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GENERAL POLICIES AND IMPLEMENTATION GUIDELINES

RURAL ELECTRIFICATION PROGRAM
PAKISTAN

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EXECUTIVE SUMMARY

A. Observations

This report summarizes the results of a program to review the plans and impacts of the Rural Electrification Program and to identify what, if any, changes might be considered to make it more effective in meeting national goals within realistic resource constraints. The information contained in this report was obtained, in part, during field trips and interviews in Pakistan over a five-week period during January and February of 1983. The final output of this activity was a set of General Policies and Implementation Guidelines recommended to assist WAPDA in their development of the Rural Electrification Master Plan. The Rural Electrification Program impacts on many aspects of economic development so that this output may also prove useful to organizations, such as the Planning Commission, engaged in more comprehensive energy planning activities.

The primary observations resulting from this review were:

(a) The Rural Electrification Program enjoys a high level of support among rural population. The guidelines suggested by WAPDA in selecting villages for electrification, based primarily on a combination of population and distance from the grid, appear to usually be followed by the local officials who make final decisions. By and large the existing guidelines tend to result in those villages (and associated tubewells) being selected with the most favorable economics. The Master Plan now being prepared will further improve this process and result in a more rationale extension of the local grid structure.

The discussions associated with the give and take of the village selection process are among the most important made at the local level and represent one of the most visible forms of participatory democracy in Pakistan.

(b) The national benefits of a quantifiable nature resulting from rural electrification are estimated to be large by virtue of increased

generation shortfalls due to the coincident nature of household loads with utility system peak loads.

(e) The economics of electrified tubewell irrigation would remain highly favorable in most cases even if electricity costs are raised significantly from present highly subsidized levels. So doing would improve the financial viability of the overall rural electrification process and encourage irrigation efficiency measures.

(f) For small loads distant from the grid (2-3 miles) decentralized energy technologies, such as Diesel generators and, in the future, photovoltaics, often show potentially, favorable economics as compared to grid extensions if all the costs associated with incremental grid suppled electricity are used in the comparison. In this regard, it should be noted that electricity from thermal plants will be increasingly generated with oil.

(g) There is presently inadequate attention given to data collection, management, and evaluation relative to such critical issues as the level of new and existing connections, the nature of existing loads, price elasticity, and technical performance (line losses, etc.). This complicates the important tasks of load forecasting, local grid design, and pricing policies. As a result, decisions made with regard to rural electrification expansion and policies are often made with insufficient information to ensure that limited resources are most effectively utilized.

(h) The management and operational procedures of electric sector distribution are in many ways not consistent with international standards in LDCs. This is manifested in very high levels of staffing (2-4 times LDC standards), inadequate staff training, poor inventory control, and poor reliability of local grids. These and other problems could result in the planned rapid expansion of the rural grid being more costly to implement and operate than necessary if high priority is not given to modernizing management and operations.

agricultural productivity and displacement of imported oil. For example, the incremental value of crops grown on land irrigated with electric tubewells is estimated to be in the range of $200 million to $450 million per year based on prices in Pakistan. Replacing these agricultural products with imports would cost 30-90 percent more than the above figures.

Other significant but difficult to quantify benefits, include increased employment opportunities, establishment of small scale industries and social benefits (lighted school houses, etc.)

(c) There are substantial costs associated with expanding the rural electrification network. These include the direct costs of extending the local grid structure and the indirect costs associated with the requirement to increase generating capacity and upgrading transmission line capacities to bundle the increased loads.

For example, the generating capacity which will be required to service the rural loads is estimated at 600-800 MW by 1988. The cost of providing this capacity will be approximately $600 to $800 million assuming new generation facilities cost $1,000 per kW. These indirect costs of rural electrification, exceed the direct costs associated with local transmission system extensions.

Rural electrification impacts the whole energy sector infrastructure by virtue of requiring additional generation capacity and increasing fuel use in thermal generation. Rural electrification policies should, therefore, be considered within the context of overall utility and energy sector planning.

(d) Presently, the major rural loads are the irrigation wells which now consume about 23 percent of all the electricity produced in the country. The rural loads are projected, however, to become increasingly associated with household and light industrial loads based on WAPDA's assumed saturation levels. The rural loads will increasingly contribute to

B. General Policies

The analysis leading to the above observations, dealt with a broad range of issues such as agricultural productivity on irrigated lands, impact of rural loads on utility operations, and the mechanics of the implementation process. Based on these analyses a number of policy recommendations were identified which would allow for pursuing the implementation of the rural electrification program while; (i) reducing the electric sector infrastructure requirements and associated costs, and (ii) improving the financial viability of the utility system. These policies should be considered within a comprehensive framework of planning within the energy sector so that rural electrification needs and national benefits derived from it are considered along with those of other energy consuming segments.

The general policies which were identified as being useful in guiding the planning and implementation of the Rural Electrification Program are:

- To closely integrate rural electrification planning with overall utility sector planning and national energy sector planning, so that rural electrification expansion is consistent with system generation and distribution capabilities, overall energy balance considerations, and national economic goals.

- That future rural distribution network (11 kV) expansion is in accordance with a Master Plan which will ensure that lines are laid out so as to meet long-term goals of minimizing costs, increasing reliability, and reducing line losses.

- To distribute financial resources for rural electrification among provinces, in large part, on the basis of population (with appropriate exceptions to take account of regional development potentials) thus ensuring that all regions are treated equitably and that development and social benefits of electricity are spread throughout the country.

- To allocate a portion of the annual rural electrification resources to regional development projects in particularly under developed areas, i.e., Baluchistan and NWFP where a reliable supply of electricity is one of the essential ingredients for the development process.

- To actively involve local participation in the process of selecting villages thereby providing local populations with a stronger sense of community and some understanding of the practical constraints on the utility system, as applied to their needs.

- To encourage villages to obtain local financing for rural electrification by giving connection priority to villages that successfully arrange for partial financing.

- To consider the use of power for potential productive purposes when selecting villages as well as the existing guidelines of proximity to the distribution network (11 kV) and population size.

- To implement load management measures on the private tubewells and SCARP pumps and other concentrated loads in order to reduce their impact on electricity shortfalls during peak demand periods and the need for costly generating capacity expansions.

- To implement improved efficiency standards for electrical devices used in rural areas particularly with regard to the mechanical efficiency of the irrigation pumping process where most electricity is used in the rural sector.

- To develop a program that will increase awareness by farmers of the energy cost benefits to be gained through greater efficiency of water use in the irrigation process.

- To reduce line losses to technically and economically justified standards in order to decrease fuel consumption in power plants and decrease the effect of capacity shortfalls.

- To balance, appropriately, the needs of rural and urban populations in developing load shedding guidelines taking into consideration critical agricultural and industrial priorities. Ensure that necessary load shedding be done as predictably as possible to reduce economic cost.

- To establish tubewell tariffs at a level that more nearly takes into consideration the costs of providing electric service, maintain WAPDA revenues at an adequate level, and encourage efficient irrigation practices.

- To encourage efficient use of electricity both through public education programs and appropriate tariff structures.

- To consider the use of decentralized energy technologies for electrification where they are more economic than distribution system extension.

- To achieve and maintain management and operational procedures consistent with those accepted as good practice in developing countries.

- To collect, manage, compute, and evaluate data on such critical issues as electricity consumption patterns, new connection distribution, new connection backlogs, and price elasticity of demand in order to facilitate both electric sector and national energy planning activities.

- To accelerate the divesture to the private sector of SCARP wells which provide irrigation water.

(C) Implementation Guidelines

Pursuit of the general policies are of critical importance in achieving overall national goals in the energy sector and economic development. In many cases, WAPDA and others already have programs which are serving to implement the general policies. In these cases, the Implementation Guidelines serve to reinforce and improve upon existing activities. In other cases, no programs

now exist which address the policy issues. In these cases, programs must be initiated which better define the manpower, technical and financial resources, as well as institutional arrangements for effective policy implementation. The following are suggested as guidelines to assist in the initial stages of implementing the policy recommendations.

a. Integration with National Energy Planning

In cooperation with national energy planning organizations, WAPDA will initiate a review of the information and analysis requirements to effectively integrate rural electrification programs with overall utility sector and national energy planning. This review will identify what, if any, additional data collection and analysis is required to facilitate overall energy planning in addressing such issues as:

- Load forecasting.
- Estimating generation and distribution needs (resulting from rural electrification expansion).
- Estimating benefits of various rural electrification strategies and options.
- Setting equitable and financially sound rate structures.
- Projecting the impacts of energy conservation and load management programs.

Recommendations relative to staffing, procedures, and resources for addressing additional data collection and analysis needs in support of integrated energy planning identified by this review will be prepared.

b. Master Plan Preparation

The preparation of the Rural Electrification Master Plan will continue and then the plan will be used as a blueprint in all future rural grid expansions. The plan will be reviewed periodically so it can be modified as appropriate to reflect changing population, technologies, regional development potentials, and economics. The plan will include information on such issues as availability of sweet groundwater and the existing level of small scale industry activity so

that the village selection process can consider the productive as well as the social benefits of electrification.

c. Regional Development

WAPDA is presently involved in regional development functions through such activities or the tubewell electrification program and its participation on Industrial Facilities Boards. These activities will be reviewed to determine if, and how, this process can be made more responsible to regional development opportunities.

Questions which will be addressed by this review will include:

- Are there adequate mechanisms at the national and provincial level for identifying regional development opportunities which could open up new areas for agriculture and other economic activities (mining, fishing, etc.)?

- Is the allocation of financial resources for tubewell development between provinces on the basis of population consistent with pursuing the most attractive regional development opportunities?

- What national economic and social benefit criteria should be utilized in evaluating regional development opportunities requiring substantial inputs of electric power - particularly in view of the shortfalls in electric generating capacity which is likely to persist over the foreseeable future?

Based on this review, measures will be identified which would further promote the identification and implementation of productive regional development projects.

d. Load Management Options

In order to establish appropriate guidelines, a review of both technical and

non-technical load management options and practices will be initiated to determine what measures can be realistically utilized on the irrigation pumps and other concentrated loads. This review will consider the full range of technical options used in the United States and elsewhere including on-site timers and over-the-line signals. It will take into consideration practical implementation issues such as tempering and frequent outages which occur throughout the system. Consideration will also be given to non-technical options such as those involving the cooperation of local users in manually shutting down large pumps and other concentrated loads.

In cooperation with local officials and farmers, irrigation practices will be reviewed to determine how load management can be implemented with minimum disruption to agricultural production activities.

Pilot load management projects will be designed, implemented, and evaluated before a widespread load management system is implemented to ensure that appropriate technical and institutional approaches are selected.

e. Irrigation Pumping and System Efficiency

The design and performance characteristics of electrically driven pumps commonly used in Pakistan will be reviewed and appropriate efficiency testing initiated. This information will be used by an appropriate institution in Pakistan (perhaps the Pakistan Institute for Standards) to establish pump efficiency standards that are a reasonable trade-off between cost and performance.

Irrigation practices will be reviewed by irrigation and water management specialists to determine the efficiency of water distribution and utilization and, thereby, the quantities of water which must be pumped. This team of specialists would identify irrigation system design and utilization practices that can be used to lower pumping requirements. A pilot project utilizing the recommended practices will be implemented through the appropriate institution so that the practices can be fully tested before widespread dissemination.

Based on the above, recommendations will be prepared on how pumping and irrigation practice efficiency standards should be implemented and enforced.

f. Energy Loss Reduction

The ongoing line loss reduction program will be reviewed and measure identified which can increase the effectiveness of line loss reduction measures.

Based on the above review, modifications in the line loss reduction program will be identified which could accelerate achieving the goals of reducing line losses to economically justifiable levels given the nature of the grid system in Pakistan. The budget, management structure, and technical innovations required to implement accelerated program options, will be defined. The national benefits in reduced capacity shortfalls, increased line reliability, and reduced fuel consumption resulting from the program options will be quantified so that the economic returns can be estimated as part of the overall planning process.

g. Load Shedding

WAPDA, in cooperation with local business, rural development, and agriculture=a organizations, will continue to review load shedding practices and their impact on rural productivity and standards of living.

When appropriate, load shedding procedures and schedules for rural areas will be modified in order to better achieve an appropriate balance between the needs of rural and urban areas. One objective of these load shedding policies will be to result in the least possible disruption of critical agricultural and industrial activities.

h. Tariff Structure Review

A review of electricity tariff structures in rural areas will be undertaken with emphasis on those which apply to tubewells. This review will include determining:

- The affect of tubewell tariffs on agricultural production costs.
- The tariff needs to cover the costs of providing service.
- The price elasticity of demand for various functions of importance in rural areas.

Organizations involved in this review will include WAPDA, the Ministry of Finance, Planning, and Economic Affairs, and representatives of affected interests such as provincial planning and development departments and the Ministry of Agriculture.

Based on the above, electricity tariff structures will be recommended which are consistent with WAPDA's financial needs, national agricultural production objectives, and the needs to encourage efficient use of electric power.

i. Decentralized Systems

A detailed evaluation of decentralized energy technologies will be initiated taking into account their technical and institutional requirements in different regions and for different applications. This activity will include a detailed evaluation of the experience of WAPDA, local governments, and private parties with diesel generators to determine operating experience with such units and to identify how their operation can be made more reliable and cost effective. The status and prospects for other decentralized technologies will also be reviewed taking into account the in-country experience with small scale hydro, biogas digesters, and photovoltaic technologies.

Organizations involved in this process will include WAPDA, ATDO, DGER, Planning Commission, gas transmission companies and provincial planning and development departments.

A primary focus of the review will be to determine how decentralized system can be most effectively implemented and what technical and financial support infrastructure would be required, if decentralized technologies are to be an important element in the rural electrification process.

Recommendations on the implementation of decentralized technologies will then be prepared.

j. Improved Operational Efficiency

A review of management and operational procedures will be initiated which include the participation of the General Manager of Distribution, the Rural Electrification Office, and the Area Electricity Boards of WAPDA. This review will address the full range of organizational, management, and operational issues as they relate to the Rural Electrification Program, including:

- Management, organization, and structure of the Rural Electrification Program.
- Staffing levels in all categories including technician, engineering, and management.
- Technical specification of critical components such as poles, connectors, and transformers.
- Field communication networks.
- Field repair and maintenance equipment and procedures.
- Meter reading procedures and documentation.
- Billing Procedures.
- Training, for improving technical and management skills.

The organizational and operational practices of WAPDA will be compared with those of Rural Electrification Programs in other LDCs to assist in determining how these practices might be modified to improve implementation and reduce recurring costs.

Based on the above, a plan will be prepared whereby the management and operational procedures associated with the Rural Electrification Program can be improved to be consistent with internationally accepted practice.

k. Data Collection, Management, and Evaluation

The present system for collecting, managing, and evaluating data on such critical issues as number and distribution of existing connections, new connections, electricity consumption patterns, price elasticity of demand, and appliance utilization will be reviewed. Appropriate measures will be identified which will improve this process so that essential information needed for both utility sector and national energy planning is obtained and reported in a format which can be effectively utilized.

The financial resources, computer data base management resources, training, and changes in procedures needed to implement these measures will be determined so that appropriate steps can be taken.

BACKGROUND REPORT

1.0 INTRODUCTION

At present, out of a total of 48,000 villages (1981 census estimate) about 13,000 villages have been electrified. This implies that 35,000 of Pakistan's villages are not yet electrified. For this reason the Pakistan government is planning to include an expanded Rural Electrification Program as a part of its 6th five year plan. The announcement of the plan objectives, while not yet final, set forth a program to electrify 15,000 new villages during the plan period. This is an ambitious program since it aims to more than double in five years the number of villages electrified to date. These villages began to be electrified in the late 1960's.

The primary support for rural electrification within diverse groups ranging from national politicians to small farmers is based on the perception of significant productive and social benefits which result from its introduction. These benefits include:

- Decreased use of imported petroleum products in lighting (kerosene) and for diesel pumps (diesel fuel).

- Increased agricultural output due to reliable irrigation water.

- Introduction or expansion of cottage and small-scale industries in rural areas.

- Improved living standards for the rural population as a result of lighting, T.V., and other domestic electricity uses.

- Reduced out migration of rural persons to over populated urban centers.

- Increased social benefits, such as education, health, drinking water, and communications will be promoted.

- Increased social cohesion resulting from direct participation of local and national political groups in bringing valued services to outlying regions.

Generally these benefits have been shown to derive to some extent from the Rural Electrification Program. This is evidenced, in part, by the tremendous popularity of the program in the countryside and the willingness of consumers to purchase electricity at rates which are substantial compared to income levels. Also over 2.8 million acres of land are now irrigated totally or, in part, from electrified tubewell irrigation.

At this time a National Rural Electrification Master Plan dealing with central grid expansion is being prepared. The Planning Commission is working to set the broad goals and budgetary requirements of the program as part of its deliberations to prepare a 6th five year plan which will guide overall development activities. WAPDA is preparing detailed operationally oriented master plans for each province. This WAPDA plan will provide the implementation basis for execution of the GOP decided goals as applied to extending the central distribution system.

As indicated above, the Rural Electrification Program is now based primarily on extending the central distribution system. This is in keeping with overall government policies to bring the benefits of relatively low cost central low grid power to as large a portion of the population as practical. This report, likewise, gives major emphasis to the grid expansion program and its impacts on WAPDA.

The present grid expansion program would still leave over 15,000 villages without access to electric power at the end of 10 years. These would tend to be smaller and remote settlements, many of which could not be economically serviced by distribution system extensions in a time frame of practical interest. Particularly for these villages, the wider use of decentralized energy systems merit serious consideration. In fact, decentralized technologies based on renewable energy resources might become practical alternatives to distribution system expansion in many regions if cost reduction

goals in such technologies as photovoltaics are achieved. So doing would serve to reduce central generating capacity expansion requirements as well as reduce direct costs associated with distribution system extensions.

This report discusses the economics of decentralized technologies and their potential contribution to overall rural electrification strategy. Emphasis is given to identifying necessary institutional support which would have to be developed if decentralized technologies are to have a significant impact. In this regard, WAPDA is probably not an appropriate implementing agency given the diverse nature of decentralized technologies, the requirements for local O&M capability, and the need for WAPDA to focus its managerial and technical resources on the ambitious distribution system and generating capacity expansion programs.

The purpose of the effort leading to this report was to prepare a set of "General Policies and Implementation Guidelines" which would be useful to the GOP in preparation of both the Rural Electrification Master Plan and in their broader policy deliberations leading to the 6th five year economic development plan. It deals with both central grid expansion and decentralized energy technologies since both approaches to Rural Electrification have a role in Pakistan.

The Rural Electrification Program has a multiplicity of benefits which have already been listed. However, its implementation has considerable direct and indirect costs associated with local grid extensions, additional primary generation capacity, and increased fuel usage in thermal power plants.

A primary objective of this activity was to identify policies which would enhance or at least maintain the benefits of rural electrification while keeping the financial resources required for its implementation consistent with national capabilities. To this end, this report identifies and, where possible, seeks to quantify both the benefits and the costs of the Rural Electrification Program.

To meet these objectives, a team from Arthur D. Little, Inc. has, over a three month period, reviewed the pertinent literature, performed various analyses and met with individuals involved in the rural electrification process. The team consisted of:

Dr. W. Peter Teagan - Energy Planning and Decentralized Technologies
Dr. Robert Lee - Rural Sector Economics
Mr. William Downey - Policy Formulation
Mr. Wilson Hodgin - Rural Electrification Technology and Implementation (Independent Consultant)

Members of this team met with representatives of WAPDA in both its headquarters in Lahore and in five of its Area Electricity Boards. In addition the team met with representatives of many diverse organizations at both the national and local level which closely interact with the Rural Electrification Program and are among its beneficiaries. Organizations contacted include:

- National Planning Commission
- Ministry of Industry
- Local Government and Rural Development Boards (in each Province)
- National and Provincial Agricultural Departments
- Small Industries Associations (in each Province)
- Agricultural Development Bank
- Planning and Development Departments (Provincial)
- Directorate General of Energy Resources (DGER)

Finally, three to five villages, both electrified and non-electrified, were visited in each province. Interviews with the villagers, in general, confirmed the views of the private and government representatives, but in some cases increased our insight considerably. A complete list of the specific people met by the team is included as Appendix 1-1.

From the literature reviews, analysis, and meetings, this report has been prepared. In it is provided:

- Executive Summary
- Introduction - Section 1
- The Goals of Rural Electrification - Section 2
- The Present Rural Electrification Program - Section 3
  a. Decentralized Energy Systems
  b. Central Grid Expansion
- Energy Sector Impacts of the Rural Electrification Program - Section 4
- The Benefits of the Rural Electrification Program - Section 5

These discussions of the implementation of the Rural Electrification Program and its costs and benefits served to identify a wide range of policy and program implementation issues which should be considered in planning the Rural Electrification Program. The pros and cons associated with these issues are discussed in Section 6. The issues considered are:

- The Village Selection Process
- Regional Development
- Irrigation Efficiency
- Load Management
- Choice of Connections (grid extension vs. backfill)
- Pricing of Electricity
- Line Loss Reduction
- Decentralized Energy Generation
- Data Collection, Management, and Evaluation
- WAPDA Management and Procedures

Based on these discussions of policy issues a set of General Policies and Implementation Guidelines were prepared.

2.0 GOALS AND BENEFITS OF RURAL ELECTRIFICATION

The purpose of this review of Pakistan's Rural Electrification Program is to identify a set of General Policies (GP) and Implementation Guidelines (IG) which can provide the framework for the expanded program of rural electrification during the 6th five-year plan. Before any GP and IP can be developed, it is essential that the goals of the rural electrification program be clearly understood. The real goals of any Rural Electrification Program (Pakistan's no exception) relate to the perceived productive and social benefits derived from the program for the nation. The plan of the 6th five-year plan to electrify 3,000 villages each year is an operational goal for WAPDA, but it is only a means to achieving the real goals of the program. The real goals must relate to the "why" of the program. Why do you want to electrify 3,000 villages each year? Why do you want to improve technical standards associated with distribution of electricity to rural areas? Why do you want to improve skills of persons responsible for the technical and managerial aspects of the rural electricity distribution network?

In Pakistan, the real goals of the 6th five-year plan expanded Rural Electrification Program include political, social, and economic objectives. Politically, the government is interested in maintaining stability and distribution of electricity to rural areas on an equitable basis as this is visible evidence that the government is doing something for the people. Socially, the government is faced with improving social conditions - education, health care, employment opportunities, public water supplies, etc., - and it is felt that electricity can contribute to this objective. Economically, the government of Pakistan is interested in stimulating increased productive activity through the most effective use of resources. This includes agricultural production and cottage industry development in rural areas. It includes supplying electricity in the most efficient and cost-effective manner.

The achievement of these broad based goals is generally felt to be measured by a myriad of direct and indirect benefits that accrue to electrification, such as those listed in Appendix 2-1. These benefits have rarely been quantified empirically but several of the benefits are considered important by GOP and the

real goals of the Rural Electrification Program. A discussion of these benefits follows.

2.1 Direct Benefits

(a) Households - Household owners who choose to use electricity presumably receive a direct benefit. The measure of the benefit relates to the extent of use. In Pakistan, it is estimated that an average of 35 to 50% of the rural households, in electrified villages, use the electricity after 3 to 5 years; thus a reasonably large number of persons benefit.

