PN-ABE-957

65216

BANGLADESH RURAL ELECTRIFICATION:

PRELIMINARY ASSESSMENT

FINAL REPORT

PREPARED FOR

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
DHAKA, BANGLADESH

UNDER CONTRACT NO. 388-0249-C-00-9120

Prepared by

deLUCIA AND ASSOCIATES, INC.
THE CARRIAGE HOUSE
5 HASTINGS SQUARE
CAMBRIDGE, MA 02139

(617) 576-0646
TELEX: ITT 4944478
FAX: (617) 547-4286

NOVEMBER 1989

ABBREVIATIONS

BADC - Bangladesh Agricultural Development Corporation
BARC - Bangladesh Agricultural Research Council
BBS - Banagladesh Bureau of Statistics
BHP - Brake Horse Power
BRAC -
BSEC - Bangladesh Steel and Engineering Corporation
BKB - Agricultural Development Bank
BPDB - Bangladesh Power Development Board
BST - Bulk Supply Tariff
BSCIC - Bangladesh Small and Cottage Industries Corporation
BWDB - Bangladesh Water Development Board
CDSS - Country Development Strategy
CNG - compressed natural gas
CSIR - Council of Scientific and Industrial Research, New Delhi
DSSTW - Deep Set Shallow Tube Well
DTW - Deep Tube Well
IBRD - International Bank for Reconstruction and Development
IFPRI -
kW - kilowatt
kVA - Kilovolt Ampere
LLP - Low Lift Pump
LRMC - Long Run Marginal Cost
M/E - Monitoring and Evaluation
MW - megawatt
MB - Megabyte
MIS - Management Information System
MOA - Ministry of Agriculture
NRECA - National Rural Electrification Cooperatives of America
P&L - Profit and Loss
PBS - Rural Electricity Cooperatives
PURPA - Public Untilies Regulatory Power Act
RE - Rural Electrification
REB - Rural Electrification Board
SQL - Standard Query Language Used for Programming Database Applications
SRMC - Short Run Marginal Cost
STW - Shallow Tube Well
TA - Technical Assistance

NOTE

Numbers in brackets, [ ], refer to documents listed in the bibliography in Annex I

Table of Contents

I. Pre-assessment of Social and Economic Impacts of Rural Electrification in Bangladesh 1

1. Purpose of Pre-assessment 1

2. Findings and Conclusions 2

3. Approach 5

4. Problems with Earlier Surveys 7

5. Description of the Current BPDB/REB/PBS System 8

6. Benefits of Rural Electrification 12
   - 6.1 General Role of Electricity in Development 12
   - 6.2 Household Uses and Street Lighting 14
   - 6.3 Electrified Irrigation 16
   - 6.4 Rural and Cottage Industries 18
   - 6.5 Commercial Uses 22
   - 6.6 Impact on Family Planning 22
   - 6.7 Environmental Impacts 23
   - 6.8 Finance and Management 24
   - 6.9 Management Issues 26

7. Recommendations 28
   - 7.1 Future Expansion of the System 28
   - 7.2 Pricing 29
   - 7.3 Organizational Objectives 30

8. General Conclusions 32

II. Scope of Work For a Comprehensive Impact Assessment 34

1. Purpose of the Assessment 34

2. Structure of the Survey Components and Survey Instruments 36

3. Site Selection and Sampling 37

4. Organization of the Survey 39

5 Training 40

6. Data Analysis and Reporting 41

7. Scheduling 42

8. Survey Budget 42

Attachments 43
Preliminary Budget for Rural Electrification Assessment 43
Issues and Hypotheses to be Tested 45
Data to be Collected and Use of Secondary Sources 47

III. Development of a Socio-Economic Monitoring and Evaluation Activity Within REB 52

1. Current Activities of the Rural Electrification Board 52

2. Role of the Evaluation Division 52

3. Additional M/E Activities 58

4. Staffing and Equipment Requirements 60

5. Conclusion 61

Annexes

I. Annotated Bibliography

II. REB Historical Demand Data

III. Financial Performance Data for the PBS's

IV. Choice of Technology for Shaft Power

V. Impacts on Rural Industry

VI. Households

VII. Irrigation

VII. Survey on Household Willingness-to-Pay

IX. Techno-economic Assessment of Diesel Versus Electric Sources of Mechanization

X. Decision-Making in the Selection of Energy Sources

EXECUTIVE SUMMARY

The Rural Electrification Program in Bangladesh was established over a decade ago. Since then the program has grown considerably and now encompasses some 186 Upazilas and 40 cooperatives (PBS's). Donor support has also increased and broadened as the program has demonstrated its success in extending electric services to the rural areas. From a financial and engineering perspective, the program has been closely monitored and the results reported in the quarterly reports of both the Rural Electrification Board (REB) and the technical consultants (NRECA). From the social and economic perspective, much less is known. While several surveys of the impacts of the program have been performed beginning with a Baseline Survey in 1983, no comprehensive effort has been undertaken to evaluate the socio-economic impacts of the program.

This pre-assessment has three specific goals; to develop some preliminary findings regarding the social and economic impacts of the program for inclusion in the planning effort associated with the CDSS; to prepare terms of reference for a more comprehensive assessment to be performed in the near future; and to devise a system for the REB to monitor and evaluate the socio-economic impacts of the program. This report addresses each of these as well as specific questions posed by USAID regarding the impacts of the RE program on agricultural productivity, rural industrial growth and employment, cottage industries, social well-being, family planning and equity. The pre-assessment was also to examine the complementary inputs required to achieve significant impacts from the introduction of electricity and to judge the financial and economic viability of the project. Since the time given for this effort was short, it was necessary to rely on secondary sources, interviews and micro-surveys to develop responses to these questions and to meet the goals of the pre-assessment.

Electricity offers significant amenities to rural households and improves access to production technologies which can reduce the costs and improve the product quality of rural industries. It also offers commercial establishments improvements in their working environments and in the services and products they can offer. The issue to be considered when evaluating the social and economic impacts of a rural electrification program is not whether the electricity provides these benefits, but whether the timing of the introduction of this infrastructure was appropriate. Rural development cannot take place without some form of rural energization but there is a question of whether this should come first from the electric grid, from autogeneration or from other sources.

Within the context of development, electricity is a form of infrastructure. Its importance to the development process is not disputed but its contribution is often

intertwined with the provision of other infrastructure, both physical and social, and with the nexus of other factors influencing development. Therefore, the benefits solely attributable to electrification are difficult to quantify.

The introduction of grid electrification should follow the development of other infrastructure such as roads and markets in order that there will be sufficient demand for electricity during the initial years following energization. The Bangladesh program has been extremely successful in this regard. The site selection process has explicitly incorporated the level of development of a potential site in its criteria. The areas so far selected have represented extensions of the existing grid into areas which have good transport, central markets and some amount of mechanized rural industries. The RE program has provided these areas with a reliable source of electricity, has made hookups with little delays or irregularities and has, in most cases, collected payments for the electricity in a timely manner.

Therefore, our primary concern in evaluating the Rural Electrification program in Bangladesh is to determine whether there was sufficient demand within a reasonable period to insure financial viability. The economic viability is assumed since the utility attached to the availability of electricity is greater than the amount paid for that electricity in all cases and the economic costs, as measured by the LRMC, are comparable to current charges, except for households and for irrigation. For the former, the willingness-to-pay is thought to be considerably above the tariff, but for the latter, the use of electricity does not appear economically justifiable.

The success of the RE program is confirmed by the financial performance of the PBS's. Almost all are able to meet their operating costs and are expected to be able to pay back their debt. The five year grace period for the first 18 PBS's is now completed, but, for some, the period has had to be extended another two years. Despite the delay in servicing their debt, the financial performance of the PBS's continues to show a positive trend. There is little doubt that the majority of the PBS's will be able to meet their debt service if priority is given to this activity rather than to setting up of a sinking fund for depreciation.

The marginal impacts of the introduction of electricity on productive uses have been relatively small. This is not due to a lack of economic activity associated with the RE program but rather to the fact that the BPDB formerly provided a basic service to the major rural markets which are now served by the RE program. The BPDB served most of the large industrial and commercial loads, albeit less reliably and with poorer financial results, that the REB currently serves. It was also in a position to provide electricity to most of the new commercial and industrial loads which have developed since the RE program was established. Furthermore, the use

of diesel engines represents a readily available substitute for electric motors in many industrial activities as well as in irrigation. As a result, the benefits are limited to savings in costs relative to the use of the BPDB and diesel engines.

Other economic impacts are harder to measure but perhaps more important. The country benefits from better pricing of electricity (through better enforcement of tariffs) and lower cost access (through better enforcement of policies and procedures for connection). The industries and the commercial establishments in the market places benefit from a more reliable source of electricity. The broader coverage of the REB system allows the development of village-oriented and cottage industries by lowering the cost of production or improving the quality of the product. Domestic consumption provides a benefit to the consumer well in excess of the rates paid. The household are willing to spend considerable amounts on housewiring and appliances. Amounts much greater than the price paid for the electricity consumed. These benefits have not been explored with any precision in earlier studies of the program.

The specific social and economic benefits that rural electrification provides to individual sectors can be addressed qualitatively since quantitative data is hard to come by. The impact of electrification on rural industry has been to attract industries to the rural areas. The availability of electricity is often a pre-requisite for footloose industries when deciding where to locate their production facilities. These industries provide rural employment for both men and women and thus contribute to rural economic development.

Other industries process local resources and/or provide goods and services to the local markets. For these industries, the ability to use electric equipment to lower production costs or improve product quality provides the marginal producer with the opportunity to make a profit. In this way, electricity promotes the establishment of new industries. These industries provide not only employment but also better and/or less costly goods and services to the rural population.

The benefits of rural electrification on agriculture are associated with better processing of crops and greater use of irrigation. The former is part of the benefits to rural industry. The latter are associated with the introduction of minor irrigation schemes using mechanized pumping. Although diesel and electric pumps provide a similar level of performance, the lower financial cost for electric pumping has increased the number of pumps by reducing the break-even point. On the other hand, the seasonality of pumping has resulted in a peak in electricity demand which is very expensive to serve. As a result the economic costs of electric pumping are

thought to be greater than diesel pumping when the electricity is valued at its long-run marginal cost.[1]

The impact of rural electrification on cottage industry and commercial activities is not well understood. There appears to be general agreement that the primary use of electricity is for lighting and that this permits the hours of operation to be extended while reducing the drudgery of the work. While this may improve the quality of the product or the service, it also increases the cost. The benefits appear only when complementary developments in economic development have created a demand for better services and products.

The impact of rural electrification on family planning has been much discussed but rarely evaluated with any rigor. More direct impacts result from increases in female employment, improvements in health and child morbidity, access to knowledge of contraceptive technologies, and increases in household income. The availability of electricity can contribute to these factors and thereby have an indirect impact on family planning. It is these indirect relationships which are thought to result in the correlation between the reduction in family size and the availability of electricity. The introduction of electricity, *per se*, should have no impact on family size or the desire for children.

The impact of rural electrification on women is positive in that it contributes to the establishment of rural industries in which women are employed and eases working conditions for crop processing and cottage industries. Rural households rarely have the income to afford "labor-saving" devices for other domestic chores such as cooking or water pumping.

The impact of rural electrification on the environment is expected to be small. The development of the distribution system does not have deleterious effects on the immediate environment. The productive activities which use electric equipment to process local non-renewable resources will create some environmental stress, but there are alternative methods for processing these same resources, so the contribution of electricity to this problem is marginal.

---

[1] This conclusion is mitigated by two factors. First is the accuracy of the economic cost for electricity which were developed several years ago by Coopers and Lybrand. The second is the proposed introduction of time-of-day metering which would help to reduce the coincidence of the seasonal and daily peaks for irrigation loads.

The equity benefits of rural electrification are significant. RE provides better lighting and communications for the rural household at a price comparable with that incurred by urban consumers. It also attracts additional industrial activity and employment to the rural areas.

Perhaps the most important contribution of the RE program is the institution-building which has resulted from the establishment of the REB/PBS organization. The success of this organization in managing a large-scale procurement activity, developing an efficient service organization, controlling costs and monitoring financial performance is widely recognized throughout the country and the donor community. The potential for continuing to expand while maintaining the quality of this system appears good, however, additional TA will be helpful in this area.

In terms of future USAID participation, the results of the pre-assessment indicate that the current efforts are well thought out and should be continued. Additional support of the management activities in the form of continuing TA is strongly recommended especially as the REB and other donors push for the expansion of the system into less developed parts of the country. Commodity assistance is recommended for continued intensification of the services in the older PBS's. Other donors will undertake higher risk ventures which extend the coverage of the system, but the contribution of USAID to consolidating the position of the older PBS's and insuring their financial viability is more important for the health of the total system.

While the qualitative answers presented above should provide a basis for continued support of the RE program, more quantitative information is needed to support future planning of the system. This quantitative data can be obtained through two mechanisms. The first is a full-scale assessment which includes a survey of domestic and productive users of electricity in the rural areas. The survey would provide more detailed information about the benefits to different classes of users. This survey would provide input to the on-going decision process and serve as a necessary building block for the proposed social and economic monitoring activity of the REB. The second is an on-going social, economic and technical evaluation activity instituted within the REB with the twin tasks of monitoring the services provided and promoting/planning future services. The REB needs this capability in order to evaluate past and planned activities both within the national context and in comparison with efforts in other countries. This capability is critical if the program is to expand into new areas and to do so at a reduced cost and more equitably.

CHAPTER 1

PRE-ASSESSMENT OF SOCIAL AND ECONOMIC IMPACTS OF RURAL ELECTRIFICATION IN BANGLADESH

1. Purpose of Pre-assessment

As part of the Rural Electrification III Project, a pre-assessment of the project's social and economic impacts was undertaken by the consultants.

This effort had three specific tasks as follows:

a. To conduct a preliminary assessment for the CDSS based on secondary sources of information and some preliminary field work;

b. To develop the Terms of Reference and budget for a subsequent full-scale study of socio-economic impacts to include a comprehensive field survey;

c. To propose a methodology for developing Rural Electrification Board's (REB) institutional capability for monitoring and evaluation.

The first task was to identify and briefly examine the more direct quantitative and qualitative impacts of the Rural Electrification Project. The following specific impacts were to be addressed:

1. The impact of electrified irrigation on productivity, output, incomes and employment of men and women in the agricultural sector;

2. The impact of electrification on the small-scale industrial and commercial sectors in terms of productivity and production of existing and new enterprises, and on the employment of men and women;

3. The impact upon household economic activity, particularly cottage industry production and employment;

4. The impacts upon family planning decisions and fertility rates;

5. The impacts upon social well-being, including education, health, leisure time, and availability of social services;

6. The equity effects in terms of (a) affordability of services and (b) distribution of benefits between areas.

In assessing these impacts, the main complementary conditions and development activities that create the conditions for an effective contribution of rural electrification to development were considered.

The first task also included an examination of the role of subsidies and other financial support in relation to the overall costs and benefits of rural electrification. In this regard, the potential for economic viability and financial self-sustainability was also to be assessed.

The second task was to assist in planning for a full-scale assessment of the socio-economic impacts of rural electrification. This assessment would include a survey which would collect the additional information required for a proper evaluation of the RE program's socio-economic impacts. This information was also to be used in planning USAID's contribution to subsequent phases of the project.

The third task was to review the REB's current monitoring and evaluation activities and to propose a simple system for monitoring future socio-economic impacts which could be incorporated into REB's ongoing monitoring function.

2. Findings and Conclusions

The principal conclusions of this pre-assessment are as follows:

1. The benefits of rural electrification are only one of the contributing factors to development. The complementary nature of development activities and inputs makes it difficult to separate out the impacts of rural electrification except in cases where there are clear substitutes for electricity.

2. The benefits provided by rural electrification are significant only where the general level of development has reached a point where the latent demand for electric equipment and appliances is significant. The REB's site selection procedure, which emphasizes development as a precondition to energization, is a key to the success of the current program.

3. The current demand for electrified irrigation leads to almost a doubling in the level of consumption during the four months when pumped irrigation is used intensively. Since the time of irrigation extends into the early evening, this also affects the daily peak. As a result, the capacity of the REB distribution

network and the BPDB generating capacity must be designed for this peak load.

4. In irrigation there is a clear substitute for electricity in the form of diesel engines. The current market prices for electricity and electric motors are lower than for diesel engines and diesel fuel. This has led to a rapid increase in electrified irrigation. However, the economic costs are higher for electric pumping because of the capacity costs associated with the seasonal peak.[2] The seasonal nature of irrigation has also led to an increasing use of portable diesel engines which can be redeployed to transport or other productive uses during the off-peak periods. As a result the benefits of RE for irrigation are small and in economic terms are less than the cost. This situation is expected to improve somewhat with the introduction of time-of-day metering.

5. In rural industry, the availability of electricity is a key factor in the location of industry. Diesel engines provide a less desirable form of shaft power. As a result, many industries will incur additional transport costs for collection of their raw materials and distribution of their products in order to locate in an area where electricity is available. Since rural industries tend to congregate in primary markets which were previously served by BPDB, the net benefit of the REB program has been relatively small. It will be many years before the market places that are recently electrified will reach a level of development that allows for the formation of rural industries other than small-scale crop processing activities or simple metal working services.[3]

6. Little is known about the impacts of electricity on commercial activities or cottage industries. The main contribution of RE is lighting which in some cases allows for extension of operating hours into the evening. However, a serious study of this phenomenon has yet to be made. It is difficult to understand how the electricity contributes to an increase in demand for the services of commercial establishments and the products of cottage industries.[4]

---

[2] These are primarily capacity costs for the distribution network. The peak in demand for generation associated with irrigation loads is not as significant.

[3] Programs for integrated rural development may speed this process, but these industries remain dependent on the growth in local economic activity.

[4] In this regard, M.S. Uddin mentions the saying, "Electricity enables more baskets to be woven at night, but not more baskets to be sold by day."[32]

7. The benefits of rural electrification to households are significant as measured by their willingness to invest significant sums for a household connection and for electric appliances. The traditional measures of benefits based on the costs of alternative sources of lighting and communications appear to underestimate the benefits the connected households attach to the availability and use of electricity. These measures are more relevant for the decision-making in those households which are not connected. Once connected, the value attached to that electricity appears to be considerably higher.

8. Where there are cottage industries or other productive uses of electricity in the household, then the willingness-to-pay for connection and for consumption are both higher.

9. The REB, by providing a more reliable service and by requiring f payment for the services delivered, provides a significant benefit to the natio:. It is able to insure better allocation of resources by requiring the consumer to pay for the electricity used and it reduces the level of government subsidization through its pursuit of financial autonomy.

10. The financial performance of most of the PBS's is improving and it is likely that in the future most will be able to meet their debt service. Thus a reduction in subsidies and a growing financial autonomy is anticipated for most of the organizations. There is no indication that the most recently energized PBS's will be any less financially strong than the older PBS's after they have matured.

11. The role of USAID in the future development of the RE program should build on past strengths while at the same time acknowledging the growing participation of other donors. The USAID contribution should focus on three areas; technical assistance, institution building and commodity assistance. Technical assistance should continue, but more emphasis should be placed on promoting autonomy in the older PBS's. The institution building should be directed at improving the REB's capabilities in monitoring and evaluation and demand promotion. Commodity assistance should continue to focus on the intensification of existing systems, but should expand this activity to include all of the PBS's established before FY86 regardless of who the original funding agency was.

3. Approach

The pre-assessment of the impacts of the rural electrification program began by separating these impacts into five categories based on the uses and users. These were:

1. rural industry
2. irrigation
3. commercial uses
4. cottage industries
5. household uses and street lighting

The impacts of the RE program on women, the environment, family planning and regional equity were then added to the list. Because of the breadth of these categories, a literature search was undertaken of recent reports covering rural industry, agriculture/irrigation and family planning. A list of the literature consulted is presented in Annex 1 along with an annotated bibliography of those documents specifically concerned with the RE program.

Particular attention was given to surveys performed to measure the impacts of the RE program beginning with the 1983 baseline survey. Although the quality of these surveys has improved over time, none has examined the causal relationship between the introduction of electricity and changes in rural activities. Therefore, a series of three micro-studies was initiated to examine these relationships. These three covered:

1. a household survey of the willingness-to-pay for electricity,
2. a techno-economic survey of the substitutability of diesel engines and electric motors[5], and
3. a rural industry survey of the choice of energy technology.

The first micro-survey was designed to determine if the willingness-to-pay of the household could be directly measured. A structured close-ended questionnaire was used for this purpose and was found to be a successful technique for soliciting this information. The survey results appear to support the hypothesis that there are significant differences in the decision to connect and the decision to use electricity; and that the factors affecting the willingness-to-pay for these two also differ. The decision to connect is very much affected by the level of development in the area,

[5] Gasoline and natural gas motors were excluded from this effort since they are not currently used in the rural areas.

which affects not only the value the consumer places on the electricity but also the ability-to-pay of the consumers. For non-connected households, the comparison between the current costs of kerosene lighting and the cost for connection and housewiring was the major consideration in not using electricity. For the connected households, the level of use was determined by appliance ownership rather than any consideration of previous fuel budgets. For these households, the value attached to consumption of electricity was found to be considerably higher than the current tariff.

The second micro-survey was meant to determine the benefits provided to rural industry and irrigation though electrification of shaft power which could not have been obtained through the use of diesel engines. The survey used an engineering economics approach. It revealed that not only do electric motors have certain performance characteristics which make them superior to diesel engines in many applications, but they are also less expensive to own and operate at current market prices.

The third micro-survey was designed to determine the factors affecting an entrepreneur's choice of production technology as well as the factors that lead to the establishment and siting of the industrial activity. An open-ended questionnaire was used to interview the owners and operators of different types of rural industries. Most of the industries surveyed were established after electricity was available since the area surveyed had been electrified by BPDB long before the arrival of REB. The survey results confirmed that the location of an industry was determined by a number of factors other than electricity, including the location of markets and raw materials, the availability of land, central marketplaces and good road connections, and the proximity to the traditional home. These interviews also provided an insight into the gestation period required before the industries are established in response to electrification. This period is thought to be related to the general rate of economic development in the area rather than only to the introduction of electricity.

Because these micro-surveys were limited in scope, their main function was to pretest sections of questionnaires and gather reference data from which to develop a survey methodology. The results including the pretested questionnaires are presented in Annexes VIII to X.

As a final component of this study, the historical data on demand for electricity and the financial performance of the PBS's were computerized. The resulting database, which has been turned over to REB, was used to analyze the changes over time in the demand for electricity by class and the trends in financial performance by PBS. The former provides useful information both for planning

future requirements and for evaluating pricing alternatives. The latter provides an indication of the future financial performance of the PBS's especially as they relate to the ability to meet their debt service. The contents of these databases and some preliminary analysis are presented in Annexes II and III.

4. Problems with Earlier Surveys

A review of earlier survey work on the impacts of the RE programme in Bangladesh has pointed towards three principal weaknesses:

a. problems of methodology,
b. reliability of results, and
c. relevance of results to the proposed assessment.

Most of the surveys have attempted to produce "random samples" on which to base their statistical analysis. However, neither the method of surveying nor the data analyzed has proved very enlightening. The surveys have all employed structured interviews with close-ended questionnaires. These questionnaires incorporate standard questions regarding income, employment, household characteristics and agriculture activities. To these are grafted a simple set of questions regarding energy use and perceptions of changes resulting from electrification. The questions regarding personal perceptions are not followed up with attempts to determine the basis for these perceptions or even for the individual's response. What is more, the bias in these efforts has to be assumed relatively high since much of the survey work was done for the REB or the donors and the respondents were informed of the purpose of the survey.

Once the data was collected, simple statistical comparisons between the "haves" and the "have-nots" were performed or the ritual of regression analysis was used to establish weak correlations. No attempt was made to develop and test hypotheses about how and why the introduction of rural electrification affected both productive and non-productive activities. This is a particularly important problem because most of the measures employed in evaluating the benefits attributable to rural electrification are general measures which can be affected by a wide variety of development activities as well as an underlying trend of economic growth.

The marginal contribution of electricity to productive activities was never addressed nor was the economic utility of better lighting delved into at the household level. Indeed, outside of some baseline data and a knowledge of appliance ownership, there is little hard information about the quantifiable benefits of rural electrification that can be obtained from these surveys. Nor can the information collected concerning social benefits be considered reliable. While the responses indicate that

people who use electricity feel better about their lives, their responses do not provide the more critical information as to:

1. How good they feel relative to other improvements in their lives?

2. How much they would be willing to give up other goods and services to have electricity?

3. How much of the improvement in the quality of their lives (as measured in education, health, ownership of goods, strength of inter-personal relationships and community structure) has been achieved because of electrification rather than other development activities?

The answers to these questions can only be guessed at from anecdotal information. Before examining the impacts of rural electrification, it is useful to review the structure of the program as introduced in Bangladesh

5. Description of the Current BPDB/REB/PBS System

The Rural Electrification Program (RE) purchases power generated by the Bangladesh Power Development Board (BPDB), distributes it through the network developed by the Rural Electrification Board (REB) and sells the power through cooperatives (PBS's) which also constructs the local distribution system.

The BPDB is responsible for power generation throughout the country. It sells electricity to the REB from its 33 kV lines at the 11 kV side of step-down transformers. For this electricity it charges its Bulk Service Tariff (BST) which is currently 1.28 Taka per kilowatt-hour.

The role of REB as set out in its ordin , is:

a. "To establish electricity generation, transmission and distribution systems in the rural areas of Bangladesh"
b. "To organize the prospective consumers into formal and informal groups, such as PBS's, electric and other cooperatives, societies, associations and companies for the purpose of execution and management of schemes and providing related services" [4,p.3]

The REB currently employs a staff of 703 which are involved in all phases of system design, procurement, operation and financial management. The REB receives loans from the Government of Bangladesh (GOB). It uses the funds to construct the distribution networks for each PBS. The cost of the network is then paid for by each PBS in the form of a mortgage. The terms of these mortgage are

similar to those used in the loans to REB from GOB and are stipulated in the Uniform On-Lending Terms.

Each PBS is an independent corporate body which according to its bye-laws is:

(a) responsible for the efficient and effective management of its affairs, including proper and successful construction, operation and maintenance of its electric distribution facilities;
(b) expected to repay all indebtedness on schedule according to the terms of its loans agreement and established policy." [4, p.3]

The REB is expected to assist in the development of the resources and abilities of each PBS so that they will be able to:

> "meet its needs, handle its own affairs effectively, and achieve as soon as possible the internal strength and soundness to assure its success as an independent enterprise." [bye-laws, 4,p.3]

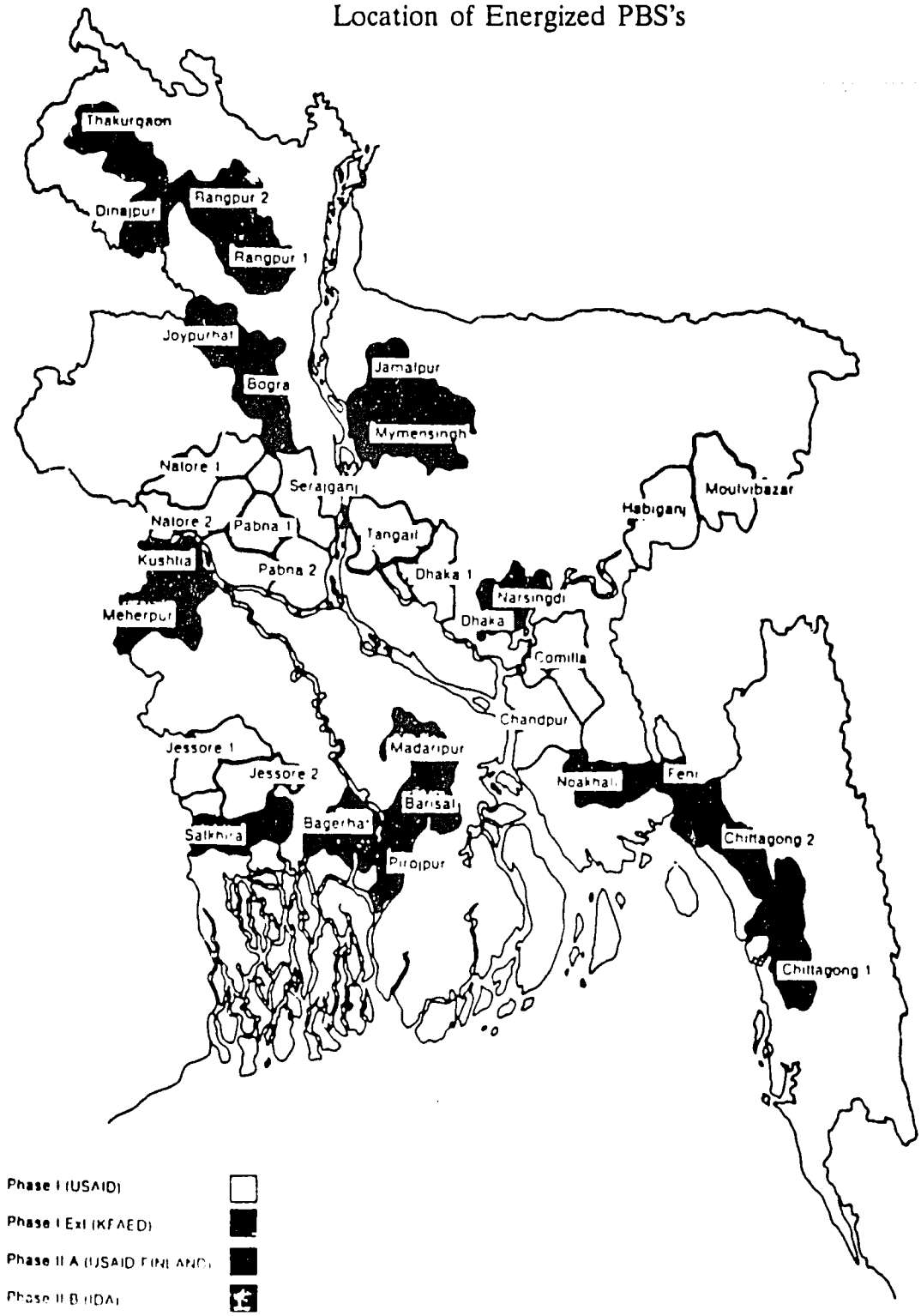
Therefore REB's assistance to the PBS is expected to diminish as the PBS develops.

At present there are 33 PBS's which are distributing electricity and 7 additional PBS systems under construction. These 40 PBS's will provide service to 186 Upazila. The currently energized system is shown in Figure 1. The connections in this system include 315 thousand households, 56 thousand small commercial users, 7.6 thousand industries, 14.4 thousand irrigation pumps, and 2.9 thousand street lighting systems. The industrial hookups account for about 43% of the total consumption. Households and irrigation pumps are next each consuming about 25%. Small commercial establishments consume only about 7% of the electricity supplied and street lighting less than 1%.

The PBS's set their own tariffs for the electricity supplied to the coop members, however, their autonomy in this area is severely limited. The covenants of the donor's loans to the GOB for this program stipulate that the tariffs should not be less than the BST rate. The GOB stipulates that the PBS tariff must be comparable to the BPDB tariffs where they serve adjoining areas. In addition, the REB also monitors the tariffs and indicates where they are unreasonable. Finally, the PBS is constrained by the requirement to meet its operating expenses and eventually its debt service. As a result, the tariffs of individual PBS's are very similar. The range of tariffs is shown in Table 1.

Figure 1

Location of Energized PBS's



Source : Coopers and Lybrand Report

Table 1

Typical Tariffs in the PBS's at the Beginning of FY90

Category		
Domestic	First block (70-125 kWhr/month)	1.45-1.55 Tk./kWhr
	Second block (up to 200 kWhr/month)	1.65-2.05 Tk./kWhr
	Thereafter	2.55 Tk./kWhr
	Minimum Charge	25-30 Tk./month
	Meter Charge	2.5 Tk./month
Commercial	Energy Charge	2.35-2.55 Tk./kWhr
	Capacity Charge	5 Tk/kW
	Minimum Charge	25-30 Tk./month
	Meter Charge	5 Tk./month
Industrial (A)	Energy Charge	2.45-2.55 Tk./kWhr
	Capacity Charge	50 Tk/kW
	Minimum Charge	500 Tk./month or 20 Tk/kVA
	Meter Charge	125 Tk./month
Industrial (B)	Energy Charge	2.55-2.80 Tk./kWhr
	Capacity Charge	10 Tk/kW
	Minimum Charge	100 Tk./month
	if load 25-85 kW	30 Tk/kW
	if load >85 kW	12.5 Tk/kVA
	Meter Charge	125 Tk./month
Commercial	Energy Charge	1.9-2.05 Tk./kWhr
	Minimum Charge	800 Tk./hp/season
	Meter Charge	20 Tk./month
Street Lighting	Energy Charge	2.05 Tk./kWhr
	Minimum Charge	140 Tk./month

The ultimate goal of the RE program is to provide electricity to all populated areas of Bangladesh by the year 2005. Within this framework, the REB is currently planning to expand its network. The last several years of the program have involved a combination of intensification in the use of existing systems (sponsored by USAID) and development of systems in new areas (sponsored by other donors). In the next decade it is planned to more than double the size of the current network through the establishment of 19 new PBS's and the extension of services to another 207 Upazila. This plan is currently proposed to take place in two five-year phases, although an accelerated effort is now under consideration.

6. Benefits of Rural Electrification

The broad development objectives of the RE program are:

"a. to encourage the development of industry and irrigation in the rural areas
b. to discourage migration from rural to urban areas,
c. to decrease inequalities in income distribution,
d. to improve the position of women in rural areas by enhancing their opportunities for employment,
e. to reduce unemployment in rural areas,
f. to foster rural development in order to assist disadvantaged sections of the community to improve their standard of living,
g. to reduce the use of those indigenous renewable fuels which are of higher socio-economic cost,
h. to reduce imports of fuel, and
i. to improve allocation of resources through providing correct pricing signals to the different categories of consumers."[4,p.3]

The current pre-assessment is meant to access the success of the program in meeting this agenda.

The benefits of rural electrification in Bangladesh include both its general contribution to economic development in the rural areas and its specific contributions to the program objectives listed earlier. Both will be addressed in the following discussion.

6.1 General Role of Electricity in Development

There are a variety of economic development activities taking place in the rural areas, both externally sponsored and internally generated. The individual contribution of each activity to the improvement of rural life is difficult to determine because of the complementary nature of these activities. Hossain [3] and

others have examined this complementary relationship within Bangladesh's agricultural sector. Various integrated rural development programs have attempted to take advantage of these complementary relationships. So far, the role of electricity as one of the complementary inputs has not been examined in any detail. Past attempts at assessing the benefits of the Bangladesh RE program have settled for the simple correlation between improvements in rural life and the presence or absence of electrification. This approach is particularly evident in the earlier survey work [29,33] but even appears in later, more sophisticated surveys [30,32]. In order to get beyond this approach, it is necessary to understand where electrification fits into the general sequence of rural development and the causal relationships between the availability of electrification changes in rural activities.

The causal relationships have to do with identifying what can be accomplished with electricity that could not be accomplished (or accomplished only at a much higher cost) without electricity. If there are close substitutes, e.g. diesel engines and pump kerosene lamps, then the benefits are the savings from the use of electricity rather than the nearest substitute. If the provision of electricity permits an activity to take place which has a secondary impact such as refrigeration for health clinics which improve rural health, lighting for cottage industries which increase female employment or pumping for irrigation which increases agricultural output, then the benefits from electrification are the savings relative to alternative methods for achieving the same impacts. Any savings in costs between the use of electricity and the next least costly alternative can be considered a benefit of electrification.

The impacts of rural electrification are greatest towards the end of the cycle of rural infrastructure development. Roads and markets play a leading role in opening up an area and introducing a trading economy. Agricultural improvements in the form of fertilizer, irrigation and seed permit increased production which is then distributed through the road and market network. Industry develops in response to the opportunities for downstream processing of local agricultural production and raw materials and to serve the new demands associated with the increased wealth of the rural populace. Electrification comes at the end of this chain. It provides improvements in processing agricultural goods and permits the introduction of mechanized industries. It also serves the demand for better lighting and household conveniences. Not only is the impact of electrification greatest at this point, but, only then is the latent demand sufficient to permit a chance of financial viability. This has been observed by Barnes [1] in the general context of rural electrification and by Uddin [32], Assaduzzaman[6] and others in the specific context of Bangladesh.

---

[6] Dr. Assaduzzaman, BIDS, personal communication

Part of the success of the RE [illegible]ram in Bangladesh relative to programs in other countries, is directly attributab[illegible] the concern for introducing RE later in the development cycle. The site selec[illegible]n process emphasizes indicators of development such as density of roads and level of industrial activity in choosing the areas for establishing the PBS's. [20,21]

6.2 Household Uses and Street Lighting

With regard to the household, there appears to be a genuine enthusiasm for connecting to the electric grid. The willingness-to-pay of the connected households is considerably higher than the charges under the PBS tariff would indicate. The relatively high consumption limit associated with the "lifeline" block, 70-125 kWhr, further disguises this willingness-to-pay.

The long-run elasticity of demand with respect to price is thought to be relatively low. The Bangladesh Household Expenditure Survey in 1986 found that fuel and lighting accounted for only 6% of household expenditures in the urban areas and 9% in the rural areas. Electricity accounted for only 1/6 of the fuel and lighting experience in the urban areas and less than 1% in the rural areas. The latter number is skewed by the fact that so few of the sample houses were electrified. The average for electrified households is probably closer to 20%-25%, which would imply that the electricity accounts for about 2% of total expenditures. The survey conducted by Coopers and Lybrand [5] found the expenditure on electricity in electrified homes to be only 1.6% of total monthly expenditures with the exception of the high consumption households where this percentage rose to 3.7%. With electricity amounting to such a small percentage of total expenditure, it is reasonable to assume that the sensitivity of demand for electricity to price would be relatively low. Rushdie [24] estimated the price elasticity to be -.4 or less.

The benefits associated with the substitution of electric lighting for kerosene lamps and of firm power for batteries in larger communications devices (TV's, two-for-one) are very real to the rural population but have yet to be quantified. The benefits actually realized are limited by the high cost for appliances and by the regimen of work which limits the leisure time available to use electric appliances. The latter constraint is especially true for lighting in the evening. The Coopers and Lybrand survey [5] estimated the period of night time lighting to be 3.5 to 4.5 hours while the household micro-survey produced estimates of 2 to 3 hours.[Annex VIII] Uddin's observations fell in between these two.[32]

The household demand for electricity is difficult to measure unless the demand is separated according to the willingness-to-pay for connection/housewiring, appliances, and electricity. The first is the major impediment to the introduction of electricity because of the high one-time cost which must be paid out of savings. The second also introduces a significant one-time cost. Once these two hurdles have been passed, then the demand for electricity is relatively insensitive to price.

The willingness-to-pay for a connection depends on the level of wealth of the household and on the prevalence of connections within the village [Annex VIII]. The willingness-to-pay for the energy is determined much more by the number of appliances which have been purchased by the household than by the price for that electricity. The average consumption of electricity per domestic hookup tends to increases over time as new appliances are purchased. The sequence in which these appliances are purchased begins with a few incandescent bulbs followed by either a cassette recorder or fan and finally a TV. Only wealthier houses will possess electric irons, cookers or refrigerators. This information is confirmed by the appliance ownership data collected in previous surveys as shown in Table 2.

Table 2

Household Electric Appliance Ownership [4]

Item	Percentage households Possessing this item
Radio	36%
Fan	43%
Television	26%
Iron	27%
Cooker	5%

The impacts of household electrification on women is generally positive but no more so than for men. The general benefits of better lighting and communications are not gender specific. Electric cooking appliances, irons, refrigerators or other "labor-saving" devices which might benefit women more than men appear only in the wealthier homes.

At present, the average monthly consumption per hookup is on the order of 28 kWhr and would probably amount to about 24 kWhr if cottage industries were excluded. This still appears relatively high at almost 1 kWhr per day and is

probably attributable to multiple connections off the same meter.[7] As the system expands, more marginal users are brought in and the average consumption per household will decline as has happened in the older PBS's.

The demand for street lighting has been relatively stagnant despite the expansion of the system and an increase in the number of villages electrified. The problem of providing street lighting is thought to be associated with difficulties in mobilizing community resources to pay for the lighting and to maintain the system.[8]

6.3 Electrified Irrigation

The benefits from electrification of irrigation are limited by the option to use diesel pumps in most minor irrigation schemes. This substitutability applies to low-lift pumps, shallow tube wells, deep-set shallow tube wells, and deep tube wells. Diesel pumps have the advantage that the source of shaft power can be transferred to alternative uses after the pumping season (e.g., shallow-bottom boats, land transport and farm mechanization). Electric pumps have the advantage that they can be used at greater depths. So far, this has not been an issue in Bangladesh. Neither technology appears to have any operational benefits other than portability. There are no significant differences in the use of electric and diesel pumps in terms of the hours of use, area irrigated or pattern of ownership. [32]

The principal factor affecting both the decision to purchase a pump and the choice between a diesel and an electric pump appears to be financial cost. The fluctuation in sales of tube wells over the last decade points out the importance of the financial cost to farmers when deciding to introduce pumped irrigation. This fluctuation and its relationship to costs has been documented by Palmer Jones [51] and others. More recently, David Guizzelquist has examined the impact of the lowering of diesel and electric pump prices (by removing the duty and permitting competition in the distribution) on the increase in sales.

The principal advantage of electric pumps is their lower financial cost for acquisition and operation as shown in Annexes VII and IX. Lower financial costs have also led to some switching from diesel to electric pumps [31,32]. From an economic perspective, electric pumps have the disadvantage that they create a very peaked seasonal demand which requires a significant increase in the capacity of the

[7] The extent of multiple connections on household meters is not known but is thought to be extensive, M. Khandaker, REB, personal communication.

[8] Dr. Assaduzzaman, personal communication

generation and transmission system and contributes to the relatively low load factor experienced by REB. Even in the peak period, pumping time is only about 100 hours per week or about 1700 hours per season. [32,38]

The economic cost of supplying electricity to these units is quite high [3,4] and when factored into the total cost results in a much higher life cycle cost for electric pumps than for diesel pumps since diesel fuel is already priced above the current economic cost. The difference in economic cost is examined in Annex VII. A similar situation of a lower financial cost but higher economic cost for electric pumping has also been observed in India and Pakistan. The higher economic cost for electric pumping translates into a negative net benefit in terms of the RE program. By encouraging the use of electric pumping through prices which are below the economic cost, the program causes farmers to switch away from diesel pumping which is less costly to the nation.[9]

The problem of the seasonal peak in electricity demand is expected to increase in the short run due to a dramatic increase in the number of irrigation pumps. There is however, some indication that many of these new pumps will be diesel powered to take advantage of the alternative uses of this equipment. While the financial analysis does not indicate that the savings justify such a decision, a number of persons involved in both irrigation and the RE program feel that this will occur. [31, personal communication] The impact of this seasonal peak has generally been compounded by the practice of pumping during the peak period of the day. This problem may be mitigated if the REB follows through on its intention to install time-of-day metering on irrigation loads.

The average consumption for irrigation hookups depends on the predominant type of well. For most PBS's, the majority of electric pumps are used in STW's and the average consumption is on the order of 1.75 MWhr/month during the four months in which they are used, as shown in the consumption figures in Annex II.

The present tariff structure for irrigation hookups is a flat energy charge and a fixed seasonal charge per unit of installed capacity. This tariff does little to encourage more efficient use of the electric pumps through the introduction of smaller units pumping over more hours. Nor does it encourage shifting the load away from the early evening peak demand period. This tariff could be revised to encourage these changes. It could also be tailored to encourage the use of smaller

[9] This higher cost is based on the Long Run Marginal Costs developed by Coopers and Lybrand. These numbers are currently being re-computed as part of a World Bank participation in rural irrigation.

units in an attempt to redistribute benefits away from the wealthy land-owner to the poorer rural farmer as has been done in India on a broader perspective. The higher economic cost of electrical pumps should cause the government and REB to consider raising their tariff towards the LRMC.

6.4 Rural and Cottage Industries

The use of machinery in rural industries was found to be quite limited in the 1981 survey of rural industry. [69] The major exception was the metal products industries and to a less extent the textile, pottery and oil/gur making industries. Much of the machinery used in these industries was second hand. While the level of mechanization has increased significantly in the intervening years, especially where electricity has been introduced, the fact remains that mechanization and the use of electrical equipment occur only where there are significant financial benefits.[10]

The benefits of electricity to the development of industry in rural areas can be significant. However, these benefits are limited by the fact that diesel engines can be used as an alternative source of shaft power for most applications. The savings with the use of electric motors rather than diesel engines can be significant where elaborate systems for power transmission or speed control are required with the diesel engines. They can also be significant where the technical skills required for operation and maintenance for diesel engines are more costly or not available.

The analysis performed in Annex IV indicates that the electric motors for a typical application would have a 1/6 lower annual financial cost taking into account capital, operation and maintenance costs. The analysis, which was performed for a 25 hp engine/motor, indicated a savings of 1.4 Tk per hp-hour for the electric motor over the diesel. In contrast, when the economic costs for electricity are used, the cost per hp-hr would be 1/6 higher for electric motors than for diesel engines.[11] However, this comparison is limited to the engine/motor and does not take into account the additional costs and losses in efficiency which are associated with the

[10] The toothpick factory mentioned above is a good example. Although the forming of the toothpicks was done on an electrically powered shaper, all of the preparation of the bamboo for input to the shaper was done manually, even though this was a turnkey operation with foreign participation.

[11] the difference would not be so great as for irrigation, because the industrial demand does not create a seasonal peak. Therefore, the economic cost of service for this demand is less.

power transmission and speed control systems. These are both higher for diesel engines in many of the industrial applications.

The findings of the techno-economic assessment of diesel engines and electric motors [Annex IX] indicate that for shaft power, electric motors provide a better technological fit than diesel engines for most productive activities. The notable exception is rice-milling. However, these results should be conditioned by the understanding that there is almost no diesel-powered autogeneration used in the country and the power transmission systems available for diesel engines are relatively simple. Given the lack of familiarity with alternatives, there is a tendency to favor electric over diesel for most applications.

The average consumption for industrial hookups fluctuates from year to year as new units are brought on. It appears that this industry can be divided into small units which consume less than 2 MWhr per month and larger units which consume in excess of 5 MWhr per month. [Annexes II and X] For the smaller enterprises, the utilization of the electric motors is relatively low (probably not exceeding a 20% load factor during working hours and less than 10% for the day as a whole). Higher levels of utilization would apply for the larger industries.

The gestation period for the formation of rural industries is quite long as it depends on the economic growth in the region generally. The micro-survey of rural industries observed a number of enterprises started within the last 5 years although the area has been electrified for nearly 20 years.

The majority of the REB industrial hookups are thought to be establishments which were connected to BPDB system prior to the REB takeover or those which are located in the central market places near to the old BPDB lines.[12] The conversion of these former BPDB connections provided a significant increase in REB's industrial connections and consumption during the FY86-88 period which has since diminished as shown in the analysis in Annex II. The tendency of industries to locate in central markets near metal roads [31,32,69] implies that many of the industries served by REB are in the command area of the old BPDB system. Therefore, the benefits from electrification are attributable to the rural electrification but not to the REB program.

[12] This was observed to be the case in the rural industry micro-survey [32] survey and has been referred to in various reports on the REB system.

The combination of comparable economic life cycle costs for diesel engines and electric motors and the fact that electricity was available to most users prior to the establishment of the REB suggests that there are little or no economic benefits to current users from the RE program. However, this ignores the preference of entrepreneurs for electric motors and the catalyst to rural industrial development provided by its availability.

Rural industries develop in response to the general economic development of the rural area. The availability of electricity affects the formation of rural industry in two ways. First, it affects the decision on where to locate productive units and second, it affects the decision on whether to establish a productive activity. The decision on location is dependent on the type of rural industry. For this purpose, the industries can be divided into three categories: footloose, resource-based and market-based. Footloose industries use inputs imported from urban markets or overseas and produce products which are exported to urban markets or overseas. The choice of location for these industries has considerable latitude and will be determined by a number of factors such as transport costs, the availability of labor and electricity, and the traditional home of the entrepreneur.

If footloose industries decide to locate in the rural area then this decision will not provide efficiency benefits to the nation since this industry could have located elsewhere. However, it will provide significant equity benefits by allowing for increased rural employment. For most footloose industries, the availability of electricity is a prerequisite. Two examples of this type of industry, a textile plant and toothpick factory were observed during the rural industry micro-survey. Both are turnkey operations with significant foreign participation. The only local inputs are the labor and the bamboo used for the toothpicks. All of the products are sold outside of the rural area. Their location was premised on the availability of electricity to operate the imported machines.

On the other hand, the location of resource and market based industries, which range from village rice mills to spinning and weaving mills, are constrained by transport costs to be near the source of raw materials or the markets for their services and products. For these industries, rural electrification offers the option of mechanizing their production activities and thereby improving the quality of their product or reducing the cost of production. Where alternative forms of energy are available, the electricity offers a slightly lower-cost or easier to manage source of mechanization.

Electricity has an impact on the choice of location for these industries but more of an influence on the decision to establish the industry. The availability of electricity and electrical equipment may reduce production costs or increase product quality

to the point where the activity can make a profit. This assumes that the regional transport and market systems have reached a level of development to permit efficient collection of inputs and distribution of the outputs.

Some of the resource and market based industries require firm power for mechanization. For these industries, rural electrification contributes significantly to their development. Examples are sawmills, machine shops and cold storage facilities, for which diesel or autogeneration is too costly. Some of these industries also require a high degree of reliability and will provide their own backup generators. The industries which are situated in the villages rather than market centers clearly benefit from the RE program. These are primarily resource-based industries, such as small rice/flour mills and oil presses, which consume relatively little energy and have in the past been operated using diesel engines. [31,32]

In the long-run the impact of RE on employment should be positive because:

a. new products can be produced both for export to the urban areas and as substitutes for imports from the urban area,
b. labor skills are increased, and
c. goods and services can be made available to the rural populace at lower cost which will promote additional economic activity.

In the short run, those industries which are being mechanized as a result of connection to the grid will reduce their level of employment. In contrast, employment will be increased where an industry is being established, because the use of electricity lowers the cost of production to the point where the activity is profitable. For industries which are already mechanized but convert from diesel engines to electric motors, there would be relatively little change in the level of employment.

The 1981 rural industry survey indicated that about 32% of the rural industrial employees were women. The impact on women from the electrification of rural industry is generally positive but limited in extent. The most commonly referenced example is the substitution of the mechanized rice mill for the dhenki which reduced the employment opportunities of women, but at the same time lowered the price of milled rice and reduced a source of drudgery. However, this example refers to mechanization rather than electrification. The availability of electricity for footloose industries is probably more of a benefit to female employment. These industries tend to be large scale production units which employ both females and males. [69] The participation of women is especially significant in textiles.

The impact on women would be far greater if it increased the development of cottage industry, but it is not clear that the introduction of electricity causes an increase in cottage industry. The primary use of electricity in cottage industries is for lighting. [31,32] The high cost of equipment and the low cost of family labor tends to discourage its use for mechanical processes whereas the high cost of electric heat precludes its use in food processing.[69]

A NORAD study [72] observed that the principal employment of women was in cottage industries which were extensions of traditional activities such as rice processing, raising livestock and maintaining household gardens. Other productive activities included spinning and weaving of textiles, processing of bamboo, wood and coir products, and pottery. The potential for use of electricity in these activities is much greater at the level of rural industry rather than for cottage industry.

6.5 Commercial Uses

Rural electrification may have extended the hours of operation and increased the income of commercial establishments which have been connected [31,32], but it is difficult to determine whether this has been at the expense of the un-electrified shops or a result of a change in consumer habits with a more cash-based economy.[32] The Coopers and Lybrand survey found that commercial establishments used electricity primarily for lighting and that the introduction of lighting allowed an extension of working hours from an average of 11.5 hours to 13.5 hours. [5] The BCAS survey found a similar lengthening of hours. [31] Although both surveys found that the owners felt that revenues has increased following electrification, the basis for this response was not explored. These commercial activities tend to be concentrated in the market areas many of which had access to electricity prior to the establishment of REB. As a result, the impact of the RE program has been limited.

6.6 Impact on Family Planning

The impacts of electrification upon family planning are difficult to measure since the linkages are quite complex. The impacts are much more direct for increases in female employment, income and life expectancy, improvements in health, education, and the availability of birth control technologies, and reductions in the child morbidity rates. The relationship between these factors and a reduction in population growth has been established through both observed correlation and

causal explanations.[13] Changes in these factors have been brought about through changes in rural economic activity, the establishment of rural health centers, schools and family planning clinics, improvements in nutrition through more reliable food supplies, and access to better communication. The contribution of rural electrification to family planning is found only where it provides:

a. better lighting and cold storage for health centers and family planning clinics
b. a wider use of communications devices in the home and the school
c. an additional source of energy for the agriculture and industrial sectors which along with other factors will stimulate female employment.

6.7 Environmental Impacts

The direct impacts of rural electrification on the environment are probably equally balanced. The environmental impacts from construction of the electricity distribution system are minimal since the "backbone" system is built along existing roads wherever possible. The replacement of diesel power and kerosene lighting with central generation eliminates a local source of pollution but substitutes a concentrated source. Since the present generation expansion plan calls for increased use of natural gas, there will be a net reduction in the introduction of pollutants to the atmosphere.

Rural electrification will permit the expansion of resource-based industries and as such may place added pressure on non-renewable resources. This is especially true for the introduction of rural sawmills which permit the processing of local trees at a lower cost than the mills located near urban centers. The lower cost of wood products in the rural area will stimulate demand. While it is possible to credit the local sawmills with an increase in the rate of cutting trees, rural consumption is not the only source of demand. Also, the failure to protect or replant existing woodlands or establish new forests is the major cause of deforestation. Finally, there are other methods for mechanized wood cutting, most notably through the use of diesel powered saws.

[13] The Contraceptive Prevalence Study in 1985 [59] studied the factors affecting acceptance, determination and duration of contraceptive use. Specifically identified in this study were the total number of living sons/children, the employment status of women and the knowledge of contraceptive methods. Electrification was observed to be correlated with contraceptive prevalence but not identified as a separate factor.

Other resource-based industries may also increase the rate of extraction of local, non-renewable resources as a result of the introduction of electricity, but with less impact than the sawmills. At the same time, activities which permit recycling of non-renewable metals, such as electrified machine shops and re-rolling mills, benefit from the availability of electricity.

The introduction of STW's and DTW's will no doubt put pressure on the water table as the draw-down exceeds the recharging rate in isolated areas. However, the direct substitution of diesel for electric pumps argues against attributing this environmental impact to rural electrification. [48,52]

6.8 Finance and Management

The PBS's benefit from three types of subsidies; a low interest rate on loans for capital investment, an operating subsidy to meet shortfalls in operating margins and an electricity supply cost which is less than the economic cost. [4] The low interest rate represents a pass through of the low interest rate charged the government by the donors. Since this is an investment in infrastructure, this is not an unreasonable form of subsidy. The local share of the program, which is in the form of direct government allocations to REB is on-lent to the PBS's. When it is repaid, these funds will be rolled over for investment in future system expansion.

The GOB provides an operating subsidy to each PBS during the first five years of operation (extendable to seven years). This subsidy is based on the difference between accrued revenues and costs. The analysis of financial performance for the individual PBS's indicates that most PBS's do not require an operating subsidy or have improved their performance to the extent that they are not expected to require this subsidy in the future (see Annex III). This subsidy is larger than necessary because it is based on the operating margin rather than cash flow requirements of the PBS. It also distorts the PBS's tariffs by providing a disincentive to raise tariffs.[4]

The subsidy on the cost of electricity applies not only to REB but also to BPDB customers. In fact, the REB customers pay a higher rate for their electricity. The current plan is for the BPDB to gradually adjust its tariff towards its economic costs for power generation. The tariff increases are expected to be passed on to the REB and the PBS's as they are implemented.

