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Economic Impact of Poor Power Quality on Industry

Nepal

Nexant

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List of Acronyms

ABC	Aerial Bundle Cable
DoED	Department of Electricity Development
DCS	Distribution and Consumers Services
EIS	Economic Impact Study
FNCCI	Federation of Nepalese Chambers of Commerce & Industry
ESCO	Energy Service Company
GDP	Gross Domestic Product
HMG	His Majesty's Government
IPP	Independent Power Producer
NEA	Nepal Electricity Authority
SARI/Energy	South Asia Regional Initiative on Energy
SBG	Standby Generation
TOE	Tons of Oil Equivalent
USAID	United States Agency for International Development
WB	World Bank
WEC	Water and Energy Commission

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Executive Summary

The electricity industry, which is essential for economic and social development, has an important role to play in the development of the Nepalese economy. 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 poor quality of electricity delivery on the industrial installations in Nepal. The study was designed to consider the economic and direct environmental impacts of power interruptions, voltage fluctuations, and other significant problems, such as, supply harmonics. To provide a basis for the assessment, existing guidelines on power quality were reviewed, the economic impact of power quality was analyzed for a sample of industrial consumers, self-generation costs and their environmental impact were estimated, and recommendations for power quality improvements were developed.

The investigation was carried out using a detailed nationwide sample survey of more than 200 installations covering the main categories of industries contributing to the country's gross domestic product (GDP) growth. A structured questionnaire was administered during August through October 2002. The data used in the study are as reported for FY 2001.

The study found that industrial sector losses in Nepal attributable to unplanned interruptions averaged 0.49 US$/kWh, but such losses were only 0.14 US$/kWh for planned outages. Thus, the unplanned interruptions result in losses 3.5 times greater than those associated with planned interruptions. Further, the voltage fluctuations can cause major problems in certain industrial categories, such as food, beverages, and tobacco manufacturing, and textile and leather manufacturing, while other categories, such as, the non-metallic and mineral industries, are completely unaffected. Since the response on other supply problems, such as, harmonics was extremely limited no analysis was carried out in those areas.

The study found that the frequency of unplanned interruptions during the year was almost one interruption every two days and that each lasted about an hour and a half. However, planned interruptions were less frequent occurring only twice in a month but each interruption lasted about 2 hours. Therefore, **86%** of the total unserved energy demand resulting from interruptions is due to unplanned outages, but only **14%** is attributable to the planned outages. In total, approximately **8%** of the industrial sector demand cannot be met by the electric utility due to planned and unplanned interruptions.

Further, these outages result in an economic loss in Nepal's industrial sector amounting to US$ 24.7 million a year. This translates into **4.43%** of the industrial sector GDP or **0.47%** of the national GDP in 2001.

On average **76%** of the industrial installations in the country have standby generation (SBG) facilities, but they are able to supply only about **74%** of the full load electricity requirements. Assuming that the SBGs are in operation throughout the grid supply outages, the additional financial burden on the industrial sector can be estimated to be about US$ 1.2 million a year.

Over **80%** of the participating industries reported that they over-pay for the quality of power they receive, yet **51%** of the sample still would be willing to pay even more for higher power quality. Also, approximately one-third of the sampled industries would have invested more in electricity dependent industries if the quality of power supply were better.

The study also examined the prevailing regulations (Electricity Regulation, 1993) associated with power supply quality. Under this regulation, the licensee should ensure that the voltage at the distribution level below 33kV does not fluctuate beyond ±**5%** (Sections 4.0-4.2). For transmission voltages that are 33kV and above, this fluctuation needs to be within ±**10%**. The frequency of fluctuations needs to be maintained within ±**2.5%** of the standard frequency of 50Hz. Other power quality issues, such as, frequency and duration of planned and unplanned interruptions, supply harmonics, etc., are not dealt with in the existing legislation.

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. Voltage fluctuations cause a significant adverse impact on certain types of industries, and this impact needs to be seriously addressed. The very high level of SBG in the industrial sector is likely to increase in the future unless the necessary measures are taken to reduce grid supply outages.

If the number of outages and the voltage fluctuations are reduced, a higher tariff is likely to be acceptable to important industry categories, such as, food, beverages, and tobacco; textile and leather products; and iron and steel. Further, the implementation of energy conservation measures in the industrial sector at present is relatively low. Hence, this sector needs an aggressive energy conservation program.

To address these issues, the following recommendation can be made:

- Strengthen end-user participation in the electricity supply industry and establish a regular dialogue between the end-users, utilities, and policymakers

- Improve codes and standards on the quality of service, especially requirements concerning supply interruptions

- Adopt measures to reduce unplanned interruptions by converting them to planned outages wherever possible

- Strengthen ongoing South Asia Regional Initiative on Energy (SARI/Energy) initiatives on energy efficiency, such as, energy service company (ESCO) activities and standard setting and labeling of end-use appliances, to ensure wider awareness and implementation of energy efficiency measures

- Improve the power system performance by timely and appropriate transmission capacity additions, as well as distribution system improvements

- 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 improving transmission and distribution network reliability; and
    - Developing institutional and legislative frameworks required for aggressive implementation of energy efficiency programs in the electricity sector

1.1 Energy Sector

Only **1%** of the energy needs of Nepal are currently being met by electricity. The electricity grid is centered in urban and semi-urban centers; and, about **15%** of the population is being supplied by the national grid, although **32%** of the population has access to electricity. However, the vast majority of the rural population, representing about **53%** of Nepal's total population, is yet to have access.

In rural areas, wood is still the major source of energy consumption (**74%**) with animal residues providing a further **20%**. This practice is no longer sustainable, resulting in deforestation and soil erosion. Moreover, population growth is placing further stress on the land.

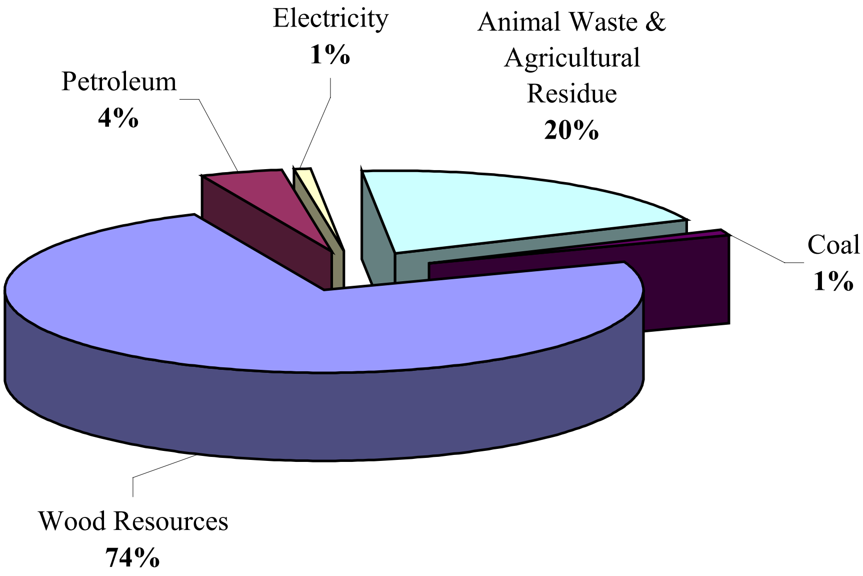


Figure 1-1: Primary Energy Supply Scenario with Main Contributing Sources

1.2 Present Power Sector Structure

The key institutions responsible for power development include:

- Ministry of Water Resources
- Ministry of Population and Environment
- Department of Electricity Development (DoED) (licensing and overall policy)
- Electricity Tariff Fixation Commission
- Nepal Electricity Authority (NEA)
- Independent Power Producers (IPPs)

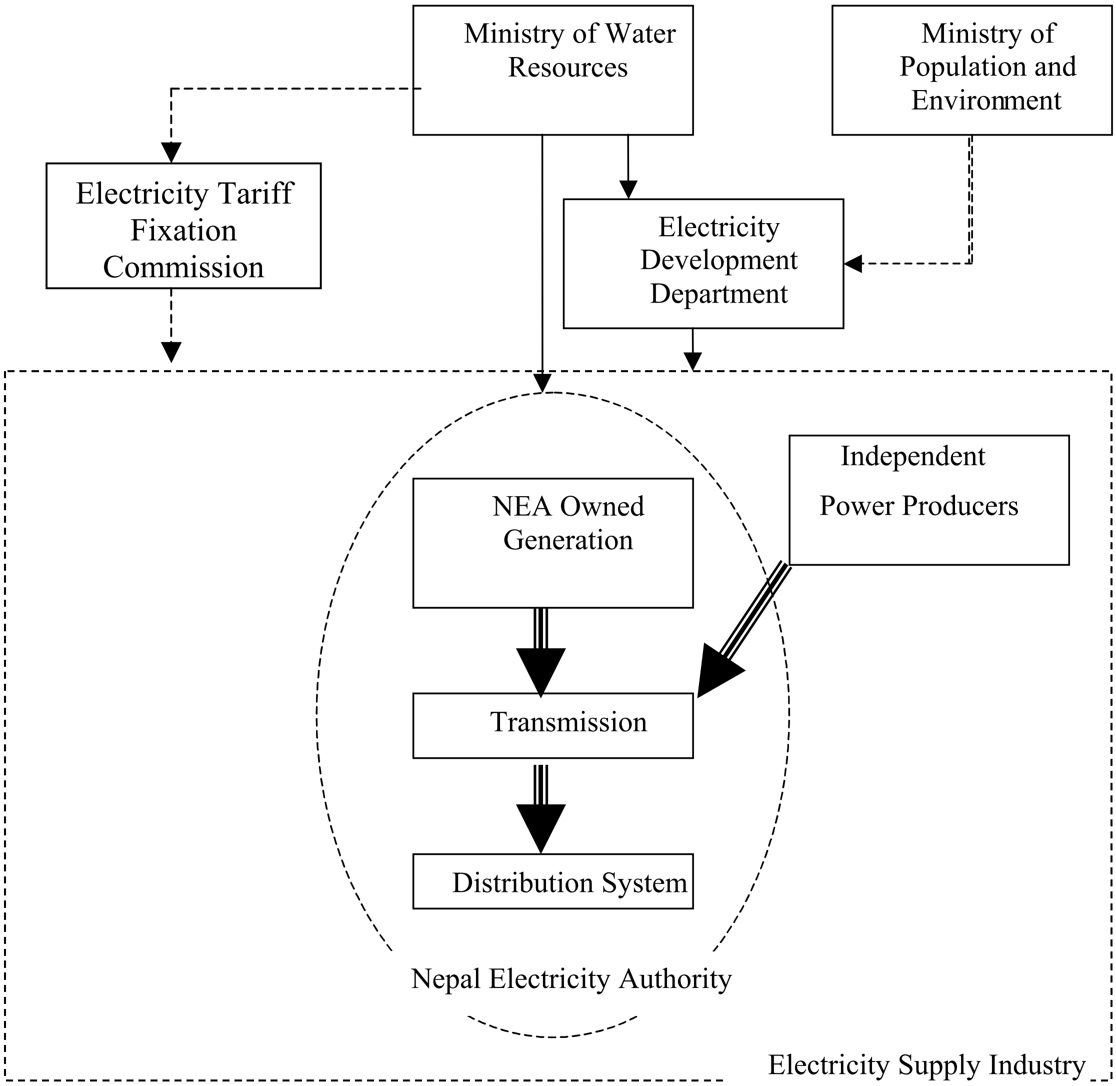
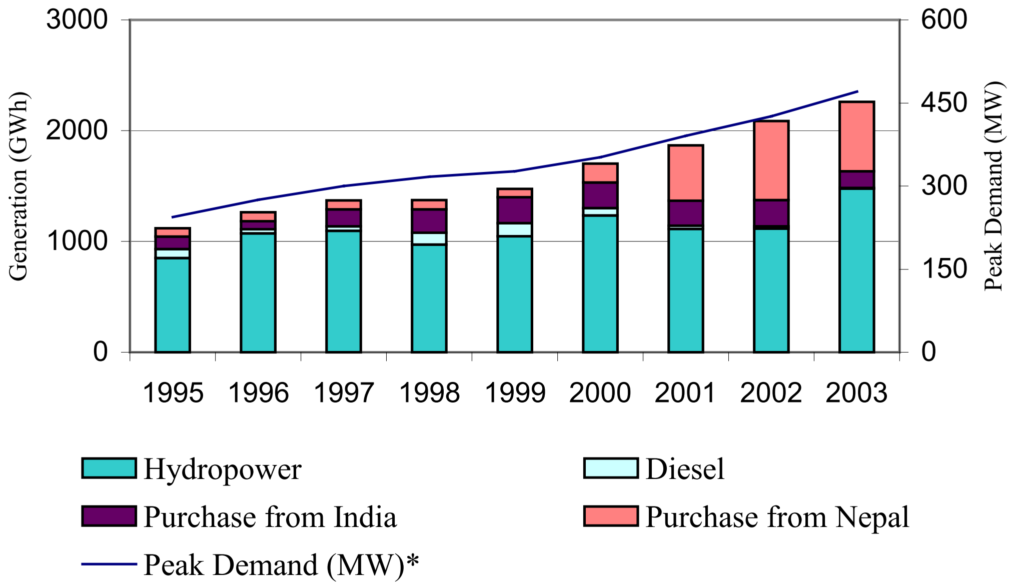


Figure 1.2: Institutional Arrangement in the Power Sector

1.3 Electricity Generation

The Nepal Electricity Authority (NEA) owns and operates the national grid. In 2003, the total estimated energy generation is 2261GWh where 1478GWh come from NEA owned hydropower and the remainder is attributed to purchases from Independent Power Producers and NEA owned thermal generation (NEA Annual Review, 2002/03).