(b) Agriculture - If agricultural production can be increased or the cost of production decreased as a result of electrification, a positive direct benefit can be attributed to electrification. In Pakistan agricultural production is dependent on irrigation water and much of this is supplied by electrically powered tubewell pumps. In fact, over $180 million in agricultural output each year can be attributed to electrically driven tubewells. Certainly expanded agricultural production is a GOP goal.

(c) Industry - If industrial output can be increased or cost of production can be reduced as a result of electricity, a positive direct benefit can be attributed to electrification. This forms a third direct goal, as many Pakistan villages do have small black smith shops, flour mills, rice mills, oil expellers and similar cottage industry at work and, when electrified these industries may be able to increase output and expand their capability to undertake more complicated jobs.

(d) Petroleum Savings - The substitution of kerosene and diesel oil by electricity for cooking, lighting, heating and motive power results in a net benefit in foreign exchange savings -- if the central electric supply is not based on oil imports. Benefits of this nature do accrue in the case of lighting and pumping, but in the case of cooking and heating electricity hasn't been a major substitute for other forms of energy. For lighting alone, significant kerosene replacement is possible.

2.2 Indirect Benefits

(a) Political Stability - At the local and district level of government in Pakistan, representatives of the people are elected. A major platform on which many of these representatives seek political office is the bringing of roads and electricity to their district or local areas. Thus, to achieve the important goal of political stability, the government must work to assure that electricity is distributed on an equitable as well as productive basis.

(b) Social and Public Uses - Another important goal of the GOP is to use electricity for lighting schools, provide refrigeration in health clinics, improve and stabilize water supplies, and provide street lighting. The accomplishment of the social objectives, particularly if subsidized, provide benefit to the lower income population.

(c) Employment - Another GOP goal for rural electrification is the creation of employment in rural areas. This comes mainly from using electric power to pump irrigation water or from electrification of cottage industries. When used for both purposes, employment is created.

(d) Environmental Improvements - Pakistan does use a great deal of wood for heating and cooking. This has created a problem of deforestation and erosion. Therefore, another perceived goal of the rural electrification program is to help stem deforestation and erosion by providing people an alternative energy source for cooking or heating, but often these benefits appear overstated.

(e) Migration - Electricity is often attributed with stemming migration from rural areas to urban areas. This is an important goal of the GOP, but there appears to be very little evidence that electricity per se stems migration. It is felt rather, that electricity creates local development and employment opportunities and that these opportunities lead to stemming out migration. In some development areas within Pakistan, employment

opportunities have increased and out migration has been stemmed as a result of electrification. Thus, this does represent a reasonable goal for the rural electrification program.

(f) Population Growth - It has been shown that electrification is statistically associated with higher incomes and acceptance of family planning programs. If true, an indirect tie between electrification and population growth can be made. Again, this forms another goal important to Pakistan.

(g) Innovation and Modernism - Another goal important to the GOP is development of awareness and innovativeness in today's modern technological world. It has been shown in several studies that electricity can be important as a "change agent." In Pakistan electricity has brought about technological change in agriculture which in turn has assisted the GOP meet national food sufficiency objectives.

The GPs and IGs developed for the Rural Electrification Program in Pakistan have been developed as a function of the operational, political, social and economic goals set forth above. Our analysis supports that these are the primary "real goals" of the program during the 6th five-year plan. The GPs and IGs suggested provide a guiding framework for the National Rural Electrification Program consistent with these goals for the program.

3.0 DESCRIPTION OF PRESENT RURAL ELECTRIFICATION PROGRAM

3.1 Decentralized Energy Systems

3.1.1 Implementation of Present Programs

There are presently about six organizations in Pakistan with programs to develop and install decentralized energy systems. The main participants are:

- WAPDA — Small Scale Hydro
Diesel Generator
- DGER — Biogas Digestor Systems
Photovoltaics
- ATDO — Mini-Hydro
Biogas Digestor Systems
- Ministry of Science & Technology — Photovoltaics R&D
- Local Development & Electricity Boards — Small Scale and Mini-Hydro
- Agricultural Development Bank — Photovoltaic Pumps

As indicated above, most attention is being focussed on renewable energy resource systems with only WAPDA taking responsibility for small diesel generators in non-grid connected areas.

The status of each of the decentralized energy technologies under consideration is discussed briefly below.

Diesel Power Units

WAPDA operates about 35 diesel generators (50-200 kW) in remote areas of Baluchistan and has plans to install about 10 additional units. In general, WAPDA undertakes the installation of diesel generators with great reluctance since doing so diverts management and technical resources from their main function of central grid expansion and maintenance.

It should also be noted that there are over 100,000 diesel operated pumps with a combined capacity in excess of 1000 MW. The installed decentralized power capacity in the form of diesel pumps is, therefore, about one-third that of the central grid.

Biogas Digestion

Over 1,000 biogas digestor units have been installed in Pakistan by DGER and ATDO. Present plans call for installing over 15,000 additional units over the next 5 years. Most of these units are for use by families using the dung from 4-6 cattle. The gas from these units is used for cooking and, possibly, lighting.

However, DGER is considering larger units which would use the dung from several hundred cattle at larger dairy facilities. The biogas from these units could operate modified I.C. engines for local power generation (up to 10 kW).

Photovoltaics

Primary responsibility for implementing photovoltaic power projects is with the DGER. However, other organizations are participating in special projects. The Ministry of Science and Technology is responsible for the newly inaugurated Silicon Research Institute and the Agricultural Development Bank has initiated the testing of over 20 small photovoltaic pumps. This latter activity is to provide the ADB with information to assist in developing financing policies for such pumps as their cost decreases.

The DGER has installed and operated for over a year a 5 kW village power unit. Five additional village size systems are now being installed with individual capacities up to 30 kW. Present plans call for 130 photovoltaic village installations over the next 5 years with an installed capacity in excess of 2 MW. This activity will be done in parallel with the establishment of a private sector photovoltaic fabrication and service industry. It is expected that at the end of this period there will be sufficient in-country experience in the private sector for the process of widespread implementation of decentralized photovoltaic power units to proceed with minimal government involvement (primarily financing).

Mini and Small Scale Hydro

Several organizations are involved in implementing mini and small scale hydro systems. In the 1960's WAPDA installed five units with capacities of 50 to 400 kW. These units were later turned over to the Northern Area Public Works Organization for operations and maintenance. This activity led to WAPDA being asked to survey small scale hydro systems in northern mountainous areas and subsequent purchase of 100 standardized hydraulic turbines from Germany with capacities in the 50-100 kW range (in 1974). Twenty of these units were installed at sites in the Northern Areas, and the NWFP. Installation of the remaining units will be the responsibility of local authorities including the Kohistan Development Board, the NWFP Irrigation and Public Health Department, Northern Areas Works Organization, and Azad Kashmir Electricity Department. In short, WAPDA's present policies are to focus on grid extension and to limit their involvement in non-grid connected small scale hydro facilities to technical support functions to local organizations.

The ATDO has been developing mini hydro units with capacities in the 5-20 kW range for use in the smaller streams of northern mountainous regions. To date about 40 units of local manufacture have been installed via cooperative efforts of ATDO and local organizations. It is hoped to expand this effort with the implementation being the responsibility of local

organizations, such as the Kohistan Development Boards and ATDO functioning primarily in a technical development and support role.

As indicated above, there are a multiplicity of organizations involved in the development and deployment of decentralized energy technologies. These activities are not presently coordinated to any great extent and no strategy has yet been developed on the role of decentralized energy technologies inthe overall rural electrification process.

3.1.2 Economics of Decentralized Energy System (Examples)

There are two general types of decentralized energy systems which can be considered:

- Conventional fuel-fired systems based on the use of diesel engines or possibly small coal fired steam plants.
- Renewable energy resources ignitions using solar, wind, hydro, and biomass as their basic energy service input.

Examples of each type are discussed below to illustrate that decentralized technologies may often be a more economical option than capital intensive grid extensions.

a. Conventional Systems

The most common type of fuel fired decentralized energy systems are diesel engines. Such engines require purchasing, transporting, and storing diesel fuels which can be particularly burdensome in remote areas where they are most likely to be considered. These engines can, however, be adapted to burn biogas or gas from a small coal gasifier which might be an interesting option in specialized cases. The following discussions focus on diesel fuel fired engines since these would have, by far, the widest range of potential applications.

Table 3.1 summarizes cost of power estimates for a diesel generator of 25 kW capacity which might serve basic needs in a small, remote, community. Estimates are provided for two cases, one where the primary loads are household with an equivalent capacity factor of 15 percent and one where part of the load is a small pump with an average net capacity factor (pump plus household) of 40 per cent.

As indicated, the cost of power is very high in comparison with present WAPDA rates which is one reason why such systems are not in widespread use. However, the economics of diesel generators should be compared to the marginal cost of supplying the same service with grid extensions. In this regard the following points are worth noting:

- The capital cost of a robustly built high duty cycle diesel generator is in the $400-600 per kW range. This cost is considerably less than supplying the same capacity in a central facility ($1,000-2,000 per kW depending on fuel type).

- The efficiency of a well maintained diesel generator is about 30 percent. This is comparable to a good steam plant. As such, the fuel consumption of the diesel generator per kWh delivered will actually be lower than in the central facility if line losses are considered.

- Marginal central station thermal power generation will be increasing by oil over the next decade so that there will be reduced advantages to central facilities in reducing petroleum use as compared to operating diesels in the field.

The primary disadvantage of the diesel option is the relatively high cost of routine maintenance and periodic major overhauls (typically at 5,000 hour intervals). Even these costs could, however, be greatly reduced if supporting infrastructure is developed to train local technicians in O&M procedures and to provide spare parts within a high level of standardization.

Table 3.1

COST OF POWER FROM DIESEL GENERATOR

	Capacity Factor = 0.15 Capacity Factor = 0.15 (1314 hours/yr)	Capacity Factor = Capacity Factor = 0.7 (3509 hours/yr)
Capital Cost[1] (¢/kWh)	6.8	2.5
Maintenance Cost[2] (¢/kWh)	7.6	2.8
Fuel Cost[3] (¢/kWh)	9.6	9.6
Cost of Energy (¢/kWh)	24.0	14.9

1. Engine-Generator Cost = $500/kW, Annual Capital Charge at 18 percent.
2. Assumed at 20 percent of Capital Costs Per Year.
3. 30 percent Engine-Generator Efficiency, Delivered Fuel at $1.20/Gallon.

Figure 3.1 shows the breakeven distance from the grid where a small diesel generator becomes less costly than a grid extension. This figure assumes that each kW of diesel would, on average, require 0.5 kW of additional central generation capacity (probably conservative if loads are primarily household) valued at $1,200 per kW and the marginal grid power is produced half by oil and half by hydro. Grid extension costs are assumed to be $1,900 + $5,500 per mile of line.

As indicated, the cost of the diesel option is lower once the distance from the grid is on the order of 2-3 miles, depending on capacity factor. This suggests the diesel generation should be seriously considered as an integral part of rural electrification planning - particularly as it pertains to the more remote regions of the country.

b. Renewable Energy Systems

There are a number of renewable energy resource systems which are being considered for use in Pakistan, including micro hydro in the NWFP and biogas generators providing fuel for internal combustion engines. However, the renewable energy technology which probably has the greatest potential for widespread use throughout Pakistan is photovoltaics. These systems directly convert solar radiation into electricity with no moving parts. They, therefore, do not require a fuel delivery infrastructure (as do diesel), are highly reliable, and require only minimal maintenance. They would perform very effectively in most areas of Pakistan due to the generally high solar availability in all but northern mountain areas.

The favorable attributes of photovoltaic power units for serving remote loads is widely recognized and has resulted in several dozen demonstration units being installed in developing countries to serve such diverse loads as irrigation pumping, minimal village power, and cold storage. About 15 systems are operating in Pakistan on a demonstration basis including a 5 kW village power unit (installed by the DGER) and a dozen 500 watt pumps installed by the Agricultural Development Bank (ADB).

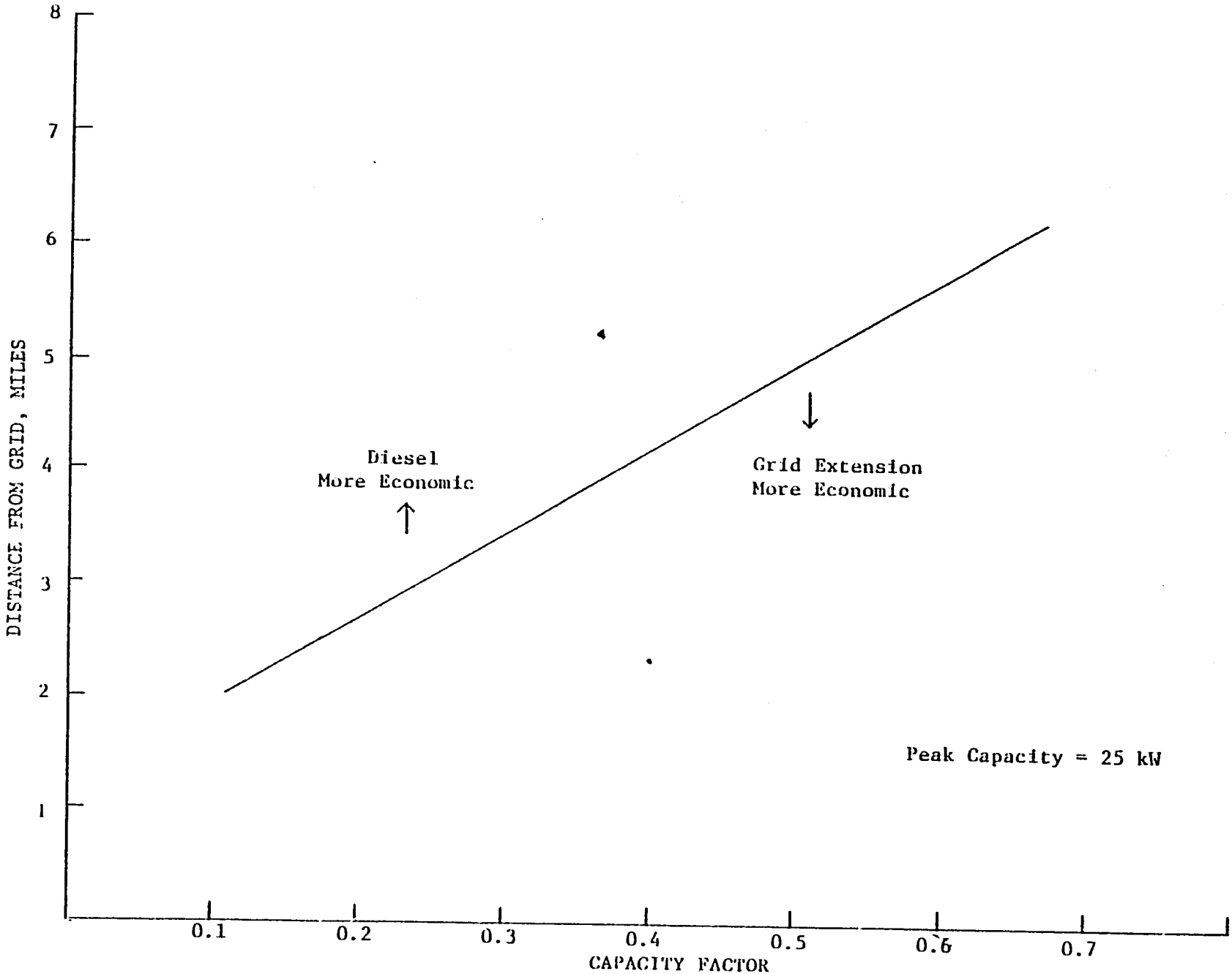


Figure 3.1 BREAK-EVEN DISTANCE: DIESEL GENERATOR VS GRID EXTENSION

The present cost of photovoltaic panels is about $10,000 per peak kW and complete systems (battery storage, wiring, and controls) cost in the $15,000 to $25,000 per peak kW range. At these very high costs, photovoltaic power units are economically justified only for a limited range of small scale unattended power applications to serve communication and safety functions. However, the photovoltaic industry projects large cost reductions so that panels may cost only $2,000-$4,000 per peak kW by the mid 1980's and possibly as low as $1,000 per peak kW by 1990. System costs will similarly decrease to under $5,000 per kW in the same period of time. As costs approach this lower range, photovoltaic power units may provide a lower cost option for serving some rural loads than distribution system extensions.

This is illustrated by Figure 3.2 which shows the distance from the grid at which the capital cost of a grid extension equals the cost of a photovoltaic power unit. It was assumed that each kW of distribution system extension demand required, on the average, 0.5 kW of generation capacity at a cost of $1,200 per kW. If the loads are primarily household, the generation capacity requirements might actually be higher since these loads tend to occur during peak hours. The grid extension cost assumed is $1,900 plus $5,500 per mile of distance to serve a 10 kW load in a rural area with low population. These are consistent with experience in rural regions; such as Baluchistan where photovoltaics are most likely to be considered for early implementation. As indicated, at present costs ($15,000 plus per kW) photovoltaics would not be lower in cost than a grid extension for any distances of practical interest. At photovoltaic power system costs of $5,000 per kW, photovoltaic power units would have a lower cost than low capacity factor (such as households) distribution system extensions once distances exceeded 4-5 mile km and at $2,500 per kW would be lower in cost under most circumstances.

The above implies that in a post mid 1980's time frame, photovoltaic power units may be the lowest capital cost approach for serving many of the rural loads that might be considered for grid extensions. This, combined with the fuel savings derived from not having to operate additional thermal

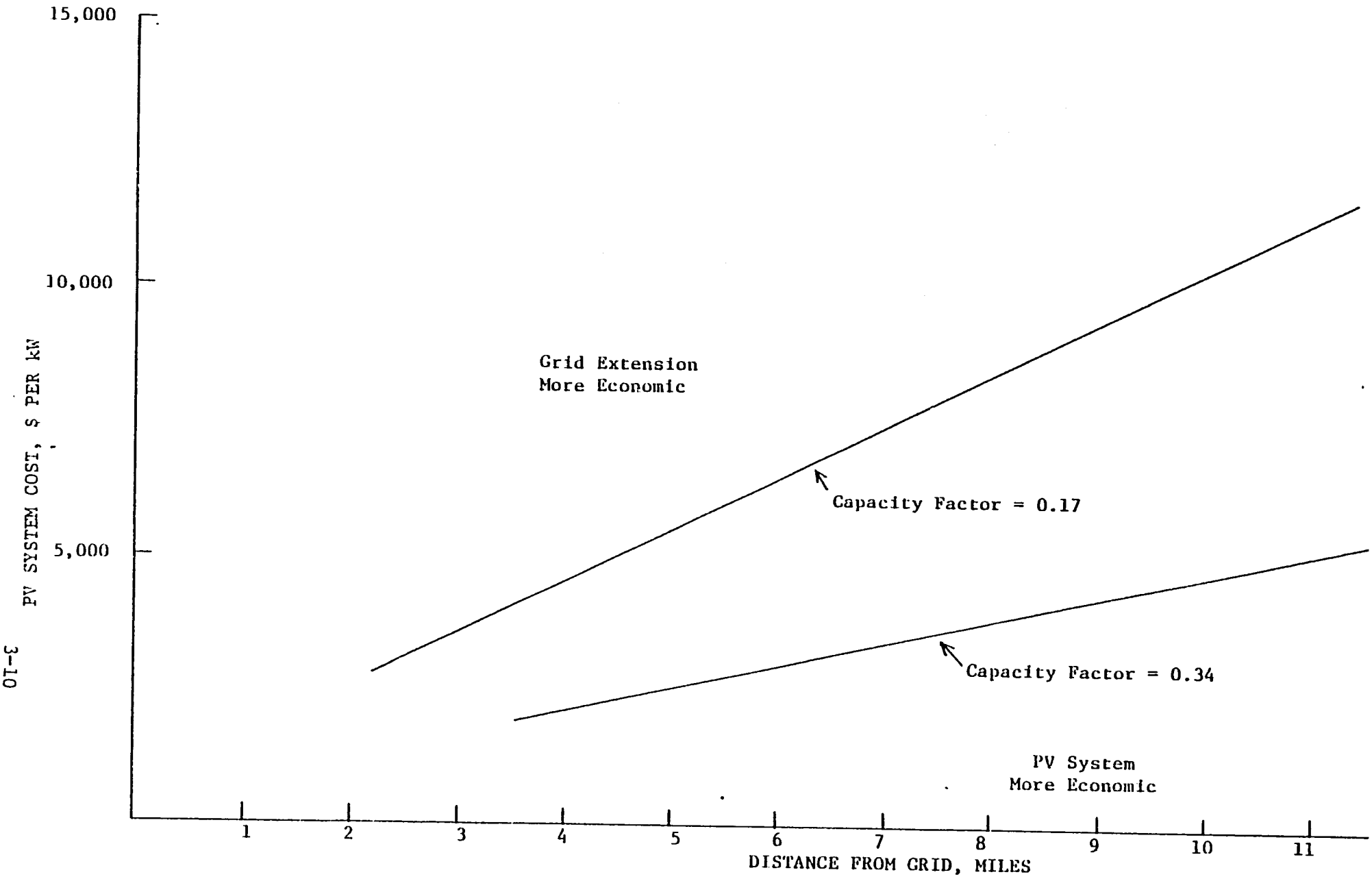


Figure 3.2 BREAK-EVEN DISTANCE FROM GRID, PHOTOVOLTAIC VS GRID EXTENSION

power plants, provide a strong case for considering photovoltaics in longer range rural electrification planning. For example, photovoltaics might become the preferred approach for providing power to a portion of the more than 20,000 small, remote villages which would not be served by the grid expansion resulting from the 6th five year plan.

c. Implementation Issue

The successful introduction of decentralized energy technologies will require establishing an infrastructure which can:

- Provide technical assistance and training to local technicians who will have the responsibility for system operation and maintenance.

- Establish a high level of standardization within each technology class to ensure a high degree of interchangeability in spare parts, allow for large scale purchases and facilitate O&M.

- Develop a capability to rapidly provide spare parts and specialized repair service to individual villages so that costly back-up capabilities (such as spare diesel engines) will not be necessary to provide an acceptable level of service.

- Provide financing for system installation so that decentralized facilities are not finalized relative to central areas (for example, village being grid connected do not have to pay directly for new central generation facilities).

Without such an infrastructure the capital and maintenance costs of decentralized technologies will probably be too high for them to be widely utilized. It may be preferable to establish such a capability in one of more of the organizations responsible for rural development rather than WAPDA so the latter organization can focus on the central grid system which will remain the primary source of electric supply.

3.2 Central System Expansion

3.2.1 Historical Accomplishments of the Present Program

During the period 1957 to 1977, approximately 6,000 villages were electrified in Pakistan. In contrast, during the last five years, over 7,000 villages were electrified. This process has been funded from WAPDA's Annual Development Program; approximately 7 percent of this program has been devoted each year specifically to electrifying villages. As a result of the increased emphasis on rural electrification, about 13,000 villages, over 75,000 tubewells, 36,000 lift pumps for a total of 111,000 agricultural connections have been made. These tubewells are, in fact, the major rural consumer of power and use over 23 percent of all the electric energy generated in Pakistan.

