STATUS OF POWER SYSTEMS IN THE ARAB WORLD

I

Interconnection of Arab Power Systems

MOHAMED SAKI

II

Current Problems and Standardization

HISHAM AL-KHATIB

Interconnection of Arab Power Systems

MOHAMMED ZAKI
Mosul University

1. STATUS OF ARAB POWER SYSTEMS

1.1 Introduction

The development of power networks in the Arab world started with isolated power stations in or near capitals and main cities. Those small stations, after a certain level of growth, were connected together forming regional networks or in some cases national networks. The latter exist only in some countries; isolated towns or villages must be supplied locally or be without power at all. Hence, what we shall seen when looking at the status of Arab power systems, is a set of systems with different states of development largely related to economic development in the respective countries. Since rates of development differ from one country to another, the future may show even higher diversity. At the same time the interconnection of some neighboring Arab countries may hasten the development process of other countries or at least some communities.

1.2 Status in Figures

The following tables provide a quick look at the status of electric power generation and consumption in various Arab countries.

Table 1 shows the total gross production of electric energy in GWH in various countries for the period of 1968 to 1977. The figures were obtained from UN publications [1] and corrected whenever more accurate figures were found. The figures for 1977 show a range of gross production for different countries ranging from about 65 GWH for North Yemen to 13000 GWH for Egypt.

This wide range of energy production should be studied in relation to population of various countries. Using population data [2], Table 2 was constructed for four selected years, namely 1969, 1972, 1975 and 1977. From this table, the Arab countries may be divided into three different groups:

Table 1. Total Gross Production (GWH)

		68	69	70 =	71	72	73	74	75	76	77
Algeria		1631	1800	1979	2126	2325	*3002	*3250	*3800	*4615	*4650
Egypt		6735	7134	7591	8017	8030	8104	8915	10336	12256	*13000
Libya	(3,5)	274	351	426	508	569	698	864	1163	1405	*1500
Mauritania	(3)	44	56	73	78	79	94	*95	*95	*96	*96
Morocco		1705	1832	1935	2193	2459	2706	2837	3042	3329	*3673
Somalia	(3,6)	22	26	28	38	*40	*45	*42	*42	*45	*45
Sudan		298	338	337	*378	*380	*435	*533	*620	*715	*820
Tunisia		678	731	794	887	1013	1130	1275	1340	1525	1725
Djibouti	(4)	30	33	36	37	41	45	50	58	*60	*62
Bahrain		217	249	264	277	283	*350	*500	*700	*900	*1110
Iraq	(1)	1490	1694	1858	2175	2512	*2685	3216	3834	4578	5658
Jordan	(1)	156	*170	181	209	249	281	307	356	435	513
Kuwait	(3	1648	2001	2601	3087	3738	4138	4582	5100	5667	*6500
Lebanon		1035	1139	1230	1375	1545	1791	1975	*1850	*1450	*1600
Oman		----	99	105	111	130	173	228	306	413	550
Qatar	(1)	207	240	277	315	359	420	460	625	801	1011
Saudi Arabia	(3)	865	990	*1060	*1150	*1350	*1564	*1670	*2500	*2800	*3100
Syria		773	1034	947	1049	1223	1154	1366	1673	1785	2034
U.A.E.	(7)	60	100	140	210	255	382	*454	*500	*600	*700
N. Yemen		17	18	18	*24	*29	*32	*39	*49	*60	*65
S. Yemen		124	124	125	139	138	*140	*182	*245	*271	*286

Notes:
- * Estimate figure
- 3 Production by public utilities only
- 5 Only national grid
- 6 Only four major cities
- 4 Consumption
- 7 Abu Dhabi only
- 1 UN Figures - corrected

Table 2. Annual Consumption Per Capita (KWH)

	69	72	75	77
Algeria	129	152	226	260
Egypt	220	230	279	336
Libya	184	266	479	570
Mauretania	46	60	67	64
Morocco	122	155	176	202
Somalia	10	14	13	13
Sudan	25	26	39	48
Tunisia	145	190	239	293
Bahrain	1132	1286	2692	4111
Iraq	284	208	345	475
Jordan	91	157	209	280
Kuwait	2943	4450	5100	5752
Lebanon	475	594	661	544
Oman	164	186	397	679
Qatar	2400	2762	3676	5321
Saudi Arabia	164	205	343	406
Syria	171	183	228	259
U.A.E.	526	750	893	1045
N. Yemen	4	6	9	12
S. Yemen	89	91	145	155

a/ Countries with energy consumption above 1000 KWH per capita. This group includes: Kuwait, Qatar, Bahrain and United Arab Emirates.

b/ Countries with energy consumption less than 100 KWH per capita. This group includes: North Yemen, Mauritania, Somalia, Djibouti and Sudan.

c/ The rest of the Arab countries' consumption per capita ranges between 100 and 1000 KWH for 1977.

These figures show a very low energy consumption. The overall average for all the Arab countries is around 326 KWH compared to a world average of 1705 KWH. The figures for some developed and developing countries are:

U.S.A.	10218
Britain	5072
Russia	4442
China	212
India	158

1.3 Installed Capacity

United Nations figures were also used [3,4] for Table 3, which shows installed capacity for 1973 to 1978. Again, some figures were corrected using more accurate data [5,6,7].

Countries with more than 1000 MW installed capacity are Egypt, Algeria, Kuwait and Iraq. Countries with less than 100 MW are Mauritania, Somalia, North and South Yemen.

Most of the electrical energy in the Arab countries is generated by thermal power stations. Only a few countries have hydroelectric power generation capabilities. Table 4 shows the hydroelectric installed capacity and its percentage of overall installed capacity for Egypt, Tunisia, Algeria, Morocco, Lebanon, Syria and Iraq. This shows that about 62% of the installed capacity in Egypt is hydro while 13 other Arab countries have no hydro energy at all. On the average about one quarter of the installed capacity in the Arab world is hydro.

Table 4. Hydroelectric Installed Capacity 1978

	MW	% of total
Egypt	2445	62
Tunisia	29	7
Algeria	330	27.5
Morocco	412	42
Sudan	120	50
Lebanon	246	24
Syria	523	55.6
Iraq	484	21

1.4 Individual Countries' Situations

Since the Arab countries are at different levels of development, it is necessary to study the detailed situation of each.

