Egyptian rural society represents over half of its total population. Since 1970, rural society had not experienced any progress either in social or economical fields. As it is well known that electricity plays the main role in a country progress. In 1971 it was decided to start a limited program for electrification the rural areas. In early 1990s, the Egyptian Government has given priority to implement full-scale rural electrification program to cover the whole country. In fact, this project is not limited to electrify villages and attachments but also extends to play an active role in supplying electricity to different national projects (land reclamation, new residential cities, industrial zones, … etc.) to serve the continuous development of the society as a whole. This calls for extending thousands of kilometers of medium and low voltage lines, constructing of hundreds of distribution panels and transformer points and erecting high voltage networks up to 66 Kv. Challenges has started to face decision-makers for design and planning of such distribution systems which have required new modern and effective software programs. Rural Electrification Authority’s top management decided to modernize its work procedures to have a proper design and reducing the time it takes to design the new electrical network and develop and rehabilitate the existing one.

Latest Electricité de France (EDF) software programs and know-how have been introduced within the framework of French - Egyptian cooperation to perform such complex planning and design. Now, immense change is achieved having significant influences on the way electric systems are planned and designed.

On the other hand, because there are still limited communities scattered very far from the unified electric networks, where it is very costly to extend the grid to such communities. The Egyptian Government has launched a program to apply new and renewable energy technologies. Technical feasibility studies are carried out to supply electricity to such various remote and desert areas.

Rural Electrification project is considered a success project since about 98% of rural inhabitants in Egypt are now enjoying electricity and passing through dynamic changes with better style of life. As illustrated, Egypt is one of the world achievers and certainly the lead country among the developing countries in that field. A quick look at the electrical distribution map of Egypt realize that design and planning of the distribution of electrical networks are performed now in a manner that will assure the continuity and reliability of the power supply, and in the meantime reducing the distribution system losses and costs.
1- INTRODUCTION

This paper presents the topic of implementation of the extensive rural electrification programs in Egypt. It demonstrates how Egypt, like many other countries in the developing world, is seeking to provide better living standards to the people specifically in rural zones throughout the accelerated economical and social development plans. This project throughout its long history was considered to be a top priority and treated with a sense of utmost urgency to curtail the wide gap between urban and rural inhabitants. A strategy has been established to reach rural areas, remote and isolated zones all over the country that can be supplied with electrical energy, either by the conventional way or by using new and renewable energy sources. This calls for extending thousands of kilometers of medium and low voltage overhead transmission lines and constructing hundreds of transformer points.

Challenges facing decision-makers for design and planning of distribution systems have required new modern and effective software programs. So, Rural Electrification Authority's top management decided to modernize its work procedures. Latest Electricite' de France (EDF) software and know-how programs have been introduced to perform such complex studies and in the meantime to ensure reliability of power supply. Egypt has made rural electrification a priority and, as a result, close to 8 million dwellers now have access to electricity. This figure includes about 36.3 million (out of 37.3 million) people who were provided with access to electricity in the 29-year period from 1971 to 2000.

2- RURAL ELECTRIFICATION PROJECT HISTORY

Before the start of the project, most of rural inhabitants were essentially dependent on traditional fuels such as kerosene, biomass, dung cake, ... etc. The electrification of the rural areas was very limited, it represent only 5% of total number of towns and main villages. In 1970, having enough installed electrical power and extended networks covering most of the country, the Egyptian Government realized that supplying electricity to rural areas is the gateway for the sustainable development for such areas and to achieve real development for transferring rural society from a primitive consumption community into a productive civilized one.

It was agreed to give full attention to initiate a national project for electrification to cover such areas. Implementing such sizable project was so costly for private sector or any non-governmental bodies to afford. Accordingly, the Egyptian Government decided to launch that project. In 1971, the Rural Electrification Authority (REA) has been established to take over this responsibility. REA has been charged with following tasks:
1) Implementing all works related to rural electrification projects, its development and enforcement of the existing distribution networks, all including substations and overhead transmission lines of low, medium and high voltage up to 66 Kv.
2) Performing all electrical connections to supply loads from 0.5 Mw and more for governmental projects, authorities and similars in cities, villages, and land reclamation areas.
3) Planning and studies in the field of REA's activities.

At the start of the project the total population of Egypt were about 27.5 Million inhabitants over 17.5 Million of them were living in rural areas and the rate of population growth was 2.8 %.