The GOP has been having in depth deliberations on the appropriate rate of rural electrification over the period of the next five year plan (1983-87). There has been widespread discussion concerning electrifying essentially all villages by the end of this planning period; a goal which would require approximately 6,000 village connections per year. However, due to financial constraints, the present plan being debated by the GOP assumes only 3,000 villages per year will be connected over the planning period. By achieving this goal each year for the next five years, approximately 65 percent of the villages, in which over 75 percent of the population live will be served by electricity.

3.2.2 Implementation of the Present Rural Electrification Program

In order to develop practical and implementable GP and IG for rural electrification, it is important to understand the present system for making the decisions involved in rural electrification. Knowing this, it is possible to determine which parties need to be involved in implementing any proposed GP and IG. For example, WAPDA alone can establish technical guidelines to reduce line losses. On the other hand, the cooperation of numerous provincial government authorities would be required to effectively

implement policies pertaining to the village selection process. Hence, the following section provides guidance on who makes what decisions and how.

At present, many organizations within Pakistan contribute to the decision process of bringing electricity to the rural areas. WADPA is, of course, the primary organizations involved. In addition, the National Planning Commission (NPC) of the Ministry of Finance and Planning influences the process as do each of the Provincial Government.

In this section of the report, the goals, policies, and practices of these contributors to the process will be discussed. To summarize their roles:

WAPDA

- Locates transmission lines and grid stations, siting them on the basis of an annual Power Market Survey.
- Develops detailed plan for bringing distribution (11 kV) lines to specific villages.
- Is developing detailed data on all villages, meeting minimum population criteria, for all districts, in support of overall electrification planning.
- Provides to the provincial government's information on villages which are candidates for electrification during the following year.
- Participates in discussions at the national level to influence the goals of the NPC.
- Participates in the process of choosing the specific village to be electrified in each province.
- Maintains the waiting lists for new connections within electrified villages.
- Actually installs appropriate hardware for village electrification and customer connection.
- Owns, operates, and maintains the rural distribution network.

National Planning Commission (NPC)

- Establishes budgetary allocation to WAPDA.
- Apportions budgetary allocation between provinces.
- Establishes goals and priorities for WAPDA in conjunction with WAPDA.
- Coordinates overall national energy planning, in which electricity is one element.

Provincial and Local Governments

- Local governments propose villages for electrification.
- Provincial governments choose in consultation with local government bodies and WAPDA, the villages and areas to electrify.
- Certain provinces provide for other specific programs, such as "valley development" programs in Baluchistan.

a. National Rural Electrification Program Objectives, Policies, and Practices

At the national level, the two main parties to setting rural electrification goals, policies, and practices are WAPDA and the NPC.

The NPC is responsible for developing the sixth five year plan. This plan will provide for budgetary allocations to WAPDA for WAPDA's Annual Development Program which includes allocations for extension of the rural electric grid. The actual allocations are accepted by the GOP cabinet, usually endorsing the view of the Annual Plan Coordination Committee. Hence, the NPC plays an important role in establishing the balance between allocations to generation, transmission, and distribution within WAPDA and in balancing the allocations for the growth of the rural electric grid between provinces. At present, financial allocations to the provinces for rural electrification are in proportion to the population in each province.

The NPC has asked WAPDA to propose a Master Plan for central grid rural electrification (discussed in Section 3.3) that will indicate the priority of extending lines to different areas and villages, will give information on specific designs to extend the lines, and will estimate the budget requirements to do so. Based on a preliminary indication to WAPDA of what their annual budgetary allocation will be, the NPC has also asked WAPDA to estimate how many villages per year can be electrified while maintaining a balance between their generating system and the demand for electricity. The NPC has indicated to WAPDA their desire to increase the rate of rural electrification and will be negotiating with WAPDA to establish a financial allocation and a target for the number of villages to electrify.

The NPC has also requested that WAPDA's planning, focus on electrifying villages that maximize economic return. However, they also recognize political needs for equitable development of the provinces and will, therefore, not be allocating development funds strictly on the basis of economics. However, within the constraint of political equitability, the NPC favors electrifying villages with strong economic potential.

b. Financing of the Rural Electrification Program

Financing of the rural electrification program arises primarily from WAPDA's Annual Development Plan. In the past, the direct costs of the rural electrification program has absorbed approximately 7 percent of WAPDA's annual development funds to do an average of 800 villages per year. Additional financing is given by the GOP for electrifying villages in the federally administered tribal areas (approximately 150 villages per year), by the Punjab provincial government (approximately 600 villages per year), and by villages on a 50 percent cost-sharing (with WAPDA) basis (approximately 30-40 villages per year).

In addition to GOP funds made available to WAPDA's Annual Development Program, funds have been made available and/or negotiations are in progress for loans and grants from the Kuwait Fund for Arab Economic Development, the International Fund for Agricultural Development, the British Overseas

Development Administration, the Canadian International Development Agency, USAID, and the Asian Development Bank. These loans and grants carry various obligations and covenants, but to summarize, they favor development of agriculture - specifically tubewells - and favor the province of Baluchistan. Specific financial characteristics of these programs are not relevant to this report. However, some observations about them are. The specific criteria that each of the proceeding agencies use to determine which villages they will or will not electrify influences which fund is earmarked for which village, but probably does not influence which village will be done or when. In the larger perspective, these criteria cause a shifting of GOP annually budgeted funds from villages that meet funding agency criteria to those that do not. Second, the program under the Asian Development Bank does set forth the specific requirement that any village electrified with its funds must meet an economic internal rate of return (EIRR) target of 10 percent. The information required on each village to support the ADB's calculation of EIRR is presently being gathered by WAPDA's field offices, written on appropriate forms, and sent to Lahore for processing. The information so gathered is similar to the information being gathered by WAPDA's local consultants preparing the Master Plan; in fact, the same format is apparently being used. This suggests that by mid-1983, information on each village adequate to calculate an EIRR, will be available to WAPDA on computer files.

c. Summary of Present Process of Village Selection

WAPDA's Master Plan, to be discussed in the next section. is expected to be completed by mid-1983. Until it is completed, villages chosen for rural electrification are chosen on the basis of population and distance from feeder lines. At present, the WAPDA suggested criteria, target villages with a population of 1,000 in Punjab and Sind and 300-500 in Baluchistan and N.W.F.P., coupled with suggested distance targets of ½ mile in Punjab, and 1 to 2 kilometers in N.W.F.P. and Sind. No specific distance targets exist for Baluchistan. These criteria serve as guidelines, and are used in the majority of instances. However, they are not rigidly adhered to in all cases because, primarily there may be a lack of village meeting criteria in any given district. Also, if they were, some regional development

opportunities or other important economic or social considerations might be overlooked. The interactive decision process which goes on between WAPDA and the provincial governments seems to provide a flexibility in making decisions that would be suppressed if the criteria were held rigid. The combination of criteria and the interactive decision process seem to result in a reasonable choice of villages for electrification. In Punjab, where the majority of villages exist in the country, WAPDA does provide the Provincial Government with a list of villages which meet these criteria. The Provincial Government does not choose exclusively from this list.

3.2.3 Discussion of Present Rural Electrification Program

The present program as just described is, in our judgement, an acceptable process for using the financial allocations for village electrification to promote GOP goals. Within the general constraint of distributing the funds equitably between villages, it promotes the electrification of larger villages that are reasonably close to existing distribution lines. In general, this increases the likelihood that the chosen villages will have favorable economics as, in general, larger villages have more productive uses for electricity in commerce, industry, and agriculture. Also, the fixed allocation to provinces promotes electrification of villages that can be done at less cost, before villages with a higher cost are done. The conclusion that the present program promotes the electrification of villages with favorable economics is supported by the fact that (in Sind) under the Asian Development Bank village electrification program, 75 percent of the villages examined met the 10 percent economic rate of return criteria. It is also supported by the observation of this team.

There are, however, some opportunities to improve the present system of choosing villages. The single most important opportunity arises from the electrical distribution system that results from the present system. The present system tends to be more chaotic and more expensive to implement than need be if it were properly designed from the outset. The emphasis on low cost (to maximize the number of villages under the fixed allocation) promotes running of 11 kV feeders from existing 11 kV feeders to electrify a nearby village rather than running feeders from a grid station.

Eventually, though this may require 20 years, new grid stations may be required and existing lines may need to be reassigned to grid stations. A second opportunity arises from the fact that the federal village electrification budget is allocated primarily on the basis of population. In some provinces, population is the basis on which the allocation is divided even at the district level. Although this appears to meet equity criteria, it ignores differences among districts with respect to degree of electrification and between districts and provinces with respect to development potential and benefits of rural electrification. That is to say, some unpopulated districts or provinces may offer much more development potential than highly populated districts. By allocating budgets on the basis of population alone, the potentials may take much longer to develop if electric power is important to the development.

The first opportunity is being addressed by WAPDA's Master Plan. A discussion of this Master Plan follows, in Section 2.4.

The second opportunity, to the best of the teams knowledge, has not been addressed by any present programs. Therefore, ideas and policies have been suggested in the policy section of this report that can help to bring about expanded benefits from rural electrification in the future.

3.2.4 The Master Plan Being Developed by WAPDA

WAPDA is proceeding with the development of the Rural Electrification Master Plan envisioned by the NPC. Five local consulting firms are developing detailed operational master plan reports for each area electricity board by district of Pakistan. The information being collected will include the location of the existing 11 kV lines and grid stations and the relevant socio-economic characteristics of all significant villages in each district. In addition the consultants are using the data for preparation of maps that will indicate the most appropriate way to expand the 11 kV system to electrify these villages. Their statement of work appears as an appendix to this report and Table 3.2 summarizes the data they are to collect. Note that this summarizes not only their statement of work, but also the specific data forms they are completing.

Table 3.2

SPECIFIC RESPONSIBILITIES OF CONSULTANTS PREPARING RURAL ELECTRIFICATION MASTER PLAN

SCOPE OF ASSIGNMENT

Develop data and information for all villages of more than 1000 population in Punjab and Sind; 300 in N.W.F.P. and Baluchistan.

DATA TO GATHER

1) Location and description of existing 11 kV distribution system and grid stations.

2) Location of sweet ground water areas and underdeveloped areas.

3) Specific socioeconomic data (to be filed on computer)

- population of village and local revenue unit
- adult literacy rate
- number of households, and number of pacca houses
- distance from existing high tension lines and pacca road
- numbers of mosques; other community centers; hospitals; health centers; dispensaries; primary, middle, and high schools; and colleges
- presence of union council, post office, police station, land assessor, WAPDA field assistant, and railway station
- number of veterinarians and veterinary dispensaries
- number of commercial shops, repair shops, hotels, restaurants, and banks.
- number of blanket, carpet, tailoring, mirror work, and "other" producers
- number of looms and saw mills
- number of animal-powered oil-expellers, fodder cutters, cotton gins, flour mills, rice huskers, tobacco grinders, and "other" agro-industrial units

DATA TO GATHER (cont'd)

- saline, or sweet ground water
- presence of open wells, springs, "KAREZ" (tunnel wells), and hand pumps
- numbers of electric and diesel tubewells, number of animal-powered-wheel-pumps
- use of rain-fed irrigation, perennial canals, non-perennial canals, flood irrigation, and reservoirs
- depth-to-water table

INFORMATION TO PREPARE

1) Forecasts for the years 1983-1993, 2003, and 2013.

- load by village of KW and kwh
- revenue for WAPDA by village
- population and household by village
- load by grid station, secondary transmission lines, and generating stations

2) Cost estimates and material schedules for electrifying each village.

3) Financial, economic, socioeconomic, and environmental analysis for each district.

PLANS TO PREPARE

1) Maps of existing system.

2) Proposed network of distribution system considering extension, segmentation, re-routing, and/or bifurcating existing lines, and considering SCARP (Salinity Control and Reclamation Projects (electrification plans.

As mentioned, the single most important opportunity for improving rural electrification distribution is to do a better job of designing, in advance the layout for distribution systems. WAPDA has identified this opportunity and is addressing it via the master planning effort. When complete, the consultants preparing the Master Plan will have designed the most appropriate layout for 11 kV lines. Also, cost estimates for doing each village according to pre-established plans, and not an ad-hoc plan, will have been prepared. Presuming that the federal government will continue to make provincial allocations, and that the provincial governments will then decide on the actual villages, it is anticipated that these plans will provide provincial and local leaders additional information on which to base their choice of villages and not merely constrain the local and provincial choice.

The benefits of the master planning effort are illustrated by Figure 3.3. In any given year the unplanned expansion may lead to choosing the least expensive approach to electrifying villages. However, it results in a meandering grid system which is inadequately equipped for future expansion, is more prone to interruptions, is less controllable from the grid stations, and most importantly, may lead to excessive voltage drop and line losses in serving the village at the end of the line (Village #3). In contrast, the planned expansion produces a system where faults will effect fewer villages, individual feeders are controllable from the grid stations, and shorter lines will lead to less voltage drop, even in remote villages.

When the Master Plan is in operation, it will eventually lead to reduced costs for system expansion. At first, the cost per village may increase as the cost of running a feeder line, such as that shown on Figure 3.3 as running from the grid station to Village #2 may exceed the cost of running it from Village #1. However, serving the villages that surround Village #2 will now be possible. Under the present system, the line losses and voltage drop in serving Village #3 might become excessive if villages surrounding Village #1 or #2 were electrified. Any expansion might have required radically revising the feeder line system from the grid station, and would have been very expensive. In addition to cost savings associated with expansion, transmission losses and maintenance problems under the

planned system should be reduced. Hence, in the long run, the new system will save money.

The Master Plan will also provide additional technical information to the provincial governments as they choose which villages to electrify. Again Figure 3.3, even though lines could be run from Village #2 to Village #3 under the present system at less cost, once the plan is prepared, the provincial governments will not be able to electrify Village #3 without providing from their allocation sufficient funds to pay for the technically preferable approach. In other words, the order in which provincial governments select villages for electrification will no longer affect the final design of the system, where at present, it does.

3.2.5 Provincial Policies on Village Selection

Each province applies a somewhat different process to choosing villages. A description of these processes follows. Understanding them is important, as the provincial governments play an important role in the specific decision concerning when a village is to be electrified.

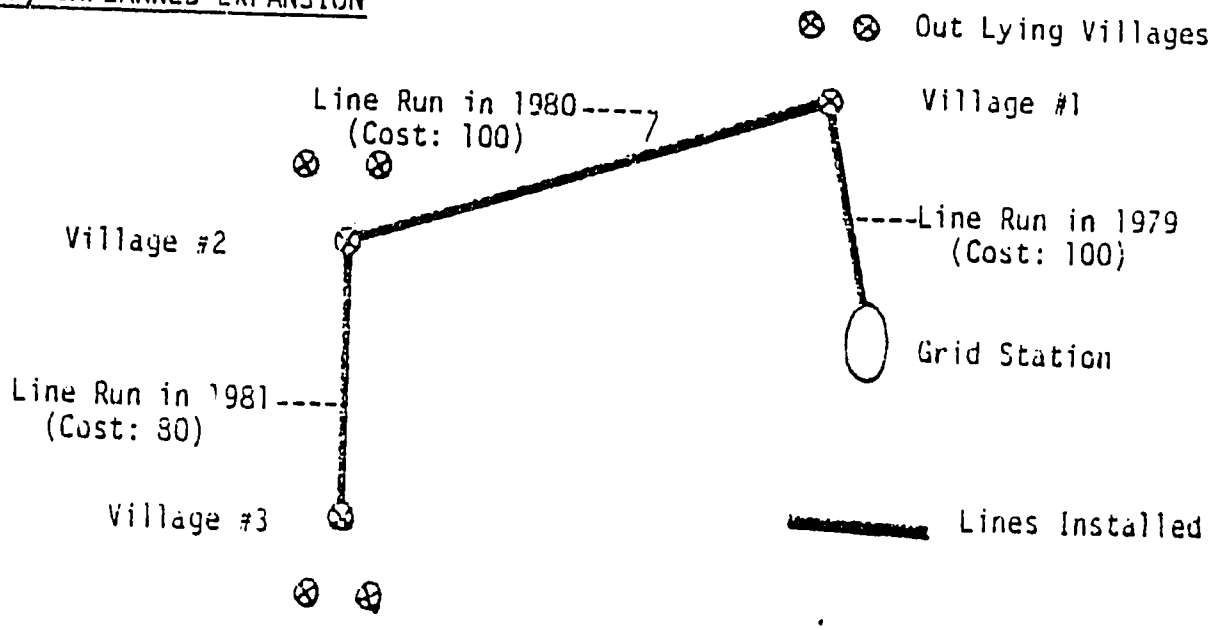
a. Punjab Objectives, Policies, and Practices

The primary objective influencing the choice of villages to electrify in Punjab is equity. In practice, this means that Punjab officials attempt to ensure that each tehsil (a sub-unit of a district; usually 3-6 tehsils per district) in the province has approximately the same percentage of villages electrified. The program for running new feeder lines, however, considers other objectives, primarily the electrification of tubewells and development of industry.

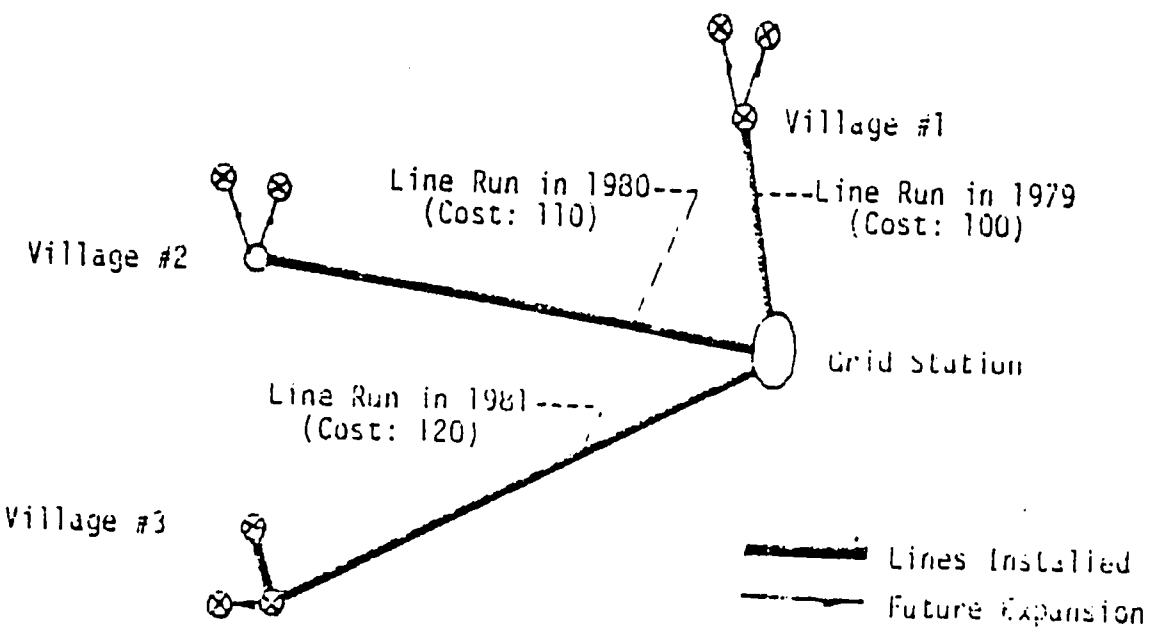
Annually, villages to be electrified are generally chosen in the following way. The Irrigation and Power Division within the Planning and Development Department of the Punjab provincial government calculates the percent of villages in each tehsil which have electricity. Tehsils which lag the provincial average are targeted for accelerated electrification. Based on the provincial and federal budgetary allocation for village

FIGURE 3.3: EFFECT OF MASTER PLAN ON GRID EXPANSION PROCESS

PRESENT, UNPLANNED EXPANSION



PLANNED EXPANSION



electrification, the appropriate total number of villages to be electrified is determined. These are allocated to specific tehsils, according to a formula that promotes an equal percentage in each tehsil in the province. These quotas are communicated to the District Councils. The District Councils prepare lists of the villages selected for electrification, usually including a 25 to 30 percent surplus over quota. This provides WAPDA and the Irrigation and Power Department of the provincial government a range to choose from when making the final selection. Following the above selection procedure, WAPDA prepares accurate estimates of distance each village is from feeder lines and estimates the cost of bringing power to the village. WAPDA and the Irrigation and Power Department then consult on final village selection, keeping within budget constraints.

The District Councils consider both population and distance in choosing villages within tehsils. First, they consider the distance from existing feeder lines. If more villages exist within one-half kilometer of existing lines than are acceptable under the tehsil's quota, the quota is filled from the villages with the greater population. If too few villages are within one-half kilometer, the distance criteria is relaxed and villages further away are considered.

Even this apparently straightforward system does leave room for disagreement. Village population is based on the 1972 census, sparking disagreement, and the distance to the lines is also often debated.

At the present, the government of Punjab extends the federal budget allocation, roughly doubling it; the amount involved has grown from Rs.30 million in 1980-1981 to Rs.227 million in 1982-1983. In fact, the Punjab government would like to increase its budgetary allocations, while continuing to match the WAPDA village electrification budget. Also, the Punjab government will finance up to two-thirds the cost of electrifying any village which will contribute one-third of the cost; last year, 27 villages contributed.

Agricultural and industrial development are also important goals in Punjab, as everywhere, and have some influence over the location of feeder lines and villages to electrify. Out of the Rs.227 million provided by Punjab,

the Department of Agriculture controls Rs.40 million. They allocate the total amount to tubewell electrification and attempt to focus on new tubewells in preference to converting diesel tubewells; a philosophy the Punjab Agriculture Department believes is appropriate in all rural electrification planning. Also, in the Punjab, as in other provinces, there exists a Provincial Utilities Board, chaired by the Chief Secretary of the Province. This Board attempts to ensure that utilities are available to industry. Also represented on the Board is local industry, the Provincial Department of Industry, the Small Industries Corporation, WAPDA, and other utilities. The Board does not have actual authority but it does have effective influence. For example, through this Board, requests to WAPDA for feeder lines to "industrial estates" are presented.

b. Sind Objectives, Policies and Practices

The approach to choosing villages for electrification in Sind revolves around what is known as the "District Village Electrification Advisory Committee." It is this bodies' function to develop a prioritized list of villages recommended for electrification, for each district, considering population, distance to the feeder line, tubewells, and potential industrial development. This list is submitted through the Division Coordinating Committee to the Provincial Irrigation and Power Department. Irrigation and Power allocates villages to districts based on the population in each district. Also, they consider the present level of electrification already achieved in the district in order to maintain parity between districts. They also ensure that the total cost of the program remains less than their budget allocation. The chosen villages are approved by the governor and submitted to WAPDA for execution. Sind has no programs, such as Punjab has, for augmenting the federal budgetary allocation.

One issue of particular importance of Sind is the definition of a village. The Planning and Development Department has established records for 68,324 villages in Sind and have computerized them. Therefore, there is some feeling that the present program of village electrification, which is electrifying 324 villages this year, will require a very long time to

complete the electrification of Sind. However, there are only 5,774 "dehs" in Sind. Dehs are the basic revenue unit in Sind and may contain many settlements and/or villages. Once a deh has been electrified, any resident of the deh can apply for a connection. Therefore, it is most reasonable to consider that, effectively, a village is a deh and it seems to be what WAPDA and the federal government seem to be considering dehs as villages.

