit 1.3. Demand in Northern Sinai is expected to grow to ca. 110 MW by 1990, dominated by tourism, land reclamation and housing. Electrical load in Southern Sinai is projected to be approximately half this size in 1990 (ca. 60 MW), with the primary demand from housing and land reclamation.

Over the near-to-medium term (six years), electricity planning for Sinai will be conducted in three stages. The first stage, which is regarded as the most important, will last two years, until mid 1982. In this stage, the main objective will be the installation of generation stations and the low and medium voltage transmission and distribution system. This electrical network will be installed in coastal areas to meet the needs of tourism, industry and land reclamation and in the interior at St. Catherine's, at St. Catherine's airport and at Maleze (See Annex 4, Electrical Distribution System Diagrams).

The second stage, which will be conducted from mid-1982 to mid-1984, will consist primarily of establishing gas generating stations utilizing natural gas, to be connected by a 66 kV grid. The third stage, planned for mid-1984 to mid-1986, would include connection of both Northern Sinai and Southern Sinai to the national grid, the construction of the thermal generating stations, utilizing Maghara coal and the extension of the 66 kV and 220 kV networks.

Plans for the second and third stages will not be finalized until funds become available in the next five-year plan. However, detailed first-stage activities are underway, and total investment is expected to be LE 41.6 million, and foreign currency of U.S. $20 million equivalent.

A particularly important component of electrical demand planning will be an accurate estimate of the per-feddan requirement for irrigation, because there is a stated commitment to land reclamation. One estimate is that irrigation of each feddan requires approximately 1 kW including associated infrastructure requirements (Source: El Sharkawi, personal communication February 1981). A disaggregated estimate for irrigation of 30,000 Sinai feddans is as follows:

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Eleven villages	1,550	kW
Distribution and distillation	2,250	kW
Machine shop	400	kW
Siphon	0	kW
Small pumps, etc.	250	kW
Pivot systems (16 hr/day)	18,800	kW
Subtotal	23,250	kW
Contingency (10%)	2,325	kW
Total Power Requirement	25,575	kW

(Source: Ministry of Reconstruction and Development, private communication).

Thus, the two estimates are in general agreement, and a figure of 1.0 kW/feddan is adopted in our irrigation estimates.

EXHIBIT 1.2

ANTICIPATED LOADS DURING THE FIVE YEAR PLAN
AT FIRST STAGE 1981-1982
NORTHERN SINAI

PROJECTED POWER REQUIREMENT BY LOAD CATEGORY (in KW)	1981	1985	1990
Tourism and Hotels (Letter from the Deputy Minister of Tourism)	3,000	30,000	42,000
Ministry of Health	150	300	400
Military and Other National Security	1,500	1,900	1,900*
Ministry of Industry (Maghara Project)	400	2,000	2,000*
Training Centers	200	400	400*
Private Sector Projects	1,500	2,000	6,000
Ministry of Irrigation (Poultry, Canning, Livestock at El Arish)	1,500	1,500	3,000
Town of Bir-El-Abd	300	500	800
Industrial Schools at El Arish	200	300	300*
Ministry of Supply (Corn Grinding and Bakery at El Arish	400	600	600*
Ice Production Units at El Arish	500	1,000	2,000
Other Ice Production Units and Governmental Food Shops	300	300	300
Ministry of Development-Housing	1,500	2,500	20,000
Ministry of Development--Land Reclamation	1,500	3,000	30,000
TOTAL-Governorate of North Sinai	12,950	46,300	109,700

Source: CEDC

* Assumed values - no estimate provided.

EXHIBIT 1.3

ANTICIPATED LOADS DURING THE FIVE YEAR PLAN
AT FIRST STAGE 1981-1982
SOUTHERN SINAI

PROJECTED POWER REQUIREMENT BY LOAD CATEGORY	1981	1985	1990
Tourism and Hotels (Letter from Deputy Minister for Tourism)	1,000	2,000	2,000
Ministry of Health	100	150	150
Training Centers (Ministry of Industry)	100	200	200*
Private Sector Projects	800	1,200	4,500
Ministry of Irrigation	---	---	---
Ministry of Higher Education	200	200*	200*
Ministry of Supply (Corn Grinding and Bakery)	200	300	300*
Ice Making and Government Food Shops	300	600	2,500
Ministry of Development-Housing	1,500	2,500	20,000
Ministry of Development-Land Reclamation	1,500	3,000	30,000
TOTAL-Governorate of Southern Sinai	5,700	10,150	59,850
Power Requirements for Sinai Ferromaganese	---	20,000	20,000*

Source: CEDC

* Assumed values - no estimate provided

1.4 FIRST-STAGE NETWORK PLANNING

Information made available by CEDC indicates that nine major projects are planned in Northern Sinai for the period November 1980-December 1981 (see Exhibit 1.4). These include installation of generating stations and associated distribution networks at Romana, Bir-El-Abd, El Arish, and Maleze. Total cost is expected to be LE 17.85 million. A more limited expansion program for Southern Sinai is shown in Exhibit 1.5, where major population centers have already been furnished with electrical generation and distribution networks. The four 500 kW diesels scheduled for the temporary Southern capital of Ras Sudr are in place, providing four times the current demand. Total costs for the first stage in southern Sinai are estimated to be LE 11 million. Additionally, essential power requirements for those portions of the canal governorates that lie geographically in the Sinai peninsula are shown in Exhibit 1.6 at a cost of LE 12.75 million. The total anticipated cost for the first-stage electrical system development for three sections of Sinai is LE 41.6 million.

Systems diagrams for each of the distribution networks are included in Annex 4.

EXHIBIT 1.4

NORTHERN SINAI

ESSENTIAL DISTRIBUTION NETWORK REQUIREMENTS

10/80 - 12/81

ITEM	PROJECT	COST (1000 L.E.)
1	Installation of a generating station 3-90 kW diesels at Romana Village, including step-up transformer and 11 kV distribution network	600
2	Installation of 11 kV transmission line from East to South Romana (45 km) including pole transformers and cabinets	900
3	Installation of electric generating station (3-90 kW diesels) at Bir-El-Abd with step-up transformers and distribution network	600
4	Installation of 11 kV transmission line, from east to west in Bir-El-Abd (50 km) including pole transformers and cabinents	1,000
5	Increasing El-Arish generating station temporarily by 2-5 MW gas turbines with distribution network	5,000
6	Installation of 11 kV transmission line plus cables (75 km) plus transformers in El-Arish	1,500
7	Installation of generating station at Maleze, 3-500 kW, including switchboard and step-up transformers	450
8	Installation of aerial transmission line from east to west in Maleze (90 km) including transformers and cabinets	1,800
9	Installation of low voltage electric network in various villages and towns (750 km) including interval network and street lighting	6,000
	TOTAL	17,850

EXHIBIT 1.5

SOUTHERN SINAI

ESSENTIAL DISTRIBUTION NETWORK REQUIREMENTS
10/80—12/81

ITEM	PROJECT	COST (1000 L.E.)
1	Improvements to present electric generation station at St. Catherines 3-90 kW installing complete with step up transformer.	600
2	Development of generating station in Feiran Village; 2-500 kW units and switchboard	300
3	Development of present generating station at RAS Sudr 4-500 kW units	500
4	Installation of 11 kW transmission line from generating stations for 200 km total length including transformers and cabinets	4,000
5	Installation of low voltage electric transmission lines for street lighting and internal network	5,600
	TOTAL	11,000

EXHIBIT 1.6

CANAL GOVERNORATES
ESSENTIAL DISTRIBUTION NETWORK REQUIREMENTS

1981 - 1982

ITEM	PROJECT	COST (1000 L.E.)
1	60 km reinforced electric cables, 11 kV, type XLPE, 3 phases 240 mm^2 section	2,000
2	60 km reinforced electric cables, 11 kV, type XLPE, 3 phase 50 mm^2 section	1,500
3	40 km reinforced electric cables, 11 kV, type XLPE, 3 phase 70 mm^2 section	600
4	150 cabinets and transformers, 500 kVA and extra material for medium and low voltage	2,250
5	250 tonnes of conductors, variable sections	500
6	6000 light poles, various makes, 8-10 meters in length	600
7	20 distribution boards, medium voltage	1,700
8	100 km low voltage cables, various sections	1,500
9	Cable connection boxes and insulators of low voltage, various iron parts	500
10	Electric switches, medium voltage, indoor and outdoor types	1,000
11	2000 poles, metal structure, for 11 kV, 12-15 meters length	600
	TOTAL	12,750

1.5 CONCLUSIONS AND RECOMMENDATIONS

Planning for short, intermediate and long term electrical demand has been initiated by the Canal Electrical Distribution Company (CEDC) in consultation with the Northern Sinai and Southern Sinai Governorates, and with the Ismailia Governorate for the portion near the Suez Canal. Funds are available and the CEDC appears to be proceeding in a disciplined and orderly manner in providing the electrical power network to meet the present needs and future growth requirements for Sinai.

The diesel-electric generator is the principal equipment utilized to meet essential power requirements for the short term except at El Arish where two 3.2 MW combustion gas turbines were installed.

The intermediate term planning includes Natural gas-fired generating plants utilizing a 66 KV grid to interconnect the principal load centers. The third stage would connect both Northern Sinai and Southern Sinai to the national power grid and would include a fossil-fired power plant utilizing coal from the Maghara mine.

Two conclusions that can be drawn are that the initial installation of diesel-electric generators at principal load centers will greatly increase the consumption of diesel fuel oil, and the ultimate interconnection of the loads with a transmission line and the addition of natural gas-fired plants can (potentially) reduce the oil consumption. Although efficiency varies greatly as a function of load, a rule of thumb for estimated fuel consumption for diesel plants is one gallon of fuel consumed per hour for every 10 kW of generator rating. If the units are oversized and lightly operated, the "heat rate" or fuel required per Kwh generated, becomes as much as twice the above.

It is recommended that strong conservation plans be implemented to establish prudent guidelines and procedures to minimize the waste and inefficiency in the electrification plans for Sinai. Technical support services should be provided to the CEDC, particularily in the development of models and tools for electrical power planning for Sinai. The functions of planning, system design and system operation and control are so interrelated that system planning must encompass all of them.

Some specific recommendations for consideration by CEDC are:

a) Diesel-electric plants should include a "mix" of generator power ratings such that the smaller units could operate during low load periods, conserving fuel.

b) Installation of natural gas-fired power plants should be accelerated to utilize flared gas at an early date.

c) Heat recovery systems should be considered for utilizing the waste heat from diesel-electric and combustion gas turbine generators.

2.0 NATURAL GAS

2.1 INTRODUCTION

Published data concerning natural gas production in Sinai was not available, although it is known to exist in the Ministry of Petroleum. Much of the following data was obtained from a reliable source and is compatible to currently published data within the Ministry of Petroleum

Petroleum production in Egypt is concentrated in the Gulf of Suez area with more than 90% of the national output coming from those fields which lie primarily offshore. Although past production has been greater from fields identified with the western side of the Gulf, the additions to new reserves over recent years have been primarily in that portion of the Suez identified as Sinai production.

For example, in 1980, one billion barrels of petroleum were added to the proved recoverable reserves in Egypt as a whole, a figure that represents all newly-discovered fields and all new discoveries in previously-identified fields. Of this amount, 450 million barrels of new recoverable reserves were identified in the Marine Bellayim field and 190 million barrels of new reserve were located in Location 195, which also lies in the Abu Rudeis area. Thus, approximately 64% of the additional proved recoverable national reserves were in the Sinai area.

The capture and utilization of associated natural gas that is currently flared in the central and western Gulf of Suez fields has been the subject of a thorough project evaluation by the World Bank in cooperation with the Egyptian General Petroleum Corporation (EGPC). Although details of this project have not been released, it appears to be going forward, and a general outline could be gleaned from interviews with knowledgable sources.

At present, only minor quantities of associated natural gas are captured for internal utilization in the petroleum production operation. The fields from which gas recovery is being considered in the western Suez project are Ramadan, July, Location 382, as well as the Amal field, which produced non-associated gas. Additionally, gas from some single-well fields, including Location 195 may be dedicated to this project. Of these fields, only the Ramadan and July fields are currently producing.

A major uncertainty facing the gas recovery project is the volume of gas production attainable from Location 382 and Amal, which are both currently non-producing fields.

The western Suez project involves the capture of currently flared gas and transport to a compressor location at Ras Shukeir. There, liquefied petroleum gas (LPG) and natural gas liquids will be stripped, and the dry gas will be transported by pipeline to Suez City. In Suez, the gas is assigned to industrial use, primarily by an extant fertilizer plant, a 30 MW electrical generation station and a proposed cement plant. Excess gas will be transmitted to Cairo by existing pipeline facilities.

The plans for use of gas from these fields are important to Sinai energy planning. Should the western Suez project not prove feasible, it may be desirable to designate gas production in certain fields for use in Sinai gas capture projects. Notably, gas from Amal, Location 382 and Location 195 might equally well be transported to the eastern side of the Suez for treatment and utilization in Sinai.