From a financial perspective, the performance of the PBS's is improving over time as the density of demand increases. There will be some increase in financial pressure on the PBS's in the future due to debt service requirements, the inevitable increase in maintenance costs for aging distribution systems and the difficulty of

keeping rates in line with inflation. Some PBS's may require continuing government subsidy. However, a large percentage of the PBS's are in a relatively strong financial position and will probably be able to pay most or all of their debt as indicated in Annex III.

There are two notable financial problems facing the PBS's. The first is the need for significant increases in rates if the recommended increases in the Bulk Service Tariff are implemented. This may require some political will but should not be a difficult problem giving the high willingness-to-pay of most users and the fact that the BPDB would have to institute parallel rate increases.

The second problem is the need to adjust tariffs in line with the long run costs for expansion of the distribution system. This problem is aggravated by the rising costs of construction which give newer systems a much higher cost base, when debt service is included, than older systems. Future expansions will be harder to justify because the marginal cost of these expansions will be in excess of the marginal revenues which would be generated by the current tariffs. The most economically efficient means for dealing with this problem is to allow each PBS to set its tariff according to its costs, however, this raises equity issues particularly with respect to the impact on the most isolated areas being served. If a uniform tariff for all PBS's is considered desirable, then the level of the tariff would have to be raised. If financial autonomy remains a goal then the effect of rising capital cost would be for the most costly systems to become the price setter and the less costly to make a large profit. There appears to be a significant conflict between the goals of autonomy and equity which will be further exacerbated as the system is extended into more remote areas.

The Coopers and Lybrand report has pointed out the need for the introduction of cash flow management in place of the traditional P&L based management currently practiced. This is quite reasonable given that the PBS's are still expanding and many are about to begin paying debt service. This report also recommended the formation of a central fund for transferring funds in the form of deposits/loans from strong PBS's to weak ones. Such a fund would only be useful if the capital were laying idle. The financially strong PBS's should be allowed and encouraged to use their surplus funds to expand and strengthen their own systems. The ability of the co-ops to become autonomous depends on their ability not only to manage their assets but to grow through investment of retained earnings. The proposed fund, no matter how well managed, would inevitably link the performance of the PBS's and restrict their autonomy.

6.9 Management Issues

The institutional impacts of the rural electrification program are quite substantial. The REB and the PBS's are recognized as one of the few successful organizations dedicated to promoting rural development. But unlike other successes such as BRAC and the Grameen Bank, the RE program provides a basic infrastructure to the rural areas through the mechanism of cooperatives. The RE program is widely respected and has managed to sustain a high level of fiscal management and infrastructure development for over a decade.

One of the strengths of the REB appears to lie in its attention to detail. The technical assistance has been extremely useful in establishing reporting structures and standardizing equipment purchases. Both are critical elements in the success of any RE program. A recent IBRD survey observed:

> "Our broad conclusion is that the success or failure of R.E. efforts in a country depends much less on the specific institutional framework used, rather than on proper planning and the existence of certain pre-requisites. These critical factors include:
>
> (a) having a clear cut national objective and an R.E. master plan (broad strategy, criteria for selecting areas to be electrified, etc.);
> (b) codification of design standards and engineering practices appropriate to R.E.;
> (c) adequacy of initial and continued financing (through government equity, foreign and commercial borrowing, tariff revenues, etc.);
> (d) proper planning and implementation of individual schemes (market surveys and promotion, load forecasting, design and construction, supervision, etc.)
> (e) quality control, operation and maintenance." [13]

The REB has been successful in each of these areas.

Another strength of the RE programme is the priority given to financial viability. The guidelines for extension of power lines are based on the expected revenues which will be generated relative to capital and O&M costs. Furthermore, the lines are not energized until 75% of those signed up for connection have been connected. RE programs have traditionally been plagued by losses and other financial difficulties, the success of the REB in this area has been fundamental to its continued development and growth.

Given the limited absorptive capacity of the national economy, this program has managed to meet its growth targets while maintaining its technical standards. It provides a valuable lesson concerning the importance of good management practices in the delivery of development services. The program sets a standard against which to measure comparable program. However, it is unclear whether this management structure can be replicated, or even maintained as the area covered and the number of customers increases. The further growth of the REB system will be constrained not by access to financial capital but by the availability of human capital to manage the expansion. The proposed expansion of the system into less developed areas of the country will place a significant strain on the REB even with its proposed 25% increase in staffing. It is this area which most needs the continuing support of USAID.

One way for the REB to effectively manage its expansion is to spin-off some of the older, financial strong PBS's. There is a need to increase the autonomy of the older PBS's in terms of their ability to manage their financial activities and the expansion of their networks. Only by increasing their ability to stand alone will it be possible for the REB to focus its management capabilities on the new PBS's proposed for the less developed areas of the country.

In order to better supervise the performance of the existing and proposed PBS's, a better socio-economic monitoring and evaluation system should be established. This system would focus on the quality of services provided by the PBS's to the co-op members and would identify additional services which could promote the use of electricity. It would also examine operational problems such as illegal connections and misunderstandings regarding fees and users' rights.[14] Many of these M/E activities, which are described in detail in Chapter III, would be undertaken by the REB's evaluation division.

[14] A discrepancy between the PBS's stated policies and the understanding of these policies by the co-op members have been observed on a number of occasions as part of surveys and other field work. This is thought to be a problem of communications in most instances, but there is always the potential for violation of these policies.

7. Recommendations

A number of recommendations have been developed with regards to future planning of the RE system as a result of this pre-assessment. These are not new recommendations, but rather they support earlier recommendations based on the findings of this study. These recommendations relate to two areas: system expansion, pricing and financial requirements, and organizational objectives.

7.1 Future Expansion of the System

The lines in the rural areas currently controlled by BPDB should be turned over to the REB. The latter has shown greater responsibility in the area of providing reliable service and collecting fees for the services provided. An expeditious transfer would provide significant financial benefits to the REB in the form of increased revenues and to GOB through better collection of tariffs.

The expansion of the system should focus on semi-rural and peripheral urban areas. The network should be expanded through enlargement of the areas currently served (intensification) rather than through extension to remote areas. Much of the success of the early phases of the project are attributable to the careful selection of sites with an emphasis placed on a reasonable level of development. This technique should be continued and refined. The survey described in Chapter II would identify factors to be included in this selection process.

The decision to expand into new areas should be gradual. The exclusive authority of the REB to provide electricity in these areas should be clearly established[15], but the rate at which it assumes this authority should be commensurate with the development of these areas and with the expansion of its management capabilities.

The REB should promote demand in areas where they will be operating in the future. Encouragement of battery charging activities at the end of their lines and the promotion of auto-generation in areas targeted for hookup in the next five years should be an integral part of REB's planning process. The Power Use Department's role in this regard is discussed in Chapter III.

---

[15] Exclusive with regard to BPDB, but this should not preclude local use of auto-generation.

There are several options for energy supplies which the REB should investigate to determine their effect on the demand for electricity or their role as a technology to be promoted by the PBS's. Clearly the availability of natural gas and CNG in the future will encourage the use of gas engines which have been shown to be more cost-effective than electric motors.[16] Options for cogeneration from local industries should also be considered as a potential source of electricity for the grid.

The REB is considering generating its own electricity and increasing the voltage level at which it takes power from the BPDB. The latter is clearly a natural extension of REB's activity and should be encouraged where it provides lower cost power. The decision to move into power generation, while clearly covered under the REB's bye-laws, must be entered into cautiously. In order for the REB to generate its own power, a new level of expertise and management capability would have to be developed over time. It would also be necessary to establish regulations governing the selling of power back to the BPDB (e.g. the PURPA laws in the U.S.). Since the problem for both BPDB and REB is the peak load during the irrigation season, it is also important to understand how the REB contribution to the overall system capacity would affect the least-cost expansion plan for the nation.

7.2 Pricing

The current tariff structure for domestic hookups utilizes too large a life-line block. The system-wide average consumption is about 30 kWhr/month whereas the first household block is 70 kWhr/month. A minimum household use would be two 40 watt bulbs operated for 3-4 hours per night for a monthly generation of 9 kWhr. Add an 80 watt fan running at 70% for 4 hours and the total would still be only 16 kWhr. Above the level of 20 kWhr, a higher rate would be justified given the willingness-to-pay. At the same time, the minimum monthly bill should be revised downwards since it affects nearly half of the users and places a heavy burden during the low income months.

The pricing structure for domestic hookups should be further revised to offer a rate which allows the household to amortize the cost of hookup. This implies that the PBS would provide, directly or through subcontracting, the housewiring but given the current quality of work this might not be a bad idea. The PBS would then charge a monthly fee over the first few years of service with which to amortize the cost for the wiring and any cost for connection.

---

[16] These technologies are the subject of a recent IBRD project appraisal related to the uses of natural gas.

Several changes in the tariff for irrigation hookups should be considered. The first is the introduction of an escalating block rate which, given the high proportion of pumping costs accounted for by energy, would encourage the use of smaller pumps. The second change is the use of time-of-day metering to move the irrigation of the evening peak periods thereby limiting the impact of this load on the system. This tariff should be introduced if the BPDB introduces a peak/off-peak rate in their Bulk Service Tariff. Since the time of day peak is less of an issue than the seasonal peak for irrigation, a general increase in the tariff for irrigation should be considered to reflect the long run marginal costs of supply capacity for irrigation. This third change would also encourage the marginal user to switch to diesel pumps. The increase should be designed to cover only the incremental cost associated with REB's distribution system. Additional increases to reflect BPDB's higher costs should be considered only if a seasonal premium were introduced by BPDB.

The fourth change relates to the current capacity charge of 800 Taka/hp per season. This charge is small compared to the energy charge. It should be increased and used in place of the energy charge as a mechanism for capturing the long run marginal costs for the transmission capacity needed to serve the irrigation load. Alternatively, this charge could be escalated with pump size as a means for encouraging the use of smaller pumps, either to encourage small farmers thereby meeting equity objectives or to encourage more intensive use during the irrigation season thereby spreading the load over more hours and days.

7.3 Organizational Objectives

The current REB/PBS structure has worked well in expanding the rural electrification network and promoting use of electricity in the rural areas. Its principal objective of promoting financial self-sufficiency has contributed significantly to the success of its program. However, the program has been largely constrained to the traditional structure of the rural electrification cooperatives distributing electricity from the grid as was done in the US in the first half of this century. More recent approaches which promote the use of autogeneration in areas which are remote or which are not scheduled for connection to the central grid for several years have not been considered by the REB.

Also the exclusive focus on electricity has prevented a broader program addressing the general energy needs of the rural areas. The survey of rural industries has pointed up the limited technical knowledge of rural entrepreneurs with regards to types of equipment and alternative sources of energy which can be used for shaft power and heat. The widespread use of incandescent lighting in households is a result of the high cost of fluorescent bulbs and fixtures, however, these more

efficient sources of lighting are used in rural areas throughout Southeast Asia. For irrigation, the objective of the REB has been to promote electric pumping despite the high cost of serving this demand. Clearly, the REB's objectives could be expanded to determine and promote the most cost-efficient form of energy for different applications.

The REB is currently considering vertical integration of its activities to include connecting to the grid at 132 kV rather than 33 kV and possibly generating its own power. It remains to be determined whether the REB has the expertise and management structure to operate generation facilities, however, there is no reason not to extend the role of REB into this area or any other area which promotes cost-efficient energy use in the rural areas. The current structure of REB/PBS is relatively rigid and this has perhaps been the key to its success, but the organization is evolving and it is time to look beyond this structure not so as to reject it rather to evolve it so that the REB can both offer new services and continue to provide existing services in a more cost efficient and equitable manner.

8. General Conclusions

It is our opinion that the RE program in Bangladesh is a good one. It has not only produced direct benefits, but more importantly, it has established infrastructure from which substantial benefits are expected to derive. However, the REB/PBS organization is still evolving in a very positive manner although it has yet to achieve some aspects of institutional maturity associated with a well-functioning rural electrification organization. Outside assistance is needed not only to expand the physical system, but, more importantly, to strengthen the management system, especially its evaluation capability. There is some discussion of USAID withdrawing support from this program because it has not produced immediate and significant results in generating employment and other targeted benefits. This decision would not be in the best interests of either USAID or Bangladesh. First there is a donor credibility problem of discontinuing funding for a successful program which continues to require external financing. Second, there is the issue of long-term benefits which have not yet been realized and will evolve only with the development of rural areas.

However, this is not to stay that alternative forms of participation or changes in strategy for the system should not be considered. The growing interest of other donors in funding the capital investment for expansion of the system leaves USAID to focus on strengthening the RE institutions. In order to strengthen the REB, USAID should continue its technical assistance program and assist in developing a monitoring and evaluation system. These two activities would strengthen the REB's ability to oversee the activities of the PBS's. They would be separate from the REB's ongoing efforts to establish new PBS's and extend the distribution system. There is a recognized need to improve the site selection and cost control activities of REB as well as to develop more cost-effective systems of delivering energy. These areas would also benefit from technical assistance.

To the extent that USAID continues to be involved in commodity loans, the best strategy would be to continue the intensification program by expanding it to other PBS's. This would put USAID in the position of providing funds for PBS's established by other donors but this is necessary if these PBS's are to become autonomous. One of the chief objectives of the USAID program should be to achieve operating and financial autonomy for the PBS's. The sustainability of the program will be enhanced by moving these organizations out from under the REB/donor umbrella. Once these institutions are able to stand on their own, then the REB will be able to direct its manpower to the development of new PBS's.

CHAPTER 2

SCOPE OF WORK FOR A COMPREHENSIVE IMPACT ASSESSMENT

1. Purpose of the Assessment

The review of earlier survey efforts and the conclusions of the pre-assessment suggest that additional information is required not only to improve our understanding of the socio-economic impacts of the rural electrification program in Bangladesh but also to plan subsequent phases of the project and USAID's participation in these phases. Since USAID has taken a lead in providing technical assistance to the project and in performing monitoring and evaluation activities related to the different phases of the project, it is important that the results of the assessment provide guidance for improving these TA and M/E activities.

Among the questions which require further study are:

1. What types of industries benefit from rural electrification and how does the availability of electricity affect their decisions on where to locate, what type of production technology to employ and what mix of capital and labor to use?

2. How does electricity contribute to the decision to establish an industrial activity; what are the preconditions in terms of other development factors?

3. What is the average household's willingness-to-pay for connection and for energy and what factors determine this willingness to pay?

4. How do cottage industries use electricity and how does it affect their productive activities in a quantitative sense?

5. How do commercial activities alter their activities as a result of connection to the grid?

6. How does electricity pricing affect the choice and use of irrigation pumping?

7. What are the impacts of RE on female employment?

8. At what stage in the rural development process should electricity be introduced?

Answers to the first two questions are necessary not only for estimating the economic benefits of rural electrification that result from productive uses, but also for planning where the greatest benefit can be obtained through extension of the main power lines (3 phase, 440 volt and higher). It is expected that the response to these questions will differ for the different categories of industry (small or large, service or product, footloose, resource-based or market-based).

The answer to the third question is needed to provide proper estimates of the benefits to rural households from electrification. This answer will also provide a better understanding of where to locate lines so as to achieve the highest connection rate and how to adjust rates to reflect these benefits and encourage connections. It is anticipated that the response to this question will differ not only with the income/wealth of the household but also with the level of development of the village and surrounding area.

The answer to the fourth question is important because relatively little is currently known about cottage industries and their contribution to male and female employment and rural incomes. The present assumption is that cottage industries use electricity only for lighting. The extent to which that is true and how this affects their level of production and profitability is not known. The answer to this question can be used to compute the benefits of providing electricity to this sector. It will also help REB in deciding how to promote the use of electricity and electric appliances in this sector.

The fifth question is similar to the fourth. There is greater potential for uses of electrical appliances other than lighting in the commercial establishments, but it is difficult to understand how the value added is altered merely through the introduction of these appliances.

The answer to the sixth question would be used to develop a better pricing policy for irrigation hookups. In order to evaluate alternative pricing policies, it is important to understand the relative costs for diesel and electric pumps. Also the issues of maintainability, reliability and portability of these two technologies must be considered when evaluating the price cross-elasticities. Since the irrigation load has a significant and growing impact on REB's capacity requirements, a better understanding of the demand for this service is required not only for pricing but also for planning system expansion.

The answer to the seventh question would add to the knowledge about women in development and how electrification contributes to their productivity. While it is not anticipated that the answer will affect system planning, it will suggest how the REB's promotional efforts might be targeted towards women.

The last question is the most difficult, but the answer has the greatest importance for the planning process. Currently the RE programme emphasizes electrification of relatively developed areas and these have proved to be the most financially viable. Now the REB is moving into a phase of expansion which will take it into more remote, less developed areas. Before undertaking this new direction, it is important that the REB have an understanding of how electrification contributes at different stages in that development process and how the benefits will vary with the point of intervention.

The answers to these questions would be obtained through field surveys. The specific questions to be asked in these surveys would concentrate on the causal relationships between the introduction of rural electrification and the marginal changes in social and economic activities.

2. Structure of the Survey Components and Survey Instruments

The survey would include two separate components. The major effort would be a household level survey of electricity use for domestic, cottage industry and irrigation activities. For domestic activities, the household survey would use a structured interview and some participant observation to determine the factors which lead to connection and use of electricity, the willingness-to-pay for these, and the changes in economic and social activity which result from connection to the grid.

Village irrigation units and cottage industries would be the subject of separate structured interviews carried out in tandem with the domestic users survey. The former would focus on the costs and value added from the use of mechanization in general and electric equipment/appliances in particular. These surveys would investigate the factors considered in: a) deciding to mechanize (or not to), b) choosing electricity or a substitute source of energy, and c) changing the level and cost of production as a result.

The second component would be a marketplace survey of commercial and industrial establishments in the primary markets. This survey would use structured questionnaires to collect data on the nature and costs of production, the demand and price for the outputs, and the impacts of mechanization and electrification on the quality, production costs, sales price and demand for the output. The survey would employ open-ended questions to determine the factors considered in starting up and locating the production facility, in deciding to mechanize (or not to) and in choosing between electricity and substitute forms of energy. Open-ended questions would also be used to assess the contribution of electricity as a complement to the

other inputs, such as markets, transport, training in technical skills, credit, and supplies of equipment and spare parts, to the development of rural industries.

For both survey components, the procedures and instruments would be built on past experience in Bangladesh. Some sample questionnaires, which were pretested as part of this study, are included in Annexes VIII and X. Other relevant examples can be obtained from the Village Study Group which was active at the University of Dhaka in the late 1970's, the village development survey conducted by BIDS and IFPRI in the early 1970's, the rural energy surveys conducted in the late 1970's by John Briscoe (now at IBRD) and Nural Islam (now at BUET-ATI) and the recent rural electrification survey by Md Salleh Uddin (now at the University of Chittagong).

Foreign consultants would participate in the study to add objectivity and breadth of experience. They would assist in removing potential biases in the survey instruments currently used and would provide survey instruments which were used in other countries to analyze decision-making in the choice of energy sources and to quantify the impacts of new technologies on the economic and social activities of rural areas.

3. Site Selection and Sampling

The site selection and sample size would differ for the two survey components. Sampling would be purposive. The basic parameters used to define the sample would be the level of development of the area in the PBS and the availability of electricity.

For the household survey component, the first strata would be the PBS's and Upazila within the PBS's. They would be chosen to reflect a range of development, agricultural regimes and proximity to major urban centers and transport links. All should have an established electrical service (4 years or more). The second strata would be the villages and markets within these sites. These would be selected in pairs, one electrified and one not. They should have similar characteristics in terms of access to transport, topography and agriculture. The third strata would be the households. Selection would be made based on income (low, medium and high) and primary activity (agriculture and non-agriculture).

A total of 5 PBS/Upazila would be selected. For each, two clusters of two villages each (one electrified and one not) would be selected. For the electrified villages, the households would include both connected and non-connected households in a ratio of 2:1. Similarly, for the electrified and non-electrified villages, the ratio of sample size would be 3:1. Two research assistants would be assigned for three

weeks per cluster. The sample size would depend on the time required for both the structured interview and the participant observation. Assuming two households per day there would be a sample size of about 60 for the electrified village and 20 for the non-electrified village. In addition the research assistants would survey the local irrigation units, commercial activities and cottage industries. Per cluster, these are not expected to exceed 30 and therefore all activities would be surveyed.

The results from the household survey of domestic users should be extrapolated to the target population. Since the sample size for the village survey is relatively large, a procedure for weighting the sub-samples and extrapolating the results should be developed based on available district and Upazila-level socio-economic data and REB consumption data.

The marketplace survey would also use purposive sampling. A total of three PBS's would be selected from the 5 included in the household survey. These would have a significant amount of rural industry and an established electrical service (4 years or more and may include former BPDB areas). One would be located near a major urban center (i.e., Dhaka), one near a regional centers (e.g., Comilla, Chandpur, Moulivibazar), and one in a less-developed area. Two to three large local markets with a high concentration of industrial and commercial activities would be selected in each PBS. Also two smaller markets would be selected which have a moderate concentration of industrial and commercial activities. Three research assistants would work in the field for two months. The use of participant observation would limit the sample size and a time budget of two per research assistant per day has been assumed. The average sample size per PBS would be 100 or about 24 in each major market and 12 in each smaller market.

The rural industries and commercial establishments to be interviewed would be selected to include both electrified and non-electrified facilities covering the range of industrial activities found in the marketplace. They would be selected according to the following criteria:

Electrified industries:

1. should have been electrified within the last 5 years so that the reasons for deciding to connect can still be recalled;
2. should use less than 1.5 kWhr per month since these will provide better information about the marginal benefits from electrification, however about 10%-15% should be large footloose industries so as to determine the contribution of electrification to the siting these sources of employment.

Non-electrified industries:

1. should be located near enough to the power lines to make connection possible now or in the near future;
2. should employ at least four persons.

Both the owner and the operator should be interviewed since the former will know about local investments decisions and costs and the latter about technical and maintenance issues.

Most of the data will be categorized by type of industry, size and use of electricity. Some of the results may be generalized according to type of industry. For this purpose, data on the rural industry population should be collected through a complementary industry census conducted by the REB.

Some initial work on the development of the survey instruments was undertaken as part of the micro-surveys reported in Annexes VIII and X. Some of the hypotheses to be tested and some of the data to be collected are included in the attachment to this TOR.

4. Organization of the Survey

The survey would require a variety of expertise including rural sociology, basic electro-mechanical engineering, and economics. In order to develop such a team, it is assumed that the foreign consultants would take the lead in identifying individuals or institutions which can contribute to the individual components of this study. The participants should be selected based on their past field experience in similar or related efforts and on their ability to produce meaningful analysis and reports.

Because of the need for tight management and a consistency of style, a single local firm should be selected to assume responsibility for all survey components. A number of research institutions, including the three organizations used in this pre-assessment, have the capability to undertake the full range of survey activities but only by sub-contracting some of these components. A research institute would be preferable to a university because of the former's orientation towards producing a product and its ability to mobilize resources. However, university participation should be encouraged because the universities are able to provide a more rigorous understanding of how to measure the behavior of the rural population. The foreign consultants would have final responsibility for insuring that the sub-contractors have the necessary skills.

The foreign consultants would include one full-time person and one part-time data specialist. The full-time consultant would be responsible for insuring the quality of the effort. This would entail:

a. coordinating the activities of the local survey components,
b. reviewing the survey instruments and methods to insure that the results can be analyzed to produce meaningful results on the economic and social benefits attributable specifically to electricity,
c. participating in field tests, training and initial survey work to insure that the information is being properly collected,
d. planning the data analysis activity to insure that the information is properly encoded and can be analyzed to produce the information desired within the time and budget allocated, and
e. reviewing the quality of the analysis and the conclusions derived.

The short-time data analyst would assist in planning data analysis (part d).

5. Training

Since the survey cannot fall back on the comfort of a large random sample, it is important that the quality of the data be insured through adequate training and close supervision in the field. The crucial element will be training. Local experience with participant observation is relatively limited, therefore sufficient time must be given to training the research assistants in:

a. methods for establishing and maintaining rapport,
b. working from a general outline of questions,
c. recording information without breaking the flow of conversation, and
d. dealing with sensitive questions and showing proper respect towards respondents.

These techniques are learned through practice. It is important that sufficient time and attention be given to this activity in addition to the normal training concerning the purpose of the survey and the questions being asked. It is expected that the time for training in the household survey, including practice interviews with the survey supervisors, will require 1 to 2 weeks.

6. Data Analysis and Reporting

The methods of analysis will vary with the type of survey. For the household survey, the data from the structured questionnaire will require computer analysis. This should be supplemented with general information on the contributions of electrification to rural development. This information can be obtained from essays prepared by the research assistants and categorized by their supervisors.

For the market survey, the sample size is smaller and the results should be categorized according to type of enterprise. Therefore simple manual processing of the results may be sufficient. The cost data should be used to develop simple cost models to analyze the advantages/disadvantages of electrification at different levels of price and utilization. Again the research assistants should prepare essays summarizing their impressions on the effects of entrepreneurship, locational needs and investment criteria on the choice of technology and the use of electricity. The results should be categorized and presented by survey area.

A separate report would be produced for each survey component. These reports would include a description of the methodology and any survey instruments used. They would also summarize the available secondary data used to extrapolate the results to the total population within the RE programme. The results of the data analysis will be presented in tabular form with discussions of the implications of these findings as they pertain to the benefits of rural electrification.

A summary volume will then be produced in which each of the eight questions presented at the beginning of this TOR will be addressed. The findings of the survey will be presented in the form of quantifiable and non-quantifiable benefits from the RE programme. The recommendations for future expansion of the REB system and USAID's participation in this expansion will also be presented. These recommendations will be backed up by the results of the analysis and will be evaluated with regard to the impacts on economic development and financial sustainability.

7. Scheduling

The survey components are expected to begin simultaneously. The proposed time budget for the household survey includes:

a. 3/4 month for organization of effort and development of an approach,
b. 3/4 month for site selection, development of the survey instruments, pretesting and training
c. two months for surveying and data preparation
d. one and one-half month for data analysis
e. two months for report writing

The last two activities would overlap, constituting a total survey time of 6 months.

The marketplace survey would be organized during the same initial month with some allowance for slippage. A period of three weeks would be needed to develop and pretest the survey instruments and train the research assistants. The survey would then last for two months including time for data compilation. This would be followed by a month for data analysis and development of computerized cost models for alternative sources of energy. Report writing would require an additional month.

The timing of the surveys should be made with due consideration of the rainy period starting in mid-April. It would require that the survey activity be commenced by the first week of January 1990 or delayed until after August of 1990 to permit the survey to be conducted in the non-monsoon period.

8. Survey Budget

A survey budget was prepared based on the schedule presented in the previous section and available information about unit costs. it is included in the attachments.

ATTACHMENTS

PRELIMINARY BUDGET FOR RURAL ELECTRIFICATION EVALUATION SURVEY

COST ITEM	AMOUNT REQUIRED	UNITS	UNIT COST	TOTAL COST
FOREIGN CONSULTANTS				
Compensation Fully Loaded				
Survey Coordinator	6	MN-MONTHS	$10,000	$60,000
Data Specialist	1	MN-MONTHS	$12,000	$12,000
Per Diem				
Dhaka	105	MN-DAYS	$115	$12,075
Rural Areas	45	MN-DAYS	$50	$2,250
Travel				
International	2	TRIPS	$3,000	$6,000
Domestic	3	TRIPS	$300	$900
Miscellaneous				
Secretarial	6	MN-MONTHS	$400	$2,400
Communications	6	MONTHS	$300	$1,800
Reproduction	6	MONTHS	$250	$1,500
Office Space	6	MONTHS	$500	$3,000
G&A and Fee			35%	$35,674
SUBTOTAL				$137,599
HOUSEHOLD SURVEY				
Compensation				
Principal Investigator	6	MN-MONTHS	$1,500	$9,000
Supervisor	4	MN-MONTHS	$800	$3,200
Research Assistants	23	MN-MONTHS	$600	$13,500
Data Analyst	4	MN-MONTHS	$700	$2,800
Per Diem				
Principal Investigator	20	MN-DAYS	$25	$500
Supervisor	60	MN-DAYS	$25	$1,500
Research Assistants	450	MN-DAYS	$10	$4,500
Transport				
Principal Investigator	3	ROUND TRIPS	$200	$600
Supervisor	6	ROUND TRIPS	$30	$180
Research Assistants	30	ROUND TRIPS	$15	$450
	450	MN-DAYS	$5	$2,250
Computer Expense, Data Entry	1		$2,500	$2,500
Secretarial Support	6	MN-MONTHS	$300	$1,800
Communications	6	MONTHS	$150	$900
Reproduction	200	100 PAGES	$10	$2,000
Overhead and Fees			30%	$13,704
SUBTOTAL				$59,384

COST ITEM	AMOUNT REQUIRED	UNITS	UNIT COST	TOTAL COST
MARKET SURVEY				
Compensation				
Principal Investigator	6	MN-MONTHS	$1,500	$9,000
Research Assistants	9	MN-MONTHS	$600	$5,400
Computer Programmer	1.5	MN-MONTHS	$600	$900
Per Diem				
Principal Investigator	30	MN-DAYS	$25	$750
Research Assistants	180	MN-DAYS	$10	$1,800
Transport				
Principal Investigator	3	ROUND TRIPS	$200	$600
Research Assistants	9	ROUND TRIPS	$15	$135
	180	MN-DAYS	$5	$900
Computer Expense	1		$500	$500
Secretarial Support	6	MN-MONTHS	$300	$1,800
Communications	6	MONTHS	$150	$900
Reproduction	75	100 PAGES	$10	$750
Overhead and Fees			30%	$7,030
SUBTOTAL				$30,465
OVERALL STUDY				
Foreign Exchange				$137,599
Local Costs				$89,849
GRAND TOTAL				$227,448

ISSUES AND HYPOTHESES TO BE TESTED

The following is a list of some of the issues to be considered and hypotheses to be tested in the two surveys.

Household Survey - Domestic, Cottage Industry, Irrigation

The initial investment for connection is the most important decision followed by the decision to purchase appliances and finally the decision regarding the amount of electricity to use per month.

Where there is the potential for cottage industry or for water pumping, the household will connect for these reasons rather than domestic uses.

The most important factor in the decision to connect is household credit/wealth.

Ownership of appliances is the most important determinant of how much electricity is consumed followed by the level of recurrent income.

The purchase of appliances generally follows the sequence of lighting, radio-cassette, fan and television.

The level of development in the area has a general effect on the rate of household connections.

The household's willingness to pay for both connection and electricity is quite high but the latter, being smaller, has a much higher relative willingness-to-pay.

Monthly payments are a problem during the low income time of year.

Reliability of supply is relatively unimportant for households.

Many cottage industries use electric lighting but very few use electrical equipment or appliances.

Electricity does not lead to the introduction of new cottage industries but may increase the capacity of existing ones.

Market Survey - Industrial and Commercial

The location of markets and the availability/cost of transport are the key elements in deciding on the location of rural industry and commercial establishments. The availability of electricity may be a precondition.

Tradition plays a part in the location of industries in the sense that an entrepreneur very often prefers to locate near his traditional home or that of his relatives.

The factors leading to mechanization of productive activities are: the potential for a reduction in the cost of production, improvements in product quality, an increase in the capacity or rate of production, and a reduction in demands on management.

Rural industries can be divided between resource and market based units which locate close to the source of their raw material or their consumers and footloose units whose locational decision takes into account a number of other factors.

Footloose industries are more sensitive to the availability of electricity.

The production technology adopted by the industry or commercial establishment is most often determined by that used by a neighbor or relative and not by an evaluation of alternatives.

The scale of a rural industry is also a major factor in selecting the production technology

The type and scale of the industry affects both the decision to mechanize/electrify and the amount of energy used.

Larger facilities tend to be turnkey plants often involving foreign participation. Small facilities tend to be locally constructed using technologies from the urban market.

Scale is limited by risk aversion. There is a clear preference to diversify rather than expand.

Diesel is a potential source of shaft power for most industrial applications but is less desirable than the electric motors.

The marginal impact of electricity differs for those industries which can use diesel and those which cannot, and for those commercial activities which can use batteries/kerosene and those which cannot.

DATA TO BE COLLECTED AND THE USE OF SECONDARY SOURCES

The data to be collected in the surveys should be supplemented with information from secondary sources including national agricultural and census data, and major survey efforts such as the rural industry currently being implemented by the Planning Commission. Local data should be obtained from the PBS records, the Upazila government offices and from informants such as the village headmen. The types of data to be collected through the surveys and local level sources are listed below.

Household Survey - Domestic Energy Use

Baseline data from Upazila, village headman, and PBS on the level of development - pukha roads, female/male literacy, proximity to large markets, and use of electricity

Gross income, land, and major physical assets

Energy use by activity including electricity and other fuels but excluding biomass for cooking or heating

Monthly expenditure for electricity and fuels

Appliance ownership, sequence of purchase, and use

Reliability of electricity and fuel supplies

Cost data for connection, hookup, appliances,

Sensitivity of demand to changes in the price of connection and energy

Basic family parameters, size, ages, sex, number, wage earners

Changes in social habits as a result of electrification (comparison or recall)

Household Survey - Irrigation

Baseline data from Upazila and PBS on arable land, areas cropped, irrigated land, method of irrigation, electricity use, and prices of products and inputs from marketplace

Irrigation technology

Command area

Period of use

Purchase price

Operating requirements (quantity and unit costs for labor, parts, energy)

Reliability of equipment

Repair and maintenance requirements (frequency, type of repair, man-hours and skill levels required

Reliability of energy supply

Marginal benefit of mechanized irrigation versus traditional methods

Non-cost benefit of electrified irrigation versus diesel

Household Survey - Cottage Industry

Types of products and level of production

Types of inputs, sources and costs

Market for products and prices

Production technology employed

Source, type and number of labor employed

Use of electricity and other sources of energy

Effect of electrification on level and type of activity

Marketplace Survey.

Baseline data from the proposed REB census of rural industries within the PBS areas and from the on-going USAID/Planning Commission survey of rural industries

Factors affecting locational decision including availability and cost of land, labor, transport costs and energy sources

Source of raw materials

Market area served

Factors leading to growth in the market/demand

Level of production, weekly and seasonal variation

Uses of equipment and labor

Type of technology used, capacity of motors/engines and source of processing equipment

Reasons for choice of production technology and source of information

Factors affecting selection between diesel and electric shaft power

Equipment age, cost of acquisition, age and whether new or second-hand

Costs for operation and maintenance of equipment broken down by labor, material and energy

Factory gate price for outputs

Energy consumption

Skill requirements for operation and maintenance

Labor recruitment/training

Reliability of energy, equipment

Actual benefits of mechanization:
- savings in production costs,
- improvement in product quality,
- reduction in labor force,
- increased reliability of production activity,
- extended hours of operation
- increased rate of output
- reduction in management/supervision requirements

Sensitivity of decision to electrify to the costs for connection, equipment and monthly charge

Source of finance and importance of credit in establishing industry

Plans and possibilities for expansion of production activity

CHAPTER 3

DEVELOPMENT OF A SOCIO-ECONOMIC MONITORING AND EVALUATION ACTIVITY WITHIN REB

1. Current Activities of the Rural Electrification Board

At present the monitoring and evaluation activities of the REB are performed by three groups each operating under different directorates (see Figure 1). The first is the Rate Cell, which reports directly to the Member for Finance. It prepares a monthly MIS report based on the submissions of Form 550 by the individual PBS's. This report contains data for each PBS about the supply of electricity, the number of customers, the extent of the distribution system and the monthly and year-to-date financial performance (see attachments).

The second is the Power Usage Department which is split between the Directorates of Planning and Management Operations (Figure 3). This department is responsible for working with the PBS customers to promote the use of electricity.

The third is the Evaluation Division which operates under the Director of Programs and Planning (Figure 4). It assists in the preparation of:

1) The Quarterly Progress Report for submission to IBRD.

2) Pre-feasibility reports on new sites for the RE program for review by REB and the donors.

3) Project pro-forma for review by the Planning Commission.

It also participates in the preparatory field work related to the formation of new PBS's. The only socio-economic monitoring performed by the Division is in the form of occasional surveys of the demand for electricity in selected PBS's.

2. Role of the Evaluation Division

Before suggesting the monitoring and evaluation activities to be undertaken by the REB, it is necessary to consider the general monitoring/evaluation needs (M/E) of the REB. The basic need is to lend support to the planning, operational control, and promotional activities of REB and the PBS's.

Figure 2

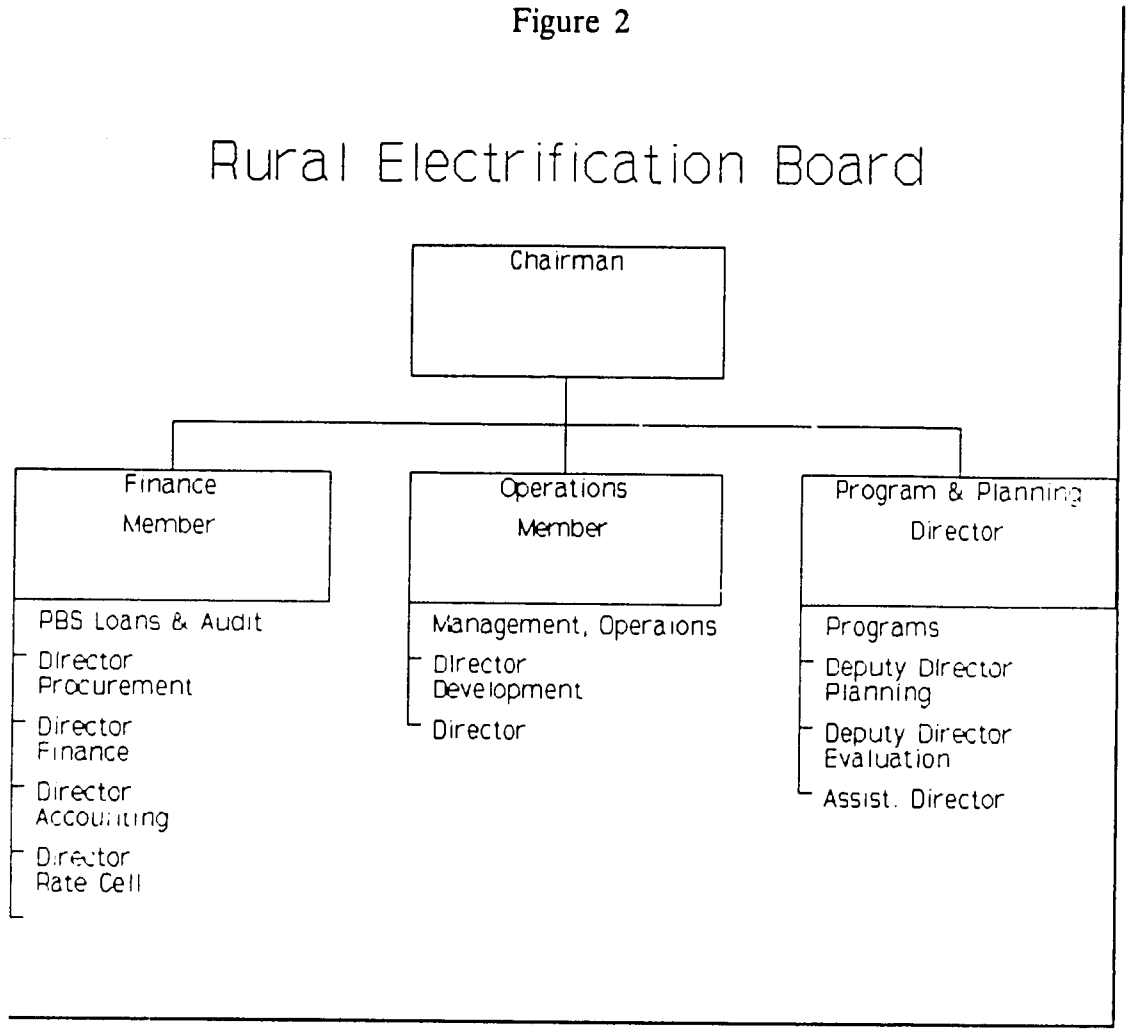
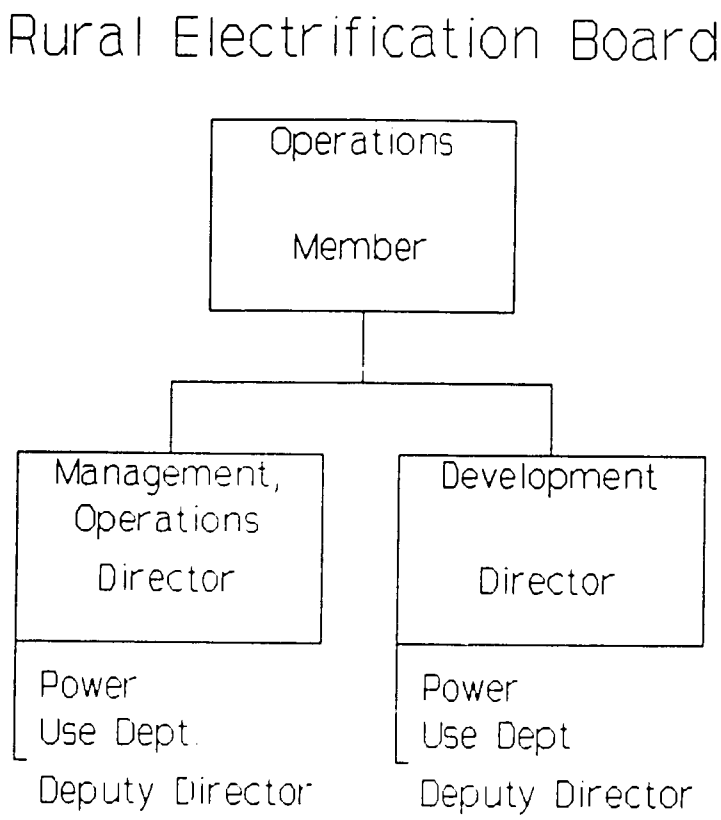

Rural Electrification Board
Chairman
Finance
Member
PBS Loans & Audit
Director
Procurement
Director
Finance
Director
Accounting
Director
Rate Cell
Operations
Member
Management, Operations
Director
Development
Director
Program & Planning
Director
Programs
Deputy Director
Planning
Deputy Director
Evaluation
Assist. Director

Figure 3


Rural Electrification Board
Operations
Member
Management,
Operations
Director
Development
Director
Power
Use Dept.
Deputy Director
Power
Use Dept
Deputy Director

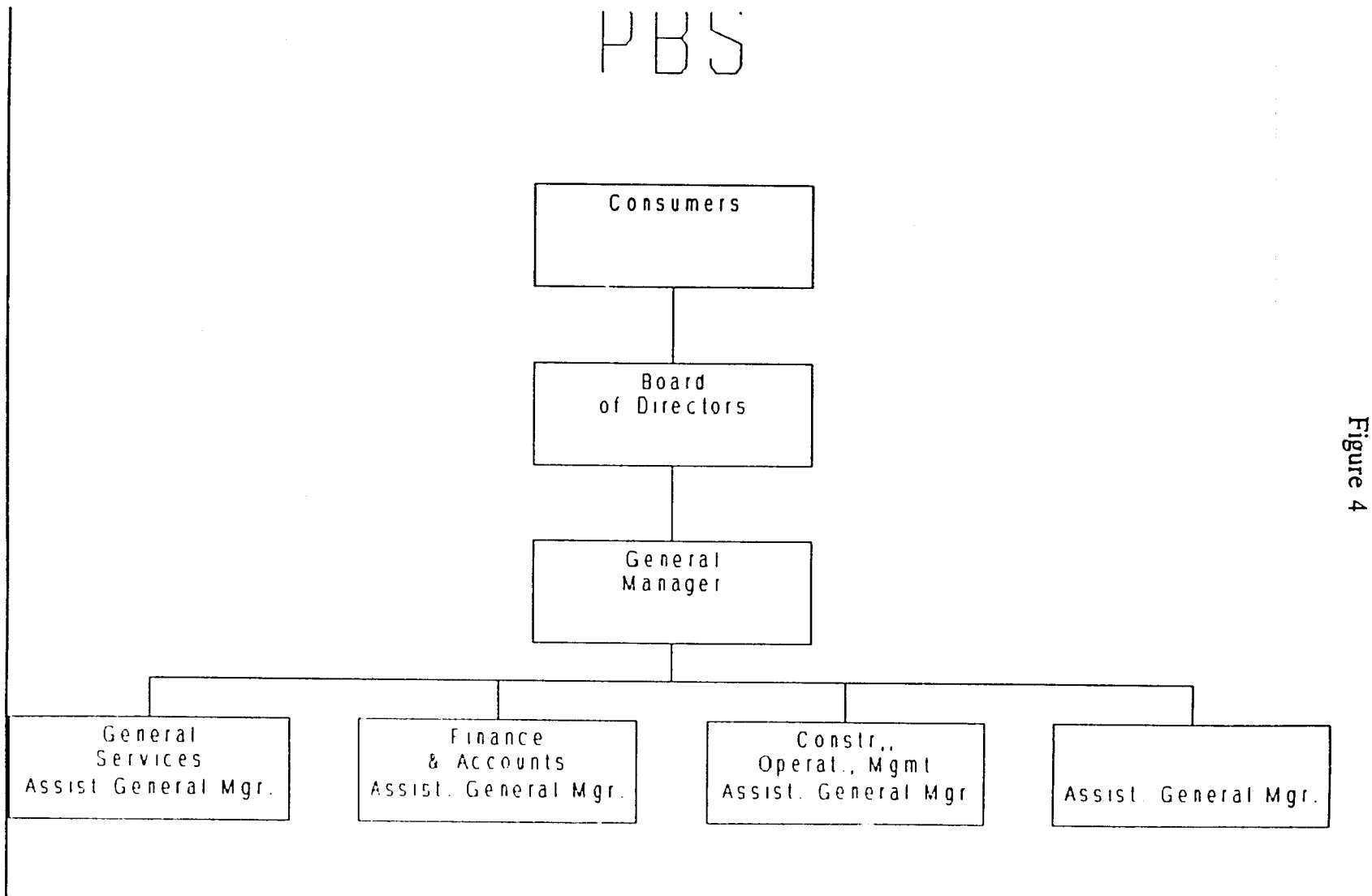

PBS
Consumers
Board of Directors
General Manager
General Services Assist General Mgr.
Finance & Accounts Assist. General Mgr.
Constr., Operat., Mgmt Assist. General Mgr
Assist. General Mgr.

Figure 4

In the area of planning, the M/E activities should improve the procedures for selecting areas to be electrified and the setting up of new PBS's. When selecting an area to be electrified; the density of consumers and the expected financial return from the extension of the power lines are estimated. These estimates are computed from standards developed during the earlier phases of the RE program. Although considerable data has been collected concerning the rate of growth in hookups, the consumption for each class of user, and the average costs and revenues for hookups in each class, this data has not been used to update the standards. Since there are now a large number of PBS's with a considerable range of performance, it should be possible to develop better standards for estimating future demand and financial returns.

When setting up new PBS's, the REB helps in the organization of an effective management structure. The PBS boards are elected by the local populace, but the REB assists in identifying potential candidates who can provide effective leadership. Good management at the local level is the most important element in the success of a PBS. An important M/E activity would be to review the performance of the different PBS's and the contribution of Board members to their success. This information could then be used as a guide to the setting up of future PBS's.

At present, the operational control activities of the REB focus on the financial performance, procurement activities and the growth in consumption of the PBS's. The relevant data is collected from Form 550 and reported monthly and annually in varying levels of detail. The most effective use of this performance data is to report trends in performance. Where a deterioration is observed, a closer analysis should be performed. For example, a PBS with a negative surplus but improving operating ratio may be in much better condition than a PBS with a positive surplus but deteriorating operating ratio. Management reports can be produced to emphasize these trends and alert the REB to potential problems. The graphical and tabular analysis shown in Annex III provides a starting point for this reporting function. The data shown in Annex II should be combined with this financial data and with additional performance data to generate reports which compare a PBS's financial performance and its system characteristics (e.g. density of users, consumption by class, average consumption per hookup, average revenues by class and system losses). This report could be used to assist the REB and the PBS's in planning for expansion, revision of tariffs and improvements to the distribution system.

The operational control activities also include intermittent user surveys organized by the REB. This activity should be extended to include performance audits to evaluate the quality of service provided to cooperative members. The features of the RE programme which contribute to its success such as system reliability,

equality of access and enforcement of billing procedures should be audited. As an example, data on the frequency and duration of outages of individual PBS's could be collected from the PBS's and confirmed through field interviews with current users. Data on the charges levied (formal and informal), the customer's understanding regarding these charges, the rates and conditions quoted for hookups to households not yet connected, and the charges for house-wiring could be collected in a similar manner. The survey required to collect this data should not be performed by REB or PBS employees because of problems of credibility. However, the REB should design and supervise the survey. These interviews would include recent hookups and potential customers so as to provide information on the efficiency of PBS in providing connections for potential users and their efforts to minimize costs for these connections.

A performance audit should also be used to examine the sources of non-technical losses through a combination of line metering and informal observation. This would be done by the Evaluation Division in cooperation with the individual PBS's and would focus on those co-ops with the highest rates of non-technical losses.

In the area of promotional activities, the REB's efforts could be extended beyond the current activities of the Power Outage Divisions. As the RE program expands, this function will become increasingly important. The new promotional activities could cover a broad range of concerns as follows:

1. assist technology transfer by providing rural entrepreneurs with information regarding the production technologies available with electrification.

2. prepare cost evaluations regarding the life cycle costs for diesel and electric irrigation pumps and shaft power, to identify areas in which the costs advantages are significant and electrification should be promoted.

3. identify markets for promotion of electrification through review of secondary data on irrigation and tube-well sales within the Upazila, and the formation of industrial activities and through a review of the rate of requests for connection.

4. promote demand in non-electrified areas through the introduction of battery recharging technologies at the furthest extension of the REB lines, sponsoring mechanization through diesel engines in areas which would be eligible for electrification once sufficient demand has been established, and encouraging small auto-generation units in areas out of reach of the planned distribution system.

The M/E activity could contribute to these promotion activities by undertaking the second and third activities directly. It could also contribute to this activity by surveying the unmet energy demands in areas located beyond the existing distribution network and by monitoring productive activities in the area served by the network.

3. Additional M/E Activities

The scope of this review was meant to focus on the socio-economic monitoring function of the REB in general and the means for strengthening this function as well as the role of the Evaluation Division in specific. The present focus of REB is on expansion of the rural electrification system and promotion of the use of electricity. This is its proper role and provides the greatest benefit. Its success is attributable to the quality and enthusiasm of its staff. However, these conditions make it is difficult for the REB to collect objective data on the socio-economic impacts of rural electrification, especially since the survey respondents would be aware that the surveyors work for the REB.

This is not to say that such information would not be useful to the REB, but rather to suggest that they would have difficulty in collecting such information. The REB should not conduct surveys but rather contract for surveying activities with organizations experienced in the design of the survey instruments and the performance of rural surveys . The data would then be collected by the contractor.

With regard to socio-economic surveys undertaken by donors or local research institutions, it is important that the REB be responsible for coordination of these activities. At present, the socio-economic surveys of rural electrification range for large-sample, institutional efforts to small-sample surveys for academic credit. The exact number of the surveys undertaken in the last 8 years is unknown. It would be useful if the Evaluation Division could act as a clearing house for these studies, especially where donors are involved. The Division could provide assistance to these efforts by identifying appropriate sample frames using their data on the consumption in different PBS's.

The REB should also conduct its own marketing surveys to determine the characteristics of existing demand and to identify latent demand. Specific areas in which surveys should be conducted by the Evaluation Division are:

1. A census of industries and commercial establishments within the boundaries of the PBS's to determine their number and type, their size (based on a simple numeraire such as employees or size of facility), their production technology, and if not electrified, their potential for electrification and their distance from existing lines. If electrified, it should be determined whether they were initially connected to the BPDB.

2. A census activity to determine the type of irrigation wells within the PBS, their command area, size of engine/ motor, and source of energy.

3. A survey of appliance ownership from a random sample of electrified and non-electrified households and commercial establishments. This survey would only be performed in PBS's which did not have earlier survey results and for which BBS census data was considered inadequate.

These surveys would be used to provide not only data for future sample frames, but also a database for use in the promotional efforts of REB.

Another activity which the REB could undertake that would contribute to all three planning, operational control, and promotional efforts is the development of a database of performance measures for the individual PBS's. This database would utilize the historical data reported in the Form 550, some of which is already entered into Lotus spreadsheets by the REB's Rate Division. However, this data has been entered for only the last two years. Information from earlier periods must be obtained manually from the monthly or year-end Form 550 for each PBS. Also no attempt has been made to integrate this data into a single relational database.

As part of this assessment, a database has been developed (using a Lotus spreadsheet) which includes information on consumption and hookups by class and PBS and revenues, costs, assets, debt service and subsidies by PBS since FY82. The Rate Cell should build upon this database by collecting additional information on the distribution of demand (for both power and energy) within each class and season, the amount of connections currently requested and the number of potential users not currently connected.

The database could then be used by the Evaluation Division to analyze the pattern of growth in demand for each class of user. Additional sample data could be collected regarding the distribution of demand within classes.

Among the questions to be addressed when analyzing the information in the proposed database are:

1. Which PBS's have a faster rate of growth in connections and what characteristics of the Upazila and the PBS might explain this.
2. How does the mix of consumption by energy class affect financial performance?
3. What has been the contribution of the takeover of the BPDB's lines to the financial performance of the REB systems?
4. How does the average consumption per connection change over time and as the lines are extended?
5. What regional factors can be used to explain differences in demand and consumption for irrigation, Group A and Group B connections?

Other M/E efforts in support of REB's promotional activities should be undertaken by the Evaluation division together with the Power Usage Divisions. These would evaluate the technologies available for productive activities (agricultural, industrial and commercial) in the rural area which use both electricity and diesel and compare these with the technology commonly used. The comparison would consider issues of the capital and operating costs, the reliability, quality and scale of production, and the technical skills required for operation. The information collected would be evaluated and summarized for use in developing pamphlets and programmes aimed at promoting electrified technologies where they are clearly advantageous, and for promoting related technologies in areas which are not currently electrified but will be incorporated in the future. The analysis would be done by the Evaluation Division for use by the Power Use Divisions.

4. Staffing and Equipment Requirements

The above activities would be undertaken in addition to current efforts. The Power Usage Divisions and the Rate Cells appear to have sufficient manpower for these tasks, however the Evaluation Division would require additional staff. This Division is currently has only one officer although in the past there have been four officers (1 Deputy Director, 2 Assistant Directors and 1 Statistician) and three field investigators. One programmer familiar with database systems or able to be trained in database systems would have to be recruited. One data analyst familiar with statistical techniques, one technical analyst with knowledge of electrical and mechanical systems, and one field supervisor for the survey activity would also have to be added to the existing staff.

In addition, two 286-based desktop computers should be obtained with sufficient hard disk capacity (40-60 MB) and high density floppy disk drives to organize and analyze survey data. These should be supported by a wide carriage, letter quality printers and basic software (spreadsheet packages with good graphics capability and

SQL-based programmable database systems). One would be assigned to the Evaluation Division and one to the Rate Cell.