However, this issue does promote some question about the degree to which villages in Sind are electrified, and the appropriateness of the 1000 population criteria being used by WAPDA in its master planning effort. The Statistical data on Sind indicates that only 4 ½ percent of the population lives in settlements with a population of more than 1,000. However, 90 percent of the dehs have a population in excess of 1,000. The Irrigation and Power Department of the Sind provincial government believes that approximately 2,800 villages have been electrified out of 68,434 settlements, that most settlements with a population above 1,000 have been electrified and that there are 5,774 dehs. WAPDA also believes that approximately 2,800 villages have been electrified but believes that there are only 6,091 villages. Therefore, in Sind, the provincial government does not consider that the stated population target of 1,000 should have any impact on their selection procedure. On the other hand, since 90 percent of the dehs have populations above 1,000, most of the dehs electrified do meet the population criteria.

c. Baluchistan Objectives, Policies, and Practices

Baluchistan is characterized by small villages separated by great distances. At present, there are approximately 5600 villages in Baluchistan of which 3500 have a population of more than 300. Of these, approximately 365 have been electrified. During the upcoming year, approximately 100 villages more will be electrified from federal funds allocated for village electrification, and 300 more will be electrified from the Kuwait Project funds. Many of these villages are subject to seasonal migration as people leave the cold mountains in winter for the warmer plains. The vast regions make comprehensive village electrification uneconomical in the short run and promote a strong desire to use

electrification as a tool to promote selected development, and reduce seasonal migration. An important objective: therefore, in Baluchistan is valley electrification rather than village electrification. With this objective, the focus is on providing electricity to regions with proven non-saline groundwater resources where agriculture has only limited productivity without tubewells. WAPDA and the Planning and Development Department of Baluchistan share this objective and have the close ties required to promote it. In addition, an objective is to focus development of electrification in regions with mineral resources; Baluchistan has only partially developed its reserves of chromite, fluorite, barite, magnesite, iron, marble, gypsum and coal--all of which can benefit strongly from the availability of electricity. In addition, antimony and copper are present but do not benefit as much from electricity.

However, equity objectives do require that existing villages not be totally overlooked when electrifying villages. This process occurs as follows. The Planning and Development Department is notified by WAPDA of the budgetary allocation available from the federal government for electrifying villages. The approximate number of villages this implies is allocated on the basis of population to Baluchistan's four divisions. The Division Coordinating Council allocates the divisions allocations to each district. This allocation is not necessarily based on population; also, only districts with grid stations already installed receive an allocation of villages for their selection.

The Baluchistan, though, the local District Councils accept advice from the Planning and Development Department on which villages to electrify. The Planning and Development Department recommends specific villages in consultation with WAPDA to the Districts. They select these to further their goals of promoting the development of specific valleys which offer good promise of agricultural or other economic benefits. The Ministry of Local Government and Rural Development has corroborated the unusual cooperation of these District Councils in accepting these suggestions. This has the desirable side benefit that it promotes migration to electrified areas and encourages small villages to atrophy. This in turn makes the provision of social and health services more convenient. The

combination of the cultural phenomena of acceptance of annual migration and of individualism has caused a relatively rapid development of population in the selected regions. These close ties between WAPDA and the Provincial Government, and the influence they bring to bear on the District Councils is not as apparent in the other provinces but appears to be extremely successful in Baluchistan.

As another approach to village electrification, Baluchistan electrified approximately 45 villages with non-grid connected diesel generators of from 200 to 500 KW. Ten more will be installed this year. These have been installed and are maintained primarily by WAPDA but there are a few installed by local councils. The average generator cost is Rs.500,000, they cost RS 3 per kwh to run, and operate an average of 14 hours per day. The Provincial Government subsidizes Rs 2 per kwh.

Baluchistan is presently the only province where WAPDA operates decentralized power units (35 diesel generators). This indicates the potential role for decentralized technologies in Baluchistan and the need to factor in decentralized options in developing overall Rural Electrification plans.

d. N.W.F.P. Objectives, Policies, and Practices

In N.W.F.P., approximately 40 percent of the villages are electrified--3147 of a total of 8422. The main objective of their village electrification program is to promote equitable distribution of electrification, while maximizing the population which has access to electricity, within the constraint of their budget allocation.

Annually, the District Councils submit the names of all the villages they wish to have electrified. These villages should have a population of more than 500 and fall within 2 km of an existing grid. Some districts have no grid station and hence, receive no allocation. This list is considered by WAPDA and villages with opportunities for tubewells and small industry are favored for electrification. Also, WAPDA calculates the population to distance ratio for each village and, in general, favors those with the highest ratio. WAPDA passes on a list of villages, selected from those

submitted by the District Councils based on the above considerations, to the Water and Power Division of the Planning and Development Department. Water and Power makes a final selection of the villages, ensuring that the total expense is less than the allocation and that villages are allocated to districts in proportion to the district's population. Within the district, they select villages primarily on the population to distance ratio. However, they also consider the degree of electrification of each district and may adjust the allocation slightly. Also, based on the Governor's directive, one or two villages must be done in any district which has a population of 5000 or more, regardless of population of the village or distance from the grid.

As another approach to village electrification, N.W.F.P. also has remote, non-grid connected, hydro generators that provide electricity to villages and small areas. Three groups operate the bulk of these systems--the Kohistan Development Board, the N.W.F.P., Irrigation and Public Health Engineering Department and the Appropriate Technology Development Organization. They operate, respectively, eleven 50 to 100 kw units, twenty-four 50 to 100 kw units, and forty 5 to 20 kw units. There are also a few privately owned units. Based on information obtained during interviews, it was learned that the bulk of these units are apparently being successfully operated.

4.0 IMPACT OF PRESENT AND PROJECTED RURAL ELECTRIFICATION PROGRAM

4.1 Introduction

The ambitious program of rural electrification planned by the GOP has significant implications for the electric power sector in its effect on the already strained power generation capacity of the system and for the increased consumption of oil and gas in thermal power plants. This section reviews the supply and demand projections and provides a preliminary quantification of how the Rural Electrification Program contributes to electricity demand, the need for expanding generation and transmission capability, and the level of planned investments in generation, transmission and distribution. Future sections will identify measures and policies which could reduce the financial impacts of the Rural Electrification Program while still maintaining most of the economic and social benefits.

4.2 Electrical Supply and Demand

The total rated installed capacity of the WAPDA and KESC systems including the Kanupp nuclear plant is 4,7978 MW. Of this total, 2,547 MW is hydroelectric and 2,250 is thermal. Capacity of the hydro plants, due to variation is in reservoir levels and discharges for irrigation, ranges from a maximum of 2,830 MW to a minimum of coincident capability of 1,390 MW. Derating of thermal units due to age reduces effective capability of these plants to 1,802 MW. The minimum effective capability of this system is thus 3,192 MW.

This capacity, however, makes no allowance for spinning reserves or equipment outages. As indicated later, when these are accounted for the effective capacity during the dry season is only about 2500 MW which is below present demand levels. As a result, the system experiences frequent capacity shortfalls leading to load shedding in both rural and urban areas. This load shedding is a great source of concern to the government and has raised questions in many circles as to the desirability of rapidly expanding the rural distribution system which will result in higher demand and thereby increase capacity shortfalls.

Additional generating capacity proposed through 1990-91 is 9,367 MW. Hydro additions total 2,774 MW and thermal 6,587. The thermal total includes an increase in capability of the Kanupp nuclear plant of 137 MW and the Chashma nuclear plant of 900 MW. Oil fired capacity scheduled to be placed in service is 3456 MW. If this program can be implemented and the in-service schedule maintained, total installed capacity will be 14,158 MW with minimum capability of 11,287 MW at the end of 1990-91. Installed capacity at that point would be 38 percent hydro and 62 percent thermal. Capability in the most critical month, May, would be 10,588 MW against peak demand of 8846 MW. Schedules for placing new plants in service are tight and some slippage is quite probable. Also the availability of funds for the program has not been established. Estimated cost in 1982 prices is over Rs. 120 billion ($9.5 billion).

Electrical energy demand has been increasing at a rate of about 11.3 percent per year for the past 5 years. Total generated electricity was about 18 million GWh in 1981-82. The WAPDA system alone shows generation growth rates of 12.6 percent over the next 15 years. (See Figure 4.1.)

Peak demand on the WAPDA system was 2,846 MW in 1981-82. Projected peak demand in 1990-91, including KESC which will be integrated with WAPDA on completion of the 500 kV transmission line to Karachi in 1985, is 9,139 MW. Energy generated is forecast to reach 49 million GWh during that period. Energy and peak demand forecasts include village electrification at the rate of 3,000 villages per year and tubewell pump additions at the rate of 5000 per year. By 1990-91, therefore, WAPDA projects that peak demand will be consistent with generating capacity and that the present shortfall in capacity leading to load shedding during the winter months will no longer be necessary.

However, the present imbalance requiring load shedding and other measures to keep peak demand within system capability is expected to continue through the decade. From 1982-83 through 1987-88, the WAPDA projections shows a deficit in capability in several months each year. In 1984-85 a deficit is projected for 10 months of the year reaching a maximum shortfall of almost 800 MW one month. These shortages are in terms of total installed capability. In terms of firm generating capability after allowance for maintenance and spinning reserves,

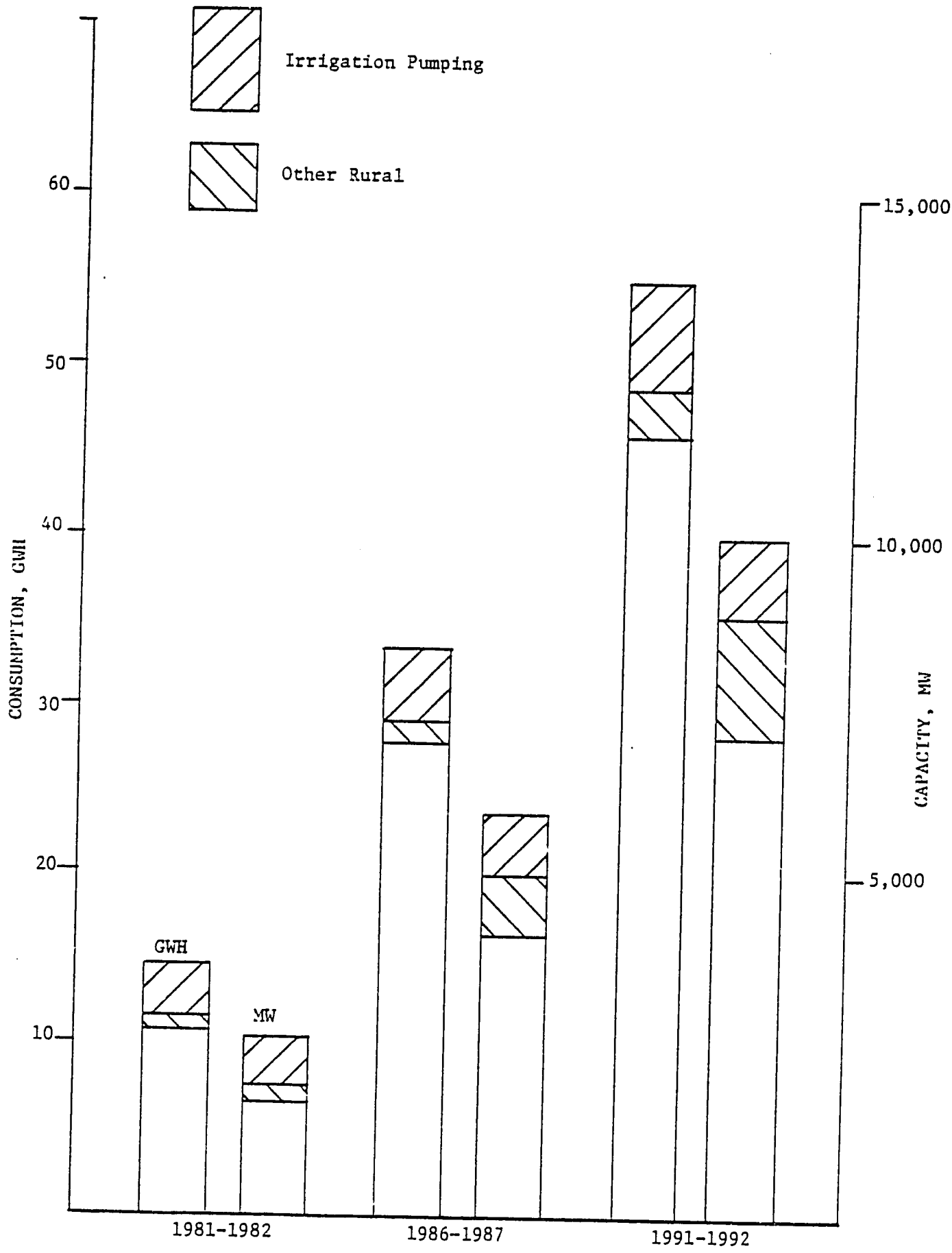


Figure 4.1 EFFECT OF RURAL LOADS ON ELECTRICITY CONSUMPTION AND CAPACITY

deficits appear through 1990-91. The projections are based on annual growth in peak demand of 12.3 percent through 1985-86 and 11.3 percent from then through 1990-91. Since some slippage in the schedule for additional generation seems probable and there may be limitation on funds to carry out the program as scheduled, the shortfall in capacity could be considerably higher than present forecasts.

Table 4.1 which summarizes estimates for electric sector peak demands, the effective capacity in the system to meet these demands, and the impact of the rural loads. The projected load resulting from implementing the Rural Electrification Program (including the tubewell pumps) are estimated to contribute about 1600 MW to the WAPDA system peak demands by 1987-88. This demand contributes significantly to the shortfalls projected at that time.

It should be noted, however, that rapidly increasing urban household loads and industrial loads are equally responsible for the increasing peak demand and the Rural Electrification Program should not be singled out as responsible for the shortfall problem.

4.3 Impact of Expansion Program

Agricultural connections for irrigation pumping are presently the predominant electrical loads in rural areas. About 23 percent total electric energy delivered to consumers in the WAPDA system in 1981-82 was for irrigation pumping. No statistics differentiating urban and rural are maintained for other economic groups but estimates derived from WAPDA plans indicate rural consumption exclusive of irrigation pumping is about 8 percent of total usage in the WAPDA system. The rural demands including irrigation pumping is estimated to contribute about 900 MW to the generation demand. A program to electrify 3000 villages per year over the next 10 years will create additional demands for generating capacity estimated at about 800 MW in the next 5 years and 1800 MW at the end of 10 years as shown in Table 4.2 and attached bar chart.

Table 4.1

Contribution of R.E.Program to Demand and Shortfall

		1982 MW	1987 MW
Effective Capacity*		2490	**5450
(A) With Rural Electrification			
Peak Demand		2505	5763
Deficit/Surplus - no reserve capacity	-	15	- 313
Deficit/Surplus with reserves	-	272	- 727
(B) Without Rural Electrification***			
Peak Demand		1755	4173
Deficit/Surplus-no reserves	+	690	+ 1050
Deficit/Surplus-with reserves	+	433	+ 650

* Source AID Project Paper, p.58 furnished by WAPDA for 1982. Total capability and demand for month of May when greatest deficits occur. Peak demand severly depressed due to load shedding.

** WAPDA Generation Program for 1988 & 1991.

***Demand for rural electrification loads assumes rural peak demands occur in May.

Table 4.2

Energy and Peak Demand on WAPDA System with 3000 Village/Year Expansion

	1981-82		1986-87		1991-92	
	GWh	MW	GWh	MW	GWh	MW
Total Generation	14,768	2846	32,340	5954	55,116	10,148
Irrigation Pumping	3,150	550	3,957	750	5,343	1,100
Other Rural	430	325	1,100	842	2,250	1,585

Notes: Energy and Peak Demand estimates for 3000 village/year expansion for 10 years based on WAPDA projections used by ADB for 2000 villages/year program.

(1) 1981-82 figures are actual from WAPDA Power System statistics for total generation and demand. Other years from WAPDA projections.

(2) 1981-82 energy for pumping from WAPDA Power System statistics, Agriculture Connections, at 20,000 kwh/year. Other years add increment for 3000 villages/year expansion. Irrigation pumping assumes 50% of pumps on at peak.

(3) 1981-82 energy for other rural estimated from WAPDA Action Plan for Rural Electrification, p. 195. Demand estimated from projections used by ADB for 2000 village/year expansion.

The estimates assume that only 50 percent of the irrigation pumps are on line during hours of peak demand on the system. The numbers are significantly higher than some used by WAPDA due to inclusion of irrigation pumping loads in the above estimates.

The most noticeable effect in the longer term is the increasing demand imposed by non-irrigation pumping loads. Irrigation pumping demands may double in the next 10 years whereas other requirements may be almost 4 times present demand considering saturation levels anticipated. Under this scenario, irrigation pumping will no longer be the dominant rural load. At the end of 10 years, energy requirements other than for pumping are estimated to be more than 30 percent of total rural electric energy consumption. Since much of the village load is lighting and therefore on peak, the effect on generating capacity is even greater.

Plans for the 3000 village per year expansion relate only to villages presently on or scheduled to be within range of connection to the WAPDA distribution system. Some remote areas in the NWFP and Baluchistan are not included in the 3000 village electrification program. Efforts to provide electricity to these areas in the past have included some isolated diesel generating plants in Baluchistan and some small hydel stations in NWFP. The projected village electrification program planned for WAPDA does not include consideration of decentralized systems.

The Rural Electrification Program in relation to WAPDA's total proposed investment program is shown in Table 4.3.

Direct cost of the 11 kV and low voltage lines and connections for a 3000 village per year program is estimated by WAPDA to be Rs. 1,200 million ($95 million) per year, a total of Rs. 12,000 million ($950 million) over 10 years. The added generating capacity of 1800 MW attributed to the program will cost approximately Rs. 24,000 million ($1.9 billion) 1982 prices over the next 10 years based on an average of WAPDA's estimated costs for new generation during that period. A portion of the costs for expansion and reinforcement of transmission lines and grid stations, assigned on the basis of energy

Table 4.3

ESTIMATED TOTAL COST OF 10 YEAR RURAL ELECTRIFICATION EXPANSION

	Rs. Million
Distribution system for 3000 villages per year	12,000
Generating capacity addition for R.E.	24,000
Transmission and grid station addition	6,000
TOTAL	42,000
Total WAPDA Investments* 6th and 7th Plan	271,000
Portion of Total WAPDA 10 Year Investment Program for Rural Electrification	15%

* Excluding nuclear plants.

transmitted adds Rs. 6,000 million. The overall cost of the Rural Electrification Program over the next 10 years is about Rs. 42,000 million ($3.7 billion) which is about 15 percent of the WAPDA budget.

4.4 System Efficiency

Losses in the system and consumption by power plant auxiliaries exceeded 30 percent of energy generated in 1982. Power plant auxiliaries accounted for 2.6 percent and the remainder was in the transmission and distribution system. Over 60 percent of the losses are in the distribution system. Efforts in the past 3 years have reduced losses about 1 percent per year. Reducing losses by replacing overloaded lines and transformers, adding capacitors and improving some design and construction practices is a good investment saving energy and deferring capital investment for generating capacity. A program to reduce the losses can effectively increase system generating capability at significantly less cost than for new generating plants. If it is assumed that distribution system losses are proportioned to energy consumed, the existing rural distribution system would contribute about 30 percent of the total distribution losses.

A loss reduction program in the distribution system appears to have been given little attention by WAPDA in the past. Capacitors to improve power factors are in use in many places and other changes in design and construction practices to improve efficiency of the system seem to be getting attention. Losses charted by distribution circles visited ranged from 12 percent to about 40 percent. These were not segregated between technical and administrative losses, so the extent the technical losses in high loss areas is not known.

There are two benefits from reducing the technical losses in the system:

- Less fuel is consumed at the power plant to be later dissipated as I^2R losses in the system. This factor is becoming increasingly important as the use of oil in thermal generation increases.

- Less high capital cost generating equipment is required to overcome these losses.

Cost analysis for specific improvements calculated by USAID as part of its rural electrification support program show that the investment for improvements is recovered within one year if energy saved is 20 kWh per dollar spent (which might be typical of that associated with such measures as replacing undersized transformers). The equivalent oil saved in thermal generation resulting from a 5 percent reduction in system wide loses would be about 100 thousand barrels/year at present demand levels with roughly 30 percent of this attributable to the rural sector.

Also, it is estimated that a 5 percent reduction in losses would be equivalent to increasing system capacity by roughly 125 MW having a value of Rs. 1562 million ($125 million) assuming new generating capacity at Rs. 12,500/kW ($1,000/kW).

The financial impacts of line losses are seen to be considerable and preliminary analysis indicates very favorable cost/benefit ratios for programs geared to their reduction.

It should be emphasized that the Rural Electrification Program as now being implemented appears to be following reasonably good utility practice and should not be contributing disproportionately to increasing line losses. This will become ever more the case when line extensions are done in accordance with the Master Plan now under preparation which will insure that lines are sized for future as well as present loads. The major thrust of line loss reduction program in rural areas would, therefore, be directed toward upgrading existing lines, many of which are undersized and use poor connection practices.

4.5 Management and Operations

The major question on the ability of WAPDA to sustain a program of electrifying 3000 villages is probably whether sufficient funds will be available. If funds are available for both the extension of the distribution system and the

5.0 BENEFITS OF THE RURAL ELECTRIFICATION PROGRAM

Considerable costs are associated with implementing the rural electrification program; however, these costs are counteracted by many benefits resulting from the program including:

- Increased small scale rural industry
- Increased agricultural productivity
- Reduced consumption of kerosene and diesel fuel in rural areas
- Social and political programs

Increased agricultural productivity is most important. Over 6 percent (2.8 million acres) of the cultivated land in Pakistan is now either totally or partially irrigated with electrically driven tubewells and a somewhat larger amount by diesel driven tubewell pumps (many of which may be converted to electricity over the coming years). Tubewell irrigation is one of the reasons Pakistan is now self-sufficient in food and is increasing agricultural exports. The incremental value of crops grown as a result of electrified tubewells is estimated at between Rs.2.45 billion ($191 million) to Rs.6.0 billion ($468 million). This alone is felt to be sufficient justification for providing electricity to Pakistan's rural areas. However, in addition, the reduction in petroleum imports as a result of substituting electricity for kerosene and diesel fuel are projected to remain positive even in the face of increased thermal power generation from oil. When combined with the other, albeit less quantifiable benefits, the value of the rural electrification program in Pakistan is considerable.

5.1 Industrial/Commercial Benefit

Electrifying a village does not, of itself, cause immediate industrial development. Many other infrastructural, and market factors are required for development of industry. However, electricity may increase effective disposable income in a village by freeing time, reducing the cost of lighting and motive power, and providing additional hours in the evening for productive work. Also, electricity often triggers the demand for electric goods. These effects create

the opportunity for additional cash flow in the economy which eventually fuels cottage and small-scale industrial expansion.

Electrification of villages not only electrifies villages, but brings electricity to the rural areas. This makes possible the development of small-scale industrial activity throughout the region and not only at the village level.

