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Economic Impact of Poor Power Quality on Industry: Review of Studies

India

Nexant

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Economic Impact of Poor Power Quality on Industry: Review of Studies

India

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Prepared by

Nexant SARI/Energy

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List of Acronyms

ASSOCHAM	The Associated Chambers of Commerce and Industry of India
CCUE	Corrected Cost of Unserved Energy
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CII	Confederation of Indian Industry
CRISIL	Credit Rating Information Services of India Limited
CUE	Cost of Unserved Energy
DG	Diesel Generator
EPW	Economic & Political Weekly
FICCI	Federation of Indian Chambers of Commerce and Industry
GDP	Gross Domestic Product
HT	high voltage
IDFC	Infrastructure Development Finance Corporation of India
IGIDR	Indira Gandhi Institute of Development Research, Mumbai
IIM-A	Indian Institute of Management – Ahmedabad
IIM-B	Indian Institute of Management – Bangalore
IIT-M	Indian Institute of Technology – Mumbai
IT	Information Technology
kVA	kilovolt ampere
kWh	kilowatt hour
LT	low tension
MOP	Ministry of Power, Government of India
NASSCOM	National Association of Software and Service Companies
NCAER	National Council for Applied Economic Research
PFC	Power Finance Corporation
REC	Rural Electrification Corporation
Rs	Rupees
SBG	stand-by generation
SD	standard deviation
TERI	The Energy and Resources Institute
USA	United States of America
USAID	United States Agency for International Development
WTP	willingness to pay

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Executive Summary

USAID under the South Asia Regional Initiative for Energy (SARI/Energy) has identified power quality an important issue for all SARI/Energy member countries. A large part of the industry in most member countries, are now served from standby generation due to poor power quality and power shortages, leading to significant environmental impacts and higher energy costs to end-users.

In the context of the Task 9[1] of the USAID funded SARI/Energy Project, Nexant SARI/Energy was tasked to assess the economic impact of poor power quality on industry in the South Asia region, especially in the countries of Sri Lanka, Nepal, Bangladesh and India. While the assessments have been completed for Sri Lanka, Bangladesh and Nepal, in the context of India, USAID requested Nexant SARI/Energy to undertake a literature search and review of the work done in India in the area of economic impact of poor power quality and power shortages. Accordingly, Nexant SARI/Energy has prepared this document that reviews the work done in India in this area in recent times.

At the end of a comprehensive literature search undertaken by Nexant SARI/Energy, following two documents were identified as being most pertinent to the subject matter under study, i.e. impact of power shortages/poor power quality.

1. TERI Report on "Cost of Unserved Energy", prepared for the World Bank and Department of International; Development, in the year 2001.
2. A Paper entitled "Convergence & the role of infrastructure and power shortages on economic growth across states in India", by Dr. Krishna Rao Akkina of the Department of Economics of the Kansas State University, Manhattan, USA, published in The Indian Economic Journal, Vol. 47, No.2.

Nexant SARI/Energy has carried out a detailed review of the identified documents and has the following observations, comments and recommendations.

Findings of both the sources together indicate that, at the aggregate national/regional level, the chronic power shortages have not only had adverse economic impact in terms of reduction in value added (GDP), but also in terms of reduced growth rate in value added and reduced growth rate in per capita income. Thus, the TERI Report indicates that, for the year 1998-99, shortages in the availability of power to the manufacturing sector resulted in loss of value added (GDP) to the extent **1%** and **2.2%** of the total manufacturing sector value added (GDP) in the States of Haryana and Karnataka respectively. The Report also indicates that for the year 1998-99, shortages in the availability of power to the agricultural sector resulted in loss of value added (GDP) to the extent **3.1%** and **13.3%** of the total agricultural sector value added (GDP) in the States of Haryana and Karnataka respectively. The Dr. Krishna Rao paper reveals that, while a **10%** shortage of power supply during the 1970s has reduced the average growth rate of per capita income by **0.1%**, the same **10%** shortage of power supply

[1] " Task 9 of SARI/Energy project: Increase private sector role in sector reforms and energy efficiency".

during the 1980s has resulted in reducing the average growth rate in per capita income by about **0.5 %**.