5. Conclusion

The monitoring and evaluation effort requires a coordination between the REB's Rate Cell, Power Usage Divisions and Evaluation Division. The Rate Cell would focus on financial performance, through expansion of its MIS system, the Power Usage Division would focus on technology promotion and extend this effort to alternative energy sources to non-electrified areas. The Evaluation division would focus on surveys, performance audits, and economic analysis of alternate technologies.

Attachment

FORM 550

FINANCIAL AND STATISTICAL REPORT TO RURAL ELECTRIFICATION BOARD	BORROWER _____ MONTH ENDING _____

PART A STATEMENT OF REVENUE AND EXPENSE

ITEMS	YEAR TO DATE		THIS MONTH
	LAST YEAR	THIS YEAR	
1 Sale of Electricity			
2 Other Operating Revenue			
3 Total operating Revenue (1+2)			
4 Cost of Purchased power			
5 Distribution Expense-Operation			
6 Distribution Expense -Maintenance			
7 Customer Accounts Expense			
8 Customer Service Expense			
9 Sales Expense			
10 Administrative and General Expense			
11 Total Operating and Maintenance Expense (4 thru 10)			
12 Depreciation and Amortization Expense			
13 Tax Expense Other			
14 Interest on Long Term Debt			
15 Other Deductions			
16 Total Cost of Electric Service (11 thru 15)			
17 Operating Margins (3-16)			
18 Government Subsidy			
19 Non-Operating Margins-Interest			
20 Non-Operating Margins-Other			
21 Extraordinary Items			
22 Margins			

PART B-AGING OF CUSTOMER ACCOUNTS RECEIVABLE ELECTRIC

Class of Service	Total Receivable		current		Over 30 days		Number now disconnected
	No.	Amount	No.	Amount	No	Amount	
1 Domestic							
2 Commercial							
3. Irrigation							
4. Gen Power'A							
5. Gen Power'B							
6. Streetlight							
7. Total							

	This Month	Year to Date
8. Collection		
9. Percentage of Collection		
10. Month Revenue Outstanding		

REB FORM NO. 550 REV. PAGE 1 OF 4

FINANCIAL AND STATISTICAL REPORT TO RURAL ELECTRIFICATION BOARD	BORROWER MONTH ENDING

PART C-BALANCE SHEET

ASSETS AND OTHER DEBITS		LIABILITIES AND OTHER CREDITS	
UTILITY PLANT		**EQUITIES & MARGINS**	
1. Electric Plant in Service		27. Membership Issued	
2. Construction Work in Progress		28. Membership Subs. But not Issued	
3. Total Utility Plant		29. Operation Margins-Prior Year	
4. Accum. Provision for Depreciation		30. Operating Margins-Current Year	
5. Electric Plant Acquisition Adjmnt		31. Non-Operating Margin--Prior Year	
6. Net Utility plant		32. Non Operating Margins-Current Year	
OTHER PROPERTY AND INVESTMENTS		33. Donated Capital & Capital Gains	
7. Non Utility Property		34. Total Margins & Equities	
8. Special Fund Depreciation		**LONG TERM DEBT**	
9. Special Fund-Others		35. REB Loans - Cash	
10. Total Other Property & Investments		36. REB Loans -Provisional Plant	
CURRENT AND ACCRUED ASSETS		37. REB Loans-Construction Close Out	
11. Cash-General and Other Funds		38. REB Loans -Other	
12. Special Deposits		39. Total Long Term Debt	
13. Working funds		**CURRENT AND ACCRUED LIABILITIES**	
14. Temporary Investments		40. Notes and Accounts Payable	
15. Account Receivable-Electric		41. Consumer Deposits	
16. PROV for Uncollectible		42. Accrued Taxes	
17. Accounts Receivable-Others		43. Matured Interest	
18. Material & Suppliers-Electric		44. Matured Long Term Debt	
19. Material & Suppliers-Merchandise		45. Other Current & Accrued Liabilities	
20. Prepayments		46. Total Current and Accrued Liabilities	
21. Other Current & Accrued Assets		**DEFERRED CREDITS**	
22. Total Currents Accrued Assets		47. Customer Advance for Construction	
DEFERRED DEBITS		48. Other Deferred Credits	
23. Misc. Deferred Debits		49. PDB Customer Dues Outstanding	
24. PDB customer Dues		50. Total Deferred Credits	
25. Total Deferred Debits		51. Total Liabilities and Other Credits	
26. Total Assets and Other Debits			

PART D-CONSUMER SALES AND REVENUE DATA

Class of Service	THIS MONTH				YEAR TO DATE		
	Number Billed	KWH Sold	Amount Billed	Number Min. Bill	Number Billed	KWH Sold	Amount Billed
1. Domestic							
2. Commercial							
3. Irrigation							
4. General Power'A							
5. General Power'B							
6. Street Light							
7. Total Sale of Electricity							

REB FORM NO. 550 REV.

PAGE 2 OF 4

FINANCIAL AND STATISTICAL REPORT
TO RURAL ELECTRIFICATION BOARD

BORROWER _____
MONTH ENDING _____

PART E-ENERGY AND DEMAND DATA

ENERGY	THIS MONTH	YEAR TO DATE	PEAK DEMAND	THIS MONTH	YEAR TO DATE
1. KWH Purchased			1 SUB-STATION		
2. KWH Sold			1		
3. PBS Use			2		
4 Total (2+3)			3		
5. KWH Loss (1-4)			4		
6. Percent Loss			2 DATE OF PEAK		
			1		
			2		
			3		
			4		

PART F-PLANT AND CUSTOMER DATA

DESCRIPTION	THIS MONTH	YEAR TO DATE	CUMULATIVE FROM INCEPTION
1. Services Connected			
2. Services Removed			
3. Services in Place			
4. Houses Wired			
5. Wired Houses Inspected			
6. Villages Electrified			
7. Miles Constructed (Except 100-41)			
8. Miles PDB Renovated			
9. Miles Constructed 100-41			
10. Total Miles Constructed			
11. Total Miles PDB Take Over			
12. Total Miles Energized			

CONSUMER CONNECTIONS BY CATAGORY

	DOM	COMM	DTW	STW	LIP	GP-A	GP-B	ST.LT	TOTAL
1.This month									
2. Cumulative									

PART G-AGING OF ACCOUNTS PAYABLE

DESCRIPTION	CURRENT	31 to 60 DAYS	61 to 90 DAYS	Over 90 DAYS	TOTAL
1. PDB-Power Billing					
2. REB-Housewiring					
3.					
4					
5.					
TOTAL					

REB FORM NO. 550 REV.

PAGE 3 OF 4

FINANCIAL AND STATISTICAL REPORT
TO RURAL ELECTRIFICATION BOARD

BORROWER _____
MONTH ENDING _____

PART C-1 CHANGES IN UTILITY PLANT

Description	Balance Begining Fiscal year	Additions year To Date	Retirement year To Date	Adjustments and Transfers	Current Balance	Deprn. Rate
DIST. PLANT						
1. REB Project Sub-Stations - Not Classified						
2. REB Project Line Construction - Not Classified						
3 REB Project Line Renovation - Not Classified						
4. PBS constructed Not Classified						
5. Total Plant not classified						
6. Distribution plant classified						
7. Total Energized Plant						
GENERAL PLANT						
8. Land and Land Rights						
9. Structure and Improvements						
10. Office furniture and Equipment						
11 Transportation Equipments						
12. Stores, Tools & Lab Equipment						
13. Power Operated Equipment						
14. Communication Equipment						
15 Miscellaneous Equipment						
16. Total General Plant						
17. Intengible Plant						
18. Construction work in Progreses						
19 Total Utility Plant						

NOTES :

CERTIFICATION
WE HEREBY CERTIFY THAT THE ENTRIES IN THIS REPORT ARE IN ACCORDANCE WITH THE ACCOUNTS AND OTHER RECORDS OF THE SYSTEM AND REFLECT THE STATUS OF THE SYSTEM TO THE BEST OF OUR KNOWLEDGE

A G M-FINANCE _____ DATE _____ GENERAL MANAGER _____ DATE _____

REB FORM NO. 550 REV.

PAGE 4 OF 4

Annex I

ANNOTATED BIBLIOGRAPHY

USAID, "Project Paper : Bangladesh Rural Electrification III", 1986

The project paper listed three objectives for the Third Phase of the Bangladesh RE program:

a. reducing human fertility,
b. increasing agricultural productivity, and
c. expanding rural employment.

A preliminary economic evaluation was made by combining two elements:

a. the savings in annualized costs through conversion from diesel pumps to electric pumps for irrigation and
b. the revenues paid by industrial, commercial and domestic users.

The latter was used because it was not possible to estimate the willingness-to-pay of industries or households. This approach amounts to little more than a financial analysis except that the costs of supply were adjusted to reflect the shadow prices for traded goods and labor.

For non-quantifiable social benefits, the paper pointed to the institution-building associated with the development of the PBS cooperatives and the REB management, the purported impact on family planning and the benefits to commercial and household activities from improved lighting and the extension of commercial activities into the evening hours. The report included a projection of energy demand increasing by 15% p.a. through 1990, 13% p.a. through 1995 and by 11% p.a.. through 2000.

The project paper also included a strong recommendation for the continuation of TA and for adjustment of the PBS tariffs to more accurately reflect the economic cost of the electricity. The latter was to correspond to a similar adjustment in the BPDB's tariffs to reflect their marginal costs. The financial situation of the PBS's at the time of the report raised concerns as to the long-term financial viability of the cooperatives. The present situation requires three levels of subsidy to cover capital and operating costs. These three are:

a. subsidization of the interest rates for the original investment loans
b. subsidization of the operating deficits for the PBS's
c. subsidized bulk tariffs charged by BPDB to REB

The project paper also included a recommendation for an extended monitoring and evaluation activity to be undertaken by the REB for the purposes of better planning and financial control.

IBRD, "Staff Appraisal Report for Bangladesh : Rural Electrification Project" and "Staff Appraisal Report for Bangladesh : Second Rural Electrification Project"

The reports appraise the two World Bank rural electrification projects. The load forecast for the projects was based on a disaggregated forecast for a model PBS with average annual growth rates between 22% and 34%. This reflected the slower initial growth versus the system-wide growth over the previous two years of 100% to 200% in all categories.

The benefits were computed by distinguishing between diverted and generated demand. The benefits from the diverted demand were computed by comparing the cost of the second best source of energy with the cost of the electrified alternatives. The second best source included diesel for irrigation and mechanization of rural industries and kerosene for lighting. The savings were measured by comparing the full capital, energy and O&M costs for each alternative. The economic costs were computed using an SCF of .8 for local expenses relative to border prices and .75 for unskilled labor. For generated demand, a fraction of these savings was attributed as benefits to electrification.

Rahman, Quazi Mafizur; "Rural Electrification in Bangladesh - A Baseline Study", March 1983, University of Dhaka

A survey for USAID of 8 PBS's conducted beginning in 1981. This survey included separate surveys of households, agricultural units, community facilities, commercial establishments and rural industries. The data collected was similar to that covered in other household, agricultural and industrial surveys of these activities but provided relatively little information on energy use. The compiled data were presented without analysis.

For households data was collected on the source of electricity. Of the 8691 households surveyed only 65 had electricity prior to the introduction of RE and 54% reported having signed up for connection. Despite the lack of electricity, 15% reported owning radios/cassette players. The expenditure for lighting was measured and 3% reported spending more than 50 Taka a month, 31% between

20 and 50 Taka per month, 44% between 10 and 20 Taka and 23% less than 10 Taka per month.

For the agricultural unit data was collected on the type of irrigation and the area irrigated for each household. Of the total sample only 414 were found to use manual irrigation, 1228 to use mechanical irrigation and 163 to use electric pump irrigation. In addition a sample of 665 agricultural units using irrigation (252 individual households and 413 pump committees) were surveyed in more detail. Of these 172 used low-lift pumps, 325 used shallow tubewells, and 168 used deep tubewells. The capacity of these pumps was 49% 2 cusecs, 47% of 1/2 cusecs and the rest in between. Data was collected on the hours of use, the costs for the operator and for repair. The area irrigated by these pumps was relative small: 35% irrigated less than 10 acres and only 31% irrigated areas over 30 acres. Most of the owners indicated an interest in electrifying their pumps.

For the community institutions data was gathered on the amount of electricity and kerosene used each month by type of establishment but the data was presented in aggregate form. The principal users of electricity where is was available were post offices, mosques, union councils.

For the commercial businesses, 1515 establishments were surveyed as the their size, number of employees, and monthly expenditures. Of the sample, approximately 2/3 had hookups prior to the creation of REB. Data was collected on monthly consumption of electricity with 28% reported no consumption, 15% reporting consumption in excess of 40 kwhr and the rest in between. The monthly consumption of kerosene was also reported as was the ownership of electrical appliances. The latter were aggregated in a meaningless way.

A total of 683 rural industries were surveyed of which 58% were mills for rice, pulses or other agricultural products. Only 47 of these were not already electrified and nearly all of those having electricity were electrified prior to the introduction of REB. Of the total, 80% reported having 1 or more electrical motors and 11% reported having installed capacity in excess of 30 horsepower. In contrast only 2% reported having diesel engines. The consumption of and expenditure for electricity were also determined. Only 18% of the electrified industries reported a consumption in excess of 1 MWhr per month and 30% reported a consumption of less than .4 mwhr.

68

Rahman, A. Atiq and Hug, Saleemul, "Rural Electrification in Bangladesh: Its Impact on Rural Commercial and Industrial Sectors" October 1988, Bangladesh Center for Advanced Studies

This survey was conducted in 1987-88 and covered four PBS's. A total of 464 commercial enterprises and 174 rural industries were surveyed. The survey utilized a series of questionnaires. One was for PBS officials and concerned on connection activities and priorities. Another was an informant survey in which commercial and industrial organizations were classified according to when they were established (before or after RE). Three commercial institution questionnaires were used: one each for those not-electrified, those which were electrified under REB, those electrified by BPDB. Two industrial questionnaires covering entrepreneurship and use of electrification were also used. The sample was drawn from the main market areas in each of the PBS's but the sampling technique seems to have fallen somewhere between random and purposive.

The report tends to attribute growth in commercial and industrial activity with the introduction of RE. This argument is based on the formation of new industries but is weakened by the lack of a random sample, the failure to compare the results with un-electrified areas, and the lack of information on establishments which were started after the introduction of RE but failed prior to the survey. The results can quite reasonably be interpreted as a normal Markov birth-death process.

The survey collects the perceptions of the respondents as to the effect of electricity on their income. This is acceptable since it is only a perception but the attempt to have the respondents estimate the increase in sales attributable to electricity shows a lack of insight into the information which can be reasonable collected through structured questionnaires. Other attempts at correlation between electrification and the characteristics of the commercial enterprise are largely intuitive and lack either a statistical or empirical basis. The same is true for comparisons between electricity use and the age of the enterprise or the period of electrification. This is not to say that these relationships might not be true, but rather that the survey results do not provide statistical proof as to their validity.

A survey of appliance ownership in electrified commercial establishments indicated an average of 2.5 bulbs, .6 fans and .3 radio/cassettes. Only 3% of the establishments reported using televisions or refrigerators. Most of the establishments spent less than 100 Taka per month on electricity. The reported power outages were relatively high averaging about 3.5 hours per week. The follow on question of the perceived loss in profit from power outages cannot be considered to yield meaningful results.

The survey of rural industries identified the preponderance of agricultural mills. The rural industries used an average of 4 motors and 8 light bulbs. The level of electricity use ranged between .3 and 1.5 mwhr per month. A more intensive use of appliances and a higher consumption of electricity was observed in the sample villages located nearest to major urban centers. The reported outages were similar in frequency and duration to that reported for the commercial establishments. No attempt was made to relate the consumption, employment or use of appliances to the level of output of the industries.

The survey observed an interest among mill owners and agricultural units in converting back from electricity to diesel to overcome problems of reliability of energy supply, to take advantage of the lower price of diesel and, in the case of irrigation, to take advantage of the potential mobility of supply. The survey made several observations regarding the complementary inputs required to increase the use of electrification. These include a relaxation of the 100 foot constraint on hookups and the provision of credit for hookups and equipment.

USAID and REB, "1983 - Impact Evaluation of Rural Electrification Programme in Bangladesh", August 1983

This was the second baseline survey performed by USAID in 1983 and covered 4 PBS's (Dhaka I, Comilla I, Rajashahi I and Pabna III) and 10 Upazilas. In each PBS a survey was made of 100 electrified households and 50 non-electrified households. A purposive sample procedure was used to focus on villages with a high rate of electrification. Although the questionnaire was not included in report, it appears to have focused primarily on the respondents perceptions with regards to the benefits of rural electrification. In addition a survey of commercial and industrial establishments was conducted at 175 electrified establishments and 70 non-electrified establishments and a survey of irrigation pump users was conducted for 81 electrified pumps (238 users) and 45 non-electrified pumps (132 users).

For the household survey, questions concerned whether the benefits from electricity included:

a. a reduction in fuel costs
b. an increase in working hours
c. in increase in household income
d. an increase in reading and children's study
e. an improved social life and increased amusement
f. an improvement in security.

10

The response categories were relative measures such as "don't know", "greatly increased", "increased", "decreased" and "greatly decreased". These perceptions were related to factors such as the period of energization, land holdings, education level of the respondent, and household income. Further comparisons were made between the year of energization and the relative standard of living and structure of the house. The reliability of these results can be questioned on the grounds that the no attempt was made to explore the basis for these perceptions. Moreover the resu'ts were surely biased as a result of the suspicions generated by such questions such as how much gold the household owned.

Quantitative data on the consumption of different fuels was reported for electrified and non-electrified households. This data showed that the electrified household spent half as much of kerosene as the non-electrified household but spend more on wood and cow dung for cooking. The study did indicate a average 50% higher income for electrified households versus non-electrified.

This survey was poorly conceived, the analysis of the data provided few insights and a certain amount of confusion, and overall seemed directed at promoting rather than evaluating the rural electrification programme.

Khan, Mahbubul Huque, "Impact Evaluation of Rural Electrification in Bangladesh", REB, 1987

This report shows a considerable evolution over the REB's 1983 effort. The survey was originally intended to use the baseline survey sample frame but found that the villages were to dispersed. Instead the survey used the same PBS's but chose adjacent villages where one was electrified and one was not. Households were selected at random or a complete sample was used where the village was small. Four documents were used, a village schedule, a household schedule, an industry schedule and an irrigation schedule. Each of the villages selected is described in the report as to its location, since, access, and availability of services, mechanized irrigation and industry..

The analysis was primarily a comparison of the average characteristics for electrified and non-electrified households and for the different Upazila. Electrified households were found to have more land, more moveable assets (watches, bicycles and radios), and a higher average income. Shallow tube wells were more common then diesel tube wells and were used to irrigate larger command areas for more people per well as lower cost. The absence of rural

industry in the survey areas, except for a few rice mills, was attributed to the absence of any significant markets.
The survey included a question regarding the respondents' perception of the impact of electrification. Not surprisingly, high percentages of respondents indicated an increase in working hours, household income children's study and employment of both males and females and security. On the other hand only a half the households reported an increase in reading or a reduction in fuel costs. No attempt was made to ask the a similar question regarding changes in non-electrified households. The questionnaire included at the end of the report indicates that there was considerable additional data which was collected but not incorporated in the analysis.

Coopers & Lybrand with A. Qasem & Co., "Financial Policies and Performance of the PBS's", USAID, Nov 1988

This study follows on an earlier study of BPDB's supply costs and pricing practices. The review of the financial performance of the PBS's is relatively complete. The target for their analysis is that both the REB and the PBS's should achieve financial soundness and the combined organization should increase the level of self-financing of the programme. The proposal to provide power from BPDS's 132 kV system through the 33 kv side of a substation was mentioned.

The financial performance of the PBS's has been below expectation because of a number of factors including:

a. lower than expected growth in hookups and consumption
b. inflation in costs of supply systems without corresponding increase in rates
c. slower than anticipated transfer of BPDB's rural lines with their existing customer base which tends to be commercial and industrial
d. lower than anticipated sales because planning is based on typical PBS's rather than actual characteristics and consumers who indicate their intention to sign up at the time of the survey have not done so

e. a failure to reduce losses at the projected (and somewhat unreasonable) rate which drops to 13% in the fifth year
f. increases in the Bulk Supply Tariff which were not anticipated in the feasibility studies
g. changes in the exchange rate and continued inflation leading to significantly higher capital costs
h. a larger proportion of non-domestic sales than anticipated.

The REB currently pays BPDB a flat rate under the Bulk Supply Tariff. There is an alternative two-part time of day tariff under which REB would pay much more because of the peak demand characteristics of its load corresponds with the system peak. The PBS's set their own rates within the broad guidelines set by the GOB that rates should be comparable to those charged by adjoining BPDB systems, by the IBRD that the rates must exceed the BST and by the REB regarding maximum charges.

The report discussed the illogical practice of setting aside funds for depreciation in a bank account but not repaying the principal and interest on the loan. The report also pointed out that the 5 year grace period on loans to the REB ends before the 5 year grace period for on-lending of the funds to the PBS's causing a cash flow problem and requiring an extension of the period of subsidies by the GOB.

The PBS's sign a legal mortgage for a loan-in-kind at the time that the system construction is completed and the assets are handed over to the PBS's. The REB is supposed to fund its investments through a roll-over of investments and the 1% differential in interest rates (3% p.a. to REB, 4% p.a. to the PBS's). However, neither of these mechanisms will provide a significant level of funds for future capital investment. The financial performance of the PBS's is measured against depreciation which is historical or debt service which is also historical given the rate of interest. Therefore the older PBS's have lower capital costs structures and appear to perform better.

The REB's loan agreement with the IDA requires a debt service ratio of 1.5 and a operating ratio of no more than .75. IDA established further criteria for the PBS's that the average revenue per kWhr is not less than BPDB's average revenue, that revenues should cover operating costs, depreciation and interest expense after fifth year, and produce a surplus after debt service equivalent to 20% of annual capital expenditure after the sixth year, that accounts receivables should not exceed two months revenue and accounts payable should not exceed 45 days worth of expenditures.

The report questions these criteria in the light of the variable performance experienced by the PBS's, fluctuations in the REB's level of capital expenditure from year to year, and the relatively few instances in which these criteria have actually been met. Also the financial viability of the programme does not imply the financial viability (by strict performance criteria) of each part of the organization.

The three forms of financial subsidy at present are the low interest rates applied by the GOB (and protection from exchange rate fluctuations) in on-lending funds, the operating subsidies paid by GOB to REB and the PBS's; and the economic subsidy in the form of BST rates which are below the marginal cost of the power generated. In addition there is cross-subsidy of domestic consumers whose peaked demand and low load factor is the most costly to serve. The question of the efficacy of this form of indirect subsidization of the rural poor by rural industrial users was raised.

The principal factors explaining the variability in performance of the PBS's are the density of consumers and the percentage of non-domestic consumption. There is also an issue of the rate of hookups which have been slowed by the connection charge although this effect has been masked by the REB's takeover of BPDB's lines. Another factors is delays in receiving power from BPDB, which is a planning problem originating on both sides. There is also the constraint of the BPDB's tariff in adjoining areas which limits the rates which can be charged by the PBS's even though the capital costs for and reliability of their distribution are much higher and do not benefit from system averaging.

The report projected the financial performance of the PBS's and the REB under alternative assumptions about the rate of increase in the real price for the BST assuming that the PBS tariff was adjusted in line with inflation. The results indicate that the REB would continue to be unable to meet its debt service for the foreseeable future. Suggestions for alleviating this problem include:

a. increasing the number of connections through loans to cover the cost of connection which would be repaid as part of the electricity bill.
b. a more rapid hand over of the BPDB's lines with their industrial and commercial connections
c. merging PBS's to improve their system demand characteristics, (this would affect the performance in individual PBS's but not the system as a whole)

74

d. us[illegible]e projected net income per mile of new line [illegible]than the gross income as a basis for expansion [illegible]ng, this would account for factors such as load [illegible]. power factor and losses
e. generating other sources of revenues through sales of electric bulbs and appliances, or through a higher membership fee
f. greater flexibility in the movement of surplus funds held by profitable PBS's to less profitable PBS's through a general fund

The report recommended that the provisions for calculating subsidies not be relaxed since the ultimate goal of financial viability should be maintained, but it did recommend that the method for calculating the amount of the subsidy should be adjusted to allow for the cash flow requirements of the different PBS's. This would avoid the problem of differences in value of assets, would recognize the sources of non-operating income available to the different PBS's, and would appear to reduce the overall level of subsidy from that paid at the time the report was prepared.

For monitoring financial performance, the report recommended setting performance target for each PBS's separately. These targets would include the first year in which revenues would cover :

a. operating costs exclusive of interest and depreciation
b. operating costs inclusive of interest and depreciation
c. operating costs (exclusive of interest and depreciation) plus debt service.

Additional goals would be set regarding system losses, costs for O&M per line mile and costs for administration per customer, levels of personnel, inventory and accounts receivable/payable relative to amount of activity.

In order to meet these goals the PBS's would have to prepare medium-term load forecasts and investment plans and prepare short-term financial projections.

The issue of time of day pricing in response to the potential use of BST time of day pricing and as a mechanism for improving load factors was addressed but the results as presented were inconclusive. A recommendation for uniform tariffs was also presented with justification based on equity of transferring of income from the lower cost more urban areas to the higher cost rural areas. The size of the minimum charge was also questioned because of its impacts on those least able to pay. There was the additional suggestion that this charge

15

encourages a certain minimum level of consumption which make represent leads to inefficient use among the lower income consumers. Overall there was a recommendation for a gradual increase in the tariff towards the economic cost for the electricity.

Coopers & Lybrand and A Qasem & Co., "Financial Policies and Performance of the PBS's : Volume 3 - Appendices", USAID, November 1988

The appendices included a consumer survey, an analysis of price elasticity and a calculation of the relative costs for electricity and substitute petroleum-based fuels. The consumer survey was conducted in nine PBS and included 399 households of which 287/399 were electrified. In addition 84 commercial establishments, and 199 users of electrified irrigation were interviewed. A structured close-ended interview was conducted and the survey schedule was included in the appendix. Unfortunately this analysis used level of consumption rather than income as the principal parameter for differentiating consumption-related characteristics. Therefore, the results are of relatively little use in estimating benefits.

This survey like others before it observed a correlation between size of household, income and electricity use. The estimates of fuel use prior to electrification are of questionable validity since the period of recall was several years. The monthly consumption was relatively low rarely exceeding the initial lifeline block. The bill as a percentage of total household expenditures increased with income but was less than 2% for most households. Not surprising, the ownership of electrical appliances increased with average monthly income. The respondents who used electricity were asked about the reasons for their preference for electric lighting over kerosene lighting. The choices offered were quality, comfort, price and safety and the responses were 62%, 21%, 6% and 11% respectively. There was no attempt for prioritization of these benefits or development of a cardinal scale of preference.

For non-electricity users, the connection cost was a greater hinderance to electrification than energy charges. The questionnaire asked whether electricity has enabled the household to increase the working hours, the study by children, reading, writing and visiting. The majority answered in the affirmative but no attempt was made to understand how, why or to what extent the electric lighting contributed to these changes. It is interesting to note that less than half the respondents indicated that the availability of electricity enabled greater use of radio or TV.

The survey of irrigation users indicated that most users of electric pumping believed it was less costly than diesel pumps primarily because of the lower cost of energy. Diesel pump users indicated that they were not using electric pumps because electricity was not available, not reliable and/or too expensive. Two thirds of the pump users sell water to other farmers.

For commercial establishments, the principal use of electricity was for lighting and the major benefit was perceived to be longer hours of operation. The analysis presented in this report is very limited given the variety of information collected in the questionnaires and reflects the scope of the survey which was to support the financial analysis.

The price elasticities observed in studies from Bangladesh and India were compared. All were found to have elasticities of -.54 with the lowest for irrigation and the highest for commercial users.

Coopers & Lybrand and Mertz and Mclellan, "Bangladesh Power Sector Tariff Study", UNDP and IBRD, Aug 1986

This study examined the tariffs charged by the BPDB and recommended revised tariffs based on the long run marginal costs for capacity and the short run marginal costs for energy. The long run marginal costs were computed using the WASP program and the projected demand for power. The investments in generation capacity were primarily gas fueled and included natural gas combustion turbines, combined-cycle turbines and steam turbine as well as oil-fired combined cycle and steam turbines and coal-fired steam turbines. The gas fueled units were the lowest cost and were introduced first in the least-cost expansion plan. Once the supplies of gas were fully committed then the coal-fired units were introduced.

Several scenarios were run with different discount rates and different load forecasts, but the effect was primarily to shift the investment in time rather than to change the sequence of investment. Since the scenarios were prepared in 1985, it is likely that the change in relative delivered fuel prices and the expansion in natural gas distribution would affect this expansion plan and the type of investments recommended.

The forecast of demand for generation capacity was complicated by the relatively high non-technical losses experienced by BPDB. The forecast was further complicated by the large amount of load-shedding which occurred at the time of the analysis and prevented an accurate measure of the demand for power on which to base the forecast.

17

The long run marginal cost of capacity was computed using different rates of growth in demand. The incremental capital and O&M costs needed to serve the additional demand were computed along with the reduction in fuel costs through the availability of more efficient baseload capacity. The LRMC was also adjusted for the increased costs of unserved demand. These incremental costs were computed over an 18 year period and then discounted to provide an average value which could be applied over a longer period of time thus avoiding fluctuations in prices. The resulting time-averaged LRMC was in the range of $70-$84 per kW per annum depending on assumptions regarding discount rates and the size of demand increments. These results were extremely sensitive to the costs incurred due to unmet energy demand during the initial period from 1987-89. These costs were high because only limited additional capacity could be provided.

The costs for distribution were computed using the average incremental cost approach taking into account past expenditure patterns and the proposed expenditures in the Power System Master Plan. The transmission costs were divided between distribution up to the 132/33 substations and up to the 33/11 kV stations to allow for incremental costs for each class of user. An allowance of 1% of capital costs was included for O&M and the capital costs were amortized over their expected life using a 12% discount rate. Also losses of about 4% during peak transmission were factored into the estimate of capacity requirements. An annual cost for HV transmission of Tk. 652 per kW was derived.

The costs for distribution below the 133 kV level were computed based on the proportion of BPDB's past expenditures (computed using revalued assets) for different levels of distribution (33kV, 11kV and .4kV). These capital costs were amortized over their expected life using the same discount rate and allowance for O&M. Technical losses were then factored into the costs to determine an annual cost per kW. The results were Tk. 1079 per kW for 33 kV, Tk 1702 per kW for 11 kV and Tk 3047 per kW for .4kV. For REB a higher annual cost of Tk. 1516 per kW was computed for the 33kV distribution due to the longer lines and the more difficult terrain of the areas served. Similarly higher costs for computed at the lower voltages of Tk. 2752 per kW for 11kV and Tk. 2203 per kW for .4kV. All estimates included a 25% premium (.8 SCF) for foreign exchange.

The marginal energy costs were computed using a generation allocation model which takes into account both merit order assignment and the uncertainty of availability. The current information on energy costs was not used because the present situation of operating without merit order or planned maintenance was

expected to change in the future. The present merit order calls for gas-fired plants to be used for baseload followed by fuel-oil fired plants. The hydro-electric facility and the HSD turbines were used to service peak loads. The hydro-electric facility is used primarily as a peak load unit because of the limitation on reservoir capacity relative to generating capacity, but part of its capacity is credited as baseload capacity due to other uses of the water discharged.

Since the demand does not vary significantly by season, the only variation in marginal cost was the day of the week allowing for lower usage on Fridays and the time of the day with an evening peak between 7:30 pm and 10:30 pm (during which the HSD turbines are required) and a smaller midday peak (during which a mix of gas, fuel oil and HSD turbines are used). The marginal energy costs per kWhr for the evening peak, midday peak, and off-peak periods were respectively Tk 2.7, Tk 1.1 and Tk 0.7. These estimates are based on the expected availability of the hydropower and the existing system. Savings from changes in the generation system as well as the costs for unserved energy were not included in the marginal energy cost but were instead included in the LRMC capacity cost estimates to allow for a time-averaged cost calculation.

The final tariffs were developed taking into account limitations on the metering capacity of BPDB. For high voltage users,the recommendation is to use a time-of-day metering with a two or three period energy charge as well as a capacity charge. The latter was to be based on a kVA. The monthly kVA capacity charge was computed by taking 1/3 of both the LRMC generating capacity charge and the AIC charge for 133kV distribution and allowing for a system-wide power factor of .95. The result was Tk 84.4 per kVA per month. The remaining 2/3 of the generating and distributing costs were added to the marginal energy costs. It was apportioned to the different hours of the day according to the marginal unserved energy per kWh of incremental demand over the day. To this was added the marginal cost of energy at different times during the day. The results were then averaged over the period for which separate rates were to be charged. The resulting rates for 33Kv distribution to the REB were Tk 3.7, Tk 1.02 and Tk .87 (evening peak, midday peak nd off-peak respectively or Tk 3.7 and Tk .97 for the peak and off-peak, respectively. The comparable tariffs for heavy industries using 33kV were lower during the peak at 3.34 but otherwise were similar.

The proposed rates are considerably higher than the existing rate. For the PBS's the problem would be aggravated by their low load factor and the peak in their demand which corresponds to the evening hours. Because of the disparity with existing rates for all users was significant, the study recommended a phased approach be used based on the maximum permissible increase for each category

of customer and a minimum increase necessary to insure adequate cash flow for the BPDB. This would also allow time for the introduction of new meters and the phasing in of a new multi-part tariff. The initial increase in REB's tariff would amount to 25%.

The large increase in rates was not expected to have a significant impact in consumption because the price elasticities were projected to be between -.1 and -.25. The effect of time of day rates was expected to produce relatively small some shifts in demand away from the peak period. For the REB the total shift was estimated to be less than 10%.

The general recommendations of the study with regards to increases in tariff have been followed though ore slowly than recommended. Also the introduction of multi-part tariffs based on time-of-day metering has proceeded more slowly than expected. The changes in fuel prices, inflation, and installed capacity since the time of the study should lead to different numeric results for 1989. However, the general conclusions regarding a need for significant tariff increases and for peak/off-peak tariffs are still valid.

The methodology used was constrained by the problems of technical losses which have increased over time, of load-shedding which has abated, the changing prices for petroleum products, which has continued and by the potential uses of domestic natural gas, which are still be developed.

Robinson, Warren C., "The Impact of Rural Electrification on Demographic Attitudes and Behavior in Bangladesh", USAID, 1985

This report describes a survey conducted to determine the impacts of rural electrification on fertility. The survey involved 800 households in 4 PBS's of which 2/3 were electrified. The respondents were the women of the household. The structured interview included in addition to standard questions about family size, ownership of assets, condition of house, relative wealth, occupation and electricity consumption questions related to the births occurring in the last year, the respondent's use of family planning (method unspecified), frequency of use (regularly or occasionally), knowledge of where to obtain family planning supplies (yes or no).

The results were compared with the data from the 1983 survey conducted by REB of 400 electrified households and 200 electrified households. The sample frame was the same for both surveys though the questionnaires were different. Not surprisingly the 1985 survey found a greater ownership of electric appliances and a smaller amount of land ownership. However, "the interviewers on-the-

spot judgement of the level of living enjoyed by the respondent, on the other hand, suggested the electrified households were actually better-off on average in 1985 compared to 1983." Although the household sizes were smaller in the 1985 survey, it is difficult to determine how any major impact could be observed when electricity has only been available for about three years. The major attempt at correlation between rural electrification and fertility involved the fact that a higher percentage of regular use of contraceptives was found in electrified households (from 24% in 1983 to 33% in 1985), relative to non-electrified households in electrified villages (23% to 28%) and to households in non-electrified villages (23% in 1985). No attempt was made to separate out other variables related to income, education or other factors commonly related to changes in fertility. An increase in the solicited size of the ideal family from the 1983 to the 1985 survey is attributed to improved expectations about the future. The lack of serious survey methodology, the plethora of facile judgments and the simplistic nature of the questions, make it is hard to take this report seriously.

Timberg, Thomas A., "The Economic and Social Impact of Rural Electrification in Bangladesh", USAID, 1985

This report is more a discussion piece then a substitive contribution to the evaluation of the RE program. The principal contribution this report makes to the understanding of the Bangladesh Rural Electrification Programme is the oft-quoted story of the prodigal PBS finance minister who cut off power to a club sponsored by the local Deputy Commissioner. Despite visits to a number of PBS's, the report is generally a discussion of secondary sources and methodology. This assessment was prepared at the beginning of the Phase II project and therefore the project paper is the source of much of the data quoted. The methodology focuses on the distinction between demand which is transferred from BPDB, diverted from other sources of energy and generated by the lower cost offered through electrification, a distinction included in the World Bank's various appraisal report's over the last seven years.

The report attempted a preliminary estimate of economic benefits by taking the estimates of area irrigated and the project industrial connections and attaching some notional savings. Employment benefits from the program were through to originate in the expansion in agriculture and agro-processing resulting from irrigation although this was balanced against the loss of employment through the conversion from the Dhenki to the rice mill. The impact of electrification on fertility is mentioned in connection with Robinson's report and the comment "casual empiricism tells us that is true", is added to the lexicon of this subject.

Wasserman, G and Davenport, A.; "Power to the People : Rural Electrification Sector Summary Report". USAID, December 1983

The report examines four rural electrification programs in Bolivia, Costa Rica, Ecuador, and Philippines to determine their social impacts. The evaluation study followed on earlier works by Judith Tendler and Elizabeth Celinski which questioned the normally expected impacts of rural electrification programs. The impacts on social services were found to be minimal with the exceptio of street lighting. The availability of electricity for lighting and refrigeration did not by itself improve the social services or extend the hours of operation. In part this was attributed to a lack of coordinated development which would promote these social services. There was also relatively little use of electricity for irrigation but this was due primarily to the topography of the countries considered. The only consistent impact was the use of electricity for food processing.

The impact of electrification on the commercial and industrial sector was found to be dependent on the proximity to the market town. Electrification favored the larger organizations which has the ability to afford and utilize the electricity. Reasons for non-use included problems of reliability of service, dearth of start-up capital, and a lack of industrial or commercial skills.

The success of cooperatives as a mechanism for promoting rural electrification was found to have mixed results with the greatest success noted where there was ""the existence of supportive and mutually reinforcing attitudes and policies". Financial difficulties were observed in all of the cases due primarily to a mismatch between supply and demand in the initial years following electrification, especially where emphasis was placed on providing service to the poorest households.

Most of the households in the areas were interested in receiving electricity. Non-connections were attributable primarily to the high initial cost of installation rather than to the monthly charges. The major use of electricity in households was lighting followed by the use of radios and irons.

With regard to the complementarity of development inputs, the report observed.

> "If a certain threshold of modernity has been reached (e.g., if the area has roads, available credit) it may not be necessary for AID to link its rural electrification efforts to other development activity (for AID could expect the local inhabitants to make use of electricity relatively easily and quickly on their own).

If such threshold characteristics do not exist, AID should seek to integrate rural electrification projects with other development programs so that a host of complementary development activities are introduced along with electrification (e.g. linkages with social service programs, irrigation projects, or small business loan programs). "

Bibliography by Subject Area

I. General

1. Barnes, D.F., Electric Power for Rural Growth : How Electricity Affects Rural Life in Developing Countries, Westview, 1988

2. BBS, "Report of the Bangladesh Household Expenditure Survey : 1985-86", Bangladesh October 1988

3. Coopers & Lybrand and Mertz and Mclellan, "Bangladesh Power Sector Tariff Study", UNDP and IBRD, Aug 1986

4. Coopers & Lybrand with A. Qasem & Co., "Financial Policies and Performance of the PBS's", USAID, Nov 1988

5. Coopers & Lybrand and A Qasem & Co., "Financial Policies and Performance of the PBS's : Volume 3 - Appendices", USAID, November 1988

6. DeLucia and Assoc., Initiation Work for Rural Electrification Master Plan Revision", Gov. of Pakistan and USAID, Feb. 1988

7. Deverick, B, et al, "Rural Electrification in Bangladesh: Management, Engineering, and Financial Assessment", USAID/ORNL, July 1986

8. Halcrow, Motor Co[illegible]us, et al, "Bangladesh Energy Planning Project : Final Report Volume V, Energy Demand Analysis", ADB, June 1987

9. Hutcheson, T.L. and Rab A., "Industrial Project Appraisal: The Standard Conversion Factor and Specific Conversion Factors for Non-Tradeable Goods and Services" Trade and Industrial Policy Reform Programme, January 1986

10. IBRD, "Staff Appraisal Report: Bangladesh Rural Electrification Project" Washington, Report No 3728-BD, May 1982

11. IBRD, "Staff Appraisal Report: Bangladesh Second Rural Electrification Project" Washington, Report No 5590-BD, June 1982

12. Munasinghe, M., Rural Electrification for Development : Policy Analysis and Applications, Westview, 1987

13. Munasinghe, M. et al, "Optimizing Rural Electricity Supply (With Case Studies in Costa Rica and India, IBRD Energy Dept. Rpt. 28, October 1985

14. NRECA, "Quarterly Report to Rural Electrification Board", Dhaka, (various reports)

15. NRECA and REB, Productivity of Electricity in Rural Areas : Workshop Proceedings, Dhaka, November 1985

16. NRECA/Gilbert Consultants, "Evaluation Report for Area Coverage Rural Electrification Project", Dhaka, (various issues)

17. PCI, "Evaluation Planning for the Aguan Valley Rural Electrification Project - Honduras", USAID, January 1979

18. Rab, A. and Haque, M.M. "Updates on the Standard Conversion Factor and the Conversion Factors for Gas" Trade and Industrial Policy Reform Programme, May 1987

19. REB, "REB Annual Evaluation Report", Dhaka, various issues

20. REB, "Pre-feasibility Study Report on Area Coverage Rural Electrification Phase III", Dhaka, May 1984

21. REB, "Pre-Feasibility Study Report on Area Coverage Rural Electrification Phase IV, Dhaka, June 1988

22. REB, "Area Coverage Rural Electrification - Phase III B Extension : Project Proforma" Dhaka, July 1988

23. REB, "Progress Report for the Rural Electrification Project", Dhaka, (various issues)

24. Rushdie, A. A., "Demand for Electricity in Bangladesh", 1986

25. Smith, H.W., Strategies of Social Research : the Methodological Imagination, Open University Press, 1975

26. Timberg, T., "The Economic and Social Impact of Rural Electrification in Bangladesh", USAID/ORNL, 1987

27. USAID, "Project Paper : Bangladesh Rural Electrification III - Proposal and Recommendations for Review", Washington, June 1986

85

28. Wasserman, G and Davenport, A.; "Power to the People : Rural Electrification Sector Summary Report". USAID, December 1983

II. Surveys

29. Khan, Mahbubul Huque, "Impact Evaluation of Rural Electrification in Bangladesh", REB, 1987

30. Rahman, Quazi Mafizur; "Rural Electrification in Bangladesh - A Baseline Study", March 1983, University of Dhaka

31. Rahman, A. Atiq and Hug, Saleemul, "Rural Electrification in Bangladesh: Its Impact on Rural Commercial and Industrial Sectors" October 1988, Bangladesh Center for Advanced Studies

32. Uddin, M. S., Socio-Economic Impact of Rural Electrification in Bangladesh: Case Studies of Some Villages" PhD thesis, August 1989

33. USAID and REB, "1983 - Impact Evaluation of Rural Electrification Programme in Bangladesh", August 1983

III. Agriculture

34. Abdullah, A.A. and Child, F.C., "Bangladesh Agriculture : Performance, Resources, Policies and Institutions" Main Volume of the "Bangladesh Agricultural Sector Review", UNDP, January 1988

35. Ahmed, R. and Hossain, M, "Infrastructure and Development of the Rural Economy of Bangladesh", IFPRI, Feb. 1988

36. Ahmed, Akhter Uddin, "Diesel and Electric Powered Irrigation: A Comparative Cost Analysis", USAID, May 1981

37. Alam, M. "Level and Composition of Capital in Irrigated Agriculture of Bangladesh: Evidence from Tubewell Irrigated Villages of Comilla and Rajshahi" Bangladesh Development Studies, Vol XII, No. 4, December 1984

38. Alam, M., "Capacity Utilization of Deep Tubewell Irrigation in Bangladesh : A Time-Series Analysis of Comilla Thana" Bangladesh Development Studies, Vol III, No. 4, October 1975

96

39. BBS, "Yearbook of Agricultural Statistics of Bangladesh ; 1985-86", Feb. 1987

40. Biswas, M.R. and Mandal, M.A.S.,)n Farm Irrigation Water Management Problems, Bureau of Socio-Economic Research and Training, BAU, Mymensingh, 1982

41. Christopher,S. Rahman, M.B. and Rahman, M., "An Evaluation of Small-Scale Irrigation Project in Bangladesh" USAID, Dhaka, 1982

42. Chowdhury, A., "Modern Irrigation, Growth and Equity" Volume V of the "Bangladesh Agricultural Sector Review", UNDP, June 1988

43. Hamid, M.A., "Low Lift Pump Irrigation in Bangladesh" Volume VII of the "Bangladesh Agricultural Sector Review", UNDP, August 1988

44. Harza Eng., et al, "National Water Master Plan", Min. of Irrigation, Water development and Flood Control and UNDP, Dec. 1986

45. Hossain, M., Nature and Impact of the Green Revolution in Bangladesh, IFPRI and BIDS, Washington, July 1988

46. IBRD, "Bangladesh Staff Appraisal Report; Low Lift Pump Project", Washington, Report No 2481-BD, Feb. 1980

47. IBRD, "Bangladesh Staff Appraisal Report; Deep Tubewells Project II" Washington, Report No 3835-BD, June 1982

48. Johnson, S. H.,"Economic and Technical Criteria for Location of Deep and Shallow Tubewells", BARC, April 1985

49. Johnson, S.H., "Economic and Technical Operation of Deep Tubewells in Bangladesh", BARC, March 1984

50. Mondol, M.A.S., "Market for and Returns from Groundwater Irrigation in Bangladesh" Volume V of the "Bangladesh Agricultural Sector Review", UNDP, June 1988

51. Palmer-Jones, R., "Groundwater Irrigation in Bangladesh" Volume II of the "Bangladesh Agricultural Sector Review", UNDP, July 1988

52. Palmer-Jones, R., "Water Control Problems and Issues", Volume 5 of the "Bangladesh Agricultural Sector Review", UNDP, March 1988

53. Planning Commission, "The Impact of Rural Electrification on Fertility in Bangladesh", 1984

54. Rashid, Haroun Er, "Irrigation and Water Control", Volume XII of the "Bangladesh Agricultural Sector Review", UNDP, March 1988

55. Shahabuddin, Q., "the Investment Analysis Model: An Application to Water Resources Planning in Bangladesh" Bangladesh Development Studies, Vol XV, No. 3, September 1987

56. Sidhu, Baanante, and Ahsan, "Agricultural Production, Fertilizer Use, and Equity Considerations", IFDC, 1982

IV. Family Planning

57. Kabir, M, "The Impact of Rural Electrification on Demographic Characteristics: A Discriminant Analysis, Paper presented at 5th National Geographic Association Conference, March 1989 (mimeo)

58. Ministry of Health and Population Control, "Population Control Programme in Bangladesh : Past, Present, and Future" 1984

59. Mitra and Assoc., "Bangladesh Contraceptive Prevalence Survey - 1985 : Secondary Analysis" Dhaka, 1985

60. National Academy of Sciences, Population Growth and Economic Development : Policy Questions, 1986, Washington

61. National Institute of Population Research and Training, "Population and Family Planning - Research : Bangladesh : An annotated Bibliography", Bangladesh, 1985

62. Robinson, W. "The Impact of Rural Electrification on Demographic Attitudes and Behavior in Bangladesh", USAID, December 1985, (mimeo)

V. Women in Development

63. CIRDAP,"Role of Women in Rural Industries : Bangladesh and Nepal"; Volume I : Introduction and Summary', June 1988

64. IBRD, "Bangladesh : Strategy Paper on Women in Development " Volume I and II, Report No. 7899-BD, June 1989

65. Jahan, R, "Women and Development in Bangladesh : Challenges and Opportunities", Ford Foundation, Bangladesh, March 1989

66. Safilios-Rothschild, C. and Mahmud, S., "Women's Role in Agriculture : Present Trends and the Potential for Growth", "Bangladesh Agricultural Sector Review", UNDP, March 1989

67. Schaffer, T.C., "Survey of Development Projects and Activities for Women in Bangladesh", Bangladesh, December 1986

68. Tsuda, Ayako, "Women Participants in Small Scale Enterprises", NORAD, April 1988

VI. Rural Industry

69. BIDS, "Rural Industries Study Project : Final Report", Dhaka, Feb, 1981

70. BSCIC, "Industrial Profiles : Small Industries Sector : Vol II", March 1986

VII. Women in Development

71. IBRD, Startegy Paper on Women in Development : Volume I - Towards a Better Understanding of Women's Role in the Development Process"

72. NORAD, "Women's Participation in Small Scale Industries"

Annex II

REB HISTORICAL DEMAND DATA

Review of Systemwide Demand

The growth of the REB system has been quite dramatic over the last eight years as shown in the first two tables below. For all classes, the number of connections system-wide has risen from 23.2 thousand at the end of FY82 to 396.1 thousand at the end of FY89. The amount of billable energy has increased during the same period from 11.4 Gigawatt-hours per year to 373.4 GWhr. The rate of growth has varied depending on the class of service.

For domestic hookups, the annual increase has been relatively linear at about 42 thousand per year resulting in a linear increase in billable energy of 13.1 GWhr per year. As a result, the average consumption per hookup has remained relatively steady at about 26 kWhr per month as shown in Figure II.5 below. this level is only about 1/4 of that for the BPDB's domestic hookups, so an increase is expected in the long run.

For commercial hookups the growth has been linear with an increase of 8500 connections per year. The billable energy has risen at a rate of 4.1 GWhrs per year during the last 8 years. The average consumption per connection has fluctuated between .42 and .54 MWhr per year but appears to be rising as shown in the Figure II.5.

The number of industrial hookups has risen by an average of 1100 per year resulting in an increase in billable energy of 23.5 GWhr per year. The average consumption per hookup rose during the first few years but is now in the process of a steady decline. The peak was reached in FY84 with an average of 30.1 MWhr per year versus the current 22.6 MWhr per year. This trend is shown in Figure II.2 below.

The number of irrigation pumps connected to the REB system has increased by nearly 2000 per year and the resulting increase in load has been 10.8 GWhr per year. The average level of consumption has fluctuated between 5.5 and 7.3 MWhr per year after falling dramatically as shown in Figure II.6. Assuming a pumping period of four months in the year, the load placed on the system is equivalent to an addition of 43 GWhr of industrial or domestic load.