The largest share of rural cottage industry develops around agriculture. Local people own and operate oil expellers, flour mills, saw mills, rice huskers, cotton gins, fodder cutters, and tobacco grinders. Other industrial/commercial applications for electricity include small cafes and local shops, blacksmithing operations, sawmills, woodworking, small-scale embroidery, carpet weaving and tailoring shops. Interviews with government ministry officials and WAPDA officials indicated that if roads and electricity were present, small scale industrial and commercial activity of this sort would appear spontaneously within one to two years. However, field work findings suggest that the most likely development path is the conversion of existing diesel-operated equipment to electric equipment. If this equipment is not already present in a village when it is electrified, the village probably serves primarily as a residential center and nearby commercial villages will provide for the above services. Although less likely, development of the above operations directly in an electrified village does and will occur, particularly if the commercial center which presently provides services is some distance away.

Electricity is very useful to these cottage industries. Electricity is used in the above operations principally to provide lighting and to power a motor. In addition, blacksmiths indicated their intent to use it for welding equipment.* Based on a variety of previous studies, the cottage industry and small

* One use for electricity <u>not</u> mentioned is electrifying sugarcane crushers. The economics of doing so are extremely favorable; however, a Rs.10,000 tax is levied for this conversion, in support of state owned sugar mills, making the conversion unattractive.

commercial users of electricity in Pakistan receive an excess of value from the electricity they purchase of between 100 and 200 percent of the cost of the electricity.[1] Table 5.1 presents an example of the financial benefits to a diesel operated unit of converting to electricity. For this operation, electricity will reportedly double profit. Also, for some small-scale industries, (for example, brick making), electricity makes possible two and three shift operations. All of these benefits from rural electrification flow back as wages to the local villages, from which the industries recruit their workers.

The supporting infrastructure strongly influences the development of any of the above cottage industries. Electricity and roads are equally important to development. Capital is the next most important requirement. Education and training and finally the presence of an appropriate entrepreneur are other important elements.

It was found during village inspections that an infrastructure adequate to support the development of cottage industries is present in most villages which will be candidates for electrification in the next few years. Roads for cottage industries are acceptable and capital is generally adequate or obtainable. However, if small-scale industries are to develop, hard top roads may be necessary.

Capital comes from two personal sources - past profits and resale of the diesel. For cottage and some small-scale industries, capital is also available from Pakistan workers in the mideast. Returning workers often desire to settle in their village and; therefore, often send money to be invested for them in a family business by their male relatives. Contrary to some reported expectations, the majority of the mideast workers invest their wages productively. They may invest in land or transport equipment, but they also invest in all of the previously mentioned cottage industries. One of the

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[1] FIKRI and Associates, Rural Electrification District Master Plan: Pishin, p.19.

TABLE 5.1

PROFITS FROM RURAL DIESEL OPERATED SAWMILL AFTER ELECTRIFICATION

Present Profits

Rs.50 per day: 1,500 Rs./month

Expenses - Diesel

Maintenance:
Rs.550 per month[1]

Fuel:
Rs.100 per day[1]

Expenses - Electricity

Maintenance:
Assume 50% of diesel; Rs.275 per month

Fuel:

Consumption

$$\frac{(100\ \text{Rs./Day})\ (18{,}408\ \text{Btu/Liter})\ (.3\ \text{Diesel Efficiency})}{(2.85\ \text{Rs./Liter})\ (3413\ \text{Btu/kWh})} = 56.7\ \text{kWh/day}^{2}$$

Kwh Charge

(56.7 kWh/day) (.63 Rs./kWh) = 35.76 Rs./day

KW Charge

(22 Rs./kW) (20 HP) (1/1341 kW/HP) = 328 Rs./Mo.

Increased Profits, Before Taxes and Capital Charges

(Rs.550-Rs.225) + (30 days) (100 Rs./day-35.76 Rs./day) - (328 Rs/Mo.) = 1824.2 Rs./Month

Total Profits

Present Profits:1500 Rs./Mo. + Increased Profits:1824.2 Rs/Mo. = Total Profits: 3324.2 Rs./Mo.

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[1] Information from local interviews.

[2] Equivalent consumption of electric motor replacing diesel motor.

benefits of rural electrification is, in fact, to make this type of investment possible and to thereby encourage the application of mideast wages to productive applications. It is true that mideast workers often buy luxury goods - radios, TVs, refrigerators - but often these are an additional source of gain from resale.

Capital may also be procured from banks. For the cottage-scale industry the Agricultural Development Bank of Pakistan has a program of "bankers on motorcycles." Their agents are given responsibility for covering a specific region and meeting regularly with clients and potential clients. They can make loans for agro-based industries, but are not commonly asked to do so by villagers. Most financing of these cottage industries still develops from personal resources, and not from loans.

The next element in the required infrastructure, education and training, probably is in short supply. However, each province operates training centers for the more common handicrafts - embroidery, carpet weaving, woodworking - and these are reasonably effective. The Agricultural Development Bank, under its previously mentioned "bankers on motorcycles" program also provides some advice to local farmers on how to establish any directly agricultural cottage industry, such as rice husking or flour milling.

Effective entrepreneurship is also probably in short supply. However, team interviews with local village headman, shop owners, and craftsman indicated that they were formulating plans for the productive use of electricity. Even some individuals not presently operating a cottage industry had plans for developing one. If given a chance, many Pakistani are good businessmen.

Rural electrification also affects small-scale industry. "Small-scale" industry is defined as industrial units with less than Rs.3 million of equipment and working capital. However, the average size of these firms is only Rs.140,000 and 80 percent employ fewer than 10 people. The major types of small-scale industries are workshops for repair of equipment, carpet centers, metal fabricators, woodworking shops, onyx carvers and textile, hosiery, towels, tents, garments, appliances, footwear, gloves, surgical goods and sports goods

producers. Following electrification, workshops for tractor repair, and light metal fabrication for locally used products (doors, for example) are the first small-scale industries to develop. The others will follow, but will require more time.

The GOP is trying to encourage the development of small scale industrial units in rural areas for many reasons. Due to its effects on exports and imports, small-scale industry has more importance in the national economy than might be expected. Small-scale industry employs 85 percent of the industrial work force, 20 percent (in 1979) of its production is exported, and fully 47 percent of manufactured exports are produced by small-scale industry. Also, its average capital requirement per job is less than one-tenth of the average capital requirement of large-scale industry. The extension of these industries to rural areas will eventually accompany tubewell developments as one of the most valuable benefits of rural electrification. As can be seen from the preceding statistics, they are a boost to employment and an excellent producer of foreign exchange. However, electrification is a primary catalyst for developing these industrial activities.

In order to encourage the rural development of these industries, the "Small Industries Corporation" is developing "industrial estates: and (at federal request) attempts to locate them in rural areas. A Small Industries Corporation is associated with each provincial government and provides support to small industry in each province.

Interviews with the Small Industries Corporation and Small Business Finance Corporation in each province, have provided information which suggests that education and training, entrepreneurship, and capital are probably sufficiently available to promote the growth of small-scale industry in rural areas. Each Small Industries Corporation offers training programs for potential workers at these facilities, and offers free consulting to potential entrepreneurs on the process for setting up a facility. It also provides referals to the Small Business Finance Corporation and other sources of credit. Terms of credit are quite liberal; 9-11 percent interest, 5-year repayments on secured loans, and collateral is not seized for 5 to 7 years if loans are not being repaid.

However, it was indicated that even these larger businesses remain primarily (70-80 percent) financed by equity from the owner, his family and/or friends.

However, the absence of electrification, the lack of hard surfaced roads, and the distance from markets for its products and supplies discourages small-scale industry from locating in regions far from metropolitan centers. In discussions with the Ministries of Local Government and Rural Development at both the federal and provincial level, it was made clear that high priority programs exist for extending hard surfaced roads, schools, health services, and water supplies. Therefore, although electrification is only one element required to promote rural small-industries development, it is critical and needs to be supplied to match the programs of extending roads and other services. It is a required element, and its introduction is one more step towards increased industrialization of rural Pakistan.

Large-scale industry is also affected by rural electrification. Briefly, large extractive industries, concrete, and large agricultural processors all benefit from rural electrification. However, large industry is not generally dependent on electrification of rural areas as special lines will be strung to these facilities if raw materials and other factors favor development of a large-scale industry in the rural area. In fact extending the rural grid may be a negative benefit for some large industries if the increased load on the grid system caused by rural electrification increases the need for load shedding. Due to widepsread load shedding, large industries now routinely install back-up generation, a direct economic loss. The overall effect of rural electrification on large-scale industry is, however, comparatively minor.

In summary, both villages and rural electrification positively impact cottage, small-scale, and to some extent large-scale industry. However, during the first few years following electrification of an area, probably 95 percent of the productive benefits result from increased tubewell dependent agricultural production and only 5 percent from industrial and commercial effects. These benefits are, however, quite important. Rural industrial growth is of value in promoting exports, and in reducing the import of vegetable oils, consumer goods and other products, and all of this growth requires electricity.

5.2 Agriculture Benefit

5.2.1 Importance of Electricity to Agriculture

Rural electrification impacts positively on agriculture if production can be increased or costs reduced. In Pakistan where 72 percent of agricultural production is dependent on irrigation and some 14 percent of this on tubewell water it was found by Dr. Mohammad Ruaf[1] in a study conducted in 1979, that use of electricity to power tubewells (Table 5.2) was the single most important use made of electricity in the agricultural system and rural area . In fact WAPDA reports that it accounts for about 23 percent of total electrical consumption. This was certainly largely promoted by the fact that the rural electrification program was administered as an adjunct to the promotion of tubewells during the second and third Five-Year Plans.

TABLE 5.2
AGRICULTURAL USE OF ELECTRICITY (NO. OF RESPONDENTS)

Target Area	Irrigation Pumps	Tube-wells	Rice-Husking Plants	Poultry Farm
Rawalpindi	-	2	-	2
Lahore	4	41	7	2
Hyderabad	1	54	-	-
Thatta	-	3	8	-
Peshawar	-	-	3	1
Total	5	100	18	5

In addition to the overshadowing importance of electricity to power tubewells found electricity as by Ruaf[1], and by our team during field inspection, is used to power cottage type flour mills, rice husking plants, saw mills, oil expellers and blacksmith/mechanic shops. All of these activities are important to improve the rural life and support agriculture in the area and do aid in maintaining the employment level in agriculture. Since tubewells represent the single most important use of electricity in the rural sector demonstrating the economic

[1] Source: Rural Electrification in Pakistan, a Socio-Economic Impact Study, Dr. Muhammad A. Rauf, July 1979.

benefits of this electrical use provides major support for the rural electrification program. In this section, the contribution tubewell water makes to agriculture and the economic benefits derived from its use are discussed.

5.2.2 Importance of Tubewells to Agriculture

It is reported that at June 1982, about 194,000 tubewells had been installed in Pakistan (Table 5.3). Of these, about 180,000 tubewells have been installed by the private sector and the remainder by the public sector Salanity Control and Reclamation Project (SCARP). This tubewell water is used to irrigate new land areas as well as supplement water in canal serviced regions. It is reported in USAID's Agricultural Data Book that tubewell water does irrigate 2.86 million hectares (7.06 million acres), and accounts for 14 percent of the cultivable area in Pakistan and 20 percent of the total irrigated area. It is estimated that electric tubewells account for 40 percent of the tubewells presently and this represents 2.82 million irrigated acres or 6 percent of total productive acreage. It is not clear whether this 2.82 million acres is totally irrigated by tubewells or supplementally irrigated by tubewell. However, using the increased return to land, labor and capital attributed to irrigating with electric tubewells for wheat and rice (winter and summer crop, respectively) where water is assumed to be 100 percent supplementary to canal water (Table 5.4) the increased agricultural output would be equivalent to Rs.2.45 billion ($191 million) per year. In the case where the water is assumed to be 100 percent of the irrigation water used (Table 5.5) the increased agricultural output would be equivalent to Rs.6 billion ($468 million) per year. The actual benefit likely lies between these extremes. If the wheat and rice represented by the production from electric tubewell water had to be imported at international prices, it could cost consumers between 35 and 90 percent more.

5.2.3 Economics of Tubewell Water for Agricultural Production

Agricultural production in Pakistan, due to climatic conditions is limited to a single growing season without irrigation water. Use of irrigation water permits increased yields of rain fed crops and permits at least double cropping in many areas of the country. The use of tubewell water plays an important role in

TABLE 5.3

NUMBER OF TUBEWELLS IN PAKISTAN - JUNE 1982

Province	Private			Public			Grand Total
	Elec.	Diesel	Total	Elec.	Diesel	Total	
Punjab[2]	53,673	107,566	161,239	10,047	140	10,187	171,426
SIND	4,965	2,445	7,410[1]	NA	NA	2,741[5]	10,151
N.W.F.P.	3,782	582	4,364[3]	620[5]	38[1]	658	5,022
Baluchistan[4]	3,240	3,793	7,033	70	60	131	7,164
Total			180,046			13,717	193,763

Source:

[1] Agricultural Statistics of Pakistan, Ministry of Food and Agriculture, GOP, Islamabad.

[2] Agricultural Department, GO Punjab, Lahore

[3] Agricultural Department, GO N.W.F.P., Peshawar

[4] Agricultural Department, GO Baluchistan, Quetta

[5] WAPDA, Lahore

TABLE 5.4

ECONOMIC BENEFITS OF TUBEWELLS IN AREAS IRRIGATED BY CANALS

Crop	Yield Without Tubewell Water Supplement[1] (Kg/ac)	Yield With Tubewell Water Supplement[2] (Kg/ac)	Increased Yield With Tubewell Water Supplement (Kg/ac)	Price/Kg[3] For Crop (Rs)/Kg	Increased Value/ Acre With Tubewell Water Supplement (Rs)/ac)	Tubewell Water Supplement Required[4] (ac/in)	Cost to Supply Required Tubewell Water with Diesel[6] (Rs)/ac	Cost to Supply Required Tubewell Water with Electricity[6] (Rs)/ac	Other Increased Input Costs[5] (Rs)/ac	Tubewell Water Supplement as a Percentage of Purchased Inputs: Diesel	Electric	Return to Land, Labor and Capital Without Tubewell Rs/ac	Return to Land, Labor and Capital as Result of Supplemental Tubewell Water: Diesel Rs/ac	Electric Rs/ac	Incr Retu Land, and C as Re Suppl Tubew Diesel Rs/ac
Winter Crop															
Wheat	901	1,214	313	1.35	409	4.2	86	40	384	18	0	846	1,169	1,214	323
Summer Crop															
Rice	1,064	1,417	353	1.69	598	8.4	172	81	432	28	16	1,364	1,790	1,881	426
Cotton	606	899	293	4.20	852	4.2	86	40	412	18	0	2,133	2,898	2,945	776

[1] Arthur D. Little estimate. It is assumed that without the tubewell water the crop would be imported severely at peak stress periods. For this reason, yields without tubewell supple were considered to be 20% lower than with tubewell supplement.

[2] With the exception of apples, the yields used were those reported by Renfro for irrigated land: Economics of Local Control of Irrigation Water in Pakistan: A Pilot Study, by Renfro, unpublished Ph.D. thesis Colorado State University. Apple estimate is based on Ministry of Agriculture data.

[3] Ministry of Finance, Planning and Economic Affairs, Minimum Prices for Ag. Commodities 1982/83.

[4] Based on data from "Cost of Production of Major Crops Under Irrigated and Un-Irrigated Conditions," Planning Division Agriculture and Food Section AGR-137.

[5] Cost of Producing Major Crops in SEHARI DISTRICT, 1979-80, by Dr. Ali Mohammad Chaudhry, Dr. Bashir Ahmed, University of Agriculture Faisalabad. Cost of Production of Major Crops in irrigated and un-irrigated (barani) conditions, Planning Division Agricultural and Food Section, AGR-137, Government of Pakistan.

[6] Based on estimates prepared by Arthur D. Little.

Best Available Document

TABLE 5.5

ECONOMIC BENEFITS OF TUBEWELLS IN AREAS NOT IRRIGATED BY CANALS

Crop	Yield on Non-Tubewell Irrigation Land[1] kg/ac	Yield with Tubewell Water Irrigation kg/ac	Increased Yield with Tubewell Water Irrigation kg/ac	Price/kg for Crop[2] (Rs)/kg	Increased Value/ Acre from Tubewell Irrigation (Rs)/ac	Irrigation Water Required[3] (ac/in)	Cost to Supply Required Tubewell Water with Diesel[4] (Rs)/ac	Cost to Supply Equivalent Tubewell Water with Electricity[6] (Rs)/ac	Other Purchased Input Costs[5] Non-Tubewell Irrigation (Rs)/ac	Other Purchased Input Costs[5] Tubewell Irrigation (Rs)/ac	Tubewell Irrigation Water as Percentage of Purchased Inputs Diesel	Tubewell Irrigation Water as Percentage of Purchased Inputs Electric	Return to Land, Labor and Capital Without Tubewell Rs/ac	Return to Land, Labor and Capital as Result of Tubewell Diesel (Rs)/ac	Return to Land, Labor and Capital as Result of Tubewell Electric (Rs)/ac	Increased Re to Land, Labor and Ca as a Result Tubewell Wa Diesel (Rs)/ac	Increased Re to Land, Labor and Ca as a Result Tubewell Wa Electric (Rs
Winter Crop																	
Wheat	973	1,214	911	1.15	1,230	21	431	202	150	384	53	24	260	834	1,053	564	
Summer Crop																	
Rice	992	1,517	1,215	1.69	2,053	40	421	384	130	432	66	27	211	1,141	1,528	930	1
Cotton	132	800	668	4.20	2,805	29	595	379	206	412	59	20	386	2,301	2,708	2,005	2
Maize	1,619	4,048	2,429	2.95	10,310	58	391	433	450	850	28	33	12,421	30,592	31,036	18,171	18

[1] Arthur D. Little estimate. This estimate is based on low yields reported by the Ministry of Agriculture and on the fact that rainfall does occur in many areas and rudimentary system exploiting water is used; therefore, minimal yields will be obtained even without irrigation.

[2] With the exception of apples, the yields used were those reported by Penfro for irrigated land: Economics of Local Control of Irrigation Water in Pakistan: A Pilot Study, by Ber Ahmad, Ph.D. thesis, Colorado State University. Apple estimate is based on Ministry of Agriculture data.

[3] Ministry of Finance, Planning, and Economic Affairs, Minimum Prices for Ag. Commodities 1982/83.

[4] Based on estimates provided in "Optimal Cropping Pattern for Basin in India," Journal of Irrigation and Drainage Division, March 1977. This was a basin similar to Lahis but on Indian side.

[5] Cost of Production of Major Crops in VEHARI DISTRICT 1979-80, by Dr. Ali Akbar Chaudhry, Dr. Bashir Ahmed, University of Agriculture Faisalabad. Cost of Production of Major Crops u Irrigated and unirrigated (barani) conditions, Planning Division Agricultural and Food Section, MR - 137, Government of Pakistan.

[6] Based on estimates provided by Arthur D. Little.

Pakistan agriculture as it supplements canal water in areas like Punjab and is the primary water for irrigation in areas like Baluchistan. Also, it provides a means for control and flexibility in the use of irrigation water supplies. Control and flexibility is important if you keep in mind the conceptual link between soil, crops, and water requirements in relation to temperatures, evapo-transpiration and stress in selected periods of the growing season, which will result in sub-optimal yields and production if not satisfied by water applications to root zones at the right time. Extreme climatic conditions can cause drastic fluctuations in water demand in periods as short as one week, where crop requirements may exceed rainfall supplies or a combination of rainfall and canal water supplies as is the case in many areas of Pakistan. Canal water (a major source of water in Pakistan) provides limited flexibility to farmers in controlling water supplies because of a lack of storage capabilities outside the government - administered dams and reservoirs; thus, tubewell water acts as demand water, in the sense of supplementing canal water supplies in transient peak demand periods. Of course, where no canal water exists tubewell water is the main supplement to rainfall. Tables 5.4 and 5.5 set forth yield estimates under non-irrigated, irrigated with canal water and irrigated with supplemental tubewell water conditions. This information shows that for most crops irrigation water increases yields significantly. Of course, the increased yields are not only associated with the increased use of water, but also with the use of improved seed, better fertilization practices, pesticide control, better soil preparation and similar improved production practices. On the other hand if the water did not exist the other improved practices would probably not be possible. Therefore, the irrigation water is important and is likely the last input to be eliminated if price/cost relationships for agricultural commodities force the farmer to use fewer purchased inputs. Also, in Tables 5.4 and 5.5 data has been set forth in an effort to understand the benefits of electrically driven tubewells under the two predominant agricultural situations for irrigation water use in Pakistan. Table 5.4 sets forth the situation when tubewell water is used as a supplement to canal water such as in Punjab and SIND and to a certain extent in NWFP. Table 5.5 sets forth the situation when tubewell water is used as a supplement to rainfall only, such as in Baluchistan.

The primary reason for developing this data is to try and understand the comparative advantages of diesel tubewells to electrically driven tubewells. An examination of the data developed leads to the following observations:

- From a national perspective connecting new tubewells to the electric grid is more beneficial than connecting existing diesel tubewells to the grid. In both situations examined tubewells (diesel or electric) created increased return to land, labor and capital. At present electricity rates the electric tubewell contributed more than the diesel. For example, in the case of tubewells in areas where canals did not exist (Table 5.5), the diesel and electric tubewells increased per acre returns to land, labor, and capital on wheat by Rs.564 and Rs.793, respectively.

  The electric tubewell contributed Rs.229 more than the diesel. Therefore, by connecting a new electric tubewell to the system Rs.854 are generated per acre while replacing a diesel with an electric motor provides an incremental gain of Rs.229. This leads to the conclusion that connecting new tubewells to the electric grid is more beneficial nationally than electrifying existing diesel engines. Of course any farmer who can cut his costs by electrifying his tubewell will be interested in doing so, but this may not be the national choice.

- Returns to land, labor and capital by installing an electric tubewell in an area with canal water (Punjab) is still higher than in a non-canal water area (Baluchistan). For Example, in the case of wheat the return to land, labor and capital using an electric tubewell for

  supplemental water vs. using an electric tubewell as the primary irrigation source is Rs.1214 (Table 5.4) and Rs.1053 (Table 5.5), respectively. The primary reason is that in the canal areas, small quantities of tubewell water are used/acre; therefore, its cost is a smaller portion of the purchased input costs.

- Return to land, labor, and capital on an incremental basis is higher when a tubewell is added in Baluchistan than in Punjab. For example, in the case of wheat the incremental return to land, labor, and capital using an electric tubewell for supplemental water vs using a tubewell as the primary irrigation source is Rs.368 (Table 5.4) and Rs.793 (Table 5.5), respectively. The primary reason is that productivity in Baluchistan is increased much more than in Punjab.

- Returns to land, labor, and capital without a tubewell in Punjab is less than in Baluchistan where a tubewell is operating. For example, in the case of wheat, the return in Punjab without tubewell water is Rs.846 (Table 5.4) vs. Baluchistan where with a tubewell, the return is Rs.1053 (Table 5.5).

5.2.4 Impact of Increasing Electric Rates to Tubewell Irrigators

At present the electric rate for electricity supplied to tubewells is only Rs.0.23/kWh in Punjab and Sind, and Rs.0.16 in Baluchistan and N.W.F.P. The very low rates provided to the tubewells must be subsidized by other sectors; primarily commercial consumers. They are also well below the marginal costs of power from either oil fired or coal fired facilities which are estimated at 6-8c/kwh (Rs.75/kwh-Rs.1/kwh). Therefore, increasing the rates to the tubewells would improve the financial viability of the whole WAPDA system. It would also encourage improved irrigation practices by making electrically powered supplied well water more expensive.