2.2 NATURAL GAS AVAILABILTY IN THE EASTERN GULF OF SUEZ AREA

Unpublished information on current and projected availability of natural gas to the year 2003 in the eastern Gulf of Suez was obtained from a reliable source and is shown in Exhibit 2.1. In 1980, it is estimated that approximately 50 million cubic feet per day were available but not captured in this area. It is estimated that production will rise to 54 million cubic feet per day by 1985 and then decrease to 29 million cubic feet per day by 1990.

EXHIBIT 2.1
NATURAL GAS AVAILABILITY IN THE
EASTERN GULF OF SUEZ AREA

(1980 - 2003)

FIELD	PRODUCTION (MMSCF/day)				
	1980	1985	1990	1995	2003
El Belayim Area Petrobel Marine Field	31	25	21	17	0
Abu Rudeis Area Locations 195,185,173	9	20	7	0	0
Shoab Ali Area Alma Field	10	9	1	0	0
TOTAL	50	54	29	17	0

Note: The above data is believed to have been presented to the Supreme Council on Petroleum in February 1981.

The significant feature of this projection, which was obtained from reputable high-level sources, is the dominance of the production from the Petrobel Belayim field. Only this field furnishes a major quantity of gas over a sufficiently long period for serious consideration in planning Sinai developments.

2.3 CHARACTERIZATION OF ASSOCIATED GAS IN THE PETROBEL BELAYIM FIELD

Information is not available on the analysis of associated gas from the Belayim field. However, its composition is likely to be very similar to that of Ras Shukheir associated gas, which is shown in Exhibit 2.2 (The information, although unpublished, was obtained from a reliable source).

One major uncertainty is the possible existence of absorbed hydrogen sulfide (H_2S). Some initial studies indicate that this gas, which is potentially corrosive to stripping and compression equipment, has been found to exist in 300-400 ppm in recent tests associated gas from the Location 382 field. Pre-treatment to remove hydrogen sulfide would be required if it were found to exist at these levels.

2.4 POTENTIAL NATURAL GAS UTILIZATION IN SOUTHERN SINAI

Immediately prior to the 1967 War, a ferromanganese facility was constructed at Abu Zenima, approximately 53 kilometers above the Belayim field. An electric furnace was planned for use in a duplex smelting of the ferromanganese ore at this facility, with a total capacity of 25,000 tons-per-year of ferromanaganese. Electricity

EXHIBIT 2.2

CHEMICAL COMPOSITION OF BELAYIM ASSOCIATED GAS BASED ON THAT OF RAS SHUKHEIR ASSOCIATED GAS

CHARACTERISTIC	LPG REMOVED	LPG NOT REMOVED
C_1 Fraction	0.832	0.811
C_2 Fraction	0.103	0.097
C_3 Fraction	0.042	0.0485
i-C_4 Fraction	0.0019	0.0067
n-C_4 Fraction	0.0017	0.0124
i-C_5 Fraction	0.00005	0.003
n-C_5 Fraction	0	0.0022
C_{6+} Fraction	0	0.0006
CO_2 Fraction	1.16	1.11
N_2	0.77	0.75
Molecular Weight	19.2	20.4
Density kg/m^3 (0°C-76 cm Hg)	0.866	0.915
Density K/m^3 60°C-76 cm Hg	0.82	0.87
Specific Gravity(air=1)	0.67	0.71
Low Heating Value (Btu/SCF)	1031	1086
High Heating Value (Btu/SCF)	1140	1190

was to be generated on-site by three Brown Boveri Type TA 8007 gas turbine generators (see Project Summmary, Abu Zenima Electrical Generation and Desalination Facilities). Desalination facilities powered by waste heat boilers were designed to furnish 245,000 m^3/year of desalinated water, although the anticipated requirement was only 191,000 m^3/year.

The electrical generation-desalination plant had a projected requirement of 33 million cubic meters per year of natural gas, which was to be furnished from the Belayim field. Supply was to be transported through an 8 inch spiral weld steel pipe, and, although there are conflicting reports as to whether this pipeline was ever completed, at least part of it can still be seen in place. The original compressor facilities at Belayim reportedly have been scrapped. The anticipated ferromanganese load requirement translated to approximately 3.2 million SCF per day of natural gas.

Thus, it appears that flared gas in the eastern Gulf of Suez area is approximately fifteen times greater than the supply requirements for the major ferromanganese facility at Abu Zenima as originally designed. Projected supply will remain at more than five times the demand of such an industrial use until the year 1995.

2.5 CONCLUSIONS AND RECOMMENDATIONS

The energy content of the associated natural gas which is available in Sinai but currently being flared is in the order of one to two percent of the total national crude oil production, or equivalent to 6000 barrels of oil per day. Thus, the potential value of the flared gas in the Suez gulf region of Sinai is in the order of LE 50 million per year. Recovery and utilization of the flared gas could therefore directly offset the consumption of fuel oil and improve the net trade balance of Egypt.

As a rough estimate, the flared gas in the eastern Gulf of Suez area (Sinai) is approximately ten times the requirement for current electric power production for all Sinai and about three times the projected demand for 1985.

One conclusion is that the flared gas could be used to generate electricity through the 1990 time period. However, since the national power grid is not scheduled to be extended to Southern Sinai until the 1985-1986 period, alternative uses might be considered which could more rapidly utilize the flared gas.

It is recommended that a study be made to determine the value of various alternatives in order that maximum utilization be made of the flared gas in Sinai.

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3.0 PETROLEUM

3.1 OVERVIEW

Petroleum production has become one of the most dominant factors in Egyptian economic growth, accounting for more than 15% of gross domestic product in 1979. Total crude output grew from about 21 million metric tonnes in 1977 to an estimated 30 million tonnes in 1980. The Egyptian petroleum export price moved from approximately U.S. $12 per barrel in 1978 to U.S. $30 per barrel in 1980.

Export earnings from petroleum amounted to approximately U.S. $2.8 billion in 1980. An increase in domestic consumption has cut into potential net exports, which have risen by 4.2 million tonnes in the 1977-1980 period out of a potential increase in the exportable surplus of approximately 9.5 million tonnes.

Although petroleum exports account for more than half of Egypt's export earnings, the current export account deficit is close to 10%. A modest improvement in petroleum or natural gas export would contribute significantly to Egypt's export trade balance.

There are indications that a significant portion of new production may come from Sinai fields. Of 1 billion barrels added to proved recoverable reserves in all of Egypt in 1980, 450 million barrels were from the marine Belayim field and 190 million barrels in the Location 195 field.

Concomitant with rapid development of Sinai will be increased consumption of refined petroleum products. Data for Sinai fuel consumption by fuel type could not be obtained, although it is understood that this information is available in the Ministry of Petroleum.

It is expected that much more data on petroleum production and refined product demand will be obtained during the study. However, there is a clear indication that an overall development plan for Sinai must include both petroleum demand planning and a well-defined role for petroleum production companies in infrastructure development.

3.2 CONCLUSIONS AND RECOMMENDATIONS

Sinai petroleum production is a significant factor in the economy of Egypt, and the 1980 additions to the proved recoverable reserves indicate that Sinai production can be expected to increase in the years ahead. However, the rapid development of Sinai will require large amounts of energy, and this will tend to offset the exportable energy production of the region.

Much more detailed data is required to identify the current and projected future demand for petroleum products in Sinai. An energy audit for the entire region will show the current energy consumption by fuel category by functional area. Until such data is available, only general observations and conclusions can be drawn from a study of energy in Sinai.

One observation is that the current plans for regional development will add significantly to the energy demand in Sinai. Electrical demand growth is projected to

be 32 percent per year through 1985 and 25 percent per year from 1985 through 1990. Road construction will require large quantities of asphalt and other petroleum products, as will the amount of cars, trucks and buses which will be expected to make use of the new roads. Expansion of the industrial base, tourism, fishing or agriculture will each have need for additional power. In large measure, the energy needs for Sinai appear to be provided by petroleum resources in the short to intermediate term.

It is recommended that an energy audit be conducted to identify the current and projected future energy needs for Sinai over the next two decades. An aggressive energy conservation program can then be developed to establish the preferred or optimum energy mix for Sinai. Early identification and application of alternative energy programs can prevent the spread of energy intensive approaches which will reduce the net available petroleum products for export.

4.0 COAL AND OIL SHALE

4.1 COAL RESOURCES

Although coal resources are known to occur at several locations in Egypt, only those in the Sinai region are believed to be economically extractable. The largest deposits are at Maghara where proved and probable net metric tonnage is estimated to be 35.6 million tonnes (Source: Powell Duffryn Technical Services Report for The General Organization for Industrialization, May 1966). Of this, approximately 2 million tonnes lies in an upper seam that possibly could be extracted economically at a rate of 600,000 tonnes/year (Source: Ben Gurion University Research and Development Authority Report, August 1976). The overburden ratio is approximately 29 cubic meters per cubic meter of coal. During the occupation years 1967-1979, Israel considered extraction at two different rates of production, but reserve was not developed because it would have provided slightly sub-marginal economic returns. Also, there was a question concerning the length of time available to recover the investment at the higher rate. The more economical seam at Maghara is mineable by underground shaft techniques. Characteristics of this coal are contained in Exhibit 4.1. It is a sub-bituminous coal with a gross heating value of 7,215 kilocalories per kilogram (12990 Btu per pound) and a relatively high, though washable, sulfur content.

There are two other known coal deposits in Sinai, one of which contains 60 million tonnes and is located at Wadi Thora. Although extraction is not now considered economical, it may prove so in the future should gasification or liquefication prove

feasible. Coal also occurs in leuticular beds at Ayun Musa approximately 400-600 meters beneath the surface. Exploitation of this deposit is also complicated by high rates of water flow from an artesian aquifer, and economic extraction is not possible (Source: Joint Egypt/United States Report on Egypt/ United States Cooperative Energy Assessment, Vol. 2, Annex 1-April 1979).

4.2 OIL SHALE

Known Sinai oil shale deposits at Buda attain thicknesses of only 10 to 15 feet. The low hydrocarbon content of these deposits make it unlikely that they will ever be economically extractable.

4.3 MAGHARA COAL UTILIZATION

The Egyptian Geological Survey has moved forward with plans for reactivation of the Maghara Coal mine, and a request for proposals for this project was issued in 1980 with a closing date of 10 December 1980. There are indications that 10 proposals were submitted and reviewed and that by 1 February 1981 one was chosen as technically feasible. The selected proposal apparently plans to use the coal in coking, blended with better European coking coals, and also for electrical power generation.

EXHIBIT 4.1

ANALYSES OF COAL FROM SAFA MINE, SINAI PENINSULA, EGYPT (POWELL DUFFRYN TECH. SER. LTD., 1963)

UPPER SEAM

Proximate and Ultimate Analyses of Selected Sample

	Proximate				Ultimate							Kilocalories per Kilogram
	Moisture	Ash	Volatiles	Fixed Carbon	Moisture	Ash	Carbon	Hydrogen	Nitrogen	Combustible Sulfur	Oxygen (by difference)	
As received	4.9	6.5	50.7	37.9	4.90	6.50	70.66	5.67	1.04	2.97	8.26	Gross 7,215 Net 6,850
Dry		6.8	53.3	39.9		6.84	74.33	5.96	1.09	3.12	8.69	Gross 7,610 Net 7,292
Dry, ash free			57.2	42.8			81.98	6.58	1.21	0.65	9.58	Gross 8,476 Net 8,[illegible]

Range in Values Based on Ultimate Analyses of 13 Samples

Moisture	Ash	Carbon	Hydrogen	Nitrogen	Sulfur Combustible	Oxygen (by difference)	Chlorine	Phosphorous	
								in ash	in coal
3.50-5.00	3.61-27.25	52.32-73.96	4.73-6.18	0.70-1.28	1.13-3.89	7.32-9.96	0.032-0.082	0.016-0.049	0.001-0.011

Sulfur, Phosphorous, and Carbon Dioxide in Bulk Sample

Sulfur				Phosphorous		Carbon dioxide
Sulfate	Sulfide	Organic	Total	In ash	In coal	
0.10	2.40	0.56	3.06	0.040	0.003	0.08

EXHIBIT 4.1 (continued)

Minor Elements in Ash of Bulk Sample as Determined From Spectral Analysis*

Germanium	Gallium	Arsenic	Barium	Boron	Beryllium	Bismuth	Cadmium	Cobalt
0.003-0.007	0.004-0.008	<0.003	Not detected	0.02-0.20	0.005-0.010	<0.002	Not detected	0.001-0.004

Chromium	Magnesium	Manganese	Molybdenum	Nickel	Lead	Tin	Vanadium	Yttrium	Zinc
<0.004	<0.01	0.10-0.40	<0.003	0.005-0.10	0.004-0.008	<0.002	0.005-0.010	Not detected	<0.005

* Calcium was beyond the range of sensitivity, not detected.

Gray King Assay at 600°C

Coke, Type "C" kg/Ton	Tar kg/ton	Liquor kg/ton	Ammonia kg/ton	Quantity Nm^3	Gas Calorific Value kcal/Nm^3
561.1	247.3	87.1	0.53	95.1	9,020

4.4 CONCLUSIONS AND RECOMMENDATIONS

Coal reserves at Maghara, although slightly submarginal economically during the years of Sinai occupation by Israel, are considered to be a viable resource for exploitation by Egypt. By blending Maghara coal with imported European coking coal, it should be possible to reduce the cost of coal imports and provide an industrial base for settlement in Sinai. Also, by using a portion of the coal for producing electricity, Sinai can export electrical power to the Egyptian national grid.

