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Economic Impact of Poor Power Quality on Industry

Bangladesh

Nexant

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List of Acronyms

ADB	Asian Development Bank
BPDB	Bangladesh Power Development Board
BUET	Bangladesh University of Engineering and Technology
DESA	Dhaka Electric Supply Authority
DESCO	Dhaka Electric Supply Co. Ltd
EIS	Economic Impact Study
ESCO	Energy Service Company
GDP	Gross Domestic Product
IPP	Independent Power Producer
MOEMR	Ministry of Energy and Mineral Resources
PGCB	Power Grid Corporation of Bangladesh Ltd
REB	Rural Electrification Board
SARI/Energy	South Asia Regional Initiative on Energy
SBG	Standby Generation
T&D	Transmission and distribution
USAID	United States Agency for International Development

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Executive Summary

Electricity, which is an essential requirement for economic and social development, plays an important role in the development of the Bangladesh economy. It is a main component in the efforts to reduce poverty, which is the overarching goal of the government. In Bangladesh, the power sector exists within a context of a low level of development and weak public sector institutions.

This study is intended to highlight the importance of active end-user participation in the decision-making process of the electricity supply industry. To achieve this goal, the study examined the economic impact of the quality of electricity delivered to the industrial installations in Bangladesh, including power interruptions, voltage fluctuations, and supply harmonics. The assessment consists of reviewing existing guidelines on power quality, analyzing poor power quality and its economic impact on a sample of industrial consumers, estimating self-generation costs and environmental impacts, and providing recommendations for power quality improvements.

The investigation was carried out using a detailed nationwide survey sample of industries consisting of 208 installations covering main categories of industries contributing to the country's gross domestic product (GDP) growth. The survey was based on a structured questionnaire administered during August through October of 2002. The study data used are based on responses to the questionnaire concerning fiscal year (FY) 2001.

Industrial sector losses attributable to unplanned electric power interruptions average 0.83 US$/kWh, while they are only 0.34 US$/kWh for planned outages. Thus the unplanned interruptions result in economic losses that are nearly two and one-half times those of planned interruptions. Further, voltage fluctuations can cause major problems in certain industries, such as tobacco manufacturing and chemicals, while others, such as the wood and cork industry, are completely unaffected.

The study found that the frequency of unplanned interruptions during the year averages nearly one interruption per day lasting about 2 hours. In contrast, the number of planned interruptions is about one in two months but with each lasting about 7 hours. Therefore, **94%** of the total unserved energy resulting from interruptions is due to unplanned outages, but only **6%** is attributable to planned outages. Overall, nearly **14%** of the industrial sector electricity demand cannot be met by the utilities due to planned and unplanned interruptions.

Further, these outages result in a substantial economic loss in the industrial sector amounting to US$ 778 million a year. This translates into **11.54%** of the industrial sector GDP or **1.72%** of the national GDP in 2000-01.

On average, **64%** of the industrial installations in the country have standby generation facilities. In almost all industrial installations surveyed, these standby facilities are diesel-oil fired. Assuming that the standby generation facilities are in operation throughout the grid supply outages, the additional financial burden on the industrial sector is estimated to be about US$ 4.5 million a year.

Although 95% of the participating industries felt that they over-pay for the quality of power they receive, 50% of the sample still would be willing to pay even more for higher power quality. Also, more than half of the sampled industries would have invested more in electricity-dependant industries if the quality of power supply were better.

The study also examined the prevailing regulations (Electricity Act 1910) as well as the recently enacted Electricity Regulatory Commission Act, 2003, with regard to power quality. Under the Electricity Act of 1910 the voltage levels and the system frequency are expected to be maintained within certain limits, and the Regulatory Commission under the Electricity Regulatory Commission Act is empowered to formulate codes and standards on the quality of service. These codes and standards, which have been drafted, will be reviewed and adopted by the Electricity Regulatory Commission for technical regulation.

The relatively high cost of unplanned outages in comparison to planned outages requires special attention to reduce the frequency and duration of unplanned outages and to convert such outages to planned outages whenever possible. The problem of voltage fluctuations, which cause a significant adverse impact on certain types of industries, needs to be seriously addressed. The standby generation level in the industrial sector is significant and is likely to increase in the future unless necessary measures are taken to reduce grid supply outages. Further, these future standby generation facilities are likely to be based on natural gas.

If the number of outages and the voltage fluctuations are reduced, a higher tariff is likely to be acceptable to important industries such as Tobacco, Wearing Apparel, and Leather Products. Further, the awareness of energy conservation measures in the industrial sector is extremely low at present, and implementation of an aggressive energy conservation program is needed.

To address these issues the following recommendation can be made:

- Strengthen end-user participation in the electricity supply industry and establish an environment for a regular dialogue between the end-users and utilities.
- Convert unplanned interruptions to planned outages where possible.
- Introduce an Interruptible Electricity Tariff to industries that can absorb planned interruptions without serious disturbance to their production processes.
- Strengthen ongoing South Asia Regional Initiative on Energy (SARI/Energy) initiatives on energy efficiency, such as energy services company (ESCO) activities and standard setting and labeling of end-use appliances.
- Implement measures to increase energy conservation awareness in the industrial sector.
- Introduce a well-planned load management scheme, particularly to reduce the system peak demand.

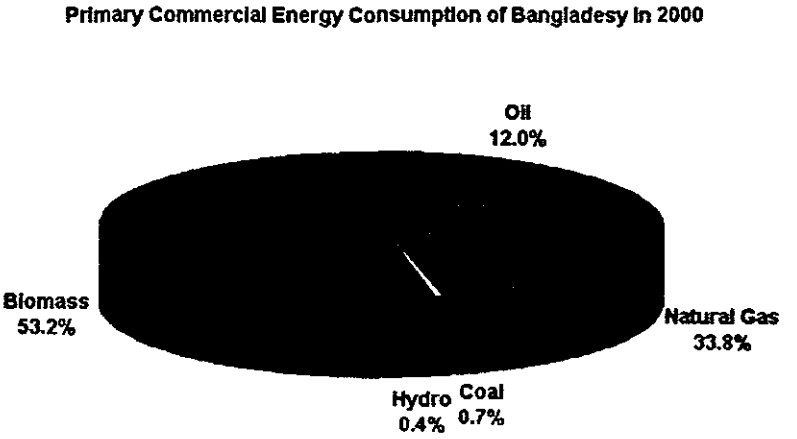
- Improve power system performance by timely and appropriate generation and transmission capacity additions, and distribution system improvements.

- Commission detailed technical studies in specific areas identified for performance improvement in the generation, transmission distribution, and supply of electricity. These studies can include activities, such as:

  - Examining ways to improve reliability of transmission and distribution network;
  - Analyzing the present electricity tariff structure and designing an interruptible electricity tariff for industrial and commercial consumers; and
  - Developing institutional and legislative frameworks required for aggressive implementation of energy efficiency programs in the electricity sector.

1.1 Energy Sector

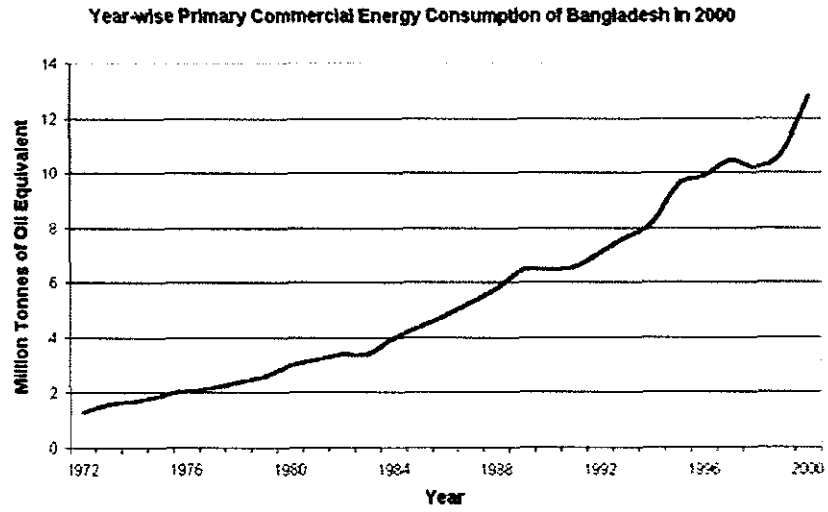
Bangladesh national primary energy supply is dominated by three main sources: biomass, natural gas, and oil. In addition, hydropower and coal also contribute to the energy supply on a small scale. The primary energy consumption in the year 2000 is shown in Figure 1.1



Source: Energy Web Site of Bangladesh (http:// shakti.hypermart.net)

Figure 1.1: National Primary Energy Consumption in Bangladesh (2000)

The overall energy consumption, which was approximately 13 million tons of oil equivalent in the year 2000, has been growing at a rate of about 7%; biomass consumption grew only around 1%, oil and natural gas grew at 7% and 8%, respectively. Figure 1.2 shows the growth of primary energy consumption over the years 1972 –2000.



Source: Energy Web Site of Bangladesh (http:// shakti.hypermart.net)

Figure 1.2: Growth of Primary Energy Consumption 1972-2000

1.2 Current Power Sector Structure

The power sector activities fall within the purview of the Ministry of Energy and Mineral Resources (MOEMR). The seven main institutions dealing with the power sector operations directly under MOEMR are given in Figure 1.3.

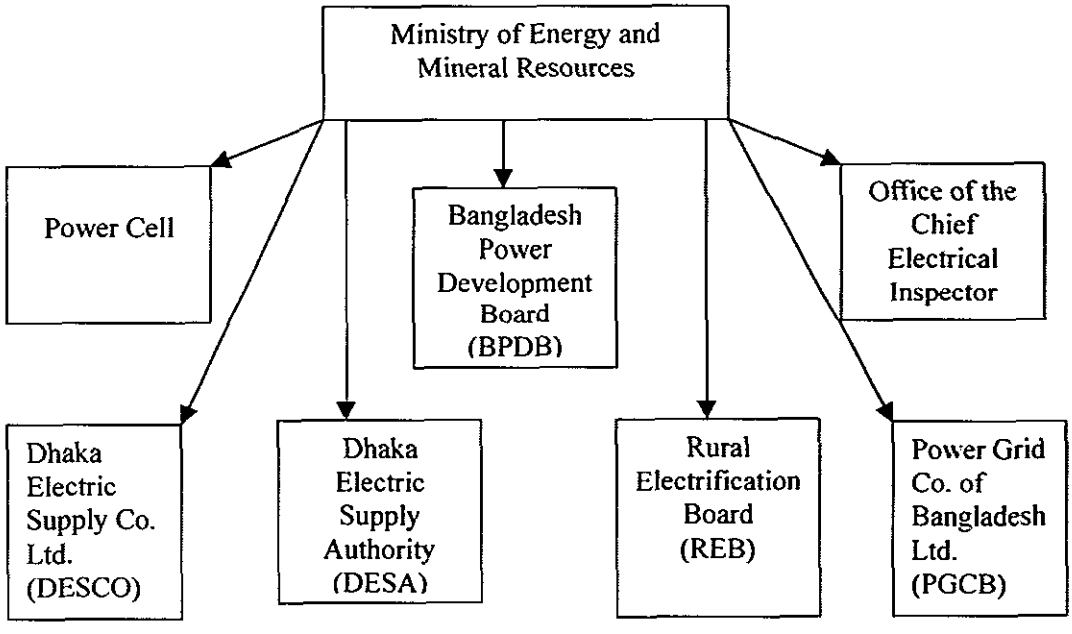


Figure 1.3: Institutional Arrangement in the Power Sector

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1.2.1 Bangladesh Power Development Board (BPDB)

The Bangladesh Power Development Board (BPDB) until 1972 was responsible for generation, transmission, and distribution of power throughout Bangladesh. After the creation of the Rural Electrification Board (REB) in 1978, the distribution of power in rural areas came under its purview, and BPDB's responsibilities were reduced to generation, transmission, and distribution in urban areas. With the establishment of Dhaka Electric supply authority in 1991 and with the introduction of Independent Power Producers (IPP) and establishment of Power Grid Corporation of Bangladesh Ltd. (PGCB) in 1998, BPDB's functions were further reduced to power generation and distribution in urban areas, except the Dhaka metropolitan and Narayangonj areas.

1.2.2 Dhaka Electric Supply Authority (DESA)

Dhaka Electric Supply Authority (DESA) is responsible for distribution of electricity in the Dhaka metropolitan area including Narayangonj Municipality. It receives power from PGCB at 132kV level.

1.2.3 Dhaka Electric Supply Co. Ltd. (DESCO)

Parts of DESA's distribution area such as Mirpur, Gulshan, Baridhara, and Uttara are currently operated by Dhaka Electricity Supply Co. Ltd. (DESCO), which has been established under the Companies Act and is owned by the government in fulfillment of a covenant of the Asian Development Bank (ADB) supported Ninth Power Project.

1.2.4 Rural Electrification Board

The Rural Electrification Board (REB) was established in 1978 under President's Ordinance to distribute electricity in the rural areas through co-operatives. The cooperatives receive power at 33kV level.

1.2.5 Power Grid Corporation of Bangladesh Ltd. (PGCB)

The Power Grid Corporation of Bangladesh Ltd. (PGCB) is responsible for high-tension power transmission at 132kV and 230kV levels from generating stations to the distribution areas.

1.2.6 Office of the Chief Electrical Inspector and Electrical Advisor

The function of Chief Electrical Inspector and Electrical Advisor is primarily to ensure human safety from electrical accidents. It is the responsibility of the Chief Inspectorate to ensure standard equipment and appliances are used and standards are maintained during construction in providing electricity supplies. It is empowered to issue licences to electricians, electrical contractors, and all entities working in electricity supply construction, operation, and maintenance.

1.2.7 Power Cell

The Government of Bangladesh created and set up a Power Cell under the Ministry of Mineral Resources in 1995. It is responsible for power sector reforms, restructuring, tariff studies, and establishing a regulatory framework. Under private sector power development activities, which it handles as a part of power sector reforms, the Cell solicits and evaluates proposals, negotiates and processes the awarding of contracts, and

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finalizes projects. At the same time, it represents the interest of the Government of Bangladesh in the private sector power projects.