The comprehensive literature search carried out by Nexant SARI/Energy revealed that, similar to the studies done under the SARI/Energy project for Sri Lanka, Bangladesh and Nepal, no comprehensive study on the economic impact of poor power quality and/or power shortages either on the economy as a whole or on specific sectors exists for India. Given the fact that, the actual power supply position for India as on March 2002 indicates that, at the aggregate level, power consumers in India face power shortages to the tune of **12.6%** in peak power (kVA) availability and to the tune of **7.5%** in energy (kWh) availability; it is clear that India's GDP and GDP growth rate would continue to be adversely affected in future. It therefore, becomes important that the extent and nature of impact is not only estimated, but is also understood and monitored. Since no comprehensive study on the economic impact of poor power quality and/or power shortages either on the economy as a whole or on specific sectors and /or sub-sectors exists for India, it is recommended that such a study be carried out for India.

Power outages and/or shortages resulting from supply constraints and reliability issues have led to poor power quality not only in India but also in other South Asia countries. Consequently, such power quality problems have had a detrimental effect on the local economies of the entire region. USAID under the South Asia Regional Initiative in Energy (SARI/Energy) has identified power quality as an important issue for all SARI/Energy member countries. A large part of the industry in most member countries is now served from standby generation because poor power quality and power shortages, leading to significant environmental impacts and higher energy costs to end users.

Under Task 9 of the USAID sponsored SARI/Energy project, Nexant was engaged to assess the economic impact of poor power quality on the industrial sector in the South Asia region, especially in the countries of Sri Lanka, Nepal, Bangladesh, and India. While the assessments have been completed for Sri Lanka, Bangladesh, and Nepal, in the context of India, given its large size, it was initially decided that the assessment of the economic impact of poor power quality would be taken up for one sub-sector within the entire industrial sector. The sub-sector initially chosen for assessment was the information technology (IT). In particular, it was decided to assess the impact of poor power quality on the IT industry in Chennai, Bangalore, and Hyderabad.

Consistent with the methodology adopted for such a study in Sri Lanka, Bangladesh, and Nepal, as a first step in the conduct of the assessment in India action was initiated to establish an end-user stakeholder group. NASSCOM**,** a dynamic and very pro-active industry association of majority of the IT/software industry in India, was identified as the most suitable prospective stakeholder group and action was initiated to open a dialogue. Despite persistent efforts, however, no meaningful dialogue could be initiated with NASSCOM, largely on account of lack of interest shown by NASSCOM in getting involved in the assessment study[2].

Because of NASSCOM's lack of interest, Nexant had suggested to the USAID that, instead of the IT industry, the economic impact of poor power quality and power shortages be studied with respect to the foundry and/or other small-scale industry. The basis for the Nexant suggestion to include the foundry sub-sector instead of the IT sub-sector was the interaction Nexant had with the leading industry association of India, namely the Confederation of Indian Industry (CII). During their interaction, CII suggested that it would make sense to study the impact on the foundry industry. CII mentioned that, since industries like cement, fertilizers, and IT have **100%** back up power, by and large, they do not suffer loss of

[2] On the basis of the informal dialogue Nexant has had with NASSCOM and other IT/software industry personnel, it is felt that NASSCOM's lack of interest in associating with the assessment study perhaps stems from the fact that, at present, the IT/software industry in India does not see poor power quality or power shortages as an important challenge. Besides, given that the cost of electricity in the total operational cost of the IT/software industry is very low (for a company like Wipro, which also makes chemicals and electric bulbs besides software, it is about 2.4 percent of the total production cost; for companies like INFOSYS, SIFY, Polaris software, Hughes Technology, and Kale Consultants, the manufacturing cost is less than five to eight percent of total cost of sales for the year ending 2003); that, in India, the cost of self generation is lower – across the board – as compared to the tariffs charged by state electricity boards to the industrial and commercial sector; and also that penetration of self generation in IT/software industry in India is almost 100 percent, it is evident that neither the competitiveness nor the profitability of the Indian IT/software industry is affected a great deal by poor power quality or power shortages.