Oil shale deposits and other known coal reserves in Sinai are not considered to be economically recoverable, although the Wadi Thora deposits may become feasible in the future.

It is recommended that the plans of the Egyptian Geological Survey for the reactivation of the Maghara coal mine be studied to see how it will impact other aspects of Sinai development. Location of the fossil fired power generation plant should be studied to see if dual fuel firing is feasible. Utilization of associated flared gas from the Suez gulf region may be combined with Maghara coal to fire a high efficiency combined cycle power plant to add to the economic development of Sinai.

5.0 GEOTHERMAL

5.1 RESOURCES

While substantial sources of geothermal energy may exist in Egypt, there has been little systematic evaluation. Of the known hot springs, two are located in Sinai at Hamman Fara'un and at Hamman Saidna Musa. As displayed in Exhibit 5.1, the measured temperature of the Hamman Fara'un spring is between 75°C and 80°C, and its volumetric flow rate exceeds that of all other Egyptian sources. The published volumetric flow data was collected in 1961, and a site visit to Hamman Fara'un during the February trip indicated that current flow rates may, in fact, be somewhat less, although within a factor of 3.

5.2 CONCLUSIONS AND RECOMMENDATIONS

Proven geothermal resources in Sinai are limited in number and temperature. Although an intensive and systematic study may be merited in the future, current prospects and the relatively high economic cost of developing such resources, dictate against an extensive early program.

The Hamman Fara'un source is probably too isolated from potential industrial centers to be considered for power needs. The natural beauty of this region suggests that exploring the touristic appeal of hot spring pools from natural sources may be a possibility.

EXHIBIT 5.1

VOLUMES OF FLOW AND TEMPERATURES OF HOT SPRINGS OF SINAI

LOCATION	TEMPERATURE °C	VOLUME m^3/day
Ain Hammam Fara'un	75	880
Ain Hammam Saidna Musa	34	?

Source: I. M. Ramly, "Recent Review of Investigations on Thermal and Mineral Springs in the UAR," Twenty-third International Geological Congress, Vol. 19, pp. 201-213 (1969).

6.0 RENEWABLE ENERGY

Renewable energy resources in Egypt were studied in early 1980 by a joint Egyptian and American Team under the Technical leadership of the MITRE Corporation. (Ref. 6-1) The study attempted to ensure that the options recommended could be fully integrated into Egyptian economic, social and physical realities. Earlier, in 1978, data on potential use of renewable energy resources in Egypt was included in a Joint Egypt/U.S. Cooperative Energy Assessment (Ref 6-2). The descriptive and economic discussions in these two resource documents form a basis for the study of renewable energy resources in Sinai.

The economic value of petroleum resources on the world market is a strong impetus for the extensive utilization of solar, wind and biomass energy resources in Sinai. Displacement of petroleum use by alternative energy resources will directly benefit the export trade balance for Egypt since all petroleum production in excess of the national needs is sold at world market prices. The remoteness and the low population density of many portions of Sinai will also greatly restrict the use of electricity from the main electrical power grid for the foreseeable future. Thus, the development of various renewable energy resources may be the key to the long term economic growth and stability for the remote portions of Sinai.

6.1. SOLAR PHOTOVOLTIAC APPLICATIONS

Photovoltiac cells provide a means for direct conversion of solar energy to electricity. Cell efficiency is in the order of 12 percent, providing up to 120 watts per square meter of surface normal to the direct insolation. For large photovoltaic installations, tracking systems and concentrating optics can be used to maintain a high level of solar insolation and thus maintain a higher than normal output per solar cell. Electric storage batteries are normally used to provide electric power at periods when the sun is not shining, and solar cells are used to charge the batteries during sun periods. Some applications, principally water pumping for irrigation, can be accomplished as the sun shines with a resulting reduction in cost of the (storage) system. Cost of photovoltaic systems is expected to drop over the next four years because of major cost reduction programs by the U.S. Department of Energy.

Initial capital cost for solar-powered systems is much higher than equivalent fuel oil or electricity-powered systems because the internal combustion engine or electric motor is less expensive to build than solar cells. The advantage of the solar-powered system is that it does not require fuel to operate. Cost comparisons should therefore be made on a longer range basis to include the cost of operations. For example, a 10KW diesel-electric plant with an initial cost of $6,400 will consume 8000-10,000 gallons of fuel oil per year. Over a ten-year period, a 10KW solar-powered device can save 80,000 to 100,000 gallons of fuel oil. The value of the fuel oil saved is thus much more significant than the initial purchase price for the 10KW diesel electric plant.

It is recommended that a number of demonstration sites be selected for solar-powered water pumps to replace or supplement existing diesel-powered pumps at remote wells and for irrigation purposes. Fuel consumption data for diesel-powered pumps should be the basis for comparison with solar-powered replacements since the fuel savings will be the primary reason for utilizing solar photovoltaic-powered systems.

6.2 SOLAR THERMAL APPLICATIONS

Numerous solar thermal energy applications are presently under test and evaluation in Egypt today. Several applications, principally solar domestic water heating and solar distillation of brackish ground water, are technically viable for use in Sinai and demonstration sites are recommended to establish economic factors and infrastructure requirements.

6.2.1 SOLAR CROP AND FOOD DRYING

Solar crop and food drying represents an application employing solar collectors or greenhouse-like structures wherein air is heated and used to dry crops and food products. The scale of units may range from small chest-type collectors with a few square meters of area for use at the small, single farm to much larger commercial-scale units capable of producing several tonnes or tens of tonnes per day of dried goods (Ref 3-1 Page 77). Since commerical food and crop drying already takes place on a large scale in Egypt, it is likely that solar crop and food drying might be readily applied to Sinai. Furthur study or demonstration sites should be undertaken to establish the economic benefits for solar drying of fruit, fish, and other products in Sinai.

6.2.2 SOLAR PONDS

Solar gradient salt ponds can be a source of solar thermal energy of sufficient quality (i.e., temperature) to be useful for the generation of electrical energy or for a variety of applications which can utilize mechanical shaft power.

The solar gradient salt pond is an emerging technology which appears to have near term application for Sinai (Ref 6-3, 6-4, 6-5).

The salt gradient pond has high concentrations of salt near the bottom, decreasing to low concentrations near the surface. Salts most commonly used are NaCl and $MgCl_2$, although there are numerous other possibilities. Solar radiation enters the pond, and although some is absorbed in the water the majority is absorbed on the dark bottom (which may be an artificially blackened liner). As a result of this heat collection at the bottom, the deeper waters become warm.

Because of the higher concentrations of salt in the lower pond regions, the warmer, deep waters have a higher density than the cooler waters near the surface. Pure water becomes less dense when heated, and if there were no salt gradient in the pond there would be a continous convection of the warmed water from the bottom of the pond to the cooler layers near the top. The increased density caused by the salt prevents this natural convection and traps the heat in the bottom of the pond. Heat transfer to the surface of the pond which normally occurs by convection, is broken up to enable the lower regions of the pond to maintain a high temperature (100°C has been measured in actual ponds).

In practice, the salt gradient pond has three layers. Vertical convection takes place in the top layer due to the effects of wind and evaporation. The layer serves no useful purpose and is kept as thin as practically possible. This next layer, which may be approximately one meter thick, contains an increasing concentration of salt with increasing depth and is nonconvecting. The bottom layer is a high density convecting layer which provides most of the thermal storage and facilitates heat extraction.

Solar gradient salt ponds have operated in Israel, Canada, and in Ohio and New Mexico in the United States. The largest unit in operation at present has been producing 150 kilowatts of electrical power since 1980. It is reported that solar ponds can produce electrical power at a total cost of $.07/kWh and much larger units are under study.

One possible application of solar ponds in Sinai is to generate electrical power and manufacture ice for the fishing industry at Lake Bardawil. The high salt concentration in Lake Bardawil and the existing terrain which could minimize the cost of excavation are two factors which could be significant in the economics of building and operating the facility. Further study is suggested to determine the significance of these factors and to establish the practicality of salt gradient pond technology today.

6.2.3 SOLAR CONCENTRATORS

Solar concentrating reflectors, including trough type (line focus) and paraboloidal (point focus) optical systems can be utilized to provide higher temperature water or process steam for industrial applications of solar energy. The added complexity of single axis or two axis tracking adds to the cost of concentrator type systems and thus precludes their use for small applications.

Concentrator type solar collectors are under test and evaluation at the Solar Test Laboratory of the National Research Center in Dokki, Cairo. Operation and maintenance expense may be excessive because of the high incidence of sand and dust storms. However, the potential for producing industrial process steam at temperatures over the range of 250°F to 750°F suggest that tracking, concentrator type solar thermal systems may be an attractive alternative for industrial and commercial applications in the size range from ten to a few thousand kilowatts.

6.2.4 VACUUM TUBE COLLECTORS

Vacuum tube collectors represent a variety of reflective optics which do not require a tracking system and which achieve a higher temperature than flat plate collectors as a result of the vacuum layer between the outer transparent glass tube and the special absorptive coating on the inner (co-axial) tube.

These collectors can operate at temperatures in the 200°F-250°F range to operate absorption-type air conditioning systems. They have also been used for onion drying, commercial hot water systems and as preheaters for point focus type tracking mirrors to produce industrial quality steam.

Vacuum tube type solar collectors are suitable for factory assembly and could be used in place of flat plate collectors for domestic hot water systems.

6.3 WIND

The potential for utilizing wind power exists along both the Mediterranean Coast and the Gulf of Suez, as well as certain higher elevation sites such as Saint Catherines. No data were obtained on wind velocity in Sinai, although a monitoring station has recently been established at El Arish. Additional monitoring stations should be installed at representative sites to establish wind profiles before any conclusions can be reached concerning the practicality of wind power utilization in Sinai.

6.3.1 WIND ENERGY STUDIES

A joint Egyptian/U.S. program of study on wind energy in Egypt was conducted over a period of several years by the Egyptian Ministry of Electricity and Oklahoma State University. (Final Report - 1975) A Phase II effort, which was completed in November 1979, added a detailed measurement and experimental hardware program. (Final Report - Contract EH-78-C-02-4638 - Wm L. Hughes - Oklahoma State University, Stillwater, OK 74074)

The wind monitoring stations in Egypt and the duration of monitoring at each station were as follows:

1.	Mersa Matruh	7 months
2.	Ras El Heckma	8 months
3.	Sidi Abdel Rahman	10 months
4.	El Alemain	11 months
5.	Borg El Arab	11 months
6.	Safaga	5 months
7.	Hurghada	7 months
8.	Ras Gareb	4 months

Along the Mediterranean Coast, it was found that wind speeds were suitable for small machines for irrigating garden plots, or providing small amounts of electricity to charge batteries. Wind conditions, however, were not considered to be suitable for placement of large machines to provide continuous power to the grid.

It was felt that wind energy, especially on the coastal areas, should correspond reasonably well to the normal daily work cycle. Preliminary data indicated that the wind peaks in the morning and blows throughout the afternoon. This is due to the thermal heating of the inland deserts immediately adjacent to the relatively cool seas. Thus, the wind power profile corresponds to the work day requirements for energy in the rural coastal area.

The prospects for obtaining significant amounts of commercial power from wind energy for the electric grid were found to be much better along the Red Sea Coast where the wind velocities averaged several kilometers per hour higher than on the Mediterranean.

6.3.2 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of wind energy surveys in Egypt to date, it is recommended that similar measurements be made at selected sites from Port Said to El Arish on the Mediterranean Coast and from Suez City to Ras Muhammad on the Gulf of Suez. Other readings might be made at more mountainous sites such as the Oasis of Feiran and the Monastery of Saint Catherine. Demonstration wind powered machines might be constructed at selected sites to gain operational experience for utilization of wind energy in Sinai.

6.4 BIOMASS

Photosynthetic capture of solar energy from growing plant material is being considered as a method of producing energy. Generally, the processes to date are not considered to be a practical means for producing energy in and of themselves. When coupled with other infrastructure functions, such as food production or sewage treatment, photosynthesis and biogas production (bioconversion) may become a practical, economic alternative to other forms of energy production.

6.4.1 CONTROLLED ENVIRONMENT AGRICULTURE

Growth of vegetation in arid lands is particularily difficult and energy intensive. Excessive solar insolation, hot, dry winds and blowing sand result in low yields and poor quality production. Considerable research has been undertaken to develop controlled environment agriculture and other cultural practices to make food production possible.

Middle Eastern examples of controlled environment greenhouses for high volume vegetable production in coastal and inland deserts are the Arid Lands Research Centre, Abu Dhabi, United Arab Emirates, and Kharg Environmental Farms, Kharg Island, Iran. The Solar Engineering Group has prepared a concept paper on controlled environment agriculture for food production in Sinai for reference and as an aid to the development of agriculture projects The effective use of energy in controlled environment agriculture is a critical element in the economic success of crop production in arid lands.

6.4.2 GROWING BIOMASS FOR ENERGY

Biomass, or plant material in any form from algae to wood, has a remarkably uniform energy content of about half that of the better coals. A variety of land and water crops which might be easily and economically grown for harvesting and burning as fuel material are presently under investigation. While there are serious problems associated with large-scale energy farming, even a partial solution could add importantly to future energy supplies.