Electricity Generation

The total installed power plant capacity of the country is 4680 MW (as of October 2002). Of the total installed capacity of power plants, about 3000-3300 MW is available at any given time to serve a peak demand of 3218 MW. The composition of the plants and their relative contributions to the total installed capacity are given in Figure 1.4.

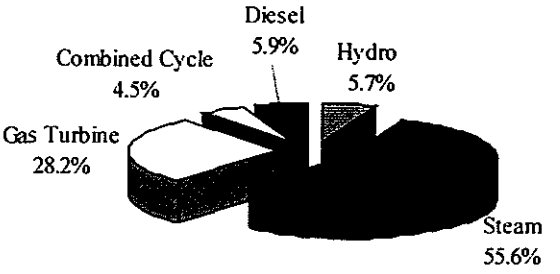

Figure 1.4: Contribution of Different Plant Types to Total Installed Capacity (2000-01)

In 2000-02 13674 GWh of energy was generated in the public sector power plants under BPDB. In addition 3771 GWh of electricity was purchased by BPDB from the IPPs giving a total generation of 17445 GWh. The composition of the energy source used in power generation is given in Figure 1.5.

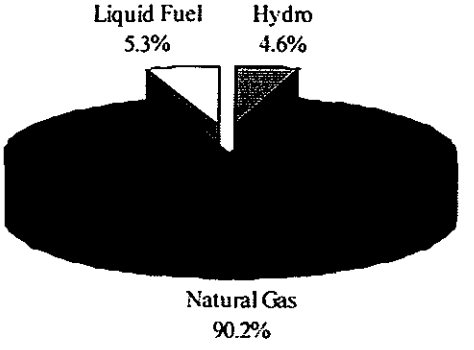

Figure 1.5: Contribution of Each Energy Source in Electricity Generation (2001-02)

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1.3 System Losses

The overall annual transmission and distribution (T&D) losses have varied from **27.2%** to **40.2%** of net generation during the past 25 years; a significant proportion of these losses can be attributed to nontechnical causes. In the year 2001-02, the T&D losses stood at **27.96%** of net generation, and analysis shows that this can be brought down to **17%** through upgrading and reinforcement of transmission and distribution systems, retrofitting plants with more efficient auxiliary devices, and by taking strong measures to reduce nontechnical losses A loss reduction programme has been implemented by the BPDB to address these issues.

1.4 Electricity Consumption

The number of distribution connections of the BPDB in the year 2001-02 was 1,644,550 (**26%**), while the numbers for DESA, DESCO, and REB were 521,429 (**8%**), 107,854 (**2%**), and 4,058,362 (**64%**), respectively. Electricity sales in the same year by BPDB stood at 15237 GWh, including bulk sales to DESA and REB, while sales by DESA were 5875 GWh including bulk sale to REB and DESCO. The Rural Eclectic Board's total sale of electricity in 2001-02 was 3921 GWh, while DESCO's sale in the same year stood at 494 GWh.

Although electricity consumption is still dominated by the industrial sector (as shown in Figure 1.6), during the period from 1982 to 2001 the share of domestic consumption of electricity increased from **15.3%** to **41%**, whereas the productive use (i.e., commercial, industrial, agriculture) decreased from **77.3%** to **59%**. This trend is likely to continue in the near future with an additional 300,000 household consumers being connected to the national grid every year. At present, only **30%** of total households are electrified and only as few as **15%** are electrified in rural areas.

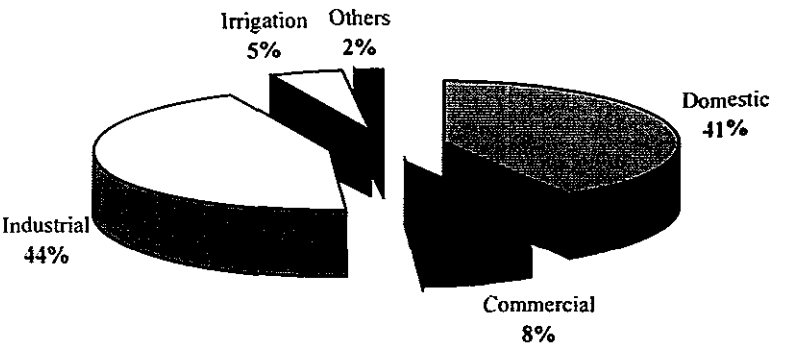

Figure 1.6: Contribution by Consumer Category to Electricity Consumption (2000-01)

1.5 Power Sector Reforms

The power sector of Bangladesh is undergoing reforms as a result of the following inter-ministerial committee's recommendations:

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- Restructure BPDB along functional lines for further unbundling;
- Create an electricity transmission company;
- Create electricity distribution companies;
- Corporatize and commercialize operation of the above companies;
- Initiate and expand private investment in generation;
- Attempt private investment in distribution; and
- Establish a regulatory body.

These recommendations have led to the introduction of the IPPs in the generation system. Also, the Power Grid Company of Bangladesh, Ltd. was established in 1996 to own, operate, maintain, and expand the national power grid. Further restructuring of the BPDB is also underway. In 2003, a new Electricity Reforms Act was passed, which should have a large impact on all aspects of the industry.

1.6 Power Shortages

In June 2002, the maximum actual generation by all the power plants in the system was only 3171 MW compared with a maximum demand of 3459 MW, leaving a generation capacity shortage of about 300 MW. In addition to this generation capacity shortage, there are frequent power interruptions due to transmission and distribution network failures resulting in significant losses to end-users.

Section 2 Project Scope

A study by the United States Agency for International Development (USAID) under SARI/Energy identified power quality an important issue for all SARI/Energy member countries. Under the technical assistance component of SARI/Energy project, NEXANT SARI/Energy proposed to conduct a technical assessment of the impact on the economy from loss of production due to poor power quality and shortages, higher energy costs, and environmental impacts from self-generation in the industrial sector of Sri Lanka, Nepal, Bangladesh, and India.

This study involving the Bangladesh industrial sector is intended to provide data, analysis, and recommendations for stakeholders and policymakers to:

- Obtain a better understanding of the impact on the local economies from poor power quality;
- Consider immediate and long-term remedial action;
- Consider amendments to existing policy and guidelines; and
- Widen the agenda and strengthen the role of end-users as advocates for change.

This report provides a technical assessment of the economic impact of power quality based on the following topics and activities:

- Reviewing existing guidelines;
- Analyzing power quality for the identified samples of customers;
- Estimating the cost of poor power quality to the economy from lost production, high-energy costs, and environmental impacts from standby generation;
- Estimating anticipated self-generation and associated cost over the next five-year period;
- Providing recommendations for immediate and long-term power quality improvements; and
- Proposing improvements for existing energy sector policy and guidelines based on the results of this assessment.

The methodology adopted during this study is very similar to that of the studies conducted in other countries[1] in the region with a few exceptions addressing local needs.

3.1 Study Team

The study team was formed according to the structure shown in Figure 3.1.

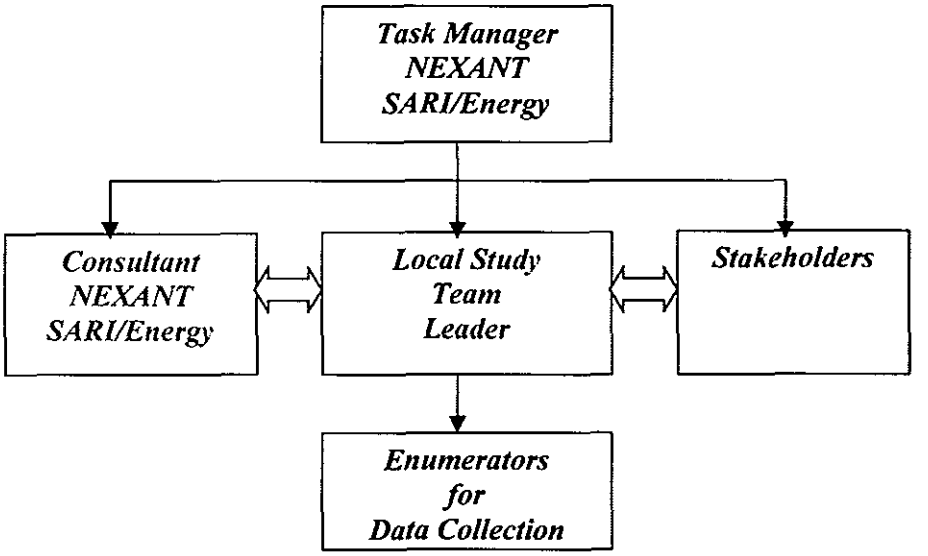

Figure 3.1: Organisational Structure of the Study Team

The study team was comprised of the task manager, a consultant, and a local team leader appointed by NEXANT SARI/Energy, enumerators selected for the survey, and local stakeholders.

3.2 Stakeholder Participation

Stakeholder participation was sought by the study team at different stages of the study starting from its inception. After developing the initial sample and a draft questionnaire, the study progress was presented at the first stakeholder meeting. This meeting generated valuable inputs from the participants that were incorporated in the final sample and questionnaire.

The preliminary results of the study were presented in a second stakeholder meeting and one-to-one meetings with key stakeholders. During these meetings, important contributions were made by the stakeholders with regard to strengthening the reliability of the data collected and improving the final output. These contributions, for example, comparison of electricity consumption data collected during the survey with those of reliable reference industrial installations, were readily considered and incorporated in the

[1] While Sri Lanka component of this study has been already completed under SARI/Energy, a similar study has been carried out by Tata Energy Research Institute (Teri) for the states of Haryana and Karnatake in India.

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study. The minutes of the proceedings of stakeholder consultations and the lists of participants are given in Appendices B, C, D, and E.

3.3 Questionnaire

A questionnaire was designed by the study team for gathering all the relevant information to meet the project scope. The questionnaire form is presented in Appendix A. Comments from stakeholders and experience in previous studies were considered in designing the survey questionnaire, which covered the following:

- General information on the industry installation, such as the contact information and category of industry;
- Electricity consumption information based on monthly metering data;
- Financial information, such as the annual value addition of each industry installation;
- Revenue losses due to sudden interruptions (momentary losses), unplanned longer interruptions, and planned interruptions; and the frequency and duration of such interruptions during the year of survey;
- Revenue losses due to voltage fluctuations and those due to harmonics in the electricity supply;
- General comments given by the industry on the electricity supply quality, tariff levels, and related investment trend; and
- Technical information associated with any standby generators installed in the industry premises.

The information to be collected was subdivided into subcomponents of losses (e.g., those associated with raw material, manpower, and production output) for convenience in data gathering. The questionnaire, which incorporated the inputs from the initial stakeholder meeting, is given in Appendix A.

3.4 Industry Sample

The study team acquired information regarding the number of industrial installations in each of the subcategories of industries in the country. The number of industrial installations to be surveyed was then determined based on their gross domestic product (GDP) contributions and their number in the industry population. Later the specific installations for the survey were selected at random to satisfy the numbers required. A detailed description of how sampling was carried out is presented in Section 4.

3.5 Data Collection

Data collection was carried out by a team of enumerators selected from a group of newly graduated engineering students from Bangladesh University of Engineering and Technology (BUET) under the direct supervision of the local team leader. These enumerators were trained on the data requirements and collection procedures before they were sent to the field for the work.

A contact for each installation to be surveyed had been established over the phone by the corresponding enumerators before personally visiting the industry installations for data collection. Then the questionnaires were sent to these contact persons for them to be prepared with necessary data before the enumerators' visits to the installations. Each of

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the questionnaires was filled by the enumerator to minimize any erroneous data entry and to avoid any misinterpretation of the questions by the respondents.

3.6 Data Entry and Screening

Collected data were entered into separate worksheets depending on the subcategories of industries. Each of the sheets had a record for each industry installation within that group with different columns identified for individual data items. Then each of the records was screened individually to check for any obvious erroneous entry of unacceptable original data. Such records were either corrected after getting clarifications from the enumerators involved or those records were not included for processing if such entries could not be verified.

3.7 Benchmarking

In response to a request made during the second stakeholder meeting, a reference group of industry installations was investigated concerning their electricity consumption to provide benchmarks[2] and further screening of collected data. Based on the recommendation of knowledgeable stakeholders, a total of 64 industry installations was selected from different industry categories to be used as the reference list of industries for benchmarking.

3.8 Data Processing and Analysis

These screened data were processed to determine mean and standard deviation within individual subcategories for each of the numeric data items. A summary sheet was created to determine the averages for the whole sample and to extend them to countrywide sectoral values.

These calculations determined the losses from momentary interruptions measured in terms of US$ per interruption for each category, while the losses due to planned and unplanned supply outages were calculated in terms of US$ per kWh of energy loss. The losses due to voltage fluctuations and supply harmonics were determined in US$ per hour in each installation.

The value addition recorded in the national accounts for each of these subcategories and the value addition estimated from the responses during the survey were compared to develop a factor to derive the final economic values of losses under different types of supply disturbances.

[2] It was expressed during the meeting that the actual electrical consumption in some categories of industries may be higher than what is recorded due to pilferage.

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The flow chart given in Figure 3.2 clearly shows the sequencing of different activities in the study.