production. CII also mentioned that a DG set once installed is a sunk cost for companies. What matters thereafter is really the operating cost, which, given the low price of furnace oil, comes out to be lower than the electricity board tariffs. Against this, according to CII, the foundry industry does suffer from poor power quality and power shortages. CII further elaborated that it is the small-scale sector that really suffers from power shortages, as industrial units in this sector do not have the means to install DG sets.

During the interaction, CII further suggested that Nexant/USAID could consider studying either the foundry industry in Coimbatoor and/or Hyderabad. Given, however, that small-scale industry also seems to be suffering from power shortages and poor power quality, CII said that Nexant/USAID could also consider studying the impact on small-scale industry. CII suggested that Nexant/USAID identify an industry that is export-oriented or contributes significantly to employment or industrial output or that acts as a vital ancillary to big industrial units. CII further stated that the impact with respect to profitability, growth, competitiveness, employment, and contribution to government revenues should be studied.

Nexant's suggestion of studying the foundry and/or small-scale industry sector instead of the IT sub-sector was ultimately not supported by USAID. Instead, USAID asked that, in lieu of the study, Nexant undertake a literature search and review of the work done in India on the economic impact of poor power quality and power shortages. Accordingly, Nexant has prepared this document that reviews the recent work done in India.

A comprehensive literature search was initiated by listing sources that could have undertaken a study on the impact of power shortages and poor power quality. In particular, the following were identified as being potential sources:

1. Confederation of Indian Industry (CII)
2. Federation of Indian Chambers of Commerce and Industry (FICCI)
3. Planning Commission, Government of India
4. Indian Institute of Management – Ahmedabad (IIM-A)
5. Indian Institute of Management – Bangalore (IIM-B)
6. Ministry of Power, Government of India (MOP)
7. CRISIL, Mumbai
8. The World Bank, India
9. The Energy and Resources Institute (TERI)
10. The Asian Development Bank
11. Calcutta Chamber of Commerce
12. Indira Gandhi Institute of Development Research, Mumbai (IGIDR)
13. National Council for Applied Economic Research (NCAER)
14. PRAYAS, Pune
15. Rural Electrification Corporation (REC)
16. Institute of Economic Growth, Delhi University
17. Central Electricity Authority (CEA)
18. Central Electricity Regulatory Commission (CERC)
19. Power Finance Corporation (PFC)
20. Economic & Political Weekly (EPW: back volumes of the past 10 years were searched)
21. Indian Economic Journal (back volumes of past five years were searched)
22. Indian Institute of Technology – Mumbai (IIT-M)
23. ASSOCHAM
24. Infrastructure Development Finance Corporation of India (IDFC)
25. Power line publications (especially the report of captive capacity)

A detailed search of the web sites of the above listed potential sources was conducted to find out if any one of them have undertaken studies on the impact of power shortages and poor power quality and whether any one of them have published such work. Wherever the web site search provided a preliminary indication of some such or closely related work having been carried out (for example, TERI/World Bank, CII, Prayas-Pune, IGIDR-Mumbai, Indian Economic Journal*),* the web site search was followed by direct communication (via telephone and e-mail) to identify more clearly the exact nature of

work done. With the help of web site search and the subsequent follow-up communication, Nexant was able to identify the following work as being pertinent:

1. TERI Report: Cost of Unserved Energy, prepared for the World Bank and Department of International Development, 2001

Work done by Dr Krishna Rao Akkina of the Department of Economics of Kansas State University, USA:

1. "Convergence and the Role of Infrastructure and Power Shortages on Economic Growth across States in India"
2. "Impact of Electricity and Other Infrastructure on the Growth of Per Capita Income from Agriculture, Manufacturing and Services Sectors across States in India"
3. "Infrastructure and Power Shortages and Their Impact on the Growth of Per Capita Income across States in India"