As is shown in Tables 5.4 and 5.5, the cost of electrically powered tubewell water is approximately 9 to 10 percent of a farmer's total purchased input costs in areas where tubewells are used to supplement canal water, and approximately 33 to 47 percent in areas where tubewells are the exclusive source of irrigation water.

In both cases the variable cost per kWh is approximately 22 percent of the total cost, including both fixed and variable costs, of operating a tubewell. Hence, the variable cost per kWh is only 2 to 4 percent of total purchased input costs in "supplement" areas and 7 to 10 percent in "exclusive" areas. The benefit of

having tubewell water is so great (Tables 5.4 and 5.5) that increasing the variable cost per kWh for electricity would not make tubewells uneconomic for the farmer. In fact, it should encourage more conservative use of water, and consequently it may not prove to affect his costs even as much as the above percentages suggest.

The effect of doubling, tripling, and even quadrupling rates has been tested in a sensitivity analysis. This appears on Figures 5.1 and 5.2. From these figures, it may be seen that the rates of incremental benefits from using tubewells to the incremental costs from using tubewells is always more than one. In fact, at present rates, it ranges from 3.5 to 20. By contrast, the incremental benefit to incremental cost ratio ("B/C") for diesel tubewells ranges from 1.1 to 9.0. Not surprisingly, in areas where the B/C ratio for diesel is quite low, they are not much used. Baluchistan for example, where irrigation in some areas must be provided exclusively from tubewells, does not have many diesel tubewells. On Figures 5.1 and 5.2 the B/C ratios are shown for electric tubewells assuming increased costs per kWh. Even quadrupling the rates does not cause the B/C ratio on electric tubewells to fall as low as the B/C ratio on diesel tubewells. Hence, the rates can be raised considerably without making tubewells uneconomical. Farming in Pakistan is not so profitable that quadrupling the rates would be accepted without protest, or is it either necessary or probably desirable. However, even if the electric rates were doubled, the benefit to cost ratio of electric tubewells would still be almost twice the B/C ratio for diesel tubewells.

5.2.5 Comments on SCARP Wells

The above observations pertain to the private tubewells where their operation is contingent on favorable economics to the users. The situation relative to the public sector SCARP wells is quite different. These wells are operated by the provincial Irrigation and Power Departments. Even at present electric rates the operation of the SCARP wells absorb a large share of the budgets for these departments reducing the resources to undertake other necessary functions, primarily maintenance of the vital canal system.

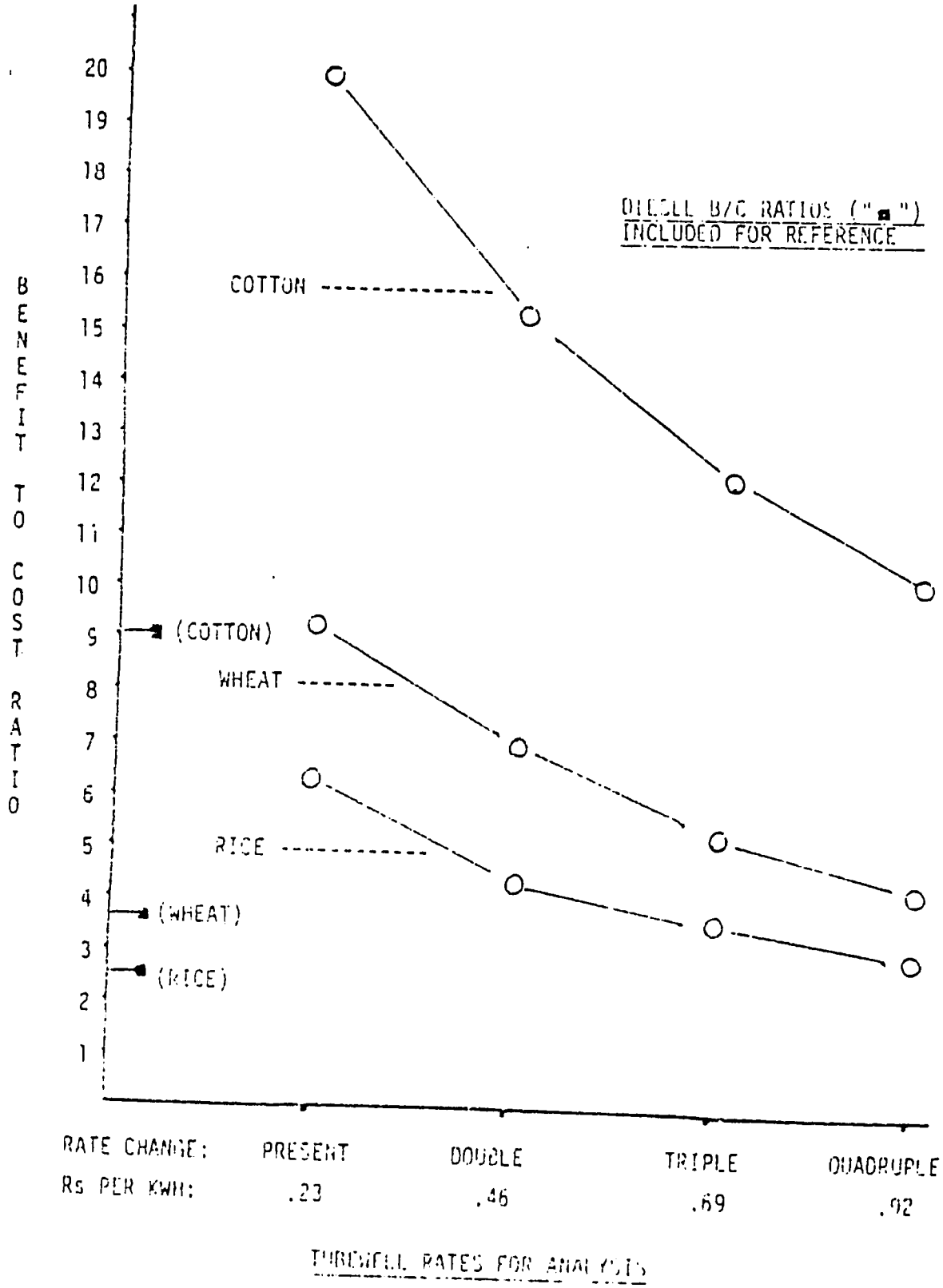

Figure 5.1 IMPACT ON BENEFIT/COST RATIO OF CHANGING ELECTRIC RATES FOR TUBEWELLS SUPPLYING WATER SUPPLEMENTING CANALS

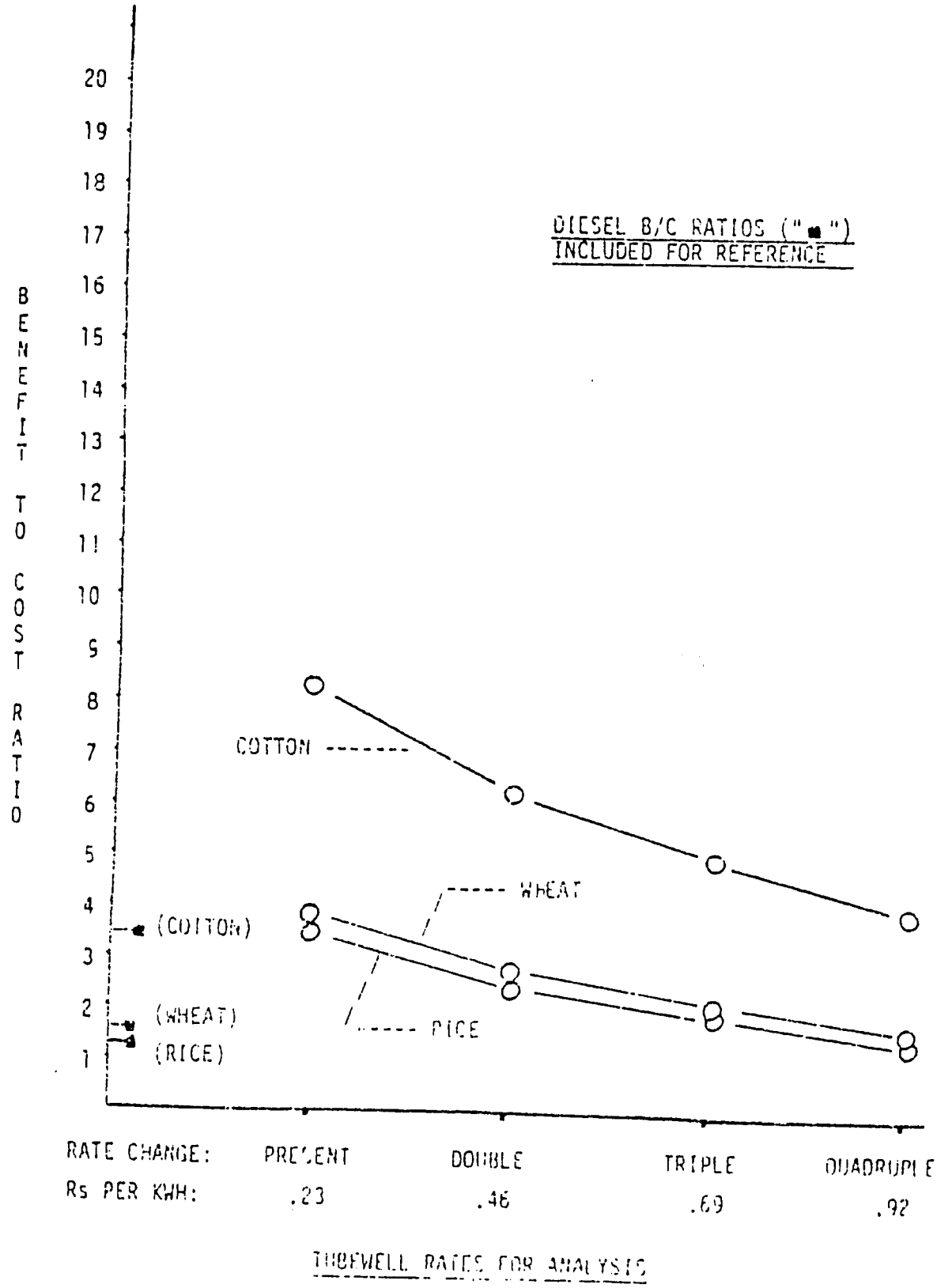

Figure 5.2 IMPACT ON BENEFIT/COST RATIO OF CHANGING ELECTRIC RATES FOR TUBEWELLS SUPPLYING ALL IRRIGATION REQUIREMENTS

This reflects a combination of the uneconomical rates charged for water from the SCARP wells and the fact that many are operated extremely inefficiently (poor maintenance, plugged intake screens). The inefficiencies are further promulgated by very strong unions which inhibit implementing good O&M practices on the pumps. For these and other reasons the GOP is being encouraged by donor groups to turn over operation of these SCARP wells which provide irrigation water* to private sector owners.

These SCARP wells are a higher percentage of the electricity used in pumping than their number would indicate since they have average capacities 2-4 times those of most private tubewells. consequently, also from an energy policy point of view the process of turning over the SCARP wells to private owners with a financial stake in efficient operation should be encouraged. This will also result in shutting down those wells which no longer serve a useful function and, therefore, can't be transferred to private owners.

5.3 Impact of Rural Energy Consumption

Energy in the rural sector is used primarily for cooking, lighting, and heat, and low-speed diesel power for pumping. In the rural sector of Pakistan, the forms of energy predominantly used for these purposes are wood, dried dung, kerosene and diesel fuel. In some instances charcoal is used for cooking and heat.

In more than six electrified villages visited, electricity was not a major factor in cooking or heating as it is more expensive to use electricity than obtain wood or dired dung. In all visits to non-electrified villages, it was asked if they would use electricity for cooking or heating and the answer was most often no. These findings are consistent with findings of other studies reviewed. A recent Resources for the Future report,[1] analyzing the role of rural electrification in development, states: "electricity is not often a substitute for wood or dung in heating or cooking."

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* Some SCARP wells pump saline water from the ground table which is unfit for irrigation purposes. These wells would remain in the public sector domain.

1 Role of Rural Electrification in Development Discussion Paper D-73#, Resources for the Future/Washington, D.C.

It should be noted that, in general, the use of electricity for cooking or heating should not be encouraged particularly where a significant portion of power generation is by thermal means. One reason for this is that fuel consumption in thermal power plants will be at least twice that which would occur if fuel is consumed in the end use devices (stoves, furnaces, etc.). In addition, the thermal loads associated with cooking and space heating are very large and would require significant increases in electric generating capacity and the distribution to serve the demand.

The introduction of electricity, as mentioned, displaces petroleum in two principal ways:

- By replacing the very inefficient use of kerosene in lamps used for lighting;

- By replacing low speed diesel fuel used in diesel pumps.

The displacement of imported petroleum products in these two functions has often been the major economic benefit ascribed to individual rural electrification projects.

A first cut analysis summarized in Table 5.6 indicates that presently rural electrification displaces about 1.7×10^6 barrels of oil annually having a value of about $51 million. This could increase to $4-5 \times 10^6$ barrels annually by 1988 with a value of about $150 million, if WAPDA's goal of 50 percent saturation is achieved.

At present only 2 percent of WAPDA's power generation is by oil. Therefore, any displacement of petroleum in the field is a <u>NET</u> displacement since minimal oil was used in the power generation process.

The situation will, however, become more complicated in the future as increased power generation relies more on oil due to constraints on additional use of natural gas. WAPDA projections indicate that roughly 45 percent of thermal generation will be by oil by 1988. By this time roughly 8.8×10^6 barrels of

TABLE 5.6

ESTIMATED PETROLEUM DISPLACEMENT RESULTING FROM RURAL ELECTRIFICATION

	Approximate Number	Per Unit Fuel Displaced (Gal/Year)	Total Fuel Displaced Gal/Year	Total Fuel Displaced Gal/Year
1982				
Lights (households)	585,000	53	31×10^6	738,000
Pumps	22,000	1,823	40×10^6	952,000
1988				
Lights (households)	1,500,000	53	79×10^6	1.9×10^6
Pumps	40,000	1,823	73×10^6	1.7×10^6

Assumptions:

- Average village size is 200 households; 15% saturation in 1983 increasing to 50% by 1988.
- Village added at rate of 3,000 per year.
- 2/3 of pump connections are diesel conversions.
- Typical household kerosine usage is 200 liters/year.
- Typical diesel pump fuel usage is 6,430 liters/year + 509 liters of oil.

oil will be consumed in power generation. This estimate is, however, subject to revision if coal utilization in power generation is accelerated as the result of recent studies undertaken by WAPDA and USAID.

With a relatively modest percentage of total power generation by oil, the petroleum displacement value of rural electrification would still be clear if the only functions of rural power was to substitute electric motors for diesel engines and electric lights for kerosene lamps. This is, however, not quite the case. For example, only about 20 percent of new tubewell connections are used to displace diesel drive systems. Rural electrification, therefore, creates demands for energy which are consistent with increasing rural productivity and improving living standards. To satisfy loads which are not presently served by kerosene or diesel fuel will require the net consumption of oil at the point of generation.

It appears, however, that there will be a net displacement of imported petroleum even considering the above factors since only 20-30 percent of the 8.8×10^6 barrels of petroleum estimated to be used in power generation in 1988 will be due to rural loads.

5.4 Social Benefits of Electrification

In addition to the economic benefits of electrification that arise from agriculture and industry, a variety of less-quantifiable, but never-the-less valued benefits result. These benefits are related to enjoyment of electricity, improved employment, environmental improvements, foreign exchange savings, reduced urban migration, reduction in birth rate, and increased political awareness. Although these are less quantifiable, still there are facts which give information on these assumed benefits. However, not all of these assumed benefits appear to actually materialize. A discussion of each benefit follows.

The most fundamental fact is that the people want electricity and the demonstration of that fact is, they spend 1 to 10 percent of their income on it.[1] In addition to its immediate benefits for lighting, TV, radio, fans, and domestic appliances, electricity also is valued in schools, health clinics, mosques, for street lighting, for enhancing villager's sense of security, and for provoking modernity. These additional benefits are even less clearly attributable to

electricity. They undoubtedly exist, but are difficult to measure. A sense of modernity, a sense that the people can hope that their lives will improve, can in fact result from almost any improvement in village infrastructure. Electricity may not be essential for health clinics, nor is its presence alone sufficient to make a particular village attractive to a doctor or health practitioner but it helps. Therefore, the benefits listed above should be at least partially credited to electrification.

Improved employment is a more tangible benefit. Statistics related to this must be formed from a very careful research plan to assess correctly cause and effect, but it is at least suggestive that occupational changes are three times more common among electricity users in Pakistan than among non-users. Also, 45 percent of those electricity users changing occupations say that the change is attributable to electricity.[2]

In association with employment, income appears to improve, and the magnitude of the improvement is proportionate to the period that the village has been electrified. Also, there is evidence that this income improvement 'trickles down' even to non-users in an electrified village.[3]

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1 Rauf, Dr. Mohammed A., "Rural Electrification in Pakistan - A Socio-Economic Impact Input Study," Department of Anthropology, Quaid-i-Azam University, Islamabad. Calculation based on data on page 78.

2 Ibid, Ruf - based on data on page 67.

3 Ibid, Rauf - based on data on page 76.

In general, these improvements are attributable to longer working hours and improvement in the productivity of capital goods. Based on village interview information, electrifying a diesel powered sawmill/cotton gin/flour mill unit, could more than double daily gross profits; see Section 5.1, Table 5.1. Also, interview information suggested that electrifying these types of facilities would increase employment at the facility from 25 to 50 percent due to longer working hours. In fact, at a brick-making facility visited, electrification tripled employment (from 15 to 45) due to running three shifts.

The major energy related environmental problem in Pakistan is deforestation and erosion caused by fuel wood gathering for cooking and heating. Generally, electrification of rural areas does not result in displacing wood as a cooking and heating fuel so the argument that rural electrification does bring about environmental improvement is not substantiated. In fact, in Pakistan, villages that have been electrified for a number of years still use wood as a prominent fuel source.

The substitution of kerosene and diesel oil by electricity for lighting and motive power are the single most important areas where foreign exchange gains are likely to be made from the Rural Electrification Program. For a detailed discussion of the potential benefits in Pakistan see Section 5.3 of this report. Basically, it is believed that net displacement of imported petroleum is still possible in Pakistan, but with an increasing share of central grid power coming from imported oil, this benefit will be of decreasing importance over the coming years.

Electrification is widely believed to reduce migration of the rural population to urban areas, based on the plausible model that electricity improves village life and, therefore, reduces the incentive to leave. Also, electrification does increase employment opportunities and the lack of employment is often cited as a reason for migration. Reduced migration could be a dramatic benefit, as Karachi (for example) is growing at approximately 8 percent per year, of which 4 percent is attributable to migration, and this is a major financial and social burden for the city. The counter arguments to the above are that electrification leads

to the development of new skills by villagers, skills that can be sold for a higher price in urban areas. Also, through media exposure, it creates new aspirations which may lead to migration.

The actual evidence to suggest that migration is reduced by electrification alone is slim. Research in other nations found no such evidence.[4] Some evidence can be inferred from other facts about migration in Pakistan. In Pakistan, it is evident that the population is fairly mobile. In one study, 21 percent of a village's residents were immigrants from other villages.[5] In many areas, seasonal migration is common. In the Katchucha Valley near Kohat, Baluchistan, tremendous in-migration has occurred following electrification as land that was formerly marginally productive is, with irrigation, now being rapidly developed for orchards, where, onions, potatoes, almonds, and other crops. Based on this mobility and the experience in Katchucha, it is reasonable to believe that villagers would be more likely to migrate from non-electrified areas and more likely to stay in electrified areas.

Most villagers and village headmen interviewed on this issue firmly insisted that the people did not wish to leave and left only because of the lack of employment in the village. They also firmly believed that electricity induced employment and eliminated migration. However, in a comparison study, non-users of electricity in electrified villages were found to be negligibly more likely to migrate than electricity users in the same village.[6] Unfortunately, the study does not provide a statistically valid indication of difference between electrified and non-electrified villages in migration patterns.

There is no question, however, that overall "life satisfaction" of villagers is increased by electricity and that electricity is at least one component in holding migration down.[7] Various programs of the provincial governments aim to provide six components of village infrastructure that are, in combination, believed to be adequate to end migration: electricity, roads, drinking water,

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4 World Bank, Rural Electrification: A World Bank Paper, 1975.

5 Op Cit, Ruaf - page 37.

6 Ibid, Rauf, page 40.

health facilities, education and rural industrialization. Electricity is an important contributor to all of these except roads. Therefore, although electricity may not in itself be adequate to end migration, it is an element that helps to reduce it.

The effect of electrification on birth rates is less amenable to statistical analysis. Evidence from other nations suggests that birth rates are lower in electrified areas, but it is more reasonable to attribute that to increased income and development than solely to electricity. To the extent that electricity contributes to development generally, it probably contributes to a reduced birth rate.

Finally, electricity may contribute to the political awareness and unity of the people. It is true that users of electricity in Pakistan have greater exposure to media of all types, particularly television.[8] Also, representatives of local government departments indicate that, "roads and electricity are the only issues debated in the local councils." It is true that in Pakistan the decision regarding which villages are to electrified each year is made in a process of participatory democracy that reaches to the grass roots level. In interviews with villagers and village headmen, the role of Union and District Councils in bringing electricity to villages was discussed. The villagers generally believed that these councils did determine where electricity went and the villagers generally did attempt to influence their council representative. Therefore, to this extent, rural electrification has value in increasing the participation of the people of Pakistan in political issues.

In summary, the social benefits of electrification in Pakistan are real, to some extent measurable, and very important.

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7 Ibid, Rauf, Based on data on pages 43-45

8 Ibid, Rauf. page 58.

6.0 POLICY CONSIDERATIONS

The previous sections provide a broad overview of the rural electrification program and technical, financial, economic, and institutional issues associated with its implementation. There is probably no other single activity which has a wider range of both direct and indirect impacts on the economic development of Pakistan. It directly effects a major portion of the whole energy sector infrastructure development needs and has been, in part, responsible for Pakistan achieving self sufficiency in food. Its impact on contributing to the social and institutional development of rural areas are difficult to quantify but undoubtedly large.

The following section discusses some of the major policy issues identified as part of this study and comments on how they are or might be addressed. Due to the above discussed factors, these issues cover a wide range of technical and institutional subjects and in large part, cannot be addressed solely by WAPDA even though this organization has primary responsibility for physically implementing the rural electrification program. As such, many of these issues must be considered within the broader context of national energy and economic development planning.

6.1 Village Selection Process Policy Options

Option Definition

The major thrust of rural electrification in Pakistan is likely to remain the village electrification program with associated electrification of tubewells. The present process of village selection with a discussion of its effects, has been described in detail in Section 3.0. Here, some possible modifications to that process are discussed. Specifically, options related to who chooses villages and how they choose them will be considered. In general, these options involve either reducing the involvement of the local and provincial governments or in some way changing the criteria used to select villages. The options will be considered in detail but, to summarize, neither are recommended. A change in the present process would most likely only change the

order in which villages are electrified and would not change either the villages which will finally be chosen for electrification nor the design of the distribution system that will finally result.