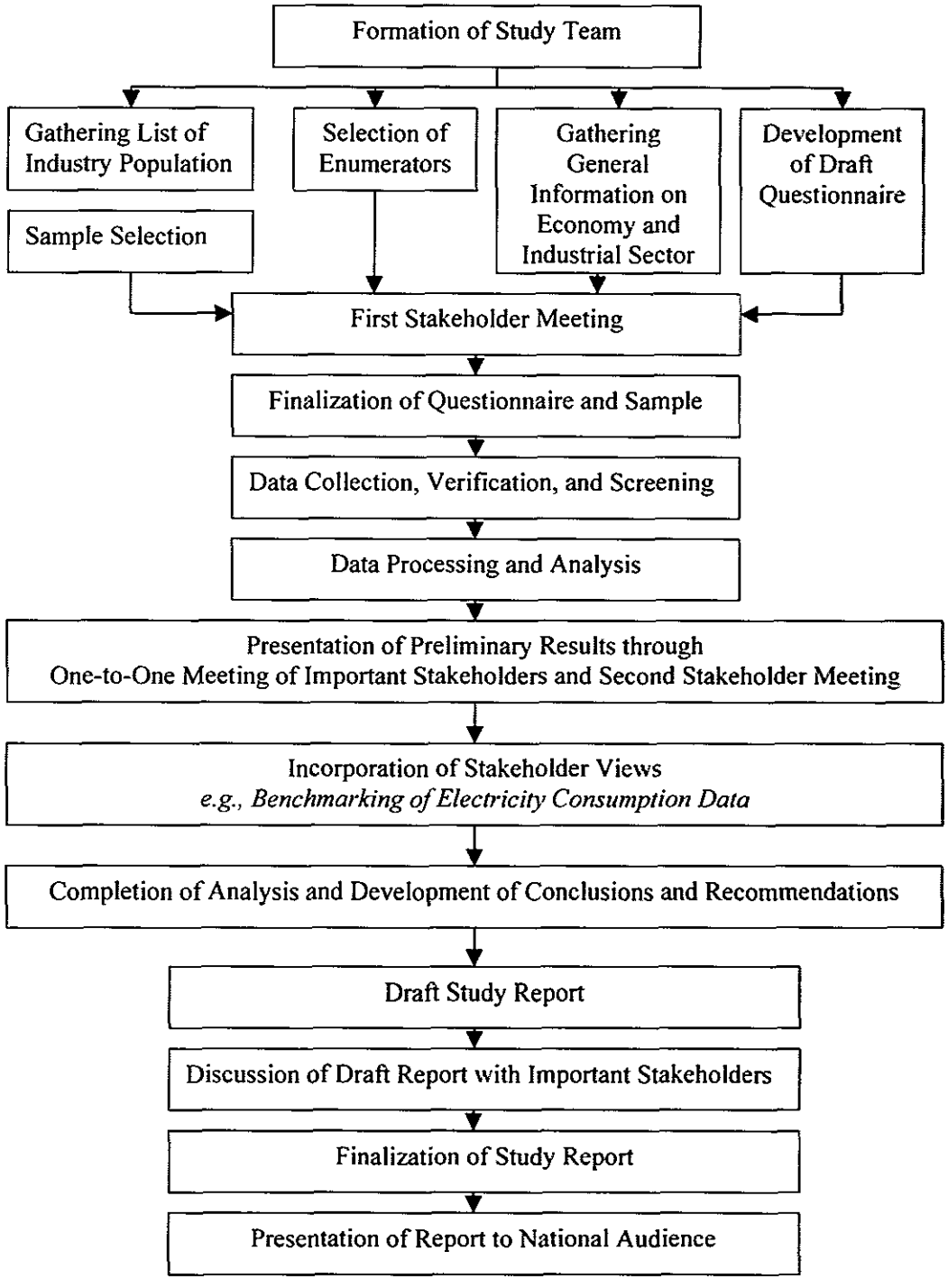

Figure 3.2: Sequence of Different Activities in the Study

The sample of industries to be surveyed was selected based on the contribution of the individual categories of industries to the industrial GDP. Table 4.1 shows the GDP contributions (2000-01) of each of these industry categories.

Table 4.1: GDP Contribution of Different Industry Categories in 2000-01

Industry Category	GDP Million Tk	Percentage Contribution
1. Food Manufacturing and Beverage Industries	46250	17.10 %
2. Tobacco Manufacturing Industries	21441	7.92 %
3. Animal Feed Industries	50	0.02 %
4. Manufacturing of Textiles	22669	8.38 %
5. Wearing Apparel	90349	33.4 %
6. Leather and Leather Products	10387	3.84 %
7. Footwear Industries	1589	0.58 %
8. Ginning, Pressing, Emb. of Textile Goods	959	0.35 %
9. Wood and Cork Products	6386	2.36 %
10. Furniture Manufacturing	2712	1.00 %
11. Paper and Paper Product Industries	2235	0.83 %
12. Printing and Publishing Industries	9304	3.44 %
13. Drugs and Pharmaceuticals	9927	3.67 %
14. Industrial Chemical and Other Byproduct Industries	8867	3.28 %
15. Petroleum Refining and Petroleum Product Industries	321	0.12 %
16. Rubber Product Industries	877	0.32 %
17. Plastic Product Industries	1409	0.52 %
18. Pottery and Chinaware Industries	2507	0.92 %
19. Glass and Glass Product Industries	703	0.26 %
20. Nonmetallic Mineral Product Industries	6499	2.40 %
21. Iron and Steel Industries	9268	3.43 %
22. Metal Product Industries	9939	3.67 %
23. Non-Electrical Machinery Industries	796	0.29 %
24. Electrical Machinery Industries	2229	0.82%
25. Transport Equipment Industries	2249	0.83 %
26. Other Industries	565	0.20 %
Total	**270487**	**100%**

Source: Bureau of Statistics, Bangladesh

Due to the limited time available for the survey, during sample selection emphasis was given to the categories with large contributions to industry sector GDP. Industries contributing less than 1% to the industry sector GDP were omitted in the final sample. The final industry categories selected are shown in Figure 4.1.

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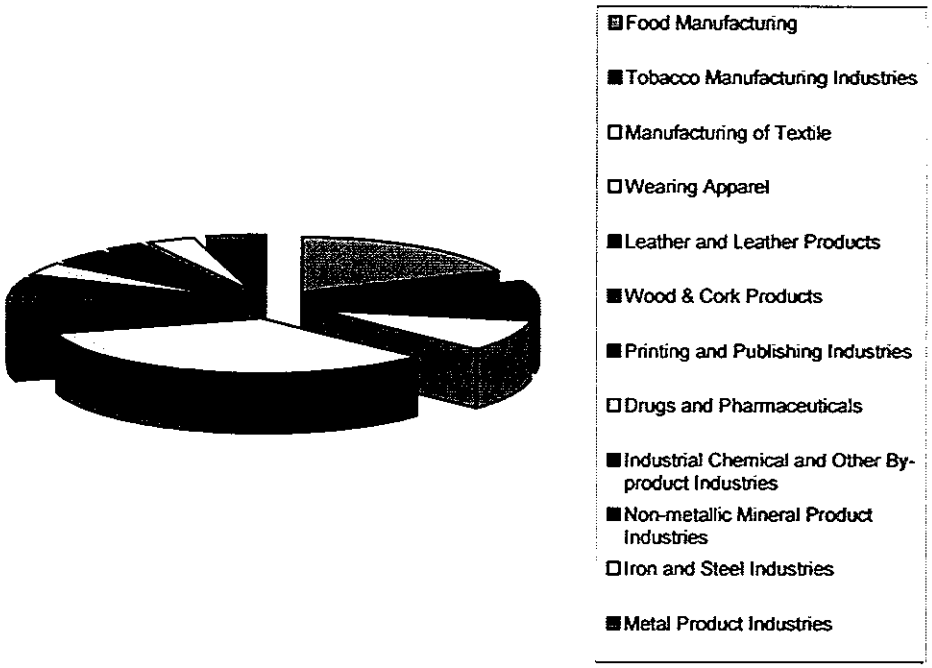

Figure 4.1: Industry Categories Finally Considered and their GDP Proportions

Further, the number of installations to be sampled in each category was decided in proportion to the GDP contribution subject to a minimum number of 10 installations in each category. If the proportion was very large in a particular category compared with others, the number of installations was reduced by inspection as the total number needed to be limited to about 175 to meet the time and resource constraints. These procedures resulted in the sample of industry installations given in Table 4.2.

Table 4.2: Industry Categories Finally Considered and Number of Samples

Category	Number of Installations in the Country (1995/96)	Number of Samples
Food Manufacturing	6082	25
Tobacco Manufacturing Industries	571	15
Manufacturing of Textiles	12220	15
Wearing Apparel	2168	40
Leather and Leather Products	198	10
Wood and Cork Products	1202	10
Printing and Publishing Industries	920	10
Drugs and Pharmaceuticals	278	10
Industrial Chemical and Other By-products	424	10
Non-metallic Mineral Product Industries	1374	10
Iron and Steel Industries	244	10
Metal Product Industries	919	10
Total		**175**

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Data collection was carried out in 208[3] industry installations, which were later screened to correct or to eliminate inaccurate records. After elimination of unreliable records, data processing was confined to 188 industry installations.

The outcome of the data processing based on the methodology discussed in Section 3 is given in this section. These results are broadly categorised into operational information, electricity supply interruption data, information related to standby generation, national economic impact, and general comments.

5.1 Operational Information

5.1.1 Working Pattern

The working pattern of each of the industrial installations is an important input in analysing the impact of supply outages in the industrial sector. Figure 5.1 shows the average operational pattern of each of these industry categories. As shown in the figure, the industries operate from 235 to 339 days a year with the number of hours of work during the day varying from about 8.2 to 18.5 hours. The industry-wide averages are 15.78 hours of operation per day and 301 working days per year.

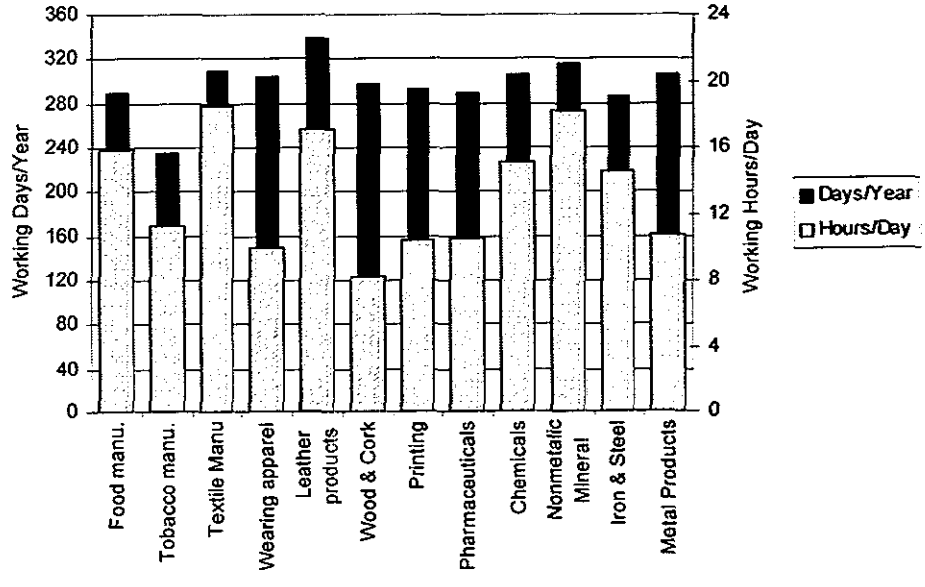

Figure 5.1: Operational Times of Different Industries

[3] Though the originally intended sample size was 175, the local team decided to enhance the number, of installations in each subcategory to address the issues of possible inaccuracies in the collected data.

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5.1.2 Electricity Usage

Figure 5.2 shows the variation of value-addition per unit of electricity consumed by each of the industry types and the industry-wide average.

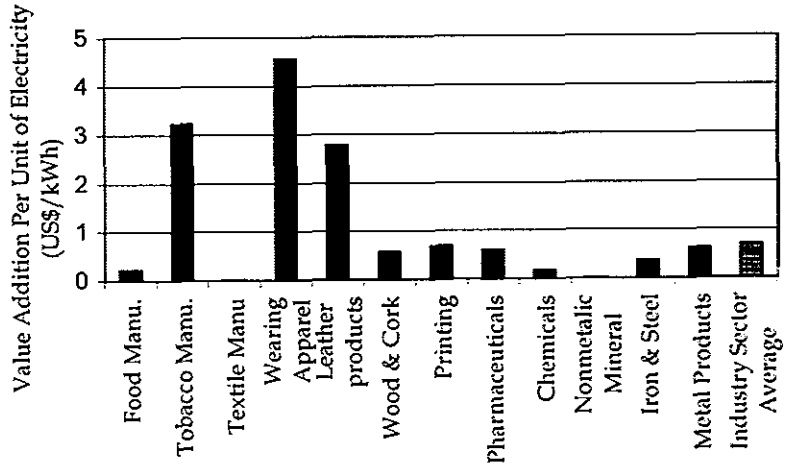

Figure 5.2: Value-Addition per Unit of Electricity Usage in Different Industry Categories

5.1.3 Electricity Cost

Figure 5.3 shows the average cost of grid electricity at different industry categories. The industry sector average is 7.02 USCts/kWh[4].

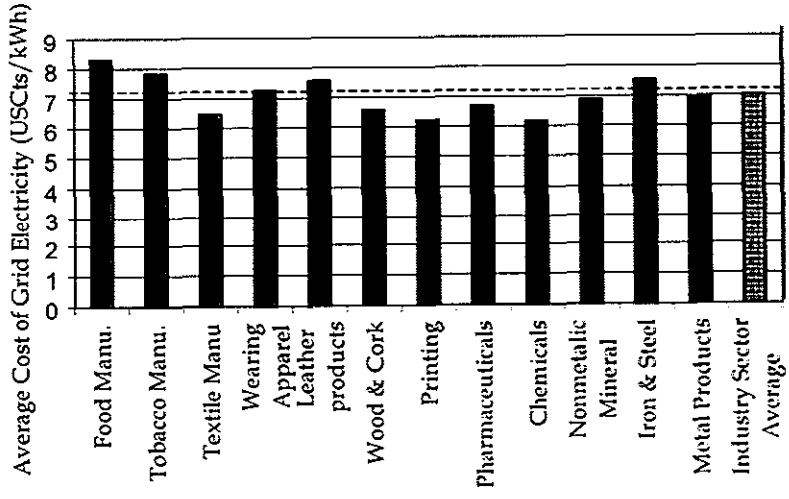

Figure 5.3: Average Cost of Grid Electricity to Different Industry Categories

[4] All US$ values are based on an exchange rate of US$ 1= Tk 57

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5.2 Electricity Supply Interruptions

The study examined the electricity supply interruptions both in terms of outages as well as loss of quality of power. These losses consisted of momentary interruptions, unplanned and planned outages, voltage fluctuations, and supply harmonics.