Source: NEA Annual Report 2002/03

Figure 1.3: Generation and Peak Demand Growth in Nepal Power System 1995-2003

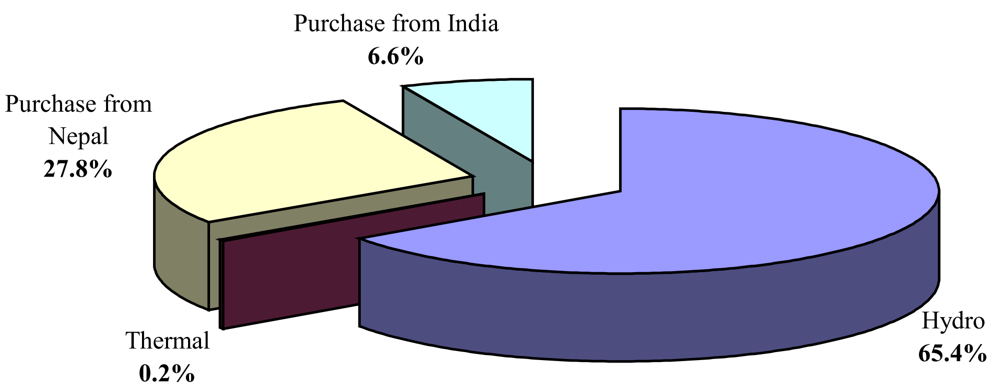


Figure 1.4: Composition of Electricity Supply in Nepal – 2003

The load forecast for the Nepal power system is given in Figure 1.5. On average**, 7.5%** annual energy growth rate and **7.93%** annual peak demand growth rate are expected in this system.

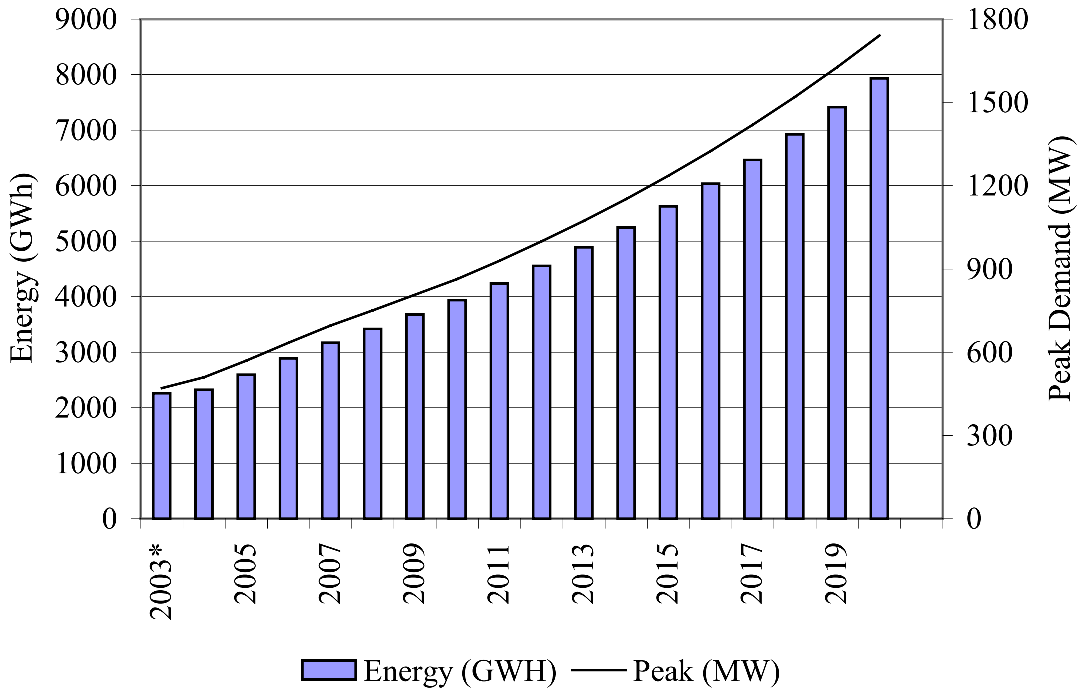


Figure 1.5: Load Forecast for the Nepal Power System — 2003-2020

1.4 System Losses

Despite intensive efforts to curb losses, loss reduction continues to be a burning issue for NEA. In 2003, the system losses stand at **23.7%** in comparison to **24.6%** in 2002. To reduce losses, Distribution and Consumers Services (DCS) has undertaken various measures, such as, installing aerial bundle cables (ABC), launching a public awareness program, implementing regular inspection of large and medium consumers, installing the correct metering system, and introducing an electronic meter system. An act to curb unauthorized leakage of electricity has recently been enacted and enforced.

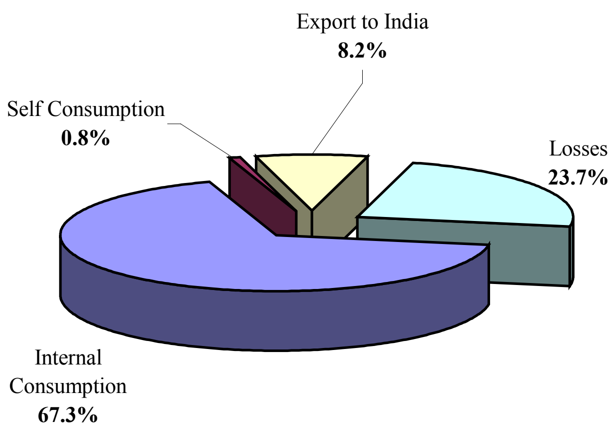
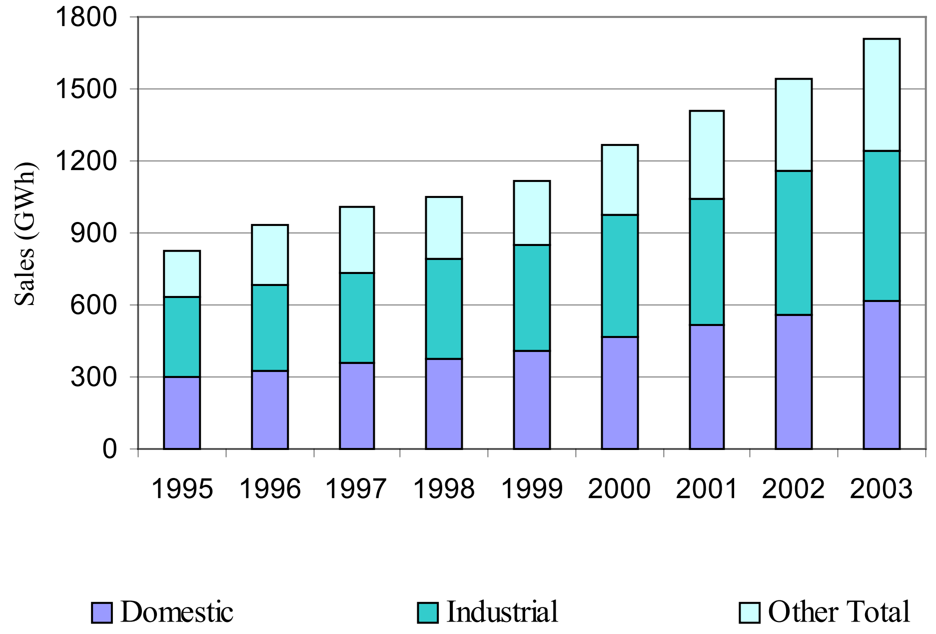


Figure 1.6: Nepal Electricity System Consumption and Losses-2003

1.5 Electricity Consumption



Source: NEA Report, page 38.

Figure 1.7: Growth of Electricity Consumption

1.6 Reform Initiatives of Nepal Electricity Authority

Hydropower Development Policy 2058 (October, 2001)

In October 2001, the government introduced the Hydropower Development Policy 2058 . Its basic objectives are as follows:

- Generate electricity at low cost by utilizing the country's available water resources
- Extend reliable and high quality electricity services throughout the country at a reasonable price
- Combine electrification with economic activities
- Support development of rural economy by extending rural electrification; and
- Develop hydropower as an export commodity

This policy has identified the responsibilities of existing as well as new institutions involved in the power sector. They are as follows:

- Electricity Tariff Fixation Commission to act as the regulatory body with a wider authority
- Water and Energy Commission to be responsible for load forecasting, system planning, and preliminary study of projects; and an

- Energy Management Institution to be responsible for training and research in the fields of management, technical, and environmental issues related to electricity

Regulatory Body

The Electricity Tariff Fixation Commission will evolve to be the regulatory body in the power sector and its functions encompass mainly the following:

- Fixing electricity and wheeling tariffs
- Monitoring and supervising the safety of the electricity system, reliability of supply, and quality standards of electricity
- Protecting consumer interest
- Preparing Grid Codes
- Approving the criteria for load dispatch; and
- Preparing the criteria for safety and quality standards of electricity, etc

The electric energy generated from the hydropower center may be purchased and sold with mutual understanding between the generator and purchaser. But the Electricity Tariff Fixation Commission should review the basis for the fixation of the rate of the sale and purchase of electricity before finalizing the agreement.

Further, the Electricity Tariff Fixation Commission would fix the rate of electricity tariff to be sold and distributed to the consumers taking their interests into consideration.

Department of Electricity Development

The Department of Electricity Development (DoED) is assigned with the following functions.

- Issue licenses on a competitive basis
- Provide services conveniently under a “one window” policy and to attract private sector development of hydropower
- Encourage private participation in hydropower projects
- Encourage optimal use of water resources as part of the approval process for hydropower projects with a capacity of more than one MW
- Undertake hydropower project feasibility studies and studies of multi-purpose projects; and
- Extend necessary assistance to the private sector in the operation and monitoring of projects and promotional work

Water and Energy Commission

The Water and Energy Commission (WECS) is expected to carry out activities related to:

- National load forecast for electricity and system planning study
- Preliminary identification of hydropower projects; and
- Policy research on electricity development

Electric Energy Management Research Institute

The Electric Energy Management Research Institute is expected to conduct research studies of the financial, legal, environmental, and technical aspects of electricity and to provide training.

The policy states that functions pertaining to the operation of the generation centers, electricity transmission and the national grid, engineering services and electricity distribution owned by the Nepal Electricity Authority (NEA) will be gradually unbundled and appropriate institutional arrangements will be set up without any changes in ownership patterns. Discrete entities for generation, transmission, and distribution have been formed as core business groups in NEA, and these groups have been organized to undertake semi-autonomous functions with accountability based on performance agreements with NEA's corporate offices. The core groups will carry on transactions within themselves through a system of transfer prices. Mechanisms have been built in to prevent the transfer of inefficiencies and liabilities between core units. However, several activities, such as, planning and monitoring, finance and administration and information technology have been retained as central activities. Emphasis has been placed on adequate monitoring from the corporate offices for activities at all levels.

Un-Bundling of NEA

The policy envisages vertical and horizontal unbundling of NEA into different entities along the following lines:

- Generation
- Transmission and operation of the national grid
- Distribution; and
- Engineering Services

The private sector would be given priority for electricity generation. To facilitate private sector involvement, projects would also be developed through public-private partnerships. Transmission and operation of the national grid would be under public domain. The private sector would be encouraged in electricity distribution. To facilitate the private sector, electricity distribution would be carried out through public-private partnerships. Rural electrification would be expanded through community-based organizations.

A study by the United States Agency for International Development (USAID) under the South Asia Regional Initiative for Energy (SARI/Energy) has identified power quality as an important issue for all SARI/Energy member countries. Under the technical assistance component of the SARI/Energy project, Nexant SARI/Energy proposed to carry out a technical assessment of the impact to 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 in Sri Lanka, Nepal, Bangladesh, and India.