Change the Parties Involved in Selecting Villages

At present, villages for electrification are selected by a process which includes both local and provincial governments, or even for the distribution function to be taken on by cooperatives.

The cooperative approach to distributing electricity in Pakistan has been reviewed extensively and has not appeared to previous researches to be a good idea.[1] Similar attempts at cooperatives for tractors, water courses, credit, and housing have not been successful. Based on this, the option of encouraging cooperatives is not encouraged.

Giving WAPDA alone responsibility for village selection also is undesirable. First, WAPDA would probably be unwide to accept this responsibility. The choice of villages will always cause some disappointment and it is probably preferable that this disappointment be defused in the local councils rather than vented on WAPDA. Also, the political awareness benefits of the rural electrification process, discussed in Section 5.4, would not exist if the local councils are not involved in village selection. Finally, given the design constraints that will be created by the Master Plan, the choice of villages will not alter the design of the overall system, an issue discussed in detail in Section 3.0. Therefore, changing the present well-entrenched involvement of the local and provincial governments is not recommended.

Change the Basis for Choosing Villages

The basis on which villages are presently selected is described in Section 3.0. To summarize, the provincial governments try to electrify large villages near existing transmission lines, while attempting to maintain an equitable

1. See WAPDA document, "Accelerated Rural Electrification Program".

distribution of electricity, and also attempt to develop areas that could particularly benefit from electricity. The second two goals, maintaining equitability and developing selected areas, are to some extent, antagonistic. The benefits of devoting more of the resources available for electrification to the development of selected areas is contained in Section 6.2 on regional development options. Here, using criteria other than the present primary guidelines of population and distance will be considered.

As discussed in Section 3.0, the Master Plan will define the design of the distribution system. Also, the Federal Government has made a commitment to electrify, in the next ten years, a very high percentage of rural villages. Therefore, if the selection process were to consider new criteria, at the most, the order in which villages are electrified and not the final villages chosen would be influenced. It is not clear that changing that order would be valuable, not is it clear that changing the present criteria would do so.

At present, and also after the Master Plan is in effect, the provincial governments are under strong pressure to electrify the largest population for the least amount of money. Since they operate with a fixed financial allocation, they tend to attempt to maximize the average population to distance ratio of the villages they choose to electrify. One possible change in criteria would be to attempt to measure the economic benefit of electrifying a specific village and compare this with the cost of extending feeder lines to this village. From that, a 'benefit-cost' ratio could be computed. However, the economic benefit of electrifying a specific village within a specific district is almost always greater for villages of larger population. If potential economic benefits are measured by the number of small industries, number of tubewells, or even something as vague as the amount of entrepreneural spirit present, in general, these characteristics will be proportional to population. Hence, to a very great degree, the present process already selects the villages in a district that has the best, "economic potential to cost of electrification" ratio. Therefore, changing the criteria would probably not alter the actual order in which villages will be electrified.

The emphasis on equity between districts does mean that in some cases villages with poorer benefit-cost ratio in one district may be electrified before those with a better ratio in one district may be electrified before those with a better ratio in another district are electrified. However, equitable distribution is a very important goal of the GOP and it probably will not be abandoned for small economic benefits.

However, criteria purporting to measure economic desirability could be adopted. The Asian Development Bank program does use such criteria, using the same data WAPDA is presently developing for its Master Plan. To compute economic value, they consider the primary benefits to result from oil displacement. However, as discussed in other sections of this report, the oil displacement benefits will decrease as oil is increasingly used in power generation. The major quantifiable benefit is increasing agricultural productivity which may be difficult to estimate on a village by village level. Hence, it is not apparent that economic benefits can be any more accurately estimated than to say they are proportionate to population. Therefore, it is doubtful that using an economic evaluation system would improve on the present approach. The Master Plan is, however, gathering all the data on villages that would be required to support such a system.

Finally, given that the same villages will also be electrified under the Master Plan eventually, it is not clear that electrifying those with strong economic benefits first is necessarily desirable. "Strong economic benefits" implies relatively heavy use of electricity and it may be better for WAPDA's overall load for these heavy users to come-on-line relatively far in the future rather than immediately.

As indicated above, despite its faults, the present approach for selecting villages for electrification encourages a high level of local participation while imposing a certain degree of discipline on the process which tends to favor those villages with the highest economic potential. The Master Plan now under preparation will provide further guidance to the selection process. As a result of the above, it is not clear that alternative approaches which have

been considered would significantly improve the results and, therefore, no policy changes in this area were identified.

6.2 Regional Development

Extention of the rural electrification system in Pakistan has been largely on the basis of population equity and distance from 11 kV or 33 kV feeder lines. However, some regional development has been fostered via rural electrification even though it has not been a criteria primary to deciding where rural electrification expansion will occur. This is because WAPDA presently addresses regional development issues through a number of mechanisms including tubewell irrigation programs, membership on Federal and/or Provincial Industrial Facilities boards, and activities associated with developing the information for the annual Power Market Survey.

WAPDA involvement in these mechanisms brings about cooperative discussion and information exchange with provincial and local authorities. This exchange brings regional development interests to the attention of WAPDA and together with local authorities WAPDA tries to effectively address longer range regional development opportunities.

The present program, while it does promote some regional development, has not focussed on regional development opportunities per se' and may require some re-thinking by the GOP with respect to the allocation of funds between and within provinces.

Allocation Between Provinces

Applying strictly the present criteria of distributing rural electrification between provinces largely on the basis of population means that Baluchistan receives a small budget for rural electrification in relation to its development potential.*

* 90 percent of economic development funds are distributed between provinces on the basis of population. The remaining 10 percent is distributed evenly between Baluchistan and NWFP. Rural electrification funding in these provinces is, therefore, at a somewhat higher level per capita than the national average.

Baluchistan comprises 43 percent of Pakistan's land area and contains 15 million acres of cultivable land and is one of the richest areas in the country in terms of its agrarian potential. For example, in Baluchistan a survey was conducted to identify valley basins having sufficient ground water to warrant development. This work identified 73 primary basins that had sufficient ground water resources to warrant exploitation.

Also, in Sind the Irrigation and Power Department in the Secretary of Planning pointed out that large riverian areas (unexploited fresh ground water and land resources of about 2 million acres along the river) about 2 million acres of unfarmed land existed. It is the provincial belief that this area should receive electrification so that tubewells can be established and unused agricultural resources brought into production. Again this is an example of a regional development rather than village focused electrification program.

The primary element required to develop these areas in Baluchistan and Sind is often exploitation of the ground water. To exploit the ground water refocusing rural electrification away from villages and to ground water areas offering agrarian potential would do much more to expand agricultural production (the major productive benefit occurring to electrification) than to replace diesel tubewells with electric tubewells.

Many studies have indicated that regional development options based on providing electricity may fail to produce the desired results unless effectively tied into a broader based development program that provides other forms of infrastructure required for development.

In Baluchistan, the team visited a valley development project which illustrated how electricity, combined with roads and other essential infrastructure requirements, could serve as a catalyst for regional development. In this region, many of the farmers has increased their agriculture tenfold, sons that had left the valley returned home, new settlers migrated into the valley, and it is becoming a major agricultural zone in Baluchistan. The above is one

example illustrating that if the regional development focus is properly carried out success can follow.

Allocation Within Provinces

The distribution of the rural electrification budget within provinces to district and local levels is again based largely on population and is primarily focussed on electrification of villages not regional development potential. However, within provinces as between provinces certain districts offer more potential for development than others. Therefore, if the provincial government would use a portion of their rural electrification budget to develop the rural potential rather than electrification of villages per se' many of the same benefits described for the shift of funds between provinces could be gained within the provinces.

Implementation of Regional Development Option

The regional development option would require the GOP to allocate a larger portion (more than the 10 percent that now goes to Baluchistan and NWFP) of the resources available for rural electrification to development projects. This is some departure from the village selection process now used to direct most of the rural electrification funds. To implement this policy would require as a minimum that;

- The national government direct a larger portion of the rural electrification budget between provinces on other than population alone.

- Review procedures are established at the national and provincial level whereby regional development opportunities are identified and evaluated. Such a review function would require close collaboration between diverse private and public sector interests including those involved in agriculture, planning, industry, and mineral development.

- WAPDA and its consultants preparing the Master Plan for Rural Electrification continue to collect information on resources (ground water potentials by district, mineral deposits, unused agricultural lands located in ground water potential areas, and similar facts) and prepare target regional development areas by province.

- WAPDA to expand its distribution via 33 kV and 11 kV feeder lines to these potential regional development areas.

Focussing a modest portion (perhaps 20-25 percent) of the rural electrification budget on this option would not significantly impact on the village electrification program and may increase the overall contribution of rural electricity in economic development.

6.3 Irrigation Efficiency

As described in Section 4.3 of this document, tubewells in Pakistan account for the greatest use of energy in rural areas. Because all indications are that the demand for power will exceed WAPDA's capacity to supply (see Section 4.1) electricity for the next decade, it is essential that the electricity which is supplied be used as efficiently as possible. This discussion focuses on a major rural use of energy and on means by which this use of energy can be made more efficient. Two basic means exist, first through more efficient use of water and second through better and more efficient use of irrigation technology.

More Efficient Use of Water

Presently flood irrigation is the most common form for irrigation used in Pakistan. This is also one of the most inefficient means of irrigation because water is lost both through canal seepage and evaporation. This form of irrigation system in many parts of the country is historically dictated and extremely difficult to change because canals and land ownership patterns are established. This obviously leads to the question of what can be done to improve the use of water.

Water use can be made more efficient through improving the present irrigation methods and/or through the adoption of different irrigation methods. Often a combination of both methods produces the greatest improvement. Also, the methods will differ between presently irrigated areas and those just being brought under irrigation.

In areas presently under irrigation where canal water is being used for irrigation and tubewell water is being used as a supplement, three basic approaches can be considered for improved efficiency of tubewell water used and include:

- Tubewell water application only after canal water has soaked the irrigation ditch;
- Lining irrigation ditches to reduce water losses through seepage;
- Introduction of different methods for applying the water such as sprinkler or drip irrigation system.

The concept behind the first method is simply to get farmers, as is practical, to use tubewell water only after the canal water has saturated the main distribution canals. In this way, lower cost canal water is being lost through seepage and 30-60 percent of the higher cost, higher energy using tubewell water is saved.

The second method, lining canals with some material that prevents water loss due to seepage, is exactly that. This method based on experience elsewhere can save 20 to 40 percent of both canal and tubewell water. Also, this helps to reduce water logging and eventual salination brought about because of water logging.

The third method, using different methods of applying water, offer another means for some reducing irrigation inefficiency. Due to the existing layout of land plots, it may not be practical to introduce standard sprinkler irrigation systems, but on orchard crops and some row crops drip irrigation systems may be practical. In cases where drip irrigation is practical, it has been found to reduce water requirements by at least half.

Present programs of the GOP together with assistance from donor organizations, including USAID, are underway to improve water efficiency through improved canal system maintenance. Education of farmers must be an integral part of this effort in order that farmers understand the economic benefit for making these canal improvements. Studies conducted in Pakistan show that water losses in canals through seepage and evaporation during transit is between 30 to 60 percent. Water losses, through implementation of a combination of the three approaches discussed above, should reduce by 50 percent. WAPDA estimates that the average tubewell operates 21,000 kWh per year, therefore, achieving this water saving objective can permit operation of tubewell pumps 5,000 fewer kWh per year and maintain acreage irrigated. If 60 percent of the electrically operated tubewells in Pakistan realize this gain, the electrical energy demand for these tubewell operators could be reduced by 76.5MW per year.

In areas where tubewell water is not used in conjunction with canal water, the primary means for reducing water use is through lining of canals, elimination of holding ponds, and the introduction of sprinkler or drip irrigation systems. As above, if these methods are introduced, water losses can be cut by 30 percent or more and at the same time reduce the number of hours the tubewell runs or permit the irrigation of more acres. Thus in these areas energy savings on the order of 3000 kWh per tube well could be saved.

The above discussion illustrates that methods do exist for reducing irrigation water used without detrimentally affecting production; in fact, use of less water may even increase production. By reducing the use of irrigation water, pumps can be run less hours or irrigate more land. In either event energy used to power the pumps is being used more efficiently. This leads to a conclusion that energy planning must be incorporated more effectively into irrigation planning in Pakistan.

More Efficient Irrigation Technology or Its Use

Another major source for reducing energy requirements by electric tubewells is through purchase of properly designed and dimensioned systems and proper maintenance of such systems once installed. If proper systems are purchased

and maintained (screens changed, impellers adjusted, etc.), the time necessary to operate a tubewell running at 75 percent efficiency vs one operating at 50 percent efficiency is significant. The effect of low tubewell pumping plant efficiencies is that utilization of electrical energy is 12-15 percent higher than required to accomplish the same work. Also, tubewell maintenance costs will be above normal on inefficient plants.

Energy savings can be realized if improvements in tubewell efficiencies can be effected. To obtain these efficiencies requires that WAPDA establish some general policies including:

1. Standards for design of the pumps, motors and other items used in the tubewell pumping plant before a connection is made.

2. Canal and pump maintenance standards which will be periodically checked by the WAPDA water wing. If these standards are not found to be met, a warning will be issued. If the system hasn't been upgraded to the standards within a pre-established time frame, WAPDA will disconnect the tubewell.

3. A price for tubewell electricity that will promote more efficient use of the tubewell water and better maintenance practices.

It is relatively easy to establish Items 1 and 3 above, but it may be very difficult to implement Item 2 due to the controls that would have to be put in place to assure proper administration of the monitoring program.

6.4 Load Management

Present shortage of generating capacity and projected continued shortages through 1990 makes it almost mandatory for WAPDA to consider whatever alternatives, in addition to building new generating plants, are available to reduce the shortfall. For the immediate problem, WAPDA has been forced to resort to disconnecting feeders throughout the country on a rotating basis each day. Additional measures to reduce the demand include disconnecting public

sector SCARP and tubewells during evening peak, turning out alternate street lights, industry reduction of usage by 25 percent and closing shops in the evening. Rural feeders are often disconnected before urban feeders. Disconnecting feeders, though effective in reducing peak demand under emergency conditions, is undesirable since it does not discriminate between users on the same feeder. Tubewells are prime targets to be disconnected yet to do so by; disconnecting the feeder means many hours without lighting for other users on the same circuit.

An additional effect of unplanned "defacto load management" by turning off feeders is that tubewells may be turned off during critical irrigation periods resulting in loss of agricultural productivity and great harm to individual farmers.

Without any form of load management it is estimated that roughly, 700 MW of capacity, will be required by 1988 to serve the tubewells (Section 4.0). The reduction in capacity shortfall from load managing even 50 percent of the pumps could therefore, be as high as 350 MW. The cost of providing this much capacity to the system would be about Rs. 4,370 million ($350 million). There will be about 100,000 electrified tubewells installed by 1988. The above financial savings resulting from the load management option amount to about $3,500 per tubewell. As a result, there is considerable flexibility in considering various load management options given the very large financial incentive to do so on a per well basis.

It is recognized, however, that load managing the irrigation pumps is easier said than done, for two reasons.

- The technical complexity of electro-mechanical devices which turn off the pumps at prescribed times.

- The institutional issues associated with reducing or changing the distribution of irrigation water.

Time clocks are subject to disruption with each power outage so that they no longer control operation per the initial schedule. More sophisticated methods such as over-the-line signalling and radio actuated switches may often be too complicated for practical use. In all cases, tampering of load management systems will have to be addressed; possibly by termination of service.

One approach to load management would be a very steep time of day pricing structure which would discourage peak hour use except in those cases where the farmers felt the water was absolutely essential. This might have the same practical benefit as absolute load management (via electro-mechanical switches) with less bureaucratic interference. Implementing even this measure would however be complicated by the frequent power outages which results in loss of timing calibration. One solution to this could be having the meters independent of the line and operated off batteries (possibly photovoltaics charged since only a few watts is required).

One of the concerns frequently expressed about load management of pumping systems is that irrigation water pumping is often required 24 hours per day if all farmers involved are to get their fair share of water. This is due to the institutional arrangements now used in many cases to distribute irrigation water whereby each farmer may be allocated a specific time of the day when the water flow is directed to his fields. Certainly this concern must be addressed when considering the prospects for load managing tubewell irrigation systems. The fact is, however, that well-planned load management should be less disruptive of rural activities (including irrigation pumping) than the present system of defacto load management resulting from black outs.

Load management of the tubewells is seen to have significant financial implications on a national basis.

Its implementation is, however, complicated by a number of technical, social, and institutional problems and uncertainties. Resolving these uncertainties might be accomplished by implementing a number of pilot projects in different regions and using differing technical approaches. Such a program would be low

in cost compared to the multi-hundred million dollar benefits which could follow.

6.5 Backfilling vs Expansion

Option Definition

The Government of Pakistan is embarked on a village electrification program that is expected to electrify 3000 villages per year. This program, when complete, will bring access to electricity to the households of 80 percent of the country's population and contribute to achieving a decisive breakthrough in the provision of physical and social services to the rural areas. At the same time, many villages that have been electrified are only partially saturated and find it difficult to obtain additional connections due to limits placed on the number of connection permitted and many of these must be allocated to new villages being added to the grid. It should be noted, however, that it is not clear to what extent people desiring connections cannot have one within reasonable length of time. In one province, Sind, the local officials indicated that there was not a significant waiting list for connections. In other areas, such as NWFP, the length of time required to get a connection was considered to be a significant barrier to increasing saturation levels. In all cases, local officials indicated that as saturation levels approach 40-50 percent, most of the people who want or can afford a connection probably have one. It was indicated during field interviews that requirements for "under the table" money to get a connection may be an impediment to more rapid saturation. The extent of this problem is, however, difficult to gauge.

Arguments can be made for both choices - backfill existing villages or extending to new villages - and the pros and cons of each are discussed below.

Backfilling Existing Villages

The primary benefits of this choice seem to accrue to WAPDA. Certainly if WAPDA could concentrate more of its connections to existing villages, the cost

per connection would be much less. The average cost to connect domestic customers in villages already electrified vs those not electrified is Rs. 1,050 ($84) and Rs. 5,500 ($440), respectively. Adding connections in previously electrified villages improves the load factors on existing lines thereby improving financial viability of the rural electrification process. Also, concentration of attention to these villages could permit improved service, better technological practice and less loss of energy due to poor standards of maintenance and materials.

As indicated above, at the local level the cost of connections in an existing village are only about one-fourth those in a new village. However, as indicated in Section 4.0, the local grid costs of rural electrification are only about 35 percent of the total. The need for increased generating capacity and transmission system upgrading will be the same for equal numbers of backfill and new village connections. The difference in overall financial requirements of existing to new villages as compared to backfilling is, therefore, only about 20 percent on a system wide basis.

While several benefits accrue to WAPDA as a result of backfilling it is not clear that productive benefits accrue to the nation at the same rate encountered as when new villages are added to the system. For example, villagers interviewed by our team and work conducted by Dr. Rauf at the University of Islamabad support that the majority of users who intend to use electricity adopt it immediately during the year following electrification. These connections usually include productive uses such as tubewells, lift pumps, small industries, and essential social services such as basic health, education and drinking water. As a result, Dr. Rauf's work indicated that many inhabitants of electrified villages benefit from the process even if they don't gave electricity in their homes. This suggests that the benefits accruing from the first 10-20 percent of connection saturation are probably larger than from subsequent increases in saturation level.

Once these primary connections are made in a village, the backfilling occurs at a gradual pace and new tubewells, lift pumps, and other productive uses are added as they occur. The majority of backfill connections will be for domestic

use, particularly lighting and some domestic appliances. As new lighting connections are added, kerosene is displaced and this benefit will remain similar between backfilled villages and newly connected villages.

Extending Electrification to Non-Electrified Villages

The arguments for extending the grid to new villages in the face of a backlog in previously electrified villages include:

- The productive and social benefits resulting from electrification appear to be larger for the first increment (10 to 20 percent) of connection saturation than for subsequent increments.

- The political benefits associated with local participation in the village selection process are in themselves an important aspect of the program.

- The extension of the grid provides rural populations with a sense that the government is attempting to be equitable in using electrification resources.

- The overall incremental cost of extending the local grid is not as high as might first appear since the indirect infrastructure requirements are similar for backfill and new village connections.

Of course, these arguments must be compared with the heretofore discussed reduced financial viability of WAPDA resulting from grid extensions to new villages and the possibility of discontent among unelectrified inhabitants of electrified villages who must wait for a connection.

In summary, it appears that a major portion of the economic and social benefits of rural electrification occur within 1 to 2 years of electrification. Many of the benefits accrue to people not even connected to the line by virtue of increased employment opportunities and improved social services (schools, etc.). This provides justification from a national benefit point of view for

Table 6.1

WAPDA TARIFF SCHEDULE

(1981)

	Fixed Charge	Energy Charge		Net Cost*	
		Rs/kWh	¢/kWh	Rs/kWh	¢/kWh
Household Use					
Up to 50 kWh	-	0.34	2.6	0.34	2.6
51-251 kWh	-	0.40	3.1	0.40	3.1
251-600 kWh	-	0.50	3.9	0.50	3.9
Tubewells					
General	19 Rs	0.23	1.8	0.34	2.6
Baluchistan & NWFP	17 Rs	0.16	1.2	0.28	2.2

* Assuming 2000 hr/year operation of tubewells.

emphasizing grid extension to new villages as is now the case. On the other hand, the financial viability of the utility system is improved by backfilling previously electrified areas and more connections can be made for a given level of financial resources.

The facts concerning benefits from saturation of electrified villages vs electrification of new villages are, therefore, inconclusive making judgements difficult to make in this area. Statistics of new vs backfill connections in rural areas do not appear to be readily available. In particular, no differentiation is made between urban and rural household connections. However, connection data obtained in the NWFP suggests that the number of backfill connections in rural areas is, roughly, comparable to connections in newly electrified villages; a ratio which might not be unreasonable at the stage of the program. Given the level of uncertainty in pros and cons of this issue, there does not appear to be a strong basis for greatly modifying this aspect of the program.

The level of uncertainty regarding this issue is, to a large extent, the result of a lack of information on such issues as rates of backfill vs new village connections, cost of elasticity of connection demand, uses of electricity at the village level, and how these uses change as saturation increases. This further illustrates the need for improved data collection, management, and analysis as discussed in Section 6.8.

6.6 Electricity Pricing

The present tariff structure for electricity in rural areas is shown in Table 6.1. The household tariffs shown are the same as in urban areas. The inverted price structure provides poorer families with up to 50 kWh per month for essential services at a low rate of 0.34 Rs./kWh (2.6c/kWh). This rate increases to 0.5 Rs./kWh (3.9c/kWh) for high income families using electricity for a wider range of functions (refrigerators, fans, etc.). The rate structure, therefore, will tend to discourage non-essential use of electricity which is clearly in the national interest.

The major electric load in rural areas is irrigation pumping. The tariff for operation of irrigation pumps are typically in the Rs. 0.28 to Rs. 0.34/kWh (2.2¢/kWh to 2.6¢/kWh) range (including the effect of the monthly hookup rate). From the point of view of the consumer, electrically driven irrigation pumps are a good economic investment at these low electricity rates. This is evidenced by the over 6,000 electric pumps connected annually and the waiting list of farmers who have expressed a desire to connect pumps in already electrified areas.