1.4.1. Egypt

Power of 2100 MW (12 x 175 MW) is produced in the High Dam, 345 MW in the Aswan Dam, and the remainder

Table 3. Installed Capacity (MW)

	73	74	75	76	77	78
Algeria	*1107	*1107	*1110	*1160	*1200	*1200
Egypt	4003	*3956	*2955	*3944	*3944	*3944
Libya	*300	*300	*300	796	*800	*800
Mauritania	39	*39	*39	*40	*40	*40
Morocco	822	857	958	980	*980	*980
Somalia	*18	*18	*18	*18	*18	*18
Sudan	*195	*200	*205	*210	*215	*220
Tunisia	382	382	426	426	532	532
Bahrain	*136	*150	*187	*220	*230	*240
Iraq	763	763	963	963	1624	2304
Jordan	77	77	92	117	185	260
Kuwait	*1196	*1464	*1473	*1566	*1600	*1650
Lebanon	*548	*608	*608	*608	*608	*608
Oman	49	77	91	121	176	*176
Qatar	126	151	204	278	313	484
Saudi Arabia	*403	*408	*425	*455	*550	*650
Syria	437	*438	*684	842	940	*940
U.A.E.	115	151	*175	*200	*225	*250
N. Yemen	17	17	14	*20	*20	*20
S. Yemen	68	*68	*70	*70	*70	*70

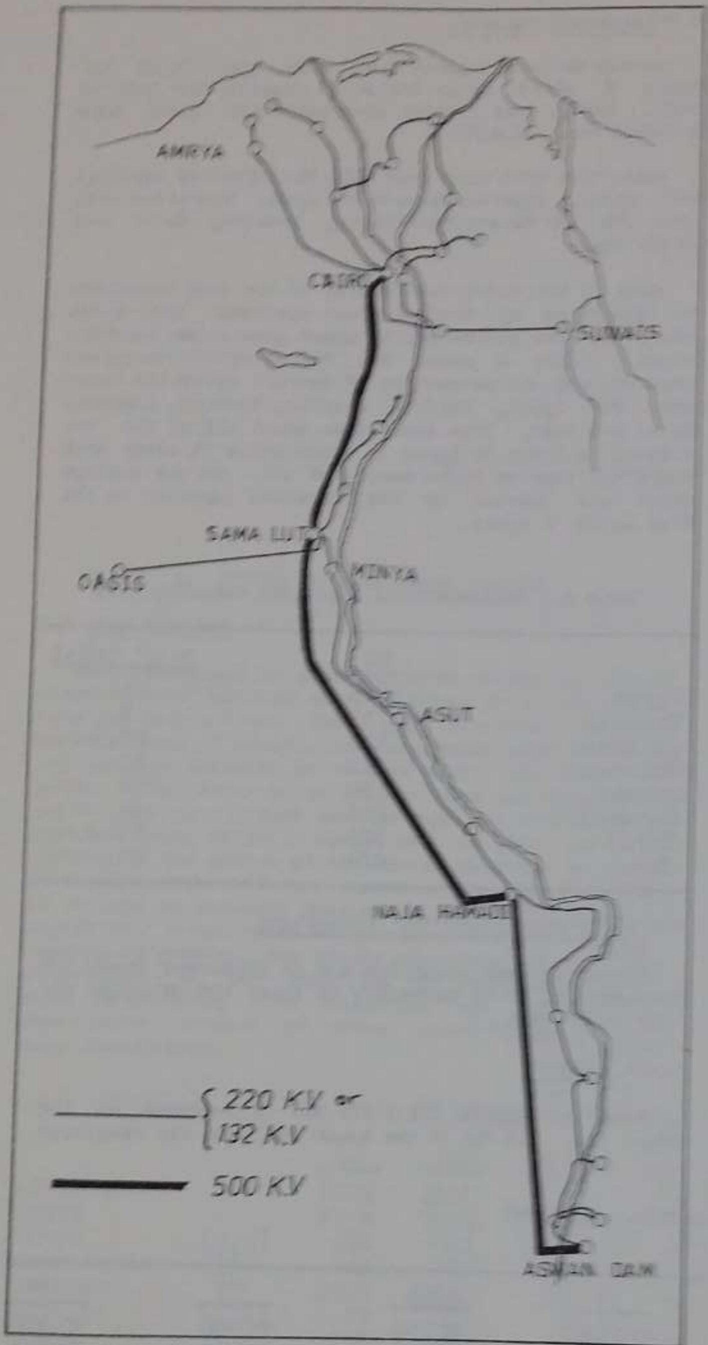

Figure 1. Egypt

in 16 thermal stations. Egypt is divided into 3 regions, Cairo and the northern, the central, and southern regions. These regions are connected by 500 KV and 220 KV lines. Voltages of 132, 66 and 33 KV are also used for transmission and distribution. Figure 1 shows the main lines.

About 62% of the generated energy in 1972 was used by industry, 9% in agriculture, 9% for rural electrification, and only 9% for domestic purposes.

Existing installed capacity should be adequate for the early eighties. Later a big project ought to be undertaken, for example, a nuclear power station or one similar to the Qatara project.

1.4.2 Sudan

Sudan is divided into 8 regions. Two of them, namely, Khartoum (with 2 power stations) and the Blue Nile, are connected by a unified network called the Blue Nile Network. 75% of Sudan's energy is supplied through this network. The other six regions are supplied locally from small units. About half the installed capacity is hydroelectric and the rest is thermal.

United Nations estimations of the Nile River water energy is 50,000 GWh. This figure is about the same as that of the energy consumption all through the Arab world in 1977.

Transmission in Sudan is done by 220 KV, 110 KV and 66 KV lines.

Figure 2 shows a typical daily load curve for a peak load period.