Work done by CII:

1. Impact of Power Tariff on Competitiveness of Energy Intensive Industrial Sector
2. Tamil Nadu power survey, February 2001

Having identified the pertinent work, efforts were then made to procure the publications. Procurement of the exact materials that actually contained the identified work, however, was not easy. Dr Krishna Akkina informed Nexant that he was trying to publish the work listed under 3 and 4 above, and because of this, he was unable to make the work or its findings available. However, since the work under 2 above was already published in *The Indian Economic Journal* (Vol. 47, No. 2, 1999-00), a copy of the same was obtained by Nexant.

Similarly, CII informed Nexant that the work listed against 5 above actually comprised of internal documents and presentations, and as such was not available in the public domain. CII, did, however, share with Nexant the summary of the two works.

For the work listed as 1 above, TERI asked Nexant to contact the local World Bank office. The local World Bank office, however, refused to provide a copy of the report, stating that, although the World Bank had commissioned TERI to prepare the report, the Bank had reservations about the methodology and some of the findings, and hence the Bank had not placed the report in the public domain. What the Bank did mention, however, was that Nexant could have a copy of the executive summary of the report from TERI. Accordingly a copy of the executive summary of the TERI report was obtained from TERI.

3.1 REVIEW OF CII WORK

As mentioned in the previous section, CII did share with Nexant the summary of the following two works.

1. Impact of power tariff on competitiveness of energy intensive industrial sector
2. Tamil Nadu power survey, February 2001

A careful review of the contents of the two works by CII, however, shows that although the works are highly useful documents in their own right, they have very little direct relevance to the subject matter under study, namely the economic impact of poor power quality and power shortages.

The work on the impact of power tariffs essentially talks about the adverse impact that the nearly three-fold increase in power tariffs in the past decade has had on the competitiveness of energy-intensive industries in India. The work, in fact a presentation made by the Energy and Power Subcommittee of the CII Southern Region to the Government[3], covers the caustic chlorine, cement, aluminum, and foundry industries in India.

The work on the Tamil Nadu power survey is actually a report on the survey of 500 industrial units conducted CII in the state of Tamil Nadu. The report, which is based on year 2000-01 figures, provides estimates of the magnitude of the present (then year 2000) and future likely power shortages in the state. The report, however, does not go into the impact the power shortages are having (or will have in future) on the industries.

3.2 DOCUMENTS REVIEWED

Out of the three sets of the work identified as being pertinent, either because of unavailability of the actual documents or because the work was not found to be directly relevant, only the following two works were finally taken up for detailed review:

1. TERI Report: Cost of Unserved Energy, prepared for the World Bank and Department of International Development, 2001
2. "Convergence and the Role of Infrastructure and Power Shortages on Economic Growth across States in India", by Dr Krishna Rao Akkina of the Department of Economics of Kansas State University, published in *The Indian Economic Journal* (Vol. 47, No. 2, 1999-00)

The review findings are discussed in subsequent sections.

[3] For the Chlor-Alkali industry, the work shows that, in India, the power cost per ton of output is nearly four-and-a-half, three-and-a half, and two times as much as Saudi Arabia, China, and United States. For the cement industry the work shows that, although Indian cement plants are more energy efficient than European, American, and Southeast Asian ones, because they face higher power tariffs the cost of Indian clinker to key export markets is about $10 US per ton higher than the cost of clinker from Southeast Asian countries. Similarly the work shows that, because of higher power tariffs in India, power cost as a percentage of manufacturing cost is in the region of 35 to 50 percent, whereas it is only about 25 to 30 and 30 to 40 percent of the manufacturing cost in Europe and Southeast Asia, respectively. For the foundry industry, the work shows that, because of higher power tariffs in India, the power cost component of sales value is about 20 percent for India, compared to about 7.5 percent in Europe.