During photosynthesis in plants, light energy is captured and used to convert water and carbon dioxide into oxygen and energy-rich carbohydrates (i.e., molecules containing carbon and hydrogen atoms). This energy is released when the plants or their products decay or are burned. Current efforts are directed at controlling and boosting natural photosynthesis so that crops can be produced which convert sunlight to carbon compounds with high efficiency and produce fuels in a matter of days, instead of the millions of years needed to produce the conventional fossil fuels.

The findings to date demonstrate that a pound of dry plant tissue, when simply harvested and burned, can produce as much as 7,500 Btu's of heat, a little more than half of the heat available from a similar amount of coal. With some engineering improvement, a ton of dry biomass can be processed to yield 1.25 barrels of oil, 1,200 cubic feet of medium Btu gas, and 750 pounds of a solid residue that is roughly equivalent to coal in heat value.

One of the major problems in growing plants for energy is that photosynthesis is a relatively inefficient process, seldom exceeding 3 percent efficiency during the growing season. This means that 97 percent of the solar energy falling on that plant is not converted into stored energy, but is reflected away or dissipated into the atmosphere. In fact, a year-round average of just over one percent efficiency is typical for most high-yield crops, so that it requires a large amount of land to produce a given energy output.

The major research interest in bioconversion technology is in increasing plant biomass, producing a maximum amount of plant tissue with a minimum investment in time and money. The development of better energy crops will depend upon improvements in agriculture and silviculture (the development and care of forests).

Current efforts are focused on developing a plant which will combine large biomass with the ability to conserve water and nutrients. Under current technology, for instance, an acre of corn will produce about 6 tons of dry organic material. By comparison, certain plants, such as Eucalyptus trees, have biomass yields on the order of 8 to 25 tons per acre. Other large yield crops which were noted in a recent University of Oklahoma study include: sugar cane (12 to 50 tons), sorghum (8 to 30 tons), algae (15 to 30 tons), and sunflower (10 to 20 tons). It is hoped that the large biomass yield characteristic of these plants can be extended to other crops through techniques such as hybridization.

Pilot plants for algae cultivation have been constructed in which special nutrient culture mediums are kept in circulation by a complex system of circulating pumps and heat exchangers. These have proven to be very expensive, however, mostly due to the problem of harvesting and dewatering the crop. It may well be that algae, which has a very high protein content, will prove to be better suited as a food crop. For example,

researchers at the National Research Center in Dokki, Cairo, have studied an integrated system which includes growing algae for animal food using sludge from a biomass digester.

Similar production problems are affecting the development of water hyacinths as a fuel, even though these rapidly-growing, nutrient-rich water plants have a productivity of up to 85 tons of dry matter per acre per year. There has been some success with growing both algae and water hyacinths in sewage treatment waters

Experiments conducted by NASA in which water hyacinths are grown in sewage water are particularly interesting. One acre of sewage can produce enough nutrients to produce 800 to 1600 lbs of dry water hyacinths per day. This amount of plant material can be used to generate 3,500 to 7,000 ft^3 of methane gas (along with half a ton of fertilizer). What is of even greater interest, however, is that this energy production is a by-product of growing these plants in sewage. The primary goal is to clean up the water by absorbing the sewage nutrients and chemicals in the plant.

Other promising biomass schemes are those which call for the cultivation of land perennials, such as eucalyptus and sycamores, and of large marine algae, such as the giant sea kelp. Kelp farming is currently being studied on open-ocean rafts at San Diego, California where large brown kelp is being grown for conversion to methane. Kelp is a particularly attractive crop: it is fast growing, occupies inexpensive space, does not require irrigation, and offers the additional benefit of enhancing the local fish crop.

There is also growing interest in the possibility of converting agricultural crops to intermediate fuels, such as alcohol, which can be distilled from grain. Some attention is also being directed to the possibility of capturing the hydrogen in plant material for use as a fuel, but this is an idea which is still in its infancy.

In another direction, there is discussion of the attractiveness of rubber plants as an energy crop. The sap of this plant is already hydrocarbon and could perhaps replace the petrochemicals in many synthetic substances. An ideal plant of this type may in fact be the guayule which can grow on marginal desert areas and for which there is considerable enthusiasm currently as an additional source of natural rubber. The fact that it does not compete with food crops for land will be in its favor.

The relative abundance of arable land, the easy convertability of biomass into desirable liquid and gaseous fuels, and the low environmental impact of either the production or combustion of these fuels (organic materials are generally low in sulfur, for instance) have all served to stimulate interest in growing plants for energy.

To date, no bioconversion system has been demonstrated to be cost competitive with conventional fuels and it may be that energy farming will develop environmental problems which will offset much of its appeal. Little is known, for instance, about the long-term effects of large-scale, single-crop farming (monoculture), but there is evidence that there are inherent problems, in such a system, with insect and disease epidemics. For the present, bioconversion of agricultural crops into fuel remains an exciting, if unproven, alternative to conventional fuels and power plants. Increasingly, however, attention is being focused on a related bioconversion scheme, the use of organic waste as fuel, and it may be that large-scale future efforts will be focused in that direction.

6.4.3 CONCLUSIONS AND RECOMMENDATIONS

1. The use of biomass as a source of energy is most likely to become a reality in conjunction with food production or sewage treatment. The effective use of night soil, animal manure and agriculture waste to produce biogas and a nutrient rich sludge for use as natural fertilizer and humus for farmland is currently being attempted by the Egyptian Ministry of Agriculture and the National Science Foundation. Demonstration sites based on the National Research Center designs should be established in El Arish and other popular areas in Sinai to work out operational problems, train operating personnel and determine actual economic parameters.

2. Controlled environment agriculture has been demonstrated to be an effective method for growing high quality vegetables in harsh arid lands. Quality produce can be one of a number of inducements for Sinai settlers, and controlled environment agriculture can provide employment for Egyptians living in Sinai. Several such facilities should be built and operated at selected sites in Sinai to obtain operational experience, train personnel and determine economic parameters of this energy intensive agri-business.

3. The use of biomass as an energy source is most likely to be economically viable when integrated with other infrastructure systems such as food production and sewage disposal. A project should be initiated at the Desert Research Institute to evaluate the biomass energy alternatives and determine which alternatives should be implemented for Sinai. Specific biosystems for consideration are growing giant sea kelp in conjunction with fishing in the gulf or the Mediterranean, growing algae from sewage sludge and growing guayule plants or other arid land plants for hydrocarbon feedstocks.

SECTION 6 REFERENCES

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6-2 Joint Egypt/United States Report on Egypt/ United States Cooperation Energy Assessment
April 1979 - US Department of Energy

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6-4 Solar Ponds
by T.S. Jayadev and Michael Edesess
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6-5 Solar Pond Economics
by Michael Edesess
July 1980 SERI (DRAFT)

ANNEXES

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18 JANUARY - 8 FEBRUARY 1981

Annex 2: PROPOSED OUTLINE OF FINAL REPORT

Annex 3: PROJECT SUMMARIES

Annex 4: ELECTRICAL DISTRIBUTION SYSTEM DIAGRAMS

Annex 1:

LIST OF CONSULTATIONS
18 JANUARY - 8 FEBRUARY

ANNEX 1: CONSULTATIONS BY D. E. LEE AND T. V. LONG - 1/18-2/6/81

H.E.Dr. Ali Abu Zeid
Chairman, Sinai Development Authority
Ministry of Development

Lic. Samir Said
Chief of Foreign Affairs in Sinai
Ministry of Reconstruction and Development

H.E.General Yousef Sabri Abou Taleb
Governor, Governorate of North Sinai

Lic. Mohamed El-Hafiz Korayem
Director, Technical Office
Governorate of North Sinai

Engr. Mohamed Sabri
Director, Hydrology Section
Governorate of North Sinai

Eng. Mustafa Osman
Director, Mining Section
Governorate of North Sinai

Eng. Fawzy
Secretary General
Governorate of South Sinai

Eng. Ahmed Nour El-Din
Energy Consultant
Egyptian General Petroleum Corp.

Geophysicist Ibrahim A.F. Rahman
General Manager, Petroleum Agreements
Egyptian General Petroleum Corp.

Eng. Ghaim Tawfic
Egyptian General Petroleum Corp.

Eng. Mohamed Eid
General Fields Manager
GUPCO

Eng. Hussein Sirry
Chairman, Egyptian Electrical Authority
Ministry of Electricity

Dr. Fuad El-Sharkawi
Deputy Chairman, Technical Affairs
Egyptian Electricity Authority
Nasr City, Cairo

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Dr. Ahmed A. Amin
Undersecretary, Ministry of Electricity
Managing Director of Manpower and Training
Egyptian Electrical Authority

Dr. M. Abdel Baky El-Bohairy
Director, Technical Secretariat
Supreme Council of Renewable Energy

Dr. Talaat A. El-Tablawi
General Director of Planning and Investment Studies
Egyptian Electricity Authority
and Deputy Chairman, Supreme Council of
Renewable Energy

Dr. Kamal Hamed, Chairman
Qattara Hydroelectric and Renewable
Energy Authority

Dr. Abdel Latif Mabrouk
Director of Research, Study and Development
Qattara Hydroelectric and Renewable
Energy Authority

Dr. Anhar Hegazi
Director, Dept. of Energy Studies
Specialist (Solar Energy)
Qattara Hydroelectric and Renewable
Energy Authority

Dr. Assad
Qattara Hydroelectric and Renewable
Energy Project

Eng. El Sayed Mohamed Gad
Head, Technical Sector
Canal Electricity Distribution Co.

Eng. Ahmed Reda
Managing Director, Project Department
Canal Electricity Distribution Co.

Eng. Ismaiel El-Sharfi
Egyptian Electricity Authority
Canal Area

Professor E. M. El-Shazly
President, Egyptian Nuclear Materials Corp.

Professor Dr. Ismail Abdu, Director
Egyptian Petroleum Research Institute

Dr. Mohitar El-Helwagi
Head, Engineering Research Division
and Director, Pilot Plant
National Research Center

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Dr. Abed Abdel-Dayem
Head, Biogas Engineering Project
National Research Center

Dr. Kawal Helwa
Head, Solar Energy Laboratory
National Research Center

Dr. Attia El-Mallah
Head, Mechanical Engineering and
Director, Wind Energy Project
National Research Center

Dr. Aladin
Director, Biogas Project
Ministry of Agriculture
Agricultural Center

Dr. Abdu A. Shata
Director, Desert Research Institute
Agricultural Research Center
Ministry of Agriculture

Dr. Essam Montassir
Professor of Economics
American University of Cairo

Eng. Mohamed Khatab
Field Manager
Abu Zenima
Sinai Manganese Co.

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Annex 2:

PROPOSED OUTLINE OF FINAL REPORT

ANNEX 2: PRELIMINARY OUTLINE - ENERGY IN SINAI

EXECUTIVE SUMMARY

I. Introduction with terms of reference

II. Energy in Egypt

A. Resources and Supply
B. Demand
C. Planning
D. Petroleum exports, imports and foreign trade accounting

III. The Sinai Peninsula in Egyptian energy planning

A. National electric grid
B. Petroleum supply
C. Water
D. Other aspects (El Maghara, flared gas)

IV. Governorate of North Sinai

A. Current demand
1. Petroleum
a. Gasoline
b. Diesel
c. Heavy fuel oil
d. Kerosene
e. Greases and lubricants
f. Asphalt and road materials
2. Electricity
a. Industry
b. Residential, commercial and town
c. Irrigation
d. Transmission-distribution
e. Connection to grid
f. System efficiency and total thermal equivalent
3. Non-commercial fuels
a. Animal wastes
b. Wood
c. Grasses and scrub
4. Rationalizing energy use

B. Current and projected conventional resources and supply
1. Petroleum
2. Coal - El Maghara
3. Electricity
4. Gas
a. Associated
i. Flared
ii. Captured
b. Non-associated

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C. Renewable energy
   1. Solar
      a. Resource potential
      b. Water heating
         i. Factory for solar water heaters
      c. Space conditioning
         i. Heating
         ii. Cooling
      d. Water pumping
      e. Photoelectric
      f. Desalination
      g. Salt ponds (refrigeration - Lake Bardawil)
   2. Wind
      a. Resource potential
      b. Water pumping
      c. Electric generation
   3. Biogas and biomass
      a. Cooking
      b. Lighting
      c. Heating
      d. System descriptions
   4. Geothermal
      a. Resource potential
      b. Potential applications

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D. Projected demand 1980--2000
   1. Projection bases
      a. Population
      b. Per capita income
      c. Number of vehicles
      d. Number of irrigated feddans
      e. Industrial growth
      f. Infrastructure construction
   2. By area

E. Supply - demand reconciliation (matching)

F. Special projects
   1. El Maghara
   2. Lake Bardawil
   3. Glass factory
   4. Irrigation by Nile siphon via Suez
   5. New cities (Kit Abu-El-Ruwa)