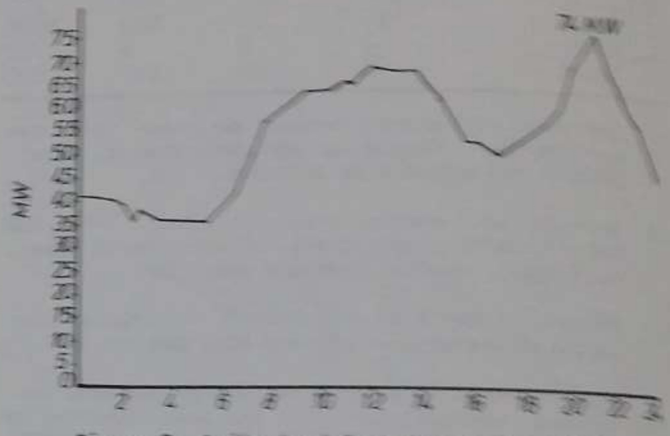

Figure 2. Daily load in Sudan on 24-4-1972.

1.4.3 Libya

Libya's electrical power system is divided into two regions. The first is 350 km long from the Tunisian boarder to Misrata including the Tripoli area. The second includes Bengazi, the Green Mountain, Tibrik and Ajabia.

The estimated domestic peak load of 1979 was about 400 MW: 165 MW at the first region, about the same at the second region, and the rest here and there. In addition, there was about a 100 MW load for industrial projects. There are 5 thermal generating stations in Libya. The highest voltage line in use is a 220 KV line between Misrata and Ujanlat. Figure 3 shows the daily load curve of 19th Feb., 1972.

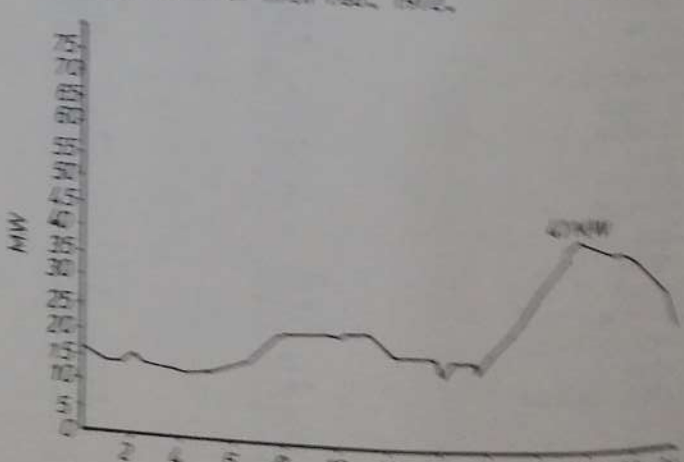

Figure 3. Daily load in Libya on 19-2-1972.

1.4.4 Tunisia

The Tunisian Co. of Electricity & Gas is responsible for generation of about 87% of electric power in Tunisia. Hydroelectric power is generated at two dams in northwest and northeast Tunisia. This power represents about 7% of the total installed capacity. The rest is supplied by thermal power stations. Three big power stations, two at Jouliet and one at Ghannoush, produce most of the thermal power.

The transmission voltages used are 150 KV and 90 KV.

Peak load usually occurs on October evenings with load curves similar to that of Libya (Figure 3).

1.4.5 Algeria

Northern Algeria is connected by a 150 KV line which may be increased in the future to 220 KV. There are three thermal power stations in the northern region at Anaba, Wahran and Algiers. There is also a hydroelectric power station at Darjeva which produces 70% of the hydro power in Algeria. Installed capacity in 1978 was around 1200 MW; 330 MW of which is hydroelectric and the rest is thermal. Peak load normally occurs in December. Figure 4 shows the development of thermal, hydro and total electric power generation for the period of 1948 to 1970.

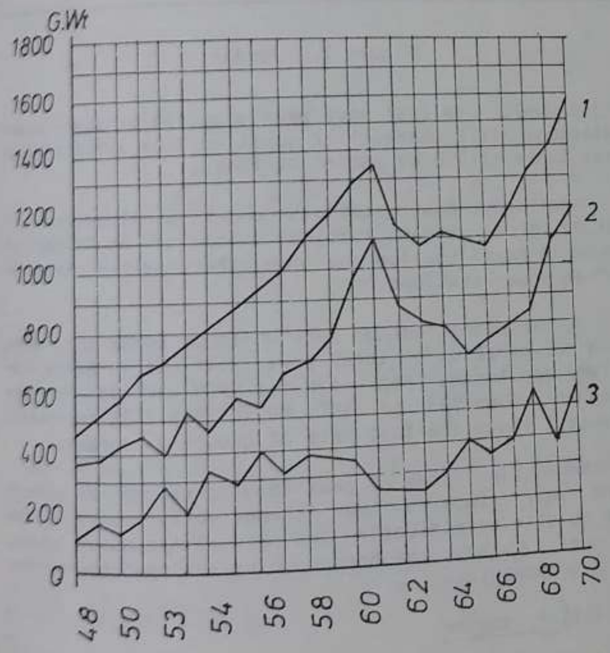

Figure 4. Algerian Electrical Power Generation

1.4.6 Morocco

The national office of electricity in Morocco is responsible for generation and distribution of electric power in Morocco. The estimated energy production for 1980 was 3810 GWH. 75% of this energy is produced by hydroelectric units, at Abeed Valley and other locations.

High voltage transmission is performed at 225 KV, 150 KV and 60 KV, and interconnection with Algeria is made at 22 KV (Wajda-Hughnya).

Another interconnection (Wajda-Ghazwat) at 225 KV was planned for 1975. There are in total about 14 generating stations each with one to four units (Jarada is the largest of 115 MW) and about 16 hydro generating stations.

Figure 5 shows the growth of transmission and distribution lines in Morocco.

Annual peak load usually occurs on evenings in December.