4.1 REVIEW OF TERI REPORT

While the TERI report, in the main, provides estimates of the CUE for industrial and agricultural consumers in the two Indian states of Haryana and Karnataka, it also attempts to provide estimates of the economic loss being suffered by the two states due to the poor power supply to the two sectors. Considering the context of the present report, namely the economic impact of poor power quality and power shortages, it is the latter part of the TERI report, dealing with the estimation of economic loss being suffered by the two states due to poor power supply, that is more relevant in the present context. For the sake of completeness, however, the review below discusses both the estimation of CUE as well as the estimation of economic loss.

4.2 ESTIMATION OF CUE

The estimates of CUE have been provided in rupees per kilowatt hour terms. Three methods have been used to estimate CUE. They are:

1. Value of production or output loss for each unit of power outage or shortage (the production loss method):

   For industrial sector consumers, CUE by the production loss method has been derived from the value of production or output loss attributable to disrupted power supply or power shortage. The value of aggregate production or output loss over a period of time was first estimated, then divided by the value of aggregate power shortage experienced during the same time period to provide an estimate of CUE in Rs/kWh terms. For agricultural sector consumers, the value of net production or net output loss was taken as the incremental crop output not realized due to unavailability of power for irrigation.

2. Cost of alternative or back-up power generation (captive generation method):

   CUE here has been derived from the value of the cost incurred by consumers due to the use of standby generation (SBG). For industrial consumers, the average economic cost of back-up power generation by SBG units was calculated using a sample of 1,054 industrial units (553 for Haryana and 501 for Karnataka), which was then used as an estimate of CUE by this method. For agricultural consumers, the average cost of supplying an equivalent amount of water using diesel pumps provided the estimates of CUE by this method. The average cost was calculated using a sample size of about 1,800 (900 for Haryana and 900 for Karnataka) consumers.

3. Willingness to pay (WTP) for reliable and uninterrupted electricity supply (WTP method):

   Under this method, WTP was arrived at by using the contingent valuation method (estimating the consumer willingness to pay in a hypothetical improved power supply scenario) using a bidding game approach.

As mentioned above, for estimation of CUE by the three methods, a sample of about 1,054 industrial consumers and about 1,800 agricultural consumers was used for collecting primary data, using a pre-tested questionnaire. The data pertained to the year 1998-99. A stratified random sampling technique was used for identifying a particular industrial unit in the sample.

For the industrial consumers, under all the three methods, the estimates of CUE have been provided separately for low tension (LT) and high tension (HT) consumers. Estimates of the combined value of CUE for the industrial consumers taken together have also been provided. Similarly, for agricultural consumers, under all three methods, separate CUE values have been calculated for different categories of farmers: marginal, small, semi-medium, medium, and large. Here too, estimates of the combined value of CUE for the agricultural consumers taken together have been provided.

Under all the three methods and for both categories of consumers (industrial and agricultural), apart from the average or mean CUE value (average of the sample), the report provides information about the standard deviation and the **75%** confidence level interval. The report also discusses the limitations and advantages of the three methods used in the estimation of CUE.

4.3 RESULTS

The following table shows the estimates of the value of CUE by the three different methods. The estimates of CUE values pertain to 1999 prices.

Table 4.1 Estimated CUE Values by Sector and Method

Method	Value	Industrial		Agricultural	
		Haryana	Karnataka	Haryana	Karnataka
Production Loss	Mean (Rs/kWh)	7.15	24.71	1.32	3.28
	SD (Rs/kWh)	3.46	6.6	2.53	21.68
Captive Generation	Mean (Rs/kWh)	3.38	3.74	3.85	10.71
	SD (Rs/kWh)	0.07	0.08	1.33	3.29
WTP	Mean (Rs/kWh)	5.16	5.22	2.92	1.99
	SD (Rs/kWh)	0.32	0.41	7.6	10.4

SD = standard deviation

4.4 ESTIMATION OF ECONOMIC LOSS

The estimates of economic loss have been provided in terms of aggregate loss of industrial and agricultural sector value added due to power shortages in the two sectors. The estimates of economic loss are based on the CUE figures calculated using the production loss method. As has been seen in the previous section, the CUE figures estimated under the production loss method for the industrial sector, provide a measure of production or output loss per unit of shortage of power. The economic loss, however, which is actually the loss in value added (or loss in GDP), is not the same as loss in production or output. Hence the TERI report uses the figure it calls as "corrected CUE" to estimate the economic loss in the industrial sector. The report defines "corrected CUE" as follows:

Corrected CUE (CCUE) = CUE * (value added/value of output)

CCUE is actually thus a measure or reflection of loss in value added per unit of shortage of power in the industrial sector.