G. Summary of potential energy projects
   1. Immediate
   2. Prefeasibility: near-to-medium term
   3. Long term

V. Governorate of South Sinai

A. Current demand
1. Petroleum
a. Gasoline
b. Diesel
c. Heavy fuel oil
d. Kerosene
e. Grease and lubricants
f. Asphalt and road materials
2. Electricity
a. Industry
b. Residential, commercial and town lighting
c. Irrigation
d. Transmission-distribution
e. Connection to grid
f. System efficiency and total thermal equivalent
3. Non-commercial fuels
a. Animal wastes
b. Wood
c. Grasses and scrub
4. Rationalizing energy use

B. Current and projected conventional resources and supply
1. Petroleum
2. Gas
a. Associated
i. Flared
ii. Captured
3. Electricity
4. Coal

C. Renewable energy
1. Solar
a. Resource potential
b. Water heating
c. Space conditioning
i. Heating
ii. Cooling
d. Water pumping
e. Photo electric
f. Desalination
g. Refrigeration - El Tor fishery
h. Solar pond communities
2. Wind
a. Resource potential (particularly Ras Sudr, El Tor, St. Catherines)
b. Water pumping
c. Electric generation
3. Biogas and biomass
a. Cooking
b. Lighting
c. Heating
d. System description

4. Geothermal
   a. Resource potential
      i. Hamam Fara'un
   b. Potential applications

D. Projected demand 1980-2000
   1. Projection bases
      a. Population
      b. Per capita income
      c. Number of vehicles
      d. Number of irrigated feddans
      f. Industrial growth
      g. Infrastructure construction
   2. By location

E. Supply-demand reconciliation

F. Special projects - summary
   1. Flared gas
   2. Gypsum
   3. Abu Zenima
   4. Fishery

VI. Sinai energy supply-demand summary

VII. Data base recommendations

APPENDICES:

1. List of individuals interviewed and consulted

2. Project descriptions

Annex 3:

PROJECT SUMMARIES

PROJECT SUMMARY

1. TITLE: Test Solar Desalinization of water from Sinai sites.

2. LOCATION: Solar Test laboratory National Research Center
Dokki, Cairo

3. DESCRIPTION: The Solar Test Laborator, under Dr. Nawal Helwa, has in operation five (5) designs of low cost water distillation units (stills) which have been tested for over three months. Each still has a surface area of about 20 square meters. Productivity of potable water during the test period ranged from 0.7 to 4.25 liters per day per square meter and is expected to be higher during the summer months.

The stills at the Solar Test Laboratory are of simple construction and could be used to provide potable drinking water to small communities distributed in arid regions of Sinai.

The Desert Research Institute, under the direction of Professor M. Atef Abdel Salam, could easily participate with the Solar Test Laboratory to provide supplies of brackish water from at least three localities in South and North Sinai such that actual test results could be obtained. Later the Desert Research Institute could coordinate the installation and operation of demonstration stills at sites in Sinai.

4. STATUS: Dr. Helwa at the Solar Test Laboratory has stated that the laboratory will be happy to cooperate in testing the operation of the existing Solar stills using actual water from sites in Sinai. Tests are at present being conducted with artifically salted Cairo water. Tests will be conducted and reports will be prepared to show actual performance of the stills using brackish water from Sinai.

5. FUNDING STATUS: No funding is required since both laboratories have existing capabilities to perform the required efforts and have indicated a willingness to participate in the cooperative demonstration project.

.../...

6. FEASIBILITY: Project is entirely feasible and acceptable from all points of view.

Reviewer D. E. Lee
T. V. Long

Date February 4,

1. TITLE Automatic Solar, Wind and Meteorological Monitoring Station

2. LOCATION: Multiple locations throughout Sinai and possibly throughout Egypt.

3. DESCRIPTION - including inputs, outputs, origin of inputs, destination of outputs, capital investment, overall cost, gestation period.

Inputs include various characteristics of solar insolation including direct and indirect insolation. Haze & dust occlusion, percent cloudiness and to develop data base for atmospheric infra-red radiation, also wind data to provide time varying direction and velocity.

4. STATUS French design "Shak 7" stations are installed and data collection has started. Many more sites are needed to develop site specific data for solar/wind sites.

5. FUNDING STATUS No funding identified as yet.
Could be added to existing Sinai Development Study.

6. FEASIBILITY - financial, technical, economic, environmental and social

Egypt must move rapidly to establish technical and economic feasibility of solar, wind and other alternative energy projects in order to move into full scale production and utilization at an early date. Additional monitoring stations will make this possible.

REVIEWER DATE

D. E. Lee 1-26-81

PROJECT SUMMARY

1. TITLE: Energy Audit for Sinai

2. LOCATION: All significant energy use sites in Sinai

3. DESCRIPTION: The energy audit will identify the present flow of energy in all significant energy use sites in Sinai and will show those locations where significant reductions of energy can be made by conservation or by redesign to accommodate alternative energy.

4. STATUS: No known activity at this time.

5. FUNDING STATUS: None. Could be added to existing Sinai Development Study

6. FEASIBILITY: Energy audits have been shown to be a practical, low cost method for reducing consumption of non-renewable energy resources; and, in most cases, they provide a return on investment of 35 to 100% per year.

REVIEWER: D. E. Lee DATE: January 26, 1981

PROJECT SUMMARY

1. TITLE: Evaluation of Potential Infrastructure Use of Abu Zenefima Electrical Generation and Desalination Facilities After Rehabilitation

2. LOCATION: Sinai Manganese Co. facilities at Abu Zenefima

3. DESCRIPTION: The original (pre-1967) electrical generation station at Abu Zenefima included three brown Boveri Type TA 8007 gas turbines complete with main compressors; combustion chambers; gear reducers; Type WT 321, 7-MW, 11-kv generators; exciters; starting motors; and auxiliary control and other equipment. Also, there were two auxiliary diesel generators. Stacks for two of the gas turbines are fitted with heat exchangers that supplied heat to a flash distillation plant for sea water desalination.

The power station suffered significantly less war-related damage than any other facility in the Abu Zenefima complex. A site visit by the Solar Engineering Group - DAMES & MOORE team revealed the following. Although the resident architect-engineer stated that a fire burned for 27 days, this was apparently combustion of a heavy fuel oil that was very smoky but did little damage other than depositing a soot coating. Light bulbs and ceramic tiles are still in place and are not cracked, as would have been expected from a high-temperature fire. The wiring and electrical cables were damaged or have been removed, and the control cabinet and control systems were removed or destroyed. However, the generation units themselves appear to be unharmed, and the power circuit breakers likewise seem to be in good condition. Thus, a potential 21 MW gas turbine electrical generation capability lies unused.

The heat exchangers (gas-to-water) appear to be only slightly damaged, with the aluminum flashing on one ripped. The original desalination facility consisted of a Weir Westgarth Ltd. multistage flash distillation unit that had a design capacity of 800,000 cubic meters per year (equivalently, 500,000 gallons per day). This unit, which had an installed cost in the early 1960's of 270,000 British pounds, had a performance of 10:1 with a maximum product quality (from sea water) of 50 p.p.m. The desalination plant was completely transferred after the Six-Day War by the Israelis to Eilat, where it has operated since. A "ballpark" estimate of a similar-size facility currently is US$ 1,250,000 (quotation from Sasakura International Corporation to Kaiser Engineers, 17 July 1980).

A Brown Boveri engineer examined the power station in 1976, and they estimate that rehabilitation of the electrical generation unit would cost US$ 11,057,000, a figure that seems high, given the apparent damage to the facility. It is noteworthy that they simultaneously quoted a cost of US$ 12,952,000 for two new Type 9, 29 MW turbine generators.

The power plant was originally to be supplied by an 8-inch spiral weld steel pipe from Bellayim. Some of this pipeline has been des-

4. RECOMMENDATION: The Kaiser Engineers and Constructors, Inc.'s Report to The Sinai Manganese Co. (September 1980) recommends abandonment of rehabilitation efforts of existing power station equipment. Replacement by two, 7.4 MW turbines is suggested. Because the ferromanganese plant fresh water needs are not anticipated to be greater than 191,000 cubic meters a year, they recommend installation of a reverse-osmosis desalination unit with a 245,000 cubic meters a year design capacity. This would be sufficient to service only this plant with only marginal amounts available for other uses. However, their subsequent evaluation recommends that fresh water and electricity must be furnished from off-site sources.

Because it appears that Sinai Manganese Co. does not plan to renovate the power plant and desalination facilities, the Ministry of Reconstruction and Development may wish to consider immediate evaluation of the rehabilitation potential of these facilities for more general infrastructure use. The Abu Zeneima area provides an excellent location for an industrial complex that would include gypsum, glass-making, kaolin, cement and other potential industries in addition to the ferromanganese plant (see other Project Evaluations from SEG). Economies of scale dictate that the desirable plan would be to furnish fresh water and electricity from a central facility for this complex, presumably making use of associated gas from the Bellayim field that is currently flared, rather than having individual plant generation. The central facility could also furnish water and electricity requirements for community development.

In any case, the Ministry should consider immediate use of this valuable equipment, which apparently will be scrapped, in a productive application in Sinai, whether in Abu Zeneima or elsewhere. A team of specialized engineers should be dispatched to carefully examine this possibility in cooperation with the Sinai Manganese Co. at the earliest possible time.

5. STATUS: No activity.

6. FUNDING STATUS: None. This evaluation could readily be added to the existing Sinai Development Study.

7. FEASIBILITY: Recommendation can be immediately implemented.

REVIEWERS T. V. Long
D. E. Lee

DATE February 4, 1981

PROJECT SUMMARY

1. TITLE Sinai Glass Factory

2. LOCATION South Sinai - Suez Gulf Region

3. DESCRIPTION Sheet glass and glass containers are an essential element in a developed country, and sheet glass will be a major cost element in many solar energy applications. South Sinai has deposits of high quality white sand for glass making at El Khaboula (near Abu Zeneima). These were exploited prior to the 1967 War. Also, there are significant quantities of gas associated with oil production in the Bellayim fields that presently are flared. A glass factory in the region of the sand and gas supply could be an effective means for utilizing the natural resource (sand) and the flared gas, while providing an industrial base to support growth and development in Sinai. Output of the factory can provide glass needs for Sinai, elsewhere in Egypt and may also be exported to other locations in the Middle East and Mediteranean countries.

A modern glass factory can be designed to be energy efficient and can utilize significant labor in material handling, operation and maintenance of the plant.

4. STATUS Concept definition - No known plans for implementation.

5. FUNDING STATUS None. Funding for prefeasibility study could be added to exisitng Sinai Development Study.

6. FEASIBILITY The utilization of local resources and flared gas should provide an economic basis for glass making which could be competitive with existing glass factories in Egypt, the Mediteranean and Middle East regions. The economic and social impact on development of South Sinai should be positive.

REVIEWER: D. E. Lee
T. V. Long

Date: February 3, 1981

PROJECT SUMMARY

1. TITLE Industrial Complex near Abu Rudeis to Utilize Flared Gas from Sinai Oil Wells

2. LOCATION South Sinai, Suez Gulf Region

3. DESCRIPTION The availability of associated gas from oil wells in the Sinai side of the Gulf and the availability of various raw materials may justify the development of a sizeable industrial complex near Abu Rudeis.

   Examples of potential industries that would utilize natural gas and petroleum (for feedstocks or energy) as well as other raw materials indigenous to the area:

   a. fertilizer
   b. cement
   c. gypsum
   d. copper
   e. ferromanganese
   f. petrochemicals
   g. glass

   A single industry, such as fertilizer production or cement manufacture might not be economically viable because of the significant infrastructure required.

   However, the combined requirements of a multi-industrial complex for public services, roads and utilities would justify government support of investments in infrastructure. It is estimated that energy based industrial development in the Abu Zenima - Abu Rudeis region would support a population of at least 25,000 by the late 1980s. Fishing, agriculture and other activities would expand in response to the demand for food products and other services generated by the growing industrial base.

4. STATUS No activity concerning a combined industrial complex exists. However, individual studies have been made on individual industrial operations. The EGPC has considered possibilities of combining the seperate oil communities to provide the basic infrastructure to support non-petroleum based expansion in the Suez Gulf region of Sinai.

5. FUNDING STATUS None. Could be added to existing Sinai Development Study.

6. FEASIBILITY Synergism of a multi-industrial complex will improve the feasibility of all industries by a sharing of all infrastructure, technology transfer and a general increase in availability of personnel and supplies.

REVIEWER: D. E. Lee
T. V. Long
R. T. Mott

DATE: February 7, 1981

PROJECT SUMMARY

1. TITLE: Lake Bardawil Power & Ice Project

2. LOCATION: Lake Bardawil Region - North Sinai

3. DESCRIPTION: Salt ponds have been shown to be technically feasible for collecting and storing Solar Thermal Energy near the boiling temperature of water. Research at the National Physical Laboratory in Jerusalem is producing electricity, and a 600 megawatt solar salt pond generating complex is planned for the Salton Sea in California. Hot brine from the bottom of the pond is pumped to an evaporator, where a fluid is vaporized to drive a turbine and generator. Cool water from the top of the pond condenses the vapor back to a fluid. Numerous ponds are in construction or operating in Israel.

   The high salinity at Lake Bardawil could be an ideal source for concentrated brine. Additional salt can be furnished from surrounding evaporation ponds. Only a small portion of the lake should be required for solar pond electrical generation. This would be separated by dikes from the remainder of Lake Bardawil, and there would be no increase in general lake salinity.