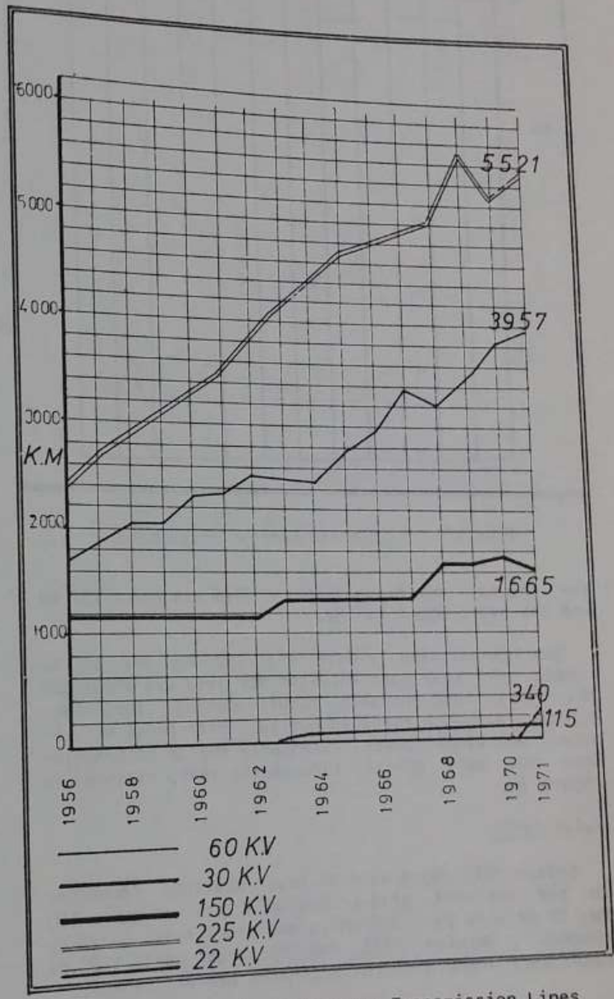

Figure 5. Growth of Moroccan Transmission Lines 1956-1971

1.4.7 Mauritania, Somalia and Djibouti

Information in addition to that in Tables 1 and 2 from UN sources is not available.

1.4.8 Lebanon

The Administration of Electricity in Lebanon has two main thermal power stations (South and Thoq Makeel). It buys electricity from a few other establishments (e.g., Litany River Administration and some private companies). The total installed capacity of

Table 5. Jordanian Development

Some data for Jordan

Table Year	Population Million	Percentage supplied Electrical supply	Generated G.H	Per capita K.H
71	1.723	30 %	230	133
72	1.774	33 %	270	157
73	1.831	35 %	315	172
74	1.890	37 %	350	165
75	1.952	39 %	407	205
76	2.037	40 %	503	245
77	2.127	43 %	595	290
78	2.217*	45 %	703	317
79	2.159	55 %	877	405

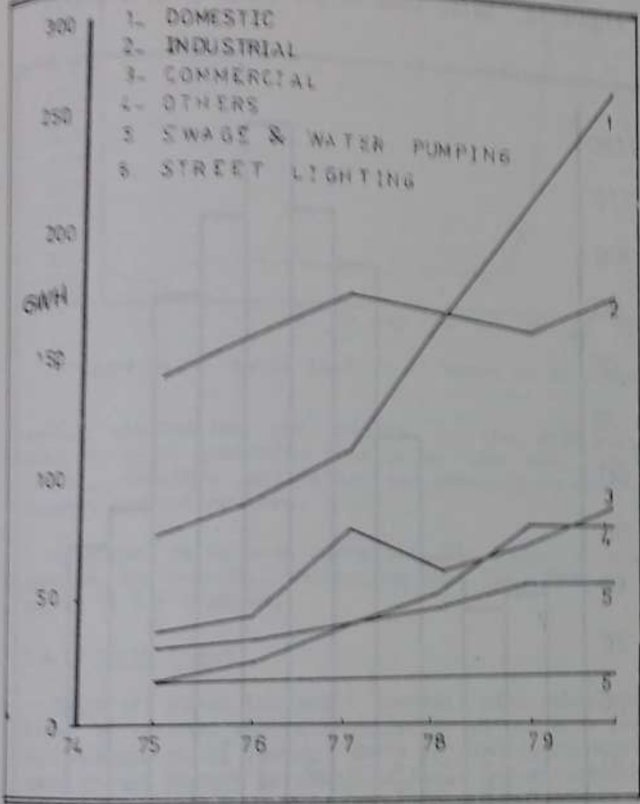

Figure 8. Sources of Energy Consumption in Jordan

More than 1000 km of 400 KV lines and over 2000 km of 132 KV lines are used for transmission. Distribution is done via 66, 33 and 11 KV lines.

Peak load occurs during July, usually with a peak at the evening and an ever increasing secondary peak at noon. Figure 9 shows a typical load curve for July.

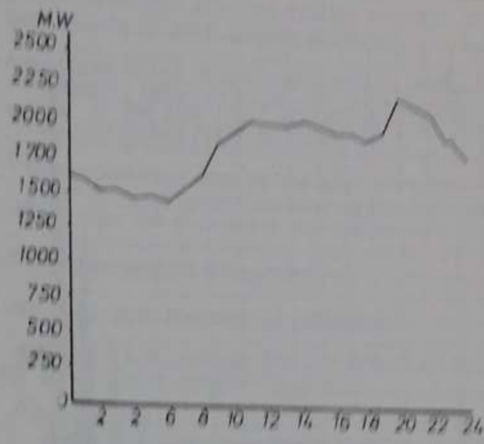

Figure 9. Daily load in Iraq on 23-7-1980.

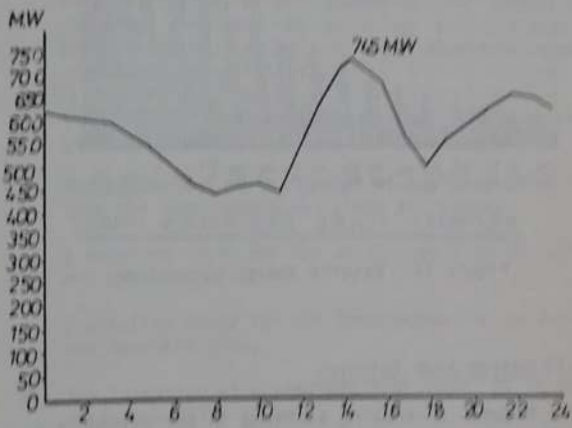

Figure 10. Daily load in Kuwait on 23-8-1972.