5.2.1 Momentary Interruptions

The study recorded momentary interruption details for each of the industry categories and these values are given in Table 5.1.

Table 5.1: Cost of Momentary Interruptions in Each Installation

Industry	Average Momentary Interruption Cost (US$/Interruption)	Maximum Deviation with 95% Confidence (US$/Interruption)
Food Manufacturing	28	11
Tobacco Manufacturing	30	18
Textile Manufacturing	179	65
Wearing Apparel	337	99
Leather products	26	4
Wood and Cork	6	1
Printing	574	265
Pharmaceuticals	4680	2085
Chemicals	3176	1369
Non-metallic Mineral	1724	472
Iron and Steel	44	10
Metal Products	1131	552
Industry Sector Average	**365.35**	**53.76**

5.2.2 Unplanned Outages

The variation of economic cost of unplanned outages in different industry categories is given in Table 5.2.

Table 5.2: Economic Cost of Unplanned Interruptions

Industry	Average Unplanned Interruption Cost (US$/kWh)	Maximum Deviation with 95% Confidence (US$/kWh)
Food Manufacturing	0.17	0.03
Tobacco Manufacturing	2.75	0.33
Textile Manufacturing	0.39	0.06
Wearing Apparel	2.34	0.26
Leather Products	9.60	1.16
Wood and Cork	2.18	0.06
Printing	2.25	0.23
Pharmaceuticals	1.02	0.43

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Chemicals	2.36	0.61
Non-metallic Mineral	0.12	0.04
Iron and Steel	1.27	0.19
Metal Products	0.56	0.17
Industry Sector Average	**0.83**	**0.04**

5.2.3 Planned Outages

The variation of economic cost of planned outages in different industry categories is given in Table 5.3.

Table 5.3: Economic Cost of Planned Interruptions

Industry	Average Planned Interruption Cost (US$/kWh)	Maximum Deviation with 95% Confidence (US$/kWh)
Food Manufacturing	0.11	0.03
Tobacco Manufacturing	0.00	0.00
Textile Manufacturing	0.14	0.03
Wearing Apparel	1.00	0.30
Leather Products	0.94	0.51
Wood and Cork	1.33	0.16
Printing	1.87	0.46
Pharmaceuticals	0.05	0.03
Chemicals	0.18	0.10
Non-metallic Mineral	0.04	0.01
Iron and Steel	1.06	0.20
Metal Products	0.00	0.00
Industry Sector Average	**0.34**	**0.03**

In addition to these time-dependent costs, planned outages result in fixed outage costs at the time of interruption. The fixed costs of these planned outages are given in Table 5.4.

Table 5.4: Fixed Cost of Planned Interruptions per each Installation

Industry	Average Planned (Fixed) Interruption Cost (US$/Interruption)	Maximum Deviation with 95% Confidence (US$/Interruption)
Food Manufacturing	0.64	0.23
Tobacco Manufacturing	0.00	0.00
Textile Manufacturing	1.17	0.40
Wearing Apparel	52.02	11.95
Leather Products	60.12	32.68
Wood and Cork	18.05	5.68
Printing	22.10	8.02
Pharmaceuticals	0.00	0.00

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Chemicals	735.56	393.28
Non-metallic Mineral	134.61	61.08
Iron and Steel	0.40	0.15
Metal Products	0.00	0.00
Industry Sector Average	**25.29**	**7.01**

5.2.4 Voltage Variations

The costs of supply voltage fluctuations beyond the stipulated levels[5] are given in Table 5.5 for different categories of industries.

Table 5.5: Cost of Voltage Variations per Installation

Industry	Average Cost of Voltage Variations (US$/hr)	Maximum Deviation with 95% Confidence (US$/hr)
Food Manufacturing	12.07	4.58
Tobacco Manufacturing	332.54	59.31
Textile Manufacturing	18.86	5.79
Wearing Apparel	85.98	6.47
Leather Products	46.48	5.19
Wood and Cork	0.00	0.00
Printing	19.65	4.60
Pharmaceuticals	167.42	66.45
Chemicals	401.48	235.05
Nonmetallic Mineral	33.36	18.94
Iron and Steel	38.76	9.79
Metal Products	166.73	85.16
Industry Sector Average	**42.02**	**5.77**

5.2.5 Frequency and Duration of Supply Interruptions

The average frequency of interruptions and their durations were recorded during the survey for each of the industrial installations. Their expected values and deviations from those values based on **95%** confidence level are given in Table 5.6.

Table 5.6: Frequency and Duration of Interruptions

Interruption Type	Frequency/Year	Period of Each (hrs)
Unplanned Outages	335.56	1.81
Planned Outage	5.57	6.82
Voltage Variation	96.31	1.66

The outcome of both the planned and unplanned interruptions listed in Table 5.6 is that energy is not provided to the industry during those periods.

[5] The supply voltage is expected to be within the ranges of ± 5% for low and medium voltage consumers and ± 12.5% for high voltage consumers. (Electricity Act 1910; chapter IV, section 28)

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5.3 Standby Generation

The penetration level of standby generation (SBG) for different industry categories is given in Figure 5.4.

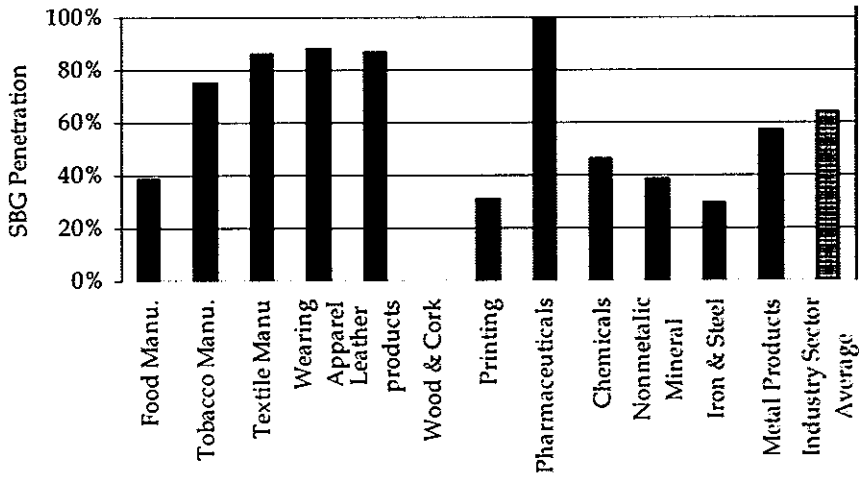

Figure 5.4: Penetration Level of Standby Generation in Different Industry Categories

Most of these industrial installations do not have SBG facilities to supply their full load. The level of SBG capacity as a percentage of the full load considering only those industries having SBG facilities is given in Figure 5.5.

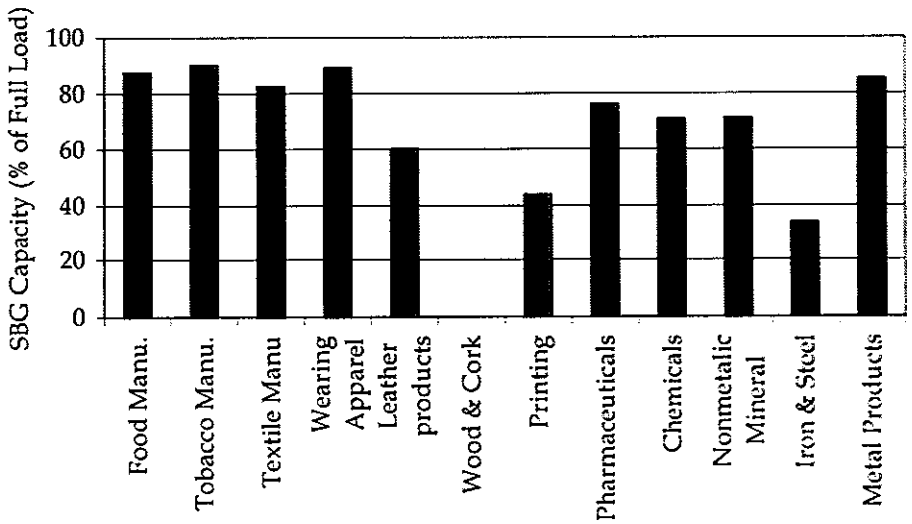

Figure 5.5: SBG Capacity as a Percentage of Full Load Considering only those Industries Having SBG Facilities

5.3.1 Environmental Impact

The use of SBG facilities causes approximately **6.5%** more environmental emissions due to relatively poor operating efficiencies of these low capacity generators. Further, the use of SBG results in an additional financial burden on the industries due to difference in

operational cost of SBG (7.89 USCts/kWh) and the average cost of grid electricity (7.02 USCts/kWh) in the industrial sector sampled.

It is assumed that these SBG facilities are always fully used when there are outages (Table 5.6); the additional emissions and financial burden due to SBG usage in the industrial sector are given in Table 5.7.

Table 5.7: Incremental Emissions[6] and Additional Financial Burden Due to SBG

Emission	Incremental Emissions (MT/yr)
Carbon Dioxide	23849
Carbon Monoxide	31
Sulfur Dioxide	1
Nitrogen Oxides	486
Particulate Matter	35
Annual Additional Cost to Users Due to SBG	**4.48 (US$ Million)**

5.4 National Economic Impact

The unplanned and planned outages given Table 5.6 result in substantial economic losses in the industrial sector. For 2000-01, these losses amounted to US$ 778 million within the industrial sector GDP of US$ 6737 million.

The total percentage or survey respondents replying positively to five important questions concerning energy use posed to each of the industries are given in Table 5.8.

Table 5.8: Responses of Industries in the Sample to Energy Use Questions

Question	% Responding Yes
Are you willing to pay more for high quality power?	**50.48%**
Do you think that the industries pay too much for the quality of power received?	**95.19%**
Do you depend on standby generation more than you depend on utility power?	**14.01%**
Would you invest more on electricity dependent enterprises if the quality of power is higher?	**51.44%**
Have you implemented energy conservation measures in your industry?	**31.73%**

[6] Emission factors are based on values published by the Intergovernmental Panel on Climate Change (IPCC)

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6.1 Industry Operational Pattern

As was shown in Figure 5.1, the tobacco manufacturing industry has the lowest number of days of work per year, which is 235 days or approximately 4.5 days a week. The wearing apparel industry has the highest number of working days, which is 339 days a year or approximately 6.5 days a week. All the others work approximately 5.5 to 6 days a week. While the wood and cork industry works only one shift a day or 8 hours, food, textile, leather, and non-metallic mineral industries all record two or more working shifts. On average, the industrial sector in Bangladesh works approximately 6 days a week and two shifts a day.

6.2 Electricity Usage

Value additions to the economy by different industries vary depending on the nature of their output. The effect on the value addition by power supply problems and outages is entirely based on the level of dependency of each of these industries on the power supply. As it can be seen in Figure 5.2, the highest value addition per unit of electricity use (4.56 US$/kWh) is recorded in the wearing apparel industry, while it pays an average price of 7.25 USCts/kWh for grid electricity. Also the tobacco manufacturing and leather product industries have relatively high value additions per unit of electricity consumption in comparison with other industries. The lowest value addition is in the non-metallic mineral industry, where its average electricity cost stands at 6.88 USCts/kWh. The industrial sector average value addition per unit of electricity use is approximately 0.68 US$/kWh, while the average cost of electricity is 7.02 USCts/kWh.

6.3 Interruptions

Momentary interruptions in most of the industries result in significant losses. Table 5.1 also shows that these losses vary substantially from 6 US$ per interruption per installation in the wood and cork category to 4680 US$ per interruption per installation in the pharmaceutical industry giving an industry sector average of 365.35 US$ per interruption with a deviation of 53.76 US$ per interruption at 95% confidence. Also industries such as chemicals, non-metallic minerals, and metal products record substantial losses due to sudden interruptions. These losses are evenly distributed among loss of output, manpower, raw material, and damaged equipment.

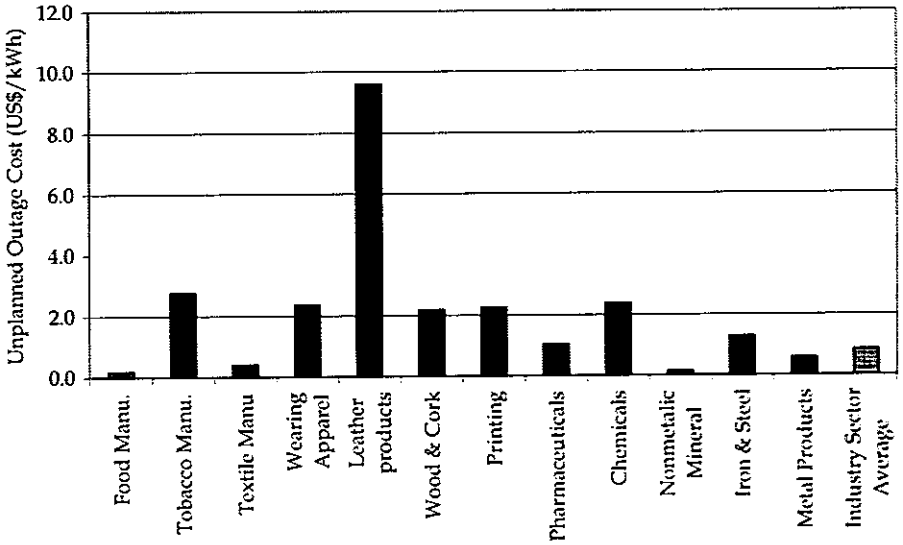

Figure 6.1: Comparison of Economic Cost of Unplanned Outages in Different Industries

As given in Table 5.2 and shown in Figure 6.1, losses attributable to unplanned interruptions vary from 0.12 US$/kWh in non-metallic mineral products to 9.6 US$/kWh in leather products giving an industry-wide average of 0.83 US$/kWh (with a deviation of 0.04 US$/kWh at 95% confidence). Also the industries such as tobacco manufacturing, wearing apparel, wood and cork, printing and chemicals record significant losses due to unplanned outages.