For estimating the economic loss in the agricultural sector, however, the report uses the CUE figure as obtained under production loss method for agricultural consumers (that is, Rs. 1.32/kWh and Rs. 3.28/kWh for Haryana and Karnataka, respectively) as this CUE figure, as mentioned in the previous section, is a measure of net loss in production or output per unit of shortage.

The report then estimates the economic loss by multiplying the CCUE (for industrial sector) or CUE (for agricultural sector) values by the estimated power shortage (in kWh) faced by the particular sector in a time period of one year (the year 1998-99 in the report). The estimate of power shortages in the industrial sectors of the two states have been arrived at by subtracting the actual consumption that did occur in the sector during the year 1998-99 from the estimated consumption that would have taken place if the outages/shortages had not occurred. The estimates of the power shortage in the agricultural sector have been arrived at by multiplying the additional hours of power supply demanded by the farmers with the stated rating of the pump sets.

The table below shows the values of CCUE and estimated economic losses in the two states of Haryana and Karnataka for the year 1998-99 in the two sectors – industrial and agricultural.

Table 4.2: Estimated CCUE Values and Estimated Losses by Sector

Item	Industrial		Agricultural	
	Haryana	Karnataka	Haryana	Karnataka
CCUE (loss in value added in Rs/kWh shortage)	HT = 1.63 LT = 1.24	HT = 6.52 LT = 4.20	1.32	3.28
Estimated power shortage (M kWh)	HT = 546 LT = 94	HT = 339 LT = 108	3,940	9,288
Estimated loss in value added or economic impact (M Rs)	HT = 890 LT = 117 Total = 1,007	HT = 2210 LT = 454 Total = 2,664	5,201	30,464
Estimated total value added in the sector (M Rs)	95,328	120,222	165,155	229,122
Estimated loss in value added or economic loss as a % of total value added in the sector	1.06	2.22	3.1	13.3

4.5 OTHER FINDINGS

One other supplementary but important finding of the TERI study is that, for the sample of industries studied (about 1,054), the cost of self generation is across the board lower than the tariff charged by the respective state electricity boards.

The primary purpose of the paper by Dr Krishna Rao is to test the various propositions of the neoclassical growth models of Solow and Swan. The paper, however, has also attempted to ascertain the role of infrastructure and power shortages on the rate of growth of per capita income using cross section data from Indian states. The paper uses data pertaining to the period 1970-1990.

With regard to the role of power shortages on the rate of growth of per capita income across states in India, the paper concludes that power shortages have had negative/adverse impacts:

> Further, the results suggest that the power shortages existing in different states of India during the period 1970-90 had a significant negative impact on the average rate of growth per capita income. The results suggest that a **10%** shortage of power supply during the 1970s has reduced the average growth rate of per capita income approximately by **0.1%** whereas the same **10%** shortage in power supplies in the 1980s reduced the average per capita income growth by **0.5%**.

The paper while noting that the above results must be interpreted with caution, nevertheless states that

> These results are quite useful to indicate, as a first approximation, the natures of the impact of the power shortages on the rate of growth of per capita income across states in India.

One thing that clearly emerges out of this exercise is that, similar to the studies done under the SARI/Energy project for Sri Lanka, Bangladesh, and Nepal, no comprehensive study on the economic impact of poor power quality and power shortages either on the economy as a whole or on specific sectors exists for India. The two India specific sources reviewed here, however, do provide limited insight into the extent of economic impact the power shortages have had on the growth rate of per capita income in India (paper by Dr Krishna Rao Akkina) and on the industrial and agricultural sector value added (industrial and agricultural sector gross domestic product [GDP]) for the states of Haryana and Karnataka (the TERI report).