1.4.13 Kuwait

There were three large power stations in Kuwait: Al-Shuwaikh power station and Al-Shuaiba (North and South). The latter two produce most of the energy for Kuwait. Voltages used are 132 KV for transmission and 33 KV for distribution. A peak load of 2000 MW was estimated for 1980.

Peak load usually occurs in Kuwait during August/September. The daily load curve (Fig.10) shows two peaks in summer, one at about 3 pm and one at about 10 pm. The first one is due to the heavy use of air conditioning equipment and the second one is due to lighting. The increase in the standard of living and the inexpensive electricity tariffs may shift these two peaks towards each other and make a flat top of peak load.

1.4.14 Qatar

Energy is supplied mainly by two large power stations; Abu Aboud at Doha has 12 generating units with 210 MW installed capacity, and Abu Fontas has 14 units with 618 MW capacity. The latter units were installed between 1977 and 1979.

The peak load of 1979 was 425 compared to 332 MW at 1978 (28% annual increase). Anticipated peak loads for 1980, 1985 and 1990 are respectively 550, 1079 and 1534 MW. Installed capacity at Ras Abu Fontas power stations was expected to increase to 828 MW during 1980 and a new power station was planned.

Peak load in Qatar usually occurs in July/August. High voltage transmission is done by 132 KV oil filled cables (13.8 km commissioned and 30.4 km under installation) and overhead lines (119 km under construction).

Further 66 KV cables and lines are either commissioned or under construction. Figure 11 shows the rapid increase in generated energy in Qatar, especially in recent years.

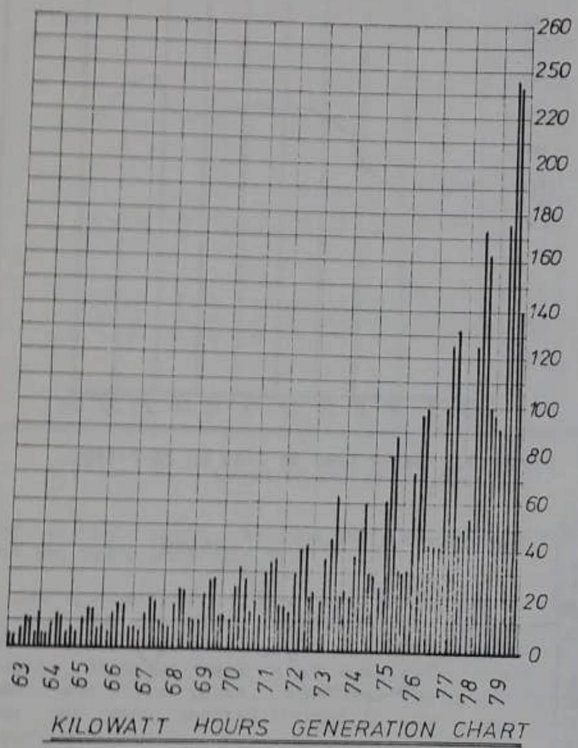

Figure 11. Qatar's Energy Generation

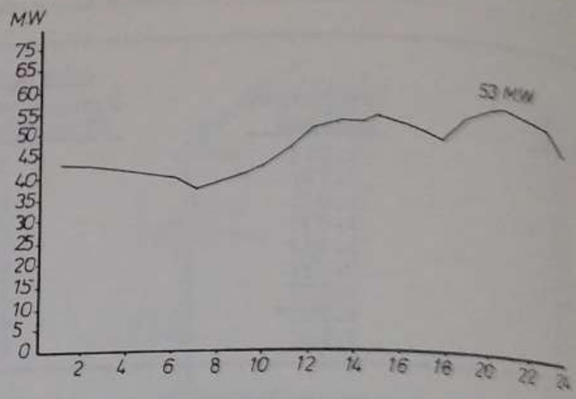

Figure 12. Daily load in Abu Dhabi on 28-8-1972.

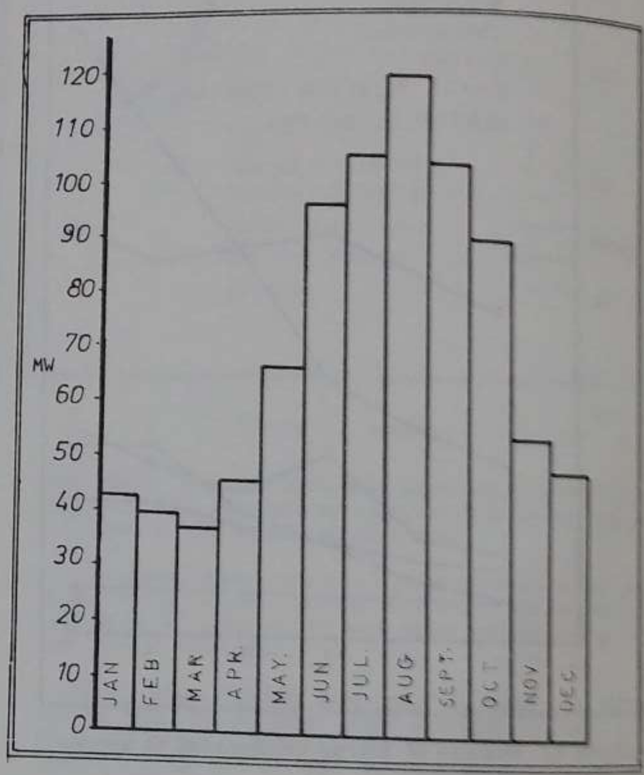

Figure 13. Energy Consumption in Bahrain

1.4.15 United Arab Emirates

The biggest generating stations in the United Arab Emirates are in Abu-Dhabi where there are three power stations. A new station at Um Al-Har Island for sea water treatment is to be connected to Abu-Dhabi and Al-Ain station by 132 KV line (about 160 km).

Peak load usually occurs in August/September with noon and evening peaks nearly the same. A typical daily load curve is shown in Figure 12.

1.4.16 Bahrain

The highest voltage in use on Bahrain Island is 33 KV. There are two thermal power stations.

Peak load occurs during August. Daily load curve shows two peaks, one at noon and one in the evening. Figure 13 shows the large difference between summer and winter energy consumption in Bahrain.