2-1 Planning and Technical Studies

Several studies were conducted covering different alternatives of electricity policies based on economic variables. The studies have been carried out using technical assistance of other countries that have experience in this field. It was decided to focus first on those areas with high-density population, high economic growth potential and lowest cost. The target of the project was to finalize the electrification of 3500 villages and 119 towns in 10 years. In 1971, load demand was estimated at 5 Watts/Capita but ten years later that value had to be increased to 40 Watts/Capita. The necessary equipment for the job was estimated to be:
- 24 substations 66,33/11 Kv of total installed capacity about 500 MVA together with 500 Kms overhead transmission lines 66 & 33 Kv.
- Complete transformer substations 11/ 0.4 Kv
(pole mounted/kiosks) of total installed capacity of 1500 MVA. Construction of the medium and low voltage overhead transmission lines. The following set of criteria and parameters were adopted as basis in planning the electrical networks of the rural areas:

- Operating medium voltage to be 11 Kv, 3- ph scheme and the low voltage 380/220 V, 3- ph, 4- wire system.
- The system should be solidly earthed.
- The rural loads are considered as third class category.
- Single circuit, radial system is the general configuration.
- Single circuit, ring system configuration using devices for connecting and disconnecting to ensure continuity of supply for some specific loads in urban areas.
- Using local manufactured equipment as much as possible.
- Voltages drop at the end user not to exceed ±7.5%.

During the implementation of the project, several obstacles had hindered and delayed the implementation of the project according to its schedule such as: shortage of capital investment, rapid increase of the cost of equipment, rehabilitation of the old existing electrical networks, high increase of growth rate of rural inhabitants and consequently high increase of load demand.

2-2 New Technology Transfer

As a result of the increased consumption in the electrified villages and towns, it was decided to raise the average load demand to be 150 watts/Capita in rural areas and to be 300 Watts/Capita in urban areas.

2-3 System Design

In order to achieve this big leap it was necessary to modernize the work procedures. Latest software programs have been introduced within the framework of French-Egyptian cooperation to ensure reliability of power supply, reducing the distribution system losses and determining the best feeding points. Economical studies have been carried out for the future expansions, low voltage drop, minimum losses and optimum transformer capacities. A Geographic Information System has been developed providing a reliable tool to record and update the electrical network technical data on geographic maps. This system allows now easy retrieval of any technical data required for design and planning. As an example:

In the field of planning high voltage networks. Quintet program is used to fulfill: load forecast, power flow, load balance, short circuit current and feasibility studies. Figure (1&3) show flow chart for operation in planning of high voltage networks and an output of Quintet Program.

The following tasks are performed for planning high voltage networks:

- Technical and economical studies for planning electrical networks.
- Layout general strategy for the electrical networks.
- Technical and economical studies for supplying electricity for agricultural & industrial projects...etc.

In the field of designing high voltage transmission lines. The following programs are used:

- JOVE for designing the longitudinal sections and distribution of towers, calculations of mechanical loads and determining the tension and sagging tables.
- SAFI program for designing the towers and steel structure.
- TRANS for calculating the mechanical loads on towers and designing foundations of different types of towers and soil.
Figure (2) shows an output of JOVE program.

**In the field of designing of transformer substations 66/11(22) Kv:**

The following programs are used:
- TRANS for designing steel structure and foundation.
- SAFI for structural designing tasks for concrete and metal buildings.
- Different programs which are home made to design the ground networks and lighting arrestors and short circuit calculations.

**In the field of planning medium voltage networks.** The following programs are now in operation:
- PRAO for technical and economical studies.

Figure (4) shows flow chart for operation of BASIX, PRAO & ARCVIEW programs.

The following tasks are performed in that regard:
- Planning medium voltage networks of 207 towns, technically and economically.
- Ten years master plan for each network.
- Time table to implement the required networks according to technical and economical studies.
- Development of electrical networks annually on geographical maps.

Figure (5) shows master plan for the network of a town in Delta Zone in the year 2010.

**In the field of design of medium voltage lines.** Camelia program is now used to design medium voltage overhead transmission lines.

The following tasks are performed:
- Studying loading new substations and relieving loads on the existing one.
- Preparing electrical and mechanical calculations for transmission lines.
- Designing of different types of 11 & 22 Kv poles.
- Design concrete foundation of towers.

**In the field of planning of low voltage networks.** LV PLAN program is now used to fulfill this task.

The following studies can be performed:
- Design of overhead transmission lines networks and its routes.
- Specifying types of insulators, cross section and transformer capacities.