This study involving Nepal's industrial sector is intended to provide the basic data, analysis, and recommendations for:

- Stakeholders and policymakers to obtain a better understanding of the impact to the local economies from poor power quality
- Policymakers and utility staff to consider the immediate and long-term remedial action
- Policymakers to consider amendments to existing policy and guidelines; and
- Policymakers to widen the agenda and strengthen the role of end-users as advocates for change

The major elements of the technical assessment are:

- Review existing guidelines
- Analyze power quality for the identified samples of customers
- Estimate the cost of poor power quality to the economy from lost production, high energy costs, and environmental impacts from standby generation
- Estimate anticipated self-generation and associated cost over the next five-year period
- Provide recommendations for immediate and long-term power quality improvements and
- Propose improvements to 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 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.

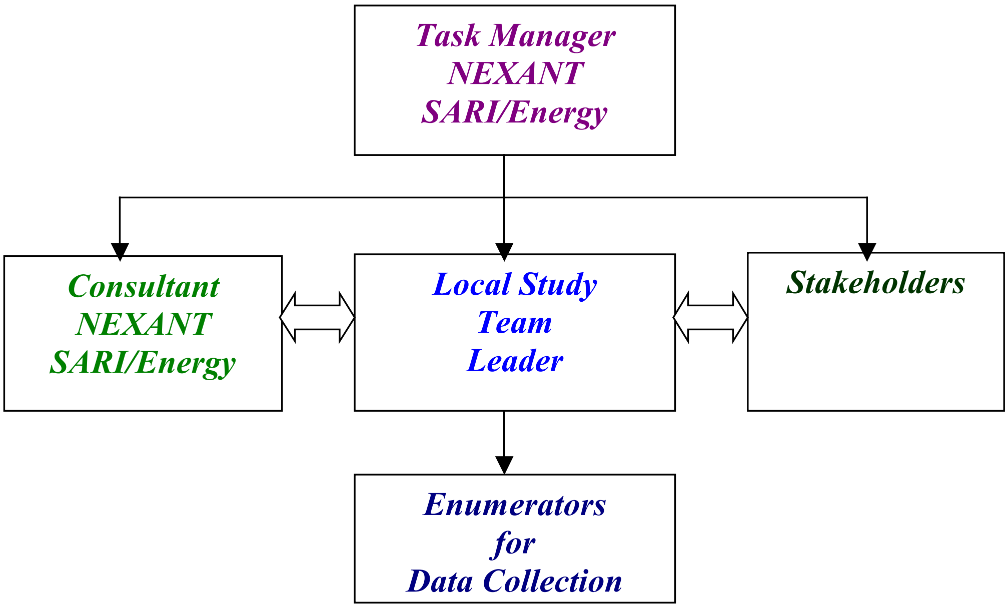


Figure 3.1: Organizational Structure of the Study Team

The study team comprises the Task Manager, a Consultant, and a Local Team Leader appointed by Nexant SARI/Energy, enumerators selected by them 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 deciding on the sample and developing the draft questionnaire, the study progress was presented in the first stakeholder meeting where valuable inputs from the participants were received. These inputs were later incorporated in finalizing the sample and the questionnaire.

The preliminary results of the study were presented in a second stakeholder meeting. 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, such as, comparison of outage data collected during the survey with those obtained from the NEA substation records were readily considered and incorporated in the study. The minutes of the proceedings of stakeholder consultations and the lists of participants are given in Appendices B, C, D, E and G.

3.3 Questionnaire

A questionnaire was designed by the study team in order to gather all the relevant information to meet the project scope giving due consideration to the comments from stakeholders and by using experiences in previous studies conducted in the region. The questionnaire used for the survey 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 sub-divided into sub-components of losses, such as, those associated with raw material, manpower, and production output for convenience in data gathering. The questionnaire, which was finalized by the study team with valuable 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 sub-categories of industries in the country. The number of industrial installations to be surveyed was then determined based on their GDP contributions and their importance 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 on their technical background and proximity to the installations selected in different regions in the country. These enumerators, who were trained on the data requirements and collection procedures before they were sent out to the field, worked directly under the supervision of the local team leader.

A contact for each installation to be surveyed had been established over the phone by the corresponding enumerators before they personally visited the industry installations for data collection. The questionnaires were then sent to these contact persons for them to be prepared with necessary data before the enumerators' visits to the installations. Each of the questionnaires was filled by the enumerator personally to minimize any erroneous entry of data 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 contained 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 see any obvious erroneous data. Such records were either corrected or not included for processing if such entries were unacceptable, after scanning through the original survey data sheets.

3.7 Data Verification

Later, in response to the comments made during the second stakeholder meeting (see Appendix E), supply outage information was collected from a few different substations to compare it with what was provided during the survey to ensure accuracy. These supply outage data collected from substations are given in Appendix F.

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 led to the losses for momentary interruptions determined 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.

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

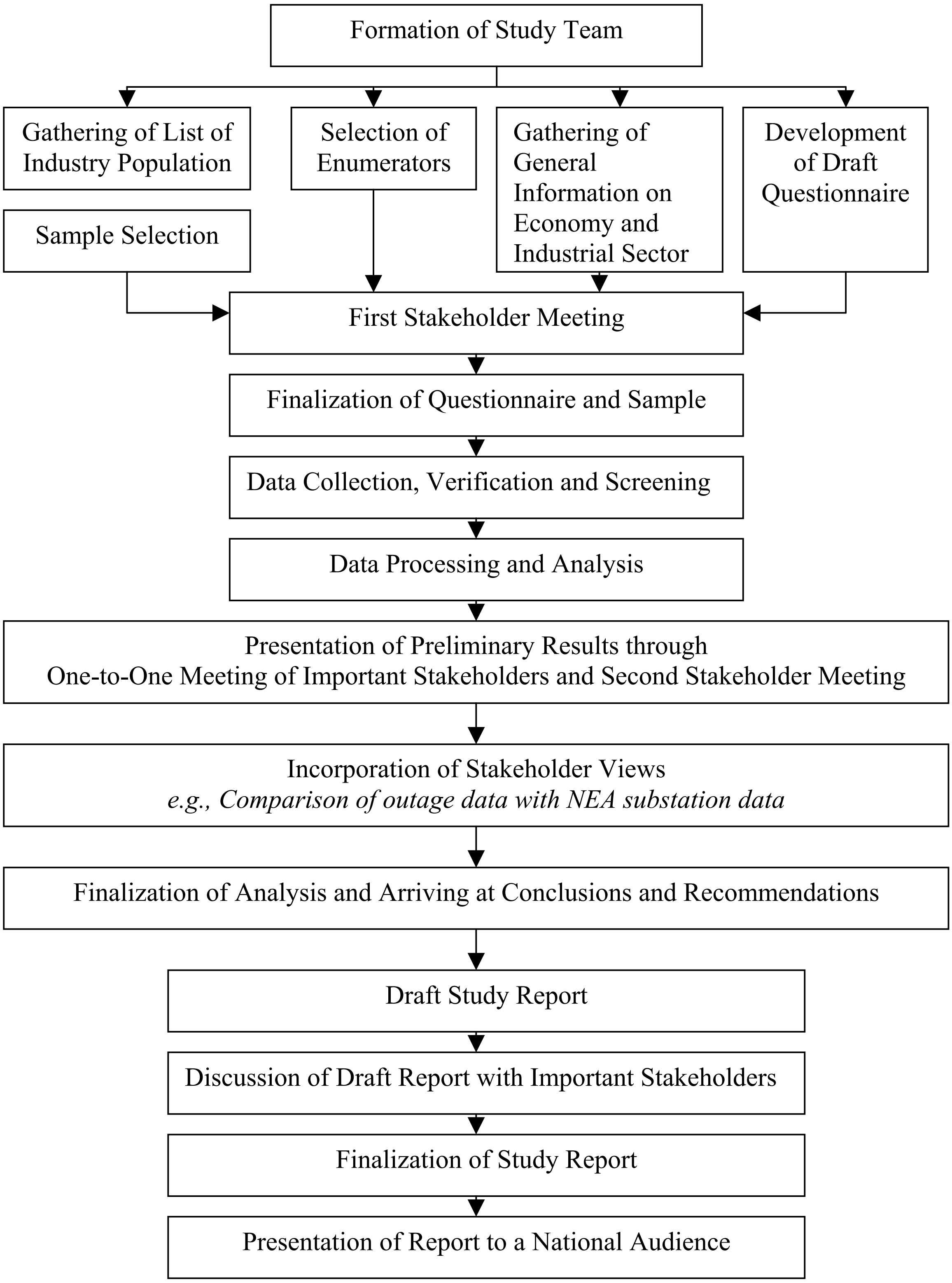


Figure 3.2: Sequence of Different Activities in the Study

The main basis for sample selection for the study was the contribution of the individual categories of industries to the industrial gross domestic product (GDP). Those having more than **3%** contribution to industry GDP were considered for representation within the sample. The main categories of industries in terms of their contribution to the industry GDP are shown in Figure 4.1. In addition to these, the hotel industry, which had an overall **2.5%** contribution to the national GDP in 2001-02, was also considered in the study.

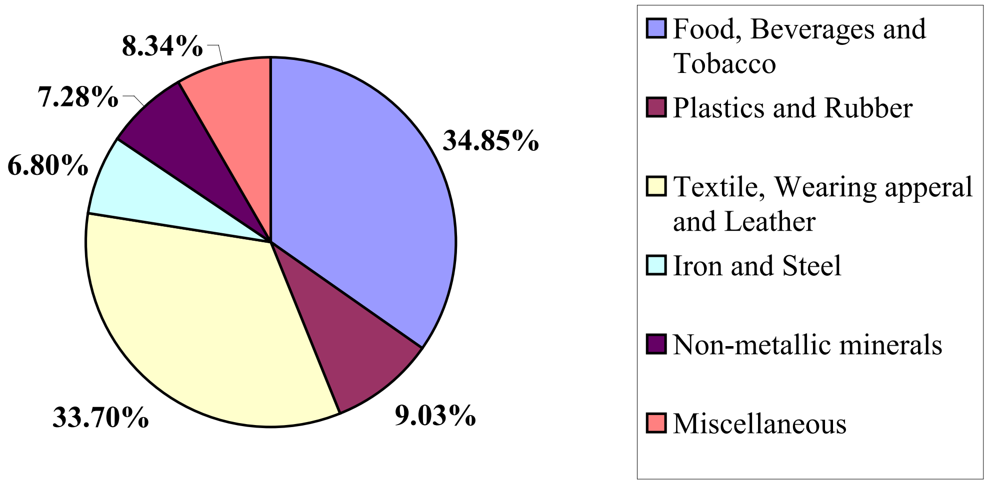


Figure 4.1: Contribution to Industry GDP by (2000-01)

Within each of these categories shown in Figure 4.1 there are subcategories of industries. Their contribution to the industry GDP was used as a measure of their importance in being represented within the sample. Those subcategories having more than **2%** contribution to the industry GDP were considered for random sampling. These selected categories are given in Table 4.1.

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

Industry Categories	% Contribution
Food, Beverages, and Tobacco	**34.85%**
Vegetable and animal oils	**2.25%**
Dairy products	**2.60%**
Grain mills	**2.94%**
Sugar	**2.95%**
Distillery	**2.73%**
Malt liquors	**4.90%**
Tobacco	**12.05%**
Textile, Wearing Apparel and Leather	**33.70%**
Spinning and weaving	**3.41%**
Textile finishing	**2.86%**
Carpets and rugs	**17.87%**
Apparels	**6.32%**
Plastics and Rubber	**9.03%**
Pharmaceuticals	**2.44%**
Soap and detergents	**2.90%**
Rubber and plastic products	**2.98%**
Non-metallic Minerals	**7.28%**
Non ref. Clay	**2.89%**
Cement	**3.21%**
Iron and Steel	**6.80%**
Rolls (metal)	**4.22%**
Miscellaneous	**8.30%**

Based on the above GDP contributions, the samples sizes shown in Figure 4.2 were considered to be appropriate.