1.4.17 Saudi Arabia

Saudi Arabia is the only Arab country where 50 Hz and 60 Hz are used. Both generation and transmission for public is shared by several companies. Table 6 shows the output of the main generation establishments in 1974.

Due to the establishment of heavy industrial projects (e.g. petrochemical, steel mills, aluminum), a large increase in the eastern region's plants will be necessary. Future plans include the erection and expansion of the Uthmania power station up to 2150 MW (in 1987) as well as the construction of a 400 KV line to connect the eastern region with Al-Ryadh region.

1.4.18 North Yemen

The Arab Republic of Yemen has the lowest rate of

Table 6. Power Generation (MW) in Saudi Arabia

	1972 60 Hz	50 Hz	50/60 Hz	Total
Private Co.	98.8	133.7	159.9	392.5
Petroleum Ministry	28	49.7	6.95	77.9
Agriculture Ministry	2.4	—	64	66.4
Finance Ministry, other Ministries	18.3	2.4	6.0	96.7
Industrial Establishments	185.5	29.3	—	[illegible]
Total	356.2	256.3	230.4	849.9

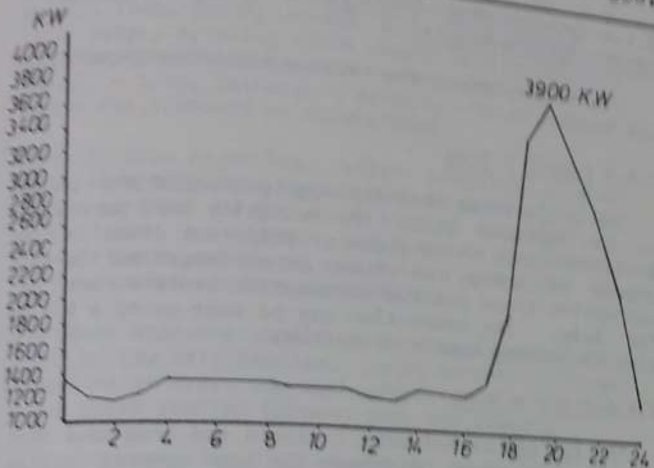

Figure 14. Daily load in N. Yemen on 23-8-1972.

energy consumption per capita in the Arab world. Electricity is generated locally in the main cities (Sana', Hydaidya and Ta'az) and there is no national network connecting them.

A typical daily load curve (Fig.14) shows a sharp peak in the evening, indicating that the major use of energy is for lighting.

1.4.19 South Yemen

There are about ten small thermal generating stations at various states (Muhafadha) of the Arab Democratic Republic of Yemen. There is no interconnection among states except between the first and the second.

The highest voltage in use until 1974 was 33 KV.

1.4.20 Oman

No information is available other than the U.N. data in Tables 1 and 2.

2. INTERCONNECTION OF ARAB POWER NETWORKS

2.1 Why Interconnection

Although power networks in some Arab countries are still developing slowly, in some cases there are merits for interconnections. Some of these are:

1. Supplying some remote areas of some Arab countries by networks from neighboring countries could be more economical, easier and faster.

2. With a shortage of technicians and engineers in nearly all Arab countries, building bigger power stations will be more economical since they would be more efficient and require less maintenance and personnel.

3. Interconnection reduces the capital costs needed for erection of static standby units.

4. Interconnection provides dynamic standby in case of failure of some running units.

5. Interconnection reduces the overall peak of the component networks since the peaks usually do not occur at the same time, as indicated by the load curves (Figures 2,3,9,10,12,and 14).

6. Interconnection enables the most efficient operation by utilizing the most economical units for base load and the others for peak loads.

2.2 Interconnections Background

2.2.1 Tenth Arab Engineering Conference

The Tenth Arab Engineering Conference at Al-Quds in 1966 gave several recommendations:

1. The formation of a committee within the Federation of Arab Engineers to prepare statistics and information about the generation and distribution of electrical energy in different Arab countries. This data was to be distributed to all countries concerned to help in planning future electric power projects, taking into consideration interconnection possibilities.

2. Standardization of voltages to facilitate interconnection schemes.

3. The completion of the design of national grids before any interconnection steps are taken.

4. A detailed study for the interconnection of Syrian and Lebanese grids.

5. A detailed study for the interconnection of Kuwait and southern Iraq.

6. The formation of a combined Arab fund to finance interconnection schemes.

2.2.2 Eleventh Arab Engineering Conference

At the Eleventh Arab Engineering Conference in Kuwait in March 1969 a booklet was presented: "The present situation of electrical energy in Arab countries with particular reference to interconnection possibilities." The conference recommended:

1. A joint committee between Iraq, Kuwait and the Federation of Arab Engineers to follow up the study and execution of the suggested interconnection between the two countries.

2. A joint committee between Syria, Lebanon and the Federation of Arab Engineers to follow up the study and execution of the suggested interconnection between the two countries.

3. A special department in the Arab League with an interest in the development of electrical energy in Arab countries. The department was to survey the available sources of energy in Arab countries and suggest possible interconnection schemes. The department could study, coordinate and follow up on the execution of such schemes as well as other big projects, such as a joint effort to establish a nuclear power station in one Arab country.

2.2.3 Further Seminars:

1. First Arab Electricity Seminar, Baghdad 1971.
2. Second Arab Electricity Seminar, Beirut 1972.
3. Twelfth Arab Engineering Conference, Cairo 1972.
4. Second Industrial Development Seminar, Kuwait 1971.
5. Development of Electric Power of Northern African Arab Countries, Tunisia 1973.
6. Development of Electric Power for Eastern Arab Countries, Baghdad 1974.
7. Second Arab Seminar for Rural Electrification, Baghdad 1976.

2.3 Existing Interconnections

2.3.1 Morocco - Algeria

1. A 22 KV line of 25 km length connects Wajdah, Morocco with Mughania, Algeria.
2. A 225 KV line of 43 km length (12 km in Morocco) connecting Wajdah to Ghazwat, Algeria supposed to have been in operation since 1975.