Systemwide Performance

Figure II.1

Proportion of Systemwide Consumption

By Class of Users

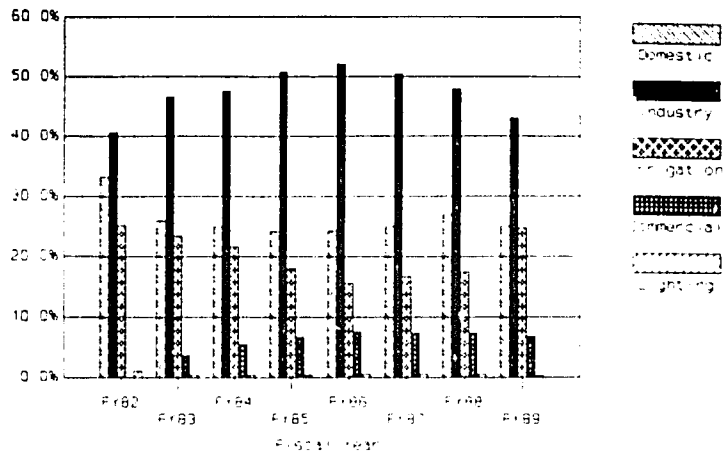


Figure II.2

Proportion of Systemwide Consumption

By Class of Users

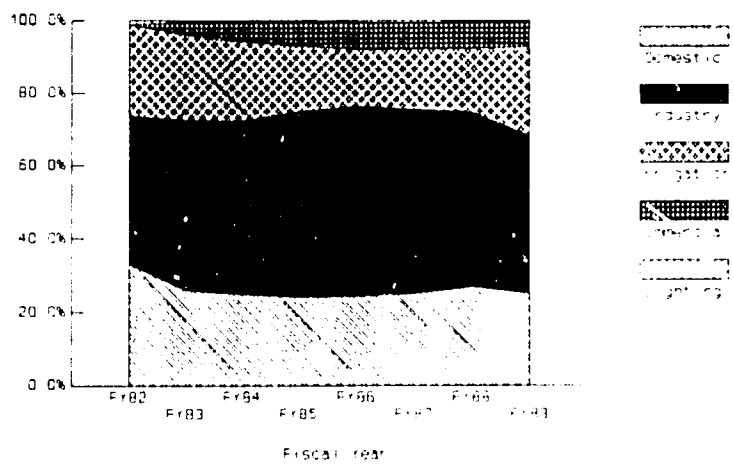


Figure II.3

Growth in Systemwide Connections

For Different Classes of Users

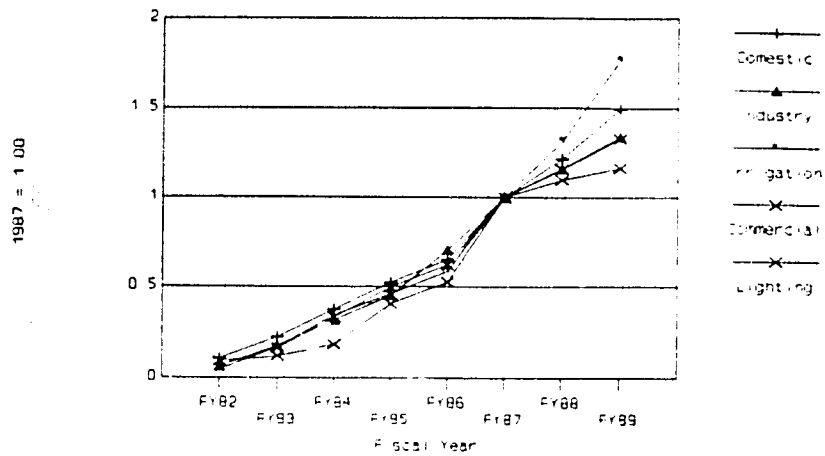


Figure II.4

Growth in Systemwide Consumption

For Different Classes of Users

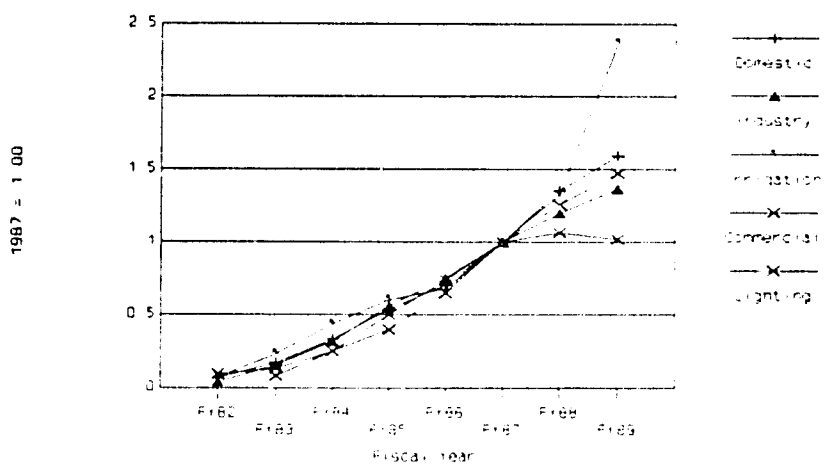


Figure II.5

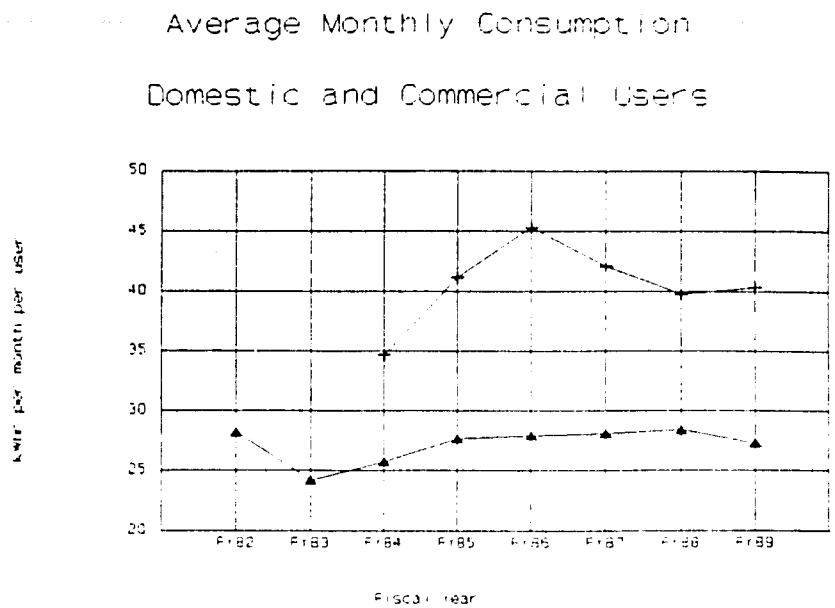


Figure II.6

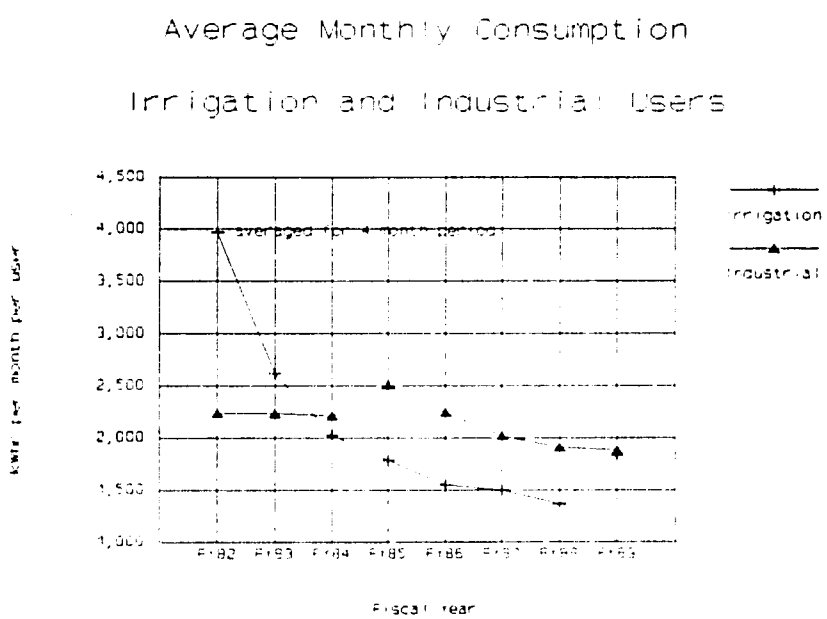


Table II.1
Consumers and Consumption by Class

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
DOMESTIC CONSUMERS								
Consumers	22,285	47,098	79,666	110,133	137,294	210,412	256,253	314,962
Consumption	3,771	10,063	19,548	31,481	41,417	58,603	79,414	93,399
Ave. Consumption	338	290	308	332	335	337	340	327
INDUSTRIAL DEMAND								
Consumers	344	1,003	1,811	2,579	4,019	5,705	6,631	7,641
Consumption	4,617	18,078	37,384	66,160	88,881	117,812	141,476	161,054
Ave. Consumption	26,845	26,842	26,570	30,141	26,942	24,231	22,937	22,569
IRRIGATION DEMAND								
Consumers	360	1,371	2,821	3,767	4,795	8,177	10,753	14,437
Consumption	2,860	9,070	16,996	23,506	26,506	38,910	51,592	92,253
Ave. Consumption	15,886	10,479	8,109	7,136	6,192	5,999	5,451	7,325
SMALL COMMERCIAL								
Consumers	0	6,799	14,054	20,985	26,220	42,189	48,935	56,150
Consumption	0	1,412	4,337	8,657	12,638	17,284	21,751	25,458
Ave. Consumption			416	494	544	505	477	485
STREET LIGHTING								
Consumers	231	296	459	1,022	1,327	2,517	2,770	2,937
Consumption	122	164	315	501	817	1,254	1,338	1,281
Ave. Consumption	1,056	621	834	677	696	652	506	449
SYSTEM								
Consumers	23,220	56,567	98,811	138,486	173,655	269,000	325,342	396,127
Consumption	11,370	38,787	78,580	130,306	170,459	233,863	295,571	373,445
Ave. Consumption	979	972	1,011	1,098	1 092	1,057	995	1,035

Table II.2
Average Growth Rates

	Connections	(R^2)	Consumption	(R^2)
Domestic				
exponential	36%	(.95)	43%	(.93)
linear	41,800	(.97)	13,100	(.97)
Industrial				
exponential	42%	(.92)	46%	(.87)
linear	1,100	(.98)	23,500	(.99)
Commercial				
exponential	34%	(.92)	45%	(.93)
linear	8,500	(.94)	4,100	(.85)
Irrigation				
exponential	47%	(.92)	42%	(.93)
linear	1,950	(.93)	10,800	(.85)
Street Lighting				
exponential	41%	(.95)	38%	(.93)
linear	450	(.94)	200	(.93)

REB DATA FOR HOUSEHOLD CONSUMERS

Figure II.7

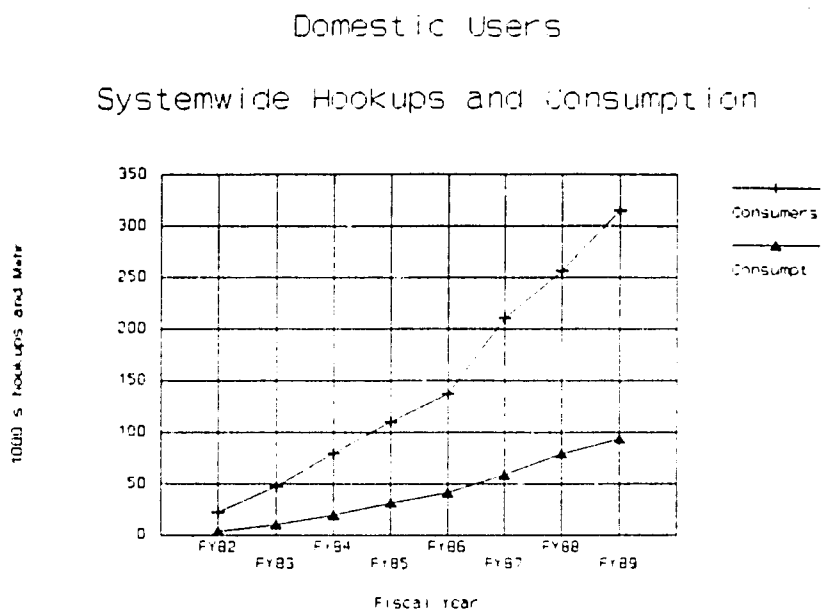


Figure II.8

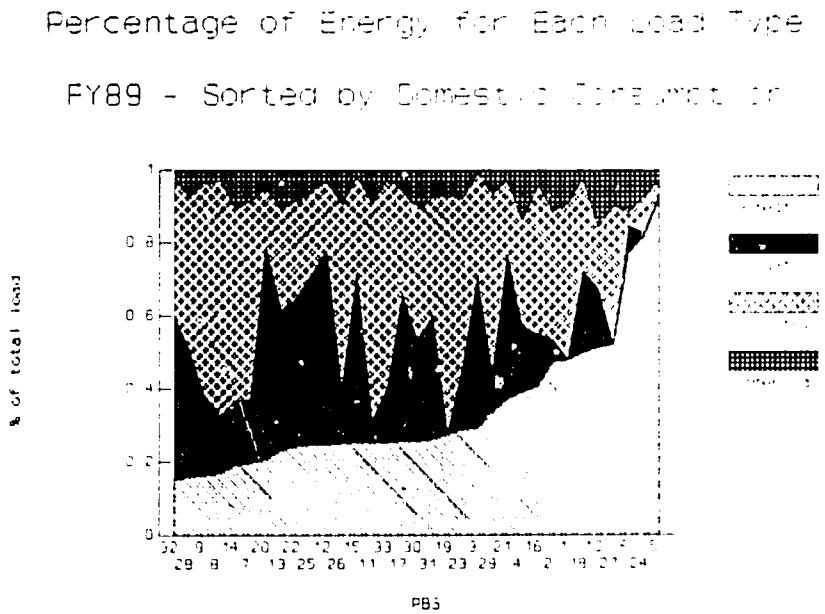


Figure II.9

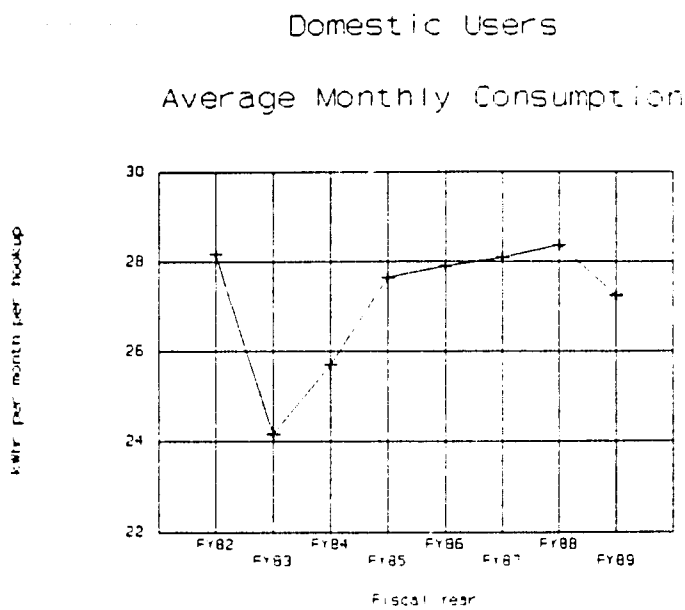
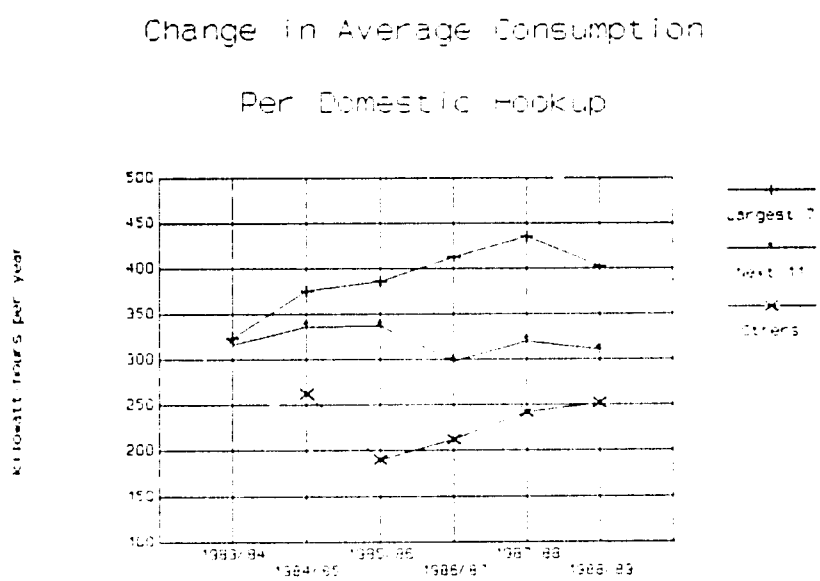


Figure II.10



97

Figure II.11

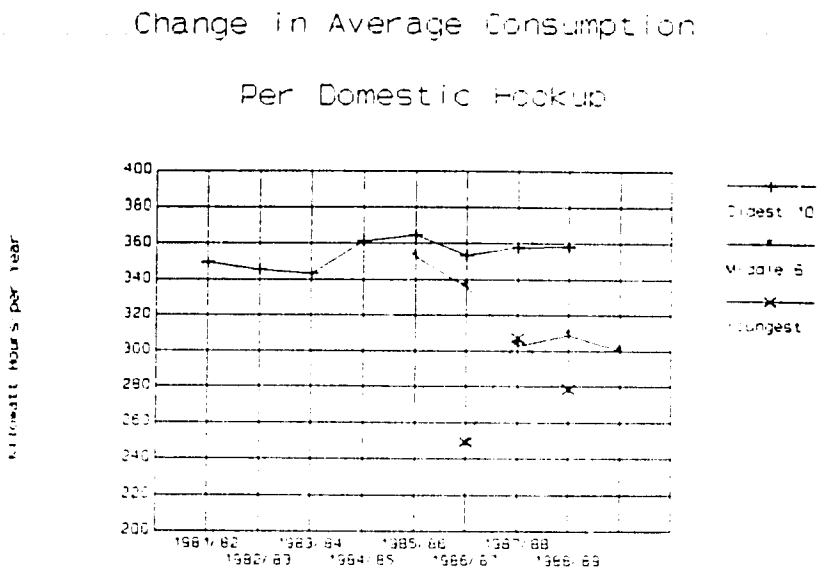

Change in Average Consumption
Per Domestic Hookup
400
380
360
340
320
300
280
240
200
1982/83
1984/85
Oldest 10
Middle 5
Youngest

Table II.3

Percentage of Total Consumption Accounted for by Domestic Demand

PBS	1986/87	1987/88	1988/89
Chittagong I		96%	92%
Noakhali	89%	84%	81%
Chittagong II	91%	18%	76%
Pirojpur	52%	56%	52%
Feni	54%	54%	51%
Meherpur	43%	61%	50%
Bagerhat	53%	51%	48%
Barisal I	43%	46%	47%
Kushtia	39%	41%	41%
Chandpur	36%	39%	39%
Narsingdi	45%	59%	37%
Rangpur II	24%	30%	33%
Bogra	42%	38%	29%
Natore II	27%	28%	29%
Moulvibazar	28%	28%	28%
Sirajganj	29%	30%	26%
Satkhira	32%	30%	26%
Madaripur	35%	33%	26%
Thaqkuragon	22%	26%	25%
Habiganj	24%	25%	25%
Joypurhat	27%	32%	25%
Pabna II	28%	25%	25%
Pabna I	29%	29%	25%
Jamalpur	48%	35%	25%
Natore I	27%	28%	24%
Jessore I	26%	25%	23%
Mymensingh	30%	28%	21%
Comilla	17%	19%	20%
Jessore II	21%	21%	19%
Dhaka	21%	21%	17%
Dinajpur	15%	18%	16%
Rangpur I	20%	19%	16%
Tangail	16%	17%	15%

Table II.4

Average Consumption Accounted for Per Domestic Connection
(kWhr/month)

PBS	1986/87	1987/88	1988/89
Sirajganj	40.6	41.8	38.9
Dhaka	40.9	40.0	37.1
Moulvibazar	34.1	34.3	35.2
Natore I	29.4	31.0	31.7
Natore II	30.0	29.0	31.0
Chittagong II		47.5	30.7
Feni	31.2	30.1	30.0
Jessore I	26.8	28.3	29.5
Tangail	31.4	30.3	28.5
Pabna II	30.5	29.4	28.0
Jessore II	28.0	27.7	26.9
Comilla	21.3	24.5	26.6
Habiganj	26.6	26.9	26.5
Pabna I	26.9	26.7	24.8
Mymensingh	22.1	24.7	24.5
Bogra	16.6	25.8	24.4
Chandpur	22.4	23.9	24.2
Madaripur	25.0	27.2	24.2
Rangpur II	20.2	24.5	24.1
Dinajpur	24.5	26.9	24.0
Chittagong II	23.1	1.0	23.9
Kushtia	25.2	23.6	23.7
Rangpur I	22.2	23.5	22.7
Satkhira	22.5	22.6	21.7
Noakhali	10.2	23.0	21.6
Joypurhat	18.4	23.9	20.7
Barisal I	17.4	21.6	20.4
Thaqkuragon	18.8	20.1	20.4
Narsingdi	10.4	22.7	20.2
Pirojpur	19.8	20.6	20.2
Jamalpur	19.5	21.4	20.1
Bagerhat	17.2	19.9	19.0
Meherpur	4.9	18.6	18.3

Table II.5

Number of Connections

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					766	3,329	4,609	5,910
Barisal I					1,100	3,212	4,872	6,413
Bogra						3,296	6,675	10,008
Chandpur	567	3,054	5,356	7,089	8,473	11,306	12,970	15,938
Chittagong II							5,918	7,121
Chittagong II						3,218	621	5,118
Comilla	4,931	6,406	8,224	10,450	11,054	13,527	15,498	19,426
Dhaka	5,576	9,589	11,627	12,775	14,131	17,536	18,854	20,532
Dinajpur				1,138	2,679	4,472	5,851	7,668
Feni			1,171	3,182	5,813	9,377	10,634	12,351
Habiganj		967	3,712	6,844	8,619	10,668	11,785	13,725
Jamalpur						2,397	3,831	5,065
Jessore I	981	3,024	5 684	6,637	7,514	9,723	10,581	11,974
Jessore II	2,303	4,987	6,912	8,058	8,812	10,505	11,071	12,058
Joypurhat					200	2,679	3,509	4,944
Kushtia				496	2,741	5,184	6,636	8,513
Madaripur					1,416	3,704	5,854	7,192
Meherpur						2,163	4,569	8,145
Moulvibazar	1,142	2,028	5,977	8,637	9,514	11,214	11,841	12,673
Mymensingh			536	2,719	3,963	5,116	6,116	7,397
Narsingdi						1,513	3,517	4,881
Natore I	1,545	4,002	5,704	7,812	7,678	9,685	10,509	12,035
Natore II	531	3,592	5,876	7,972	8,887	11,650	12,311	13,355
Noakhali						2,627	5,927	10,320
Pabna I		910	3,065	4,156	5,121	6,528	7,341	8,447
Pabna II	472	1,218	3,256	4,139	5,619	7,842	8,544	10,132
Pirojpur					196	1,494	2,272	3,087
Rangpur I			258	1,669	3,208	4,829	5,409	6,091
Rangpur II					312	3,273	5,141	7,115
Satkhira			821	2,551	4,620	6,391	7,260	8,235
Sirajganj	3,312	4,358	6,536	7,014	7,288	9,529	10,260	10,882
Tangail	917	2,963	4,951	6,795	7,570	11,273	12,512	13,620
Thaqkuragon						1,162	2,865	4,571

Table II.6

Energy Billed To Household Consumers

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					20	422	946	1,197
Barisal I					86	450	1,048	1,384
Bogra						328	1,542	2,441
Chandpur	44	493	1,417	2,118	2,120	2,663	3,478	4,206
Chittagong I							1,686	2,404
Chittagong II						446	24	823
Comilla	881	1,472	2,076	2,839	2,820	3,147	4,261	5,572
Dhaka	1,290	2,574	4,007	5,094	6,117	7,770	8,734	8,776
Dinajpur				99	737	1,053	1,665	1,948
Feni			92	776	1,516	2,841	3,617	4,142
Habiganj		148	719	1,853	2,599	3,077	3,618	4,055
Jamalpur						280	798	1,075
Jessore I	165	649	1,590	2,322	2,651	2,767	3,447	3,987
Jessore II	457	898	1,654	2,211	3,047	3,250	3,583	3,731
Joypurhat					12	317	889	1,050
Kushtia				30	521	1,200	1,675	2,152
Madaripur					124	767	1,558	1,893
Meherpur						64	755	1,397
Moulvibazar	266	818	1,622	2,650	3,667	4,241	4,753	5,192
Mymensingh			35	614	1,116	1,203	1,663	1,986
Narsingdi						94	684	1,020
Natore I	402	1,000	1,637	2,288	2,691	3,064	3,752	4,287
Natore II	91	955	1,613	2,781	3,261	3,693	4,173	4,772
Noakhali						160	1,177	2,106
Pabna I		145	858	1,320	1,639	1,878	2,218	2,350
Pabna II	37	308	836	1,568	1,932	2,483	2,891	3,142
Pirojpur					3	201	465	649
Rangpur I			17	369	847	1,071	1,442	1,563
Rangpur II					10	434	1,236	1,773
Satkhira			42	475	1,115	1,485	1,853	2,015
Sirajganj						4,098	4,972	4,939
Tangail	139	603	1,333	2,074	2,772	3,545	4,326	4,462
Thaqkuragon						131	485	910

Table II.7

Average Energy Consumed

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					52	206	238	228
Barisal I					156	209	259	245
Bogra						199	309	293
Chandpur	154	272	337	340	272	269	287	291
Chittagong I							570	369
Chittagong II						277	13	287
Comilla	357	260	284	304	262	256	294	319
Dhaka	463	339	378	418	455	491	480	446
Dinajpur				174	386	295	323	288
Feni			157	357	337	374	362	360
Habiganj		307	307	351	336	319	322	318
Jamalpur						234	256	242
Jessore I	336	324	365	377	375	321	340	354
Jessore II	397	246	278	295	361	336	332	323
Joypurhat					117	220	287	248
Kushtia				122	322	303	283	284
Madaripur					175	300	326	290
Meherpur						59	224	219
Moulvibazar	466	516	405	363	404	409	411	423
Mymensingh			132	377	334	265	296	294
Narsingdi						124	272	243
Natore I	521	361	337	339	347	353	372	380
Natore II	344	463	341	402	387	360	348	372
Noakhali						122	276	259
Pabna I		319	432	366	353	322	320	298
Pabna II	156	365	374	424	396	366	353	336
Pirojpur					26	238	247	242
Rangpur I			129	382	345	267	282	272
Rangpur II					64	242	294	289
Satkhira			102	282	311	270	271	260
Sirajganj						487	502	467
Tangail	302	311	337	353	386	376	364	341
Thaqkuragon						225	241	245

Table II.8

Percentage of Total Customers

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					82.6%	88.3%	85.3%	85.5%
Barisal I	100.0%				88.4%	77.7%	78.9%	80.6%
Bogra						95.2%	91.5%	90.1%
Chandpur	98.8%	76.9%	73.0%	75.6%	73.9%	72.9%	74.2%	76.2%
Chittagong II							92.5%	92.6%
Chittagong II						90.3%	94.7%	93.8%
Comilla	98.5%	88.7%	82.0%	78.6%	75.7%	73.6%	74.9%	74.8%
Dhaka	94.0%	90.7%	88.9%	89.3%	94.7%	85.3%	84.9%	84.6%
Dinajpur				94.2%	79.3%	77.1%	77.4%	78.5%
Feni			95.4%	87.8%	77.9%	77.3%	77.4%	78.0%
Habiganj		92.6%	77.4%	76.8%	77.0%	78.5%	78.6%	80.0%
Jamalpur						89.9%	86.5%	82.8%
Jessore I	95.7%	71.4%	75.6%	74.3%	69.3%	67.8%	67.1%	68.0%
Jessore II	96.3%	80.7%	77.5%	74.4%	73.8%	71.4%	70.8%	70.7%
Joypurhat					98.5%	89.2%	87.5%	86.0%
Kushtia				91.5%	83.6%	86.7%	88.1%	89.3%
Madaripur					87.4%	80.5%	80.2%	78.2%
Meherpur						97.8%	96.3%	95.7"
Moulvibazar	99.0%	86.5%	91.3%	84.4%	83.0%	82.4%	81.4%	80.7%
Mymensingh			95.2%	83.0%	83.5%	83.6%	83.3%	80.8%
Narsingdi						87.3%	88.7%	87.5%
Natore I	94.8%	83.6%	82.6%	83.7%	77.7%	76.6%	76.2%	76.7%
Natore II	96.5%	86.2%	78.3%	78.7%	89.9%	78.0%	77.5%	78.1%
Noakhali						94.4%	91.8%	92.9%
Pabna I		63.5%	74.9%	75.1%	75.8%	74.6%	73.9%	74.1%
Pabna II	99.4%	85.5%	74.8%	74.0%	77.8%	77.5%	77.2%	78.5%
Pirojpur					99.5%	87.8%	84.4%	85.0%
Rangpur I			44.3%	63.6%	67.4%	67.6%	66.4%	64.8%
Rangpur II					67.4%	82.9%	85.5%	85.2%
Satkhira			74.3%	88.7%	72.9%	74.7%	73.8%	73.7%
Sirajganj	93.7%	75.5%	76.3%	72.5%	72.8%	73.2%	71.6%	70.9%
Tangail	97.6%	86.9%	86.9%	83.0%	82.9%	79.3%	77.9%	77.2%
Thaqkuragon						86.3%	90.2%	89.6%

Table II.9

Percentage of Total Energy Consumed

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					43.0%	52.8%	51.4%	47.8%
Barisal I					75.6%	43.0%	45.5%	47.3%
Bogra						42.2%	37.5%	29.0%
Chandpur	31.2%	42.3%	34.7%	36.5%	34.7%	35.5%	39.2%	39.0%
Chittagong II							95.6%	92.2%
Chittagong II						90.8%	18.3%	76.3%
Comilla	44.0%	42.6%	21.9%	20.9%	18.6%	16.8%	18.8%	19.7%
Dhaka	22.0%	20.8%	19.2%	20.4%	19.2%	20.9%	20.6%	16.9%
Dinajpur				46.2%	22.7%	15.1%	17.6%	16.2%
Feni			91.9%	70.5%	47.3%	53.9%	54.3%	51.1%
Habiganj		45.8%	25.9%	21.1%	23.4%	24.2%	25.1%	25.2%
Jamalpur						48.3%	35.2%	24.6%
Jessore I	34.7%	23.4%	25.6%	26.1%	27.1%	25.8%	25.1%	22.6%
Jessore II	48.6%	36.5%	36.6%	23.9%	21.0%	20.9%	20.8%	19.1%
Joypurhat					46.0%	27.3%	31.7%	25.2%
Kushtia				69.3%	31.5%	38.8%	41.4%	40.6%
Madaripur					59.4%	35.0%	33.2%	25.7%
Meherpur						43.0%	60.7%	49.8%
Moulvibazar	60.6%	43.0%	49.6%	23.7%	29.1%	27.7%	27.6%	27.5%
Mymensingh			52.5%	36.5%	36.3%	29.5%	28.0%	20.5%
Narsingdi						45.4%	58.5%	37.1%
Natore I	43.5%	79.4%	30.1%	26.8%	27.6%	26.9%	27.6%	24.2%
Natore II	79.5%	40.4%	33.7%	28.6%	26.3%	26.9%	28.3%	28.9%
Noakhali						88.9%	84.3%	81.4%
Pabna I		16.5%	28.8%	28.4%	30.6%	28.9%	29.4%	24.6%
Pabna II	56.9%	44.9%	36.7%	34.5%	35.7%	28.2%	24.5%	24.9%
Pirojpur					99.4%	52.1%	56.2%	52.0%
Rangpur I			44.0%	26.7%	24.1%	20.3%	19.5%	16.1%
Rangpur II					40.5%	24.3%	30.4%	33.4%
Satkhira			69.9%	36.3%	35.9%	32.1%	29.9%	25.8%
Sirajganj						29.4%	30.2%	26.1%
Tangail	33.1%	8.6%	11.5%	14.1%	15.2%	15.9%	17.5%	14.5%
Thaqkuragon						21.6%	26.3%	25.3%

REB DATA ON INDUSTRIAL DEMAND

Figure II.12

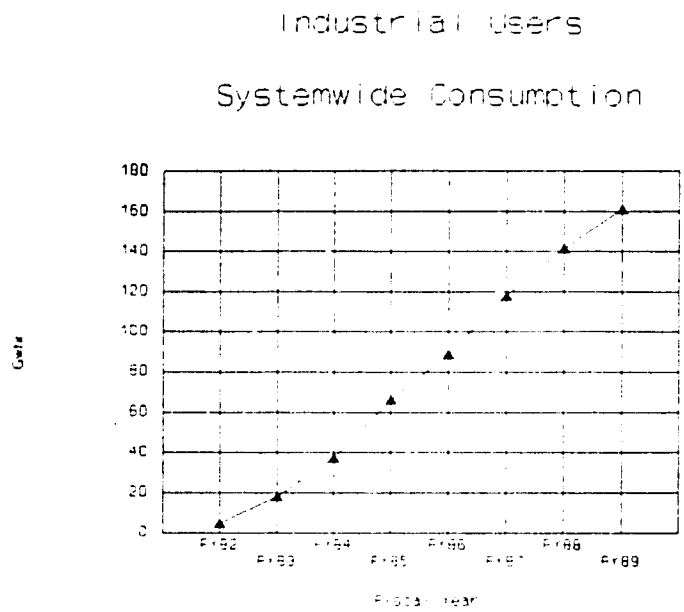


Figure II.13

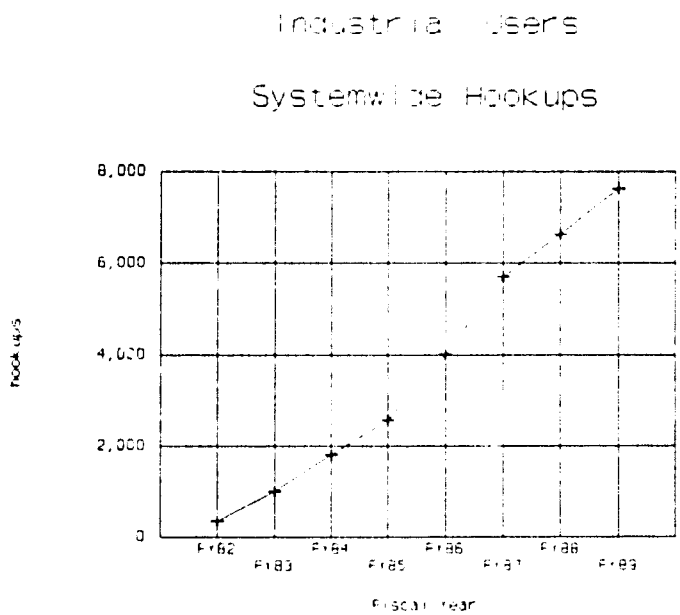


Figure II.14

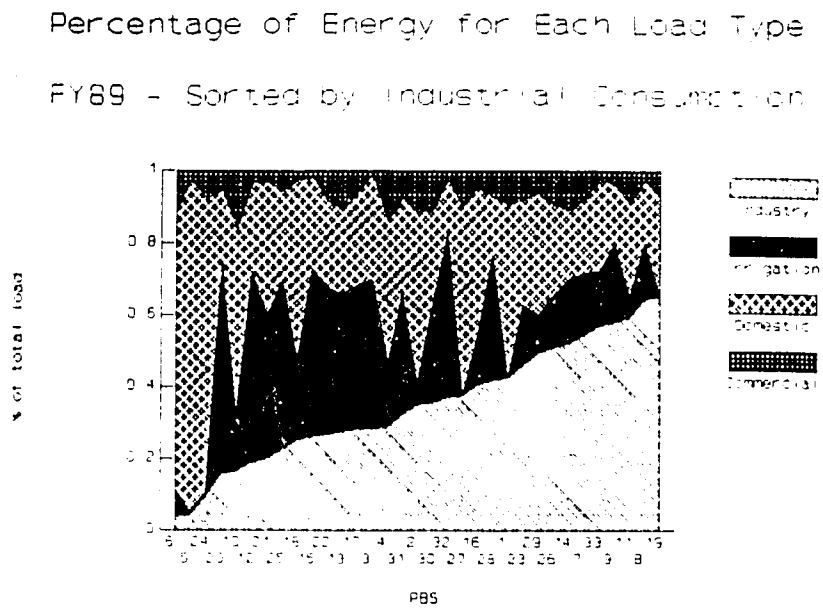
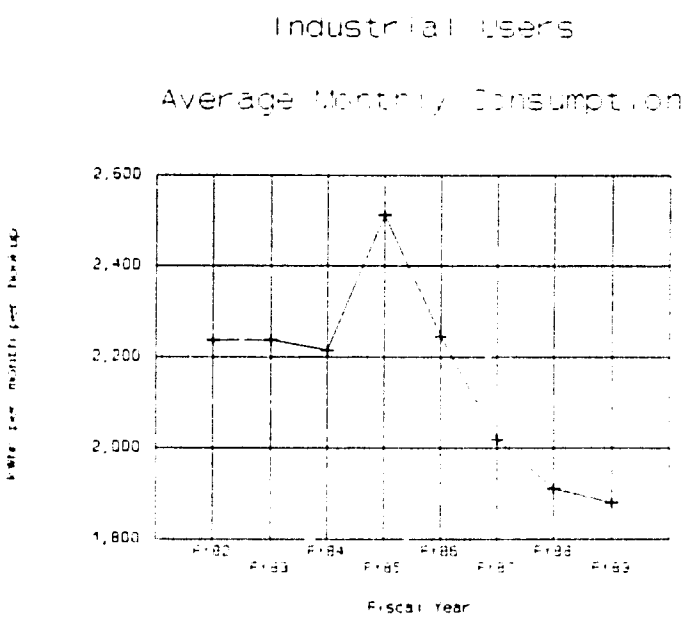


Figure II.15



104

Figure II.16

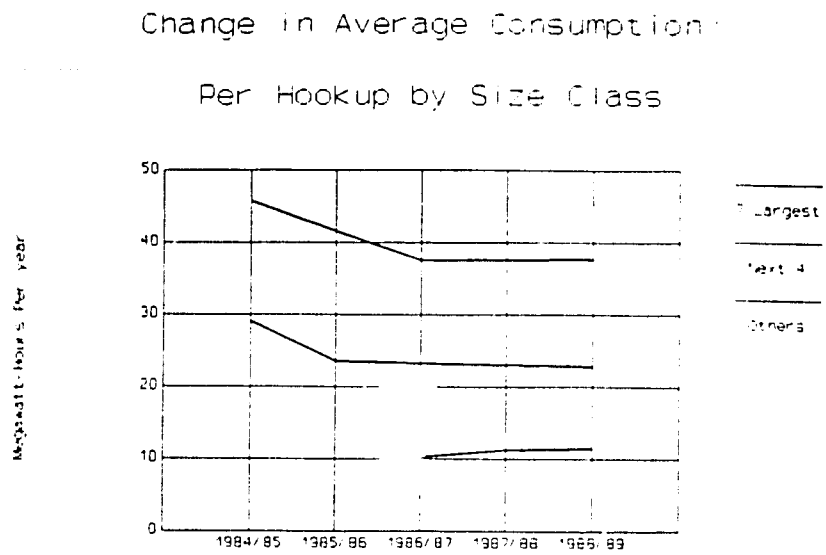

Change in Average Consumption
Per Hookup by Size Class
50
40
30
20
10
0
1984/85
1985/86
1986/87
1987/88
1988/89

Table II.10

Percent of Consumption Accounted for by Industrial Demand

PBS	1986/87	1987/88	1988/89
Moulvibazar	63%	65%	65%
Dhaka	58%	62%	64%
Habiganj	62%	61%	59%
Dinajpur	67%	62%	58%
Thaqkuragon	60%	60%	57%
Comilla	66%	63%	54%
Jessore II	60%	56%	52%
Pabna II	53%	58%	50%
Rangpur II	59%	56%	49%
Natore II	51%	50%	46%
Bagerhat	37%	40%	42%
Rangpur I	52%	48%	42%
Kushtia	43%	41%	41%
Tangail	53%	45%	39%
Pirojpur	34%	32%	36%
Satkhira	38%	37%	35%
Barisal I	42%	39%	34%
Sirajganj	35%	35%	32%
Jessore I	39%	34%	29%
Bogra	17%	28%	28%
Chandpur	35%	32%	28%
Madaripur	38%	36%	27%
Natore I	32%	32%	26%
Joypurhat	38%	34%	26%
Meherpur	38%	26%	25%
Pabna I	30%	27%	21%
Narsingdi	9%	13%	20%
Jamalpur	22%	22%	19%
Feni	16%	15%	16%
Mymensingh	27%	25%	15%
Noakhali	5%	7%	9%
Chittagong II	3%	11%	4%
Chittagong II		3%	4%

101

Table II.11

Average Consumption Per Industrial Connection
(MWhr/month)

PBS	1986/87	1987/88	1988/89
Dhaka	3.3	3.5	4.1
Moulvibazar	4.1	3.6	3.3
Jessore II	3.7	3.4	3.3
Thaqkuragon	1.6	2.1	3.0
Pabna II	2.4	3.3	2.9
Habiganj	3.3	3.3	2.9
Tangail	3.4	2.7	2.5
Chittagong I		3.3	2.1
Natore II	2.0	2.0	2.0
Dinajpur	1.9	1.8	1.9
Comilla	1.9	2.0	1.8
Jessore I	1.4	1.4	1.5
Bogra	0.5	1.1	1.4
Sirajganj	1.3	1.4	1.3
Meherpur	0.9	1.2	1.2
Rangpur I	1.2	1.3	1.2
Natore I	1.1	1.2	1.2
Rangpur II	1.3	1.4	1.2
Kushtia	0.9	1.0	1.2
Satkhira	1.0	1.1	1.1
Madaripur	1.0	1.1	1.1
Narsingdi	0.2	0.6	1.0
Pabna I	1.3	1.1	1.0
Jamalpur	0.6	0.9	0.9
Bagerhat	0.5	0.9	0.9
Barisal I	0.8	0.9	0.8
Mymensingh	0.8	0.9	0.8
Joypurhat	0.8	0.8	0.8
Chandpur	0.7	0.7	0.7
Pirojpur	1.1	0.5	0.5
Feni	0.4	0.4	0.5
Noakhali	0.1	0.4	0.4
Chittagong II	0.7	0.4	0.3

110

Table II.12

Number of Connections

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					44	46	91	105
Barisal I					14	75	91	106
Bogra						43	129	161
Chandpur	1	50	153	199	279	339	345	370
Chittagong I							3	5
Chittagong II						3	3	20
Comilla	30	72	174	297	488	579	620	772
Dhaka	161	256	346	406	486	598	653	707
Dinajpur				18	145	264	290	320
Feni			1	3	132	201	223	241
Habiganj		7	91	158	189	203	236	311
Jamalpur						37	58	94
Jessore I	19	109	123	160	219	266	290	288
Jessore II	28	75	96	164	190	228	244	275
Joypurhat						94	109	122
Kushtia				10	108	135	151	158
Madaripur					25	112	143	178
Meherpur						10	34	61
Moulvibazar	9	29	66	135	159	238	276	340
Mymensingh				48	96	123	138	166
Narsingdi						16	24	63
Natore I	35	81	122	168	265	296	317	336
Natore II	1	108	164	232	296	292	311	326
Noakhali						11	34	63
Pabna I		79	88	94	114	141	173	182
Pabna II	1	16	84	94	148	168	179	187
Pirojpur						20	69	76
Rangpur I				49	155	212	246	306
Rangpur II					15	122	151	223
Satkhira			1	68	140	171	190	210
Sirajganj	59	85	206	270	310	311	377	396
Tangail		36	96	6	2	314	382	411
Thakuragon						37	51	62

Table II.13

Total Energy Consumed in Industrial Connections

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					23	296	727	1,053
Barisal I					18	443	898	989
Bogra						135	1,160	2,387
Chandpur	0	313	1,203	2,022	2,236	2,624	2,828	3,031
Chittagong I							59	101
Chittagong II						13	15	48
Comilla	929	1,373	5,398	8,010	9,518	12,320	14,224	15,317
Dhaka	2,548	5,575	11,029	14,010	18,880	21,695	26,519	33,429
Dinajpur				14	1,791	4,659	5,843	6,967
Feni			0	11	411	831	993	1,283
Habiganj		157	1,732	5,874	7,041	7,813	8,727	9,431
Jamalpur						128	495	821
Jessore I	219	982	2,096	2,982	3,605	4,195	4,772	5,082
Jessore II	389	749	1,242	4,376	8,729	9,282	9,724	10,133
Joypurhat						441	950	1,090
Kushtia				11	779	1,340	1,662	2,145
Madaripur					48	839	1,705	2,028
Meherpur						56	319	700
Moulvibazar	166	1,014	1,437	7,853	7,952	9,711	11,148	12,205
Mymensingh				255	803	1,089	1,471	1,460
Narsingdi						19	151	546
Natore I	338	945	1,539	2,664	3,143	3,680	4,312	4,670
Natore II	2	1,011	1,898	4,761	6,444	7,065	7,352	7,525
Noakhali						9	101	236
Pabna I		591	1,325	1,715	1,689	1,939	2,034	2,036
Pabna II	27	254	809	1,728	2,093	4,602	6,797	6,367
Pirojpur						130	262	452
Rangpur I				497	1,717	2,719	3,562	4,062
Rangpur II					10	1,057	2,266	2,609
Satkhira			0	421	1,196	1,773	2,307	2,752
Sirajganj						4,825	5,608	6,060
Tangail		5,115	7,675	8,955	10,756	11,718	11,247	11,989
Thaqkuragon						366	1,108	2,050

112

Table II.14

Average Energy Consumed

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					1,029	6,578	10,613	10,745
Barisal I					2,580	9,955	10,819	10,041
Bogra						6,279	13,488	16,462
Chandpur	720	12,263	11,852	11,489	9,357	8,492	8,269	8,478
Chittagong I							39,333	25,250
Chittagong II						8,667	5,000	4,174
Comilla	61,916	26,925	43,884	34,011	24,250	23,093	23,726	22,007
Dhaka	31,652	26,736	36,643	37,261	42,331	40,028	42,396	49,160
Dinajpur				1,593	21,976	22,782	21,094	22,843
Feni			860	5,640	6,589	4,991	4,684	5,530
Habiganj		44,951	35,350	47,182	40,579	39,862	39,759	34,483
Jamalpur						6,919	10,421	10,803
Jessore I	23,011	15,344	18,070	21,077	19,825	17,299	16,914	17,585
Jessore II	27,819	14,542	14,531	33,665	49,315	44,411	41,203	39,048
Joypurhat						9,383	9,360	9,437
Kushtia				2,138	13,197	11,829	11,622	13,883
Madaripur					3,841	12,248	13,873	12,636
Meherpur						11,200	14,500	14,737
Moulvibazar	36,783	53,342	30,246	78,138	54,094	48,922	43,377	39,627
Mymensingh				10,634	11,147	9,945	11,272	9,605
Narsingdi						2,375	7,550	12,552
Natore I	19,293	16,291	15,162	18,371	14,519	13,119	14,369	14,303
Natore II	3,600	18,559	13,957	24,047	24,410	24,131	24,385	23,626
Noakhali						1,636	4,489	4,866
Pabna I		14,961	15,871	18,841	16,244	15,238	12,655	11,470
Pabna II	54 720	29,906	16,171	19,420	17,297	29,127	34,176	34,792
Pirojpur						13,000	5,888	6,234
Rangpur I				20,298	16,829	14,817	15,555	14,717
Rangpur II					1,307	15,431	16,421	13,952
Satkhira			680	12,206	11,503	11,4 2	12,781	13,760
Sirajganj						15 539	16,864	15,679
Tangail		284,149	116,292	175,585		74,165	32,319	30,237
Thaqkuragon						19,784	25,182	36,283

113

Table II.15

Percentage of Total Customers

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					4.7%	1.2%	1.7%	1.5%
Barisal I					1.1%	1.8%	1.5%	1.3%
Bogra						1.2%	1.8%	1.5%
Chandpur	0.2%	1.3%	2.1%	2.1%	2.4%	2.2%	2.0%	1.8%
Chittagong II							0.0%	0.1%
Chittagong II						0.1%	0.5%	0.4%
Comilla	0.6%	1.0%	1.7%	2.2%	3.3%	3.1%	3.0%	3.0%
Dhaka	2.7%	2.4%	2.6%	2.8%	3.3%	2.9%	2.9%	2.9%
Dinajpur				1.5%	4.3%	4.6%	3.8%	3.3%
Feni			0.1%	0.1%	1.8%	1.7%	1.6%	1.5%
Habiganj		0.7%	1.9%	1.8%	1.7%	1.5%	1.6%	1.8%
Jamalpur						1.4%	1.3%	1.5%
Jessore I	1.9%	2.6%	1.6%	1.8%	2.0%	1.9%	1.8%	1.6%
Jessore II	1.2%	1.2%	1.1%	1.5%	1.6%	1.5%	1.6%	1.6%
Joypurhat						3.1%	2.7%	2.1%
Kushtia				1.8%	3.3%	2.3%	2.0%	1.7%
Madaripur					1.5%	2.4%	2.0%	1.9%
Meherpur						0.5%	0.7%	0.7%
Moulvibazar	0.8%	1.2%	1.0%	1.3%	1.4%	1.7%	1.9%	2.2%
Mymensingh				1.5%	2.0%	2.0%	1.9%	1.8%
Narsingdi						0.9%	0.6%	1.1%
Natore I	2.1%	1.7%	1.8%	1.8%	2.7%	2.3%	2.3%	2.1%
Natore II	0.2%	2.6%	2.2%	2.3%	3.0%	2.0%	2.0%	1.9%
Noakhali						0.4%	0.5%	0.6%
Pabna I		5.5%	2.2%	1.7%	1.7%	1.6%	1.7%	1.6%
Pabna II	0.2%	1.1%	1.9%	1.7%	2.0%	1.7%	1.6%	1.4%
Pirojpur						1.2%	2.6%	2.1%
Rangpur I				1.[illegible]%	3.3%	3.0%	3.0%	3.3%
Rangpur II					3.2%	3.1%	2.5%	2.7%
Satkhira			0.1%	2.4%	2.2%	2.0%	1.9%	1.9%
Sirajganj	1.7%	1.5%	2.4%	2.8%	3.1%	2.4%	2.6%	2.6%
Tangail		1.1%	1.7%	2.6%	2.8%	2.2%	2.4%	2.3%
Thaqkuragon						2.7%	1.6%	1.2%

Table II.16

Percentage of Total Energy Used

	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89
Bagerhat					48.5%	37.0%	39.5%	42.0%
Barisal I					15.9%	42.4%	39.0%	33.8%
Bogra						17.4%	28.2%	28.4%
Chandpur	0.3%	26.9%	29.5%	34.9%	36.6%	35.0%	31.8%	28.1%
Chittagong II							3.3%	3.9%
Chittagong II						2.6%	11.5%	4.4%
Comilla	46.5%	39.8%	56.9%	59.0%	62.8%	65.7%	62.8%	54.3%
Dhaka	43.5%	45.0%	52.8%	56.1%	59.2%	58.4%	62.4%	64.5%
Dinajpur				6.7%	55.1%	66.6%	61.9%	57.9%
Feni			0.4%	1.0%	12.8%	15.8%	14.9%	15.8%
Habiganj		48.5%	62.4%	67.0%	63.5%	61.5%	65.7%	58.6%
Jamalpur						22.1%	21.9%	18.8%
Jessore I	46.1%	35.5%	33.7%	33.5%	36.9%	39.1%	34.3%	28.8%
Jessore II	41.5%	30.5%	27.5%	47.4%	60.1%	59.7%	56.4%	51.8%
Joypurhat						38.0%	33.8%	26.1%
Kushtia				24.4%	47.0%	43.4%	41.1%	40.5%
Madaripur					23.1%	38.3%	36.4%	27.5%
Meherpur						37.6%	25.5%	25.0%
Moulvibazar	37.7%	53.3%	44.0%	70.3%	63.1%	63.5%	64.8%	64.6%
Mymensingh				15.2%	26.1%	26.7%	24.7%	15.1%
Narsingdi						9.2%	12.3%	19.8%
Natore I	36.5%	27.8%	28.3%	31.2%	32.3%	32.3%	31.8%	26.4%
Natore II	1.6%	42.8%	39.7%	48.9%	52.0%	51.4%	49.9%	45.6%
Noakhali						5.0%	7.2%	9.1%
Pabna I		67.2%	44.4%	36.9%	31.5%	29.9%	27.3%	21.3%
Pabna II	42.3%	37.0%	35.5%	38.0%	38.7%	52.7%	53.7%	50.5%
Pirojpur						33.7%	31.7%	36.2%
Rangpur I				36.0%	49.2%	51.6%	48.1%	41.8%
Rangpur II					39.5%	59.2%	55.7%	49.2%
Satkhira			0.6%	32.2%	38.6%	38.3%	37.3%	35.2%
Sirajganj						34.6%	35.3%	32.0%
Tangail		73.3%	66.2%	60.9%	59.0%	52.7%	45.4%	39.0%
Thaqkuragon						60.4%	60.1%	56.9%

115

REB ANNUAL DATA FOR IRRIGATION USERS

Figure II.17

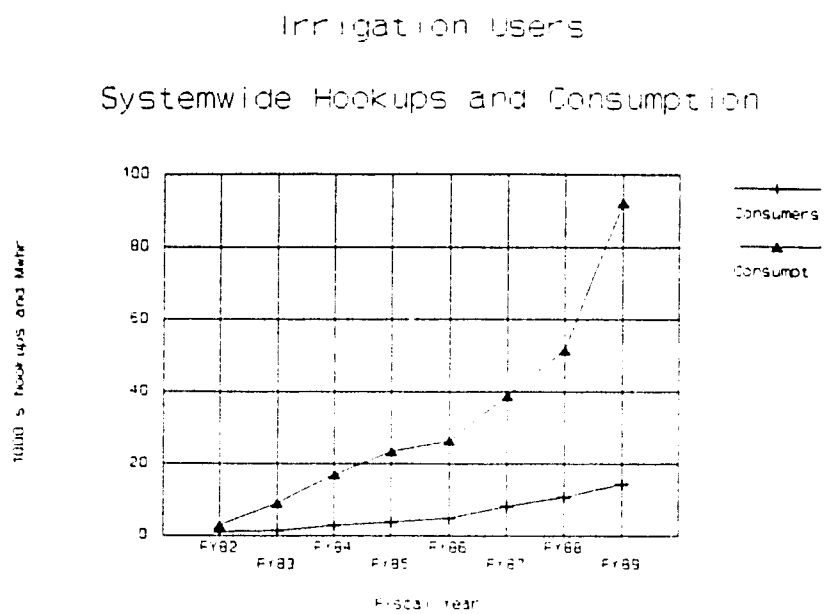
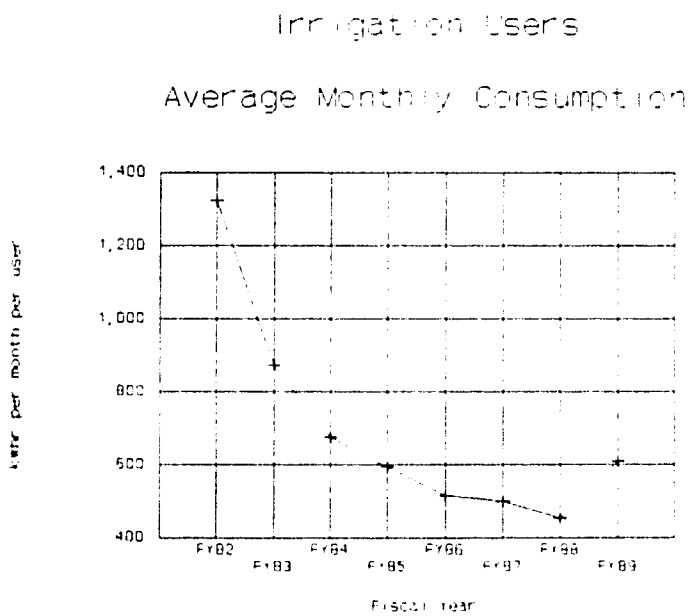


Figure II.18

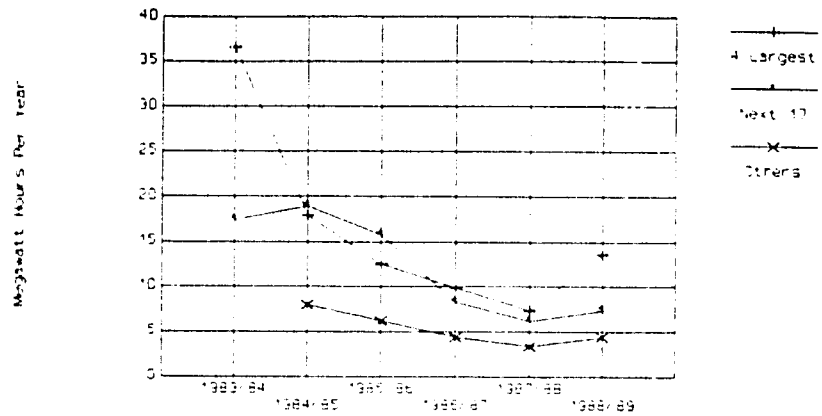


- 116

Figure II.19

Change in Average Consumption

For Irrigation Users



117

Table II.17

Percent of Consumption Accounted for by Irrigation Demand

PBS	1986/87	1987/88	1988/89
Mymensingh	35.0%	39.5%	58.6%
Jamalpur	24.1%	39.2%	53.1%
Pabna I	31.2%	34.7%	47.2%
Joypurhat	32.0%	32.1%	46.8%
Tangail	28.4%	34.3%	44.0%
Bogra	39.6%	33.3%	41.5%
Natore I	34.0%	31.5%	40.6%
Madaripur	16.5%	20.7%	40.1%
Narsingdi	41.5%	21.6%	39.7%
Jessore I	22.3%	28.3%	37.5%
Rangpur I	19.2%	24.0%	34.6%
Sirajganj	26.9%	26.0%	33.9%
Satkhira	15.4%	19.4%	27.9%
Meherpur	18.1%	10.0%	22.5%
Dinajpur	15.4%	16.3%	21.9%
Chandpur	13.5%	12.8%	18.2%
Jessore II	9.3%	12.0%	17.9%
Comilla	8.8%	9.8%	17.3%
Natore II	15.2%	13.6%	17.0%
Feni	11.4%	12.9%	16.4%
Dhaka	17.3%	13.8%	15.6%
Thaqkuragon	15.2%	10.1%	15.4%
Pabna II	7.5%	7.4%	14.6%
Kushtia	12.5%	12.4%	14.2%
Rangpur II	9.4%	7.2%	10.8%
Chittagong II	0.8%		7.7%
Habiganj	3.9%	4.3%	6.2%
Barisal I	0.9%	1.2%	6.1%
Chittagong II		1.0%	1.3%
Noakhali		0.6%	1.2%
Pirojpur	0.5%		0.3%
Moulvibazar	0.0%	0.0%	0.2%
Bagerhat		0.1%	0.2%

Table II.18

Estimated Average Consumption Accounted for by Irrigation Demand
(MWhr/month, 4 month average)

PBS	1986/87	1987/88	1988/89
Mymensingh	4.8	4.0	5.0
Meherpur	1.7	1.7	3.5
Chittagong II	2.0		2.6
Jessore I	1.4	1.6	2.5
Dhaka	3.3	1.9	2.4
Narsingdi	3.9	1.9	2.1
Tangail	1.6	1.6	2.1
Barisal I	2.3	1.3	2.1
Chandpur	2.1	1.3	2.0
Rangpur I	2.2	1.8	2.0
Madaripur	3.1	1.7	1.9
Comilla	1.0	1.0	1.9
Joypurhat	2.2	1.8	1.8
Bogra	2.3	1.7	1.8
Chittagong I		2.8	1.8
Jamalpur	2.8	1.7	1.7
Habiganj	1.6	1.2	1.6
Natore I	1.1	1.0	1.6
Pabna I	1.3	1.2	1.5
Dinajpur	1.3	1.2	1.5
Jessore II	0.9	1.0	1.5
Sirajganj	1.3	1.1	1.4
Thaqkuragon	1.0	0.9	1.4
Satkhira	1.7	1.2	1.4
Pabna II	1.1	0.9	1.4
Kushtia	1.2	1.1	1.4
Feni	0.9	0.9	1.2
Natore II	1.1	0.9	1.2
Rangpur II	1.6	1.2	1.2
Noakhali		0.6	0.8
Bagerhat		0.3	0.8
Moulvibazar	0.1	0.1	0.6
Pirojpur	1.0		0.4