   The need for ice and electrical power in the region to support the fishing industry could be an ideal application for a solar pond power plant. Estimates based on using Ormat turbines for a five megawatt prototype plant indicated that the five megawatt plant would cost about $10 million and deliver electricity for about seven cents a kilowatt hour.

4. STATUS: No activity.

5. FUNDING STATUS: None. Pre-feasibility study could be added to existing Sinai Development Study.

6. FEASIBILITY: Solar salt pond utilization is a proven but evolving technology. A pre-feasibility study should evaluate the financial, technical, economic, environmental and social impact.

Reviewer: D. E. Lee
T. V. Long

Date: February 3, 1981

PROJECT SUMMARY

1. TITLE: Solar Demonstration Site
Governorate of South Sinai
El Tor, South Sinai

2. LOCATION: The Governor's Residence - El Tor, South Sinai

3. DESCRIPTION: The application of solar energy in South Sinai will be a significant step toward establishing a practical, self-sufficient energy source for the long range development of South Sinai.

Although proven in some applications, such as domestic hot water and remote, low-power photovoltaic cell power panels, solar energy is a developing technology and much care will be required to ensure that practical, reliable, "appropriate technology" systems are selected for us in South Sinai. A solar demonstration site is proposed for installation at the Residence of the Governor of South Sinai Governorate, (or at other location(s) which may be determined to be more appropriate), such as, New Mit Abu-El-Knom at Biller Lake). The demonstration site should include solar hot water heating, solar water pumping, solar cooking, solar cooling, passive solar design of structures and provisions for expanding or modifying the installation as new and impoved solar technology becomes available. The demonstration site may be expanded to include biogas generators, wind machines, waste heat recovery devices and other alternative energy/energy conservation items. Energy consulting service and energy training activities may also be incorporated to broaden the applicability of the demonstration site.

4. STATUS: No prior activity. Dr. Kamel, President of the Egyptian National Research Center, has indicated his organization's interest in establishing such a facility.

5. FUNDING STATUS: No funds identified. Could be added to the Sinai Development Study - Phase I.

6. FEASIBILITY: Many solar power devices have been shown to be technically sound and environmentally and socially acceptable. Financial and economic feasibility will depend on many factors, including internal pricing policies for petroleum and electrical energy sources in the region. A prefeasibility study should be performed to expand on the concept definition provided herein and establish a rational basis for determination of the size and scope of the demonstration site.

PROJECT SUMMARY

1. TITLE: Solar heating and hot water for motels, hotels, and multi-family dwellings

2. LOCATION: Various sites in North and South Sinai

3. DESCRIPTION: Space heating and water heating for living quarters is either non-existent or electrically powered. As electricity is made available to more communities (via diesel-electric generators or the national electric grid), it is expected that there will be a rapid expansion of electrically powered heating systems.

   Since heating requirements are minimal in most locations in Sinai (even in winter months), it should be relatively easy to meet the space heating needs by solar collectors and thermal energy storage systems. Solar hot water systems are in use in the El Arish area and can be easily applied at other sites.

4. STATUS: Undefined. Prefeasibility study should be made to provide more detailed project definitions.

5. FUNDING STATUS: No funds authorized. Can be added to existing Sinai Development Study.

6. FEASIBILITY: Technical feasibility of solar space heating have been clearly demonstrated, especially in conjunction with passive solar designs and adequate insulation systems. Environmental and social impact should be minimal or positive. Financial and economic feasibility will depend on factors such as national policy concerning energy pricing.Studies are required to determine alternative approaches and to evaluate the financial/economic benefits of the most preferential systems.

REVIEWER D. E. Lee
T. V. Long

DATE February 7, 1981

PROJECT SUMMARY

1. TITLE Solar Domestic Water Heater Factory

2. LOCATION El Arish, North Sinai

3. DESCRIPTION There are at the present a significant number of solar powered domestic hot water systems installed and operating in El Arish. A small (3 man) plant exists in El Arish which is currently producing about 3 solar hot water systems per day for the local market and for shipment to Cairo.

The present activities could form the base for an expanded plant to produce, install and service significant quantities of solar hot water systems. Following successful development of a line of water heaters, the plant might be expanded to include solar cookers, water distillation units, biogas generators and related gas devices, and other alternative energy devices.

4. STATUS Three man operation is in place at El El Arish producing about three solar hot water heaters per day.

5. FUNDING STATUS None identified. Feasibility study and direct support during implementation could be added to the existing Sinai Development Study.

6. FEASIBILITY The concept appears to be completely feasible from all aspects. The use of local manufacture will provide employment for people in El Arish in the direct manufacturing operations as well as in service and related support functions

REVIEWER: D. E. Lee
T. V. Long

DATE: February 7, 1981

PROJECT SUMMARY

1. TITLE: Solar Cookers for Sinai

2. LOCATION: Remote locations in Sinai

3. DESCRIPTIONS: Solar cookers have long been considered as an interesting possibility for using solar energy to replace the inefficient burning of wood and other non-commercial energy sources. However, practical cooker designs have not, as yet, been demonstrated or produced in sufficient quantities to have a significant impact on the energy use in developing countries.

   The Florida Institute of Technology has cooperated with the Egyptian government to fabricate several solar cookers in Egypt, using local workshops and materials. The cookers are presently being tested at a site on the High Dam Lake (Lake Nasser). The current status (1-1-81) of cooker No. 3 is that the cooker works successfully; performance is good but could be improved via modifications, based on results of a computer simulation and further testing. Manufacturability for volume production would undoubtedly result in changes to a number of design details.

   Dr. Thomas E. Bowman, Head of the Mechanical Engineering Department at the Florida Institute of Technology, has been unable to obtain outside funding in recent years. Dr. Talaat A. El-Tablawi, General Director of Planning and Economic Studies, Egyptian Electricity Authority and Deputy Chairman, Supreme Council of Renewable Energy, has indicated that funding is available from the Ministry of Electricity but that none had been requested.

   It is proposed that a joint USAID/GOE project be initiated to continue the development of the solar cooker, using the technical direction of Dr. Bowman, of Florida Institute of Technology, and the Desert Research Institute. DAMES & MOORE, with the help of Solar Engineering Group, can coordinate the effort to ensure that the project is effectively implemented.

4. STATUS: Initial units under test at Lake Nasser.

5. FUNDING STATUS: Egyptian funds are available for further development. Details must be developed.

6. FEASIBILITY: Technical feasibility has been demonstrated. Economic and social impact can best be determined by demonstration in Sinai, under direction of the Desert Research Institute.

   Background correspondence and reports are available in DAMES & MOORE's Cairo office.

REVIEWER D. E. Lee DATE February 4, 1981
T. V. Long

PROJECT SUMMARY

1. TITLE Sinai Quality Assurance Plan

2. LOCATION Applicable to all Sinai projects

3. DESCRIPTION Sinai is a harsh environment that may cause malfunction or failure of equipment or entire projects that are not designed, built and operated to be environmentally compatible. The Quality Assurance Plan (QAP) should interact with all work functions from concept evaluation through design, construction and operation to minimize total life cycle cost for achieving the Sinai program objectives.

No capital investment is required to develop the QAP, but operating costs will occur to establish a Sinai Quality Assurance Program and operate training schools for related Sinai construction and operating personnel.

4. STATUS No known activity at present

5. FUNDING STATUS None - can be added to present Sinai Development Study.

6. FEASIBILITY A Quality Assurance Program for Sinai will define the level of effort required in all Sinai project work functions to achieve operational objectives with minimum total life cycle costs under established funding constraints. The QA concepts that have been developed in U.S. space programs and applied to the industrial sector by Japan and other developed countries can be applied to the Sinai projects from the beginning to control the quality of all work elements and achieve performance objectives at minimum total costs. The plan should be developed immediately to provide a basis for controlling early project tasks and to permit time for evolutionary changes to be made before major Sinai projects are undertaken.

7. REVIEWER: D. E. Lee DATE: February 3, 1981

PROJECT SUMMARY

1. TITLE Sinai Transportation System

2. LOCATION All of Sinai

Best Available Copy

3. DESCRIPTION An effective transport system in Sinai is an essential element of the overall development plan, and it may be a key to attracting Egyptians to relocate and develop the area. The system should include land, water and air transport for personnel, supplies and equipment to habitable and potentially habitable locations. It should be available to all Sinai personnel on a fair and reasonable basis. The transport system should be provided by the Government of Egypt as an incentive to the rapid development and utilization of the resources of the region.

One possible means for establishing an effective Sinai transport system at minimum incremental cost and with maximum benefit to the Government of Egypt is to utilize army personnel and equipment until such time as the system can be turned over to a non-military operation. The direct benefits to the army in personnel training and experience in Sinai should be apparent.

Specific elements of the transport system include desert road building and maintenance, sand control and removal, remote road patrol and road service to stranded travelers, airport construction, maintenance and operation, Sinai truck and air freight transport system and freight terminals, Sinai personnel transport by bus and air, Sinai transport system management and support services.

Overall cost of the system will be large, but the benefits in direct support to Sinai Development and effective utilization of existing military personnel in the area will more than offset the incremental cost.

4. STATUS Undefined - should be studied to establish feasibility and develop program details.

5. FUNDING STATUS None - Can be added to existing Sinai Development Study.

6. FEASIBILITY The Sinai transportation system is not only feasible, but essential to the rapid and effective development of Sinai. The use of army personnel and equipment will minimize the cost by utilizing an exisitng standby re-

exposure of Egyptian army personnel in Sinai, thus providing a pool of potential settlers after completion of military service. Training and experience can be carried over to civilian life in Sinai.

REVIEWER: D. E. Lee DATE: February 3 1981

PROJECT SUMMARY

1. TITLE: Controlled Environment Agriculture

2. LOCATION: Agriculture Research Station at Nakhl

3. DESCRIPTION: In some areas of the Sinai, controlled environment agriculture may be the only viable means for local production of certain food crops. The design and operation of a facility to provide a controlled environment must efficiently utilize available resources. Greenhouses may be constructed and operated to require a minimum of energy by incorporating insulation and shading components, micro-processor based control systems, and appropriate horticultural management and scheduling. Furthermore, greenhouses can utilize unconventional energy sources.

   A demonstration project is proposed which would include the construction and operation of a commercial size (0.5-1.0 ha) greenhouse designed specifically to be energy-efficient and minimize water consumption. Such a greenhouse would provide a facility that could be used for research in environmental control and crop production and training in horticultural techniques. The greenhouse should include passive and active cooling systems, and water-conserving production techniques, and might also incorporate micro-processor based environmental control systems, water desalination facilities, aquacultural operations, and use of wind or other alternative sources to provide mechanical or electrical power.

4. STATUS: No prior activity.

5. FUNDING STATUS: No funds identified. Could be added to the Sinai Development Study.

6. FEASIBILITY: Commercial scale facilities have been constructed and operated Abu Dhabi, Iran and Arizona demonstrating the technical feasibility of greenhouse agriculture for producing high yields of vegetable crops in arid climates using energy-efficient design and advanced horticultural techniques. Economic feasibility is very much site specific in that the facility must compete with alternative food sources. Sinai may be an ideal site for controlled environment agriculture from an economic viewpoint.