Figure (6) shows an output of LV plan program.
2-4 Project Achievements

By the year 2000, the following tasks have been achieved:

1st) In the field of high voltage networks, 315 Substations 66,33/11Kv and 66/22Kv with total capacity of 9000 MVA together with 4550 Kms cables and overhead transmission lines 66,33 Kv.

B) In the field of medium and low voltage networks, the following have been constructed to reinforce and rehabilitate towns' electrical networks:
   - 369 Distribution points 11 & 22 Kv.
   - 8591 Kiosks 11 (22) / 0.4 Kv.
   - 26500 Kms of medium and low voltage cables and overhead transmission lines.

C) In the field of electrification, the following have been executed:
   - Electrification of 36010 main villages and attachments.
   - Enforcement and rehabilitation the electrical networks for previously electrified main villages and refurbishment of obsolete electrical networks.

Fig.(5): Master Plan of a Town in Delta in the Year 2010

2-5 Investments

The rural electrification program was implemented and financed through state budget, in addition to soft loan and grant agreements in the framework of mutual economical cooperation with international donors. The total investment for implementing all the previous achievements is amounted to 8500 Million L.E. (one US$ is currently equal to 3.9 L.E).

3- FUTURE PLANS

The Ministry of Electricity and Energy has set a strategy covering the period up to the year 2017. Within this strategy, REA has to meet the growing demand of electric energy all over the rural zones, by executing the following tasks annually:

- Implementation of 7 S/Sts 66/11 (22) Kv and the necessary overhead transmission lines & under ground cables.
- Rehabilitation of the distribution networks of 213 towns.
- Finalize electrification of the remaining small residential communities (wherever possible).
- Continuous rehabilitation of the pre-electrified villages of about 300 rehabilitating process and 530 replacement of obsolete villages' networks.

4- SUPPLYING ELECTRICITY TO OTHER PROJECTS

REA scope is not limited to electrification of villages and attachments but also has the role of
supplying electricity to different projects to serve the continuous development of the society. REA is performing technical studies, design and implementing the required electrical network by using the above mentioned programs for the following projects: -

4-1 Land Reclamation:

In the frame of the Egyptian Government strategy to invade and reclaim the desert targeting 1347000 Feddans, over 440 000 Feddans have been supplied with electricity by the end of 2000. It is planned to supply 12000 Feddans by electricity annually.

4-2 New Residential Cities:

In order to meet vertical and horizontal expansion of inhabitants, 32 new cities and residential areas have been planned to be built and of course supplied with all necessary services including electricity. Up till now, fourteen residential cities have been supplied with electricity. Eighteen substations 66/22(11) Kv have been constructed with total capacity of 1245 MVA. Other four complete substations with total capacity of 470 MVA are now under construction.

4-3 Industrial Zones:

Matching up with the State’s Policy in developing local industry, industrial zones have planned to encourage new industrial projects and create job opportunities. Concentrated programs are adopted to implement the electrical infrastructure to supply 50 industrial zones with electricity nationwide. By the end of 2000, ten substations 66/ (11) 22 Kv have been constructed with total capacity of 485 MVA to supply electricity for fourteen industrial Zones. Nine substations are now under construction with total capacity of 525 MVA.

5- APPLICATION OF RENEWABLE ENERGY RESOURCES TO SUPPLY REMOTE RURAL AREAS WITH ELECTRICITY:

Since there are still limited communities scattered in the western desert, Sinai, coastal areas of Red and Mediterranean Sea, located very far from the unified electric network, it is very costly to extend the grid to such small and very far communities. So, it was decided to promote the utilization of renewable energy to meet the needs of these communities. The Egyptian Government has launched a program to apply new and renewable energy technologies. In that direction, technoeconomic studies has been carried out to identify the optimum choice to electrify these communities for residential purposes (e.g. Lighting units, pumping water, small local industries and small clinics for healthcare). Various pilot projects have been implemented using hybrid systems of Wind/Diesel and photovoltaic (PV) techniques. As example the following projects has been executed so far:

- Remote village of forty houses in wadi al-Natroun in the western desert was supplied with electricity through PV technology.
- A group of remote villages located on the northwest coast were supplied with electricity, using hybrid 25 kw diesel/windmills. Further projects are planned to be executed in the near future.

6- CONCLUSION

The Egyptian Rural Electrification Program, which began in 1971, has increased the required number of electrified main villages and attachments from 3500 to 35650 villages making over 98% of inhabitants are having access to electricity. Providing rural inhabitants with electricity have offered them a better style of life and opened up new horizons for investments resulting in transferring them from a primitive consuming community to a civilized productive one. This project took a long time, over industrious efforts and substantial amounts of money along the past three decades.