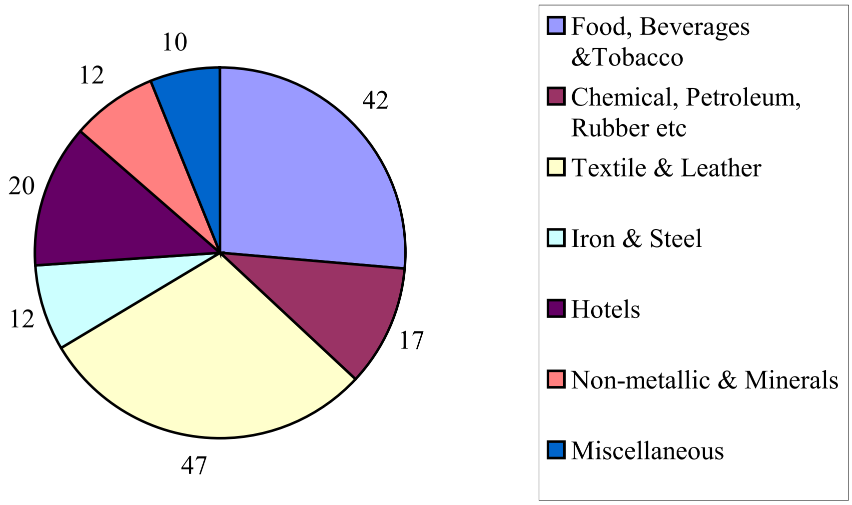


Figure 4.2: Number of Samples in Each of the Categories

These industries were randomly selected from among the industrial installations having their own transformers (40kVA and above) in the industry regions, Kathmandu Valley, Bhairawa/Butwal, Kawasoti/Chitwan, Hetauda, Pokhara, Birgunj, and Illam/Damak/Dharan/Biratnagar. In this process more than 200 installations were selected, and they were visited for data collection though the original size of the sample was 170. The final number of instillations where data collections were in complete form is given in Table 4.2.

Table 4.2: Number of Samples in Each of the Categories

Category	**Number of Samples**
Food, Beverages, and Tobacco	48
Chemical, Petroleum, Rubber etc	35
Textile and Leather	26
Iron and Steel	16
Hotels	16
Non-metallic and Minerals	7
Miscellaneous	12
Total	**160**

Data collection was carried out in more than 200 industry installations, which were later screened to correct or to eliminate inaccurate records. After elimination of unreliable records, data processing was confined to 160 industry installations and during processing of the data, a further 27 installations were eliminated after careful inspection because the data were unusable.

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

5.1 Operational Information

Working Pattern

The working pattern of each industrial installation is an important input in analyzing the impact of supply outages in the industrial sector. Figure 5.1 shows the average operational pattern of each of these industry categories. It is observed that the industries operate from 235 days 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 301working days per year.

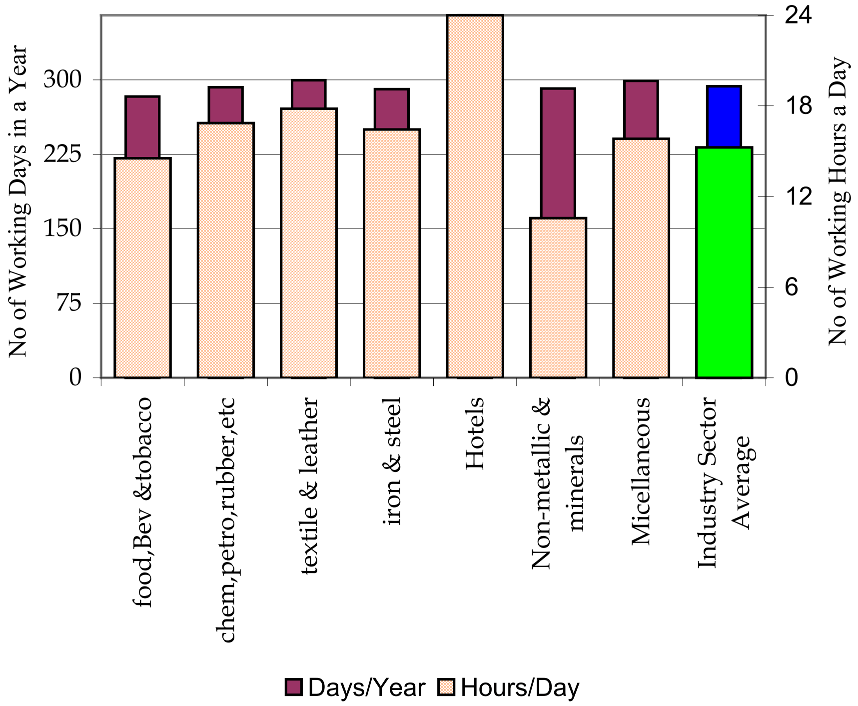


Figure 5.1: Operational Times of Different Industries

Electricity Usage

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

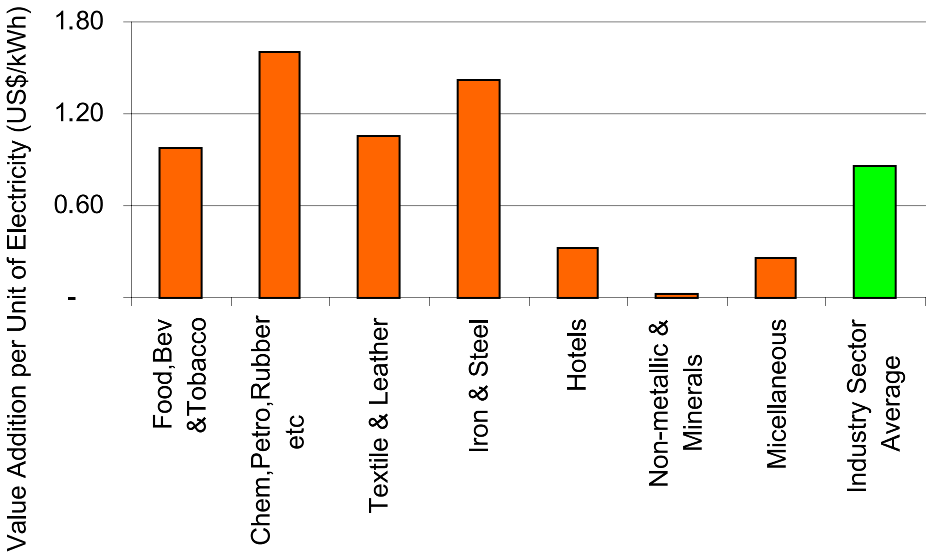


Figure 5.2: Value-Addition per Unit of Electricity Usage in Different Industry Categories

Electricity Cost

Figure 5.3 shows the average cost of grid electricity at different industry categories. The industry sector average is 9.25 USCts/kWh including the contribution from the demand charge.

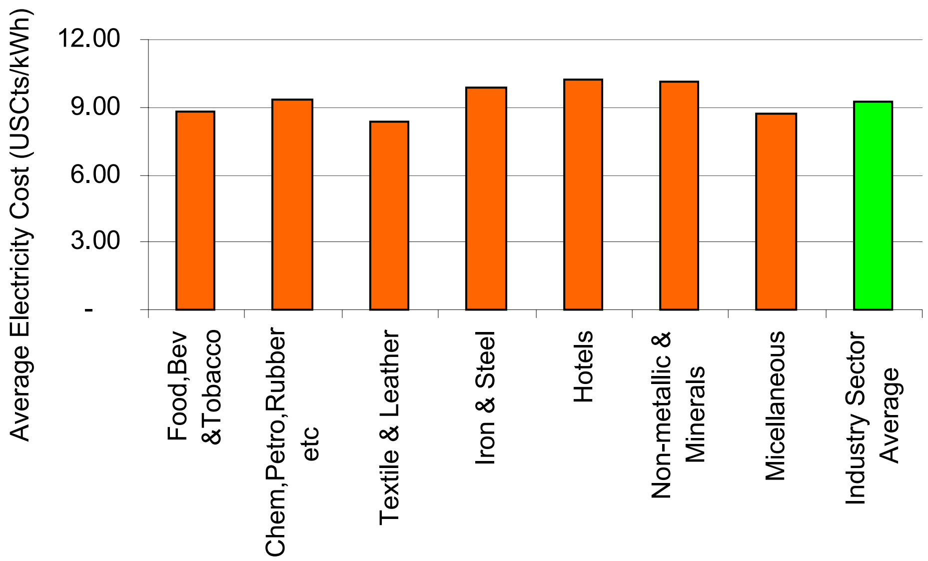


Figure 5.3: Average Cost of Grid Electricity to Different Industry Categories

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. Momentary interruptions, unplanned and planned outages, voltage fluctuations, and supply harmonics were considered.

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: Economic Cost of Momentary Interruptions in Each Installation

Industry	US$/Interruption Range with 90% Confidence	
	From	To
Food, Beverages, and Tobacco	4.19	30.01
Chemical, Petroleum, Rubber, etc	203.72	857.05
Textile and Leather	10.64	208.62
Iron and Steel	0.18	4.78
Hotels	0.00	0.72
Non-metallic and Minerals	0.00	28.19
Miscellaneous	0.00	2.26
Industry Sector Average	**70.21**	**262.83**

Unplanned Outages

The variation in economic costs of unplanned outages in different industry categories is given in Table 5.2. The industry average stands at US$ 0.49 per kWh of unplanned power outage.

Table 5.2: Economic Cost of Unplanned Interruptions

Industry	Range with 90% Confidence US$/kWh	
	From	To
Food, Beverages, and Tobacco	0.44	1.13
Chem., Petro., Rubber, etc	0.12	0.73
Textile and Leather	0.71	2.78
Iron and Steel	0.46	2.31
Hotels	0.00	0.11
Non-metallic and Minerals	0.00	0.05
Miscellaneous	0.10	0.38
Industry Sector Average	**0.35**	**0.62**

Planned Outages

The variation in the economic cost of planned outages in different industry categories is given in Table 5.3. The industry-wide average cost of planned interruption is calculated to be US$ 0.14 per kWh.

Table 5.3: Economic Cost of Planned Interruptions

Industry	Range with 90% Confidence US$/kWh	
	From	To
Food, Beverages, and Tobacco	0.00	0.15
Chemical, Petroleum, Rubber, etc	0.00	0.47
Textile and Leather	0.00	0.74
Iron and Steel	0.00	0.24
Hotels	0.00	0.00
Non-metallic and Minerals	0.00	0.57
Miscellaneous	0.00	0.16
Industry Sector Average	**0.03**	**0.25**

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. The industry sector average is approximately US$ 214 per interruption in each industry installation.

Table 5.4: Fixed Cost of Planned Interruptions per each Installation

Industry	Range with 90% Confidence US$/kWh	
	From	To
Food, Beverages, and Tobacco	0.00	1766.24
Chemical, Petroleum, Rubber, etc	17.08	277.09
Textile and Leather	0.00	0.07
Iron and Steel	0.00	7.57
Hotels	0.00	0.00
Non-metallic and Minerals	0.00	0.00
Miscellaneous	0.00	0.00
Industry Sector Average	**30.88**	**396.58**

Voltage Variations

The costs of supply voltage fluctuations beyond the stipulated levels are given in Table 5.5 for different categories of industries. Industry average stands at US$ 6.8 per hour in each installation.

Table 5.5: Cost of Voltage Variations per Installation

Industry	US$/Interruption Range with 90% Confidence	
	From	To
Food, Beverages, and Tobacco	5.46	24.42
Chemical Petroleum, Rubber, etc	0.63	3.43
Textile and Leather	8.65	33.30
Iron and Steel	1.38	18.54
Hotels	0.23	1.37
Non-metallic and Minerals	0.00	0.00
Miscellaneous	0.00	16.78
Industry Sector Average	**4.02**	**9.47**

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 are given in Table 5.6.

Table 5.6: Frequency and Duration of Interruptions

Interruption Type	Frequency/Year	Period of Each (hrs)
Unplanned Outages	185.37	1.57
Planned Outage	22.51	2.08
Voltage Variation	111.93	2.24

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

Standby Generation

The penetration level of standby generation (SBG) of different industry categories is given in Figure 5.4. The industry average of penetration level (percentage of industries having SBG facilities) stands at **75.6%**.

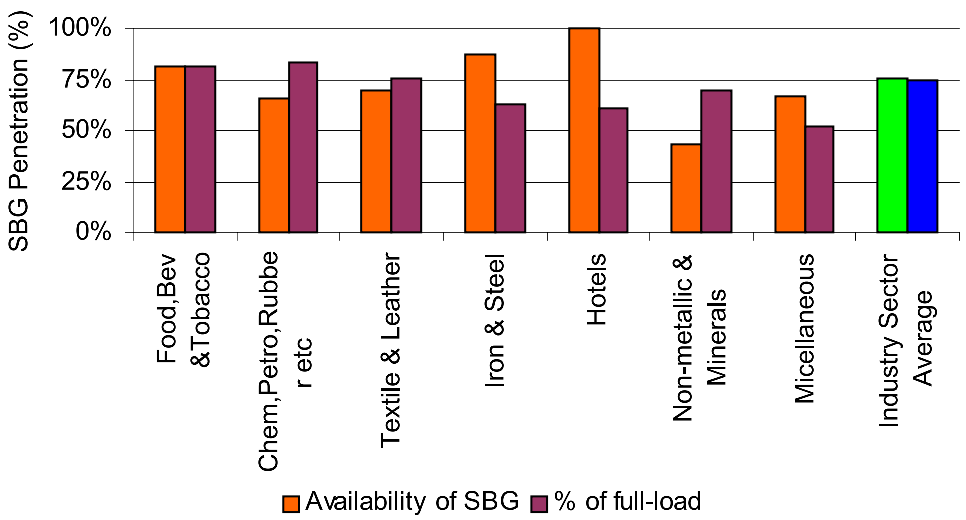


Figure 5.4: Penetration Level of Standby Generation in Different Industry Categories

Most of the 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 also given in Figure 5.4. The average percentage of full load capacity supplied by these SBG facilities is **74.2%**.