2.3.2 Syria - Lebanon

A detailed scheme was generated in 1972 suggesting the connection of Homs, Syria to Tripoli, Lebanon by means of a line of 230 KV, 150 KVA, 90 km. Expected benefits were:

1. Savings in expenditures on generating units, as the line acts as a spare supply in case of emergency.
2. Improve operating costs as the weekly and national holidays are different in the two countries. The national holidays comprise 120 days of light load on either side of the connecting line. Surplus power is therefore available for maintenance and emergencies.

2.3.3 Jordan - Syria

Two lines connect Irbid, Jordan to the Syrian network at 230 KV and 66 KV voltages.

The energy purchased by Jordan from Syria was 13 GWH, 21 GWH and 8 GWH in 1977, 1978 and 1979 respectively. These figures represent 2%, 3% and 1% of the Jordanian total consumption respectively.

2.4 Possibilities of other Interconnections

2.4.1 Saudi Arabia and Sudan

A d.c. link between Saudi Arabia and Sudan under the Red Sea may be feasible if large water dams were constructed on the Nile in Sudan.

2.4.2 Sudan and Egypt

A link is not feasible now since the northern Sudan load centre is about 900 km from the High Dam in Egypt and the load in Sudan does not warrant such a connection.

2.4.3 Eastern Saudi Arabia (Dammam) and Bahrain

A link may be feasible if the bridge connecting Bahrain to Saudi Arabia is completed. No economic benefit may result since the load curves of the two regions are similar.

2.4.4 United Arab Emirates - Qatar - Bahrain - Eastern Saudia Arabia

A link may reduce the reserve installed capacity in the region.

2.4.5 Kuwait - Iraq

The project has been thoroughly studied and proved to be feasible since the two daily load curves are different (peak loads occur at different times). The amount of energy which may be exchanged merits such connection since the two consumption centers are not far away. The connection may be made using a 400 KV line connecting Kuwait to Basrah.

2.4.6 Syria - Iraq

The two 400 KV networks in Syria and Iraq make such a connection easy. Although the load centres in Iraq (Baghdad) and Syria (Euphrates Dam) are far away, if the Haditha Dam in Iraq (on Euphrates) is complete, the exchange of power then becomes feasible in cases of emergencies.

2.4.7 West Libya - East Tunisia

The centre of generation in Tunisia is moving east toward the Libyan border, while the centre of generation in Libya is moving west of Tripoli toward the Tunisia border.

2.4.8 West Egypt - East Libya

A connection between the eastern part of Libya to the Egyptian network has been studied.

2.4.9 West Tunisia - East Algeria

Two lines of 90 KV between East Algeria and West Tunisia were suggested. The interconnections in North Africa have been studied in the Seminar in Tunisia 1973.

3. DISCUSSIONS AND RECOMMENDATIONS

In general the per capita energy consumption for the vast population of Arabs is still low. The reasonable figures indicated for some countries (especially the Gulf states) are so because populations in the respective countries are low. Hence the interconnection of Arab power network is strictly dependent on the development of the internal networks, such that interconnections become economical and feasible.

The following are some remarks for the development and interconnections of Arab power networks:

1. When plans for internal power networks are studied, the neighboring countries' circumstances should be taken into account. This is especially

important for the determination of frequency and high voltage levels. For all Arab countries, it seems that 50 Hz networks should be imposed, and 400 KV should be selected for Eastern Arab countries and 220 KV for North African Arab countries. Next, higher voltages should never be selected in one country in isolation from neighboring countries.

2. In view of the energy consumption and the concentration of load in Eastern Arab countries, it seems that a high voltage line of crescent shape connecting the Gulf to the Mediterranean deserves attention. Such a line would connect United Arab Emirates, Bahrain, Qatar, Eastern Saudi Arabia, Kuwait, Iraq, Syria, Jordan and Lebanon. As a first stage, existing links should be strengthened and interconnection between nearby networks (e.g. Kuwait - Iraq, Emirates - Bahrain - Qatar - Saudi Arabia etc.) should be established.

3. North African countries, after reaching a good level of energy consumption, may be connected with a line parallel to the south side of the Mediterranean with a segment parallel to the Red Sea between Sudan and Egypt. Such big projects may not be feasible before the 1990's.

4. Big power stations should replace small power stations of low efficiencies. Joint effort is recommended in at least one such project, e.g. a nuclear power station between Iraq and Kuwait.

5. Electric energy studies should not be in isolation from irrigation projects. Construction of water dams for irrigation purposes and for electric power generation should have a high priority. Such projects should receive much attention and joint Arab effort should be shown. For example, the development of such projects in Sudan could supply electricity to Saudi Arabia, Somalia, Yemen and Egypt.

6. Joint effort should be shown in standardization and development of electrical equipment construction.

7. Networks of neighboring non-Arab countries should be studied for interconnection at the appropriate times. Connection with Europe via Gibraltar and Turkey seems to be attractive.

8. The Arab League Industrial Development Center should provide for the exchange of information and the development of common studies.

4. REFERENCES

1. United Nations, Yearbook of Industrial Statistics, Vol. II, 1977 Edition.

2. United Nations, Monthly Bulletin of Statistics, Jan. 1980, Vol. XXXIV, No. 1.

3. United Nations, World Energy supplies, 1950 -1974.

4. United Nations, World Energy supplies, 1973 - 1978.

5. Jordan Electricity Authority, Annual Report 1979.

6. State of Qatar, Electricity Department, Statistical Report 1979.

7. جامعة الدول العربية ــ مركز التنمية الصناعية تنمية الطاقة الكهربائيــة لدول المشرق العربي ١٩٧٤.

8. جامعة الدول العربية ــ مركز التنمية الصناعية ــ تقريــــــر عن تنمية الطاقة الكهربائية لدول شمال افريقيا ١٩٧٢.

9. M. F. Sakr, "Interconnection of Electric Power Systems in Arab Countries," Proc. on the Middle East Power Conference, A.U.B. Beirut, Sept. 26-29, 1973, Vol. 1.