Reviewers:
D. E. Lee
T. V. Long
R. Richardson

DATE: March 16, 1981

Annex 4

ELECTRICAL DISTRIBUTION SYSTEM DIAGRAMS

EL ARISH SECTION

OLD STATION: 3x 800 KW (SCRAPPED)

GAS GENERATING STATIONS: 2 x 3.2 MW (UNRELIABLE)

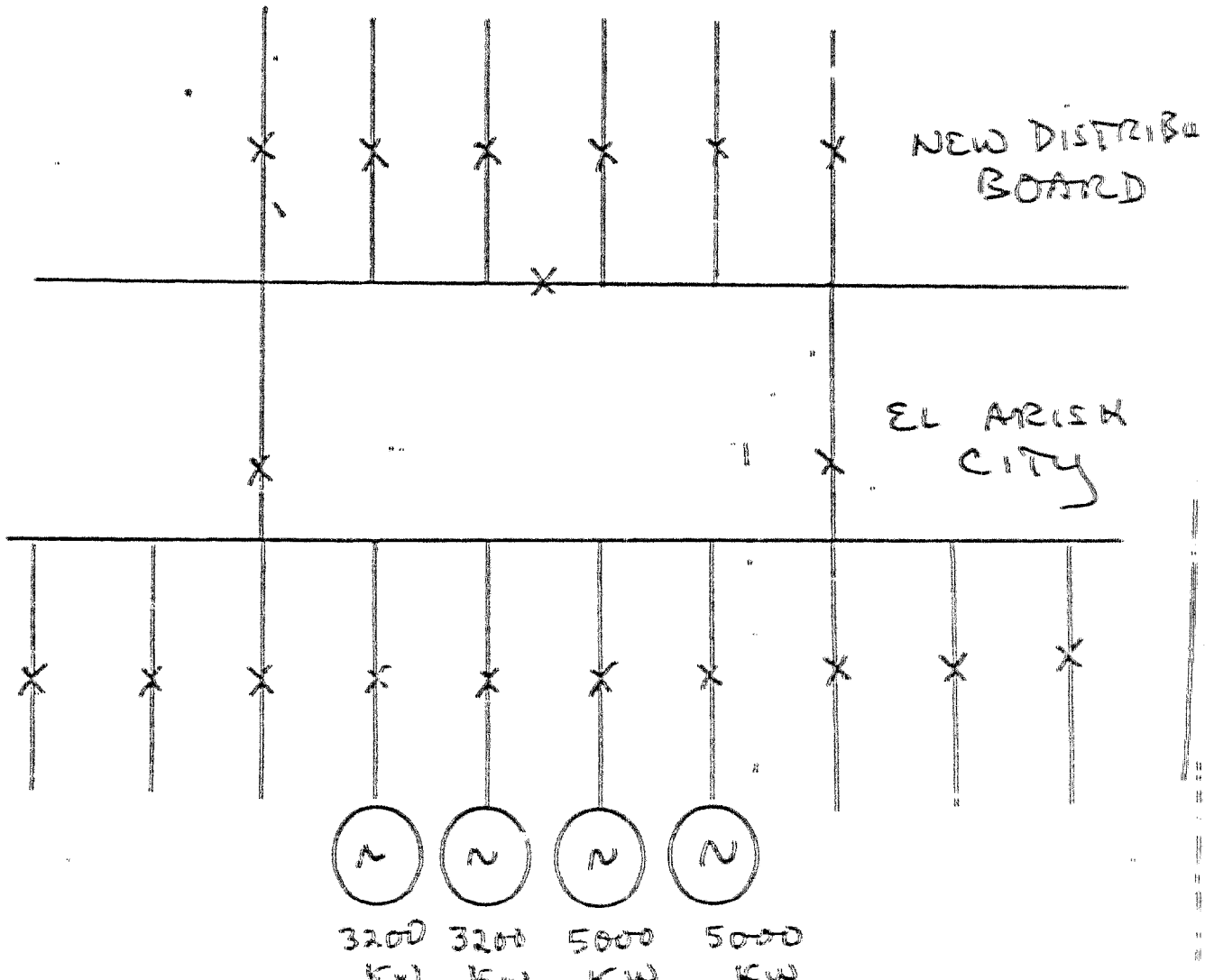
PROPOSED GAS UNITS: 2x 5.0 MW

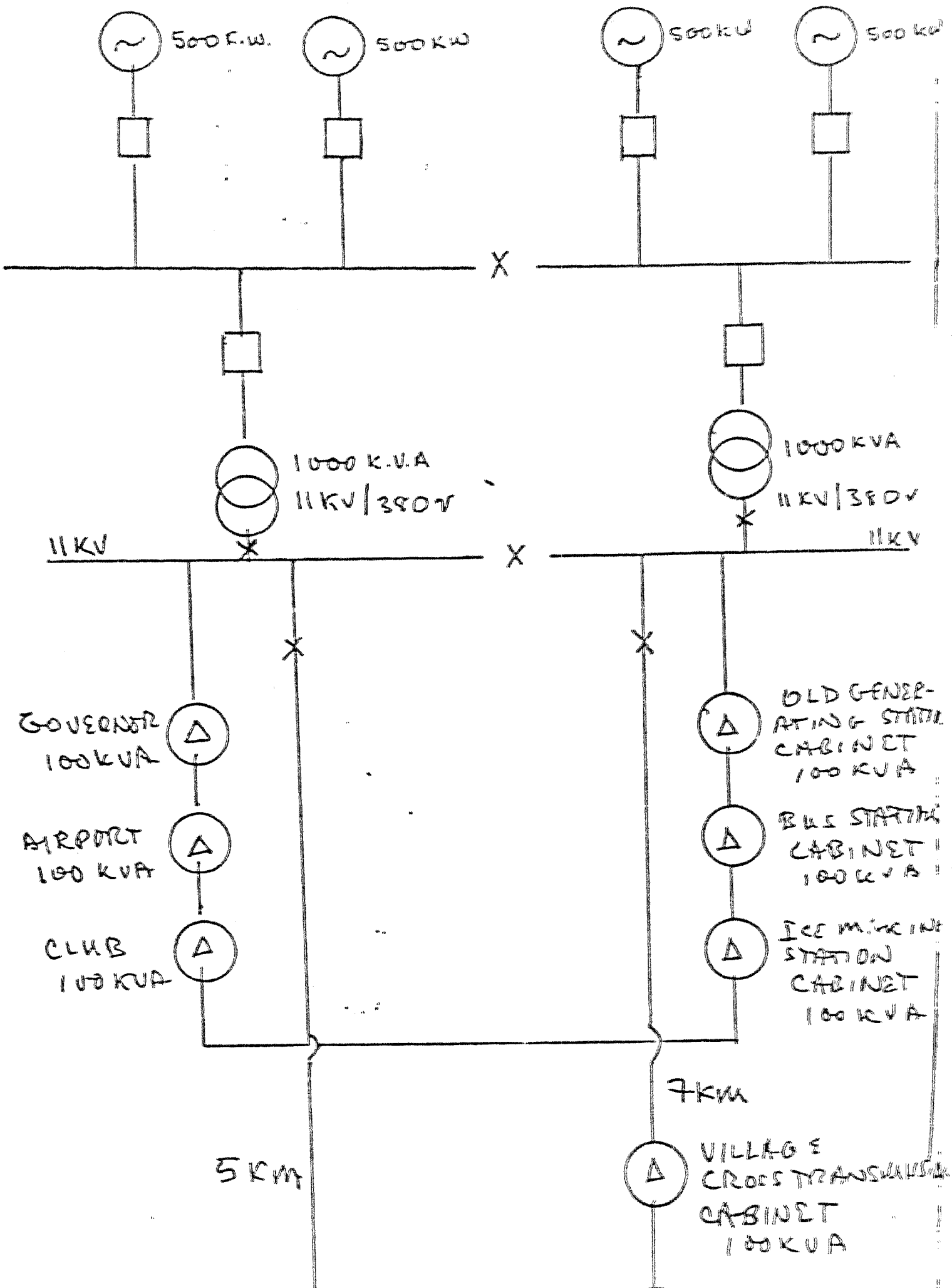
IMMEDIATELY REQUIRED

ANTICIPATED ~~[illegible]~~ LOAD AT 12/H = 12 MW

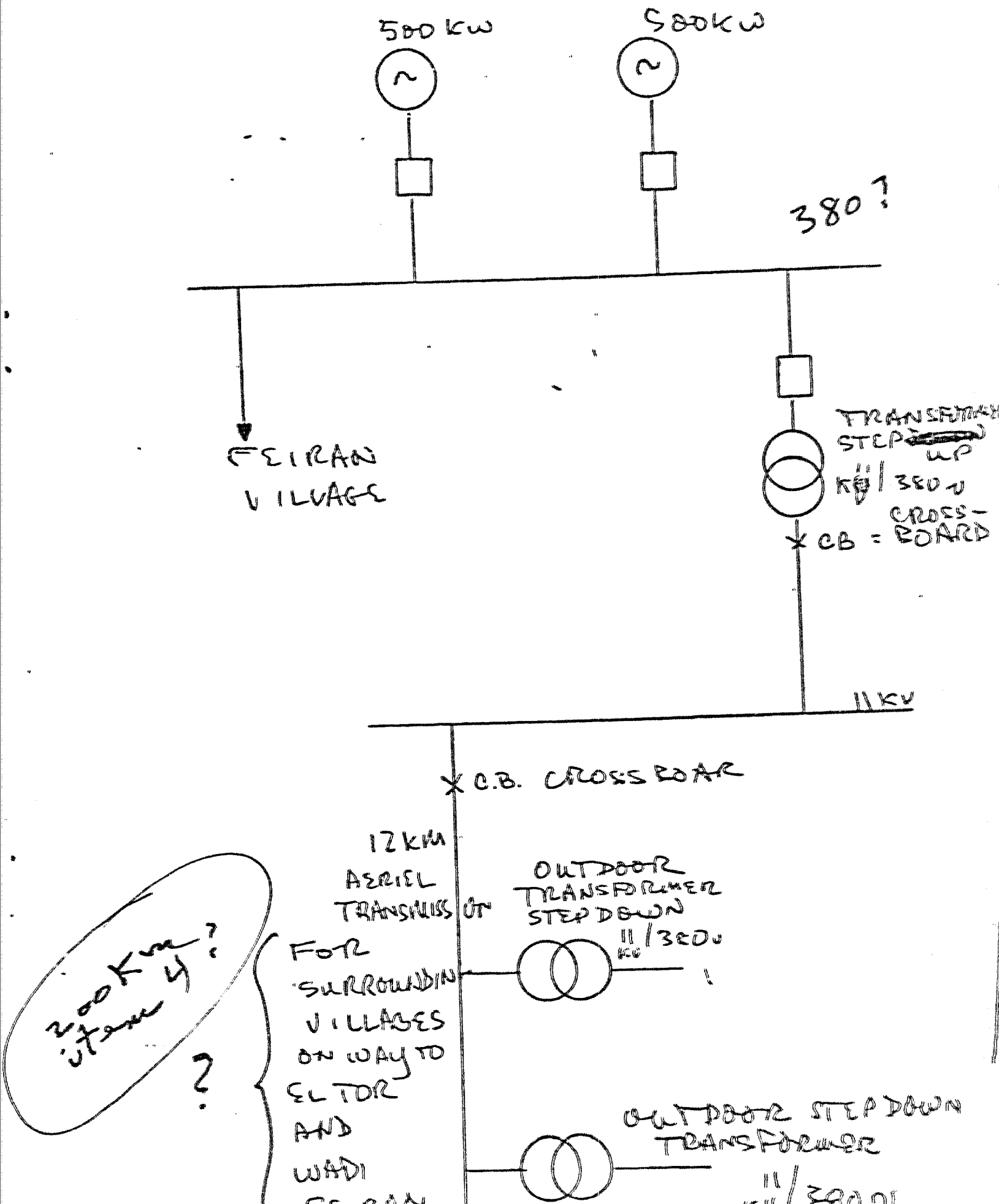
DIFFERENT SERVICE AREAS

ARISH CITY; MASSAID, TOURISTIC BEACHES HOTELS; TRANSMISSION LINE = 25 KM; BIR TAFFAN; EL MOR




500 K.W.
500 KW
500 KW
500 KW
1000 K.V.A
11 KV/380V
1000 KVA
11 KV/380V
11 KV
11 KV
GOVERNOR
100 KVA
AIRPORT
100 KVA
CLUB
100 KVA
OLD GENERATING STATION CABINET
100 KVA
BUS STATION CABINET
100 KVA
ICE MAKING STATION CABINET
100 KVA
7 KM
5 KM
VILLAGE CROSS TRANSMISSION CABINET
100 KVA

WADI FEIRAN STATION



3 - 500 KW

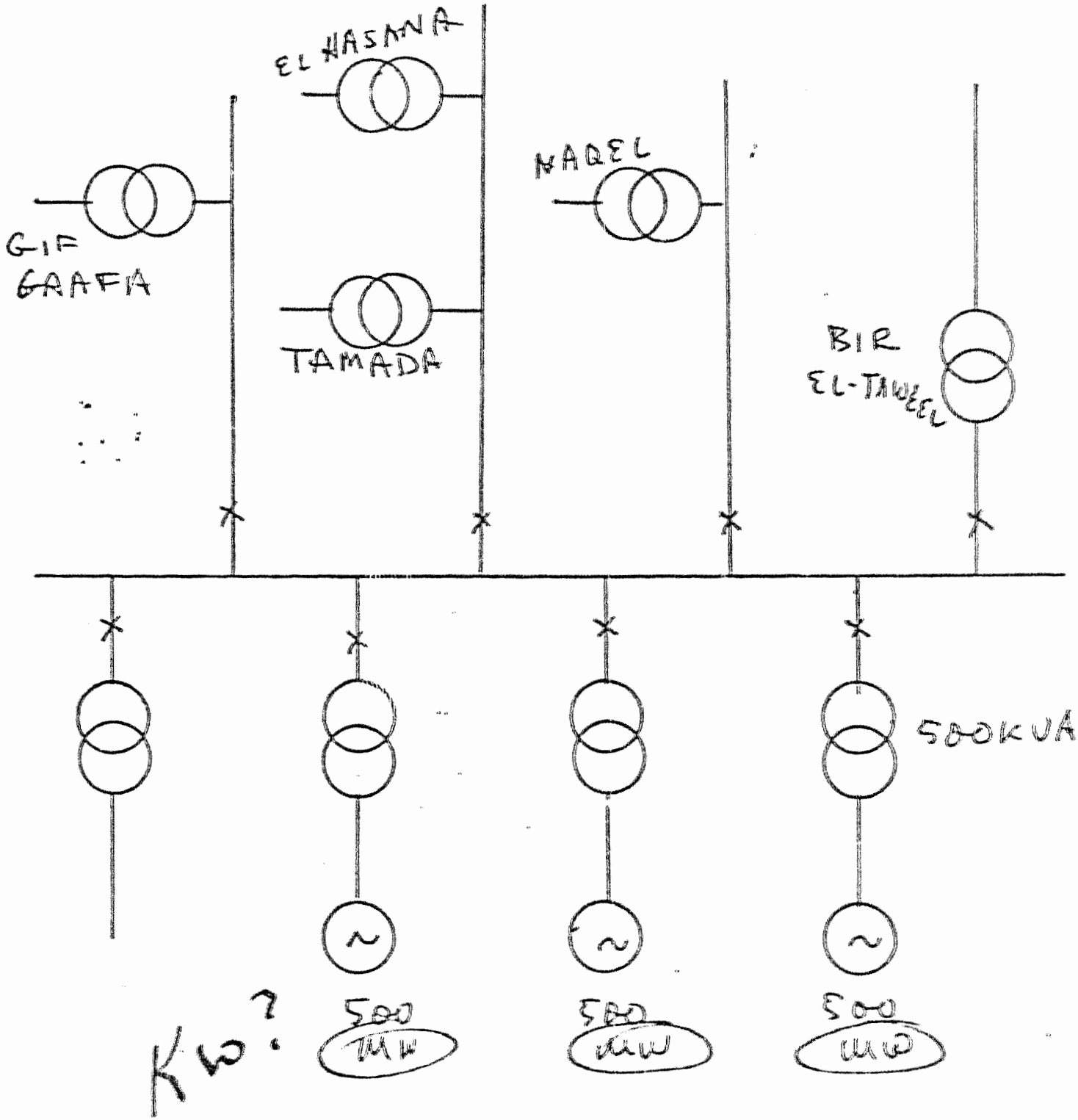
TRANSMISSION LINES :