Table II.19

Tubewells by Type for Each PBS
(%)

	Year FY88				Year FY89			
	FY88 Total	Tubewells Deep	Tubewells Shallow	Low Lift Pumps	FY89 Total	Tubewells Deep	Tubewells Shallow	Low Lift Pumps
Bagerhat	2	0%	0%	100%	2	0%	0%	100%
Barisal I	9	0%	0%	100%	34	0%	0%	100%
Bogra	336	23%	77%	0%	644	18%	82%	0%
Chandpur	225	12%	4%	84%	262	13%	5%	82%
Chittagong I	3	33%	0%	67%	7	14%	14%	71%
Chittagong II	0				16	6%	0%	94%
Comilla	575	21%	42%	37%	732	20%	42%	38%
Dhaka	771	36%	41%	24%	919	43%	37%	20%
Dinajpur	371	25%	70%	5%	497	22%	74%	4%
Feni	245	8%	37%	55%	301	7%	36%	57%
Habiganj	137	34%	52%	14%	170	31%	54%	15%
Jamalpur	231	12%	87%	1%	458	14%	85%	2%
Jessore I	633	28%	65%	7%	704	27%	66%	6%
Jessore II	539	9%	86%	5%	648	8%	86%	5%
Joypurhat	171	38%	62%	0%	368	35%	65%	0%
Kushtia	125	6%	28%	66%	150	8%	35%	57%
Madaripur	231	0%	69%	30%	533	0%	83%	17%
Meherpur	29	59%	21%	21%	60	55%	35%	10%
Moulvibazar	18	0%	100%	0%	18	0%	100%	0%
Mymensingh	188	95%	5%	0%	377	86%	14%	1%
Narsingdi	57	35%	60%	5%	200	20%	72%	8%
Natore I	1067	10%	82%	9%	1246	10%	83%	7%
Natore II	557	11%	87%	3%	606	10%	87%	2%
Noakhali	6	33%	33%	33%	13	8%	77%	15%
Pabna I	641	11%	88%	1%	819	11%	88%	2%
Pabna II	279	9%	87%	4%	385	7%	90%	3%
Pirojpur	1	0%	0%	100%	4	0%	0%	100%
Rangpur I	328	33%	60%	7%	530	26%	69%	5%
Rangpur II	75	19%	33%	48%	165	18%	36%	45%
Satkhira	319	16%	84%	0%	465	13%	87%	0%
Sirajganj	1049	11%	79%	10%	1204	10%	81%	9%
Tangail	1476	19%	77%	4%	1763	21%	76%	4%
Thaqkuragon	59	75%	22%	3%	137	71%	26%	4%

Table II.20

Number of Connections

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat							2	2
Barisal I						2	9	34
Bogra						67	336	644
Chandpur	6	48	14	14	37	205	225	262
Chittagong I							3	7
Chittagong II						1		16
Comilla	18	44	129	156	277	528	575	732
Dhaka	165	275	367	233	249	733	771	919
Dinajpur				13	139	275	371	497
Feni			4	8	140	211	245	301
Habiganj		1	3	29	34	116	137	170
Jamalpur						25	231	458
Jessore I	12	79	259	318	331	552	633	704
Jessore II	7	11	229	290	320	485	539	648
Joypurhat					3	82	171	368
Kushtia				1	67	99	125	150
Madaripur					1	57	231	533
Meherpur						8	29	60
Moulvibazar	1	1	2	5	1	17	18	18
Mymensingh			1	51	41	106	188	377
Narsingdi						11	57	200
Natore I	23	233	404	535	765	993	1,067	1,246
Natore II	3	90	235	395	442	527	557	606
Noakhali						1	6	13
Pabna I		19	117	276	334	449	641	819
Pabna II		35	79	124	91	217	279	385
Pirojpur						1	1	4
Rangpur I			1	18	63	170	328	530
Rangpur II						51	75	165
Satkhira				23	47	167	319	465
Sirajganj	102	347	577	535	616	847	1,049	1,204
Tangail	23	188	400	743	797	1,129	1,476	1,763
Thaqkuragon						45	59	137

121

Table II.21

Energy Consumed

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat							1	6
Barisal I						9	28	179
Bogra						308	1,368	3,492
Chandpur	96	225	922	812	836	1,016	1,137	1,965
Chittagong I							17	35
Chittagong II						4		83
Comilla	174	450	1,475	1,745	1,522	1,659	2,211	4,897
Dhaka	1,985	4,034	5,372	5,122	5,883	6,414	5,858	8,102
Dinajpur				96	570	1,074	1,543	2,638
Feni			4	122	687	602	860	1,326
Habiganj		1	75	205	306	490	624	1,000
Jamalpur						140	889	2,317
Jessore I	77	906	1,973	2,710	2,317	2,390	3,890	6,622
Jessore II	57	493	1,096	1,891	1,308	1,450	2,062	3,507
Joypurhat					14	372	902	1,953
Kushtia				0	271	387	501	750
Madaripur					25	362	968	2,960
Meherpur						27	125	631
Moulvibazar	2	1	6	7	7	5	7	46
Mymensingh			31	685	824	1,424	2,351	5,669
Narsingdi						86	252	1,093
Natore I	170	1,296	1,973	3,117	3,280	3,866	4,276	7,179
Natore II	17	274	870	1,445	1,774	2,090	1,998	2,807
Noakhali							9	31
Pabna I		52	440	1,157	1,470	2,026	2,616	4,504
Pabna II		104	305	574	483	651	873	1,846
Pirojpur						2		4
Rangpur I			4	279	519	1,014	1,774	3,365
Rangpur II						167	292	572
Satkhira				167	313	713	1,199	2,181
Sirajganj						3,748	4,283	6,424
Tangail	280	1,233	2,452	3,372	4,100	6,322	8,491	13,516
Thaqkuragon						92	187	553

122

Table II.22

Average Energy Consumed Per Customer

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat							1,000	3,000
Barisal I						9,000	5,091	8,326
Bogra						9,194	6,789	7,127
Chandpur	32,080	8,336	29,726	57,989	32,779	8,397	5,288	8,070
Chittagong I							11,333	7,000
Chittagong II						8,000		10,375
Comilla	19,375	14,512	17,051	12,244	7,029	4,122	4,009	7,493
Dhaka	24,064	18,336	16,735	17,074	24,411	13,063	7,790	9,588
Dinajpur				14,825	7,504	5,188	4,777	6,078
Feni			2,170	20,348	9,284	3,430	3,772	4,857
Habiganj		1,080	37,372	12,783	9,709	6,533	4,933	6,515
Jamalpur						11,200	6,945	6,726
Jessore I	12,829	19,901	11,672	9,393	7,139	5,413	6,565	9,906
Jessore II	16,407	54,802	9,134	7,286	4,287	3,602	4,027	5,909
Joypurhat					9,107	8,753	7,130	7,247
Kushtia				630	7,965	4,663	4,473	5,455
Madaripur					50,302	12,483	6,722	7,749
Meherpur						6,750	6,757	14,180
Moulvibazar	3,220	1,499	4,219	2,080	2,331	556	400	2,556
Mymensingh			61,580	26,355	17,909	19,374	15,993	20,067
Narsingdi						15,636	7,412	8,506
Natore I	14,813	10,125	6,193	6,640	5,046	4,398	4,151	6,208
Natore II	11,307	5,902	5,351	4,587	4,238	4,314	3,686	4,827
Noakhali							2,571	3,263
Pabna I		5,470	6,468	5,887	4,819	5,175	4,800	6,170
Pabna II		5,969	5,349	5,652	4,492	4,227	3,520	5,560
Pirojpur						4,000		1,600
Rangpur I			7,810	29,318	12,821	8,724	7,124	7,844
Rangpur II						6,549	4,635	4,767
Satkhira				14,545	8,934	6,664	4,934	5,564
Sirajganj						5,124	4,518	5,703
Tangail	24,374	11,690	8,340	5,901	5,324	6,565	6,519	8,346
Thaqkuragon						4,089	3,596	5,643

123

Table II.23

Percentage of Total Customers

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						0.0%	0.0%
Barisal I					0.0%	0.1%	0.4%
Bogra					1.9%	4.6%	5.8%
Chandpur	1.2%	0.2%	0.1%	0.3%	1.3%	1.3%	1.3%
Chittagong II						0.0%	0.1%
Chittagong II					0.0%		0.3%
Comilla	0.6%	1.3%	1.2%	1.9%	2.9%	2.8%	2.8%
Dhaka	2.6%	2.8%	1.6%	1.7%	3.6%	3.5%	3.8%
Dinajpur			1.1%	4.1%	4.7%	4.9%	5.1%
Feni		0.3%	0.2%	1.9%	1.7%	1.8%	1.9%
Habiganj	0.1%	0.1%	0.3%	0.3%	0.9%	0.9%	1.0%
Jamalpur					0.9%	5.2%	7.5%
Jessore I	1.9%	3.4%	3.6%	3.1%	3.9%	4.0%	4.0%
Jessore II	0.2%	2.6%	2.7%	2.7%	3.3%	3.4%	3.8%
Joypurhat				1.5%	2.7%	4.3%	6.4%
Kushtia			0.2%	2.0%	1.7%	1.7%	1.6%
Madaripur				0.1%	1.2%	3.2%	5.8%
Meherpur					0.4%	0.6%	0.7%
Moulvibazar	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
Mymensingh		0.2%	1.6%	0.9%	1.7%	2.6%	4.1%
Narsingdi					0.6%	1.4%	3.6%
Natore I	4.9%	5.8%	5.7%	7.7%	7.9%	7.7%	7.9%
Natore II	2.2%	3.1%	3.9%	4.5%	3.5%	3.5%	3.5%
Noakhali					0.0%	0.1%	0.1%
Pabna I	1.3%	2.9%	5.0%	4.9%	5.1%	6.5%	7.2%
Pabna II	2.5%	1.8%	2.2%	1.3%	2.1%	2.5%	3.0%
Pirojpur					0.1%	0.0%	0.1%
Rangpur I		0.2%	0.7%	1.3%	2.4%	4.0%	5.6%
Rangpur II					1.3%	1.2%	2.0%
Satkhira			0.8%	0.7%	2.0%	3.2%	4.2%
Sirajganj	6.0%	6.7%	5.5%	6.2%	6.5%	7.3%	7.8%
Tangail	5.5%	7.0%	9.1%	8.7%	7.9%	9.2%	10.0%
Thaqkuragon					3.3%	1.9%	2.7%

124

Table II.24

Percentage of Total Energy Used

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat							0.1%	0.2%
Barisal I						0.9%	1.2%	6.1%
Bogra						39.6%	33.3%	41.5%
Chandpur	68.6%	19.3%	22.6%	14.0%	13.7%	13.5%	12.8%	18.2%
Chittagong II							1.0%	1.3%
Chittagong II						0.8%		7.7%
Comilla	8.7%	13.0%	15.5%	12.8%	10.0%	8.8%	9.8%	17.3%
Dhaka	33.9%	32.5%	25.7%	20.5%	18.5%	17.3%	13.8%	15.6%
Dinajpur				45.0%	17.5%	15.4%	16.3%	21.9%
Feni			4.3%	11.1%	21.4%	11.4%	12.9%	16.4%
Habiganj		0.2%	2.7%	2.3%	2.8%	3.9%	4.3%	6.2%
Jamalpur						24.1%	39.2%	53.1%
Jessore I	16.2%	32.7%	31.7%	30.4%	23.7%	22.3%	28.3%	37.5%
Jessore II	6.1%	20.1%	24.3%	20.5%	9.0%	9.3%	12.0%	17.9%
Joypurhat					54.0%	32.0%	32.1%	46.8%
Kushtia				0.7%	16.3%	12.5%	12.4%	14.2%
Madaripur					12.1%	16.5%	20.7%	40.1%
Meherpur						18.1%	10.0%	22.5%
Moulvibazar	0.4%	0.1%	0.2%	0.1%	0.1%	0.0%	0.0%	0.2%
Mymensingh			45.6%	40.8%	26.8%	35.0%	39.5%	58.6%
Narsingdi						41.5%	21.6%	39.7%
Natore I	18.4%	38.1%	36.2%	36.6%	33.7%	34.0%	31.5%	40.6%
Natore II	14.8%	11.6%	18.2%	14.9%	14.3%	15.2%	13.6%	17.0%
Noakhali							0.6%	1.2%
Pabna I		5.9%	14.7%	24.9%	27.4%	31.2%	34.7%	47.2%
Pabna II		15.2%	13.4%	12.6%	8.9%	7.5%	7.4%	14.6%
Pirojpur						0.5%		0.3%
Rangpur I			10.3%	20.1%	14.9%	19.2%	24.0%	34.6%
Rangpur II						9.4%	7.2%	10.8%
Satkhira				12.8%	10.1%	15.4%	19.4%	27.9%
Sirajganj						26.9%	26.0%	33.9%
Tangail	66.9%	17.7%	21.1%	22.9%	22.5%	28.4%	34.3%	44.0%
Thaqkuragon						15.2%	10.1%	15.4%

125

REB DATA ON SMALL COMMERCIAL CONSUMERS

Figure II.20

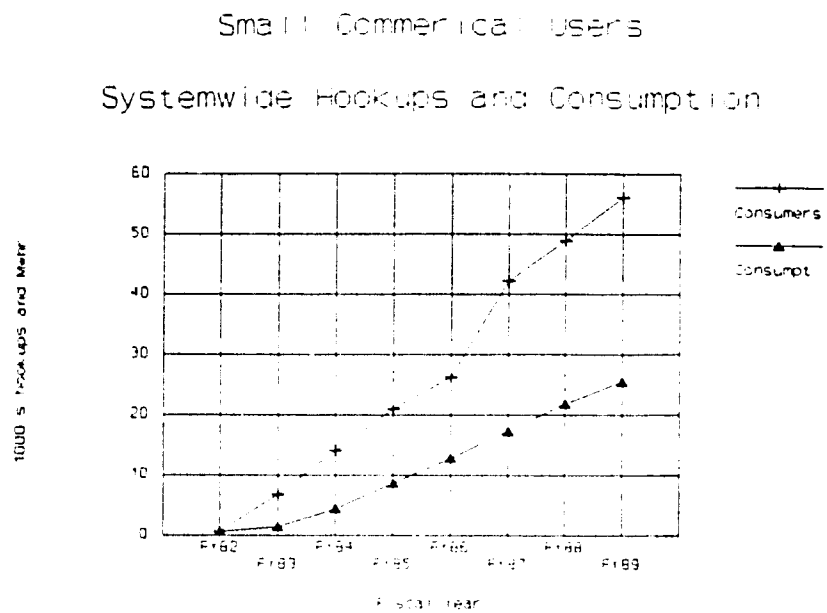
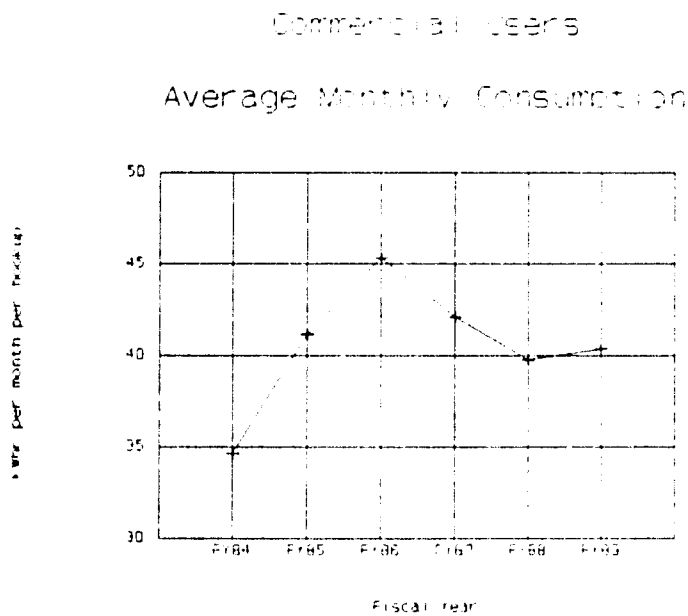
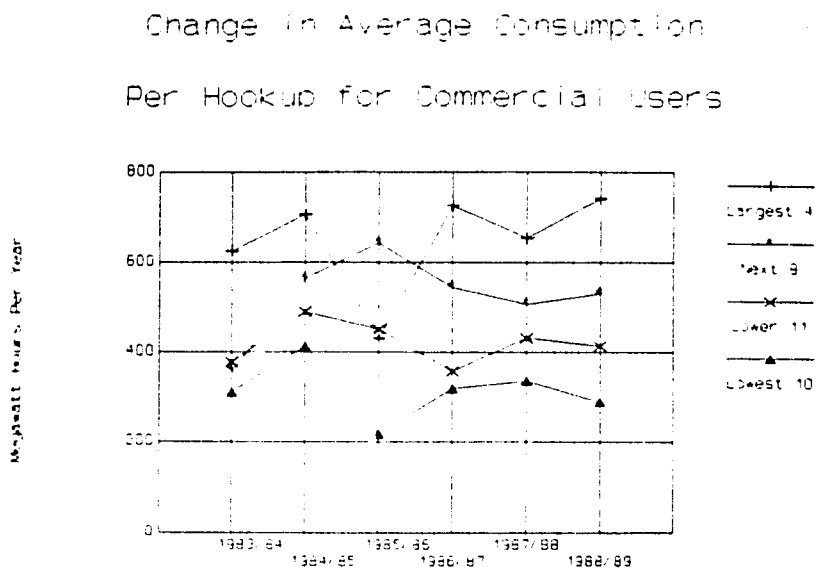


Figure II.21



126

Figure II.22



127

Table II.25

Percentage of Total Consumption Accounted for by Commercial Demand

PBS	1986/87	1987/88	1988/89
Feni	18%	17%	16%
Chandpur	15%	15%	14%
Chittagong II	5%	68%	11%
Barisal I	13%	13%	11%
Satkhira	14%	13%	11%
Jessore II	9%	10%	11%
Jessore I	12%	12%	11%
Pirojpur	12%	10%	10%
Pabna II	11%	10%	10%
Bagerhat	10%	8%	9%
Habiganj	10%	9%	9%
Comilla	8%	8%	8%
Natore I	7%	8%	8%
Natore II	6%	8%	8%
Noakhali	6%	7%	8%
Sirajganj	8%	8%	8%
Rangpur I	9%	8%	7%
Moulvibazar	7%	7%	7%
Rangpur II	7%	6%	6%
Madaripur	9%	9%	6%
Pabna I	8%	7%	6%
Mymensingh	8%	7%	5%
Kushtia	5%	5%	4%
Dinajpur	3%	4%	4%
Jamalpur	5%	3%	3%
Narsingdi	4%	7%	3%
Dhaka	3%	3%	3%
Meherpur	1%	4%	3%
Chittagong II		0%	2%
Thaqkuragon	3%	3%	2%
Tangail	3%	3%	2%
Joypurhat	3%	2%	2%
Bogra	1%	1%	1%

Table II.26

Average Consumption Accounted for by Commercial Demand
(kWhr/month)

PBS	1986/87	1987/88	1988/89
Natore I	48.7	59.1	67.6
Dhaka	127.2	65.2	65.5
Chittagong II	13.4	40.9	63.9
Pabna II	52.6	52.7	50.2
Sirajganj	51.7	48.3	47.8
Jessore II	42.0	42.9	47.1
Moulvibazar	47.8	47.9	47.1
Comilla	42.2	42.6	45.8
Habiganj	47.1	41.5	45.6
Natore II	55.2	39.2	42.5
Mymensingh	38.8	42.6	40.7
Feni	44.8	40.0	40.6
Rangpur II	31.8	39.9	38.7
Jessore I	34.6	35.1	36.6
Tangail	48.8	37.2	35.7
Meherpur	10.8	52.0	35.4
Bogra	18.9	33.2	35.1
Satkhira	32.3	35.3	35.1
Madaripur	39.0	41.7	34.7
Dinajpur	28.2	35.7	34.5
Jamalpur	24.8	26.9	31.4
Chandpur	31.0	30.9	31.3
Kushtia	28.6	28.0	31.1
Noakhali	12.4	28.1	29.4
Pirojpur	47.8	29.6	27.9
Thaqkuragon	27.5	34.7	27.7
Pabna I	35.6	30.6	27.6
Rangpur I	23.5	25.5	26.3
Bagerhat	26.6	24.3	25.5
Joypurhat	35.1	30.2	24.6
Barisal I	23.7	25.3	22.4
Narsingdi	7.0	23.7	18.6
Chittagong II		0.4	10.7

129

Table II.27

Number of Connections

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat				117	384	681	856
Barisal I				130	805	1,138	1,330
Bogra					53	153	279
Chandpur	808	1,797	2,060	2,635	3,584	3,830	4,230
Chittagong II						466	548
Chittagong II					335	28	293
Comilla	682	1,462	2,324	2,671	3,598	3,837	4,882
Dhaka	437	717	859		1,571	1,793	1,977
Dinajpur			39	412	763	1,007	1,220
Feni		52	414	1,332	2,230	2,507	2,808
Habiganj	61	964	1,754	1,949	2,418	2,671	2,763
Jamalpur					195	295	475
Jessore I	1,002	1,418	1,759	2,673	3,608	4,086	4,524
Jessore II	1,060	1,615	2,233	2,515	3,321	3,610	3,911
Joypurhat					147	223	312
Kushtia			35	360	525	577	668
Madaripur				163	662	957	1,172
Meherpur					31	110	234
Moulvibazar	282	494	1,425	1,759	1,971	2,232	2,459
Mymensingh		26	435	615	739	852	1,123
Narsingdi					191	358	423
Natore I	423	610	751	1,058	1,514	1,743	1,924
Natore II	331	1,157	1,441	160	2,319	2,554	2,661
Noakhali					134	470	688
Pabna I	421	807	897	1,060	1,432	1,574	1,747
Pabna II	149	907	1,160	1,291	1,755	1,927	2,075
Pirojpur				1	163	321	427
Rangpur I		324	876	1,321	1,878	2,105	2,405
Rangpur II				136	483	620	826
Satkhira		283	219	1,502	1,735	1,946	2,137
Sirajganj	927	1,194	1,693	1,651	2,118	2,443	2,658
Tangail	216	227	611	709	1,424	1,621	1,786
Thaqkuragon					103	200	329

130

Table II.28

Energy Consumed

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat				4	80	155	235
Barisal I				10	133	295	332
Bogra					6	41	91
Chandpur	127	527	836	890	1,157	1,374	1,515
Chittagong I						1	65
Chittagong II					27	89	123
Comilla	142	523	966	1,251	1,589	1,899	2,398
Dhaka	200	456	722	958	1,199	1,315	1,481
Dinajpur			4	154	199	379	461
Feni		3	184	571	958	1,137	1,296
Habiganj	14	233	781	1,049	1,234	1,267	1,488
Jamalpur					29	79	145
Jessore I	220	535	856	1,137	1,304	1,622	1,891
Jessore II	279	476	718	1,353	1,470	1,782	2,126
Joypurhat					31	67	79
Kushtia			2	84	152	185	232
Madaripur				10	193	405	443
Meherpur					2	44	73
Moulvibazar	63	193	638	919	1,069	1,208	1,326
Mymensingh		1	119	296	315	407	482
Narsingdi					8	78	87
Natore I	137	250	398	549	751	1,154	1,488
Natore II	101	353	676	851	821	1,145	1,329
Noakhali					10	102	204
Pabna I	88	316	377	470	532	552	550
Pabna II	15	318	635	842	961	1,165	1,205
Pirojpur				0	47	36	125
Rangpur I		17	231	398	451	609	712
Rangpur II				5	118	264	336
Satkhira		18	239	458	627	779	859
Sirajganj					1,170	1,323	1,464
Tangail	27	119	274	581	624	680	729
Thaqkuragon					17	63	88

131

Table II.29

Average Energy Consumed Per Cusotmer

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat				67	319	291	306
Barisal I				149	284	304	269
Bogra					226	398	421
Chandpur	315	405	433	379	372	371	376
Chittagong I						4	128
Chittagong II					161	490	766
Comilla	416	488	510	501	507	511	550
Dhaka	915	789	917		1526	782	786
Dinajpur			225	682	339	428	414
Feni		128	792	654	538	480	488
Habiganj	472	454	575	567	565	498	548
Jamalpur					297	322	377
Jessore I	438	442	539	513	415	422	439
Jessore II	526	356	373	570	504	514	565
Joypurhat					422	362	295
Kushtia			140	424	344	336	373
Madaripur				125	468	500	416
Meherpur					129	624	424
Moulvibazar	443	496	665	577	573	575	565
Mymensingh		97	515	565	465	512	488
Narsingdi					84	284	223
Natore I	648	484	585	606	584	709	812
Natore II	608	475	520	1063	662	470	510
Noakhali					149	338	352
Pabna I	420	514	442	480	427	367	331
Pabna II	205	602	615	687	631	633	602
Pirojpur				30	573	355	334
Rangpur I		107	384	362	282	306	316
Rangpur II				73	381	479	465
Satkhira		125	951	532	387	423	421
Sirajganj					621	580	574
Tangail	248	538	653	881	585	447	428
Thaqkuragon					330	416	333

132

Table II.30

Percentage of Total Customers

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat				12.6%	10.2%	12.6%	12.4%
Barisal I				10.5%	19.5%	18.4%	16.7%
Bogra					1.5%	2.1%	2.5%
Chandpur	20.4%	24.5%	22.0%	23.0%	23.1%	21.9%	20.2%
Chittagong II						7.3%	7.1%
Chittagong II					9.4%	4.3%	5.4%
Comilla	9.4%	14.6%	17.5%	18.3%	19.6%	18.5%	18.8%
Dhaka	4.1%	5.5%	6 0%		7.6%	8.1%	8.1%
Dinajpur			3.2%	12.2%	13.2%	13.3%	12.5%
Feni		4.2%	11.4%	17.9%	18.4%	18.3%	17.7%
Habiganj	5.8%	20.1%	19.7%	17.9%	17.8%	17.8%	16.1%
Jamalpur					7.3%	6.7%	7.8%
Jessore I	23.6%	18.9%	19.7%	24.7%	25.2%	25.9%	25.7%
Jessore II	17.1%	18.1%	20.6%	21.1%	22.6%	23.1%	22.9%
Joypurhat					4 9%	5.6%	5.4%
Kushtia			6.5%	11.0%	8.8%	7.7%	7.0%
Madaripur				10.1%	14.4%	13.1%	12.7%
Meherpur					1.4%	2.3%	2.8%
Moulvibazar	12.0%	7.5%	13.9%	15.3%	14.5%	15.3%	15.7%
Mymensingh		4.6%	13.3%	13.0%	12.1%	11.6%	12.3%
Narsingdi					11.0%	9.0%	7.6%
Natore I	8.8%	8.8%	8.0%	10.7%	12.0%	12.6%	12.3%
Natore II	7.9%	15.4%	14.2%	1.6%	15.5%	16.1%	15.6%
Noakhali					4.8%	7.3%	6.2%
Pabna I	29.4%	19.7%	16.2%	15.7%	16.4%	15.9%	15.3%
Pabna II	10.5%	20.8%	20.7%	17.9%	17.4%	17.4%	16.1%
Pirojpur				0.5%	9.6%	11.9%	11.8%
Rangpur I		55.6%	33.4%	27.7%	26.3%	25.8%	25.6%
Rangpur II				29.4%	12.2%	10.3%	9.9%
Satkhira		25.6%	7.6%	23.7%	20.3%	19.8%	19.1%
Sirajganj	16.1%	13.9%	17.5%	16.5%	16.3%	17.0%	17.3%
Tangail	6.3%	4.0%	7.5%	7.8%	10.0%	10.1%	10.1%
Thaqkuragon					7.6%	6.3%	6.4%

Table II.31

Percentage of Total Energy Used

	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat				8.5%	10.0%	8.4%	9.4%
Barisal I				8.5%	12.7%	12.8%	11.4%
Bogra					0.8%	1.0%	1.1%
Chandpur	10.9%	12.9%	14.4%	14.6%	15.4%	15.5%	14.0%
Chittagong II						0.1%	2.5%
Chittagong II					5.5%	67.9%	11.4%
Comilla	4.1%	5.5%	7.1%	8.3%	8.5%	8.4%	8.5%
Dhaka	1.6%	2.2%	2.9%	3.0%	3.2%	3.1%	2.9%
Dinajpur			2.1%	4.7%	2.8%	4.0%	3.8%
Feni		3.3%	16.7%	17.8%	18.2%	17.1%	16.0%
Habiganj	4.4%	8.4%	8.9%	9.5%	9.7%	8.8%	9.2%
Jamalpur					5.0%	3.5%	3.3%
Jessore I	7.9%	8.6%	9.6%	11.6%	12.2%	11.8%	10.7%
Jessore II	11.3%	10.5%	7.8%	9.3%	9.5%	10.3%	10.9%
Joypurhat					2.7%	2.4%	1.9%
Kushtia			5.6%	5.1%	4.9%	4.6%	4.4%
Madaripur				4.9%	8.8%	8.6%	6.0%
Meherpur					1.3%	3.5%	2.6%
Moulvibazar	3.3%	5.9%	5.7%	7.3%	7.0%	7.0%	7.0%
Mymensingh		1.9%	7.1%	9.6%	7.7%	6.8%	5.0%
Narsingdi					3.9%	6.7%	3.2%
Natore I	4.0%	4.6%	4.7%	5.6%	5.5%	3.5%	8.4%
Natore II	4.3%	7.4%	6.9%	6.9%	6.0%	7.8%	3.1%
Noakhali					5.6%	7.3%	7.9%
Pabna I	10.1%	10.6%	8.1%	8.8%	8.2%	7.3%	5.8%
Pabna II	2.2%	13.9%	14.0%	15.6%	11.0%	9.9%	9.6%
Pirojpur				0.6%	12.2%	10.4%	10.0%
Rangpur I		45.7%	16.7%	11.4%	8.6%	8.2%	7.3%
Rangpur II				20.0%	6.6%	6.5%	6.3%
Satkhira		29.6%	18.2%	14.8%	13.5%	12.6%	11.0%
Sirajganj					8.4%	8.0%	7.7%
Tangail	0.4%	1.0%	1.9%	3.2%	2.8%	2.7%	2.4%
Thaqkuragon					2.8%	3.4%	2.4%

134

REB DEMAND DATA FOR STREET LIGHTING

Figure II.23

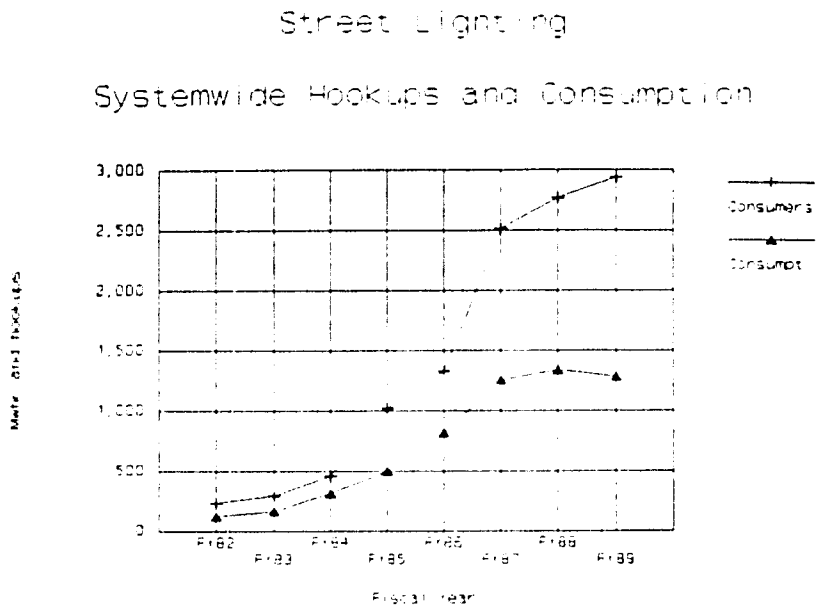
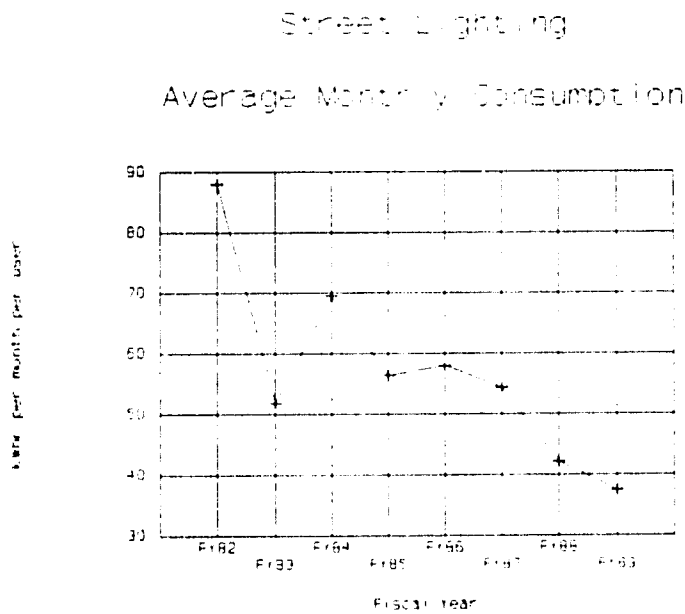


Figure II.24



125

Table II.32

Number of Connections

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						10	19	37
Barisal I						40	65	72
Bogra						4	6	11
Chandpur		10	19	21	48	65	102	103
Chittagong I							7	7
Chittagong II						6	4	8
Comilla	27	19	35	60	115	153	161	170
Dhaka	32	21	17	28	51	129	137	146
Dinajpur					2	23	38	65
Feni				19	45	112	123	132
Habiganj		8	27	124	118	191	167	183
Jamalpur						12	14	22
Jessore I	13	23	36	55	104	183	184	131
Jessore II	53	48	61	87	110	171	171	174
Joypurhat								3
Kushtia					3	39	41	41
Madaripur					15	69	110	120
Meherpur							4	8
Moulvibazar	2	4	5	27	29	166	200	210
Mymensingh				24	32	38	51	90
Narsingdi						2	9	11
Natore I	26	48	66	72	110	150	152	152
Natore II	15	46	68	94	102	146	146	146
Noakhali						10	18	23
Pabna I		3	15	109	125	197	198	198
Pabna II	2	6	27	80	73	132	132	132
Pirojpur						24	29	39
Rangpur I				14	16	55	56	62
Rangpur II						19	23	23
Satkhira				16	30	94	122	128
Sirajganj	61	52	57	156	143	209	212	215
Tangail		8	26	36	56	68	69	73
Thaqkuragon								2

Table II.33

Energy Consumed

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						1	10	15
Barisal I						11	33	41
Bogra							1	1
Chandpur		6	11	14	28	40	65	66
Chittagong I								1
Chittagong II						1	3	2
Comilla	16	18	14	22	43	46	47	45
Dhaka	32	18	15	17	34	44	44	40
Dinajpur					0	7	13	26
Feni				8	18	43	59	59
Habiganj		3	18	56	99	90	152	120
Jamalpur						3	4	8
Jessore I	14	14	26	36	66	70	65	66
Jessore II	35	40	47	46	80	85	80	75
Joypurhat								
Kushtia					2	10	22	17
Madaripur					1	31	50	55
Meherpur							1	4
Moulvibazar	6	7	10	20	49	267	94	111
Mymensingh				6	39	41	55	73
Narsingdi							4	7
Natore I	14	26	47	57	71	19	85	72
Natore II	5	24	53	65	73	67	66	56
Noakhali						1	7	9
Pabna I		3	46	74	93	117	119	103
Pabna II	1	5	12	43	54	60	62	57
Pirojpur						6	14	19
Rangpur I				7	13	16	18	10
Rangpur II						8	13	11
Satkhira				7	20	32	54	14
Sirajganj						92	56	53
Tangail		1	16	23	34	46	42	44
Thakuragon								1

137

Table II.34

Average Energy Consumed Per Customer

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						200	690	536
Barisal I						550	629	599
Bogra							200	118
Chandpur		1,140	766	692	824	708	778	644
Chittagong I								143
Chittagong II						333	600	333
Comilla	1,156	761	503	468	490	343	299	272
Dhaka	2,010	674	783	739	852	489	331	283
Dinajpur					240	560	426	505
Feni				792	566	548	502	463
Habiganj		844	1,053	740	822	583	849	686
Jamalpur						500	308	444
Jessore I	2,121	768	888	782	827	488	354	419
Jessore II	1,333	797	855	622	807	605	468	435
Joypurhat								
Kushtia					1,243	476	550	415
Madaripur					165	738	559	478
Meherpur							500	667
Moulvibazar	6,032	2,289	2,144	1,268	1,734	2,738	514	541
Mymensingh				499	1,393	1,171	1,236	1,035
Narsingdi							727	700
Natore I	1,056	702	824	825	778	146	563	474
Natore II	644	790	927	806	742	540	452	384
Noakhali						200	500	439
Pabna I		1,722	5,076	1,200	799	727	603	520
Pabna II	500	1,284	755	803	708	585	470	432
Pirojpur						500	528	559
Rangpur I				1,049	891	451	324	169
Rangpur II						842	619	478
Satkhira				915	869	516	500	112
Sirajganj						523	266	248
Tangail		126	966	734	733	742	613	620
Thaqkuragon								1,000

Table II.35

Percentage of Total Cusotmers

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						0.3%	0.4%	0.5%
Barisal I						1.0%	1.1%	0.9%
Bogra						0.1%	0.1%	0.1%
Chandpur		0.3%	0.3%	0.2%	0.4%	0.4%	0.6%	0.5%
Chittagong II							0.1%	0.1%
Chittagong II						0.2%	0.6%	0.1%
Comilla	0.5%	0.3%	0.3%	0.5%	0.8%	0.8%	0.8%	0.7%
Dhaka	0.5%	0.2%	0.1%	0.2%	0.3%	0.6%	0.6%	0.6%
Dinajpur					0.1%	0.4%	0.5%	0.7%
Feni				0.5%	0.6%	0.9%	0.9%	0.8%
Habiganj		0.8%	0.6%	1.4%	1.1%	1.4%	1.1%	1.1%
Jamalpur						0.5%	0.3%	0.4%
Jessore I	1.3%	0.5%	0.5%	0.6%	1.0%	1.3%	1.2%	0.7%
Jessore II	2.2%	0.8%	0.7%	0.8%	0.9%	1.2%	1.1%	1.0%
Joypurhat								0.1%
Kushtia					0.1%	0.7%	0.5%	0.4%
Madaripur					0.9%	1.5%	1.5%	1.3%
Meherpur							0.1%	0.1%
Moulvibazar	0.2%	0.2%	0.1%	0.3%	0.3%	1.2%	1.4%	1.3%
Mymensingh				0.7%	0.7%	0.6%	0.7%	1.0%
Narsingdi						0.1%	0.2%	0.2%
Natore I	1.6%	1.0%	1.0%	0.8%	1.1%	1.2%	1.1%	1.0%
Natore II	2.7%	1.1%	0.9%	0.9%	1.0%	1.0%	0.9%	0.9%
Noakhali						0.4%	0.3%	0.2%
Pabna I		0.2%	0.4%	2.0%	1.9%	2.3%	2.0%	1.7%
Pabna II	0.4%	0.4%	0.6%	1.4%	1.0%	1.3%	1.2%	1.0%
Pirojpur						1.4%	1.1%	1.1%
Rangpur I				0.5%	0.3%	0.8%	0.7%	0.7%
Rangpur II						0.5%	0.4%	0.3%
Satkhira				0.6%	0.5%	1.1%	1.2%	1.1%
Sirajganj	1.7%	0.9%	0.7%	1.6%	1.4%	1.6%	1.5%	1.4%
Tangail		0.2%	0.5%	0.4%	0.6%	0.5%	0.4%	0.4%
Thaqkuragon								0.0%

129

Table II.36

Percentage of Total Energy Used

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Bagerhat						0.1%	0.5%	0.6%
Barisal I						1.1%	1.4%	1.4%
Bogra							0.0%	0.0%
Chandpur		0.5%	0.3%	0.2%	0.5%	0.5%	0.7%	0.6%
Chittagong II								0.0%
Chittagong II						0.2%	0.3%	0.2%
Comilla	0.8%	0.5%	0.1%	0.2%	0.3%	0.2%	0.2%	0.2%
Dhaka	0.5%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Dinajpur					0.0%	0.1%	0.1%	0.2%
Feni				0.7%	0.6%	0.8%	0.9%	0.7%
Habiganj		1.0%	0.7%	0.6%	0.9%	0.7%	1.1%	0.7%
Jamalpur						0.5%	0.2%	0.2%
Jessore I	2.9%	0.5%	0.4%	0.4%	0.7%	0.7%	0.5%	0.4%
Jessore II	3.8%	1.6%	1.0%	0.5%	0.5%	0.5%	0.5%	0.4%
Joypurhat								
Kushtia					0.1%	0.3%	0.5%	0.3%
Madaripur					0.6%	1.4%	1.1%	0.7%
Meherpur							0.1%	0.1%
Moulvibazar	1.4%	0.4%	0.3%	0.2%	0.4%	1.7%	0.5%	0.6%
Mymensingh				0.4%	1.3%	1.0%	0.9%	0.8%
Narsingdi							0.3%	0.3%
Natore I	1.5%	0.8%	0.9%	0.7%	0.7%	0.2%	0.6%	0.4%
Natore II	4.2%	1.0%	1.1%	0.7%	0.6%	0.5%	0.4%	0.3%
Noakhali						0.6%	0.5%	0.3%
Pabna I		0.3%	1.5%	1.6%	1.7%	1.8%	1.6%	1.1%
Pabna II	0.8%	0.7%	0.5%	0.9%	1.0%	0.7%	0.5%	0.5%
Pirojpur						1.6%	1.7%	1.5%
Rangpur I				0.5%	0.4%	0.3%	0.2%	0.1%
Rangpur II						0.4%	0.3%	0.2%
Satkhira				0.6%	0.6%	0.7%	0.9%	0.2%
Sirajganj						0.7%	0.3%	0.3%
Tangail		0.0%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%
Thaqkuragon								0.0%

140

Key to Figures II.8, II.14,

1. *Bagerhat*
2. *Barisal I*
3. *Bogra*
4. *Chandpur*
5. *Chittagong I*
6. *Chittagong II*
7. *Comilla*
8. *Dhaka*
9. *Dinajpur*
10. *Feni*
11. *Habiganj*
12. *Jamalpur*
13. *Jessore I*
14. *Jessore II*
15. *Joypurhat*
16. *Kushtia*
17. *Madaripur*
18. *Meherpur*
19. *Moulvibazar*
20. *Mymensingh*
21. *Narsingdi*
22. *Natore I*
23. *Natore II*
24. *Noakhali*
25. *Pabna I*
26. *Pabna II*
27. *Pirojpur*
28. *Rangpur I*
29. *Rangpur II*
30. *Satkhira*
31. *Sirajganj*
32. *Ta ngail*
33. *Thaqkuragon*

141

Annex III

FINANCIAL PERFORMANCE DATA FOR THE PBS'S

Financial Performance of REB and the PBS's

The financial performance of the REB has been relatively strong given the newness of this effort and the general financial experience with similar efforts in other countries. In order to analyze the performance of the individual PBS's, as well as of the REb, the historical data recorded on the Form 550 was entered into a computer database. The tables and graphs presented in this annex were developed from this database. Rather than analyze the performance of the individual PBS's, they have been grouped according to their age and level of financial activity as shown in Table III.1.

The first three groups are part of the original 19 established in the FY82 to FY84. Group A has the largest gross income currently in excess of Tk. 60 million per year. The Group B PBS's have a lower gross income currently ranging between Tk 40 and Tk 60 million per year. Group C have the lowest gross income for their group ranging from Tk. 20 million to Tk 40 million. The lowest gross income in group C was reported by the newest PBS's in the group. Groups D and E were established in FY86 87. Group D has gross income between Tk 10 million and Tk 20 million whereas Group E has a gross income of less than Tk 10 million.

The rapid growth in revenues shown in Figure III.1 and Table III.1 has generally outpaced the increase in costs for all Groups except the newer ones as shown in Figure III.2. The revenues have increased faster than the expansion of the network as shown in Figure III.3 and Table III.20 whereas operating and maintenance costs have been held under control by all groups except Group C (Figure III.4 and Table III.21).

The result of the good financial performance has been a reduction in the working ratios (measured with expenditures exclusive of depreciation or interest) for all five groups as shown in Figure III.5 and Table III.6. With the exception of Group D, the ratios have settled between .7 and .8 with Groups A and B having the lowest ratios.

The financial statistics indicate that most of the PBS's are able to meet their direct expenses and to generate some surplus to contribute towards debt service as shown in Figure III.6 and Table III.7.[1] However, only the older ones are able to generate a net surplus after depreciation and interest as shown in Table III.5.

---

[1] This analysis will ignore depreciation in favor of focusing on debt service requirements. The current practice of setting aside funds for both depreciation and debt service serves no discernable purpose and is contradictory to both common accounting practices and economic rationale.

The newer PBS's have shown the same slow growth in surplus experienced by Groups A through C.

Despite the rapid growth in debt as a result of development of the distribution network (Figure III.7 and Table III.13), the surplus has grown more rapidly. The rate of return as measured by the surplus of gross income above direct expenditures (exclusive of depreciation and interest) is still relatively small but is increasing and for the older PBS's in Groups A and B have reached the acceptable level of 8% (Figure III.8).

The conclusion that must be drawn from this brief review is that the current group of PBS's have performed well in financial terms. If the current trend continues, they should be able to meet their future debt service requirements. However, it is clear that the expectation of achieving self-sufficiency with regards to debt service after five years was unrealistic. The financial success of the PBS's is not a yet a *fait accompli*, and several factors could impact negatively. The principal concern is the ability to control operating and maintenance costs as the distribution systems become older and likely downturn in revenues from extension of the lines to more marginal areas.

The expected increase in the cost of electricity charged by the BPDB is not expected to cause difficulties for the PBSs' because of the ability to pass on these increases to the customers with relatively little loss in total consumption, especially, where the same increases are passed on to BPDB's other customers.

Clearly, the performance of the PBS's is not uniform. Some of the PBS's such as Barisal, Noakhali, Chittagong I and II, Joypurhat and Tangail, have unacceptable operating ratios and need to improve their performance. However, even these have been improving their performance with the one exception of Tangail.

The financial study of the REB by Cooper's and Lybrand has pointed to potential difficulties with future investments and debt service requirements and to the need for recycling funds between the healthier PBS's and the weaker PBS's. An elaborate financial model has been developed as part of this study to assist the REB in adjusting tariffs and planning future investments in existing PBS's. While past trends provide only part of the story, they do argue for a certain level of optimism with regards to the ability of the individual PBS's to achieve financial self-sufficiency and to eventually operate as autonomous units without relying on REB for investment capital.

Table III.1

The PBS's Grouped by Volume of Turnover

Group A
Comilla PBS1
Tangail PBS-1
Dhaka PBS1
Group B
Serajgonj PBS
Natore PBS 1
Jessore PBS II
Jessore PBS1
Habiganj PBS
Moulvibazar PBS
Natore PBS 2
Group C
Feni PBS
Kushtia Bally Bidyu
Dinajpur PBS1
Mymensingh PBS1
Satkhira PBS
Pabna PBS1
Chandpur PBS
Rangpur PBS1
Pabna PBSII
Group D
Bogra PBS
Thakurgaon PBS
Rangpur PBS2
Jamalpur PBS1
Group E
Narsingdi PBS
Meherpur Pally Bidt
Chittagong PBS2
Noakhali PBS
Barisal PBS
Madaripur PBS
Pirojpur PBS
Joypurhat PBS
Bagerhat Palli Bidt
Chittagong PBS1

145

Figure III.1

Growth in Revenues Following Startup

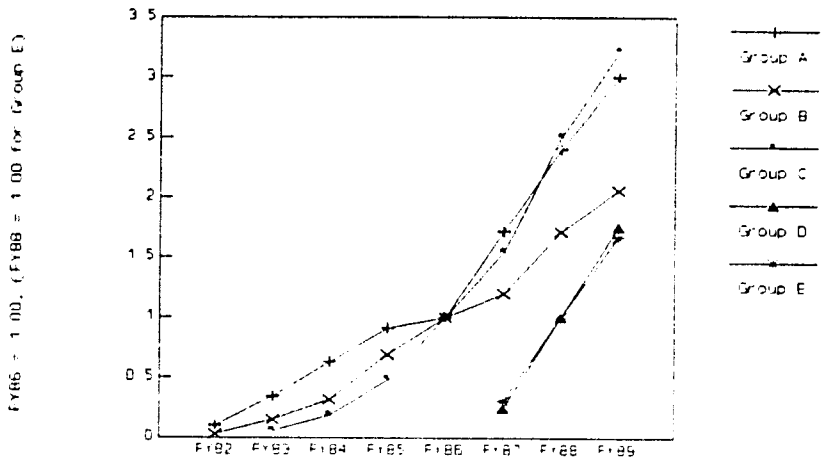
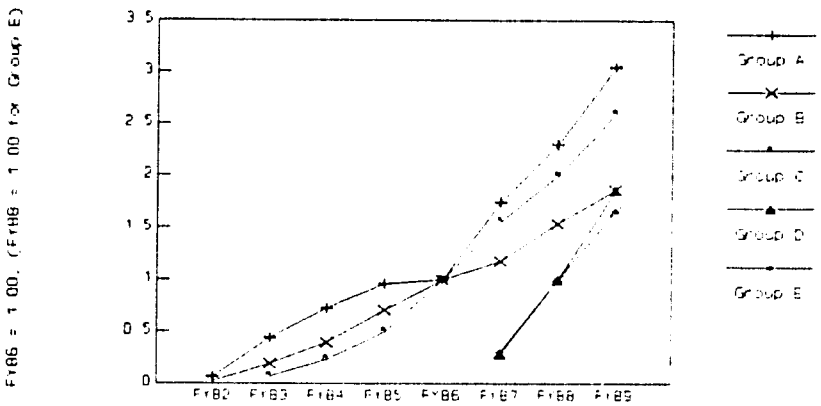


Figure III.2

Growth in Costs for Electricity

Following Startup



146

Figure III.3

Revenues per Mile of Energized Line

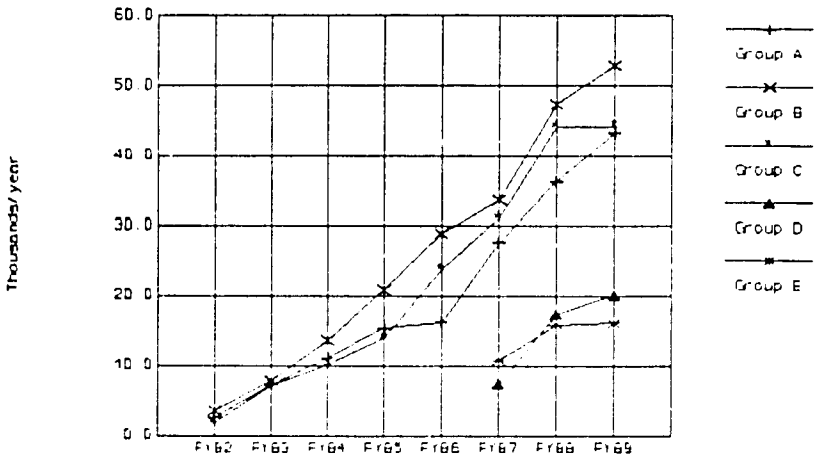
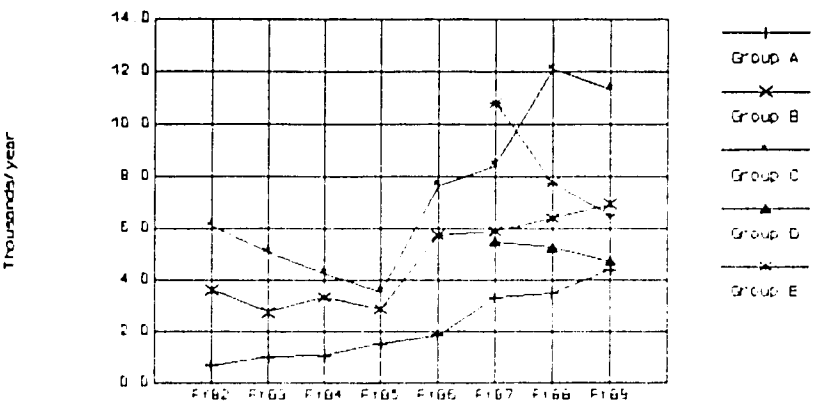


Figure III.4

Operat. and Maint. Costs Per Mile of Energized Line (Excludes Electricity)