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 (14.29 USCts/kWh) and the average cost of grid electricity (9.25 USCts/kWh) in the industrial sector sampled.

If it is assumed that these available SBG facilities are always fully used when there are outages as given in Table 5.6, then the additional emissions and extra financial burden due to SBG usage in the industrial sector are as given in Table 5.7 below.

Table 5.7: Incremental Emissions and Additional Financial Burden due to SBG

Emission Type	Incremental Emissions (MT/yr)
Carbon Dioxide	1107.54
Carbon Monoxide	1.43
Sulfur Dioxide	0.04
Nitrogen Oxides	22.58
Particulate Matter	1.64
Annual Additional Cost to the Users Due to SBG	**US$ 1.2Million**

5.3 National Economic Impact

The unplanned and planned outages given in Table 5.6 result in economic losses in the industrial sector that amount to US$ 24.69 million a year while the total industrial sector GDP for the fiscal year 2000/01 was US$ 558 million .

5.4 General Comments

Respondents were asked several questions regarding energy and power quality in Nepal (see Appendix B). The responses to five important questions posed to each of the industries are given in Figure 5.5.

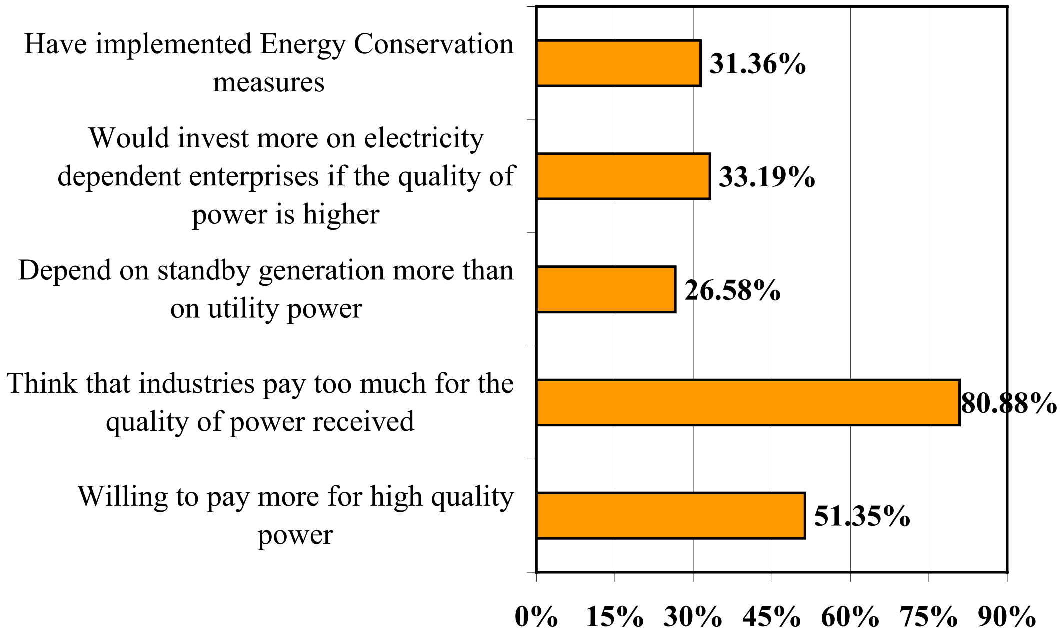


Figure 5.5: Response by the Industries in the Sample to Different Questions

5.5 Data Verification

Table 5.8 and Table 5.9 show the recorded annual interruption data of the feeders supplying electricity to three industrial areas: Birgunj, Biratnagar, and Pokhara, supplied by Nepal Electricity Authority (April 2001- April 2002).

Table 5.8: Frequency and Duration of Recorded Unplanned Interruptions

Unplanned Interruptions		
	No. of Interruptions	**Duration (hrs)**
Feeders for Birgunj Industrial Area	253.67	7.47
Feeders for Biratnagar Industrial Area	77.25	2.44
Feeders for Pokhara Industrial Area	141.00	4.95
Average Considering all Feeders	**152.07**	**4.62**

Table 5.9: Frequency and Duration of Recorded Planned Interruptions

Planned Interruptions		
	No. of Interruptions	**Duration (hrs)**
Feeders for Birgunj Industrial Area	45.50	2.69
Feeders for Biratnagar Industrial Area	8.59	5.93
Feeders for Pokhara Industrial Area	45.50	2.69
Average Considering all Feeders	**23.36**	**4.54**

6.1 Industry Operational Pattern

As shown in Figure 5.1, all the industries have similar working patterns in terms of number of working days per year, except the hotel sector. While the hotel sector operates throughout the day and the year around, others operate only on average 5.5 to 6 days a week. Non-metallic mineral industries operate only 1.5 shifts a day on average while others (excluding hotels) have a two-shift working pattern during the day.

6.2 Electricity Usage

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 was shown in Figure 5.2, the highest value addition per unit of electricity use (1.61 US$/kWh) is recorded in the category containing chemical, petroleum, rubber, etc. The grid electricity costs for this category of industries were 9.29 USCts/kWh on average. Also, the categories containing food, beverages, and tobacco manufacturing; textile and leather products; and iron and steel industries have relatively high value additions per unit of electricity consumption, in comparison to others. The minimum value addition is in the non-metallic mineral industry, where its average electricity cost stands at 10.17 USCts/kWh. The industrial sector average value addition per unit of electricity use is approximately 0.86 US$/kWh, while the average cost of electricity is 9.25 USCts/kWh.

Hotels have the highest average cost of electricity at 10.19 USCts/kWh, while the textile and leather industries have the lowest cost at 8.33 USCts/kWh on average.

6.3 Interruptions

Momentary interruptions in some industries result in significant losses at the time of interruption. As shown in Table 5.1, these losses vary substantially from 0 to 857 US$ per interruption per installation. The industry average cost of damage due to such interruptions lies within the range from 70.2 US$ to 262.8 US$ per interruption per installation with a **90%** confidence level around a mean value of 166.52 US$ per interruption per installation. Certain industry categories, including chemical, petroleum, and rubber; and textile and leather, recorded substantial losses due to sudden interruptions. Hotels and miscellaneous industries recorded minimal losses due to such outages.

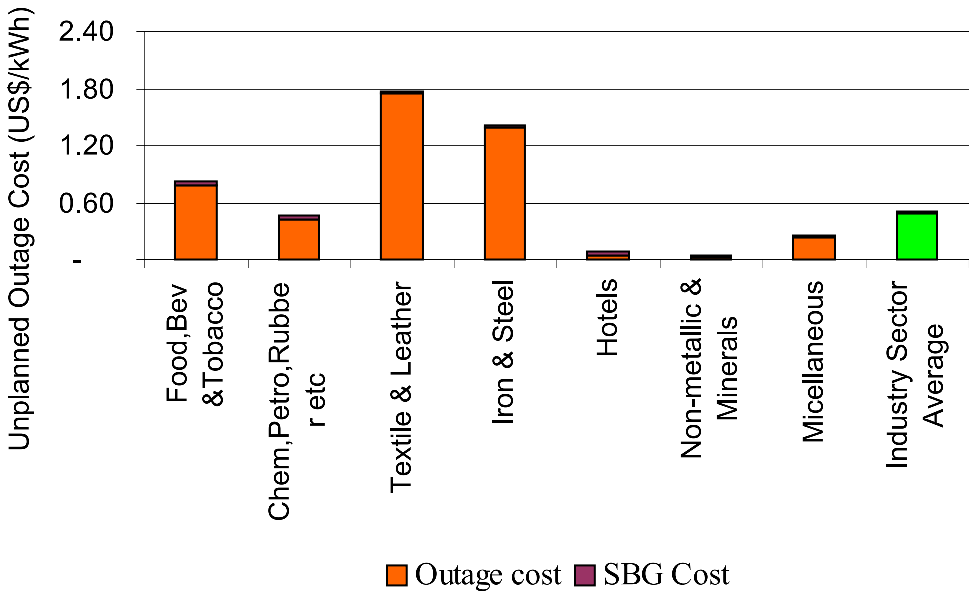


Figure 6.1: Comparison of Economic Cost of Unplanned Outages in Different Industries

As shown in Table 5.2 and in Figure 6.1, losses attributable to unplanned interruptions vary from 0.02 to 1.75 US$/kWh for the different categories at a **90%** confidence level. The industry-wide average stands at 0.49 US$/kWh with textile and leather industry category recording the highest average loss of 1.75 US$/kWh. Also, the food, beverages, and tobacco; and iron and steel industry categories recorded significant losses due to unplanned outages.

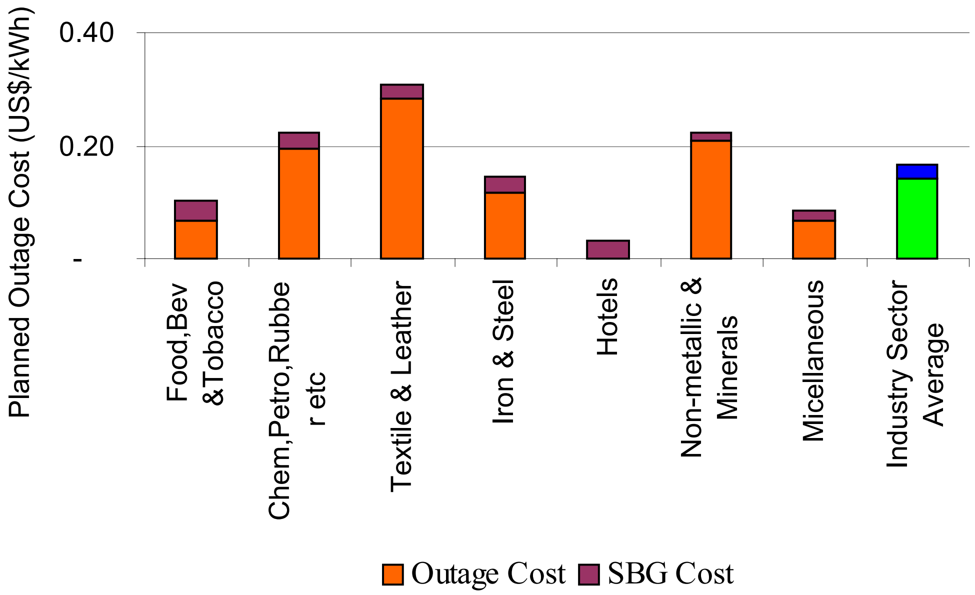


Figure 6.2: Economic Cost of Planned Outages in Industry

For planned outages, these values vary from no losses to 0.74 US$/kWh at **90%** confidence level. The industry-wide average stands at 0.14 US$/kWh. As shown in Figure 6.2, the highest planned outage costs are in the textile and leather; chemical, petroleum, and rubber; and non-metallic minerals industry categories. The other categories recorded relatively low losses under planned interruptions.

The slab on of top each of these bars shown in Figures 6.1 and 6.2 represents the incremental cost due to SBG during outages.

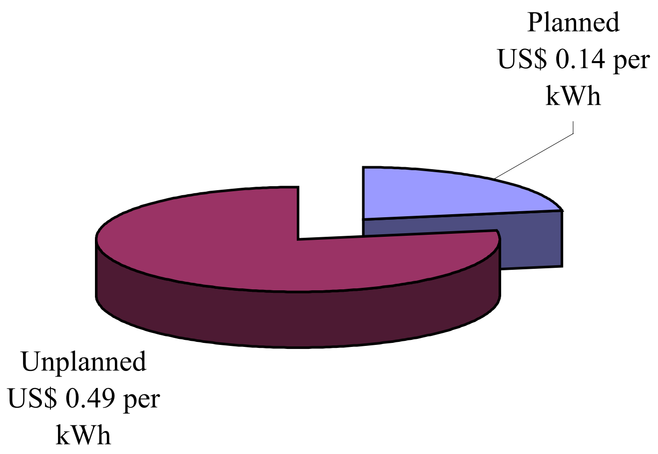


Figure 6.3: Comparison of Costs of Planned and Unplanned Interruptions

Figure 6.3 shows that the unplanned interruptions result in approximately 3.5 times more losses than planned interruptions. Similarly, the average value addition per unit of electricity use in the industrial sector is greater than the cost of both planned and unplanned interruptions. Although the average value addition is only 1.8 times the cost of unplanned interruptions, it is six times the cost of planned interruptions. These data illustrate how serious unplanned outages are in comparison to planned outages.