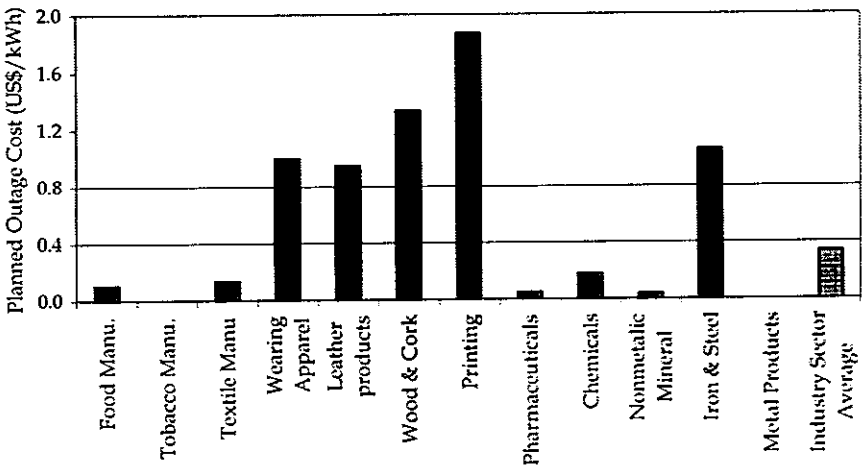

Figure 6.2: Economic Cost of Planned Outages in Industry

For planned outages, these values vary from no losses in the tobacco and metal product industries to 1.87 US$/kWh in printing giving an industry-wide average of 0.34 US$/kWh with a deviation of 0.03 US$/kWh at 95% confidence. Most of the other categories also record relatively low losses under planned interruptions. These variations are clearly shown in Figure 6.2.

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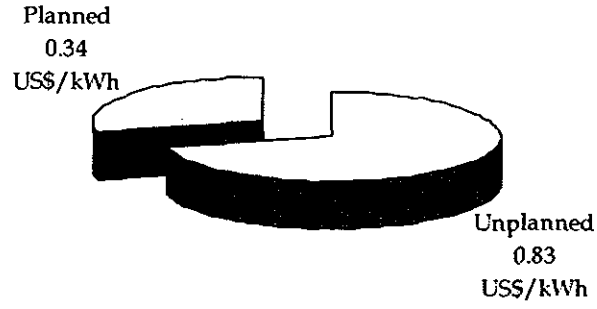

Figure 6.3: Comparison of Costs of Planned and Unplanned Interruptions

Figure 6.3 shows that the unplanned interruptions result in losses approximately 2.5 times those of planned interruptions. It is also interesting to note that the average value addition per unit of electricity use in the industrial sector is greater than the cost of planned interruptions but less than the cost of unplanned interruptions. This comparison shows how significant the unplanned outages are in terms of economic impacts. Therefore, serious efforts need to be taken to convert unplanned interruptions to planned interruptions wherever it is possible.

The fixed losses due to planned interruptions given in Table 5.4 show that they vary from no losses in tobacco manufacturing, pharmaceutical, and metal product industries to more than 700 US$ per interruption for each installation in the chemical industry. These values are significantly low compared to those attributable to momentary interruptions since the consumers are prepared for these interruptions. The industry-wide average for this type of loss stands at 25.29 US$ per interruption as against 365.35 US$ per interruption under momentary interruptions in each installation.

The voltage variations can cause major problems in certain processes, such as tobacco manufacturing and chemicals, due the sensitive nature of the equipment used in these industries, while some others, such as the wood and cork industry, are completely unaffected. Based on the survey results, it can be seen that such voltage variations cost the industrial sector 42.02 US$ per hour on average in each installation.

Though the impact of the presence of supply harmonics was part of the survey, this aspect is not analysed due to extremely poor response to related questions from the participating industrial installations.

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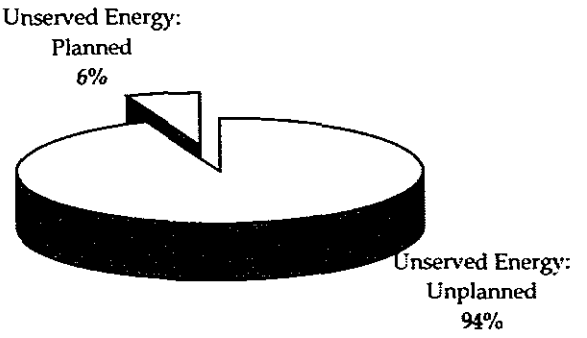

Figure 6.4: Proportions of Unserved Energy due to Unplanned and Planned Outages

Table 5.6 showed that unplanned interruptions during the year are as frequent as nearly one interruption a day with each lasting about 2 hours. In contrast, planned interruptions occur about once in two months but each lasts about 7 hours. This difference in duration may be due to events such as rehabilitation of parts of the distribution/transmission network. Therefore, as shown in Figure 6.4, **94%** of the total unserved energy resulting from interruptions is due to unplanned outages, while only **6%** is attributable to planned outages. The total unserved energy stands at 970 GWh a year, whereas the industrial electricity consumption in 2000-01 was 6161 GWh. Thus, **13.6%** of the industrial sector demand remains unmet due to planned and unplanned interruptions. Figure 6.5 compares the corresponding energy not supplied with the present energy consumption in the industrial sector.

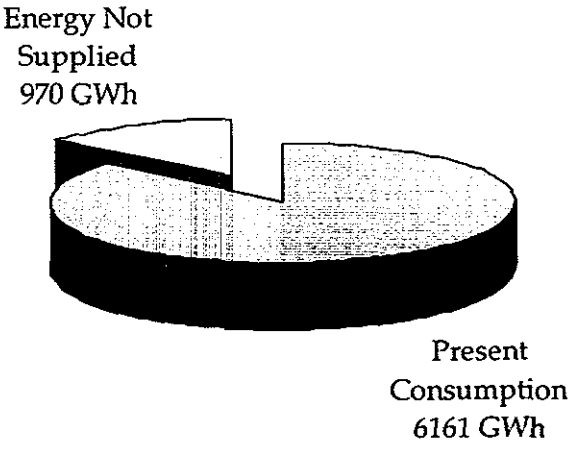

Figure 6.5: Comparison of Present Industry Consumption (2000-01) with Energy Not Served due to Outages

Both planned and unplanned interruptions are due to problems such as inadequate generation capacity and poor operational performance in the transmission and distribution

systems. These issues can be addressed through appropriate demand-side management measures and by strengthening the generation, transmission, and distribution systems

6.4 Standby Generation

The penetration level of SBG facilities varies from none in the wood and cork industry to **100%** in the pharmaceutical industry. Also the tobacco manufacturing, textile manufacturing, wearing apparel, and leather product industries have a significantly high SBG penetration level. On average, **64%** of the industrial installations in the country have SBG facilities. In almost all the industrial installations surveyed, these SBG facilities are diesel-oil based.

Though **64%** of the industrial installations have SBG facilities, many of them do not have SBG sufficient to satisfy their full load. But all the industry categories (except leather products, wood and cork, printing, and iron and steel) have SBG capacity to satisfy more than **70%** of their full load. When the average penetration level and the percentage of full load satisfied are considered, it can be seen that only **52%** of the total industrial load can be supplied with the existing SBG facilities.

Not only are the SBG facilities based on diesel an additional financial burden to the industries due to their higher operating costs compared to the utility supply, but they also they tend to cause higher environmental emissions due to relatively poor operational efficiency. It has been estimated that this situation leads to an additional 0.87 USCts/kWh of operating expenditure and an incremental emissions of **6.5%** over utility generation. Assuming that the SBG units are in operation when there are supply outages, the additional financial burden is estimated to be about US$ 4.5 million a year.

6.5 National Economic Impact

Figure 6.6 shows that the overall economic impact of planned and unplanned outages on the utility supply is substantial. This economic loss translates into **11.54%** of the industrial sector GDP or **1.72%** of the national GDP in 2000-01. In a country having an annual GDP growth rate of about **5.5%** (2000-01) this impact is significant. Thus it is important in economic planning to consider improvement of electricity supply reliability as one the major factors by which economic growth can be enhanced.

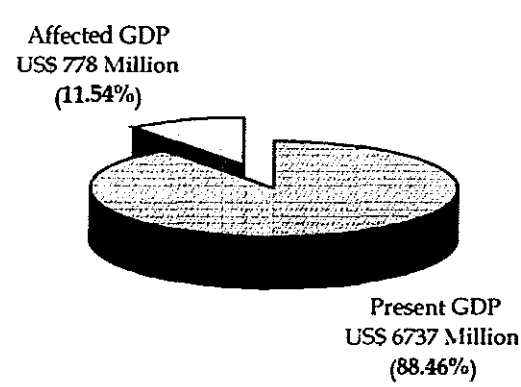

Figure 6.6: Comparison of Total Industry Sector GDP and the GDP Affected due to Outages

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6.6 General

It is important to note that more than **95%** of the participating industries reported that they over-pay for the quality of power they receive, yet **50%** of the sample would still be willing to pay even more for better power quality. Though the level of SBG penetration stands at **64%** of the industries, only **14%** expressed that they depend more on SBG. In other words, even after having SBG, due to the higher cost of generating their own power, these industries would prefer to use utility power. The other important observation from an economic point of view is that more than half of the sampled industries would have invested more in electricity-dependent industries if the quality of power supply were better. This observation needs to be seriously taken note of by the investment promotion arm of the government, e.g., Board of Investment.

Considering the fact that the country has a generation capacity shortage, it is disturbing to note that only less than **32%** of the industrial installations sampled have implemented some form of energy conservation measures. There are low cost and high return energy conservation measures, such as good housekeeping and power factor correction, which can be easily implemented in these industries. Necessary incentives need to be immediately provided in this regard. Some of the SARI/Energy initiatives, such as activities related to Energy Service Companies (ESCO) and energy labeling of appliances, need to made use of in improving energy efficiency in the industrial sector.

Absence of end-user participation in the electricity supply industry decision-making process may have created a communication gap between the suppliers and the end-users who know best what their own requirements are. Therefore end-user participation needs to be strengthened where possible.

6.7 Legislation

The Electricity Act of 1910 deals with the power quality aspects only under Chapter IV (Conditions of Supply by Licensee), Sections 28 and 29. Under these sections, the voltage should not fluctuate beyond **±5%** for low and medium voltages **±12.5%** for high voltage supplies. The frequency is not expected to move beyond **±4%**.

The Bangladesh Energy Regulatory Commission Act of 2003 recognizes the necessity of addressing power quality problems. Under Chapter 4, Section 22(f), the Commission is expected to formulate codes and standards on the quality of service that will apply to the utilities. This legislation is likely to force the utilities to improve their quality of supply not only in terms of voltage and frequency levels but also in terms of supply reliability encompassing the planned and unplanned outage levels.

Section 7 Conclusions

Based on the study results and analysis, the following conclusions can be drawn.

- The average working period of the industrial installations sampled is long both in terms of number of working hours a day as well as the number of working days a week, and therefore the economic impact of supply outages in the industrial sector is significant.
- Electricity is used more efficiently in terms of value addition per unit of electricity in the tobacco, wearing apparel, and leather product industries, and hence the economic benefit of giving preferential treatment to these industries particularly at the time of power supply shortages needs to be seriously considered in system operation.
- The operation and maintenance cost of the diesel-based SBG facilities is only **12.5%** higher that the average cost of utility delivered electricity in the industrial sector. But the utility delivered electricity is likely to be higher in cost than the operational costs of natural-gas-based SBG due to subsidized natural gas prices. This situation will cause immense difficulties to the utilities in the long term.
- Extremely high losses due to momentary interruptions in the pharmaceutical, chemical, and non-metallic industries and similarly high losses due to unplanned interruptions in the leather industry need to be addressed.
- The relatively high cost of unplanned outages in comparison to planned outages calls for special attention to reduce the frequency and duration of unplanned outages; attempts should be made to convert such outages to planned outages whenever possible. In this regard, extra emphasis is required in the tobacco, wearing apparel, leather products, wood and cork, printing, and chemical industries due to the high cost of such outages.
- Lack of SBG capacity and the non-automatic operation of standby equipment may have contributed to high cost of planned outages in the wearing apparel, leather products, wood and cork, printing, and iron and steel industries.
- Voltage fluctuations cause a significant adverse impact on the industrial sector output, and this issue needs to be seriously addressed by the utilities.
- Standby generation level in the industrial sector is significant and is likely to increase in the future unless necessary measures are taken to reduce supply outages, particularly unplanned outages. Further, future SBG units would tend to be based on natural gas, which is heavily subsided.
- Because the overall economic loss due to planned and unplanned power supply outages in the industrial sector is quite high, it has a significant impact on the country's economic growth.
- Although the industries consider the present electricity tariff to be too high for the quality of power they receive, a higher tariff is likely to be acceptable to important industries, such as tobacco, wearing apparel, and leather products, if the number of outages and the voltage fluctuations can be reduced.
- Emphasis on energy conservation measures in the industrial sector at present is extremely low, and an aggressive energy conservation program is needed that will help the electricity supply industry as well as the consumers.

Section 8 Recommendations

The conclusions given in Section 7 lead to the following recommendations to address the issues raised.