MALEZE - EL HASANA 30 km

" - NAQEL 30 km

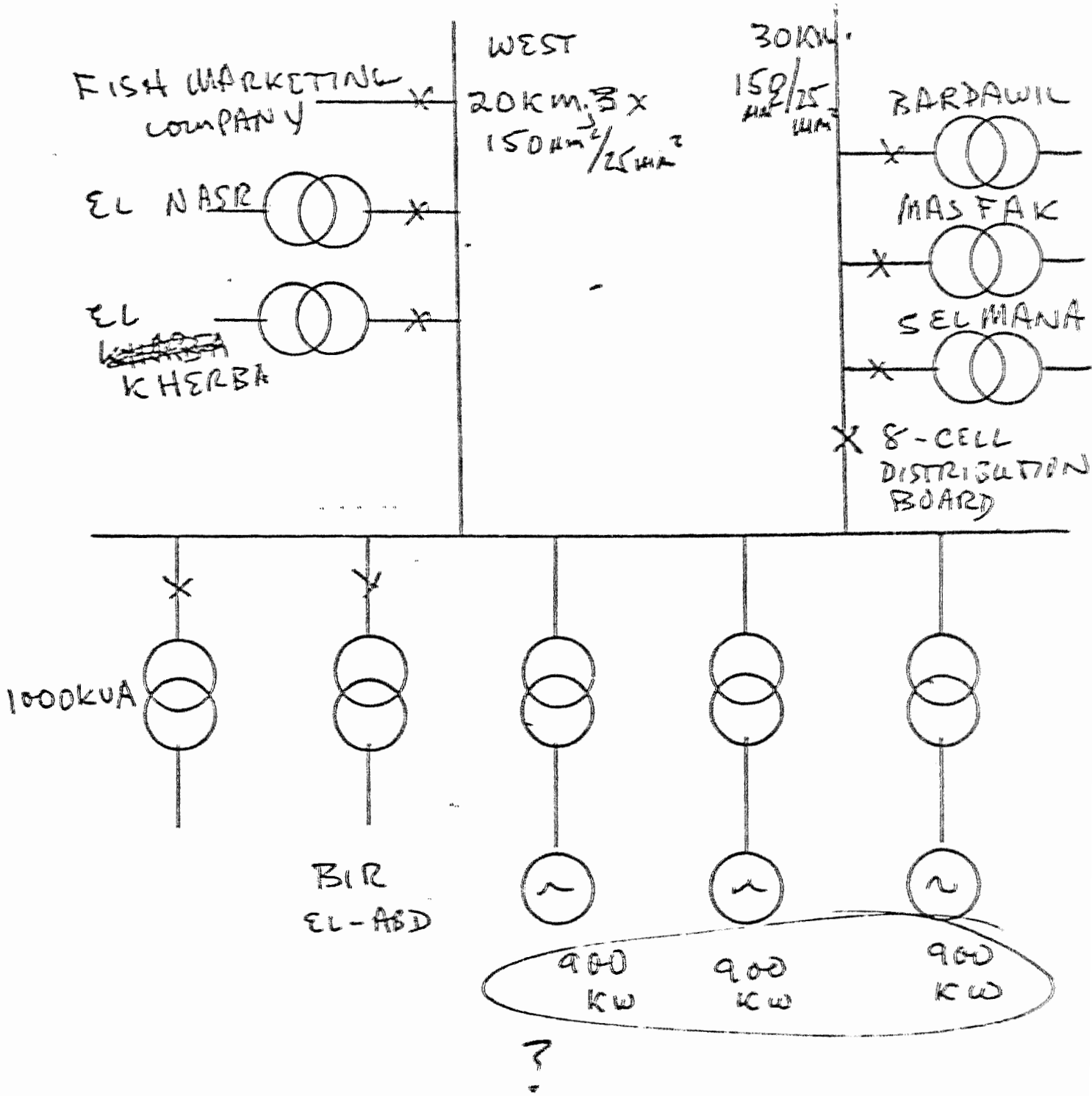
" - BIR EL-TAWEEL 25 km

" - GIF-GAFFA 25 km

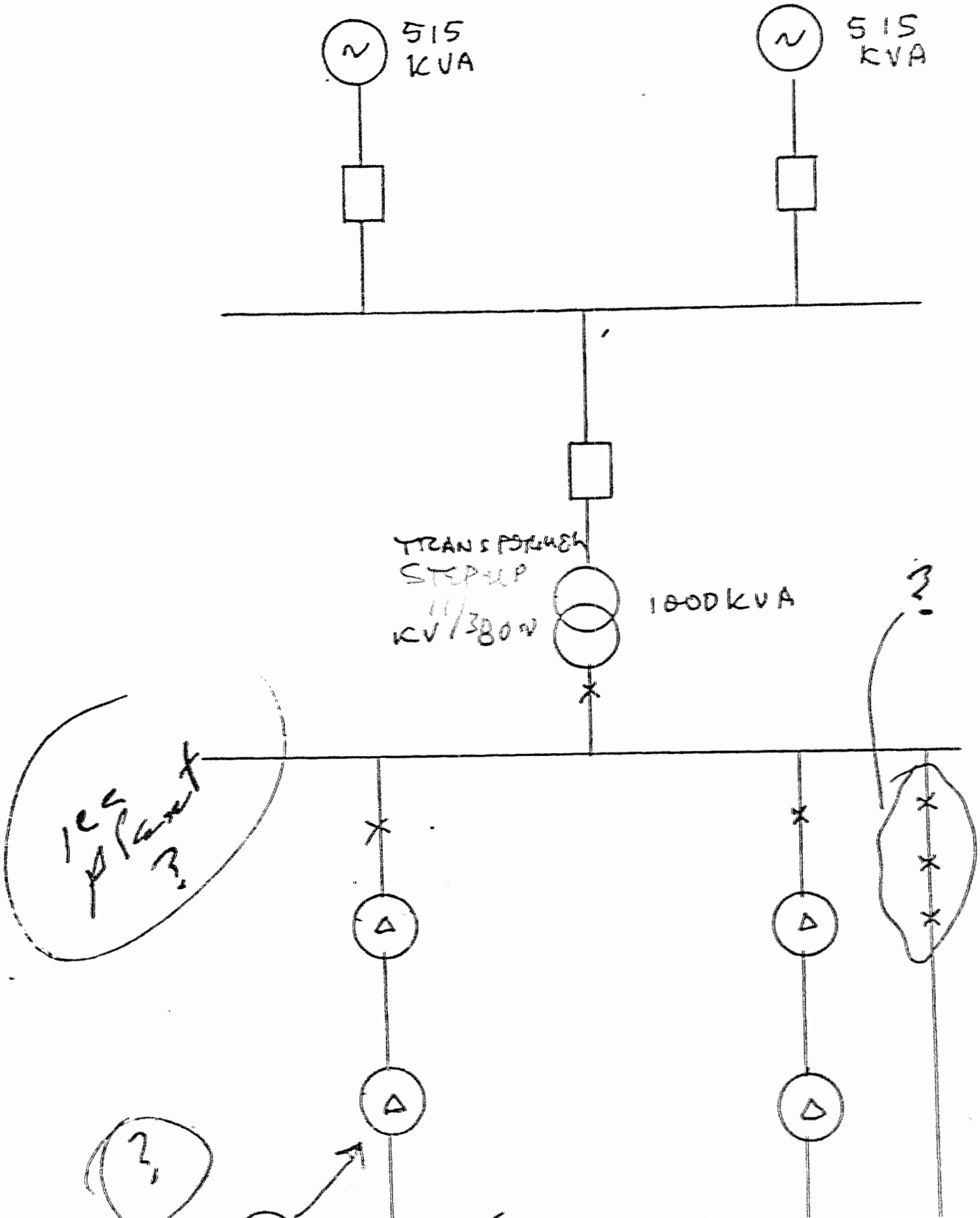
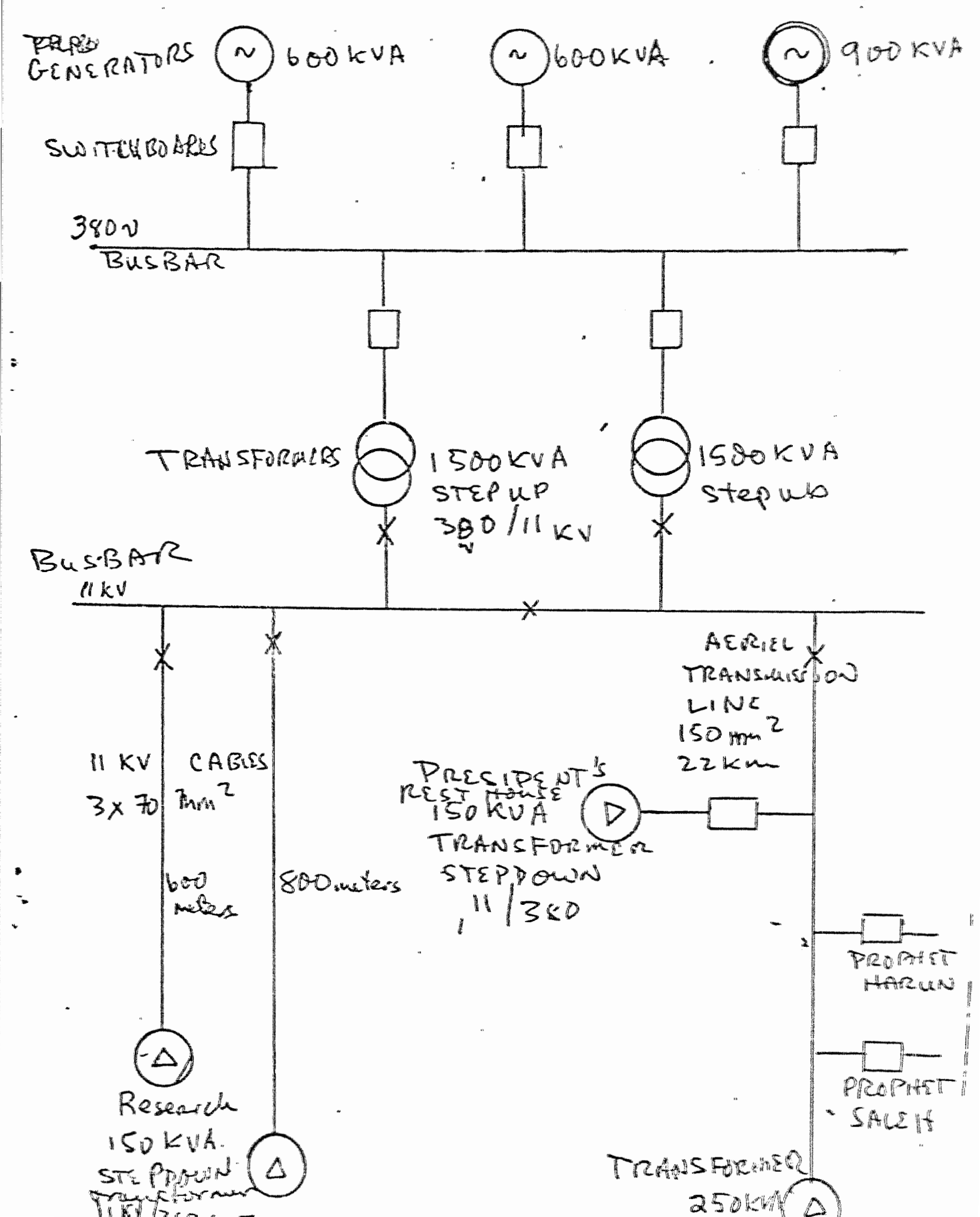


BIR EL-ABD STATION

ICE MAKING FACTORY
& FREEZING UNIT AT
BARDAWIL



EL TOR STATION



ST. CATHERINES SYSTEM