As shown in Table 5.4, the fixed losses (losses excluding energy dependent variable costs) due to planned interruptions vary from no losses to over US$ 861 per interruption per installation. The industry-wide average of this type of loss stands at US$ 213.7 per interruption.

Voltage variations can cause noticeable problems in certain categories, such as textile and leather manufacturing; and food, beverages, and tobacco industries, whereas some others, such as, the hotel industry, are relatively unaffected. Based on the survey output, it can be seen that such voltage variations cost the industrial sector on average US$ 6.75 per hour in each installation.

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

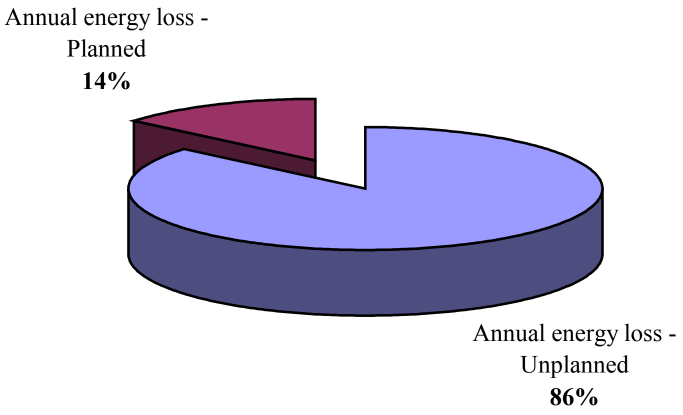


Figure 6.4: Proportions of Energy-Not-Served due to Unplanned and Planned Outages

As was shown in Table 5.6, the number of unplanned interruptions during the year is almost one interruption in two days with each lasting for a little over 90 minutes. In contrast, the number of planned interruptions is less than about twice in one month with each lasting about 2 hours. This difference may be due to events, such as, repair and maintenance of the distribution/transmission network. Therefore, as shown in Figure 6.4, **86%** of the total unserved energy resulting from interruptions is due to unplanned outages, whereas only **14%** is attributable to planned outages. The total unserved energy stands at 42.5GWh a year, whereas the industrial electricity consumption in 2001 was 520GWh. This shows that about **8%** of the industrial sector demand remains unmet due to planned and unplanned interruptions. Figure 6.5 compares the corresponding energy-not-served with the current energy consumption in the industrial sector.

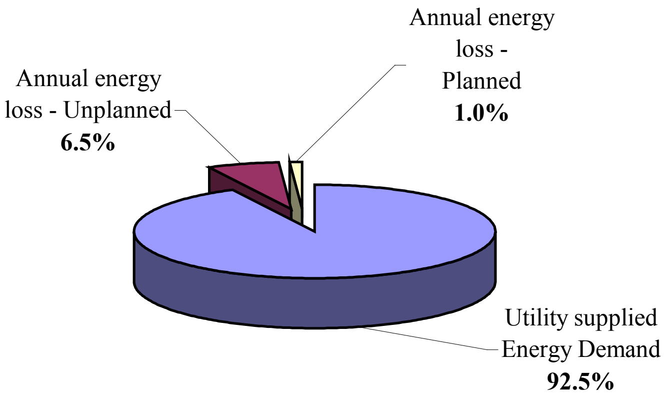


Figure 6.5: Comparison of Current Utility-Supplied Consumption (2000/01) with Energy-Not-Served due to Outages

6.4 Standby Generation

The penetration level of SBG facilities varies from **43%** in the non-metallic and minerals industry to **100%** in the hotel industry. Similarly, the iron and steel; food, beverages, and tobacco manufacturing; and textile and leather product industries have a significantly high SBG penetration level. On average, about **76%** of the industrial installations in the country have SBG facilities that are diesel fired.

Although **76%** of the industrial installations have SBG facilities, many of them do not meet their full load. Only three industry categories (iron and steel, hotels, and miscellaneous) have sufficient SBG capacity to satisfy **65%** of their full load. When the average penetration level and the percentage of full load satisfied are considered, only **56%** of the total industrial load can be supplied with the existing SBGs.

Standby generation facilities based on diesel are not only an additional financial burden to the industries due to their higher operating costs compared to the utility supply, but 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 5.04 USCts/kWh of operating expenditure and incremental emissions of **6.5%** over utility generation. Assuming that the SBGs are always in operation when there are supply outages, the additional financial burden is estimated to be about US$ 1.2 million per year.

6.5 National Economic Impact

Figure 6.6 shows that the overall economic impact of planned and unplanned outages in the utility supply is substantial. This economic loss translates into **4.43%** of the industrial sector GDP or **0.47%** of the national GDP in 2000-01. Thus, it is important in economic planning to consider improvement of electricity supply reliability as a major factor in enhancing economic growth.

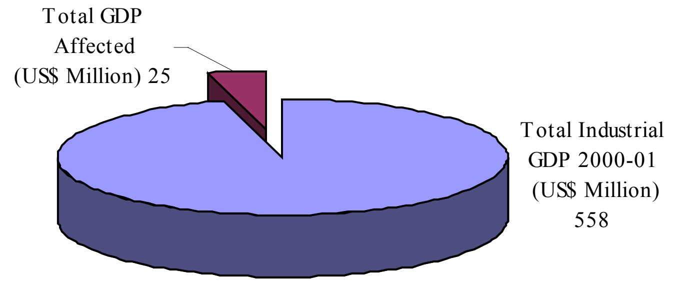


Figure 6.6: Comparison of Total Industry Sector GDP and the GDP Affected due to Outages

6.6 Industry Comments

It is noted that over **80%** of the participating industries felt that they over-pay for the quality of power they receive, however **51%** of the sample would still be willing to pay even more for better power quality. Although the level of SBG penetration stands at **76%** of the industries, only **27%** expressed that they depend more on SBGs than on utility power. In other words, even after having SBGs, due to higher cost of providing their own generation (**55%** increase in average unit cost), these industries would prefer to use utility power. The other important observation from an economic point of view is that more than one-third of the sampled industries are willing to invest more in electricity dependent industries if the quality of power supply becomes better. This observation needs serious attention of the investment promotion arm of the government.

It is disturbing to note that only about **31%** of the industrial installations sampled have implemented some form of energy conservation measures in their installations. 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.

6.7 Legislation

The Electricity Regulation, 1993 deals with the power quality aspects under Chapter 4. Under this regulation, the licensee should ensure that the voltage at the distribution level below 33kV does not fluctuate beyond ±**5%** (Sections 4.0-4.2). Transmission voltages that are 33kV and above should not fluctuate more than ±**10%**. The frequency fluctuations need to be maintained within ±**2.5%** of the standard frequency of 50Hz.

Further, the supplied power factor at the consumer premises is expected to remain between 0.8 lagging and unity. Necessary measures should be taken by the utility to eliminate any deviations from this range.

6.8 Data Verification

Table 6.1 compares the average values obtained from sub-station recorded data and those calculated using the sample data. Although the substation averages are based on only 15 feeders in three different regions, the sample averages are based on 133 installations in seven different regions. Although the frequency of interruptions agrees within **5%-20%**, the durations of sub-station recorded interruptions are two to three times higher compared to the data collected.

Table 6.1: Average Frequency and Duration of Interruptions

	No of Interruptions		Duration	
	Unplanned	**Planned**	**Unplanned**	**Planned**
Substation Data	152.07	23.36	4.62	4.54
Sample Data	185.37	22.51	1.57	2.08

While the proportions of total energy losses between unplanned and planned outages from the study sample are **14% - 86%**, they are calculated to be **13% - 87%** from substation data. Therefore, except in the absolute values of interruption durations, the processed data from substation information in general agree with the study sample.

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 following industry categories: iron and steel; chemical, petroleum, and rubber; food, beverages, and tobacco; and textile and leather. Therefore, the economic benefit of giving preferential treatment to these industries, particularly at the time of planned power supply interruptions, needs to be seriously considered in system operations.
- The operation and maintenance cost of the diesel-based SBGs is more than **50%** higher that the average cost of utility delivered electricity in the industrial sector. In the hotel sector it is approximately **20%** more. Thus, a more reliable electricity supply from the utility even at a relatively higher cost would still be more cost efficient than the current situation.
- 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 or to make strenuous efforts to convert such outages to planned outages whenever possible. In this regard, extra emphasis is required for the textile and leather, and iron and steel categories due to the high cost of such outages.
- Voltage fluctuations cause a significant adverse impact on the industrial sector output, which needs to be seriously addressed by the utilities.
- The industrial sector has a very high level of SBG, and it is likely to increase in the future unless necessary measures are taken to reduce supply outages, particularly unplanned outages.
- Overall economic losses due to planned and unplanned power supply outages in the industrial sector are very high and have a significant impact on the country's economic growth.
- Although the industries surveyed 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 industry categories, such as, textile and leather, and iron and steel, 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. Implementing an aggressive energy conservation program in the sector would undoubtedly help the electricity supply industry as well as consumers.

To address the issues raised in this study, the following recommendations are based on the conclusions given in section 7:

- Strengthen the participation of end-users in the electricity supply industry through increasing their representation in the relevant bodies dealing with decision-making and regulatory work in the industry. Establish an environment conducive to regular dialogue among end-users, utilities, and policymakers.
- Improve codes and standards on the quality of service to encompass requirements governing both planned and unplanned supply interruptions.
- Convert unplanned interruptions to planned outages where possible by taking actions such as pre-planned load shedding and informing consumers accordingly.
- Strengthen ongoing SARI/Energy initiatives on energy efficiency, such as, energy service company activities and standards and labeling, which will act as catalysts for energy conservation in the industries. These initiatives will create an enabling environment for industries to be proactive in implementing energy conservation measures.
- Improve the power system performance by timely and appropriate transmission and distribution system improvement. Private sector participation can play a major role in this regard.
- Commission detailed technical studies in specific areas identified for performance improvement in transmission distribution and supply of electricity. These studies can include activities, such as:

    - Examining the feasibility of transmission and distribution network reliability improvement; and
    - Developing institutional and legislative frameworks required for aggressive implementation of energy efficiency programs in the electricity sector
    - Examining the feasibility of a seasonal tariff to large consumers to encourage the use of electricity during excess capacity periods

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I. 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		
▪ Vegetable, animal oils and fats		
▪ Dairy products		
▪ Rice and dhal mills		
▪ Distillery		
▪ Brewery		
▪ Tobacco products		

Textile, wearing apparel, and leather products		
▪ Finishing of textiles		
▪ Apparel		
▪ Textile (spin and weave)		
▪ Carpets and rugs		

Chemical, petroleum, rubber, and plastic products		
▪ Rubber, Plastic, and PVC		
▪ Pharmaceuticals		
▪ Soap and detergents		

Non-metallic mineral products		
▪ Clay and Ceramic		
▪ Cement		

Iron and steel based industry		
▪ Steel rolling mills		

Hotel industry		

	Small	Medium	Large
Industry Category by the National Criteria on Industry Size			

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 (Rs)

	Small (<11kV)	Medium (11kV/33 kV)	High (66 Kv)
Industry Category by Electricity Connection (Voltage level)			

V. Financial Information

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

**If this is provided, other information not required*

V. Industry Operational Pattern

Average number of operating hours per day	
Average number of operating days per Year	

VI. 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 Rs*)

	Total Revenue Loss (Rs)
Loss of raw material	
Loss of output	
Loss of manpower	
Damage to equipment	

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

	Revenue Loss per Hour (Rs/hr)			
Interruption duration	0-1 hr	1-2 hrs	2-4 hrs	4-8 hrs
Loss of raw material				
Loss of output				
Loss of manpower				

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 (Rs) (moment of interruption)	Revenue Loss per hour (Rs/hr)			
		0-1 hr	1-2 hrs	2-4 hrs	4-8 hrs
Loss of raw material					
Loss of output					
Loss of manpower					

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 (Rs/hr)			
Duration of voltage variation	0-1 hr	1-2 hrs	2-4 hrs	4- 8 hrs
Loss of raw material				
Loss of output				
Loss of manpower				

Number and period of voltage variations experienced

Average number of incidents per year	
Average period of each (hrs)	

Other significant supply problems, such as supply harmonics

	Revenue Loss (Rs/hr)			
Duration	0-1 hr	1-2 hrs	2-4 hrs	4-8 hrs
Loss of raw material				
Loss of output				
Loss of manpower				
Time duration of standby Generator operation				
Damage to equipment (Rs)				

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 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