147

Figure III.5

Change in Operating Ratio

Following Startup

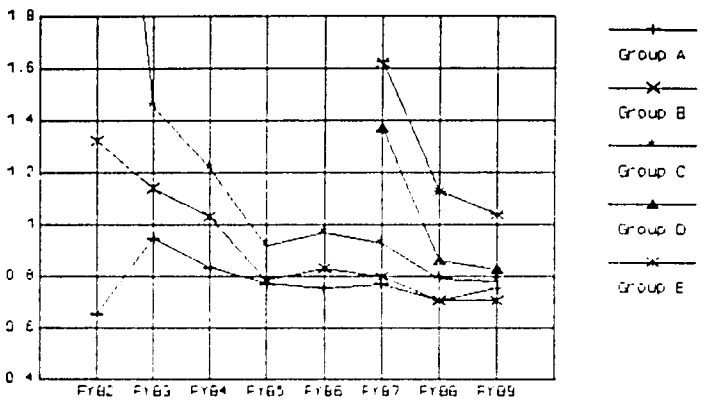


Figure III.6

Change in Surplus (before depreciation

and interest) Following Startup

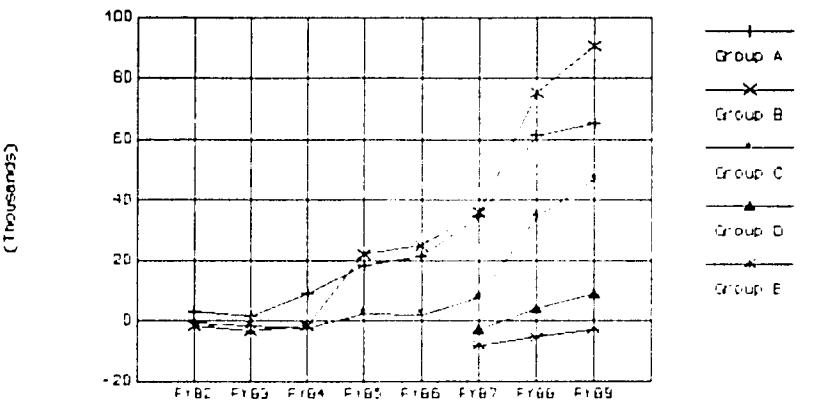


Figure III.7

Growth in Total Debt

Following Startup

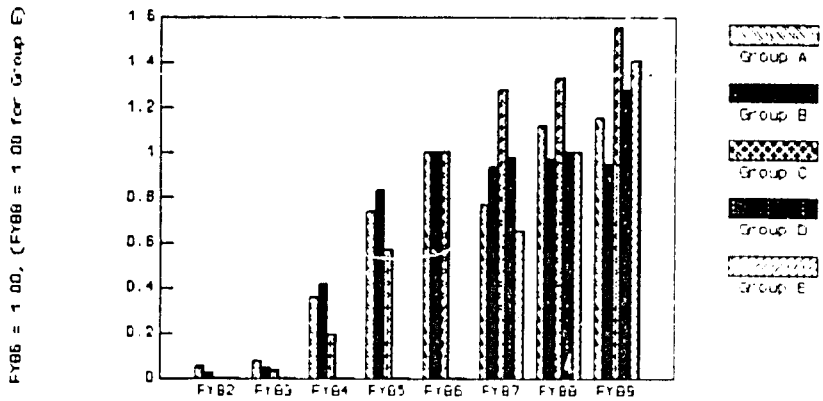


Figure III.8

Ratio of Surplus (Before Depreciation

and Interest) to Long Term Debt

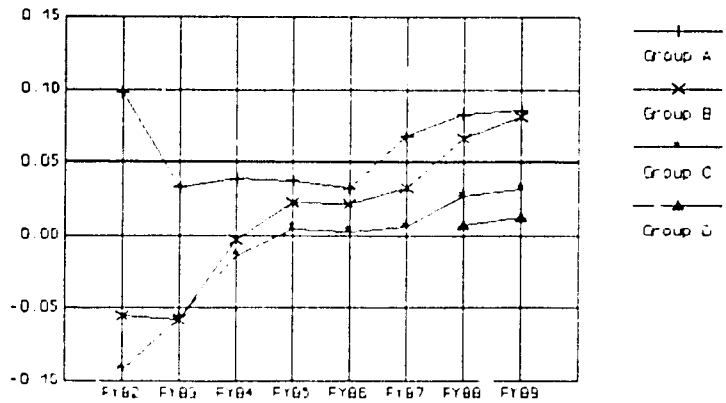
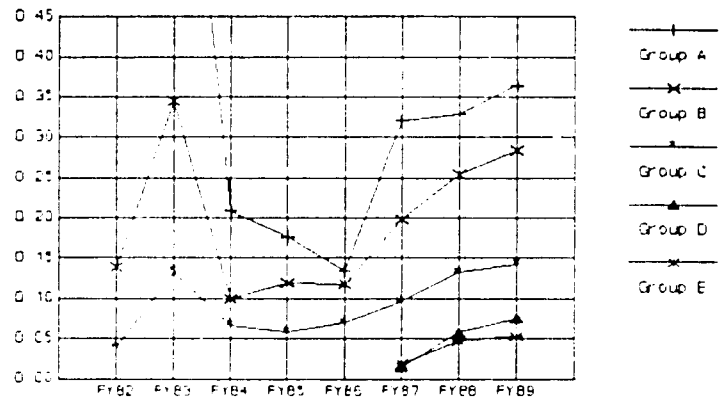


Figure III.9

Turnover as a Fraction of Assets

(Exclusive of Depreciation)



150

Table III.2

Total operating revenue
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	6,458	15,739	27,522	37,659	59,831	71,334	101,152	127,266
Tangail PBS-1	385	9,331	15,182	21,181		41,738	54,695	67,596
Comilla PBS1	2,269	5,688	12,754	21,555	28,266	38,434	55,883	69,638
Chandpur PBS	200	1,655	4,987	8,218	10,335	14,358	21,780	27,015
Habiganj PBS	5	472	4,246	14,276	20,515	24,462	36,574	41,550
Moulvibazar PBS	529	2,647	6,515	18,377	25,212	31,082	43,131	49,539
Pabna PBS1		1,212	3,748	6,521	9,247	11,981	17,495	22,575
Pabna PBS11	96	897	2,945	8,879	9,551	16,934	28,282	31,211
Serajganj PBS	1,717	5,771	10,042	17,897	21,312	26,151	38,051	45,387
Jessore PBS1	513	3,642	7,825	12,747	17,055	20,627	33,317	43,069
Jessore PBS II	916	2,974	5,792	13,631	25,793	29,479	38,298	45,770
Natore PBS 1	932	4,178	6,682	11,912	17,014	21,166	30,991	41,241
Natore PBS 2	126	3,041	6,266	14,306	21,817	25,654	35,685	40,850
Rangpur PBS1			48	2,015	6,566	10,691	18,316	24,326
Satkhira PBS			103	1,923	5,587	8,945	15,383	19,860
Feni PBS			117	1,361	8,306	9,430	15,085	19,033
Mymensingh PBS1			80	2,141	4,911	7,496	13,615	20,475
Dinajpur PBS1				263	6,404	14,675	23,906	30,746
Kushtia Bally Bidyut Samity				60	3,785	6,145	9,531	12,312
Madaripur PBS						4,195	10,963	16,661
Barisal PBS						2,237	5,677	7,418
Noakhali PBS						288	2,763	5,666
Bagerhat Palli Bidt						1,665	4,517	6,459
Joypurhat PBS						2,231	6,705	9,883
Pirojpur PBS						727	1,953	3,204
Rangpur PBS2						3,724	10,302	13,473
Jamalpur PBS1						1,038	5,151	10,149
Thakurgaon PBS						1,264	5,162	9,673
Chittagong PBS2						754	3,395	4,947
Bogra PBS						1,365	9,373	19,325
Meherpur Pally Bidt						277	2,728	6,337
Chittagong PBS1							82	2,262
Narsingdi PBS						414	2,632	6,351

Table III.3
Cost of purchased power
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	2,342	12,941	19,949	24,577	37,718	46,550	59,346	77,051
Tangail PBS-1	630	7,683	12,105	15,867		28,382	36,755	52,941
Comilla PBS1	624	4,296	8,827	13,769	18,766	23,772	33,693	42,244
Chandpur PBS	42	1,276	4,175	6,521	7,954	9,636	12,648	16,285
Habiganj PBS		114	2,658	8,476	11,938	14,488	18,764	22,486
Moulvibazar PBS	155	1,639	4,444	10,578	14,910	16,934	22,226	25,278
Pabna PBS1		1,064	3,044	4,661	6,559	8,178	10,302	14,178
Pabna PBSII		539	2,094	4,436	5,912	9,991	15,224	17,343
Serajgonj PBS	554	5,429	9,263	13,392	15,126	18,156	23,335	27,989
Jessore PBS1	200	2,824	6,684	9,303	11,965	13,381	19,137	23,847
Jessore PBS II	326	2,239	4,388	8,020	15,329	19,127	24,529	28,047
Natore PBS 1	293	3,230	5,598	7,589	10,873	13,260	18,239	24,527
Natore PBS 2	34	2,530	4,263	9,307	14,304	15,987	19,622	24,129
Rangpur PBS1			58	1,085	3,993	7,631	11,890	13,995
Satkhira PBS			46	959	3,587	5,162	7,749	11,683
Feni PBS			108	1,113	4,366	7,354	10,816	13,244
Mymensingh PBS1			98	1,797	3,650	5,235	8,477	13,323
Dinajpur PBS1				290	4,005	8,593	1,374	1,601
Kushtia Bally Bidyut Samity				41	2,163	4,147	5,915	7,717
Madaripur PBS						2,734	6,698	10,433
Barisal PBS						1,360	3,197	4,236
Noakhali PBS						251	1,977	3,550
Bagerhat Palli Bidt						1,152	2,847	3,813
Joypurhat PBS						815	4,168	6,674
Pirojpur PBS						547	1,519	2,[illegible]5
Rangpur PBS2						2,211	5,508	8,309
Jamalpur PBS1						744	3,192	5,930
Thakurgaon PBS						788	2,458	4,856
Chittagong PBS2						706	2,745	3,877
Bogra PBS						909	5,581	12,077
Meherpur Pally Bidt.						142	1,683	4,064
Chittagong PBS1							82	1,609
Narsingdi PBS						281	1,575	3,777

Table III.4
O&M Costs less Depreciation and Interest
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	3,245	14,364	21,905	28,047	43,509	53,655	66,641	85,981
Tangail PBS-1	1,165	8,988	13,638	17,957		33,641	43,040	62,640
Comilla PBS1	1,549	5,731	10,686	16,088	23,073	29,514	40,569	50,510
Chandpur PBS	356	2,290	5,743	8,282	11,464	14,660	17,787	22,078
Habiganj PBS		605	3,830	10,434	15,831	18,344	23,484	27,951
Moulvibazar PBS	889	2,714	6,189	12,630	18,531	20,666	26,863	30,643
Pabna PBS1	405	1,802	4,209	6,418	9,263	11,361	13,657	17,948
Pabna PBSII	259	1,372	3,211	5,896	9,183	13,265	16,695	21,812
Serajgonj PBS	1,404	6,882	11,130	15,522	18,989	22,835	28,374	33,549
Jessore PBS1	1,015	4,008	8,248	11,205	16,875	18,422	24,079	29,971
Jessore PBS II	1,343	3,397	6,125	10,263	19,293	24,15[illegible]	[illegible]	34,584
Natore PBS 1	1,183	4,460	7,293	9,677	14,311	17,[illegible]	22,82[illegible]	30,448
Natore PBS 2	428	3,847	6,047	11,358	16,268	20,56[illegible]	24,412	29,542
Rangpur PBS1			200	2,056	6,195	9,994	14,636	17,825
Satkhira PBS			364	2,090	5,414	8,293	11,934	15,292
Feni PBS			375	406	6,732	10,369	15,113	17,724
Mymensingh PBS1			295	2,743	5,402	7,674	11,856	17,668
Dinajpur PBS1			202	760	5,751	11,162	16,980	21,506
Kushtia Bally Bidyut Samity				214	3,799	6,393	9,291	11,125
Madaripur PBS						5,014	9,372	14,112
Barisal PBS						3,214	5,811	7,479
Noakhali PBS						898	4,132	6,233
Bagerhat Palli Bidt						3,067	5,128	6,563
Joypurhat PBS						2,312	6,617	9,558
Pirojpur PBS						1,824	3,359	4,636
Rangpur PBS2						3,876	7,825	11,458
Jamalpur PBS1						2,342	5,472	8,945
Thakurgaon PBS						1,923	4,435	7,510
Chittagong PBS2						1,711	4,726	6,798
Bogra PBS						1,996	8,085	15,612
Meherpur Pally Bidt						580	3,434	6,365
Chittagong PBS1						865	628	3,777
Narsingdi PBS						1,269	3,495	6,320

Table III.5

Surplus after Depreciation and Interest

(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	2,763	952	(7,354)	5,124	8,948	6,023	23,849	25,497
Tangail PBS-1	(962)	188	454	(5,230)	(5,576)	(5,338)	304	(1,445)
Comilla PBS1	323	(649)	(6,411)	(1,643)	(6,700)	(5,500)	6,273	4,955
Chandpur PBS	(344)	(825)	(1,760)	(6,900)	(5,661)	(9,159)	(7,339)	(7,263)
Habiganj PBS	(7)	(152)	166	(1,116)	1,235	(2,119)	6,198	6,329
Moulvibazar PBS	(631)	(273)	(361)	(2,591)	199	6,214	8,961	10,346
Pabna PBS1	(493)	(706)	(2,893)	(2,877)	(3,536)	(6,586)	(3,267)	(3,184)
Pabna PBS11	(233)	(693)	(1,079)	(2,252)	(1,992)	(4,193)	3,719	1,010
Serajgonj PBS		1,365	(3,854)	(7,187)	(2,844)	(5,277)	1,492	3,201
Jessore PBS1	526	1552	(2,558)	(8,583)	(7,194)	12,083	152	1,803
Jessore PBS II	(932)	(677)	(1,348)	(11,232)	987	(5,608)	165	990
Natore PBS 1	1,052	(761)	(2,460)	(5,305)	1,204	(4,599)	167	1,362
Natore PBS 2	(345)	(1,002)	(1,004)	(6,344)	(832)	(4,333)	2,168	982
Rangpur PBS1			(151)	(697)	(2,006)	(4,995)	619	(3,120)
Satkhira PBS			(293)	(1,989)	(3,099)	(3,152)	482	(2,836)
Feni PBS			(308)	(61,833)	60,882	(6,523)	(5,037)	(8,055)
Mymensingh PBS1			(286)	(1,879)	(2,167)	(3,189)	(2,625)	(6,754)
Dinajpur PBS1			(202)	(980)	(2,433)	1,052	3,587	1,335
Kushtia Bally B.				(202)	(1,668)	(3,346)	(1,954)	(5,041)
Madaripur PBS						(4,279)	(2,118)	(1,044)
Barisal PBS						(4,186)	(2,572)	(4,035)
Noakhali PBS						(1,743)	(3,701)	(4,379)
Bagerhat Pally B						(4,012)	(3,516)	(5,658)
Joypurhat PBS						(2,265)	(2,158)	(2,677)
Pirojpur PBS						(2,230)	(2,761)	(3,839)
Rangpur PBS2						(3,776)	41	(2,779)
Jamalpur PBS1						(3,583)	(3,615)	(2,840)
Thakurgaon PBS						(1,775)	(2,579)	(2,773)
Chittagong PBS2						(2,224)	(3,598)	(4,769)
Bogra PBS						(2,321)	(1,730)	(544)
Meherpur Pally B						(764)	(3,390)	(4,040)
Chittagong PBS1						(936)	(639)	(4,373)
Narsingdi PBS						(1,559)	(2,539)	(2,419)

Table III.6

Operating Ratio (excluding Depreciation and Interest)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	0.91	0.89	0.74	0.73	0.75	0.66	0.68	
Tangail PBS-1	0.96	0.90	0.85	0.00	0.81	0.79	0.93	
Comilla PBS1	1.01	0.84	0.75	0.82	0.77	0.73	0.73	
Chandpur PBS	1.38	1.15	1.01	1.11	1.02	0.82	0.82	
Habiganj PBS	1.28	0.90	0.73	0.76	0.75	0.64	0.67	
Moulvibazar PBS	1.03	0.95	0.69	0.74	0.66	0.62	0.62	
Pabna PBS1	1.49	1.12	0.98	1.00	0.95	0.78	0.80	
Pabna PBS11	1.53	1.09	0.66	0.96	0.78	0.66	0.70	
Serajgonj PBS	1.19	1.11	0.87	0.89	0.87	0.75	0.74	
Jessore PBS1	1.10	1.05	0.88	1.11	0.90	0.72	0.70	
Jessore PBS II	1.14	1.06	0.75	0.75	0.82	0.78	0.76	
Natore PBS 1	1.07	1.09	0.80	0.84	0.82	0.74	0.74	
Natore PBS 2	1.26	0.97	0.79	0.83	0.80	0.70	0.72	
Rangpur PBS1			1.02	0.94	0.93	0.81	0.73	
Satkhira PBS			1.09	0.97	0.93	0.71	0.77	
Feni PBS			0.30	0.76	1.10	1.00	0.93	
Mymensingh PBS1			1.28	1.10	1.02	0.87	0.79	
Dinajpur PBS1				0.90	0.76	0.71	0.70	
Kushtia Bally B.dy				1.00	1.04	0.97	0.90	
Madaripur PBS					1.19	0.85	0.85	
Barisal PBS					1.44	1.02	1.01	
Noakhali PBS					3.11	1.48	1.10	
Bagerhat Pally B.d					1.84	1.14	1.02	
Joypurhat PBS					1.04	0.99	0.97	
Pirojpur PBS					2.51	1.72	1.45	
Rangpur PBS2					1.04	0.76	0.85	
Jamalpur PBS1					2.26	1.06	0.88	
Thakurgaon PBS					1.52	0.86	0.78	
Chittagong PBS2					2.27	1.39	1.37	
Bogra PBS					1.46	0.86	0.81	
Meherpur Pally B.d					2.09	1.26	1.00	
Chittagong PBS1						7.65	1.67	
Narsingdi PBS					3.07	1.33		

154

Table III.7
Surplus Before Depreciation and Interest
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	3,213	1,375	5,616	9,612	16,321	17,678	34,511	41,284
Tangail PBS-1	(780)	343	1,543	3,224		8,096	11,654	4,956
Comilla PBS1	719	(42)	2,066	5,467	5,193	8,920	15,314	19,128
Chandpur PBS	(155)	(634)	(756)	(64)	(1,129)	(302)	3,992	4,937
Habiganj PBS	5	(132)	416	3,841	5,083	6,118	13,090	13,598
Moulvibazar PBS	(360)	(66)	325	5,747	6,680	10,415	16,268	18,895
Pabna PBS1	(404)	(589)	(460)	103	(16)	616	3,837	4,627
Pabna PBSII	(163)	(475)	(266)	2,988	367	3,649	9,587	9,398
Serajgonj PBS	312	(1,110)	(1,088)	2,375	2,322	3,346	9,671	11,837
Jessore PBS1	(501)	(365)	(422)	1,541	(1,819)	2,004	9,238	13,097
Jessore PBS II	(426)	(423)	(332)	3,427	6,499	5,328	8,249	11,185
Natore PBS 1	(250)	(282)	(610)	2,334	2,703	3,865	8,171	10,793
Natore PBS 2	(301)	(805)	219	2,948	3,608	5,093	10,773	11,257
Rangpur PBS1			(151)	(40)	371	696	3,477	6,502
Satkhira PBS			(260)	(166)	167	652	4,445	4,567
Feni PBS			(257)	955	2,174	(936)	72	1,308
Mymensingh PBS1			(214)	(601)	(490)	(167)	1,757	4,806
Dinajpur PBS1			(201)	(497)	652	3,513	6,925	9,240
Kushtia Bally Bidyut Samity				(154)	(13)	(247)	240	1,206
Madaripur PBS						(818)	1,590	2,549
Barisal PBS						(976)	(134)	(60)
Noakhali PBS						(609)	(1,348)	(566)
Bagerhat Palli						(1,401)	(611)	(123)
Joypurhat PBS						(80)	88	325
Pirojpur PBS						(1,097)	(1,406)	(1,431)
Rangpur PBS2						(151)	2,476	2,014
Jamalpur PBS1						(1,303)	(321)	1,204
Thakurgaon PBS						(659)	727	2,162
Chittagong PBS2						(957)	(1,330)	(1,851)
Bogra PBS						(631)	1,287	3,713
Meherpur Pally Bidt.						(302)	(706)	(27)
Chittagong PBS1						(865)	(546)	(1,515)
Narsingdi PBS						(855)	(863)	30

Table III.8
Electricity Cost as % total O&M (Exclusive of Depreciation and Interest)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	72%	90%	91%	88%	87%	87%	89%	90%
Tangail PBS-1	54%	85%	89%	88%	0%	84%	85%	85%
Comilla PBS1	40%	75%	83%	86%	81%	81%	84%	84%
Chandpur PBS	12%	53%	73%	79%	69%	66%	71%	74%
Habiganj PBS	0%	20%	69%	81%	75%	79%	80%	80%
Moulvibazar PBS	18%	60%	72%	84%	80%	82%	83%	82%
Pabna PBS1	0%	59%	72%	73%	71%	72%	75%	79%
Pabna PBSII	0%	39%	65%	75%	64%	75%	81%	80%
Serajgonj PBS	39%	79%	83%	86%	80%	79%	82%	83%
Jessore PBS1	20%	70%	81%	83%	63%	72%	79%	80%
Jessore PBS II	24%	66%	72%	79%	79%	79%	82%	81%
Natore PBS 1	25%	72%	77%	79%	76%	77%	80%	81%
Natore PBS 2	8%	66%	71%	82%	79%	78%	79%	82%
Rangpur PBS1			29%	53%	64%	76%	80%	79%
Satkhira PBS			13%	46%	66%	62%	71%	76%
Feni PBS			29%	274%	65%	71%	72%	75%
Mymensingh PBS1			33%	66%	68%	68%	71%	75%
Dinajpur PBS1				38%	70%	77%	8%	7%
Kushtia Bally BS				19%	57%	65%	64%	69%
Madaripur PBS						55%	71%	74%
Barisal PBS						42%	55%	56%
Noakhali PBS						28%	48%	57%
Bagerhat Palli						38%	56%	58%
Joypurhat PBS						35%	63%	70%
Pirojpur PBS						30%	45%	45%
Rangpur PBS2						57%	70%	73%
Jamalpur PBS1						32%	58%	66%
Thakurgaon PBS						41%	55%	65%
Chittagong PBS2						41%	58%	57%
Bogra PBS						46%	69%	77%
Meherpur Pally Bi						25%	49%	64%
Chittagong PBS1						0%	13%	43%
Narsingdi PBS						22%	45%	60%

Table III.9
Total Utility Plant Assets
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	9,022	9,794	147,192	155,509	205,891	159,309	203,744	260,188
Tangail PBS-1	1,878	10,893	51,164	127,298	209,005	166,399	213,406	238,739
Comilla PBS1	2,196	14,373	66,582	171,197	240,099	146,537	227,691	228,149
Chandpur PBS	4,879	11,078	44,836	105,064	141,992	119,934	193,337	202,307
Habiganj PBS	1,090	1,238	30,550	11,519	138,659	166,382	105,309	108,921
Moulvibazar PBS	2,478	12,565	44,658	141,326	225,647	86,837	129,801	146,568
Pabna PBS1	1,173	4,147	60,890	100,735	109,928	72,026	100,831	124,881
Pabna PBSII	1,724	12,961	35,332	107,962	108,501	129,850	112,304	119,340
Serajgonj PBS	2,061	10,601	136,544	141,634	146,093	83,901	118,793	121,670
Jessore PBS1	1,555	7,965	74,845	153,711	200,939	82,349	214,610	206,039
Jessore PBS II	5,241	7,575	52,657	147,805	150,483	189,981	153,847	170,546
Natore PBS 1	12,907	16,265	79,754	135,119	151,304	146,496	148,894	169,252
Natore PBS 2	8,872	9,597	54,538	128,393	245,661	142,517	137,282	158,380
Rangpur PBS1			2,178	51,803	88,128	153,431	133,141	135,010
Satkhira PBS			2,924	70,034	113,813	131,580	126,022	135,993
Feni PBS			6,137	1,207	104,393	55,558	153,311	162,679
Mymensingh PBS1			6,425	48,477	81,200	122,181	164,466	289,853
Dinajpur PBS1			117	38,580	118,974	139,806	143,901	171,631
Kushtia Bally Bidyut Samity				8,346	71,937	126,220	111,116	133,341
Madaripur PBS						121,461	127,000	135,917
Barisal PBS						119,022	120,010	150,993
Noakhali PBS						17,177	102,582	147,733
Bagerhat Palli Bidt						95,809	144,072	166,016
Joypurhat PBS						95,972	76,543	112,660
Pirojpur PBS						67,020	66,001	94,926
Rangpur PBS2						184,894	144,319	175,942
Jamalpur PBS1						119,746	116,001	164,881
Thakurgaon PBS						94,213	139,735	181,996
Chittagong PBS2						77,880	77,961	93,908
Bogra PBS						118,374	119,143	172,796
Meherpur Pally Bidt.						64,574	83,214	170,221
Chittagong PBS1						1,699	10,289	142,075
Narsingdi PBS						9,722	68,431	89,796

Table III.10
Annual Depreciation
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	448	397	12,965	4,449	5,293	5,655	4,661	6,645
Tangail PBS-1	171	148	1,077	8,436	5,576	6,836	5,251	6,401
Comilla PBS1	391	604	8,472	7,111	6,027	7,121	2,740	6,418
Chandpur PBS	188	191	502	6,835	4,532	4,367	4,974	5,812
Habiganj PBS	13	20	580	4,928	3,846	4,562	3,166	3,069
Moulvibazar PBS	271	207	682	8,339	6,480	400	3,594	4,474
Pabna PBS1	89	118	2,422	2,967	3,576	3,335	3,505	3,896
Pabna PBSII	56	177	802	5,230	2,361	4,102	1,867	3,987
Serajgonj PBS	404	255	2,765	9,562	4,102	4,346	2,958	3,836
Jessore PBS1	27	184	2,133	10,124	5,374	5,904	3,166	5,144
Jessore PBS II	505	254	1,005	14,658	5,512	5,603	3,404	5,087
Natore PBS 1	801	474	1,846	7,637	1,493	4,632	3,161	4,168
Natore PBS 2	39	129	1,216	9,258	4,377	4,934	3,361	4,820
Rangpur PBS1				656	2,377	5,691	2,658	3,715
Satkhira PBS			32	1,808	3,267	3,804	3,827	3,301
Feni PBS			50	62,789	(58,708)	5,587	4,010	4,499
Mymensingh PBS1			72	1,266	1,676	3,621	4,382	6,209
Dinajpur PBS1				483	3,086	2,460	3,337	4,719
Kushtia Bally Bidyut Samity				48	1,655	3,098	2,195	3,723
Madaripur PBS						3,461	3,709	3,594
Barisal PBS						3,209	2,438	3,974
Noakhali PBS						1,133	2,352	3,812
Bagerhat Palli Bidt						2,611	2,904	5,534
Joypurhat PBS						2,184	2,246	3,002
Pirojpur PBS						1,132	1,375	2,407
Rangpur PBS2						3,624	2,434	4,794
Jamalpur PBS1						2,279	3,294	4,044
Thakurgaon PBS						1,115	3,306	4,936
Chittagong PBS2						1,266	2,268	2,918
Bogra PBS						1,690	2,988	4,257
Meherpur Pally Bidt.						461	2,684	4,013
Chittagong PBS1						71	87	2,857
Narsingdi PBS						704	1,676	2,450

Table III.11
Accum. Provision for Depreciation
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	448	845	13,811	18,261	23,555	29,210	33,871	40,517
Tangail PBS-1	171	319	1,397	9,833	15,409	22,246	27,498	33,900
Comilla PBS1	391	996	9,468	16,579	22,607	29,728	32,469	38,887
Chandpur PBS	188	379	882	7,717	12,250	16,617	21,592	27,405
Habiganj PBS	13	33	613	5,541	9,390	13,952	17,118	20,188
Moulvibazar PBS	271	478	1,160	9,500	15,981	16,381	19,975	24,450
Pabna PBS1	89	207	2,630	5,598	9,118	12,454	15,960	19,856
Pabna PBSII	56	233	1,036	6,266	8,626	12,729	14,596	18,584
Serajgonj PBS	434	659	3,424	12,987	17,089	21,435	24,394	28,230
Jessore PBS1	27	212	2,345	12,470	17,844	23,748	26,915	32,059
Jessore PBS II	505	759	1,765	16,373	21,686	27,490	30,894	[illegible]
Natore PBS 1	801	1,275	3,122	10,759	12,253	16,856	23,018	24,[illegible]
Natore PBS 2	39	168	1,384	10,643	15,021	19,955	23,316	28,137
Rangpur PBS1				656	3,034	8,726	11,384	15,099
Satkhira PBS			32	1,840	5,106	8,912	12,740	16,042
Feni PBS			50	62,839	4,131	9,718	13,728	18,228
Mymensingh PBS1			72	1,338	3,015	6,037	10,419	16,628
Dinajpur PBS1				484	3,570	6,030	9,368	14,087
Kushtia Bally Bidyut Samity				48	1,703	4,801	6,996	10,720
Madaripur PBS						3,461	7,171	10,765
Barisal PBS						3,209	5,648	9,622
Noakhali PBS						1,133	3,486	7,298
Bagerhat Palli Bidt.						2,611	5,516	11,050
Joypurhat PBS						2,184	4,431	7,433
Pirojpur PBS						1,132	2,508	4,916
Rangpur PBS2						3,624	6,059	10,853
Jamalpur PBS1						2,279	5,573	9,617
Thakurgaon PBS						1,115	4,422	9,358
Chittagong PBS2						1,266	3,534	6,453
Bogra PBS						1,690	4,678	8,936
Meherpur Pally Bidt.						461	3,146	7,159
Chittagong PBS1						71	158	3,016
Narsingdi PBS						704	2,380	4,830

Table III.12
Turnover/Assets (exclusive of depreciation)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	0.72	1.61	0.19	0.24	0.29	0.45	0.50	0.49
Tangail PBS-1	0.21	0.86	0.30	0.17	0.00	0.25	0.26	0.28
Comilla PBS1	1.03	0.40	0.19	0.13	0.12	0.26	0.25	0.31
Chandpur PBS	0.04	0.15	0.11	0.08	0.07	0.12	0.11	0.13
Habiganj PBS	0.01	0.38	0.14	1.24	0.15	0.15	0.35	0.38
Moulvibazar PBS	0.21	0.21	0.15	0.13	0.11	0.36	0.33	0.34
Pabna PBS1	0.00	0.29	0.05	0.06	0.08	0.17	0.17	0.18
Pabna PBSII	0.06	0.07	0.08	0.08	0.09	0.13	0.25	0.26
Serajgonj PBS	0.83	0.54	0.07	0.13	0.15	0.31	0.32	0.37
Jessore PBS1	0.32	0.46	0.10	0.08	0.08	0.25	0.16	0.21
Jessore PBS II	0.17	0.39	0.11	0.09	0.17	0.16	0.25	0.27
Natore PBS 1	0.07	0.26	0.08	0.09	0.11	0.14	0.21	0.24
Natore PBS 2	0.01	0.32	0.11	0.11	0.09	0.18	0.26	0.26
Rangpur PBS1			0.02	0.04	0.07	0.07	0.14	0.18
Satkhira PBS			0.04	0.03	0.05	0.07	0.12	0.15
Feni PBS			0.02	1.13	0.09	0.17	0.10	0.12
Mymensingh PBS.			0.01	0.04	0.06	0.06	0.08	0.08
Dinajpur PBS1			0.01	0.01	0.05	0.10	0.17	0.18
Kushtia Bally Bidyamity				0.01	0.05	0.05	0.09	0.09
Madaripur PBS						0.03	0.09	0.12
Barisal PBS						0.02	0.05	0.05
Noakhali PBS						0.02	0.03	0.04
Bagerhat Palli Bid						0.02	0.03	0.04
Joypurhat PBS						0.02	0.09	0.09
Pirojpur PBS						0.01	0.03	0.03
Rangpur PBS2						0.02	0.07	0.08
Jamalpur PBS1						0.01	0.04	0.06
Thakurgaon PBS						0.01	0.04	0.05
Chittagong PBS2						0.01	0.04	0.05
Bogra PBS						0.01	0.08	0.11
Meherpur Pally Bid						0.00	0.03	0.04
Chittagong PBS1						0.00	0.01	0.02
Narsingdi PBS						0.04	0.04	0.07

156

Table III.13
Total Long Term Debt
(000's Taka)

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	25,848	23,113	173,589	181,718	207,869	186,954	272,856	256,596
Tangail PBS-1	2,655	13,723	51,766	127,417	210,997	172,376	215,095	242,527
Comilla PBS1	3,712	13,874	12,236	178,273	242,988	150,297	252,280	265,347
Chandpur PBS	3,927	11,571	45,146	103,814	141,770	133,022	213,267	195,949
Habiganj PBS	1,155	1,700	30,917	116,365	140,107	191,633	121,681	134,747
Moulvibazar PBS	3,006	13,668	45,659	142,285	226,369	96,238	134,972	132,102
Pabna PBS1	1,808	4,223	84,584	103,767	108,812	103,750	130,044	114,763
Pabna PBSII	2,080	10,850	36,571	109,591	110,104	166,711	115,110	110,224
Serajgonj PBS	2,603	11,280	140,117	144,279	150,285	122,779	147,156	146,245
Jessore PBS1	2,112	8,511	80,230	158,126	203,079	110,842	218,122	183,529
Jessore PBS II	3,402	8,668	54,137	149,676	155,059	220,888	167,834	178,883
Natore PBS 1	13,177	624	80,419	134,539	150,498	173,869	176,745	154,224
Natore PBS 2	1,998	467	5522	129,825	146,[illegible]	182,121	171,906	183,206
Rangpur PBS1			241	50,450	90,380	168,541	135,716	142,216
Satkhira PBS			3,367	72,223	116,731	148,655	135,341	140,840
Feni PBS			6,462	1,351	109,127	71,674	101,080	171,125
Mymensingh PBS1			6,708	49,842	83,520	128,039	167,222	284,440
Dinajpur PBS1			362	39,433	120,539	156,942	152,648	179,382
Kushtia Bally Bidyut Samity				8,785	72,618	142,903	120,374	142,979
Madaripur PBS						13,524	144,207	137,693
Barisal PBS						134,170	136,999	165,176
Noakhali PBS						22,834	103,787	148,970
Bagerhat Palli Bidt						108,395	159,466	183,304
Joypurhat PBS						103,603	81,038	116,175
Pirojpur PBS						75,676	72,184	103,369
Rangpur PBS2						197,289	159,509	179,877
Jamalpur PBS1						125,844	119,307	167,745
Thakurgaon PBS						99,650	151,351	185,292
Chittagong PBS2						84,662	90,746	96,830
Bogra PBS						126,504	131,888	185,357
Meherpur Pally Bidt						67,879	94,082	173,395
Chittagong PBS1						8,598	20,559	154,300
3Narsingdi PBS						16,379	77,731	97,658

Table III.14
Interest on Long Term Debt

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	1.0	26.0	5.2	37.7	2,079	6,000	6,000	9,141
Tangail PBS-1	10.6	6.2	11.4	18.7		6,598	6,098	
Comilla PBS1	3.8	1.6	5.6		5,866	7,300	6,300	7,754
Chandpur PBS			502.2			4,490	6,357	6,388
Habiganj PBS			2.4	30.6		3,675	3,726	4,200
Moulvibazar PBS			5.0			3,800	3,772	4,074
Pabna PBS1			12.2	12.3		5,867	3,600	3,916
Pabna PBSII	14.5		10.0	10.5		3,740	4,000	3,800
Serajgonj PBS			1.0		1,115	4,300	4,750	4,800
Jessore PBS1		2.5	2.0			8,183	6,224	6,150
Jessore PBS II			10.5	51.1		5,333	5,010	5,107
Natore PBS 1	1.0	4.5	2.3	2.5		3,861	4,841	5,261
Natore PBS 2		67.9	7.0	33.7	63	4,492	5,223	5,454
Rangpur PBS1								5,907
Satkhira PBS				14.3			1,100	4,102
Feni PBS							1,100	4,865
Mymensingh PBS1				10.7				5,352
Dinajpur PBS1								3,186
Kushtia B.B.S								2,524
Madaripur PBS								
Barisal PBS								
Noakhali PBS								
Bagerhat Palli Bidt								
Joypurhat PBS								
Pirojpur PBS								
Rangpur PBS2								
Jamalpur PBS1								
Thakurgaon PBS								
Chittagong PBS2								
Bogra PBS								
Meherpur Pally Bidt								
Chittagong PBS1								
Narsingdi PBS								

157

Table III.15

Positive Surplus (Before Depreciation and Interest)/Long Term Debt

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	0.12	0.06	0.03	0.05	0.08	0.09	0.13	0.16
Tangail PBS-1		0.03	0.03	0.03		0.05	0.05	0.02
Comilla PBS1	0.19		0.17	0.03	0.02	0.06	0.06	0.07
Chandpur PBS							0.02	0.03
Habiganj PBS			0.01	0.03	0.04	0.03	0.11	0.10
Moulvibazar PBS			0.01	0.04	0.03	0.11	0.12	0.14
Pabna PBS1						0.01	0.03	0.04
Pabna PBSII				0.03		0.02	0.08	0.09
Serajgonj PBS	0.12			0.02	0.02	0.03	0.07	0.08
Jessore PBS1				0.01		0.02	0.04	0.07
Jessore PBS II				0.02	0.04	0.02	0.05	0.06
Natore PBS 1				0.02	0.02	0.02	0.05	0.07
Natore PBS 2				0.02	0.02	0.03	0.06	0.06
Rangpur PBS1							0.03	0.05
Satkhira PBS							0.03	0.03
Feni PBS					0.02			0.01
Mymensingh PBS1							0.01	0.02
Dinajpur PBS1					0.01	0.02	0.05	0.05
Kushtia Bally B.								0.01
Madaripur PBS							0.01	0.02
Barisal PBS								
Noakhali PBS								
Bagerhat Palli B								
Joypurhat PBS								
Pirojpur PBS								
Rangpur PBS2							0.02	0.01
Jamalpur PBS1								0.01
Thakurgaon PBS								0.01
Chittagong PBS2								
Bogra PBS							0.01	0.02
Meherpur Pally B								
Chittagong PBS1								
Narsingdi PBS								

Table III.16
Total Miles Constructed

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1		478	6961	36	50	39	163	36
Tangail PBS-1	82	140	37	3	10	23	341	190
Comilla PBS1	147	73	11	13	168	14	25	172
Chandpur PBS	80	162	107	0	81	100	75	102
Habiganj PBS	23	72	0	0	0	28	17	92
Moulvibazar PBS	0	125	0	0	79	9	81	102
Pabna PBS1	0	146	124	0	0	50	51	88
Pabna PBSII	81	54	7	4	0	2	8	44
Serajgonj PBS	306	287	103	0	0	7,808	10	12
Jessore PBS1	166	203	221	0	0	0	5	96
Jessore PBS II	411	421	3	0	0	0	0	6
Natore PBS 1	0	145	26	0	39	13	38	114
Natore PBS 2	166	327	138	0	0	7	0	128
Rangpur PBS1			75	0	341	44	81	172
Satkhira PBS			145	2	61	50	51	147
Feni PBS			105	0	0	65	47	149
Mymensingh PBS1			71		0	51	142	701
Dinajpur PBS1			0	0	1	168	155	145
Kushtia B.B.S.				0	0	90	90	194
Madaripur PBS						130	175	103
Barisal PBS						154	202	178
Noakhali PBS						0	114	160
Bagerhat						113	151	163
Joypurhat PBS						94	89	162
Pirojpur PBS						61	66	151
Rangpur PBS2						391	199	167
Jamalpur PBS1						138	154	222
Thakurgaon PBS						572	403	166
Chittagong PBS2						0	64	151
Bogra PBS						299	0	226
Meherpur Pally Bid						223	269	174
Chittagong PBS1						0	507	202
Narsingdi PBS						155	109	75

Table III.17
Total Miles PDB Taken Over

	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1				19.0	4.7
Tangail PBS-1		10.0		88.7	
Comilla PBS1		21.0			57.0
Chandpur PBS		13.1			
Habiganj PBS					
Moulvibazar PBS					
Pabna PBS1					
Pabna PBSII	10.7				
Serajgonj PBS					
Jessore PBS1					
Jessore PBS II					
Natore PBS 1		5.4			
Natore PBS 2			5.1		
Rangpur PBS1		53.2	27.0	33.8	
Satkhira PBS		10.0			
Feni PBS			32.0		
Mymensingh PBS1			7.4		
Dinajpur PBS1			192.6	14.7	3.9
Kushtia Bally B.S.			28.0	0.3	
Madaripur PBS			19.2		5.9
Barisal PBS			25.0		
Noakhali PBS					
Bagerhat Palli Bidt.			45.8	79.2	
Joypurhat PBS			1.7	11.1	1.3
Pirojpur PBS			12.7	43.6	4.5
Rangpur PBS2					87.6
Jamalpur PBS1					
Thakurgaon PBS			67.5	2.5	34.0
Chittagong PBS2					
Bogra PBS					
Meherpur Pally Bidt.			9.1	10.7	6.8
Chittagong PBS1					
Narsingdi PBS				0.2	8.1

54

Table III.18
Total Lines Energized

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	3,247	3,725	4,264	4,300	4,350	4,389	4,552	4,588
Tangail PBS-1	82	221	417	494	504	527	682	807
Comilla PBS1	147	220	310	419	557	568	592	719
Chandpur PBS	80	242	348	769	785	840	901	1,017
Habiganj PBS	23	95	238	394	440	477	500	546
Moulvibazar PBS	0	125	125	583	583	613	677	703
Pabna PBS1	0	146	270	335	341	363	438	493
Pabna PBSII	81	135	261	302	302	304	312	356
Serajgonj PBS	306	593	696	700	700	701	710	722
Jessore PBS1	166	369	537	1,200	1,285	1,285	1,285	1,385
Jessore PBS II	399	780	782	834	834	834	834	840
Natore PBS 1	280	425	451	480	519	532	570	684
Natore PBS 2	166	493	631	757	792	834	834	936
Rangpur PBS1			75	152	272	353	372	376
Satkhira PBS			145	314	385	435	479	556
Feni PBS			105	200	354	436	444	475
Mymensingh PBS1			71	220	434	493	680	1 306
Dinajpur PBS1				156	232	445	516	631
Kushtia Bally B: Samity				9	80	80	145	242
Madaripur PBS						97	247	376
Barisal PBS						99	276	417
Noakhali PBS						257	431	675
Bagerhat Palli B						79	238	361
Joypurhat PBS						130	171	338
Pirojpur PBS						107	161	311
Rangpur PBS2						354	528	691
Jamalpur PBS1						208	256	487
Thakurgaon PBS						188	547	831
Chittagong PBS2						137	229	246
Bogra PBS						247	393	605
Meherpur Pally B						120	416	719
Chittagong PBS1							175	494
Narsingdi PBS						155	264	347

Table III.19
PDB Lines as Percent of Lines Energized

	FY86	FY87	FY88	FY89
Dhaka PBS1	0%	0%	0%	1%
Tangail PBS-1	2%	2%	14%	12%
Comilla PBS1	4%	4%	4%	11%
Chandpur PBS	2%	2%	1%	1%
Habiganj PBS				
Moulvibazar PBS				
Pabna PBS1				
Pabna PBSII	4%	4%	3%	3%
Serajgonj PBS				
Jessore PBS1				
Jessore PBS II				
Natore PBS 1	.%	1%	1%	1%
Natore PBS 2		1%	1%	1%
Rangpur PBS1	20%	23%	31%	30%
Satkhira PBS	3%	2%	2%	2%
Feni PBS		7%	7%	7%
Mymensingh PBS1		2%	1%	1%
Dinajpur PBS1		43%	40%	33%
Kushtia Bally B:		35%	20%	12%
Madaripur PBS		20%	8%	7%
Barisal PBS		25%	9%	6%
Noakhali PBS				
Bagerhat Palli B		58%	52%	35%
Joypurhat PBS		1%	7%	4%
Pirojpur PBS		12%	35%	20%
Rangpur PBS2		0%	0%	13%
Jamalpur PBS1		0%	0%	0%
Thakurgaon PBS		36%	13%	13%
Chittagong PBS2				
Bogra PBS				
Meherpur Pally B		8%	5%	4%
Chittagong PBS1				
Narsingdi PBS				2%

160

Table III.20
Revenues per Mile Energized

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	1,989	4,225	6,455	8,759	13,755	16,253	22,224	27,740
Tangail PBS-1	4,727	42,180	36,393	42,857	0	79,190	80,229	83,718
Comilla PBS1	15,412	25,814	41,180	51,450	50,775	67,610	94,453	96,90[illegible]
Chandpur PBS	2,515	6,851	14,319	10,685	13,168	17,096	24,182	26,559
Habiganj PBS	239	4,971	17,839	36,242	47,518	51,281	73,171	76,095
Moulvibazar PBS		21,266	52,327	31,538	43,267	50,677	63,663	70,498
Pabna PBS1		8,308	13,886	19,462	27,084	32,971	39,915	45,818
Pabna PBSII	1,191	6,644	11,284	29,394	31,618	55,619	90,609	87,701
Serajgonj PBS	5,613	9,733	14,429	25,572	30,451	37,324	53,589	62,852
Jessore PBS1	3,091	9,867	14,568	10,622	13,274	16,054	25,919	31,091
Jessore PBS II	2,553	3,813	7,407	16,350	30,938	35,359	45,937	54,445
Natore PBS 1	3,336	9,841	14,818	24,822	32,796	39,782	54,356	60,316
Natore PBS 2	764	6,169	9,929	18,889	27,540	30,748	42,772	43,640
Rangpur PBS1			651	13,251	24,137	30,275	49,246	64,659
Satkhira PBS			714	6,131	14,505	20,566	32,112	35,745
Feni PBS			1,117	6,821	25,176	21,631	33,978	40,061
Mymensingh PBS1			1,139	9,740	11,322	15,203	20,029	17,214
Dinajpur PBS1				1,695	27,656	32,956	46,304	48,765
Kushtia Bally B.S				7,032	47,152	76,556	65,824	50,886
Madaripur PBS						43,231	44,443	44,325
Barisal PBS						22,535	20,563	17,798
Noakhali PBS						1,123	6,456	8,392
Bagerhat Palli						21,110	18,963	17,882
Joypurhat PBS						17,185	39,190	29,225
Pirojpur PBS						6,767	12,170	10,321
Rangpur PBS2						10,518	19,497	19,485
Jamalpur PBS1						4,995	20,107	20,856
Thakurgaon PBS						6,732	9,432	11,639
Chittagong PBS2						5,521	14,859	20,083
Bogra PBS						5,529	23,830	31,940
Meherpur Pally B						2,308	6,562	8,812
Chittagong PBS1							471	4,580
Narsingdi PBS						2,672	9,969	18,316

Table III.21
O&M (exclusive of energy)/Miles Energized

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89
Dhaka PBS1	278	382	459	807	1,331	1,619	1,603	1,946
Tangail PBS-1	6,566	5,900	3,675	4,229	0	9,979	9,220	12,012
Comilla PBS1	6,287	6,509	6,008	5,487	7,737	10,099	11,284	11,502
Chandpur PBS	3,932	4,478	4,501	2,290	4,472	5,982	5,706	5,696
Habiganj PBS	0	5,102	4,924	4,971	8,844	8,082	9,442	10,008
Moulvibazar PBS		8,630	14,015	3,521	6,215	6,085	6,845	7,634
Pabna PBS1		5,059	4,315	5,242	7,920	8,768	7,654	7,651
Pabna PBSII	3,207	6,172	4,280	4,815	10,829	10,817	11,122	12,558
Serajgonj PBS	2,777	2,450	2,682	3,043	5,520	6,703	7,103	7,699
Jessore PBS1	4,904	3,206	2,912	1,586	5,378	4,079	3,845	4,421
Jessore PBS II	2,831	1,485	2,221	2,618	4,754	6,025	6,620	7,724
Natore PBS 1	3,183	2,897	3,759	4,143	6,606	7,596	8,035	8,660
Natore PBS 2	2,370	2,671	2,826	2,708	4,928	5,480	6,340	5,836
Rangpur PBS1			1,899	6,381	8,093	6,691	7,922	10,179
Satkhira PBS			2,192	3,603	4,755	7,196	6,649	6,495
Feni PBS			2,535	(3,540)	6,687	6,910	9,453	9,429
Mymensingh PBS1			2,772	4,303	4,038	4,925	4,973	3,328
Dinajpur PBS1				3,022	7,540	5,767	30,227	31,569
Kushtia Baily Bidyut Samity				20,140	20,379	27,986	23,313	14,004
Madaripur PBS						23,484	10,842	9,787
Barisal PBS						18,670	9,471	7,852
Noakhali PBS						2,516	4,997	3,973
Bagerhat Palli Bidt.						24,259	9,575	7,668
Joypurhat PBS						11,523	14,311	8,527
Pirojpur PBS						11,887	11,467	8,278
Rangpur PBS2						4,702	4,384	4,554
Jamalpur PBS1						7,685	8,897	6,196
Thakurgaon PBS						6,046	3,611	3,193
Chittagong PBS2						7,354	8,668	11,859
Bogra PBS						4,403	6,366	5,842
Meherpur Pally Bidt.						3,642	4,212	3,200
Chittagong PBS1							3,125	4,390
Narsingdi PBS						6,375	7,273	7,332

Annex IV

CHOICE OF TECHNOLOGY FOR SHAFT POWER

Choice of Technology for Shaft Power

The principal choice of a source of shaft power for industrial applications is between electric motors and diesel engines. This choice has a significant impacts on both the financial viability and the economic benefits derived from rural electrification. The primary factors affecting this decision where there are reliable sources of both diesel[1] and electricity are:

1. the initial cost,
2. the operating and maintenance costs,
3. the power transmission system between engine/motor and final use,
4. ease of operation and maintenance,

The initial cost includes the cost for the engine/motor and for installation. In the case of electric motors in new applications, this cost may include the cost for connection to the power lines. Since this is a large one-time cost, it can have a significant effect on the selection process. However, with the current market prices, the electric motors tend to be less expensive than the diesel engines as determined in the market survey discussed in Annex IX. When the connection and wiring charge is added, the initial capital costs are expected to be comparable or to favor the electric motor.

The operating and maintenance costs include the costs for energy, labor for maintenance and operation and spare parts for repairs. These costs are typically computed together with the capital costs as part of a life cycle cost. This cost is important only for those who have sufficient funds to choose between the two options. The cost will also vary with the expected life of the engine/motor. The electric motor has a much longer life and is frequently purchased as a second-hand unit. The diesel engine has a shorter life but this can be extended through proper maintenance and there are some second-hand sales.

The energy costs for the electric motor are currently slightly lower than for diesel engines. The costs for an operator are not thought to differ significantly for the two sources of shaft power, however, the operator of the diesel would need slightly higher skills to perform intermittent repairs. The costs for

1. This discussion focuses on the use of diesel engines. The same analysis is required for gasoline-powered engines and natural gas-powered engines. However, neither are currently used and the data for this analysis was collected from existing applications and experiences.

maintenance including spare parts and labor will be higher for a diesel engine than for an electric motor because of the more difficult operating environment of an internal combustion engine and therefore the more frequent and more difficult repairs.

The most commonly used transmission systems are belt drives. Since AC motors are the most common form of electric motor, there is no variability in speed except through the use of different drive wheels and multiple belts. For diesel engines there is greater variability of speed, however the engines have difficulties in providing power at lower speeds and a belt or gear based transmission system is required. Also the diesel engine has less ability to handle variable loads such as are experienced in sawmills and grinding and drilling equipment. In general, the electric motor has better operating characteristics especially since small units can be used to power individual pieces of equipment, whereas diesel engines are more economical when used in larger configurations with belts used to drive more than multiple pieces of equipment.

The ease of operation and maintenance is a very important consideration in the process of selecting between engines and motors. The most important factor appears to be the ease of maintenance, since skilled mechanics are located in central areas and must travel to the site to perform repairs. This increases the costs for maintenance and the time that the equipment is down. There does not appear to be any significant difference in ease of operation between the diesel engines and the electric motor.

At present there is a clear preference for the use of electric motors over diesel engines in almost all applications where electricity is available. The only exception is the use of diesel engines for irrigation where multiple uses are made of the engine (see Annex VII). The basis for this preference is primarily the lower financial cost. In order to understand the magnitude of this difference, a comparison was made between a 25 bhp diesel engine and a 25 bhp electric motor. This size is commonly found in rural industries (see Annex X). The results are summarized in Tables IV.1 and IV.2. A number of assumptions were made in preparing this comparison. These are summarized in Table IV.3. The average cost per operating hour is only Tk. 62.5 for an electric engine almost 20% less than for the diesel engine. The major source of this savings is the lower energy cost. The predominance of the energy cost in the total operating costs is applies to both engines and motors as shown graphically in Figures IV.1 and IV.2,

Clearly, the results of this comparison are extremely sensitive to the cost of fuel. The variation of costs per horsepower hour with the fuel price are shown in

Figure IV.3. A 50% increase in the cost of diesel or electricity would introduce about a 1/3 increase in the cost of per horsepower hour.

The comparison has also been extended to include the economic costs for the engine and motor. The economic costs were computed by adjusting the capital costs to exclude duties and taxes[2], by shadow pricing the labor and by adjusting the diesel price to the border price plus local transport and the electricity price to the long run marginal cost of generation. The economic price for diesel was estimated to be the same as the financial cost but the economic price for electricity as originally estimated in the BPDB Tariff study is twice the financial price.

The engine/motor is assumed have relatively low utilization with only 2000 operating hours per month and an average load of only 35%. This is consistent with small-scale intermittent operations commonly found in small-scale rural industries. For small sawmills, the power utilization during operations was observed to be less than 20% and the operating hours are less since they vary with season and supply of raw material. For larger operations such as textile mills, the operating hours would be longer and the average engine load would be closer to 45%-60%.
The capital costs of the engine have relatively little impact on the total cost for shaft power. This is true whether the price of the engines and motors is adjusted by $\pm$ 40% as shown in Figure IV.4 or whether the discount rate used to annualize the cost is adjusted as shown in Figure IV.5. In either case, the change in cost per horsepower is imperceptible.

Labor costs are more important in their effect on the cost per horsepower hour, however, the labor costs for engines and motors are assumed to be the same. Both require a full-time operator. The cost of the operator will depend on the type of equipment which is being driven by the engine/motor. The only labor cost which will vary is the cost for maintenance which is considerably higher for diesel engines. However, this does not appear to be a significant factor as shown in Figure IV.7. A 50% increase in labor costs increases the cost per horsepower-hour by only about 1/6 and this is true for both engines and motors.

Because most of the costs for the engine and the motor are variable, i.e. labor, energy and spare parts, there is little variation in the cost per horsepower-hour with the level of utilization. A doubling in the number of hours operated would only reduce the cost by about 3% for diesels and even less for electric motors.

---

2. At present the motors and engines being imported for irrigation are exempt from import duties, however, these values have been included in the current analysis.

Clearly, for utilization of less than 500 hours per year, the impacts would be significant. The absence of significant economies with greater utilization suggest that the expected trend towards multiple uses of engines will only be significant where the level of use in each application is relatively limited.

The power utilization will have a significant effect on the costs for shaft power because the efficiency of the engine and motor declines as the power utilization rises above or falls below the operating norm. The relationship between load and efficiency was approximated using a performance curve from a locally used diesel engine of similar size. This curve assumes a maximum efficiency at 80% load as shown in Table IV.3, but there is a significant drop off as the load approaches 100% or when the load falls below 40%. The impact of this under-utilization or over-loading of the engine/motor is significant as shown in Figure IV.9. Given the initial assumptions of a similar performance curve, the impact is the same for the engine and the motor. It is thought that the electric motor should be less sensitive to variation in load than diesel engines, but the variation in cost with power utilization will still be significant.