The present low tariff structure for irrigation pumps is subsidized by commercial and industrial users of power. This complicates the task of estimating the true economics of electrically driven tubewell irrigation from a national benefits viewpoint. It also complicates assessing the probable demand for tubewell irrigation as tariff structures are modified to reflect the rising costs of natural gas and the increasing reliance on oil generated facilities.

As indicated in Section 5.3, however, the economics of tubewell irrigation would remain highly favorable even if tariffs are increased considerably to better reflect the cost of servicing these loads and thereby improve the financial viability of WAPDA. An additional benefit of raising tubewell tariffs would be to encourage more efficient irrigation practices.

That tubewell tariffs could be increased significantly while still maintaining their highly favorable economics is also suggested by the over 100,000 diesel driven wells operating in Pakistan. At present diesel fuel prices (about $1.00/gallon), the effective cost of power based on fuel consumption alone from these diesel engines is, at least, 10¢/kWh; i.e., 3-4 times that of electricity.

The above indicates that modification in the tubewell tariff structure could be implemented consistent with national goals of increasing agricultural productivity.

Determining the appropriate rate structures and how they should vary by region (for example, in Baluchistan, agricultural costs will depend more critically on

rate structures since all irrigation water is pumped), will require examining a range of issues including:

- The existing and marginal cost of supplying electricity to tubewell customers.

- The sensitivity of agricultural economics to tubewell rate structures (by region and crop type).

- The potential for reduced electricity use by virtue of improved pumping efficiency and irrigation practices.

Based on consideration of such issues, policies should be developed which result in rural tariffs and, in particular those applicable to tubewells, which maintain the financial viability of WAPDA without detracting from the critical role of electricity in increasing rural productivity.

6.7 Decentralized Energy Systems

As indicated in Section 3.2, decentralized energy systems could often provide the most economical means of serving remote loads if all the costs of central grid expansion are considered. Furthermore, decentralized technologies may offer the only practical approach for serving many of the over 15,000 villages that are not even being considered for grid connection. Many of these villages are in Baluchistan where regional development will depend critically on supplying power for agricultural, light industry, and mining activities.

A coherent policy toward decentralized power units and their role in Rural Electrification is warranted given the demonstrated potential of conventional technologies and the tremendous promise of renewable energy resource systems. Any such policy, however, must consider that there is presently little infrastructural support for analyzing, implementing, and operating decentralized power units on a widespread basis. WAPDA is responsible for about 80 percent of the national energy budget and must devote its best

managerial and technical resources to the overwhelming concerns of generating capacity and distribution system expansion.

No other single or small group of organizations presently has the combinations of technical and managerial capability to be able to implement a decentralized power system policy on a nationwide basis. As a result, a policy to utilize decentralized energy systems as an integral part of an overall Rural Electrification strategy will require either creating a new organization (such as a Decentralized Power System Authority) or strengthening the capabilities of some combination of existing organizations (DGER, Provincial Development Boards, etc.).

A general policy to incorporate decentralized power systems into overall Rural Electrification planning must address several important issues including:

- How should such systems be financed?
- What rates should be charged to users?
- How will systems be serviced and maintained?
- What criteria will be used to select areas or villages for provision with decentralized power units?
- What level of subsidy (if any) should be provided to decentralized options?

These and other questions must be addressed as part of decentralized energy system policy. These issues must be considered in the context of what is now provided to users of power from WAPDA. For example, newly electrified villages are not (and probably should not) required to pay the marginal cost for power (upward of Rs. 1/kWh). Why then should users of power from decentralized systems be required to effectively pay the marginal cost of power from a non grid connected service?

As suggested above, the implementation of decentralized energy technologies in support of Rural Electrification involves a whole range of policy issues which will have to be addressed at high levels to be resolved.

6.8 Data Collection, Management, and Evaluation

Planning and evaluation of utility operations and overall energy sector planning requires the collection, management, and evaluation of information relative to a wide range of subjects including:

- Number and distribution of connections.
- Energy consumption patterns by connection class.
- Types of loads associated with each connection class.
- Effect of costs on energy usage and connection decisions.
- Socio-economic impacts of electric energy service.
- Line losses (technical and otherwise) associated with each segment of the grid.
- Reliability experience and nature of line failures.

This information is particularly important when considering large expansions of the rural electrification network. It is required to estimate the probable loads on the system and how it is likely to change with time, the effect of electricity pricing policies on demand, the technical requirements of distribution network, staffing at all levels, and priorities for making connections in both newly electrified villages and those electrified in the past, and the economic impact of electrification in different areas of the country.

Information in some of these areas is now sparse within the WAPDA system. It is sometimes collected at the local level but is often not available in a form which makes it useful for planning and evaluation. For example, existing and new household connections are not broken down by rural and urban customers at the national level, although the data to do so is probably available at the local level. Some of this information is not now collected at all by WAPDA since it is not necessary to carry out its day-to-day operations. For example, information on such subjects as economic impacts of Rural Electrification may be required for effective national energy planning and general policy formulation but is not a direct input for electric utility planning.

Extensive data is now being collected on the characteristics of unelectrified villages as part of the Rural Electrification Master Plan which will eventually be computerized to assist in the grid expansion program. This activity will certainly improve the data base and provide the means for more effective planning if associated with a corresponding strengthening of data management and analyses capabilities.

Given the large impact of the rural electric program on economic development, electric sector investment needs, and fuel consumption the issue of further improving the data collection and management system should be one of high priority.

6.9 Management and Operations

Last year WAPDA electrified about 2700 new villages and over 6000 tubewells. This strongly suggests that WAPDA can, in fact, implement a program involving 3000 villages and 5000 tubewells per year as is now the goal of the 6th five-year plan. However, this program could place severe strains on WAPDA which already has management and operations problems system wide resulting, in part, from the rapid system expansion. These problems are referred to in the Rural Electrification Project Paper and summarized in reports prepared by the NRECA. Several of the more important management and operational issues are:

- WAPDA presently has in excess of 85,000 employees and is adding staff at the rate of 7,000 per year. Over 75 percent of the employees are in local distribution which is precisely the emphasis of the rural electrification program. The number of customers per employee is about 52 to 1 which is a factor of 4-10 less than in well run utilities even in other developing countries. To a large extent this overstaffing is actually institutionalized in WAPDA's operating procedures which call for specific numbers of staff in different categories for each increment of customer additions. WAPDA point out, however, that the high level of staffing does not result in labor costs being significantly higher than for utilities in the United States. This is due to low labor rates prevailing in Pakistan and within WAPDA.

- In addition to resulting in higher than necessary labor costs, the high level of staffing tends to create its own inefficiencies and moral problems leading at times to poorer service and poor customer relations.

  It is important that the rural electrification expansion not further exacerbate the level of excess staffing. This will require a review of service and maintenance procedures to ensure that staffing levels are kept within reasonable limits.

- The high level of staffing referred to above is also combined with poor training procedures for staff ranging from supervisory personnel to installation technicians. The latter category are often illiterate and unable to read basic directions and procedural guidelines.

- The staff at the local levels often do not have the proper equipment to operate efficiently--particularly in a rural grid system with a dispersed customer base. This includes a lack of two-way communications capability between field crews and regional offices, vehicles to allow quick access to all areas of the grid, and specialized ladder trucks to allow grid inspection and repair.

- Many commercial operations, such as billing,* are still done manually which results in inefficiencies, contribute to overstaffing, and to a higher error rate.

- The materials procurement, control, and storing processes are inefficient resulting in local shortages of key materials and parts, and the potential for pilferage and graft at several levels.

The above and other management and operations problems are discussed in more detail in consultant reports prepared in support of the Rural Electrification Project Paper and in recommendations made by other donors such as the world

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* In the process of being computerized.

Bank. The AID Rural Electrification Project addresses many of these issues via training programs,* implementation of model warehouses, and technical assistance to operating managers. WAPDA has other programs addressing these issues including the updating of the Commercial Practice "yardsticks", more intense scrutiny of staffing level increase requests, and introduction of computerized billing. Progress is, therefore, being made in improving management and operational procedures, which bodes well for the longer terms.

However, the rapid expansion of the Rural Electrification Program envisioned by the 6th five-year plan could become more costly to implement than necessary if these procedures are not adjusted in a corresponding short time frame. In particular, the recurring costs of the expansion in terms of high staffing levels, high line losses, and excessive use of supplies could be high if these issues are not addressed in a timely manner.

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* Other training programs are being sponsored by the World Bank and the Federal Republic of Germany.

APPENDIX 1-1

INDIVIDUALS MET WITH BY PROJECT TEAM MEMBERS

INDIVIDUALS MET WITH BY PROJECT TEAM MEMBERS

NAME	AFFILIATION
Dr. Roy Renfro	Agricultural Economist Agriculture and Rural Development Section US/AID Mission to Pakistan
Mr. Wadood Ahmed Jilani	Director of Planning Rural Development Wind Ministry of Local Government and Rural Development
Mr. F. I. Malik	Joint Secretary Ministry of Industries
Mr. Izhau-ul-Haq	Chief Energy Cell, Planning Division Ministry of Finance, Planning and Coordination
Mr. A. H. Naseem	General Manager Distribution WAPDA
Mr. Afzaal Khan	Chief of Procurement and Stores WAPDA
Mr. Abdul Majid	Chief Engineer Rural Electrification WAPDA
Mr. Akram Khan	Member of Power WAPDA
Mr. Mohammad Jehangir	Director of Tariffs WAPDA
Mr. Raziuddin Shaikh	Director General Public Relations Division WAPDA
Mr. Shamas-ul-Qamar	Director Planning of SCARPS Electrification WAPDA
Mr. Khalid Saifullah	Director of Standards WAPDA

Mr. Malik Muhammad Ashraf	Chairman Area of Electricity Board and Chief Engineer Gujranwala WAPDA
Mr. Manzoon-A-Sheikh	General Manager of Finance Power Wind WAPDA
Mr. Harold R. Hopper	Chief Design Engineer Pakistan CIDA Hydro-Electric Study
Mr. William E. Bolton	Agricultural Consultant to Agricultural Development Bank Pakistan
Mr. Shahid	Executive Engineer Village Electrification Program WAPDA
Mr. M. Q. Siddiqui	Additional Secretary Ministry of Water and Power
Mr. Mohammad Arshad	Chief Engineer, Planning, Power WAPDA
Mr. Khalid Saif Ullah	Director Standards and Design Office of Chief Engineer WAPDA
Mr. S. T. H. Naqvi	Superintending Engineer Faisalabad Circle WAPDA
Mr. H. A. Blomme	CIDA Project Monitor WAPDA Power Projects
Mr. R. C. Scriban	Project Manager Montreal Engineering Co.
Mr. A. Hafeez Ibrahim	Chief Engineer, Power Control WAPDA
Mr. Mohiuddin Khan	General Manager, Planning, Water WAPDA
Mr. Mushtaq Bhatti	Principle Engineer National Engineering Service (NESPAK)

Mr. Abdul Aziz	Deputy Secretary (Power) Punjab Irrigation and Power Department
Mr. Muzzafar Malik	Agricultural Development Bank of Pakistan Foreign Assistance Program
Mr. C. A. Hafeez	Dep. Managing Director Punjam Small Industries Corporation
Mr. Nasir Saeed Khan	Joint Director Punjab Small Industries Corporation
Mr. Safdar Javed	Dep. Secretary Local Government and Rural Development Punjab
Mr. Anis Naqvi	Director Planning and Development Local Government and Rural Development Punjab
Mr. Tariz Sultan	Additional Secretary Planning and Development Punjab
Mr. Rafi Mohammad Khan	Regional Manager Small Business Finance Corporation Lahore
Mr. Mohammad Parvez Masud	Secretary of Agriculture Punjab
Mr. Fiazullah Qureshi	Chief Economist Planning and Development Sind
Mr. Ghulam Mustafa Abra	Rural Electrification Program Planning and Development Sind
Mr. Kazi	Chief External Aid, Planning, and Development Sind
Mr. Kamaluddin Qureshi	Additional Secretary of Agriculture Sind
Mr. S. N. Posho	Joint Chief Economist Planning and Development Sind

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Mr. Bari	Director General Local Government and Rural Development Sind
Mr. Manzoor A. Khan	Director Agricultural Development Bank Sind
Mr. Imtiaz Rasool	Managing Director Sind Small Industries Development Corporation
Mr. Muzzamal Qureshi	Chief Irrigation and Power Section Planning and Development Sind
Mr. S. M. Arshad Bokhari	Chairman Area Electricity Board WAPDA Hyderabad, Sind
Mr. Manzur Ahmed	Director Technical WAPDA Hyderabad, Sind
Mr. Abdul Ghafoor	Superintending Engineer WAPDA Nawabshah, Sind
Mr. Aijaz Nabi Abbasi	Superintending Engineer WAPDA Succor, Sind
Mr. Juma Khan	Deputy Director Baluchistan Small Industries Corporation
Mr. Saeed Ahmad Khan	Chairman Area Electricity Board WAPDA Wuetta, Baluchistan
Mr. Atta Mohammad Jafar	Secretary Planning and Development Baluchistan
Mr. Ferozuddin Ahmed	Secretary Local Government and Rural Development Baluchistan

Mr. Abdul Jaleel Khan	Chief Water and Power Division Planning and Development N.W.F.P.
Mr. Abdul Latif Khan	Director General Local Government and Rural Development N.W.F.P.
Major Ahmed NawazShinwari	Manager Operation Supervised Agricultural Credit National Bank of Pakistan
Mr. Niels de Terra	Senior Representative IED Consultants Pakistan
Mr. Ken Hoffman	Math Tech

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APPENDIX 2-1

POTENTIAL BENEFITS FROM RURAL ELECTRIFICATION

SOURCE: National Rural Electric Cooperative (NREC) "Social and Economic Benefits of Rural Electrification Cooperatives" (Washington, DC 1978)

1

POTENTIAL BENEFITS FROM RURAL ELECTRIFICATION

Few would disagree that one of the most significant differences between the developing nations of the world and those in which people enjoy healthy, productive lives is the establishment and widespread use of effective electric power systems. The following list of 50 indicators of social and economic benefits demonstrates that rural electrification, as part of a rural development program, can introduce immediate and tangible benefits to the rural population, especially the rural poor.

1. Irrigation system utilizing electric system equipment, tubewells, etc., allowing for multiple cropping.

2. Property formulated livestock and poultry feeds prepared in small mills.

3. Automated poultry processing/breeding systems.

4. Refrigeration of perishable farm agricultural products and utilization of milk coolers.

5. Electrically powered grain drying, processing, storage systems and fumigation.

6. Conservation of export quality timber (electricity replaces wood for cooking and heating.

7. Fish farms in areas where pumps required.

8. Working through his Cooperative provides farmer with some degree of leverage in the marketplace.

9. Agriculture employment opportunities generated.

10. Electrically powered handicraft industries allowing for varied and increased production. (Cottage or home produced items can be made during off-peak seasons of agricultural cycles.)

11. Employment opportunities, especially for women, in commercial non-agricultural industries. (Due to electricity, women with reduced homemaking chores are able to earn much needed extra income either on full-time or part-time basis.)

12. Market/stores utilizing refrigeration. Decrease in spoilage of perishables, especially in tropical areas.

13. Development of small industries to meet created demand for simple electric appliances.

14. Development of industries supplying poles, cross arms, insulators, hardware, meters and transformers for electric distribution systems.

15. Employment opportunities created by Cooperatives, contractors, National Electrification Administration, auditing and accounting firms.

16. Limited school facilities utilized for night classes.

17. Community facilities such as libraries opened in evenings.

18. Wider use of audio visual equipment and materials in schools and adult education programs.

19. Women's routine home chores eased, which allows for daughters to be freer to attend school.

21. Lighted outdoor athletic facilities such as basketball courts allows for community recreation. (Too hot in tropical countries to participate during the daytime.)

22. Teachers more productive and better prepared due to home lighting.

23. Students academically improve. Homework better prepared.

24. Refrigeration of medical supplies by clinics and hospitals.

25. Use of sterilizers and electrical detection equipment in rural clinics.

26. Reliable source of power for hospitals and operating rooms.

27. Home electrical appliances allow for sanitary preparation of food and water. Electric pumps provide potable water.

28. Home refrigeration prevents spoilage of perishable foods and reduces health hazards.

29. Restaurants utilizing electrical appliances and refrigeration reduce health hazards.

30. Correlation of home lighting and decrease in population growth rate.

31. Increased security due to night lighting. Crime rate decreases.

32. Lighted homes provide social benefits.

33. Utilization of radio and television for education, entertainment and leisure.

34. Appliances, such as irons, hot plates, simple washing machines reduce work burden for women.

35. New home construction and improvement results for electrification.

36. Cooperatives provide outlet for community and national participation by rural population. Provides experience in management and democratic decision-making.

37. Improved and increased craft production in addition to economic benefits, enhances the cultural and aesthetic values that craftsmen and crafts tradition mean to a nation (national pride).

38. Cooperative institution, organization and facilities utilized for members' services (Better Family Living) such as family planning, crafts, home economics.

39. Change in social well being. Index of satisfaction with one's current situation improves. New confidence.

40. Keeps the economic proceeds of a region invested locally.

41. Accelerates the monetization of the rural society.

42. Stems rural migration to cities and improves rural-urban balance. Increased rural economic activity absorbs expanding rural labor force.

43. Decentralizes economic activity.

44. Rural population participating in a "self-problem solving" climate rather than a "depending on the government" climate.

45. Increased net tax revenues to government.

46. Leveling of ethnic differences.

47. Improved citizens-government relationship.

48. Reduced socioeconomic imbalance in the population.

49. Expanded communications system to entire population. Government able to communicate with its citizens.

50. Reduced foreign exchange expeditures for kerosene and oil used for lighting, cooking and heating. (A central generator is a much more efficient method for supplying energy, rather than each household purchasing fuel.)

APPENDIX 3-1

TERMS OF REFERENCE FOR LOCAL CONSULTANTS PREPARING MASTER PLAN

SOURCE: Project Paper - Rural Electrification, September 1982, USAID.

TERMS OF REFERENCE OF WAPDA CONTRACTS WITH LOCAL A/E FIRMS THAT ARE ASSISTING WITH THE PREPARATION OF A NATIONAL RURAL ELECTRIFICATION MASTER PLAN

1. To make maps of all those villages of Pakistan on reproducible paper using a scale of 1:50,000 which have population more than 1,000 in Punjab and Sind and more than 300 in NWFP and Baluchistan.

2. To identify the villages by provinces, divisions, districts and tehsil and to computerize 1961 and 1972 Census data according to WAPDA formats.

3. To conduct socio-economic and technical surveys covering:
   a) 500 household interviews.
   b) 50 village surveys.
   c) 60 case studies of small industry and tubewells.
   d) Consumption data of about 500 consumers of different categories.
   e) Consumers and network data from subdivisions.
   f) Data on existing electric and diesel operated tubewells, and to computerize all the above data according to WAPDA formats.

4. To forecast the population and numbers of households for the project periods of ten years on annual basis for the first 10 years and for the 20th and 30th year.

5. To develop energy consumption, peak demand, bulk supply and revenue forecasts per district for the first 10 years on annual basis and for the 20th and 30th year.

6. To update the maps of the existing 11 kV system and grid stations, indicating conductor sizes, transformer capacities in respect of 11 kV system, along with supplying technical data of concerned grid stations.

7. To plan and mark the proposed network of Distribution System to be constructed for the purpose of electrifying the villages along with extension and augmentation of allied existing 11 kV system including proposals for re-routing/bifurcation of the existing distribution lines wherever necessary. The plans for SCARP electrification will also be incorporated.

8. To determine year-wise load demand of grid stations, secondary transmission lines and generating station for the project period.

9. To identify the following areas in the plan:
   i) Sweet sub-soil water and agricultural potential.
   ii) Under developed areas.

10. To prepare village-wise cost estimate for electrification along with schedules for materials and cost estimates per district.

11. To conduct financial, economic, socio-economic and environmental analyses similar to those conducted under feasibility studies under USAID, per district.

12. Computerization of final results of each master plan report according to WAPDA formats.

13. The Consultant will prepare and provide to WAPDA base maps to scale 1:50,000 so that WAPDA may prepare SEPIA copies within fifteen days. After the existing system has been worked out and checked, the reproducible maps to scale 1:50,000 will be submitted to WAPDA so that WAPDA may prepare SEPIA copies within 15 days and return the maps to the Consultant for preparation of Master Plan.

APPENDIX 3-2

CONSTITUTION AND FUNCTION OF THE SIND "DISTRICT VILLAGE ELECTRIFICATION ADVISORY COMMITTEE"

SOURCE: SIND Government Gazette Printed at SIND Government Press.

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The Sind Government Gazette

PUBLISHED BY AUTHORITY

KARACHI, THURSDAY, APRIL 17, 1980

PART I

GOVERNMENT OF SIND

IRRIGATION AND POWER DEPARTMENT

Karachi, the 17th April, 1980

NOTIFICATION

No. SOPP-3/49-74.—In supersession of this Department's Notification, of even number, dated 3rd April, 1979, the Government of Sind, are pleased to further re-constitute District Village Electrification Advisory Committees, in Sukkur and Hyderabad, Divisions:

PART—I

THE CONSTITUTION:

The Constitution of the Committees shall be as under:

I. *For Each District in Sukkur Division*:

1.	Deputy Commissioner	Convenor.
2.	Chairman District Council.	Member.
3.	Chairmen of Taluka Councils (all).	"
4.	Assistant Commissioners (all).	"
5.	Assistant Director Local Government Department.	"
6.	Executive Engineer, Construction Division WAPDA, Sukkur Circle	Member/Secretary.

II. *For Each District in Hyderabad Division*:

1.	Deputy Commissioner.	Convenor.
2.	Chairman District Council.	Member.
3.	Chairmen of Taluka Councils (all).	"
4.	Assistant Commissioners (all)	"
5	Assistant Director, Local Government Department	"
6	Executive Engineer Construction Division WAPDA, Hyderabad Circle	Member/Secretary

PART--II

THE FUNCTIONS:

The functions of the Committees shall be as under:

(1) To recommend names of villages in order of priority for inclusion in the Annual Village Electrification Programmes in their respective districts.

(2) While making such recommendations, following criteria fixed by the Federal Government, shall be taken into consideration.

(i) Population of the Village;

(ii) Distance of the village from the existing 11 KV Distribution line;

(iii) The requirement of Power for Irrigation Tubewells; and

(iv) Potential for development of cottage and Agro based Industry.

(3) The recommendations shall be forwarded to the Government, in the Irrigation and Power Department through the DIVISIONAL CO-ORDINATION COMMITTEE, concerned.

(4) While forwarding the lists of villages, following information must invariably be indicated in case of each village;

(i) Present authenticated population;

(ii) Names of Deh and Taluka;

(iii) Distance in Kilometers from the existing 11 KV Distribution line.

(iv) Estimated cost of village electrification.

(5) The recommendation must reach atleast three months before the begining of the next financial year for which proposals are made.

The proposals for coming financial year 1980-81 must however be sent before end of May, 1980.

(6) Each Committee shall formulate its own programme and procedure for its meetings etc, and may co-opt any other official member if necessary

A. W. F. SHAIKH,
Advisor (Technical)/
Additional Chief Secretary, I & P.

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