Manufacturer	
Generator capacity (kW)	
What percent of full load does standby generation support?	
Minimum duration of standby generator usage once turned on (min.)	
Estimated time taken to switch to standby generation after an outage (min.)	
Expected lifetime (years)	
Initial capital cost (Rs)	
Annual maintenance cost (Rs/year)	
Average fuel consumption (liters/kWh)	

Total fuel consumption for this period (liters)	
Other overhead costs (Rs/Month)	
Emission factors (Kg/kWh)	
CO_2	
CO	
So_x	
No_x	
Particulate emissions	

Meetings of NEA Team: Mr. Mahesh Acharya, Dr. Dabadi, and Mr. M.S. Jayalath; September 6, 2001

1. Meeting with Mr. Govinda K.C/ Chief of Generation, Transmission and S/S.

a. Hydro/Thermal ration is 9/1
b. High cost is due to IPPs (**34%**) and **23%** local contribution for foreign funded projects and **6%** rate of return of revalued assets
c. Adequate generation capacity to meet the demand
d. Need SARI/Energy assistance to study IPP contracts
e. Power quality affected due to transmission and distribution problems
f. Power quality affected due to equipment failure: need to have quality equipment to improve quality; if can be quantified it will be useful
g. Lack of incentives for better maintenance to reduce failures
h. Substation data will be available for the study
i. Agreed to meet and brief him after the methodology is finalized

2. Meeting with Mr. B.C. Thakuri, Chief of Rural Electrification and DCSs West

a. Power quality affected due to distribution problems
b. Data on feeder failures can be obtained from substations
c. NEA will supply the data
d. Report should help NEA to attract funds for improvements
e. Visit to Darbara station was recommended

3. Visit to NEA Load dispatch Centre:

a. Log sheet available for 132/66/11kV feeders and transformers
b. Hourly data (off peak) and half hourly data (peak) available:
   1. Voltage
   2. Current
   3. Power factor
   4. Tripping time (on/off)
   5. Type of feeder shut down (planned/unplanned)
   6. Reason for failure
c. Summary of feeder failures also available
d. Heavy failures during June/July and April/May
e. Peak hr: 18.00 hrs to 21.00 hrs: peak between 19.30 and 20.00 hrs
f. Can be extracted if a format can be developed

November 19, 2001; Hotel Yak and Yeti, Kathmandu, Nepal

Thirty-one stakeholders, including M/s. Mahesh Acharya, CCO (USAID) and Kush Kumar Joshi, Chairman (Energy Efficiency Committee) of FNCCI, participated.

Mr. Mahesh Acharya welcomed the participants on behalf of USAID.

A presentation on SARI/Energy project and activities related to assessment of economic impact of poor power quality to Industry in SARI/E member countries was presented by the task manager, Nexant SARI/Energy, M.S. Jayalath.

Dr. Siri Varadan, Consultant, Nexant Inc, made a presentation on study scope and the methodology and data collection procedure developed for Nepal by the technical team. Methodology used for sample selection and number of installations identified under each category, were discussed in detail.

A lengthy discussion of the following key issues followed:

Issue raised — the need to have a simple questionnaire:

The questionnaire was discussed in detail. The study team requested to participants to suggest amendments to the questionnaire or provide formats currently in use at their installations.

Issue raised — Accuracy of data and capabilities of enumerators:

The team accepted the need to have competent people to collect data, and it was decided to review the data collection plan in view of this, with possible options, such as, the use of engineers for the task or to train the enumerators already identified. It was also decided to forward the questionnaire well in advance to the customers so that the stakeholders will be able to get/collect accurate data and be ready for the visit of the enumerator.

Issue raised — Submission of final results:

In view of issues raised with regard to accuracy of data for the study, the team agreed to submit draft results first, before the preparation of the report.

The final report will be submitted to FNCCI, and NEA as major stakeholders.

Issue raised — Omission of service sector from the study:

Stakeholders highlighted the importance of the service sector in relation to the National GDP, however not considered for the study.

The team, while agreeing with these comments, noted that the activity is limited to industrial productivity loss due to poor power quality to industry.

Finally, the workshop was adjourned with a vote of thanks proposed by the Chairman of Energy Efficiency Committee of FNCCI.

Improvements proposed to the study methodology and data collection:

Questionnaire

1) Obtain comments from Surya Tobacco Company and propose amendments to the questionnaire
2) Forward the questionnaire at least two weeks prior to the data collection
3) After submission of the questionnaire, the local team should contact the industrialist to check whether they need clarifications or assistance to get data required
4) All data, if possible should be supported with documents, such as, bills to verify the accuracy. Enumerators should verify accuracy of data supplied by the stakeholders when collecting details
5) Data entry should be done at one central location
6) Enumerators should be paid only for accurate and clear data supplied
7) Local team should verify the accuracy of data collected by contacting a small sample
8) Add a question on EE measures implemented
9) Data should be for a specified period (Nov 15, 2001 – Jan 15, 2002)

Data collection

1) Enumerators should be competent and very well trained for this purpose
2) Identification of suitable people for this purpose is therefore important
3) Training program to be developed for the enumerator: to be designed
4) Local team leader will undergo training in Sri Lanka and discuss problems faced by the enumerators in Sri Lanka during the data collection
5) Training support can be provided by assigning few enumerators from Sri Lanka

Data required from NEA

1) Electricity act of Nepal
2) NEA act
3) Billing data for the specified period/month; industry and hotel over 40 kVA (Nov. 15 – Jan. 15, 2002): Mahesh
4) Failure data (format already submitted) for same period: Mahesh
5) Problems faced by NEA in providing a more reliable supply to customers
6) Names of key personnel who should be involved/contacted at regular intervals during the study: Mahesh
7) Emissions from NEA thermal plants: Mahesh

Other information required

1) Diesel cost
2) Types of diesel available in Nepal

3) Emission levels from Standby generators
4) List of key stakeholders for regular meetings during the study

Time schedule for the study

1) Stakeholder meeting	Nov. 19, 2001
2) Review stakeholder comments	Nov. 20, 2001
3) Finalize questionnaire	Nov. 25, 2001
4) Identify sample of stakeholders	Dec. 08, 2001
5) Finalize data collection methodology	Dec. 08, 2001
6) Questionnaire to stakeholders	Dec. 10, 2001
7) Training for local team in Sri Lanka	Dec. 10-14, 2002
8) Training for enumerators	Jan. 1-15, 2002
9) Data collection	Jan.15- Feb 28, 2002
10) Data analysis	March 01- 15, 2002
11) Presentation of draft results	March 20, 2002
12) Completion of report	March 31, 2002
13) Comments on draft report	April 15, 2002
14) Presentation of final report	April 25, 2002

March 7, 2002; Yak and Yeti Hotel, Kathmandu, Nepal

1. Enumerators selected for following industrial zones (March 7, 2002):
   a. Kathmandu Valley: FNCCI
   b. Bhairawa/Butwal (Western plain)
   c. Birgunj/Kawasoti/Chitwan/Hetauda (Central plain)
   d. Pokhara (Western hills)
   e. Biratnagar/Iiiam/Damak/Dharan (Eastern plains)

2. Updated list of industries and sample selection:

   Dr. Dabadi to update the list of industries and select samples using random sample theory and submit final list to Priyantha Wijayatunga. and MS Jayalath by March 10, 2002

3. Meetings with enumerators to be arranged by Dr. Dabadi for March 8,11,12, 2002 (mornings)

4. Priyantha Wijayatunga and MS Jayalath to give the final ok for the sample by March 15, 2002

5. MSJayalath in consultation with Priyantha W will update the questionnaire by March 15, 2002

6. Dr. Dabadi will circulate the questionnaire to sample customers and enumerator from Mar. 18-29, 2003

7. Final training to enumerators by Dr. Dabadi: April 2-15, 2002

8. Data collection will begin on April 15 and finish on May 31, 2002

9. Visit to supervise data collection: MSJ and Dr. Dabadi: April 24-28, 2002

10. Data entry to begin on April 29 and end on June 7, 2002: Methodology to be discussed on March 8, 2002

11. Data analysis and preparation of report will be undertaken jointly by Priyantha W and Dr. Dabadi from Jun 3-12, 2002

12. Draft report is expected by June 20, 2002; Stakeholder presentation on June 21

13. Comments: June 21-29, 2002

14. Final report: July 12, 2002

May 29, 2003

A brief meeting was held on May 29, 2003 to disseminate the results of the draft study document, *Economic Impact of Poor Power Quality on Industries,* to stakeholders.

A welcome address was given by Mr. Mahesh Acharya, CCO, USAID. Mr. M.S. Jayalath, Nexant SARI/Energy task manager presented highlights of the background and introduction, and he briefly presented the methodology adopted to carry out the study; Dr. Hemanta Dabadi, local team leader also assisted him. Mr. Jayalath also mentioned that the objective of this meeting was to make stakeholders aware of the economic impact of poor quality on industries overall.

Prof. P. Wijayatunga, study team leader presented the data analysis methodology followed by preliminary results. After presenting the preliminary results the floor was opened for discussion. The discussion was facilitated by Mr. M.S. Jayalath, Prof. P. Wijeyatunga, and Dr. Hemanta Dabadi.

Suggestions and recommendations arising from the discussion session were as follows:

Mr. Shambhu P. Upadhyay, Director, Technical Services/Commercial Department, Nepal Electricity Authority (NEA) requested that the study team provide more precise results, and compare the planned and unplanned power supply interruption data of industries with local NEA substation feeder data from where the industries are connected to the grid.

Mr. D.R. Joshi, Royal Nepal Academy of Science and Technology (RONAST), requested the team members to refer to old study reports, if there were any, to refine the study results and to avoid any pitfalls in the current study.

After the discussion session, Dr. H. Dabadi delivered the closing remarks on behalf of FNCCI, and the session ended with the vote of thanks given by Mr. Jayalath. The detailed seminar program schedule and list of participants is given below.

Agenda for Presentation of Preliminary Results of Economic Impact of Poor Power Quality on Industries in Nepal – Thursday, May 29, 2003

3.00 – 3.10 pm:	Welcome address (Mahesh Acharya, CCO, USAID)
3.10 – 3.20 pm:	Background/Introduction (M.S. Jayalath, Nexant SARI/Energy task manager)

3.20 – 3.40 pm:	Study methodology adopted (M.S. Jayalath, Nexant SARI/Energy task manager and Dr. Hemanta Dabadi, local team leader)
3.40 – 3.50 pm:	Data analysis methodology (Prof. P. Wijeyatunga: Study team leader)
3.50 – 4.10 pm:	Preliminary results (Prof. P. Wijeyatunga: Study team leader)
4.10 – 4.30 pm:	Discussion session (M.S. Jayalath/Prof. Priyantha Wijeyatunga/Hemanta Dabadi)
4.30 pm:	Closing Remarks: FNCCI
4.45 pm	A vote of thanks

Attendees

Name	Organization	Designation
Mr. Angira Acharya	Department of Electricity Development (DoED)	Senior Divisional Engineer
Mr. Narendra Prajapati	Soaltee Hotel	Chief Engineer
Mr. Tula Narayan Shah	Space Time Publication	Reporter
Mr. Padma Jyoti	Himal Iron Pvt. Ltd.	Chairman
Mr. Kul Ratan Bhurtel	Water and Energy Commission Secretariat (WECS)	Executive Director
Mr. Dilli Joshi	Royal Nepal Academy of Science and Technology (RONAST)	Unit Chief
Mr. Ramesh P. Nepal	Environment Sector Program Support (ESPS)-Energy Efficiency	Senior Energy Advisor
Dr. Sandip Shah	Bhote Kohsi Project	General Manager
Mr. Mahesh P. Acharya	USAID	SARI/Energy Country Coordinator
Mr. Debasis Basu	Hotel Yak and Yeti	Asst. Chief Engineer
Dr. Janak Karmacharya	Nepal Electricity Authority	General Manager
Mr. S. P. Upadhaya	Nepal Electricity Authority	Director
Mr. Rajendra Kumar	Channel Nepal	Reporter

Interruption Details (Planned)
Feeders for Birgunj Industrial Area

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Nitanpur	10	5.37	5	3.43	4	1.67	6	6.78	9	5.83	3	0.85
2	Dabur	4	2.62	4	3.82	3	1.90	0	0.00	3	0.32	2	1.00
3	Himal	3	1.97	3	3.25	2	0.47	3	7.62	0	0.00	1	0.8
4	Parwanipur	6	5.07	1	0.25	6	4.65	6	9.00	15	0.60	2	0.70
5	Krishi	3	1.17	4	2.90	7	8.00	4	2.55	3	2.00	0	0.00
6	Birgunj	6	3.82	4	5.28	8	3.00	5	9.17	3	0.50	5	6.65