DIESEL ENGINE MODEL

BELT DRIVE - 25 HP

	Financial	Economic	
Capital Cost	32,000	25,600	1000's Taka
Cost for Overhaul	6,000	5,400	1000's Taka
Period Between Overhauls	5	5	Years
Cost for Regular Maintenance	5,600	5,280	Taka per year
Cost For Mechanic	500	500	Per hour or visit
Mechanics Time Required	8	8	Hours/Visits per Year
Cost for Parts	1,600	1,280	Per Year
Fuel Consumption at 80% Load	4.50	4.50	Liters per hour
Lubricant Consumption	25.0	25.0	Liters/1000 liters
Cost of Fuel	7.8	7.8	Taka per liter
Cost of Lubricant	25.9	25.9	Taka per liter
Hours Operated	2,000	2,000	Per Year
Operators Required	1.0	1.0	Mn-hrs/operating hr
Average Load	35%	35%	%
Annualized Capital Cost	4,144	4,166	
Costs Per Hour of Operation			
Capital	2.07	2.08	
Operator	15.00	15.00	
Maintenance	3.40	3.18	
Fuel and Lubes	54.31	54.31	
Total	74.78	74.57	
Cost Per HP output	8.55	8.52	
Annual Cost	149,555	149,137	

ELECTRIC MOTOR MODEL

BELT DRIVE 25 HP

	Financial	Economic	
Capital Cost	12,500	10,000	1000's Taka
Cost for Overhaul	3,250	2,925	1000's Taka
Cost for Regular Maintenance	1,313	1,250	Taka per year
Cost For Mechanic	500	500	Per hour/visit
Mechanics Time Required	2.0	2.0	Annual Hours/Visits
Cost for Parts	313	250	Per Year
Fuel Consumption at 80% Load	16.58	16.58	kWhr per hour
Cost of Electricity	2.0	2.9	Taka per kWhr
Hours Operated	2,000	2,000	Per Year
Average Load	35%	35%	%
Salvage Value	20%	20%	
Annualized Capital Cost	927	1,140	
Costs Per Hour of Operation			
Capital	0.46	0.57	
Operator	15.00	15.00	
Maintenance	0.86	0.81	
Electricity	46.18	69.24	
Total	62.50	85.61	
Cost Per HP output	7.14	9.78	
Annual Cost	125,008	171,229	
Discount Rate	5.0%	10.0%	

CONVERSION FACTORS

Assumptions

1. diesel fuel consumption based on .225 liters per horsepower hour used
2. electricity consumption based on .746 kWhr per Hp-hour adjusted by motor efficiency of .9
3. diesel financial fuel price assumed to be Tk. 7.8 per liter and electricity price Tk 2 per kWhr.
4. economic price assumed to be same for diesel but Tk 4 per kWhr.
5. energy consumption adjusted for average load and energy efficiency at that load
6. a paid operator is used for all motors, the cost for the operator is Tk 15 per hour of operation
7. maintenance required every 250 operating hours for a diesel engine versus 1000 hours for an electric motor
8. major engine overhaul required every 5 years for a diesel engine versus 8 years hours for an electric motor
9. salvage value and economic life are both higher for an electric motor, 20 years and 20%, respectively, than for a diesel engine with 10 years and 10%, respectively
10. capital cost amortized over the life of the motor/engine at the real interest rate

Standard Conversion Factors

Skilled Labor	1.00	
Semi-skilled Labor	1.11	
Unskilled Labor	1.33	
Imported Equipment, Parts	0.80	
Electricity	0.67	
Real Discount Rate	5.0%	financial (formal source of credit)
	10.0%	economic (social discount rate)

Engine/Motor Efficiency Conversion Table

Load	Efficiency Factor
0.30	0.70
0.40	0.80
0.50	0.91
0.60	0.94
0.65	0.95
0.70	0.96
0.75	0.97
0.80	1.00
0.85	0.96
0.9	0.88

Figure IV.1

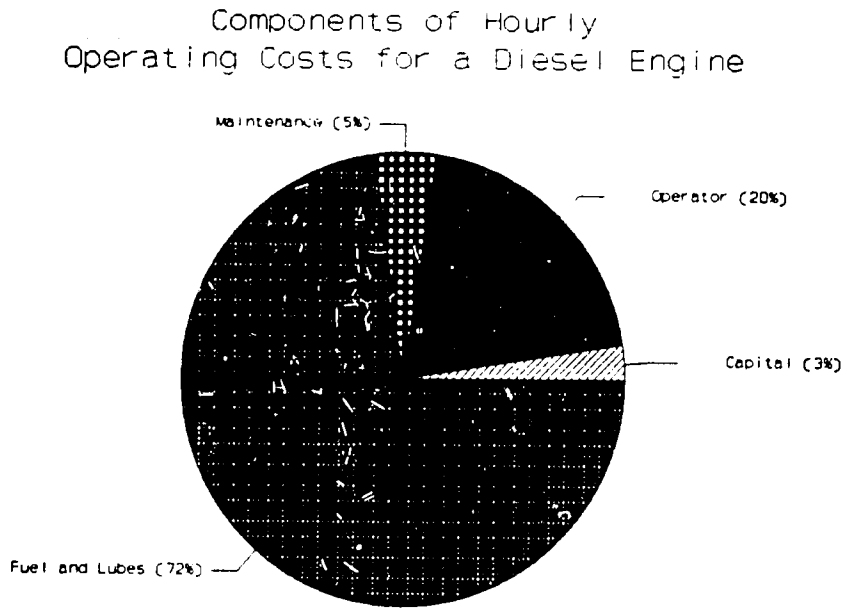


Figure IV.2

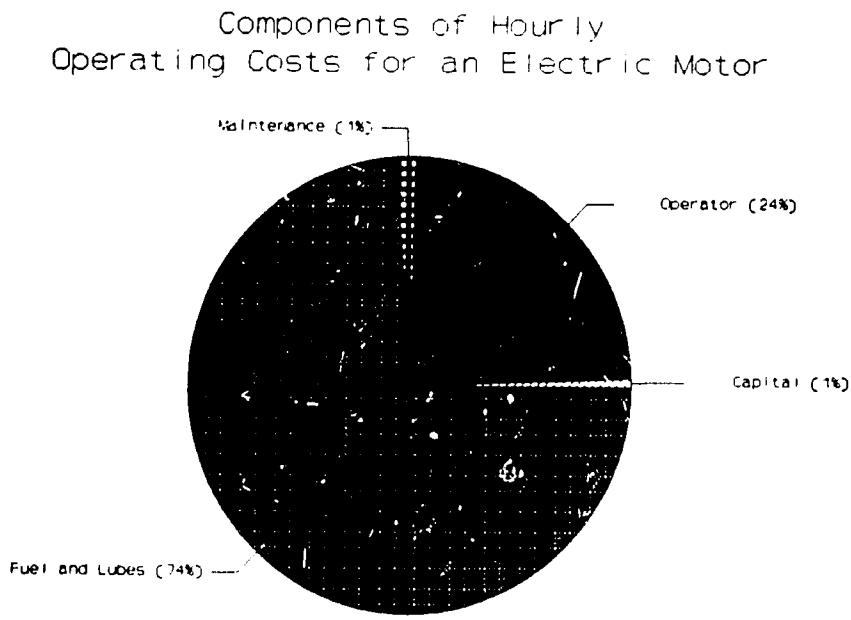


Figure IV.3

Senstivity of Operating Costs to

Change in Fuel Prices

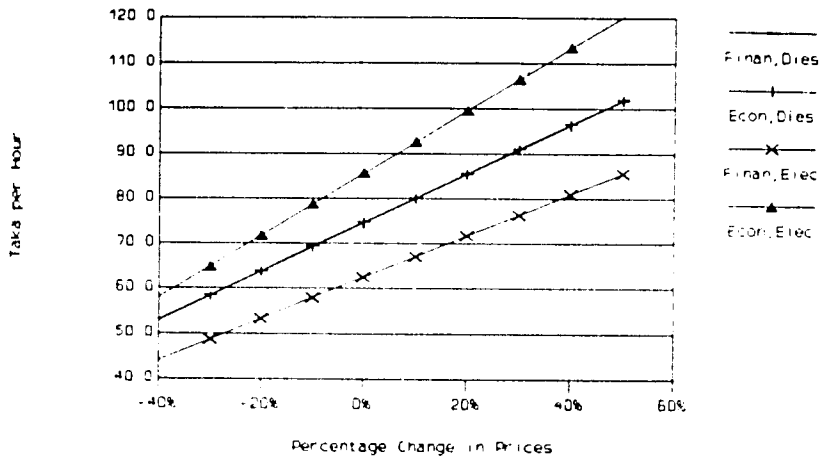


Figure IV.4

Senstivity of Operating Costs to

Change in Prices of Equipment and Parts

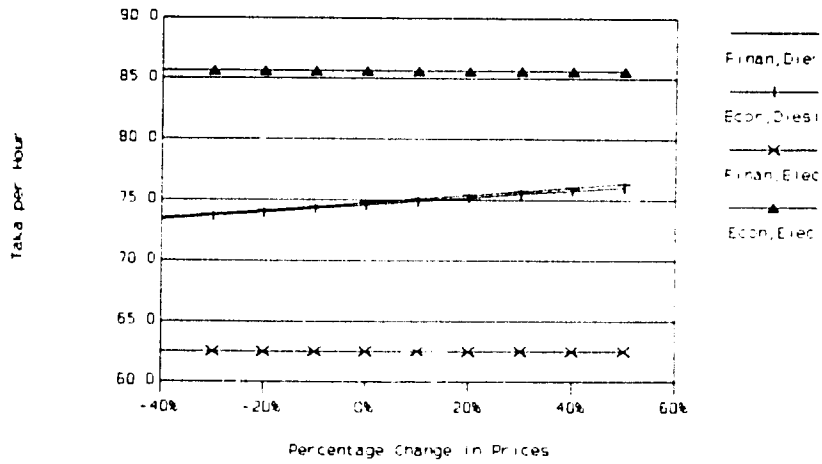


Figure IV.5

Senstivity of Financial Operating Cost

Per Hour to Change in Discount Rate

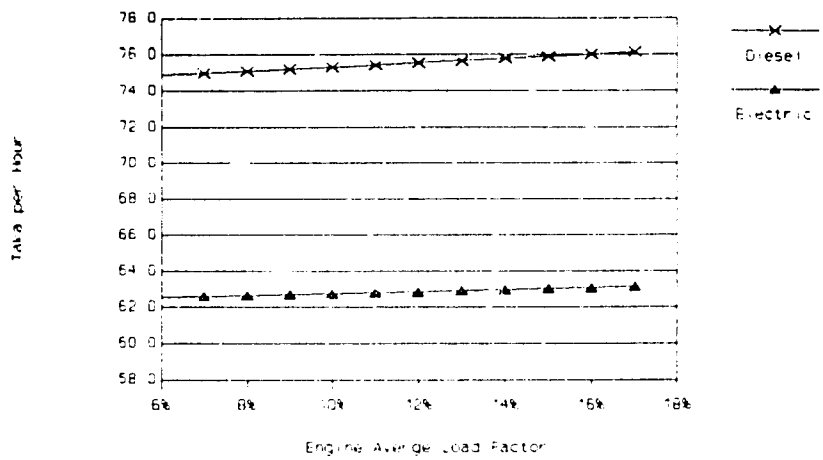


Figure IV.6

Sensitivity of Economic Operating Costs

Per Hour to Change in Discount Rate

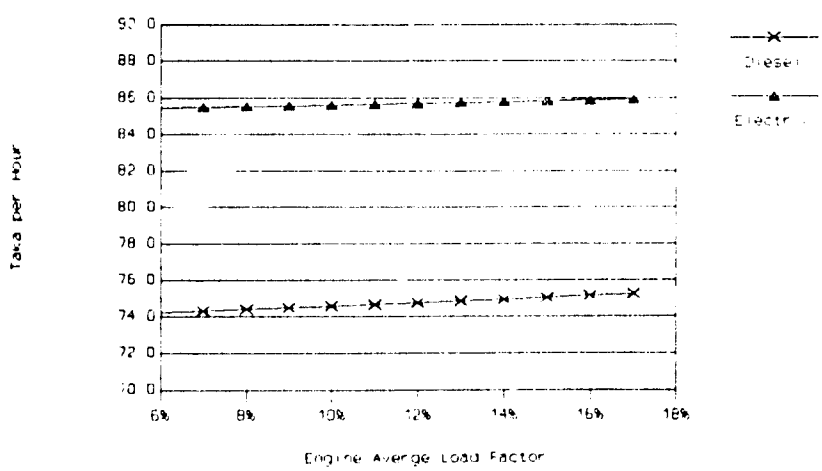


Figure IV.7

Senstivity of Operating Costs to

Change in Labor Prices

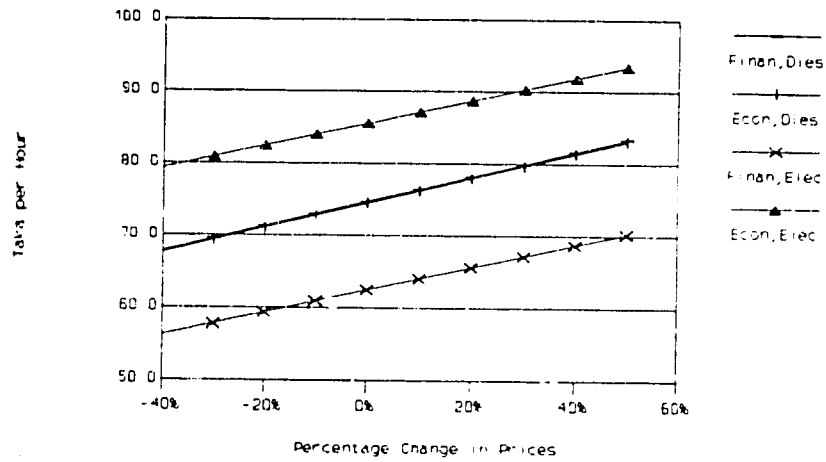
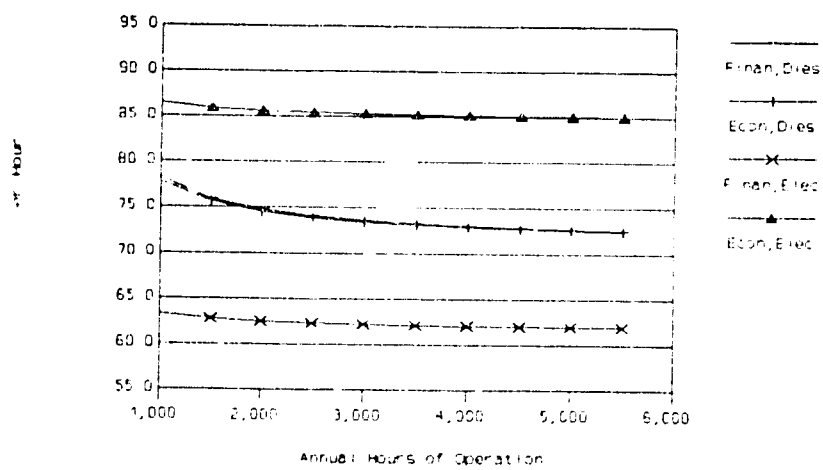


Figure IV.8

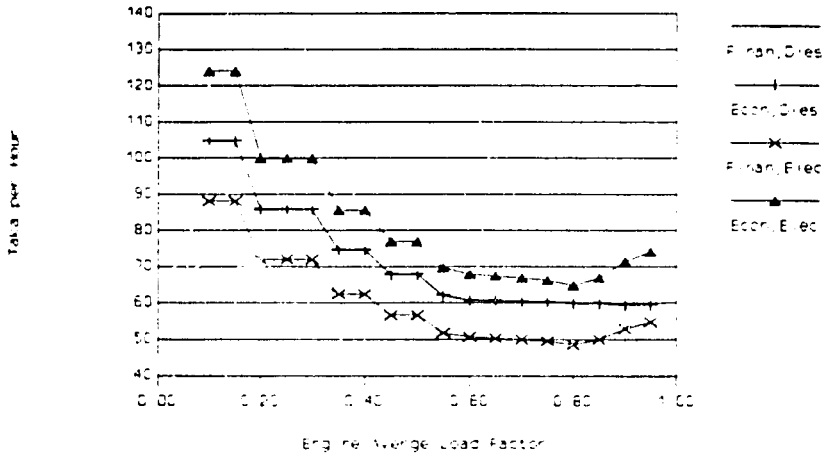
Senstivity of Operating Costs to

Change in Annual Hours of Operation



Senstivity of Hourly Operating

Costs to Change in Load



Annex V

IMPACTS ON RURAL INDUSTRY

Impacts of Rural Industry

Types of Industries

Most of the rural industries are resource-based in the sense that they are located in the rural areas to be close to the source of supply of inputs. Rural industries can be broadly grouped according to the resources used as follows:

Food and agricultural	20%
Wood, Cane and Bamboo	20%
Textiles	52%
Metals	2%
Pharmaceutical and Chemicals	1%
Printing and Paper Products	negl.
Leather and Rubber Goods	negl
Glass and Ceramics	1%
Miscellaneous	2%

The statistics to the left of these categories are the frequencies observed in the 1981 BIDS study of rural and cottage industries. Although no more recent survey is available, it is clear that the first two categories have increased relative to the others in the last decade. Another major change has been the increased use of mechanization and electricity. In the 1981 survey, only the textiles and metals industries were found to be consistent users of machinery although a majority of the chemicals, printing and ceramics industries also relied on machinery. Also the expenditure for electricity at that time was found to account for only .8% of the total cost of inputs to the production process. Only the metal working and printing industries were found to be significant users of electricity.

Today, the most common rural industry are mills for processing rice and flour. These may be single-purpose mills or combined rice\flour mills. Other mills include pulse and oil presses. Other food processing facilities include cold storage, crop drying and small-scale manufacturers of sugar or vegetable based products. Both electric and diesel powered mills can be found in the rural areas, but where electricity is available, it is the preferred source of energy. Electricity is also very much preferred for cold storage because of the reliability when combined with diesel generator backup but it is less important for other food processing activities where diesel motors are frequently used.

The wood, cane and bamboo industries process local materials either as a service to the owner of the material of for sale in the market place. Sawmills are a relatively recent but growing phenomenon in electrified areas where the motor-driven band saw is replacing hand-sawing. Downstream processing of wood for

furniture and framing for buildings are also found and employ varying levels of mechanized tools and equipment. The processing of cane and bamboo tend to be smaller less-mechanized industries.

Rural textile industries range from small tailoring shops for producing garments to large jute and textile mills. Electricity is an important source of energy for mechanization in the larger mills and medium-sized textile and jute processing enterprises. It is less important in garment making and the small-scale processing of jute.

Metal-based industries include re-rolling mills, metalworking shops, and machine shops. Most are relatively small scale but require electricity for shaft power. Even welding is done primarily through the use of crude arc welders rather than oxy-acetylene torches.

Glass and ceramic industries are mostly small scale and use various fuels for firing the product. There is relatively little use of electricity except for lighting.

Benefits of Mechanization

The decision to mechanize an industry is generally based on one or more considerations which relate to the profitability of the enterprise. These considerations can be grouped as follows:

1. to reduce the overall cost of production. In this case, the capital invested in equipment substitutes for labor or provides higher yields from the raw materials. The benefits to the owner are the savings resulting from lower unit production costs.

2. to increase product quality or to produce additional types of products. In either case, products are produced which could not otherwise have been produced. The benefit to the owner is the value added derived from these products.

3. to replace labor as a means to simplify the production process and reduce the management requirements. The difficulties of managing a large labor force can be considerable and can represent a considerable expense in terms of time and money to the owner. The benefits of mechanization in this case are to reduce the costs for managing this labor and, in many cases, to improve the reliability of production.. These benefits may be in addition to savings in production costs or may compensate for net increases in production costs.

4. to increase the rate at which the product is produced. If there are constraints of the availability of facilities and labor, then mechanization can allow for meeting production schedules without investing in new facilities or employing additional labor. The benefits of mechanization in this case are the marginal increase in production. Alternatively, the benefit may be a reduction in production time which permits the owner to engage in other productive activities or to enjoy more leisure time.

It is the decision to mechanize which leads to improvements in profitability and product quality. At the same time, this decision substitutes capital for labor except in those situations where a new product is being produced. The increase in output per worker will reduce the total employment in that industry, but at the same time will generally increase the skill levels of those working in the industry.

The decision to mechanize appears to be an effective mechanism for mobilizing rural capital. With the exception of the very large industries, most rural industries do not have access to the formal credit sector. Instead the investments are financed through a combination of sale of land and raising funds from relatives in the form of loans or partnerships. Although some studies have suggested a relatively high interest rate associated with these informal loans. The micro-study in the Comilla PBS indicated that the loans between family members are most often interest free and reflect a social obligation rather than a financial obligation. The source of the family funds is a combination of retained earnings and remittances which would otherwise not be employed in productive activities.

The decision to mechanize will also improve the quality or reduces the cost of the goods and services available in the rural area and produce products which can be exported to the urban areas or substitute for products imported from the urban area. For example, the introduction of sawmills and wood-related industries permits local production of furniture and building supplies which would otherwise be brought in from urban markets. The wood used is a combination of local supplies and logs transported for the hills tracts near Chittagong and from the Sundarbans. The introduction of mechanized rice/flour/oil mills reduces the costs for processing the rice which is consumed by the household or sold in the market. The mechanization of textile production allows the rural area to produce for sale in the urban centers. These industries either process locally grown jute taking advantage of the lower transport costs or import fibers taking advantage of the lower local production costs. The mechanization of the metal working industries permits local fabrication of simple metal products for agriculture, construction and transportation and provides the capability to repair equipment and machinery used in local industry, agriculture and transport.

Benefits of Electrification

The decision to use electricity in rural industries is generally made where a connection to the grid is available. There is very little auto-generation although some standby capacity may be provided where the reliability of supply is insufficient.[1] Where a connection to the grid is not possible then diesel engines can be used as a source of shaft power, but this option is limited by available technology to certain industries and generally involves a higher cost.[2] The quantification of the benefits from electrification requires that a comparison be made with the best alternative source of energy.

The power characteristics of the diesel are appropriate for rice/flour milling and oil presses using belt drives. The engines are less appropriate for large-scale power applications such as re-rolling mills, variable torque applications such as sawmills or constant speed applications such as lathes. Diesel motors are also not appropriate for use with hand tools or arc welding except when combined with a generator. Finally diesels are less desirable than electric motors in industries such as textile mills where multiple production units are being operated and an elaborate system of belt drives would be required to operate off of a central engine.

In situations where diesel engines are appropriate but less desirable than electric motors, the engines may continue to be used even after electricity is provided because of the capital cost to purchase an electric motor. In this case, the adoption of electricity is delayed until the end of the economic life of the diesel engine.

The higher operating cost of diesels is associated with two factors, the cost of energy and the cost of maintenance. The current price for electricity is less than the economic cost and the efficiency of the electric motors is greater than small scale diesel engines as discussed in Annex V. As a result the energy costs for the two are relatively similar as shown below:

---

[1] The government's restriction on the use of autogeneration prevents any judgement from being made as to the financial viability of this source of electricity. However, the energy transformation from diesel shaft power to electricity involves about a 10% loss in the generator and adds the capital and maintenance cost of the generator.

[2] the problems of available production technology is a major issue. Many applications which currently use electric motors could also use diesel engines if the correct form of power transmission were provided. However, most power transmission systems are limited to simple belt drives which can be easily maintained.

diesel engines

Tk. 7.8/liter * .225 liter/hp-hr = Tk. 1.76/hp-hr

electric motors

Tk. 2.0/kWhr * .746 kWhr/hp-hr * 1/.85 efficiency = Tk. 1.75/hp-hr

When lube costs are added to the these energy costs, the results are a 20% lower cost for electric motors. The maintenance requirements for diesels also tend to run higher. Electric motors operate with little of no maintenance except an overall once every 5 to 15 years. The diesel engine requires regular maintenance of the fuel injection system and a major overhaul about every five years. The capital and operating costs for diesel engines and electric motors are similar.

The benefits of the electricity can thus be quantified as the savings in production costs relative to the next best alternative. For industries which can utilize diesel, the cost savings are the lower energy and maintenance costs plus a savings from the use of several small motors rather than a central engine with belt drives.

The calculation of economic benefits requires that the costs for the energy be computed in border prices. The economic costs for the engines and motors are similar since both are imported. Therefore, these costs can be excluded from the calculation. However, the border price for imported spare parts for maintenance must be included. These benefits apply to industries which would have been able to operate using either source of shaft power.

For some industries, the cost of production with diesel engines is not financially viable. In this case, it may become viable with the introduction of less costly electric motors which lower the total production cost to a point where the products can be sold for a profit. For these industries, the benefits of electrification are less than implied by a calculation of the savings from the use of electric motors rather than diesel engines since the latter would not have been used.

For other industries, diesel shaft power is not used because of problems with access to, the cost of or the skill levels required for the appropriate type of power transmission system. In this case, the benefits are computed by comparison with diesel-powered auto-generation.[3] Again care must be exercised since many

[3] The lack of autogeneration alternatives is due less to the viability of the technology and more to the restrictions of government which prohibited the use of

industries may not have been financially viable if operating with the higher energy cost of autogeneration. Also this comparison is appropriate for future industrial activities, but it was not an option in the past.

For the benefits provided not by rural electrification but by the rural electrification programme, it is necessary to exclude those industries which had previously received electricity from the BPDB and were absorbed into the programme when these lines were handed over to REB.[4] It is also reasonable to exclude all industries located along the alignment of the former BPDB's lines since these would have had access to electrification even without the REB programme.

Types of Industries and the Effects on Benefits

So far the estimate of benefits has relied on the comparison of diesel and electric options. In order to perform a more complete analysis of the benefits of rural electrification, it is necessary to consider the locational decisions of these industries. In order to do this, it is necessary to define a topology of rural industries. The benefits of electrification to the locational decision can then be determined for each category.

The first category includes large industries, such as textile mills, which must have electricity for their processes but draw their inputs from regional centers and sell their output in urban centers or overseas. These industries are relatively footloose and are established to meet a specific demand. If such an industry moves to a rural area, then there will be no specific efficiency benefits to the nation because that industry would have located somewhere else. However, there are equity benefits because of the transfer of employment and income to the region which has electrified. Electricity is not the only basis for the locational decision but without it the decision would not have been made.

---

autogeneration except in certain circumstances. This ban was put in effect to protect BPDB for external competition and has only recently been rescinded. To date, the technology of autogeneration has not made significant inroads into the rural areas although the availability of natural gas makes this an interesting economic issue for the future.

[4] Statistics on the number and power requirements of these specific industries are not currently reported.

The second and third categories includes small and medium industries which are dependent on the local area for their supply of raw materials (resource-based industries such as rice mills, sawmills and brick factories) or for the purchase of their output (market-based industries such as furniture factories and engineering workshops). For these industries, the introduction of electricity permits them to establish near to their source of supplies or their markets. If electricity is an important component of their production activity and it is not available then these industries will locate in the nearest market which has electricity. The consumer will then absorb the additional cost of transport for collection of the raw materials or distribution of the final products.

A fourth category are those medium to large scale industries where security of energy supply is a critical factor (e.g. cold storage and certain continuous chemical processes). In this case grid electricity backed up by diesel generators is the combination required to insure reliability of supply. The decision to locate the facility will depend first on the availability of electricity and then on issues of location of raw materials and markets depending on which is more important.

The complete topology then raises three issues:

1. the dependence of the industry on electricity-based technologies
2. the dependence of the industry on local resources and local demand
3. other factors affecting site selection such as price and availability of land and labor, and the location of one's relatives.

The benefits of electricity to an industry will depend on the locational alternatives available to the industry and the relative costs of operating in the alternative sites given their access to alternative energy sources, supplies of raw materials and markets.

Demand for Electricity

The REB reported a total of 7641 rural industry connections (Group A - excludes cottage industries) consuming an average of 13.4 MWhr per month. The number of hookups has been growing at an average annual rate of 46% (Figure 1) while consumption has grown at a slightly lower rate of 42% p.a. (Figure 2). As a result there has been a drop in average consumption per hookup from 2.2 kWhr per month in FY82 and FY83 to 1.9 kWhr per month in FY88 and FY89.

The growth in demand has been dramatically affected by the takeover of BPDB lines. Since these generally serve the larger electrified factories, they provide a significant boost to the total demand. The decrease in the average consumption

per industrial hookup over time is attributable to the connection of new industries just starting up. These tend to be smaller activities whose demand will grow in the future with their level of output. It is likely that the decline in consumption per hookup will end at some point in the future and there may even be a slight increase as the size of the average industry increases.

Industrial users account for a relatively small percentage of total connections in the REB system. The lowest percentage is in the two Chittagong PBS's where they amount to less than ½% and the highest percentage is in Dinajpur, Comilla and Dhaka with percentages between 2.9% and 3.3%. The PBS's with the largest number of industrial connections are Dhaka, Comilla, Tangail, Sirajganj, and Chandpur which together account for 1/3 of the total connections.

Industrial users accounted for about 43% of total energy consumed in FY89. They accounted for nearly 2/3 of the consumption in Dhaka and Moulvibazar and more than ½ the consumption in Comilla, Dinajpur, Jessore II, Habiganj, Pabna II and Thakuragon. The consumption by rural industry in Dhaka, Comilla, Moulvibazar, Tangail and Jessore II and Habiganj together accounted for 55% of the REB total demand by this class of customer.

A typical electric load as observed in BCAS surveys in the Comilla area consists of an installed capacity of 20-30 Hp. operated from 4 to 8 hours per day with an average load ranging from 10% to 30%. This implies a monthly consumption between .5 and 1.5 MWhr. The higher average consumption is accounted for by the large industries which consume a disproportionate amount of energy and which had originally received electricity from BPDB.

Cost of Supply and Alternatives

The industrial load is considered the most desirable since it is concentrated in the market areas and therefore is easier to serve and since it extends throughout the daytime with very little weekly or seasonal peak. The load is largely reactive due to the predominance of motors in the makeup of the demand, however, switchable capacitors have been introduced to improve the power factor. Much of the major industrial load was taken over from BPDB and therefore represented relatively little additional cost for the REB for a considerable increase in revenue.

The current tariff for the industrial loads is in the form of a fixed energy charge of Tk. 2.55 -2.70 per kWhr, a meter rental of Tk 30/month and a capacity charge of Tk 10 per KW/month with a minimum monthly charge of Tk 100. For an industry with a load in excess of 25 kW and equipped with demand meters, the charge is Tk 40 per kW/month with a monthly minimum charge of Tk 500. There

is also a penalty for operating with a power factor below 0.85. The Bulk Supply Rate from BPDB is Tk. 1.28. Allowing for technical and non-technical losses of about 16%, the tariff is 76%-85% greater than the cost of the energy.

Some of these industries have the option for co-generation while others must maintain standby generators to insure reliability of supply. Since the electricity is utilized for lighting and shaft power, but not for direct heating, the impact on demand for electricity from the increasing use of natural gas as a source of fuel for process heat should be minimal.

Annex VI

IMPACTS ON HOUSEHOLDS

Impacts on Households

Household Uses of Electricity

Electricity is used in rural households for both domestic purposes and for cottage industry. In this annex, the focus is on domestic uses. Cottage industries are a productive use generally requiring lighting but not shaft power or process heat.

The domestic uses of electricity can be broadly grouped into five categories as follows:

1. lighting, in which case the electricity replaces kerosene,
2. communications, in which case grid electricity replaces electricity stored in rechargeable batteries,
3. cooling, in which case there is no substitute[1],
4. cooking heat, in which case the electricity replaces biomass, and
5. water supply, as a substitute for hand pumps.

Lighting is used in the evening after dark and before going to sleep. Because the habit of rural farmers is to rise well before dawn, this evening period rarely exceeds 2-3 hours. The minimum house connection is generally two 20 or 40 watt bulbs. Communications involve the use of radios, two-for-one (radio-cassette players) and televisions. The latter are relatively rare except in the wealthier homes. Battery-powered transistor radios continue to be used even after electrification. Cooling is generally provided by small fans. These are typically purchased after the light fixtures and radio-cassette. Cooking heat is rarely used because of the expense. Where a coil is used, it is usually because the connection is illegal or not metered. Refrigeration units are expensive and extremely rare in the rural areas. Domestic water supply is provided by hand pumps or from surface water, electricity is not currently used for this purpose.

The Benefits of Electricity and Their Measurement

The benefits from electrification of the household are generally measured in terms of the savings in cost of alternative fuels which are replaced by electricity and by the social benefits attached to better lighting and communications.

---

[1]This is true when considering the use of fans, but for cold storage, where kerosene chillers and refrigerators can be used.

he benefits from electric lighting are often measured by comparing it with the kerosene lighting commonly used in un-connected households. In some cases an effort is made to equate the fuel required to produce a similar level of lighting, but this is difficult. In fact, the light provided by electricity is an entirely different product than kerosene lighting. The only comparable source of kerosene light is the pump lamp which is not often used in the rural areas.

The benefits of electricity for communication is measured by computing the costs for the purchase and recharging of the 12 volt batteries used to power televisions and two-for-one units in non-electrified households. However, the introduction of electricity generally leads to a much wider use of these appliances. Therefore the amount of substitution due to diverted demand is less than the amount of generated demand due to lower energy costs.

The benefits of electricity for powering fans is often measured simply by the amount the user pays for electricity since there is no direct substitution.

The social benefits from electrification of lighting, communications and cooling are generally not quantified. Instead, the changes in social behavior are reported. The changes which are frequently mentioned by proponents of the program are extended hours for evening work or socializing, more school work and reading, and better family planning practices.

Since the uses of electricity provide a value to the household, it should be possible to measure this value in terms of what the household is willing to give up in order to have the electricity. This is referred to as the willingness-to-pay. It is often approximated by using the amount actually paid, but this results in a significant underestimate of the value placed on electricity by the household. The willingness to pay is much higher as indicated both by the low elasticity of demand, and the willingness of wealthier households to invest in appliances which use electricity.

The willingness-to-pay must be measured for three different components of the domestic connection. The first is the willingness to convert assets from savings to household connections.[2] The initial cost for connection includes the cost of housewiring, the cost for the initial light fixtures, the security deposit and a cost for connecting to the existing distribution lines if these are located more than 100

---

[2] The term assets is used in this discussion to distinguish from current income. A change of assets would occur when a household purchased a durable good from savings or through the sale of family assets, e.g. jewelry, animals, land, etc. It is assumed that the price of the durable good is in excess of the amount which could be allocated from monthly disposable income.

feet from the household. The second component is the willingness to purchase the appliances which use electricity. Because of the price of these appliances relative to rural incomes, this purchase is generally in accomplished through an exchange of assets. The third component is the willingness-to-pay for monthly consumption of energy. This expense is generally paid out of current income.

The willingness-to-pay is a measure of the value the household places on these three components. Although data is not currently available for the individual components, it is possible to speculate on the factors which determine their value to the rural household. The value of a connection is associated with access to electricity to meet a latent demand for the use of electric appliances.[3] This demand will depend on the level of development of the village and the surrounding areas which in turn affects the consumer's knowledge about the uses and benefits of electric appliances. The value will also be affected by the complementary uses for electricity for cottage industries and other productive activities within the home which would benefit from the use of electric appliances and equipment. Finally, the value will be affected by the wealth of the household. Since the connection is paid for out of this wealth, the greater the amount of wealth the more the household will be able to pay. Since electricity is a visible sign of wealth, the status it imparts to the user adds to its value.

The preliminary survey results indicated that the measurement of the value of connection is much more difficult to determine than the value of the other two components because of the large amount involved. However, the response of households in developed areas was more definite than in underdeveloped areas. The willingness-to-pay for connection can be quite considerable and can lead to informal payments for expediting connection. The amount of these informal fees may even exceed the formal payment for connection. Where information is available on informal payments for connections, this can be used to approximate the willingness to pay. Alternatively, households located away from the existing REB lines often indicate the maximum amount they are willing to pay for extension of service to their home. Although this amount is less that what REB will charge (otherwise they would be connected), it does provide an indication of willingness to pay.

The value attached to the ownership of appliances is directly associated with the benefits of electricity, better lighting, greater comfort, and access to information and entertainment. The household will purchase appliances in some sequence and amount which indicates the relative value of the different appliances. Light fixtures are the first appliance obtained but typically only a few are installed. The next

---

[3] This term is meant to include light bulbs.

purchase is typically a radio-cassette followed by a far and then a television. The order of investment is determined by the relative costs for these appliances. The extent of investment is determined by the wealth of the household.

A measurement of the willingness-to-pay for these appliances is not essential for determining the benefits from rural electrification. However, appliance ownership is important factor when trying to understand the value associated with the consumption of electricity. The household's demand for electricity will depend on the stock of appliances currently available in the household. Their demand function is likely to be kinked with a very high value associated with the initial amount of energy consumed then a steady drop in value for additional units of energy up to a point of saturation where very little value is placed on additional units. The point of saturation is determined by the inventory of appliances and the leisure time available to the household.

For example, a household with two electric lights will attach considerable value to the electricity required to light at least one bulb for an hour each evening. The value of lighting both bulbs for an hour will be somewhat less as will the value for a second hour of lighting. Beyond 3-4 hours, the value will become negligible since the period of darkness during which the family is awake extends for only a few hours in the evening and perhaps one hour in the morning. Lighting during other periods of time could be used to provide security but there is little indication that the household places much value on this use of lighting.

The same analysis can be performed for consumption in a household possessing communications devices and fans in addition to the light bulbs. The result is a series of kinked demand curves which are a function of the ownership of appliances (see Figure 1). The value attached to the consumption of electricity will also depend on the recurrent income of the family out of which the monthly bills are paid.

Because of the current rate structure of the PBS's includes a subsidized rate for the first 70 kWhr, the amount paid for electricity is a relatively poor measure of the value of electricity to the household. The attempt to add part of the differential cost for the nearest substitute (e.g. kerosene lighting and battery powered communications) provides a better measure. However, this technique ignores two significant problems:

1. Substitutes are not always available and,
2. where substitutes are available, the quality is sufficiently different. as in the case of lighting, to argue that they are different goods.

It is very likely that the values attached to both access to and use of electricity are considerably higher than typically estimated in rural electrification. The preliminary survey results indicated that in more developed areas a 50% increase in the tariff would cause very little reduction in consumption. However, these values cannot be estimated without a closer examination of the household's willingness-to-pay for both connection and consumption.

A survey has been proposed to perform this function. The willingness-to-pay for connection would be determined for both electrified and non-electrified households whereas the consumption would be measured for electrified households and substitute energy use would be measured for non-electrified households. The survey would also examine how this willingness-to-pay varies with:

1. development of a region (as measured by density of pukha roads and proximity to a major market area)
2. gross household income (cash and kind) and wealth (major assets)
3. appliance ownership (or plans for purchase of appliances)
4. peer pressure (as measured by percentage of households having connections and different appliances)
5. complementary uses of electricity from a domestic hookup (cottage industry, water pumping)
6. general knowledge (female and male literacy)

Demand for Electricity

The growth in domestic hookups has preceded at a relatively rapid rate both system-wide and in the PBS's. The latter has had an average rate of increase of 36% per annum. The increase in number of PBS's lead to a rapid increase in hookups from FY86 but the growth in total consumption did not accelerate indicating that the new systems were being introduced in less developed areas with lower levels of initial demand. The number of hookups is greatest among the older PBS's and those located near major urban or regional centers. The 11 PBS's energized in FY82 which include Dhaka, Comilla, Chandpur, Tangail, Moulvibazar, Sirajganj, Jessore I and II, and Natore I and II and Pabna II account for about 45% of the hookups. The first four of these account for nearly 1/4 of the hookups.

Domestic hookups account for between 65% and 93% of all the hookups in each PBS, the higher percentages are found in the newer PBS's where productive uses in agriculture and industry have not yet been established. For the same reason, the proportion of electricity consumed in households is highest for these new PBS's where the range is 25% to 92%. In the older PBS's the proportion is in the range of 17% to 25%.

The average monthly consumption per household connection for the entire REB system is currently 27 kWhr, having fluctuated between 24 and 28 since FY82. The range is much greater for individual PBS's. The average monthly consumption in less developed areas such as Bagerhat, Jamalpur, Meherpur, Narsingdi, and Pirojpur is currently in the range of 19 to 20 kWhr. In the more developed areas such as Dhaka, Moulvibazar, Natore I and II, and Sirajganj, the average household consumption is between 30 and 37 kWhr per month. These consumption figures indicate that the current lifeline rate covers a majority of the domestic users and is well above the average level of consumption. These figures also indicate that the typical household consumes significantly more than the 2-4 bulb, 3-4 hour per night minimum use even in the less developed areas, even after allowing for multiple hookups off the same meter.

There is a tendency for the average household consumption to increase over time as more appliances are connected. At the same time, the initial hookups tend to have a higher rate of consumption than the later hookups which represent more marginal consumers. As a result there should be an increase in the average household consumption during the first few years after energization followed by a gradual leveling off and eventually a decline as the initial households approach saturation and the hookups being added have needs which are much less than the average hookup. This trend can be seen in the older PBS's as shown in Figure 2.

Cost of Supply and Alternatives

Domestic hookups account for about 1/4 of the total consumption. The primary demand occurs during the evening which corresponds with the daily peak demand for BPDB. The load does not have significant weekly or seasonal fluctuation. This load is largely for lighting and there is no problem with the power factor. This is an expensive demand to serve, because of the small amount consumed per hookup, the physical dispersion of load and the daily peaking of the consumption.

The current tariff for households is a block rate beginning at Tk. 1.45-1.55 per kWhr up to a consumption level of 70 kWhr. This is the lowest rate charged to any user. Most of the PBS's then apply a rate of Tk. 1.65 per kWhr for consumption between 70 and 200 kWhr. Consumption above that level is charged Tk. 2.55. In addition a monthly meter rental of Tk 2.5 is charged and a minimum monthly charge of Tk 25-30 is applied for energy use. This demand is assumed to have a higher non-technical loss due to illegal connections and bypassing the meter and therefore the initial block rate is just sufficient to cover the cost of the power supplied by BPDB. The relatively high limit on this first block rate means that most households pay this low rate.

The only alternative sources of energy are kerosene for light. The Coopers and Lybrand survey found an average expenditure for kerosene lighting of about Tk. 42 per month. In the rare instances where electricity is used for cooking, natural gas or biomass fuels provide a more cost-effective substitute. Electricity can be provided not only through the grid but through autogeneration and rechargeable batteries. The former is not used in Bangladesh because of a government prohibition which was only recently rescinded. The latter is found in villages which are not electrified but are within a reasonable distance from a recharging point.

Annex VII

IRRIGATION

Irrigation

Demand for Irrigation

Improvements in agricultural production and productivity are achieved through a number of complementary inputs. The primary mix of direct inputs to modern agriculture include seeds, fertilizer, and irrigation. In Bangladesh there has been a parallel growth in the use of HYV seeds, the application rate of fertilizers and the areas under irrigation as shown in Table VII.1. Houssain [ ], Chowdury [ ], Palmer-Jones and others have pointed out the importance of these parallel developments, but have also recognized that irrigation is the most important not only because it increases yields but because it allows for multiple cropping. In addition to the primary inputs, there are basic infrastructure requirements which include efficient markets for the sale of farm products, storage facilities, inexpensive transport between the agricultural areas and the markets, institutional credit to support the transition from a subsistence to a cash-based agriculture, and extension services to support the introduction of new technologies.

It is difficult to weight the relative impacts of these inputs on the growth in total agricultural output and output per area cropped. The marginal benefits of irrigation can be estimated through agricultural production models and they can be observed through surveys of irrigated and non-irrigated sites. For some dry season crops it may be possible to attribute most of the value added to irrigation but for most crops the value added is derived from a package of complementary inputs.

The rapid increase in irrigated land over the last 15 years as shown in Table VII.2 indicates the growing importance of irrigation in agriculture. The increase in irrigation has been accomplished primarily through minor irrigation schemes where the command area rarely exceeds 40 ha. These minor irrigation schemes are implemented through different technologies which range from the traditional non-mechanized water-lifting techniques to large mechanized systems.

Irrigation Technology

The traditional non-mechanized technology employ dhoons and swing baskets to irrigate dry season crops in low-lying areas which have a supply of surface water in canals, ponds or streams. These systems are used to irrigate the Boro crop in command areas of 2 ha or less.

Table VII.1

Annual Growth Rates

Regions	Acreage Cultivated	Irrigated Area	Fertilizer Consumption	HYV Area	Yield Rate
Chittagong Division:	1.1	2.7	4.1	5.1	0.2
Chittagong	0.4	3.0	2.7	5.2	0.97
Ctg. Hill Tracts	-2.2	1.0	9.4	2.1	3.1
Noakhali	1.4	-7.2	5.0	3.8	-0.85
Comilla	1.1	4.5	6.9	5.4	1.2
Sylhet	1.6	4.3	10.2	6.7	-0.64
Dhaka Division:	1.0	8.3	9.9	9.8	1.9
Dhaka	0.1	2.3	7.1	8.9	1.4
Kishoreganj	1.6	1.2	9.1	7.6	0.76
Mymensingh	1.2	9.7	12.4	11.1	2.2
Tangail	0.9	11.1	12.5	7.9	1.4
Faridpur	1.4	6.9	13.6	15.7	3.8
Rajshahi Division:	0.67	10.6	13.3	17.2	3.13
Rajshahi	0.45	6.4	13.2	17.5	2.85
Dinajpur	0.7	7.9	10.4	19.1	2.5
Rangpur	0.7	12.8	13.7	19.4	3.6
Bogra	1.5	15.5	12.9	14.8	3.6
Pabna	0.1	13.0	16.2	13.6	2.5
Khulna Division:	1.25	0.8	7.6	8.3	0.85
Khulna	0.5	2.9	13.6	8.0	0.2
Barisal	0.95	3.3	9.7	3.0	0.45
Patuakhali	3.4	-5.8	9.2	0.9	-1.5
Jessore	0.24	15.3	12.6	13.0	2.5
Kushtia	2.4	10.5	10.9	11.6	2.0
Bangladesh	1.0	6.25	10.0	9.4	1.5

Note: Growth rates are calculated on the basis of initial and final year figures. Growth rates of irrigated area and fertilizer consumption are for ther period 1976/77-1985/86 and 1976/77-1986/87 respectively.

Source : Chowdury, ASR, Volume I

Table VII.2

Area Irrigated Under Different Crops
(1000's Acres)

Year	Aus	Aman	Boro	Wheat
1975/76	182	208	2,618	125
1876/77	189	208	2,022	178
1977/78	211	208	2,515	231
1978/79	228	241	2,436	351
1979/80	227	317	2,491	426
1980/81	295	347	2,467	481
1981/82	279	455	2,574	468
1982/83	309	480	2,816	478
1983/84	358	392	2,959	529
1984/85	347	385	3,175	699
1985/86	406	469	3,110	659

Source : Agricultural Statistics 1986/87

The simplest mechanized systems employ Low-Lift Pumps (LLP). These pumps increase the lifting height and expand the command area of a single source up to 16 ha. These pumps are typically diesel powered units. They have a capacity of 2 cusecs and a typical command area of 11-27 ha. They were popular in the period from 1960 through 1970, when they were widely distributed BADC under government subsidized programs. They have since become less popular as shown in Table VII.3a. Changes in the method of distribution and limits on the availability of surface water have contributed to this decline.

Shallow Tube Wells (STW) are the next level of technology. These are drilled to a depth of about 20 meters with the maximum lift of about 10 meters. The water is extracted using hand pumps or more commonly centrifugal pumps powered by diesel engines or electric motors. The centrifugal pumps have capacities of .5-2 cusecs and are used to irrigate a command area of about 5-15 ha. They are used primarily in lowland areas where the groundwater is near the surface. They have also been introduced in some upland areas in Rajshahi, Bogra, Barind and Madhupur. There the depth of water pumped has been increased by digging pits to establish Deep Set Shallow Tube Wells (DSSTW).

Table VII.3a.
LLP Rental, Sales and Acreage

	Units Fielded				
	Rental	Sales Cumulative	Canal Digging Programme	Total	Acreage Irrigated (Acres)
1980/81	31,688	2,206	2,155	36,049	1,379
1981/82	28,149	9,594	3,611	41,354	1,461
1982/83	17,619	21,973	3,447	43,039	1,365
1983/84	9,308	34,307	-	43,615	1,031
1984/85	8,337	42,324	-	50,661	1,135
1985/86	758	50,899	-	51,657	1,084
1986/87	2,699	55,397	-	58,096	N.A.

Source: BADC

Table VII.3b
Shallow Tube Well Sales

Previous	
Sales	24,615
1980/81	17,538
1981/82	26,458
1982/83	39,780
1983/84	33,560
1984/85	27,593
1985/86	8,775
1986/87	15,570
Total:	193,889

Source : Ministry of Agriculture

Table VII.3c.
Deep Tubewells In Operation

Year	Number Operated	Area Irrigated (Acres)
1980/81	10,131	641
1981/82	11,491	798
1982/83	13,794	999
1983/84	15,519	1,026
1984/85	16,901	1,090
1985/86	17,803	970
1986/87	18,744	958

Source: BADC,

Source: all three tables from Palmer-Jones, ASR Vol I,

In the early 1980's shallow tube wells became the principal form of irrigation technology introduced in the rural areas. Their introduction coincided with the increased use of high-yielding varieties. Although the government participated in the distribution of these units beginning in the mid 1970's through BADC rental programmes and BKB credits, the period of most rapid growth was from 1980 to 1986 as shown in Table VII.3b. At the end of this period the increased cost of this technology and other inputs relative to a stable price for rice resulted in a decline in sales.

The most recently introduced technology for minor irrigation is the Deep Tube Well (DTW). These are drilled to depths of 25-40 meters. A turbine pump is set in the well and the maximum pumping lift is about 20 meters. The pumps are operated by diesel engines or electric motors. They typically have a capacity of 2 cusecs and irrigate a command area of 18-45 ha. Although these units are designed for use in areas where the groundwater is low, they have been introduced throughout the country and often serve the same area as STW's. The number of DWT's used has increased rapidly in the last few years and is expected to increase in the future under the encouragement of various donor programs.

Irrigation Programs

The spread of mechanized minor irrigation over the last two decades has largely been under the control of the BADC and BKB. This former was responsible for importing the pumps, selecting sites, constructing the wells and renting the pumps for a fee. From 1974, BADC engaged in the sale of second-hand pumps. BKB has been selling STW's to farmers groups. However, sales were relatively slow until 1982 when private sector importers began selling the pumps with credit from the government. Sales rose rapidly for several years then fell in FY87 and FY88 as the economics advantages of STW's were reduced by higher costs and lower returns to the farmers. The latter resulted from output prices rising slower than the cost of inputs and from the success in meeting the demand for irrigation in areas with the greatest potential to benefit from minor irrigation schemes. It also was caused by the end of certain agricultural credit programs and, with them, the ease of defaulting on loans which had significantly reduced the cost to the purchasers in FY82-FY85.

In the last year there has been a resurgence in the sales for STW's as a result of the government's decision to end restrictions on the import and installation of shallow tubewells. This decision has resulted in a significant decrease in price of STW's due both to the elimination of import duties and the strong competition between suppliers. These wells are being bought not only by cooperatives but also by informal groups and, in some cases, individuals. Meanwhile, the BADC is in the process of liquidating its supply of spare parts and getting out of the shallow

tubewell business, although it is involved in a final program for installing STW's in underdeveloped areas of the country.

The purchase and installation of Deep Tube Wells is still largely under the control of the BADC and BWDB although efforts are being made to reduce their influence. The BADC and BWDB had maintained a monopoly on the import, installation and operation of DWT's but recently the Grameen Bank has purchased a large number of DTW's from BWDB in Thakurgoan and is currently purchasing DTW's from the BADC in Tangail.

Although donors continue to fund Deep Tube Well Projects, which are then implemented by the BADC, there is increasing attention being given to the institutional structures for the ownership and operation of the DTW's. For example, Saudi Arabian aid was recently used to fund the import and construction of 20 thousand DTW's in Dinajpur and Rangpur districts. These units were then sold to the Grameen Bank at a subsidized price and the bank will now operate these units on a for-profit basis. Also the IBRD is considering alternative methods of ownership and operation for the DTW's purchased under its proposed Third Deep Tube Well Loan. In the longer term it is expected that BADC will cease operating DTW's and eventually the importation and ownership of these wells may be turned over to the private sector as has happened with STW's.

The Ministry of Agriculture is considering introducing some restrictions on the siting of DTW's so as to improve their utilization. These regulations would limit the use of DTW's to upland areas where the low water table makes this technology more appropriate. At the present time this technology is found serving command areas which adjoin other areas served by STW's. It appears that the current subsidies offered for the use of DTW's has made them competitive in areas where STW's can provide sufficient lift.

It is expected that as privatization of the country's irrigation program continues, that ownership will increasingly be taken up by smaller groups and individual owners. The increase in competition will no doubt lead to some over-investment in minor irrigation schemes and a downward pressure on the price of water charged to users of the minor irrigation systems.

Benefits of Electrified Irrigation

The benefits of electrified irrigation relative to diesel irrigation are due to the greater reliability and lower capita costs rather than lower energy costs. A comparison of the estimated typical costs for LLP, STW and DTW units, both diesel and electric are shown in Table VII.4-9. The energy costs are less in financial terms for electricity based on a cost per kwHr of Tk. 2.0 and an energy

Table VII.4
DIESEL LOW LIFT PUMP - 18 HP

	Financial	Economic	
Capital Cost	22,000	17,516	Taka
Cost for Overhaul	3,300	2,964	Taka
Cost for Regular Maintenance	3,100	2,876	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	4.0	4.0	Hours or Visits per Year
Cost for Parts	1,100	876	Per Year
Fuel Consumption at 80% Load	3.24	3.24	Liters per hour
Lubricant Consumption	35.0	35.0	Liters per 1000 liters
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	42%	42%	%
Annualized Capital Cost	2,674	2,741	
Costs Per Hour of Operation			
Capital	2.67	2.74	
Operator	15.00	15.00	
Maintenance	3.76	3.47	
Fuel and Lubes	35.27	35.27	
Total	56.70	56.48	
Cost Per HP-hr output	7.56	7.53	
Annual Cost	56,702	56,477	

Table VII.5
ELECTRIC LOW LIFT PUMP - 15

	Financial	Economic	
Capital Cost	17,800	22,250	1000's Taka
Cost for Overhaul	2,670	3,004	1000's Taka
Period Between Overhauls	8	8	Years
Cost for Regular Maintenance	1,445	1,556	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	2.0	2.0	Hours or Visits per Year
Cost for Parts	445	556	Per Year
Fuel Consumption at 80% Load	9.95	9.95	kWhr per hour
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	50%	50%	%
Annualized Capital Cost	1,321	2,536	
Costs Per Hour of Operation			
Capital	1.32	2.54	
Operator	15.00	15.00	
Maintenance	1.78	1.93	
Electricity	21.86	43.72	
Total	39.96	63.19	
Cost Per HP output	5.33	8.43	
Annual Cost	39,960	63,189	

Figure VII.1

Operating Costs of Diesel LLP versus

Change in Annual Hours of Operation

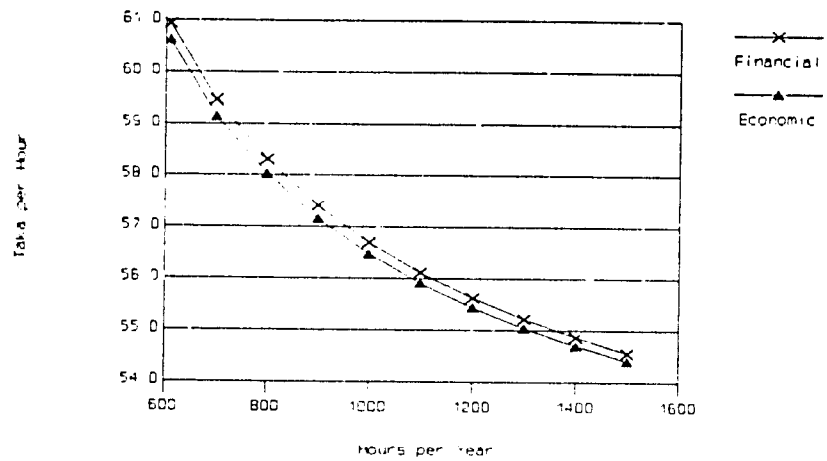
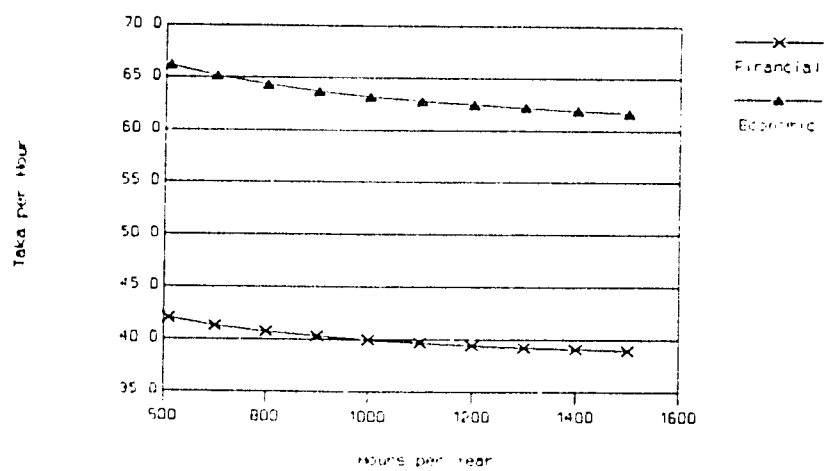


Figure VII.2

Senstivity of Operating Costs to

Change in Annual Hours of Operation



-20!