Starting from mid 1970s, India as a whole has mostly remained a power-deficient country. Although the shortages have varied in magnitude over different periods of time and across different states of India, it is to be noted that almost the whole of India has faced chronic and continued power shortages for the past three decades. Findings of both the above sources indicate that, at the aggregate national/regional level, the chronic power shortages have not only had adverse economic impact in terms of reduction in value added (GDP), but also in terms of reduced growth rate in value added and reduced growth rate in per capita income.

The TERI report indicates that, for the year 1998-99, shortages in the availability of power to the manufacturing sector resulted in loss of value added (GDP) to the extent **1.0%** and **2.2%** of the total manufacturing sector value added (GDP) in the states of Haryana and Karnataka respectively. The report also indicates that for the year 1998-99, shortages in the availability of power to the agricultural sector resulted in loss of value added (GDP) to the extent **3.1%** and **13.3%** of the total agricultural sector value added (GDP) in Haryana and Karnataka, respectively.

The paper by Dr Krishna Rao reveals that, while a **10%** shortage of power supply during the 1970s has reduced the average growth rate of per capita income by **0.1%**, the same **10%** shortage of power supply during the 1980s has reduced the average growth rate in per capita income by about **0.5%**. The findings thus indicate that during the 1970s and 1980s, had there been no power shortages, India's GDP would have risen faster.

The review carried out here clearly indicates that power shortages in India have had significant negative impacts, in the short term, on the national value added (GDP), and, in the long term, on the growth rate of value added (GDP). Given that as of March 2002, at the aggregate level, power consumers in India face power shortages to the tune of **12.6%** in peak power (kVA) availability and **7.5%** in energy (kWh) availability, it is clear that India's GDP and GDP growth rate will continue to be adversely affected in future.

1. It is important that the extent and nature of the impact be not only estimated, but understood and monitored. Since no comprehensive study on the economic impact of poor power quality and power shortages, either on the economy as a whole or on specific sectors and/or sub-sectors, exists for India, it is recommended that such a study be carried out.
2. It is recommended that the impact be measured not in terms of loss in production or loss in output but in terms of loss in value added (GDP), in the short term, and reduction in the growth of value added (reduction in economic growth) over the long term. If a study is to be carried out at a firm or sub-sector level, the impact should be measured in terms of effect on the short-term profitability and long-term growth prospect for the firm or sub-sector.
3. In view of the almost universal law of diminishing marginal productivity, it would be reasonable to expect that the productivity of power as one of the inputs in various industrial and manufacturing processes will not be constant at all levels of outputs, and perhaps even for all levels of value added, and would in fact be subject to diminishing returns as the output or value added levels increase. Consequently, it would be reasonable to expect that the valuation of the extent of production loss or extent of value added loss per unit of deficit or shortage in power availability would not be the same or constant at all levels of deficits or shortages. In fact if we agree that diminishing returns will prevail, it would be reasonable to expect that production/output or value added loss per unit deficit or shortage in power availability will become lower as the level of shortage or deficit reduces. Conversely, production/output or value added loss per unit deficit or shortage in power availability will become higher as the level of shortage or deficit increases. In view of this, it is recommended that in any study to be carried out, ways and means of assessing the impact, if any, of diminishing returns should be incorporated in its methodology.
4. As regards the focus of the study, it is recommended that it be either the foundry industry and/or a small-scale industry cluster that either contributes significantly to employment or industrial output or acts as a vital ancillary industry to big industrial units.

Finally, two related observations/recommendations:

1. 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.
2. Emphasis on energy conservation measures in the industrial sector at present is extremely low, and hence the sector needs implementation of an aggressive energy conservation program, which will undoubtedly help the electricity supply industry as well as the consumers.