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Nitanpur	3	0.83	6	1.42	1	0.72	6	1.50	1	0.95	8	10.35
2	Dabur	4	2.50	7	2.82	2	1.63	2	1.87	2	0.67	4	9.00
3	Himal	2	3.30	0	0.00	0	0.00	0	0.00	0	0.00	2	0.55
4	Parwanipur	1	0.33	3	2.00	0	0.00	3	0.97	4	1.28	6	5.35
5	Krishi	0	0.00	1	0.83	2	4.50	3	0.82	2	1.22	2	1.37
6	Birgunj	3	0.72	12	5.17	3	1.13	3	0.67	10	8.27	12	7.80

Interruption Details (Un-planned)

Feeders for Birgunj Industrial Area

S.no	Feeders	Un- Planned Interruptions											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Nitanpur	35	53.67	21	9.42	23	7.90	18	7.42	23	2.97	8	8.13
2	Dabur	22	2.07	67	14.87	33	8.57	29	6.38	7	1.23	13	1.62
3	Himal	19	1.95	8	1.18	24	18.58	35	4.82	76	2.27	36	4.15
4	Parwanipur	14	5.27	29	5.77	17	7.02	23	17.82	9	0.78	9	1.67
5	Krishi	53	43.67	44	35.03	41	9.32	46	9.05	62	12.62	41	19.22
6	Birgunj	25	13.37	34	9.02	39	12.32	39	4.97	44	7.62	51	31.92

S.no	Feeders	Un-Planned Interruptions											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Nitanpur	3	2.97	4	0.33	3	1.72	3	0.23	11	2.10	4	0.33
2	Dabur	24	2.12	12	1.12	3	0.25	5	0.58	12	12.42	6	0.58
3	Himal	18	6.27	1	0.08	6	0.50	13	1.10	10	1.00	7	1.90
4	Parwanipur	6	0.50	0	0.00	5	0.48	6	0.50	8	11.82	13	4.15
5	Krishi	51	24.83	14	1.25	12	5.38	6	0.48	23	5.80	30	6.58
6	Birgunj	18	6.17	14	2.02	11	6.08	8	0.88	13	4.88	22	16.67

Interruption Details (Planned)

Feeders for Biratnagar Industrial Area

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Dhuabi 1	5	60.3	7	2.63	4	12.95	2	2.92	5	7.35	3	4.40
2	Duhabu 2	4	5.83	6	3.17	6	13.87	1	1.08	2	2.92	3	4.00
3	Dhuabi 3	1	0.73	4	2.38	7	8.38	1	0.67	7	8.58	2	5.22
4	Mill Area	11	6.5	14	7.50	8	12.00	4	3.60	4	4.25	3	1.87
5	Hatkhola	39	18.5	25	12.92	39	18.50	4	8.50	3	4.38	4	2.22
6	BJM-RJM	9	4.58	6	7.67	9	3.82	5	1.33	1	0.43	5	3.42
7	Biratnagar	29	12.67	34	18.75	22	8.92	7	5.92	1	0.75	2	2.93
8	By pass	14	7.55	28	14.00	22	10.75	1	3.58	2	3.73	1	1.02

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Dhuabi 1	2	1.23	1	3.62	1	0.80	15	1.92	16	12.62	28	5.10
2	Duhabu 2	1	0.75	1	3.62	1	0.43	15	1.92	10	1.65	21	6.10
3	Dhuabi 3	5	11.07	2	2.62	0	0.00	15	1.92	13	3.67	31	6.77
4	Mill Area	2	1.35	1	0.18	8	5.92	5	8.75	1	1.83	12	3.50
5	Hatkhola	2	3.08	3	1.53	9	4.73	29	15.10	21	8.25	22	7.27
6	BJM-RJM	3	3.42	1	1.33	2	2.87	8	10.00	1	0.75	9	3.98
7	Biratnagar	5	4.28	1	1.07	7	7.63	9	4.78	1	1.45	17	10.45
8	By pass	3	3.08	1	0.88	4	0.97	8	6.08	8	7.72	18	11.55

Interruption Details (Un-planned)

Feeders for Biratnagar Industrial Area

S.no	Feeders	Un- Planned Interruptions											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Dhuabi 1	10	2.33	8	13.40	13	5.42	16	26.23	10	2.77	7	0.58
2	Duhabu 2	3	9.30	3	14.80	6	14.00	6	12.10	3	0.40	20	20.07
3	Dhuabi 3	6	9.40	3	0.25	10	2.05	11	2.75	1	0.08	4	3.25
4	Mill Area	11	0.92	11	0.92	7	0.58	1	0.17	1	0.13	2	0.20
5	Hatkhola	51	4.42	28	2.55	55	4.97	3	0.25	2	0.73	6	0.87
6	BJM-RJM	13	1.08	3	0.25	27	2.42	1	0.08	1	0.10	1	0.23
7	Biratnagar	21	1.75	20	1.67	15	1.25	2	0.23	2	0.40	3	0.43
8	By pass	8	0.67	37	3.13	6	0.50	4	0.17	3	0.17	1	0.23

S.no	Feeders	Un-Planned Interruptions											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1	Dhuabi 1	5	0.48	6	2.42	6	15.08	2	1.45	10	10.10	6	9.25
2	Duhabu 2	3	0.25	0	0.00	1	0.08	0	0.00	4	0.33	4	8.75
3	Dhuabi 3	6	0.75	1	0.17	0	0.00	0	0.00	7	3.60	4	4.10
4	Mill Area	2	0.23	1	0.18	2	0.20	3	0.33	9	0.30	3	0.23
5	Hatkhola	2	0.25	3	0.50	5	0.37	3	0.37	4	0.57	4	0.57
6	BJM-RJM	1	0.05	1	0.03	1	0.07	1	0.10	1	0.03	1	0.13
7	Biratnagar	1	0.17	1	0.10	2	0.17	3	0.33	1	0.03	2	0.27
8	By pass	2	0.23	0	0.00	2	0.10	1	0.07	3	0.30	2	0.20

Interruption Details (Planned)

Feeders for Pokhara Industrial Area

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1		11	6.27	5	2.27	13	9.38	5	5.08	13	4.13	4	0.4

S.no	Feeders	Planned Interruptions (Shut-Down)											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1		5	0.50	16	3.22	18	10.80	9	2.85	2	1.5	3	7.38

Interruption Details (Un-planned)

Feeders for Pokhara Industrial Area

S.no	Feeders	Un- Planned Interruptions											
		Baishak		Jestha		Asad		Shrawan		Bhadra		Aswin	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1		23	13.47	23	8.82	3	0.98	11	6.83	18	6.58	12	3.87

S.no	Feeders	Un-Planned Interruptions											
		Kartik		Margh		Poush		Magh		Falgun		Chaitra	
		No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.	No. of Interruption	Duration of Interruption in Hrs.
1		3	0.98	10	4.85	16	3.85	5	2.22	4	0.58	13	6.42

Legend

Baishak	April 15 - May 15	Bhadra	Aug 15- Sept 15	Poush	Dec 15-Jan 15
Jestha	May 15- June 15	Aswin	Sept 15- Oct15	Magh	Jan 15- Feb 15
Asad	June 15 to July 15	Kartik	October 15 -Nov-15	Falgun	Feb 15-Mar 15
Shrawan	July 15- August 15	Margh	Nov 15- Dec 15	Chaitra	Mar 15- April 15

Stakeholder response to the final draft report on
Economic Impact Assessment of Poor Power Quality to Industry in Nepal

All the stakeholders consulted appreciated the efforts of those who were involved in the project and the contents in the final draft report. Everybody considered it as a valuable document, which can be made use of, for follow up work associated with the improvement in the electricity supply industry. Further a majority of those consulted have given detailed comments on the contents of the report, which need to be incorporated in the final version.

Mr S P Upadhyay, NEA	Detailed comments provided
Mr Janak Karmacharya, MD, NEA	Comments will be provided by 14th October
Mr Mahesh Archarya, NEA	Detailed comments provided
Mr Jeevan Shrestha, USAID	Minor comments, will be provided within a week
Mr D R Joshi, RONAST	Detailed comments provided
Mr Narendra Prajapati, Soaltee Hotel	Detailed comments provided
Mr Padma Joyti, President, Himal Iron Industries (Pvt) Ltd.	Not met personally but conveyed that there are no comments from him on the report
Mr Kush Joshi, FNCCI	Meeting cancelled at the last minute

Professor Priyantha Wijayatunga, Consultant on the EIS-Nepal and Mr Prakash Awasthi, Nexant representative in Nepal, attended all the meetings.

The following tabulation lists the tariff structure of the Nepal Electricity Authority (NEA):

1. Upper Voltage Range (66 kV and above)

Tariff Rate

Demand Charge	Nrs 175.00/kVA/month
Energy Charge	Nrs 4160.00/unit

2. Medium Voltage Range (33 kV)

Tariff Rate

Details	Demand Charge (Nrs/kVA/month)	Energy Charge Nrs/Unit
Industrial	190.00	5.80
Commercial	216.00	7.40
Non-Commercial	180.00	7.80
Irrigation	47.00	3.45
Water Supply	150.00	4.00
Transportation	180.00	4.25

3. Medium Voltage Range (11 kV)

Tariff Rate

Details	Demand Charge (Nrs/kVA/month)	Energy Charge Nrs/Unit
Industrial	190.00	5.90
Commercial	216.00	7.60
Non- Commercial	180.00	7.90
Irrigation	47.00	3.50
Water Supply	150.00	4.15
Transportation	180.00	4.30

4. Lower Voltage Range (230/400 Volt)

4.1 Domestic

a. Minimum Monthly Charges

Energy Meter Capacity	Charges (Nrs)	Rebated unit (kWh)
Up to 5 Ampere	80.00	20
6-15 Ampere	299.00	50
16-30 Ampere	644.00	100
31-60 Ampere	1394.00	200
3 Phase Supply	3244.00	400

b. Energy Charges (Nrs.)

Up to 20 units	4.00/unit
21-250 units	7.30/unit
Above 250 units	9.90/unit

		Demand Charges (Nrs/kVA/month)	Energy Charges (Nrs./unit)
4.2	Industrial		
	- Rural and Cottage	45.00	5.45
	- Small	90.00	6.60
4.3	Commercial	225.00	7.70
4.4	Non-Commercial	160.00	8.25
4.5	Irrigation	-	3.60
4.6	Water Supply	140.00	4.30
4.7	Street light		
	- With Energy Meter	-	5.10
	- Without Energy Meter	186.00/kVA	
4.8	Temple	-	5.10
4.9	Temporary Light	-	13.50
4.10	Community Gross	-	3.50

Note: In rural areas installing meter at one point and line distributed to whole community is termed as "Community Gross" and to become such customer, it is required to establish the Community Based Organization (CBO).

The Time of Day (ToD) Electricity Tariff Rates are given in Table I.I below:

Table 1.1: Electricity Tariff Rates

Customer (Group)and Supply Range	**Monthly Demand Charges (Nrs/kVA)**	**Energy Charges (Nrs/unit)**		
		Peak Time (6PM - 11PM)	**Off Peak Time (11 PM to 6AM)**	**Other Time (6 AM to 6 PM)**
Upper Voltage (66 kV and above)				
Industrial	175.00	5.20	3.15	4.55
Medium Voltage (33 kV)				
Industrial	190.00	6.55	4.00	5.75
Commercial	216.00	8.50	5.15	7.35
Non-commercial	180.00	8.85	5.35	7.70
Irrigation	47.00	3.85	2.35	3.40
Water Supply	150.00	4.55	2.75	3.95
Transportation	180.00	4.70	2.95	4.15
Street Light	52.00	5.70	1.90	2.85
Medium Voltage (11 kV)				
Industrial	190.00	6.70	4.10	5.85
Commercial	216.00	8.65	5.25	7.55
Non-Commercial	180.00	9.00	5.45	7.85
Irrigation	47.00	3.95	2.40	3.45
Water Supply	150.00	4.60	2.80	4.10
Transportation	180.00	4.80	3.00	4.25
Street lights	52.00	6.00	2.00	3.00

Notes:

a. Lower voltage means 230/400 Volts, Medium Voltage means 11 kV, and 33 kV and Upper voltage means 66 kV and above.
b. In case the customer has energy meter in kW it shall be converted to kVA by multiplying by 0.8 to determine the demand charge.
c. The industry gets **10%** rebate in its monthly electricity bill if the industry is established within the declared Industrial area by HMG/N.
d. HMG/N hospital and health centers (excluding staff quarters) get **25%** rebate in total amount of electricity bill.
e. Time of Day (ToD) meter is compulsory for the customers obtaining connection at a voltage level of 11kV or above.
f. Discount of **3%** or **4%** on payment of the bills within 7 days.