- **Strengthen end-user participation** in the electricity supply industry through representation in the relevant bodies dealing with decision-making and regulatory work in the industry. Establish an environment conductive to regular dialogue between the end-users, utilities, and policy makers.
- **Convert unplanned interruptions to planned outages** where possible by taking actions such as pre-planned load shedding and informing consumers accordingly.
- **Introduce an interruptible electricity tariff** to industries that can absorb planned interruptions without serious disturbance to their production processes an as an incentive for them to make themselves available to be interrupted at the times of system capacity shortages. Such a tariff will help critical industries where a higher tariff would be acceptable if supply reliability were also provided.
- **Strengthen ongoing SARI/Energy initiatives on energy efficiency,** such as energy services company (ESCO) activities and standards and labeling, which will act as catalysts in energy conservation in the industries. These initiatives will create an enabling environment for industries to be proactive in implementing energy conservation measures.
- **Take measures to increase awareness among industrialists of energy conservation** measures and related investment costs to encourage them to undertake energy efficiency projects with reasonable payback periods.
- **Introduce a well-planned load management scheme**, particularly to reduce the system peak demand, which will help to improve the system reliability by way of reduced effective demand and transmission and distribution losses.
- **Improve the power system performance** by timely and appropriate generation capacity additions, transmission and distribution system improvement, and cross-border energy exchange. Private sector participation is likely to play a major role in this regard.
- **Commission detailed technical studies** in specific areas identified for performance improvement in generation, transmission distribution, and supply of electricity. These studies can include activities, such as:

  - Examining the feasibility of transmission and distribution network reliability improvement;
  - Analyzing the present electricity tariff structure and designing an interruptible electricity tariff for the industrial and commercial consumers; and
  - Developing institutional and legislative frameworks required for aggressive implementation of energy efficiency programs in the electricity sector.

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Tata Energy Research Institute, *Cost of Unserved Energy*, Report No 98PG42, New Delhi, 2001.

Yellow Pages 2002 (11th. Edition), Bangladesh.

1. Name and Address of the Institution

II. Name and Designation of the Person Providing Information

III. Industry Category and Final Product

Please tick where appropriate

Category	(√)	Final Product (*Please write*)
Food, Beverage, and Tobacco Products		
▪ Food Manufacturing		
▪ Tobacco Manufacturing Industries		
Textile, Wearing Apparel and Leather Products		
▪ Manufacturing of Textile		
▪ Wearing Apparels		
▪ Leather and Leather Products		
Wood and Wood Products		
▪ Wood and Cork Products		
▪ Furniture Manufacturing		
Printing and Publishing Industries		
Chemical, Petroleum, Rubber and Plastic Products		
▪ Drugs and Pharmaceuticals		
▪ Industrial Chemical and Other By-product Industries		
▪ Non-Metallic Mineral Product Industries		
Iron and Steel Based Industry		
▪ Iron and Steel Industries		
▪ Metal Product Industries		

IV. Electricity Information (*Take average over a period of one year*)

Average Monthly Energy Consumption (kWh/month)	Monthly Maximum Demand (kVA)	Average Monthly Electricity Cost (Tk)

	Medium (<11kV)	Large (11kV/33 kV)
Industry Category by Electricity Connection (Voltage level)		

V. Financial Information

Average Annual Turnover (Tk)	Average Annual Expenditure on Raw Material (Tk)	* Average Annual Value Addition (Tk)

**If this is provided other information not required*

VI. Industry Operational Pattern

Average Number of Operating Hours per Day	
Average Number of Operating Days per Year	

VII. Loss Information – *Provide losses per hour basis where appropriate*

Momentary Loss of Supply (*Loss due to a sudden interruption which is independent of the interruption duration – fixed loss in Tk*)

	Total Revenue Loss (Tk)
Loss of Raw Material	
Loss of Output	
Loss of Manpower	
Damage to Equipment	
Time Duration of Standby Generator Operation	

Unplanned Supply Interruptions (*Provide only duration dependent costs – Variable losses in Tk/hr)*

	Revenue Loss per hour (Tk/hr)
Interruption Duration	
Loss of Raw Material	
Loss of Output	
Loss of Manpower	
Time Duration of Standby Generator Operation	

Number and Period of unplanned Supply Interruptions

Average Number of unplanned interruptions per year	
Average Period of Unplanned Interruptions (hrs)	

Planned Supply Interruptions

	Fixed Revenue Loss (Tk) (moment of interruption)	Revenue Loss per hour (Tk/hr)
Loss of Raw Material		
Loss of Output		
Loss of Manpower		
Time Duration of Standby Generator Operation		

Number and Period of Planned Supply Interruptions

Average Number of Planned Interruptions per Year	
Average Period of Planned Interruptions (hrs)	

Disturbances to the production process due to voltage variations (greater than **6%** of rated voltage)

	Revenue loss (Tk/hr)
Duration of Voltage Variation	
Loss of Raw Material	
Loss of Output	
Loss of Manpower	
Time Duration of Standby Generator Operation	

Number and period of voltage variations experienced

Average Number of incidents per year	
Average period of each (hTk)	

Other significant supply problems such as supply harmonics

	Revenue Loss (Tk/hr)
Duration	
Loss of Raw Material	
Loss of Output	
Loss of Manpower	
Time Duration of Standby Generator Operation	
Damage to Equipment (Tk)	

Other Miscellaneous Comments/Questions

1. Are you willing to pay more for high quality premium power? (Yes / No)
2. Do you think you pay too much for the quality of power you receive? (Yes / No)
3. Do you depend on standby generation more than you depend on the utility? (Yes / No)
4. If power quality is not a concern, would you invest more in electricity dependent enterprises? (Yes/No)
5. Have you implemented any Energy Conservation measures at your facility?
6. Comments?

VII. Standby Generator Information

1.1.1.1 Manufacturer	
Generator capacity (kW)	
What percentage of the full-load does standby generation support?	
Estimated time taken to switch to standby generation after a grid supply outage (minutes)	
Minimum duration of standby generator usage once switched on (minutes)	
Time taken for the standby generator to switch off once the grid supply is restored	
Initial capital cost (Tk)	
Annual maintenance cost (Tk/Year)	
Average fuel consumption (liters/kWh)	
Any other variable costs (Tk/kWh)	
Other overhead costs (Tk/Month)	

Minutes of the First Stakeholder Meeting, July 17, 2002

Hotel Lake Castle, Dhaka, Bangladesh

List of Participants Present:

Name and Address

M.S. Jayalath – Nexant SARI/Energy Task Manager
Priyantha Wijayatunga – Nexant SARI/Energy Technical Team Leader
Anwarul Kabir – Chief Engineer, REB
Md. Shajahan Ali – Director, System Operation, REB
Md. Abdul Aowal – House # 14, Road # 15, Block- C, Mirpur- 12, Dhaka.
Farhana Parvin – 120, North Chashara, Narayanganj
Md. Enamul Kabr – 101 (B), Nazrul Islam Buet
Kshirod Mohan Bose – Field Engineer
Mohammed Asharaful Karim Chowdhury – 209, Suhrawardhy Hall Buet
Md. Ferdous Alam – D –21, R –4, Banasree, Rampura
A. S. M. Alamgir Kabir – Power Cell, Power Division
Towhid Ahmed Siddique – General Manager (North), DESA
Md. Mokhlesur Rahman Khandkar – D. G. Power Cell
Md. Mazerul Islam
Md. Rafiqul Islam Khan – Senior Asst. Secretary, Power Division, MEMR
Mohammed Khairul Islam – 60/9/D/1 Dhalpur, Demra, Dhaka
Rasel Mahmud – B 2, E-7 Motijheel Govt. Officers Quarter, Dhaka
Abdus Salam – Assistant Chief Engineer (Transmission), BPDB
Md. Fazlur Rahman – Director, New Energy Solutions and the Local Study Team Leader
G.M. Didarul Islam – Deputy Director, System Planning, PDB, Dhaka
Md. Hussain Ali – Economic Consultant, DCCI, 65 –66, Motijheel C/A Dhaka

1) Mr. A.S.M Bashirul Huq welcomed the participants on behalf on USAID, and Nexant Inc., the technical assistance contractor for SARI/Energy.

2) Mr. M.S. Jayalath, Nexant SARI/Energy task manager presented a brief description of the South Asia Regional Initiative for Energy (SARI/Energy), a project funded by the United States Agency for International Development (USAID).

   SARI/Energy is aimed at promoting mutually beneficial linkages between member countries to develop sustainable energy resources. Key areas include power exchange, development of clear energy resources, energy efficiency, private sector participation in the energy sector and sector reforms.

   Under the private sector participation in the energy sector, a study is undertaken to evaluate the economic cost of poor power quality on industry in all SARI/Energy core countries; India, Sri Lanka, Nepal, and Bangladesh.

Study methodology proposed, including the study team structure and key stakeholders identified for the study was discussed briefly with a presentation of activities planned.

3) Overview of the industrial energy consumption in Bangladesh was then presented by Mr. Fuzlur Rahman, local team leader of Nexant SARI/Energy. This presentation included the following:
   i. Industrial sector details and energy consumption.
   ii. Load variations.
   iii. Unplanned and planned interruptions in Bangladesh
   iv. Frequency and voltage variations in Bangladesh
   v. Impact of poor power quality.

   A brief description of data collection methodology, proposed for study was also presented by the local team leader, which included the selection of enumerators. training provided and data collection methodology proposed.

4) Prof. P. Wijayatunga, technical team leader then made a presentation on study methodology. Main components of the presentation:
   i. Type of losses to be considered for the study analysis.
   ii. Methodology:
      a. Sample selection.
      b. Questionnaire
      c. Data collection
      d. Data processing and analysis
      e. Operations of standby generations and associated environmental impacts.
      f. Final report format.

5) At the end of above presentations, a discussion followed.
   a) Comments and clarifications raised by participants:
      i. Need to include utilities and policy makers as stakeholders for the study as they contribute a lot for the study. End-user list was then expanded to include all stakeholders.
      ii. Difficulties in obtaining accurate information from Industry were highlighted by many participants.

Study team sought the assistance of Industrial organizations to obtain reliable data for the study. Local team leader was directed to coordinate activities with stakeholder organizations.

   i. Some energy audit information available with Power Cell can be made use. Local team was requested coordinate activities to obtain data.
   ii. Energy conservation is important and the study team was requested to identify EE measures implemented by Industry in Bangladesh and the potential for EE measures. Noted by the study team.
   iii. Cost of standby power from Gas based generations could be much lower that the gird power. Therefore a careful analysis of this required. Study team agreed.

The stakeholder seminar was terminated at 18.30 hrs.

Appendix C List of Stakeholders Consulted for the Study, August 2002 – January 2003

1. President/Bangladesh Cement Manufacturers' Association/O Bashundhura Droup, Suite 1303, Sena Kalyan Bhaban, 195 Motijheel C/A, Dhaka.

2. President/Bangladesh Ceramic Wares Manufacturers' Association,52/1, New Eskaton Road, Dhaka

3. President/Federation of Bangladesh Chambers of Commerce and Industries (FBCCI),Federation Bhaban, 60, Motijheel C/A, GPB Box No. 2079, Dhaka-1000

4. President/National Association of Small and Cottage Industries of Bangladesh,63/1, Purana Paltan Line, White House, Dhaka-1000

5. President/Bangladesh Agro-Processors Association, Property Heights,12 RK Mission Road, Dhaka-1203

6. President/Bangladesh Aluminum Manufacturers Association, Jahanara Manjil, 345 Segunbagicha (2nd. Floor),Dhaka-1000

7. President/Bangladesh Bread, Biscuit and Confectionery Manufacturers Association, 62/2, Purana Paltan Lane, Kakrail, Dhaka-1000

8. President/Bangladesh Furniture Manufacturers Association, B-129/C, Shopping Centre, 4th. Floor, Gulshan-1, Dhaka-1212

9. President/Bangladesh Leather Manufacturers Association, House 16, Road 24, Dhanmondi R/A, Dhaka

10. President/Bangladesh Cigarette Manufacturers Association, Sarak No. 11 (New), Puratan Sarak No. 32,House 5/D, Dhanmondi R/A, Dhaka-1209

11. President/Bangladesh Cosmetics and Toiletries Manufacturers Association, Square Centre, 48 Mohakhali C/A, Dhaka-1212

12. President/Bangladesh Knitwear Manufacturers and Exporters Association, 233/1, B.B. Road, Narayanganj-14000, Dhaka

13. President/Bangladesh Chamber of Industries (BCI), BCIC Bhaban (3rd. Floor), 30-31, Dilkusha C/A, Dhaka-1000

14. President/Metropolitan Chamber of Commerce and Industries (MCCI), Chamber Building (4th. Floor), 122-124, Motijheel C/A, Dhaka-1000

15. President/Bangladesh-Malaysia Chamber of Commerce and Industries, House-14, Road No-27, Block-J, Banani, Dhaka-1213

16. President/American Chamber of Commerce and Industries (AmCham), Room No. 319, Dhaka Sheraton Hotel, 1, Minto Road, Dhaka-1000

17. President/Foreign Investors Chamber of Commerce and Industries, Mahbub Castle (4th. Floor),35/1, Purana Paltan Line, Inner Circular Road, Dhaka-1000

18. President/Bangladesh Bidi Shilpa Malik Samity (BBSMS), 42, Topkhana Road, Pretam Bhaban (1st. Floor), Dhaka-1000

19. President/Bangladesh Energy Companies Association, SUMMIT Center (10th. Floor),18, Kawran Bazar C/A, Dhaka-1215

20. President/Bangladesh Finished Leather and Leather Goods and Footwear Exporters Association, House No. 61, Road No. 2A, Dhanmondo R/A, Dhaka

21. President/Bangladesh Frozen Foods Exporters Association, Skylark Point (10th. Floor), 24/A, Bejoy Nagar, North South Road, Dhaka

22. President/Bangladesh Hosiery Association, Hosiery Bhaban, Hosiery Shilpa Nagary, Shasonggong, Fatullah, Narayanganj-1400

23. President/Bangladesh Leather Goods Manufacturers Association, 3, Outer Circular Road, Rajarbagh, Dhaka-1217

24. President/Bangladesh Oil Mills Association, C/A Enfa Enterprises Ltd, Biman Bhaban (4th. Floor), 100, Motijheel C/A, Dhaka-1000

25. President/Bangladesh Paint Manufacturers Association, Elite House CDA Avenue, P.O. Box No. 395, Chittagong

26. President/Bangladesh Re-rolling Mills Association, Zahura Mansion (2nd. Floor), Room No. 12, 24, Kazi Nazrul Islam Avenue, Dhaka-1000