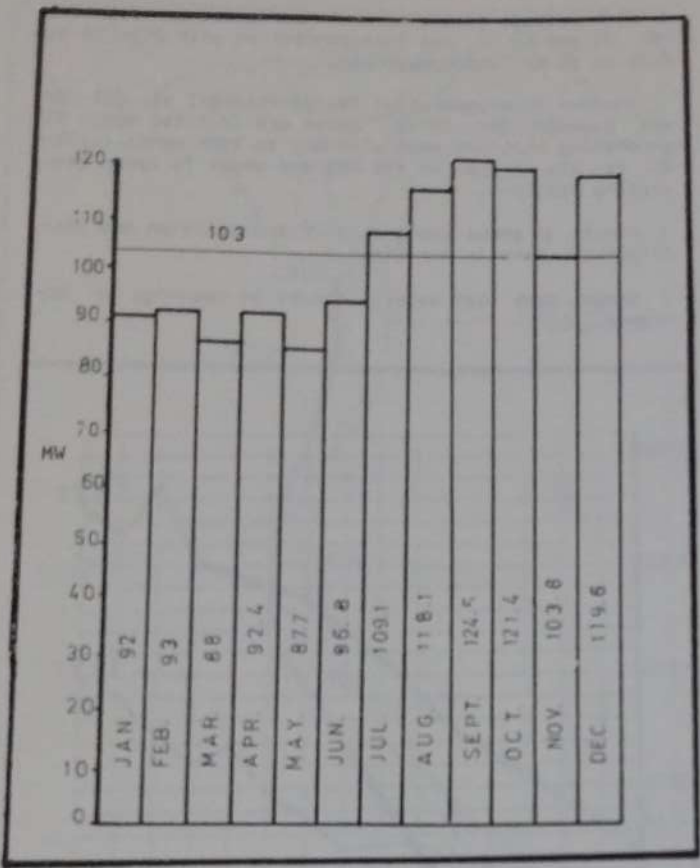

Figure 6. Lebanese Energy Consumption

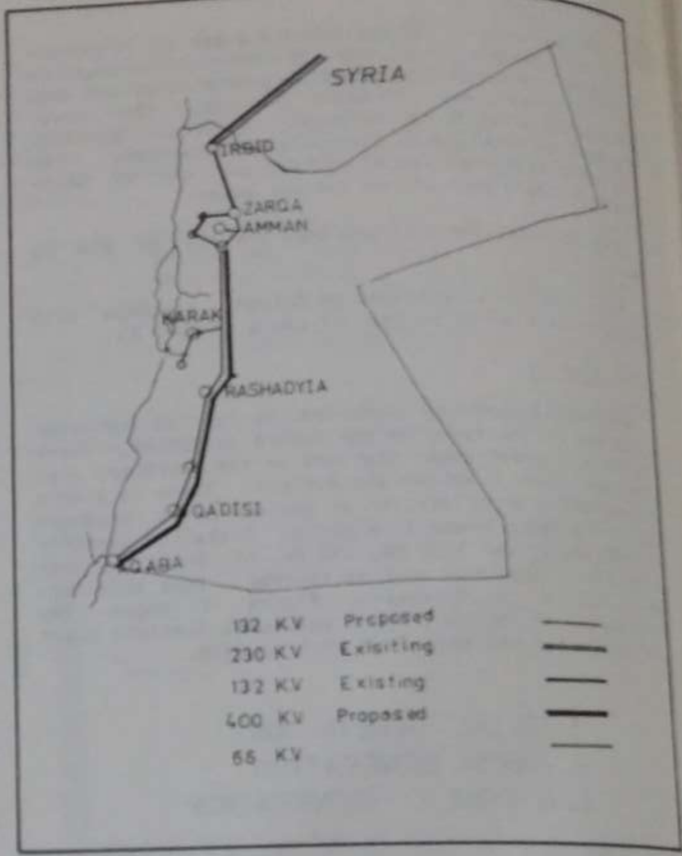

Figure 7. Jordan

the thermal power stations in 1974 was about 237 MW and the hydro about 246 MW.

The transmission is done via 150 KV and 66 KV lines. The peak load expected for 1980 was about 600 MW. Peak load usually occurs during September-October, although there is not much difference between summer and winter peaks. Similarly energy consumption does not vary greatly through the year, as shown in Figure 6.

1.4.9 Syria

Before 1973 there were 11 power stations connected to the national grid producing a total of about 300 MW; 20 MW were by hydro units and the rest were by thermal. Between 1973 and 1978 eight units (100 MW each) were erected on the Euphrates Dam and Tabaqa.

High voltage transmission is done by 220 KV overhead lines from Tabaqa to Allepo, Hama, Qatina, Damascus, Raqa and Swaidya.

Peak load in 1980 was expected to be about 586 MW with an energy consumption of about 3380 GWH. In 1972 about 10 GWH were imported from Lebanon via overhead lines.

1.4.10 Jordan

The national network (Figure 7) is administered by the Jordanian Electricity Authority. Throughout 1979 a total of 877 GWH were generated compared to 703 GWH in 1978, representing an annual increase of 25%. About 55% of the energy was supplied by Hussein Thermal Power Station at Zarka (481 GWH) and 19% at Marka (168 GWH). The rest have been supplied by small power stations (all thermal) or supplied from Syria through two links of 230 KV and 66 KV lines.

Additional power stations under construction include three steam turbine units of 66 MW each at Hussein Power Station and some other smaller units in other power stations.

Future plans include more units at Zarqa and Marka and the erection of three power stations in Aqaba, Qatrana and Amman. Peak load for 1979 was 153 MW (December) compared to 107 MW in 1978 (43% increase). Table 5 shows the fast rate of growth in Jordan.

No distinct time of peak load is recognized through the year since the load is constantly increasing due to rural electrification and network expansion plans. Figure 8 shows the breakdown of consumed energy into its components.

1.4.11 Palestine

Unfortunately, no data are available. In territories occupied in 1948, the installed capacity for 1978 was about 10,000 MW and per capita energy consumption for 1977 was more than 3000 KWH.

1.4.12 Iraq

Energy is generated in about a dozen power stations with installed capacities ranging between 50 MW and more than 800 MW. Two of the power stations are hydro, namely Sammara and Dokan. The rest of the power stations are thermal. Total installed capacity in 1979 was more than 3800 MW.