Table VII.6
DIESEL SHALLOW TUBE WELL - 6 HP

	Financial	Economic	
Capital Cost	12,500	9,952	Taka
Cost for Overhaul	1,875	1,684	Taka
Cost for Regular Maintenance	2,625	2,498	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	4.0	4.0	Hours or Visits per Year
Cost for Parts	625	498	Per Year
Fuel Consumption at 80% Load	1.08	1.08	Liters per hour
Lubricant Consumption	25.0	25.0	Liters per 1000 liters
Cost of Fuel	7.8	7.8	Taka per liter
Cost of Lubricant	25.9	25.9	Taka per liter
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	50%	50%	%
Annualized Capital Cost	1,519	1,557	
Costs Per Hour of Operation			
Capital	1.52	1.56	
Operator	15.00	15.00	
Maintenance	3.00	2.83	
Fuel and Lubes	10.03	10.03	
Total	29.55	29.42	
Cost Per HP-hr output	9.85	9.81	
Annual Cost	29,546	29,419	

Table VII.7
ELECTRIC SHALLOW TUBE WELL - 6 HP

	Financial	Economic	
Capital Cost	9,000	11,250	1000's Taka
Cost for Overhaul	1,350	1,519	1000's Taka
Period Between Overhauls	8	8	Years
Cost for Regular Maintenance	1,225	1,281	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	2.0	2.0	Hours or Visits per Year
Cost for Parts	225	281	Per Year
Fuel Consumption at 80% Load	3.98	3.98	kWhr per hour
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	50%	50%	%
Annualized Capital Cost	668	1,282	
Costs Per Hour of Operation			
Capital	0.67	1.28	
Operator	15.00	15.00	
Maintenance	1.39	1.47	
Electricity	8.74	17.49	
Total	25.81	35.24	
Cost Per HP output	8.60	11.75	
Annual Cost	25,806	35,242	

Figure VII.3

Operating Costs of Diesel STW versus

Change in Annual Hours of Operation

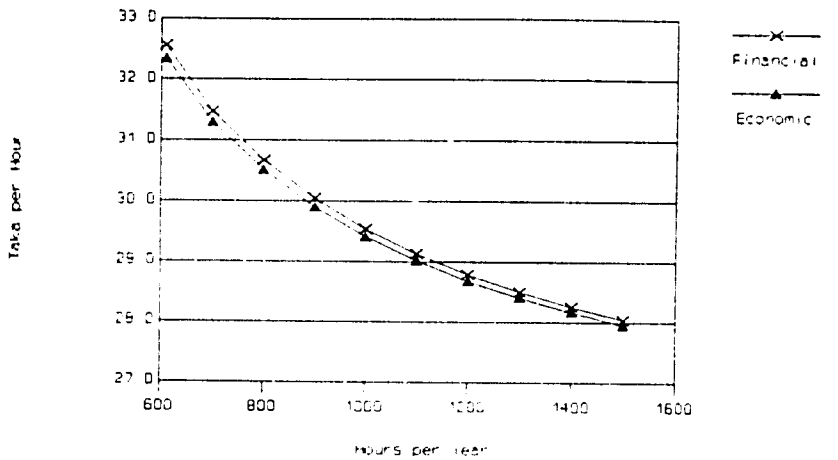


Figure VII.4

Senstivity of Operating Costs to

Change in Annual Hours of Operation

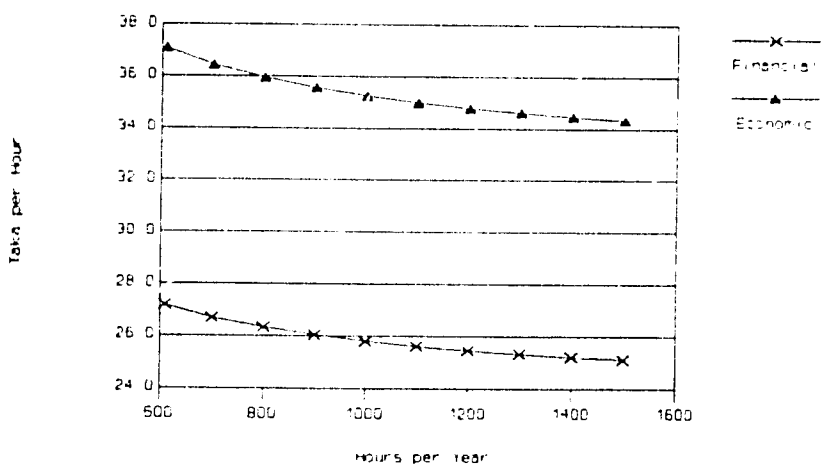


Table VII.8
DIESEL DEEP TUBE WELL - 30 HP

	Financial	Economic	
Capital Cost	45,000	35,828	Taka
Cost for Overhaul	6,750	6,062	Taka
Cost for Regular Maintenance	4,250	3,791	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	4.0	4.0	Hours or Visits per Year
Cost for Parts	2,250	1,791	Per Year
Fuel Consumption at 80% Load	5.40	5.40	Liters per hour
Lubricant Consumption	25.0	25.0	Liters per 1000 liters
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	50%	50%	%
Annualized Capital Cost	5,470	5,606	
Costs Per Hour of Operation			
Capital	5.47	5.61	
Operator	15.00	15.00	
Maintenance	5.60	5.00	
Fuel and Lubes	50.13	50.13	
Total	76.20	75.74	
Cost Per HP-hr output	5.08	5.05	
Annual Cost	76,205	75,745	

Table VII.9
ELECTRIC DEEP TUBE WELL - 30 HP

	Financial	Economic	
Capital Cost	25,000	31,250	1000's Taka
Cost for Overhaul	3,750	4,219	1000's Taka
Cost for Regular Maintenance	1,250	1,406	Taka per year
Cost For Mechanic	500	500	Per hour or per visit
Mechanics Time Required	1.3	1.3	Hours or Visits per Year
Cost for Parts	625	781	Per Year
Fuel Consumption at 80% Load	19.89	19.89	kWhr per hour
Hours Operated	1,000	1,000	Per Year
Operators Required	1.0	1.0	Man-hours/operating hour
Average Load	50%	50%	%
Salvage Value	20%	20%	
Annualized Capital Cost	1,855	3,561	
Costs Per Hour of Operation			
Capital	1.85	3.56	
Operator	15.00	15.00	
Maintenance	1.72	1.93	
Electricity	43.72	87.44	
Total	62.30	107.94	
Cost Per HP output	4.15	7.20	
Annual Cost	62,295	107,938	

-204

Figure VII.5

Operating Costs of Diesel DTW versus

Change in Annual Hours of Operation

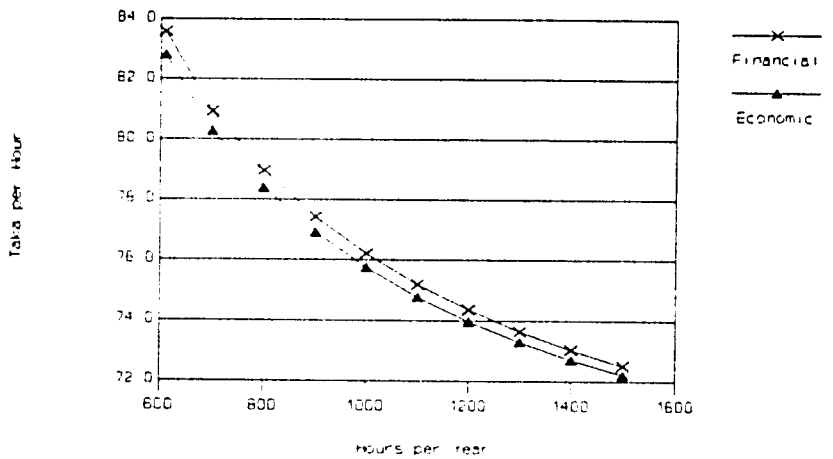
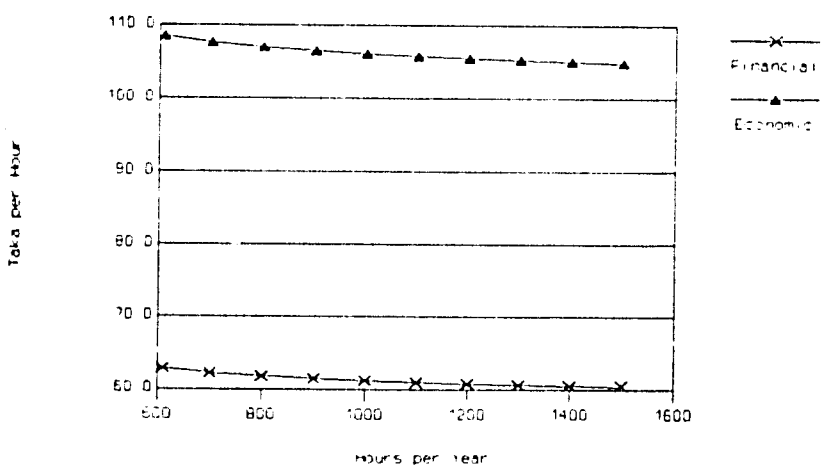


Figure VII.6

Senstivity of Operating Costs to

Change in Annual Hours of Operation



205

Notes to Tables VII.4-9 and Figures VII.1-6

CONVERSION FACTORS

Assumptions

diesel fuel consumption based on .225 liters per horsepower hour used

electricity consumption based on .746 kWhr per Hp-hour adjusted by motor efficiency of .9

diesel financial fuel price assumed to be Tk. 7.8 per liter and electricity price Tk 2 per kWhr.

economic price assumed to be same for diesel but Tk 4 per kWhr.

energy consumption adjusted for average load and energy efficiency at that load

a paid operator is used for all pumps

maintenance required every 250 operating hours for a diesel engine versus 1000 hours for an electric motor

major engine overhaul required every 5 years for a diesel engine versus 8years hours for an electric motor

salvage value and economic life are both higher for an electric motor, 20 years and 20% than for a diesel engine, 10 years and 10%

capital cost amortized over the life of the motor/engine at the real interest rate

cost for operator Tk 15 per hour of operation

Standard Conversion Factors

Skilled Labor	1.00
Semi-skilled Labor	1.11
Unskilled Labor	1.33
Imported Equipment, Parts	0.80
Electricity	0.50

	Financial	Economic
Discount Rate	5.0%	10.0%

Engine/Motor Efficiency Conversion Table

Load	Efficiency Factor
0.10	0.45
0.20	0.58
0.30	0.70
0.40	0.80
0.50	0.91
0.60	0.94
0.65	0.95
0.70	0.96
0.75	0.97
0.80	1.00
0.85	0.96
0.9	0.88
0.95	0.84

requirement of .82 kWhr per horsepower hour at the shaft versus a cost for diesel in the rural area of Tk 7.8 and a consumption of .225 liters per horsepower hour at the shaft. In economic terms the energy cost for diesel is much lower than electricity because the former is priced slightly above its border price whereas the latter is estimated to be only half of its long-run marginal costs.[1]

The differential cost of using an electric pump rather than a diesel pump, is used as the basis for computing the benefits of rural electrification for irrigation. A comparison was made using typical LLP, STW and DTW configurations and current prices for the motor engine and the pump as presented in Annex IX. The cost for the well was assumed to be the same regardless of technology. The results as summarized in Tables VII.4 to VII.9, indicate that the savings in lubricants and capital and maintenance costs give electric pumps a significant advantage both at the time of initial purchase and over the life of the pump. Based on the numbers in these tables, the financial benefits for electrified LLP, STW and DTW are Tk. 16,742, Tk. 3,750, Tk. 13,910 per year respectively assuming a 1000 hours of operation. The positive savings pertains over a wide range of pump utilization and improves with the amount of use as shown in Figures VII.1 to VII.6. Clearly, it is the much larger savings in financial costs which have lead to the rapid electrification of these units. A comparison of the wells installed and the wells electrified is shown in Table VII.10.

Table VII.10
Comparison of Growth in Wells and Growth in Irrigation Hookups

	PBS New Connections	New STWs and DTWs	Percentage PBS Connection
1981/82	360	28,458	1.3%
1982/83	1,011	42,083	2.4%
1983/84	1,450	35,285	4.1%
1984/85	946	28,975	3.3%
1985/86	1,028	9,677	10.6%
1986/87	3,382	16,511	20.5%
1987/88	2,576		
1988/89	3,684		

[1] The 1987 Tariff Study for BPDB recommended a LRMC pricing strategy in which the rate for irrigation would be more than Tk. 4 per kWhr in 1989 prices.

These benefits do not extend to the economic comparison. There the cost of energy is much higher for electric pumping. There would be a significant savings to the economy from using diesel pumps because of the lower capacity needed to meet the seasonal peak in power.

The electrified wells have benefits other than the savings in financial costs. These include better operating characteristics of electric motors, especially with regards to their greater reliability, ease of operation and speed control properties. At one time they were perceived as less reliable because of the extensive load shedding by the BPDB was occurring with serious frequency during the peak demand period which coincides with the heaviest use of the irrigation pumps. This problem has largely been resolved and is not expected to reoccur in the future if the BPDB continues expansion of its capacity in line with the demand or if the REB becomes involved in power generation.

The diesel pumps have benefits other than the savings in economic terms. Their major advantage is portability. In Bangladesh the introduction of the motorized "shallow boat" for use during the rainy season has created an additional demand for motive power. The diesel engine used on the pump is also suitable for powering the boat. This engine also has potential for powering rice mills, providing on-farm transportation, ploughing fields, etc. Several of these uses are now appearing in the rural area.[2] The potential for increasing the utilization of the diesel engine on a pump, which would otherwise lie idle for 8 months in the year, has been referred to by various field investigators. However, this conversion is expected to be limited since for many applications it is financially advantageous to use electricity for irrigation and to purchase a diesel motor for other uses.

Demand for Electrified Irrigation

The growth in demand for irrigation has growth hookups has been highest in the PBS's of Dhaka, Natore I, Sirajganj and Tangail which together account for about 30% of the total irrigation connections. The buildup in connections tends to be relatively gradual. While new wells may be designed for electricity, the older wells must be converted and this will is only done after the diesel engine has reached the end of its useful life. As a result, the newer PBS's have relatively few connections, whereas the older PBS's, with the single exception of Moulvibazar, all have more that 150 connections. Tangail is the leader with over 1750. For this reason Tangail also has the largest electricity consumption for irrigation accounting for nearly 15% of the system total for this class. The four PBS's mentioned above account for about 45% of total system consumption for irrigation.

---

[2] A good example of the extent to which this use of the ubiquitous 6-8 Hp diesel engine can be carried can be seen in rural Thailand where even locally fabricated half-ton farm trucks are powered by these engines.

The average annual energy consumed per connection ranges for 2.5 MWhr in Moulvibazar up to 20 MWhr in Mymensingh. The former has relatively few small pumps whereas the latter has major irrigation systems. Otherwise the PBS average consumption per connection falls within the range of 5 to 9 MWhr per year. From tables 2,4 and 6 above, the typical consumption per tube well is estimated to be 5 MWhr for a shallow tube well, 17 MWhr for a LLP and 35 MWhr for a DTW. Assuming a four month period of irrigation, the monthly consumption per pump would be 1.2, 4.2, and 8.7 MWhr, respectively. The predominance of DTW's in Mymensingh, Meherpur and Thakuragaon have produced high average consumption levels in the first two but not in the third. The significant proportion of LLP's in Bagerhat, Barisal, Chittagong, and Pirojpur has had little affect on average consumption, probably due to under-utilization of these pumps. Other PBS's with high average consumption such as Dhaka and Chandpur, can be partly explained by the high proportion of both DTW and LLP. However, no such explanation applies in the other high average consumption PBS's such as Tangail, Narsingdi, and Jessore I. The variation in consumption per hookup depends on the agricultural regime and average command area rather than on the type of pump used.

Cost of Supply and Alternatives

As a percentage of total annual REB electricity consumption, irrigation accounts for 25%, the comparable figure for the BPDB is only 8%. However, the concentration of this load in the period from February to May means that REB system-wide demand increases by 80% to 100% and irrigation accounting for nearly half the total. This load is spread throughout the day and evening and does not have a significant weekly variation. The load is largely reactive due to the predominance of motors in the makeup of the demand, however, switchable capacitors have been introduced to improve the power factor. Some of this load was taken over from BPDB but a considerable amount is the result of expansion of the grid throughout the agricultural areas. Because of the physical isolation of the loads and the peaking of consumption, irrigation is the most expensive demand to serve.

The current tariff for irrigation is Tk. 1.95-2.05 per kWhr. This is the lowest rate other than the domestic charge, despite the high cost of serving this demand. It has been recommended that a differential time of day charge be introduced to shift this demand away from the early evening hours, but this would require the installation of new meters. It is also possible to introduce increasing block rates, as is done in India, in order to improve efficiency and to foster irrigation water markets that favor the smaller land holders. The only alternative source of energy is the diesel power as discussed above.

Table VII.X1

Area Irrigated by Different Methods

(Acres)

Year	Power Pumps	Tubewells	Doons	Swing Baskets	Canals	Others	Total
1975/76	1,363	262	967	143	229	491	3,457
1976/77	1,232	233	728	161	265	381	3,003
1977/78	1,370	314	980	154	265	473	3,588
1978/79	1,434	396	961	171	246	452	3,661
1979/80	1,535	446	977	181	301	430	3,872
1980/81	1,645	547	911	205	371	368	4,049
1981/82	1,739	669	880	212	403	358	4,264
1982/83	1,844	1,017	726	209	396	372	4,566
1983/84	1,647	1,648	588	206	331	322	4,744
1984/85	1,681	2,171	454	195	364	254	5,121
1985/86	1,504	2,379	421	206	403	269	5,183

Table VII.X2

	Irrigaged Area As % of Cultivated Area (1985/86)	Fertilizer use (lbs/acre) on cultivated Land (1985/86)	HYV Cereal of Total Cereal Area (1986/87)	Cropping (1985/86)
Chittagong Div.	27.6	113.9	42.9	152.4
Chittagong	45.0	177.2	75.9	153.4
Ctg. Hill Tracts	16.8	157.2	73.3	123.0
Noakhali	9.4	87.5	48.3	154.9
Comilla	32.3	179.1	29.6	167.5
Sylhet	27.3	45.9	24.6	141.5
Dhaka Division:	26.8	140.6	34.7	164.3
Dhaka	26.1	224.5	34.1	137.7
Kishoreganj	42.6	133.6	44.4	161.5
Mymensingh	28.8	128.5	42.9	184.0
Tangail	35.0	148.6	32.0	171.4
Faridpur	9.1	71.8	16.0	183.1
Rajshahi Division:	25.0	133.8	34.8	158.9
Rajshahi	22.5	101.3	31.9	132.3
Dinajpur	15.9	100.8	32.4	136.2
Rangpur	27.1	104.3	35.3	191.9
Bogra	45.9	280.6	46.2	184.5
Pabna	21.7	180.4	29.3	157.1
Khulna Division:	15.8	74.5	18.4	139.7
Khulna	7.2	57.2	12.6	131.0
Barisal	9.8	46.8	11.5	146.6
Patuakhali	2.0	14.4	5.0	140.6
Jessore	23.7	93.4	26.0	135.2
Kushtia	41.5	186.5	38.9	149.2
Bangladesh	24.0	117.7	33.2	154.5

Source : Chowdury, Agricultural Sector Review, Volume I - estimated from BBS data

Source: Estimated from BBS Data.

Annex VIII

SURVEY ON HOUSEHOLD WILLINGNESS-TO-PAY

Prepared by

By: Dr. M. Asaduzzaman
Senior Research Fellow
BIDS, Dhaka

A Report on the Development of an Instrument to Understand Consumer's Willingness to Pay for Rural Electrification

1. The Principal Investigator (PI) was contracted to develop a survey instrument for understanding some of the issues related to willingness-to-pay (WTP) for electricity. The basic hypothesis was that WTP reflects the utility derived by a person from rural electricity. If they are ready to pay higher charges, they must derive higher utility, it is argued. There are, however, several factors that may condition the WTP. One is the ability to pay which may be represented by surrogate variables like income or assets. The perceptions of the (potential) customer with regards to the uses of electricity may also be a factor. These perceptions are themselves a function of education and contact with the outside world. The availability of substitute fuels/energy is also likely to influence WTP. Finally external environment, as typified by the general level of development in the area, may be a factor either because of changes in perception that it brings or because that it raises the problem of "keeping up with the Jones."

2. With these factors in mind, a TOR was developed which drew up a tentative list of questions to be tested or probed. These were:

(a) the current price paid for both capital investment in house wiring and appliances;

(b) the current level of consumption and price paid for energy;

(c) the anticipated response of the user to an increase in energy prices;

(d) the reason that the user does not increase consumption at the current level;

(e) how the user responded to earlier increases in electricity.

3. A questionnaire was prepared to develop an instrument for answering these questions and testing the hypotheses (see Annex). As laid down in the contract, the questionnaire was based on a survey instrument used in Pakistan, but modifications were made to reflect conditions in Bangladesh.

4. The pre-testing was carried out in two places, vis., Kaliakoir Upazila under Dhaka PBS - 1 and Jamalpur Sadar Upazila under Jamalpur PBS. The former represents a comparatively developed area where electricity became available in 1984 while the latter is economically less developed in which electricity became available only in 1986. In Kaliakoir, 4 electrified and 4 non-electrified households were investigated. In Jamalpur the numbers were 3 each, thus making a total of 7 electrified and 7 non-electrified households.

Findings/Discussion

5. Generally little or no problem was found in approaching the households and eliciting information. Observations for individual questions and their problems are summarized as follows.

6. (i) People can remember when they first connected their houses but not exactly when electricity became available in the village.

(ii) The source of energy used by type of use is not difficult to ascertain but among the uses, radio, TV, and two-in-one should be mentioned separately while the sources of energy such as 'coal' and 'battery' (rechargeable) should be grouped under the "other" category.

(iii) Among the appliances in use, light bulbs and electric fans are most common followed by radio-TV. Wattage is difficult to determine except for lighting, although the information on brand and model of equipment is readily available. Probably this information can be used to find out the "wattage", but this does not appear to be a critical question.

(iv) Battery use is limited to flashlight batteries (see ii above.) Hence the detailed questions on batteries may be omitted. Alternatively, the question may be asked only if rechargeable batteries are used. In this situation, their cost, recharging costs, travel time or difficulties may be determined.

(v) On household activities between meals and sleep, the universal response seems to be that there is really not much to do. The maximum time the household remains awake after meals is an hour t most. They really have to get up early in the morning, hence, people go to sleep early. Electricity really does not change this behavior much.

(vi) On the expenditure made at the time of first connection, the total expenditure is recalled without much difficulty but the breakdown by connection, wiring, etc. is difficult to recall. In any case, it is the total cost which is of concern to the consumer. On the other hand, an advance (refundable security payment) is required to guard against non-payment. Possibly this money should be treated separately and explicitly.

(vii) Whether a 50% increase in price would be borne by the consumer for getting a connection seems a bit difficult for people to answer. We got a mixture of responses. But in the case of the developed area (Kaliakoir), people are more definitively in favour of electrification even at higher cost.

(viii) The relationship with inflation and with level of development becomes clear when people are asked if they would pay 50% more for connection now. Jamalpur people seem to be hesitant, but Kaliakoir people would favor electrification, especially since inflation since the introduction of electricity has exceeded 50%.

(ix) On the maximum that may be paid now, some are not sure; while for some others 50% extra seems to be the limit. It is proposed that one should ask whether any more than 50% additional cost would be paid, and if so, how much more.

(x) Some of the respondents were not sure why they had bills above average in certain months while others can trace the reason (ramadan, marriage).

(xi) In the more developed area, the general response to the question about an increase in monthly bills of up to 50% was that it would not bring much of a change in consumption. In the less developed area, the response was more negative.

(xii) The extent of the reduction in electricity consumption which would result in a price increase was difficult to assess. So was the response to the question regarding an upper limit on cost at which point the connection would be disconnected. Also, when people talk of disconnections, they do not think that it would be done immediately, but rather that they would try to bear the cost as long as they could.

(xiii) The question of the response to a reduction in price elicits more animated response. Most would increase consumption mainly by using more bulbs and purchasing fans, if they can.

Non-Electrified Households

(i) That willingness to pay may be related to general development is again borne out by the fact that practically all who have electricity in Jamalpur village have had it since the time electricity was introduced in the area. Not many obtained it later on. In the case of Kaliakoir, the respondents have obtained connection at different times.

(ii) The cost for alternative fuels for the most important use, lighting, appears to be a major determinant of willingness to connect in the un-connected households in the economically depressed area. This appears to be less strong a reason in Kaliakoir but is not completely absent from people's mind.

A Questionnaire on
Domestic Consummers Willingness to Pay for RE

Village: Unions:

Upazila: District:

PBS:

Date of Interview:

1. Name of head of household:

Age:

Education:

Main Occupation:

Secondary occupation:

2. Do you have electricity connection in your house?

Yes ____ No. ____

3. a) Year electrification began in village?

b) If yes to (2) above, when did you have the connection?

4. Type of fuel by type of use (tick only)

Fuel type	Cooking	Lighting	Iron	Fan	Pump/motor	Other
Fuelwood						
Twigs/leaves						
Straw/Jute						
Sticks						
Cowdung						
Kerosene						
Diesel						
Charcoal						
Coal						
Electricity						
Battery (Small)						
Battery (Rechg)						
Others						

5. a) Did you experience any shortage of kerosene in your area during the last one year?

Yes ____ No. ____

b) If yes, when was the last time it happened?

_____ months/days ago.

c) Could you manage to buy the amount you normally purchase during that period?

Yes ____ No. ____

[(If yes, continue: If no, go to (e)]

d) If yes, what was the maximum price you had paid?

Tk. _____ per bottle/kg./seer

e) If not, how did you make up for the shortage ? (tick)

Using less kerosene than usual

Using more of electricity

Using other fuels: which?

f) Has there been any change in the normal quantity of fuel use in the household last month?

Yes ____ No ____

g) If yes, which one did you use more ?

Why?

Which one did you use less?

Why?

6. **Do you use the following appliances ? If so, give details:**

Appliance	Year of purchase	Source of power	Wattage	Hours run within last 24 hours	If not used if willing to	When?
Refrigerator						
Radio/two-in-one						
TV						
Iron						
Fan						
Heater						
Others (specify)						

7. a) Do you use batteries for running any of these appliances

Yes ____ No. ____

b) If yes, how many, type and what for

Type	No.	For
Small (F.L.)		
Medium		
Large (Rechg.)		

c) If, batteries are not in use whether willing to purchase them, and if so, their no. intended and use by type:

8. a) What did you and your family members do last night after meal but before sleep: (tick)

Study	Sewing
Watching TV	Washing up
Listen to radio/ two-in-one	Livestock care
Gossip	Others (specify)

(b) Are these your normal activities during that time every evening ?

Yes ____ No ____

FOR ELECTRIFIED HOUSEHOLDS

9. a) When from did you start using electricity in your household?

_____ (month of) _____ (year)

(b) How much did you spend for your connection and other charges:

For connection: Tk.

For wiring: Tk.

Others (specify): Tk.

Total: Tk.

Let X = Total connection cost X 1.56

c) If you were charged Tk. X at the time you did have connection, would you still have decided in favour of connection?

Yes ____ No ____ Not sure _____

(d) If not, would you have requested for connection at Tk. X charge now?

Yes ____ No ____ Not sure _____

e) If yes (for connection now), what is the maximum you may pay for connection at present?

Tk. _____

10. What in your view are the most important uses of electricity (rank in order of decreasing importance starting with the most)

i. _____

ii. _____

iii. _____

11. a. During the last one year, what has been your average electricity bill per month?
(see the bills, if necessary)

Tk. _____

b) What is the maximum bill you have paid in a month during the last one year?

Tk.

When?

Reason for higher bill:

Let Z = Average monthly charge X 1.5 = Tk.

12. a) If your monthly bill now becomes Tk. Z how would you react to that ?

Disconnect

Reduce consumption

Defer purchase of appliances

No change

b) If 'disconnect' is the response, what is the additional monthly bill that may be paid before deciding to disconnect.

_____ % or Tk. _____

c) If the response is reduction of consumption, what are the uses of electricity where the cut back will be made? (First three in order of importance)

_____

_____

_____

d) If consumption is reduced, in what manner will the expenditure be affected?

Shall try to keep expenditure unchanged:

Lower consumption but expenditure may still rise somewhat:

If expenditure still rises, by what percentage it may rise ?

_____ %

e) If 'defer purchase of aplliances' which ones will not be purchased?

f) If 'no change in consumption', upto what level of expendi ture will there be no change?

Tk. _____

13. a) How would you respond if your monthly charges are lowered by 25% than at present?

No change

Increase consumption: In which use?:

Buy new appliances: Which ones?

FOR NON-ELECTRIFIED HOUSEHOLDS

9. How far is the nearest household with electricity?

_____ yards/metres

10. How far is the nearest electrcity pole?

_____ yards /metres

11. a) Why do not you have electricity?

No necessity (go to b)

Not available nearby

Costly (go to c)

Others (specify)

b) Please explain why you may not need it?

c) If costly, why so?

Connection and wiring charges are high

Monthly charges are high

Appliance costly

Others (specify)

d) How much one has to pay for connection and wiring charges?

From households with electricity

Common knowledge

Guess

Others (specify)

e) Any idea about monthly charges or use?

_____ Kwh

_____ Tk.

Source of information:

From other consumers

REB

Common Knowledge

Guess

Others (specify)

12. a) If you are given connection and requested to pay the whole charge at a time would you be ready to pay?

Tk. 1000 ?

Tk. 800 ?

Tk. 600 ?

Tk. 400 ?

Tk. 200 ?

Tk. 100 ?

b) If you are allowed to pay in monthly installments, what is the maximum you would pay?

Tk. _____

13. a. If you had electricity what would you have used it for?

i. _____ (most important)

ii. ----- (2nd most important)

iii. _____ (3rd most important)

b. What is the maximum you may pay for (i) ?

For (i) + (ii) ?

c) Generally ?

Suggested Modifications to the Questionnaire on the Basis of Pretesting

General Part

Q. 4. Make explicit mention of TV, Radio/Two-in-one among uses Take out 'Coal' and Battery (rechargeable)

Q. 5. Add 5(h). Present price of kerosene? Present price of a kupi

Q. 6. Take out 'wattage' 'Ask 'brand and 'model' instead.

Q. 7. b) If batteries are in use, add another column for 'cost of purchase/hire' and 'cost of recharging'.

In case of recharging further ask the cost of travel, distance travelled.

Also, the length of time batteries have been in use may be asked.

Electrified Household

9. (e) May be modified as

9 (e) Would you still consider getting a connection, if you have to pay more than Tk. X.

Yes _____ No _____

9 (e) If yes, upto how much more you think is reasonable ?

Tk. _____

Non-electrified household

Add 11 (c) 'Costly compared to kerosene' in the list of likely responses

Annex IX

TECHNO-ECONOMIC ASSESSMENT OF DIESEL VERSUS ELECTRIC SOURCES OF MECHANIZATION

BRTC - 500/89-90

Submitted by

Institute of Appropriate Technology
BUET, Dhaka
September 11, 1989

227

Techno-economic Assessment of Diesel Versus Electric Sources of Mechanization

INTRODUCTION

Productive uses of electricity in the rural areas are the key to the viability and success of the rural electrification program and fundamental for a rural-based economy. In Bangladesh, the main thrust of rural electrification is to affect rural development through use of electricity in productive sectors as well as giving opportunities for better social life. According to the power use plan of Bangladesh Rural Electrification Board (REB), utilization of electric services in irrigation and in rural industries are among the priority areas of power use. It is therefore imperative to convince rural people about the potential benefits of energy substitution through electrification for diesel or gasoline in their various productive uses.

It should be noted that apart from the economic factors, there is a need to consider a variety of non-economic factors in any realistic analysis of energy alternatives. Various energy-based differ from each other in terms of technological, social, environmental and economical characteristics. It is important to consider these aspects in deciding on policy issues relating to the assessment and adoption of these technologies. With this aim in view, the present study has been limited to a techno-economic assessment of shaft power provided by either diesel engines oir electric motors for use in irrigation and rural industries.

Scope of the Study

The scope of the present study has been delineated as follows:

(a) Compilation of data/information on capital costs, fuel consumption, costs of the operation and maintenance, normal utilization and life expectancy of various size diesel engines and electric motors;

(b) Preparation of performance requirement matrix for different productive activities and performance characteristics matrix for diesel and electric motors in order to ascertain their appropriateness from a techno-economic view point.

Methodology

For the purpose of the present study, three sample surveys have been undertaken as follows

(a) A market survey to collect cost data for different size engines and motors from the suppliers in Dhaka market area;

(b) A user's survey to generate data/information on the relative addvantages/disadvantages of diesel engines and electric motors used in irrigation and in selecting industries; and

(c) An informants survey regarding preferences for the different physical characteristics of diesel engines and electric motors under various productive uses based on expert opinion.

All three surveys have been conducted using a predesigned questionnaire Methodologically, this type of survey is not wholly normative but rather based on a participatory approach. Secondary sources of literature have also been reviewed for comparison and relative assessment.

Data/information/expert opinion generated for the study have been processed, analyzed and finally tabulated in a format desired for the textual presentation in line with the the project's Terms of Reference (TOR).

DEMAND FOR MECHANISED SHAFT POWER: DIESEL ENGINE

Diesel engines are used in Bangladesh as a source of shaft power for a range of machinery and equipment. The major current use of engines is for irrigation. During 1981 about 73% of the population of engines in the country (about 1,74,000) had irrigation as their main use (BSEC-Market Survey, 1983). These engines are often put to other uses, such as driving threshers, rice hullers etc., when not in use for irrigation. The majority of engines in use in Bangladesh have horsepower in the range 5-9 HP (about 40% of the total population of engines) and 12.5-18 HP (about 26%). This reflects the size of engines required for minor irrigation schemes in Bangladesh.

Shallow tubewells irrigation typically uses engines of 5-6 HP. LLP typically uses 8 HP (1 cusec pump) and 16 HP (2 cusec pump) and DTW typically uses engines of 22 to 31 HP. Both water and air cooled engines are used for

irrigation. The average annual requirement for diesel engines for irrigation and the potential for substituting electric motors IN 1985-90 are shown in Table 1.

The BSEC and World Bank in Table 1 are based, *interalia*, upon investments and replacement requirements to meet agricultural production targets as well as availability of surface and ground water. However, the impact of rural electrification on the scope for substituting electric motors for diesel engines in irrigation has also been taken into account.

Apart from irrigation, rural industries (small scale) offer increased opportunity of using shaft power provided by electric motors. Considering the present market demand for diesel engines for irrigation and the increasing number of rural industries (estimated 10% yearly growth rate), the scope for substituting electric motors for diesel engines is quite high if the electric motors prove to be techno-economically more advantageous.

PRODUCTIVE ACTIVITIES SELECTED FOR THE STUDY

Four different types of productive units were visited and a set of data/information on shaft power use have been generated. The following presentation discusses briefly each of the productive units.

Rice Mill

There are different types of rice milling technologies. Among these Engleberg type steel huller is the most common mechanized rice milling technology in Bangladesh. It consists of a cast iron roller with ribs at its periphery which rotates in a housing with a metallic sieve. The housing contains the paddy for milling. Dehusked and polished husk and bran pass through the sieve leaving milled rice to come out at the end of the roller and housing.

There are three sizes of huller. The biggest size is No. 2 huller with milling capacity of 0.5 - 0.75 tons/hr. The next size, the No. 8 huller has a milling capacity of 0.35 - 0.5 tons/hr. The smallest one is the No. 4 huller which has a capacity of about 0.3 tons/hr. The No. 2 huller is used in industrial scale mills where rice processing is done commercially. The other two sizes are used primarily in mills owned by individual farmers.

Table 1

Substituting

Average Annual Requirement for Diesel Engines for Irrigation and Scope for Electric Motors During 1985-90 Based on BSEC and World Bank Estimates

	Average Annual Requirement (1985 - 1990)					
	BSEC			WB		
	Diesel Engine	Electric Motors	Electric Motors as percent of Diesel Engine	Diesel Engine	Electric Motors	Electric Motors as prercent of Diesel Engine
5-12 HP Engines						
STW & 1 cusec LLP	24,000	3200	13.1	44,000	600	1.4
12-17 HP Engines						
LLP (2 cusec)	3,380	800	23.7	11,000	980	8.9
18-25 HP Engines						
DTW	3,600	260	7.2	5,080	1240	24.4

Source: BSEC Market Survey on Diesel Engines, April, 1983. Planning Commission, Bangladesh Minor Irrigation Sector, A Joint Review by the Government and the World Bank.

Rice mills are mainly powered by diesel engine and electric motor. The No. 2 huller is driven by a 20-30 HP prime mover. The other two sizes are equipped with smaller HP prime movers ranging between 10 and 20 HP depending on the capacity. It should be noted that these hullers are usually equipped with more power than needed for themillingin order to prevent jamming and insure the safety of the prime mover. This is specially true if the prime mover is an electric motor.

Rice milling is a seasonal activity. The harvest twice is the peak season of rice milling but milling continues at a lower rate throughpout much of the year. In peak season, the mills run on average of 10-12 hours a day. However, average utilization of these mills throughout the year is about 4-5 hours a day.

The rate charged for milling is higher for diesel engine mills than for electric-powred mills. Diesel engine mills charge Tk. 8/- per maund[1] of paddy while electric motor mills charge Tk. 6/- per maund of paddy.

Saw Mill

The Saw mill is a mechanized technology for cutting and sawing tree logs into useful sizes. A steel band saw is used. This saw rotates vertically around two wheels. Mechanical power drives the lower wheel. The saw passes through a horizontal table fitted in the column in between the wheels. One end of the log is placed on the table and manually fed forward by two operators pushing and pulling at either end.
The capacity of a saw mill is determined by the maximum thickness of the log it can handle. This varies from 18-30 inches. The maximum longitudinal size of a log that can be handled by these mills is 6 feet. The output is used mainly for the construction and furniture industry. Saw mills are generally equipped with 15-30 HP electric motor. It is reported that there are diesel engine powered saw mills in the timber rich areas where electricity is not available. However, the number of such saw mills is small.

Saw mills are busiest in the dry season. Average running hours in dry season is about 6-8 hours a day whereas the yearly average running hour is about 3-4 hours a day.
Small Engineering Workshop

[1] 1 maund = 37.3 kg

Small engineering workshops using include common machine tools such as lathes, drill presses, grinders, and electric arc or gas welding machines. These workshops are suitable for making simple mental parts for agricultural implements, automobile parts, metal grills and furniture, etc. They are mostly custom order workshops.

The equipment used in these engineering workshops are typically operated by electric motors, usually 1-3 HP. Diesel engines are rare.
Because of their custom order product line, small engineering workshops are busy in dry seasons when the demand for construction and transport activity is high. These workshops are run by semi-skilled technicians some of whom posses formal technical training.

Irrigation Scheme

Irrigation in Bangladesh is done by individual farmers and or by farmers' cooperatives. In the former case, traditional non-mechanised technologies are commonly used to irrigate small plots. In co-operative irrigation systems, a mechanised pumping set is installed at a suitable location in the operated area and the pumped water is distributed in the lands of the co-operative members through a network of channels.

Water is pumped either from surface or ground water sources. In case of surface water, 1-2 cusec, centrifugal-type low lift pumps (LLP) are used. These are driven by 15-20 HP prime movers. For ground water pumping, two types of pumps areused, shallow tubewell (STW) and deep tubewell (DTW). For STW, 0.5 cusec centrifugal pumps are used where water is available up to 20-25 feet below the ground. These pumps are run by about 10 HP prime movers. For DTW, the water is extracted from 60-80 feet below the ground using turbine pumps. These pumps usually have a 2 cusec capacity and are driven by 25-30 HP prime movers. Both STW and DTW pumps are run by either diesel engine and electric motor.

COMPARISON OF PHYSICAL CHARACTERISTICS AND COST DATA OF DIESEL ENGINE AND ELECTRIC MOTOR

The results of a market survey of the physical characteristics and costs of diesel engines and electric motors ranging between 1 to 30 HP, are summarized and presented in Table 2. The names and addresses of the suppliers/marketing agents isgiven in the attachments.

For comparative horsepower, electric motors are more compact than diesel engine. The weight to power ratio for diesel engine is in between 10-17 kg/HP. While for electric motors the ratio is between 7 and 10 kg/hp. The life expectancy for diesel engines varies between 8 to 20 years depending on make and size whereas the life expectancy for electric motors varies between 15 to 20 years irrespective of make and model. Diesel engines require overhauling at least 4 times in a year ifused regularly but electric motors require overhauling only once in 5-7 years of its operation.

From Table 2 it is evident that investment cost for a 2 cusec capacity pump with diesel engine is Tk. 36,000 which is double the price of the same pump with an electric motor. For smaller pumps of 1 cusec capacity, the investment cost is in between Tk. 12,000 to Tk. 16,000 for both electric and diesel powered pumps. The cost for the pump (exclusive of prime mover) is in between Tk. 2500/- to Tk. 4000/= depending on capacity (cusec.)

For equal pump capacity, the annual operating cost in the case of diesel engine system is 1.25 to 1.5 times higher than for an electric motor system. The annual operating cost for a 1 cusec diesel pump is between Tk. 32,000/- to Tk. 35,000/-. An electric 1 cusec pump the operating cost is much lower ranging between Tk. 24,000/- to Tk. 25,000/-. The energy cost for both the sources of shaft power does not differ significantly. For diesel engine the energy cost is about Tk. 25,000/- per annum whereas for electric motor it is about Tk. 23,000/- per annum. As regards lubricating cost, the difference is very sharp. For a 1 cusec diesel pump, the lubricating cost is about Tk. 1500/- per annum, while for electric pump, the lubricating cost is only Tk. 72/- per annum. Maintenance cost for diesel and electric pumping systems also differ significantly. For diesel, they are estimated to be Tk. 6000/- to Tk. 8000/- per annum versus Tk. 600/- to Tk. 1000/- per annum for electric pump.

Basic of Cost Estimates:

(a) Investment costs is the price of equipment and their auxiliaries like speed control or switching as provided by the suppliers/marketing agents. It may be noted that the investment cost under consideration does not include the cost for civil works.

(b) Operating cost calculated for an irrigation pump system is based on the following assumptions:

(i) Pumping system works 16 hours a day with two paddy growing seasons for a total of 180 days in a year.

(ii) The brake horse power for 1.0 cusec pump is 5.5 hp and for a 2 cusec pump 14 hp. The operating costs include fuel, lubricating oil, and repair and maintenance. The cost for diesel, electricity, lubricating oil, and grease are computed at the prevailing market prices.

PERFORMANCE REQUIREMENTS FOR DIESEL ENGINE AND ELECTRIC MOTOR FOR DIFFERENT APPLICATIONS

A survey was carried out on selected productive units to determine the priorities assigned to different performance requirements of shaft power by the owner/operators of these units. The owners/operators were asked about their requirements for different performance characteristics of shaft power. The performance characteristics and the scale for their priority were fixed beforehand.

The priorities given to different characteristics in the different end uses are presented in Table 3. The productive units were from the agricultural and industrial sectors (rice mills, saw mills, small engineering workshops and DTW irrigation scheme). All these units had electric prime movers except for one rice mill which was powered by diesel engine. A list of these enterprises is given in the attaachment.

The average score for different performance characteristics across the surveyed units is shown in Table 3. It can be seen from data in the table that need for certain performance characteristics such as variability of speed, seasonal alternative application and mobility for other uses are not important. However, performance characteristics such as ease of operation, ease of repair and safe operation are very important. Precise speed control, ability for quick on/off, reliability, size, clean operation and safe energy source are less important. Alternative uses of prime movers are even less important but this isdue to the semi-urban nature of the market sureyed. Altenrative uses are thought to be more important in the rural areas.

The total score for these performance characteristics is between 28 and 42 which implies that these characteristics wee either important but not essential or 'useful' to the respondents.

TECHNICAL PERFORMANCE CHARACTERISTICS OF DIESEL ENGINE AND ELECTRIC MOTOR

An informant survey was conducted to determine the technical of diesel engines and electric motors. The technical experts were asked to give their evaluation of the different performance characteristics using a 1-10 score scale where 1 refers to very poor performance and 10 refers to excellent performance. The names and addresses of the experts from whom opinion was sought is given in the atachment.

The results are summarized in the performance matrix for diesel engines and electric motors presented in Table 4. The average scores for each expert on all characteristics is shown in the last row of Table 4. Table 5 presents the average score given by each expert on the overall performance characteristics of diesel engine and electric motor for the different application. For all applications, the experts prefer the electric motor to the diesel engine. The averge rating from each of the three experts shows an identical preference for electric motors over diesel engines. The diesel engine received about 6 points and electric motor about 8 points in the 1-10 score scale of importance.

The performance of diesel engine and electric motor with respect to individual technical considerations is shown in Table 6 where the average judgement of the three experts is presented for different end uses. On variability of speed, the performance of diesel engine is near to excellent while that of electric motor is poor. The reverse is truefor clean operation. For precise speed control, ease of operation, ease of repair, compactness and ease of installation, the score for diesel engines is average while that for electric motors is close to excellent. For low speed-high torque, high speed, precise speed control, reliability of input energy, safety of operation, safety of energy source and mobility for other uses, both are considered equally good. A summary performance matrix for these characteristics is presented in Table 7 using a simplified rating scheme.

Table 2

Physical Characteristics and Cost Data for Diesel Engines and Electric Motors

Type of Engine/ Motor	Size (HXLXW) (mm)	Weight (kg)	H.P.	R.P.M.	Life (yrs)	Frequency O/H (No. of times/yr)	Pump Capacity (Cusec)	Cost w/out pump (Tk)	Investment w/ pump (Tk)	Yearly Operating Cost with Pump (Tk) Energy Cost	Lubricating Oil Cost	Mainten. Cost	Total Cost
Diesel Engine	1120X1086X550	410	24	1500	15-20	4	2.0	32000	36000	66074	6000	10000	82074
Diesel Engine		145	13	2000	8-10	4	1.0	10700	13200	25274	1440	8000	34714
Diesel Engine	618X814X480	140	12	2000	8-10	4	1.0	10800	15500	25274	1728	6000	33002
Diesel Engine	995X1000X530	269	12	1500	15-20	4	1.0	17000	19500	25274	1440	6000	32714
Electric Motor	450X750X500	215	30	1500	15-20	0.14	1.0-2.0	10900	13400	23633	72	1000	24705
									14400	60157			61229
Electric Motor	370X680ZX450	160	20	1500	15-20	0.14	1.0-2.0	14100	16600	23633	72	857	24562
									17600	60157			61086
Electric Motor	380X640X450	145	15	1500	15-20	0.14	1.0	13700	16200	23633	72	785	24490
Electric Motor	330X550X380	95	10	1500	15-20	0.14	1.0	10100	12600	23633	36	642	24311
Diesel Engine	480X715	X350	107	7.5	1500		1.0		25000				
			10.5	2000			1.5						
Diesel Engine			14	3000			1.0	30000					
							1.5						

Source: Market Survey 1989

Assumptions:
1. Pump is used for Irrigation Purposes. Works 16 hrs/day and 180 dys/yr
2. Brake horse power for 1.0 cusec pump = 5.5 hP; cusec pump = 14 hP
3. 1 Liter of Diesel = .8 kg
4. Price: Diesel Tk. 6.90/litre
   Lubricating Oil, Tk.120/gal
   Grease, Tk.24/lb
   Electricity Tk 'kwhr

Table 3

Technology Preference Score Given by Owners/Operators

Type of Industry	Rice Mill		Saw Mill		Engineering Workshop		Irrigation Scheme
	Diesel	Electric	Diesel	Electric	Diesel	Electric	Electric
Performance Characteristics							
Speed Variability	5	5	5	5	5	5	5
Precise Speed	1	1	5	1	1	1	1
Ability of Quick On/Off	1	2	1	2	1	1	3
Reliability	4	1	2	1	4	2	1
Ease of Operation	1	2	1	1	1	1	1
Ease of Repair	1	1	1	1	1	1	1
Size	5	4	2	2	1	1	2
Clean (No Exhaust Operation	2	3	3	3	1	1	4
Alternative Uses	3	3	4	4	4	3	5
Semi-Permanent Applicat	4	3	1	4	1	1	5
Seasonal Application	5	5	5	5	5	5	5
Mobility for Other Uses	5	5	5	5	5	5	5
Safe Operation	1	1	1	1	1	1	1
Safe Energy Source	1	1	1	1	2	4	1
TOTAL SCORE:	39	37	37	36	33	32	40

Source : Field Survey 1989

1 = essential, importnat but not essential, 3 = useful, 4 = desirable if no additional cost, 5 = not needed

129

Annex X

DECISION-MAKING IN SELECTION OF ENERGY SOURCE

Prepared by

Bangladesh Center for Advanced Studies
Atiq Rahman

Table 1

	Name of Industry	Type	Products	Energy	Size of Engine	Employ	Date of Establish-ment	Investment	Existence Prior Electricity	Source of Technolology	Credit Source	Used PDB Before
1.	Madhya Bazar Rice Mill	Rice Mill	Rice & Flour	Elect-ricity	20 HP	2	1983	70,000/-	No	Father	Father's money or from another Rice Mill	No
2.	Diesel Rice Mill	Rice	Do	Diesel	17 HP	2	1987	50,000/-	Yes	Brother (Khulna)	Brother's	No
3.	MV. Faroquee	Intending Industrialist waiting for Re connection										
4.	Babul Saw Mill	Saw Mill	Wood+ Rickshaw body	Elect-ricity	20 HP	4	1985	82,000/-	No	Friend in Sylhet	Land Sold & Father-in law	No
5.	-	Engg. Workshop	Window grills	-do-	2 HP	2	1989	20,000/-	No	Technical School in Dhaka	Father Sold Land	Yes (PDB land)
6.	Bismillah Saw Mill	Saw Mill	Wood & Timber	-do-	20 HP	4	1986	90,000/-	No	Previous Business	Bank Loan & informal credit	-do-
7.	Profullah Chandra Pal	Pottery	Pottery	Human Labour	-	4	Traditiona Business	8,000/-	N.A.	Family Business	Self	N.A.
8	Tamizuddi	Saw Mill	Wood	Elect-ricity	20 HP	2	1985	85,000/-	No	Friend	Sale of Land	No
9.	Tamizuddin	Icecream Factory	Icecream	-do-	7.5 HP 1 HP	2 +12 (Part-time)	1988	95,000/-	No	Daudkandi	-do-	No
10.	Habibur Rahman Rice & Oil Mill	Rice & oil mill	Rice, wheat & oil	-do-	30 HP	3	1987 (existing factory)	1.5 lakh	No	Existing	Brother's & Own Business	No
11.	Chandina Textile Mill	Twisting Mill	Twisting Yarn	Elect-ricity	15 HP 2 HP 1 HP 0.5 HP (7)	22	1985	23 lakh	No	Father's Yarn Business	Bank loan & own	No
12.	Jenin Cold Storage	Cold Storage	Preservation	-do-	80 HP 2.7 HP 2 HP 1.7 HP (47)	22	1982	2.5 crore	No	Another Business	Bank Loan	No

Table 1 (cont.)

13.	Bamboo Tooth Pick & Wood processing Industry.	Tooth Pick & Wood process	Tooth pick & wood	-do-	0.5 HP (25)	50	1984	Unknown	No	From Japan	Bank Loan	No
14.	Satata Engineering	Engg. Work-shop.	Window Grils & Agri. Equipment	-do-	2 HP 0.5 HP (2)	2	1980	51,500/-	No	Another Workshop (as an employee)	Land Mortgage & Borrow from Brother-in-law	Yes
15.	Dadu Silk Mills	Silk Mill	Clothes (Shart, Pent, Shree, Umbrella)	-do-	1 HP (25)	32	1985	60 lakh	No	Business	Bank Loan	No
16.	Md. Rowshan Ali	Weaving Factory	Longi	Human Labour	N.A.	2	1972	.2,000/-	N.A.	Father	Land Mortgage and own	No
17.	Narenda Dab Nath	-do-	Body Street	-do-	N.A.	2	1973	34,000/-	N.A.	Father	Land Mortgage	No

RURAL INDUSTRY SURVEY

DECISION-MAKING IN SELECTION OF ENERGY SOURCE

Close-ended Questions

1. Type of Industry

2. Products Produced by this Industry

3. Basic Source of Energy

4. If Mechanized

   a. Description of engine(s)/motor(s)
      i. size
      ii. age
      iii. expected life
      iv. country of manufacture
      v. where purchased
      vi. purchase price
      vii. purchased new or second hand
      viii. direct drive or belt drive
      ix. geared for multiple speed

   b. Description of operation
      i. period of use during day, week, year
      ii. hours used last month
      iii. average and maximum hours used per day
      iv. maximum hours of continuous use
      v. problems with overheating

   c. Cost of operation
      i. frequency of major overhaul
      ii. when was last major overhaul performed
      iii. what was the cost for major overhaul
      iv. how often are regular repairs required
      v. what is the average cost for these repairs per time
      vi. what was total cost for repairs in last six months (or since some identifiable event

vii. what was the cost for fuel/electricity last month
   (a) for fuel what is the consumption per hour or normal operating period
viii. what is the maximum monthly cost for fuel/electricity
ix. who operates the equipment
x. is this the operator's sole activity
xi. what is the wage for the operator
xii. total labor force and wage structure

d. Reliability of operation
   i. how often is the equipment unavailable due to failure of the engine/motor
   ii. what is the typical duration of the period of unavailability due to mechanical failure
   iii. how often is the equipment unavailable due to failure of energy supply
   iv. what is the typical duration of the period of unavailability due to lack of energy
   v. what repairs are normally performed by the operator
   vi. where is the mechanic that repairs the equipment located
      (a) distance
      (b) place (e.g. central market)
   vii. what are the repairs normally performed by the mechanic
   viii. is there backup equipment
   ix. is there a backup source of energy

5. Selection of Production Technology
   a. where did owner learn about production technology
   b. how did he select equipment
   c. how was size of engine determined
   d. how was gearing, size of pulleys, type of belt selected

6. Markets
   a. Where are products sold
   b. Where are raw materials purchased
   c. Is market growing
   d. Is competition growing
   e. If so, is the profitability of this activity threatened

7. Source of Finance
    a. what was the total cost for the production unit
    b. how was the purchase financed
        i. sale of land
        ii. borrowings from friends and relatives
            (a) interest
            (b) interest free
            (c) partnership
        iii. savings
        iv. supplier credit
        v. institutional credit

Open-Ended Questions

1. For Mechanized Industries that converted from non-mechanized processes

   a. What lead to this conversion
      i. saw technology used by others
      ii. cost of equipment was reduced
      iii. demand increased

   b. What were the benefits from this conversion
      i. improve product quality
      ii. increase production rate or capacity
      iii. reduce cost of production
      iv. diversify products
      v. reduce labor and simplify management

2. For Mechanized Industries - What are the relative advantages of electric over diesel or vice versa
   a. alternative technology not suitable for production process
   b. lower capital cost
   c. lower operating cost
   d. reliability of equipment
   e. reliability of fuel
   f. ease of operation
   g. better control

3. For Electrified Industries - What advantages are provided in addition to the use of electric motors
   a. lighting for extended hours of operation or better visibility in work area
   b. fans

4. For all Industries - Do you have plans for expansion of your activity?
   a. if not then why not
   b. if so what technology will you employ and why