27. President/Bangladesh Rice Mills Owners Association, CIC Sadan (2nd. Floor), 22, Motijheel C/A, Dhaka-1000

28. President/Bangladesh Textile Dyeing, Printing Industries Association, Islampur Mansion (4th. Floor),17, Islampur Road, Dhaka

29. President/Bangladesh Textile Mills Association, Moon Mansion (6th. Floor), Block-M, 12, Dilkusha C/A, Dhaka-1000

30. President/Bangladesh Textile Mills Owners Association, 92, Motijheel C/A (1st. Floor-Left Side), Dhaka-1000

31. President/Gazipur Chamber of Commerce and Industries, Jame Masjid Road, Joydevpur, Gazipur Narayanganj

32. President/Narayanganj Chamber of Commerce and Industries, P.O. Box : 2, 230/1, Bangabandhu Road, Narayanganj-1400

33. President/Narshangdi Chamber of Commerce and Industries, Gazli Plaza, 304, West Brahmondi, Court Sadar Road, Upazilla Moar, Narshingdi

34. President/Chittagong Chamber of Commerce and Industries Chamber House,Agrabad C/A, Chittagong, Khulna,

35. President/Khulna Chamber of Commerce and Industries, Chamber Mansion, 5 K.D.A. Commercial Area, Khulna

36. President/Jessore Chamber of Commerce and Industries, Netajee Subhash Chandra Road, Jessore

37. President/Rajshahi Chamber of Commerce and Industries, Chamber Bhaban,Ghoramara, Station Road, Rajshahi

38. President/Rangpur Chamber of Commerce and Industries, Chamber Bhaban, G.L. Roy Road, Nawabganj, Rangpur

Appendix D

Bangladesh Stakeholder Consultation February 22–29, 2003

Team of consultants: Mr. M.S. Jayalath, Prof. P. Wijayatunga and Mr. Fuzlur Rahman

	Name of the person/organization & date/time	Issues discussed
1.	Md. Hossain Ali Economic and Financial Consultant Dhaka Chamber of Commerce and Industry (DCCI): Feb 24, 2003 at 3.00 p.m.	1. Preliminary results. 2. Problems faced by garment industry. 3. Need to develop infrastructure for industry to expand. 4. Impact of power interruptions.
2.	Mr. Md. Alamgir Kabir Director and other higher level officials Power Cell Power Division Ministry of Energy and Mineral Resources Feb 25, 2003 at 11.00 a.m.	1. Preliminary results. 2. Proposed program. 3. Leather industry consumption problems. 4. Comparison of studies. 5. Include export-processing zones.
3.	(a) Mirza Nurul Ghani Shovon President National Association of Small and Cottage Industries of Bangladesh (NASCIB) (b) Prof. M. Rashida Chowdhury Professor, Dhaka University Director, Federation of Bangladesh Chambers of Commerce and Industries (FBCCI) (c) Vice-President National Association of Small and Cottage Industries of Bangladesh (NASCIB) and other high ranking officials of NASCIB Feb 25, 2003 at 4.00 p.m.	1. Preliminary results. 2. Contribution of small industries to the National GDP. 3. SGB capital and operating costs. 4. Proposed recommendations.
4.	Mr. Meshbauddin Ahmed Member (Energy and Industry) Planning Commission Feb 26, 2003 at 3.30 pm	1. Preliminary results. 2. Weaving and textile sub sectors need to be reclassified. 3. Need to get DESCO to participate. 4. Close coordination with the Planning Commission is essential.
5.	Joint Secretary Power Division Ministry of Energy and Mineral Resources Bangladesh Secretariat, Dhaka Feb 27, 2003 at 2.30 pm	1. Preliminary results. 2. National seminar is important for disseminate the findings.

Minutes of the Second Stakeholder Meeting, February 27, 2003
Hotel Lake Castle, Dhaka, Bangladesh

Present: Following were present;

Brig. Gen. M.A.Rob – Chairman, DESA.
Md. Mohiuddin Ahmed – DESA.
Engr. A.S.M.Alamgir Kabir – Director, Power Cell, Ministry of Energy and Mineral Resources.
Engr. B.D.Rahmatullah – Director, Power Cell, Ministry of Energy and Mineral Resources.
Engr. Ahmed Ali – Managing Director, Padma Group and Chairman, BKMEA.
Engr. Mosarraf Hossain – Chief Engineer, BEPZA, Dhaka.
Mirza N.G. Shovon – President, National Association of Small and Cottage Industries of Bangladesh, Dhaka.
Engr. Md. Mohsin Ali – Superintendent Engineer, BPDB, Dhaka.
AFM Fakhrul Islam Munshi – President, Agribusiness Development Organization of Bangladesh, Dhaka.
Ms. Mousumee Rahman – Deputy Executive Secretary, Agribusiness Development Organization of Bangladesh, Dhaka.
Md. Hossain Ali – Economic Consultant, DCCI, Dhaka.
Md. Akhtar Hossain – Central E.C. Member, National Association of Small and Cottage Industries of Bangladesh (NASCIB), Dhaka.
Satya Ranjan Saha – Manager, ITDG, Agro-Processing Program, Dhaka.
Azam Khan – Deputy General Manager, Apex Footwear Ltd, Kaliakoir.
Rasel Mahmood – Enumerator
Engr. M.A. Malek – Managing Director, Energypac Engineering Ltd, Dhaka.
Md. Lutfor Rahman – Proprietor, Modern Furniture Complex, Dhaka.
Md. Fuzlur Rahman – Nexant SARI/Energy Local Team Leader.
Prof. Priyantha Wijayatunga – Nexant SARI/Energy technical team leader.
A.S.M. Bashirul Huq – Nexant SARI/Energy, Bangladesh.
M.S. Jayalath – Nexant SARI/Energy Task Manager.

1. Mr. A.S.M. Bashirul Huq welcomed the participants on behalf on USAID, and Nexant Inc., technical assistance contractor for SARI/Energy.
2. Mr. M.S. Jayalath presented a brief introduction and study methodology with Mr. Fuzlur Rahman. Presentations highlighted the following:
   iii. SARI/Energy program
   iv. Regional power quality issues.
   v. Study scope/concept.
   vi. Stakeholders identified for the Study.
   vii. PQ issues considered.
   viii. Methodology adopted.
   ix. Data collection.

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x. Sample selection.
xi. Questionnaire and information collected.

3. Prof. P. Wijayatunga then presented the data analysis and preliminary results. which highlighted the following:
   xii. Methodology adopted for data analysis.
   xiii. Preliminary results and conclusions (*Included as Attachment 1*)
4. Comments of participating stakeholders:

   Mr. Rahmatullah from the Power Cell: Questioned about the accuracy of data obtained for the study, referring to recorded consumption may not be the actual. He further stated that the output figures might also be not accurate. Therefore, it is required to identify a way eliminating above.

   Chairman, DESA also endorsed above views and agreed to assist the study team in obtaining information from few reliable installations.

- Considering above, the study team agreed to do a benchmarking exercise to fine-tune results by obtaining production and energy consumption figures from few reliable installations.

Most stakeholders felt that consumers' views on the other issues are also important and requested the team to highlight these in the report.

- Suggestion was accepted by the study team.

  Mr. Kabir from the Power Cell: Requested the study team look at increasing grid tariffs with widespread use of SBG in Bangladesh industry.

- Study team will highlight the important areas for further studies in the final report.

  Mr. Kabir also suggested a meeting of hew key stakeholders after the draft report is out and reviewed by stakeholders before finalizing it.

- Study team agreed to convene another meeting two weeks after the draft is circulated to all stakeholders.

A proposal to conduct a national seminar to disseminate the study results, was well received.

It was agreed that Mr. A.S.M. Bashirul Huq and Mr. Fuzlur Rahman will make necessary arrangements in consultation with USAID.

Meeting was terminated with Mr. A.S.M. Bashirul Huq proposing a vote of thanks.

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Attachment 1: Assessment of Economic Impact of Poor Power Quality on Industry: Bangladesh
Preliminary Results

Value addition

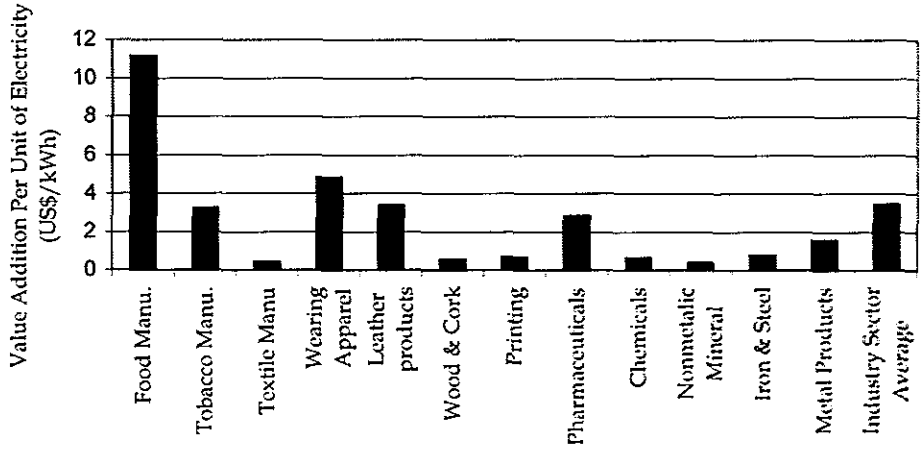

Figure 1: Value addition per unit of electricity (US$/kWh)

Outage Costs

The variation of economic cost of unplanned and planned outages in different industry categories are shown in Figures 2 and 3

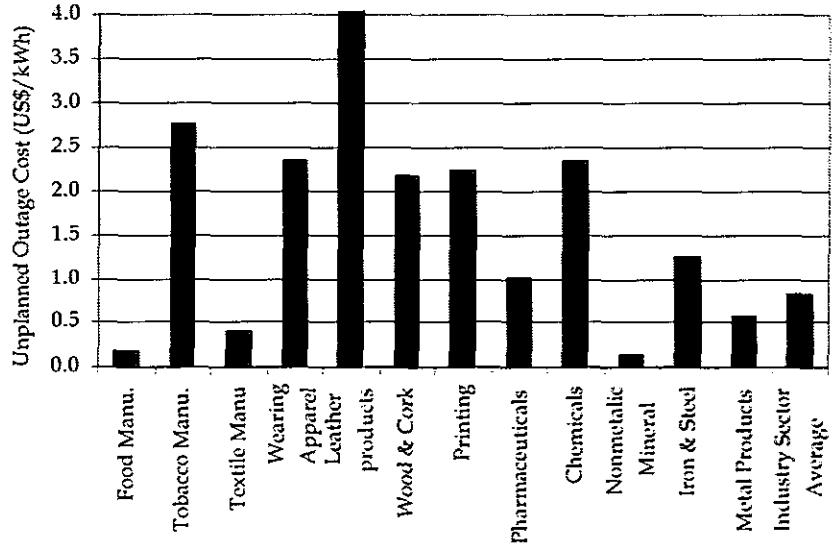

Figure 2: Economic Cost of Unplanned Outages in Industry

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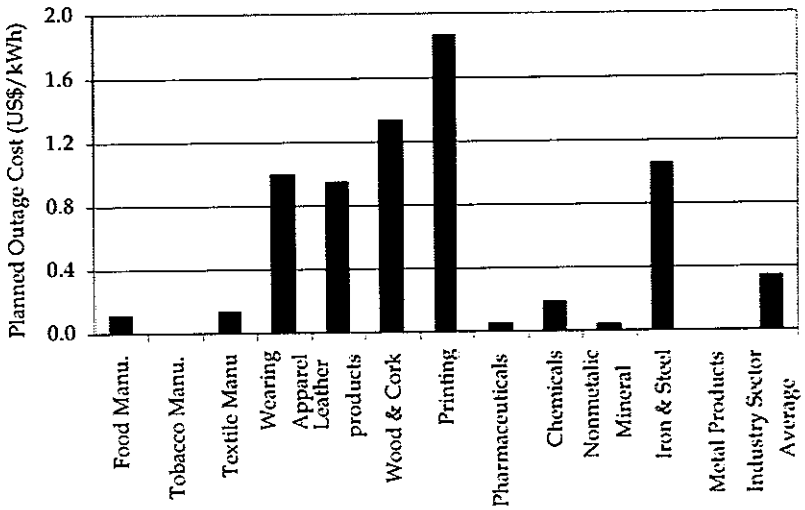

Figure 3: Economic Cost of Planned Outages in Industry

Table 1: Cost of Momentary Interruptions

INDUSTRY	Momentary Interruption Cost (US$/hr)
Food Manufacturing	28
Tobacco Manufacturing	30
Textile Manufacturing	179
Wearing Apparel	337
Leather products	26
Wood and Cork	6
Furniture	378
Printing	574
Pharmaceuticals	4680
Chemicals	3176
Nonmetallic Mineral	1724
Iron and Steel	44
Metal Products	1131
Industry Sector Average	**365.35**

Table 2: Frequency and Period of Each Interruption

Interruption Type	Frequency/Year	Period of Each (hrs)
Unplanned Outage	335.56	1.81
Planned Outage	5.57	6.82
Voltage Variation	96.31	1.66

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Table 3: Economic Cost of Each Interruption Type

Interruption Type	Losses
Momentary (US$ per interruption)	365.35
Unplanned (US$/kWh)	0.83
Planned (US$/kWh)	0.34
Planned -Fixed (US$ per interruption)	25.29
Voltage Variation (US$/Hour)	42.02
Supply Harmonics (US$/Hour)	3.24

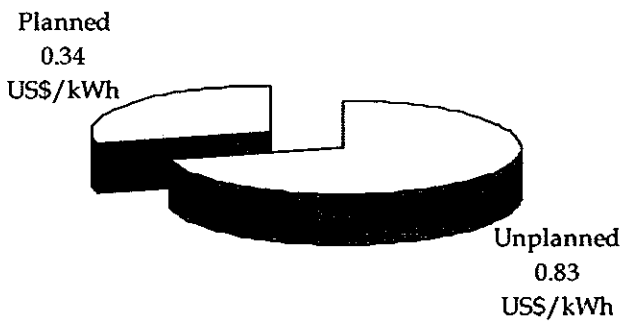

Figure 4: Comparison of Economic Costs of Unplanned and Planned Outages

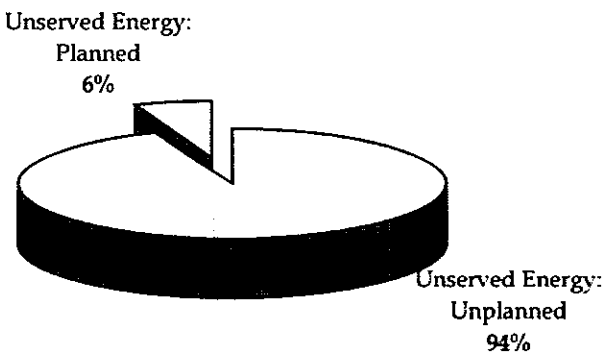

Figure 5: Proportions of Energy-not-Served due to Unplanned and Planned Outages

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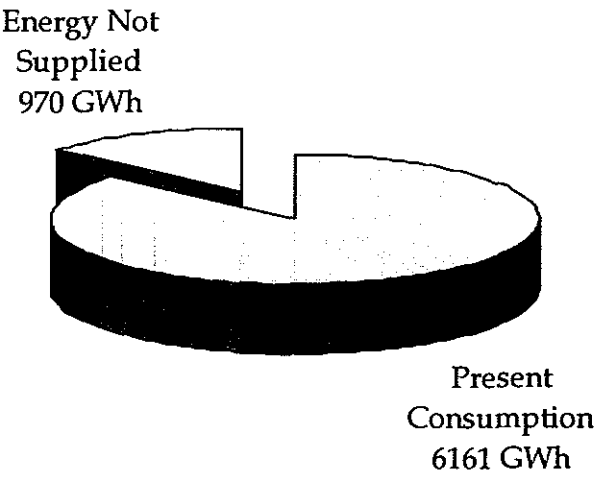

Figure 6: Comparison of Present Industry Consumption with Energy-Not-Served due to Outages (2000/01)

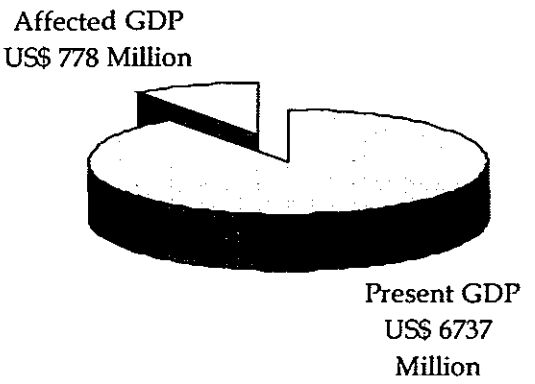

Figure 7: Comparison of Total Industry Sector GDP and the GDP affected due to Outages

Economic Cost of Outages amounted to 1.72% of the Country GDP in 2001.

Standby Generation Facilities

On average **64%** of the industrial installations in the country have standby generation (SBG) facilities.

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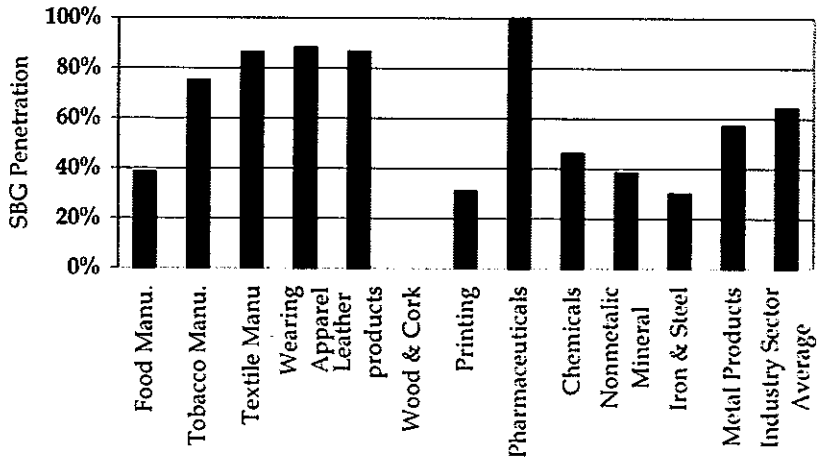

Figure 8: Penetration Level of Standby Generation in Different Industry Categories

But most of these industrial installations do not have SBG facilities to supply their full load. The level of SBG capacity as a percentage of the full load considering only those industries having SBG Facilities is given in Figure 9.

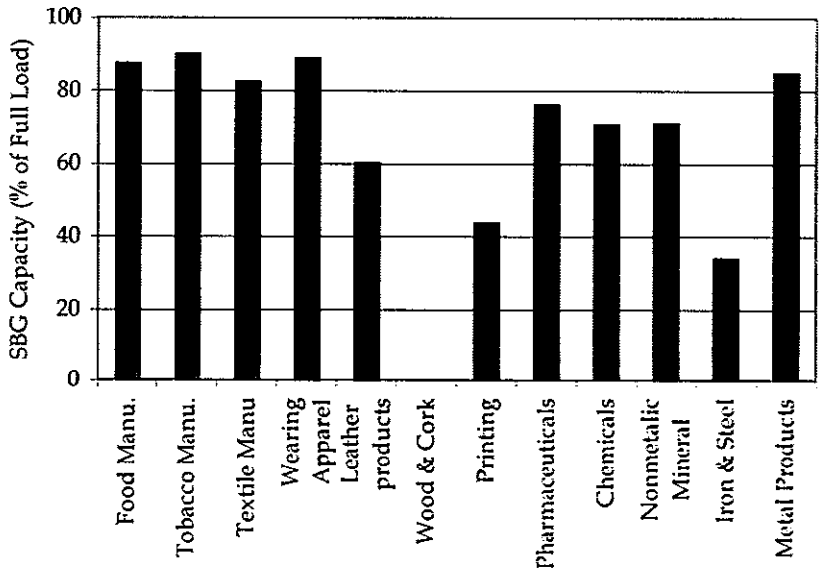

Figure 9: SBG Capacity as a percentage of full load considering only those industries having SBG Facilities

If it is assumed that these SBG facilities are always fully used when there are outages then Table 4 shows the incremental emissions and financial costs due to SBG usage in the industrial sector.

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Table 4: Incremental Emissions and Costs due to SBG

Impact due to Standby Generation	
	Incremental Emissions (MT/yr)
Carbon Dioxide	23849
Carbon Monoxide	31
Sulfur Dioxide	1
Nitrogen Oxides	486
Particulate Matter	35
Annual Incremental Cost to the users due to SBG (US$ Million)	4.48

General Comments

The industries in the sample were asked five important questions. The response to these questions are given in Table 5

Table 5: Response by the Industries in the Sample to Different Questions

Comment	Percentage of Industries
Willing to pay more for high quality power	**50%**
Think that industries pay too much for the quality of power received	**95%**
Depend on standby generation more than on utility power	**14%**
Would invest more on electricity dependent enterprises if the quality of power is higher	**51%**
Have implemented Energy Conservation measures	**32%**

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List of Reviewers

Mr. M.D. Rmatullah, Power Cell, Ministry of Energy and Mineral Resources
Mr. Kabir, Power Cell, Ministry of Energy and Mineral Resources
Mr. Beckman, SARI/Energy, USAID
Engr Mosharraf Hossain, Chief Engineer, Bangladesh Export Processing Zones Authority
Md Jillur Rahman, Executive Engineer, Bangladesh Export Processing Zones Authority
Chairman, Dhaka Electricity Supply Authority
Mr. Hassanur Rahman, Deputy Secretary Training, DCCI Business Institute
Engr Mosharraf Hossain, Chief Engineer, Bangladesh Export Processing Zones Authority
Md Jillur Rahman, Executive Engineer, Bangladesh Export Processing Zones Authority

Minutes of Stakeholders Meeting, May 2002

Mr. Ramathulla, Power Cell, Ministry of Energy and Mineral Resources:

In general the EIS report can act as a good source of information on the power sector and economic impact of poor power quality. Accuracy of the information provided by the industrialists is still a concern. Detailed comments on the report will provided by Tuesday 27th May.

Mr. Kabir, Power Cell, Ministry of Energy and Mineral Resources:

Power sector data in the Introductory Chapter such as generation mix and electricity demand needs to be updated with the latest available information.

Different functions of the power sector institutions need to be accurately reflected in the report and hence requires modifications to the existing text.

The recommendation on the need to include codes and standards on the quality of service does not arise since the new regulatory regime will require a grid code, which will eventually include these codes and standards.

It is more appropriate to include a background write-up leading to the recommendations justifying them.

Energy exchange can be another aspect to be considered under recommendations to improve the power quality.

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Improving consumer awareness needs to be recommended.

Engr Mosharraf Hossain, Chief Engineer, Md Jillur Rahman, Executive Engineer, Bangladesh Export Processing Zones Authority:

No industry will be interested in energy efficiency unless they are educated on the financial benefits of such activities. Comments on the report will be provided soon.

Written Comments

Mr. Kabir' s Comments:

Page-iv, Para-6: Due to power outages economic loss in the industrial sector amounting to US$ 778 million during the year 2000-01 which is **11.74%** of the industrial sector GDP or **1.72 %** of national GDP in 2000-01.

Comments: Detailed calculation and analysis about production and economic loss due to power outages may be included as annexure with this report.

Page-v, Para-2: It is mentioned that there is no explicit reference to power quality in either in the Electricity Act, 1910 or in Energy Regulatory Commission Act except that the voltage and frequency are expected to be maintained within certain limits and the Regulatory Commission is empowered to formulate codes and standards on the quality of service.

Comments:

- Quality power means uninterrupted power supply at a certain voltage and frequency range.
- The acceptable range of voltage and frequency variation is articulated in the Electricity Act, 1910 (Chapter IV) as follows:

Low and medium voltage	± **5%**
High voltage.....	± **12.5%**
Frequency	± **4%**

- The codes and standards to ensure reliable and quality power supply have already been drafted. This will be reviewed and adopted by the ERC and will be used for technical regulation.

Introduction; 1.2.7 Power Cell

Comments: In the draft report Power Cell's responsibilities are made limited in the private sector power development activities. But its main responsibility were power sector reforms, restructuring, tariff study and to establish a regulatory framework. Private sector power development is one of the main components of power sector reform programs. Similarly functions and responsibilities of other organizations may be checked with those organizations.

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5.1.2 Electricity Usage (Page 5-2)

The value addition per unit of electricity usage in different types of industries sub-sector is shown in figure 5.2. The detailed calculation may be annexed with the report.

5.2.1 Momentary Interruptions and 5.2.2 unplanned outages

In case of Pharmaceuticals, momentary interruptions loss is US$ 4680/ Interruption. While for the same sub-sector average unplanned interruption cost is US$ 1.02/kWh. It is not understood clearly why such a big cost difference.

The basis of calculation of the impact should be annexed with the report.

Methodology:

3.8 Data processing and analysis

Economic impact due to power interruptions and supply outage has been accounted as:

Momentary interruptions	-	US$/Interruption
Planned supply outages	-	US$/kWh
Unplanned supply outages	-	US$/kWh
Voltage fluctuation and supply harmonics	-	US$/hr

How the double counting is avoided during the calculation of total economic impact for poor quality power on industry sector. The method may be elaborated.

General Comments:

1. For better assessment about economic impact of poor power quality on industry sector concentrated load centre specially the EPZ area may be given preference.
2. More stakeholders' consultation is needed to know their views.
3. Numbers of installation may be increased at least **10%** for better assessment.
4. Some information and analysis in reading each of the recommendations need to be included in the report.
5. In the recommendation load management including use of energy efficient equipment may be included as it has a positive impact on power quality improvement at present context.

Mr. Ramdullah's Comments:

Thanks for preparing a very good report, which helps to get an idea about consumers and patterns of consumption in Bangladesh. Although I have a question about the accuracy, it is indeed a good paper for assessing the characteristics of the consumption of electricity for various consumers.

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Specific Comments

Executive Summery, page V, recommendation: You have not mentioned the method of planned outage. I have submitted to the Ministry and PDB (as a member of load management committee formed by government) a load management scheme that helps reduce demand around 300 MW during peak, which is the vital issue at this time. It reduces the cost of peak power production, reduces load loss, and increases reliability of the system.

Page 1-2 and Section - 1 h- subsection 1.2: Power sector structure is not correct - PGCB and DESCO are not placed correctly.

Section 1.2-7: The Role of Power Cell is only partly given. There are three directorates; you have given the role of only one directorate [see enclosed Role of Power Cell].

Section 1.4: The way of reducing loss is given is wrong. We have a special program on reducing system loss in the Strategic Business Unit (SBU) in PDB that is a success story. It gives a way for reducing loss and the causes of losses and segregates technical and non-technical loss. I have written many papers on loss, of which Mr. F. Rahman is aware. Please rectify things accordingly. This wrong statement will help corrupt people to invest money in the name of system loss reduction, which has a long practice in the power sector.

Section 1.6: The reform process you have described is not correct; some specific programs are under implementation, which include the PDB Holding company. Some important aspects have not been considered.

The study is fine, but not complete in the following aspects:

1. Power utilities are not enjoying autonomy; it is the lack of autonomy that is preventing utilities from establishing good quality service.
2. Accountability and transparency are missing, which that result in poor quality of service and poor monitoring, and thus poor performance. In PDB (through SBU), we have already proved that just with the introduction of specific and close monitoring service can be improved.
3. Low salary is one of the main impediments to improving the quality of the sector. Why don't you suggest a performance-based incentive / punishment scheme? We call it Performance Target Achievement (PTA), and we are going to introduce it in SBU. In PDB, we use the following calculation: by achieving a target of reducing losses and increasing revenue, PDB earns additional revenue of around 4000 million Taka /Year. To get a bonus for all the staff, they need only 400 million taka, so it is a win-win solution, since only **10%** of additional earnings are needed to get a bonus.

Conclusion: I appreciate your effort. Except for the things I mentioned, it is a good report to quote.

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