ENERGY: A RESOURCE FOR INDUSTRIAL DEVELOPMENT IN INDIA

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PREFACE

The problems of industrial development and problems of developing countries have often been studied by various groups at IIASA. In this paper both are discussed at the same time. Energy is a resource of vital importance for industrial development, which not only determines what kind of industries can be set up in a given country but also what type of technology will be used.

The paper indicates the potentials and problems underlying the process of industrial development in an industrializing country where labor is abundant, non-commercial energy is used in some industries; a part of the production technology base is obsolete, interruptions in production are many - leading to under utilizations of capacity - and often much improvements in quality of products and performance are desired. These problems imply that there would be structural changes in the industries sector - some of which are described in this paper along with certain policy implications for the industries sector.

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ENERGY AND INDUSTRIAL DEVELOPMENT ININDIA

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1. INTRODUCTION

The importance of the energy sector for the economy of India could be judged by the fact that 28.5% of the public sector investment allocations in the 6th plan[+] (1980) is expected to go to the energy sector, of which 21.3% go to the power sector alone, which is the highest allocation to any sector, followed by the agriculture sector* (25%), transport sector* (15.7%), and the industries sector* (15.3%), respectively.

Thus, one realizes that energy itself is an industry and of an enormous magnitude, particularly in India because its major energy resource is coal, investment for which has to come from within India. This contrasts with some other developing countries whose major energy resource is oil, often imported. Of course, payment for oil requires investment elsewhere in other sectors or trade of other primary goods.

In India, industries sector is the largest consumer of commercial energy. In 1978-79, the industries sector consumed nearly 65% of electricity, 60% of coal and 60% of fuel oil.

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*However, a portion of the investment for these sectors comes also from the private sector. In the case of the energy sector, the contribution of the private sector is very small.

[+]See explanatory note on reference page.

Thus, industrial development in India is closely linked to the development of coal and power sectors and to some extent to the availability of oil.

1.1 Highlights of the Issues

In order to get insight into energy planning for the industries sector and assessing the required policies to achieve the objectives, the following issues are examined:

- What is the role of industries in the economy and the role of energy in the industries sector?
- What are the characteristics of industrial mix in India and how are these changing?
- Which are the large energy-consuming (LEC) industries? What are their energy requirements and what are their growth rates?
- How do the industries in India fare in terms of energy efficiency?
- What are the energy intensities* for various industries in India and how do they compare with other countries? Why is it that the industry sector appears to consume more energy per value added now compared to a decade or two before?
- What kind of technology choice would make the developments of energy and industry sectors compatible?
- What are the energy requirements of the industries sector for the next two decades?

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*Energy intensities are defined as energy required per value added. Energy consumption norms are defined as energy required per physical output (tonnes, meters, etc.).

These are some of the questions that we attempt to answer in this paper.

In the case of India, a cursory look at the growths of the energy sector, the industries sector and the economy as a whole, may leave a lot of puzzling questions unanswered and detailed analysis is necessary. Some of these observations which need to be explained are:

- Inspite of nearly 7% growth of energy for the last few decades and more than 9% growth of power sector in particular, the energy sector is unable to meet the energy requirements of an economy growing at 3.5%. In fact, inadequate growths of power and coal production are the major bottlenecks for the growths of industries. Complaints of shortages of energy continue to be the major points of discussions at Government levels, news media and the user agencies.
- The energy consumption per output measured in physical terms (ton, meter, etc., referred to also as energy consumption norms) as well as energy consumption per value added, referred to also as energy intensities, continue to increase compared to the past and also compared to other developed countries, Yet, does it mean a gross misuss of energy notwithstanding the necessity of conservation measures which are called for from all countries?

How does one explain these observations? What implications do they have in the future of energy and industries sectors?

1.2 The Scope of this Paper

A brief summary of the past developments of the economy, industries and the energy sector and structural changes that have taken place in them is made in section 2.

In section 3, it is explained why the energy consumption norms for some industries are increasing in India compared to its own past and why they are high compared to other developed countries. In the same section, the increasing trends of the energy intensities are also discussed. In section 4, some expected developments in the industries sector, energy sector and economy as it emerges from the various government plans scenario assumptions are discussed for the next two decades. In section 5, the projections of the energy requirements for industries sector up to 2000 are made under various policy and scenario assumptions. Finally, highlights and recommendations are given in section 6.

The changes taking place in the individual industries, such as iron and steel, textiles, cement, paper, etc., are discussed within this framework in order to focus properly on the issues (rather than dealing with each of them one by one under the respective titles "textiles", "cement", etc.).

2. ECONOMY, ENERGY, INDUSTRIES: THE INTERCONNECTIONS

In this section, the developments of the economy, energy, and industries sector is reviewed and the interdependence is discussed. Are the goals of each of them compatible with each other? While the goals of the economy and industries sector is to attain as much growth as possible, the policy of the energy sector would be to encourage the users to use the least amount of energy possible. What technological changes are necessary to achieve these contradictory goals? This could be only understood from the analysis of some of the major industries. Analysis explains why 7.0% growth in the energy sector was necessary for the economy which grew at only 3.6% during the period 1950-51 to 1975-76. It is shown that the industrial growth was 5.2% during this period and even the electricity growth of 10.3% was insufficient because within the industries, those consuming high electricity had higher growth rates.

2.1 Economic Changes

The growth of the economy and structural changes that have taken place over nearly 3 decades can be seen in Table 1. The growth rates of primary, secondary and tertiary sectors have been 2.2%, 5.4% and 4.7%, respectively. The shares of industries and agriculture sectors in the economy were 10% and 59.6% in 1950-51, respectively. They have changed to 15.8% and 43.6%, respectively, in 1978-79.

The growth rate of the registered sector in the first 25 years was 5.9% and that of the unregistered 4.4%. However, partly due to deliberate policy and partly due to the emergence and spread of skills and entrepreneurship, these trends are reversed to a small degree in the late seventies.

In terms of physical output, the growth of the industries sector, i.e. measured in terms of output index, is higher than the growth indicated by value-added. This phenomenon, peculiar to India, is expected to continue in the future, as can be seen from the revised sixth plan and projections for the 7th plan.

Table 1. Gross Domestic Product at Factor Cost by Industry of Origin
(at 1970/71 prices - in Rs billion)

Sector	1950/51	1960/61	1970/71	1975/76	1977/78	1978/79	Average Compound Growth Rate (% per annum) 1950/51 - 1975/76	1970/71 1978/79
Sub-total: Primary Sector (Agricultural, Forestry, Fishing, Mining)	104.53	140.78	178.15	195.26	208.49	212.39	2.5	2.2
Manufacturing	17.50	31.35	53.15	62.81	71.67	77.06	5.2	4.8
5.1. Registered	(9.55)	(18.58)	(34.84)	(39.70)	(45.92)	(49.61)	(5.9)	(4.5)
5.2 Unregistered	(7.95)	(12.77)	(18.31)	(23.11)	(25.75)	(27.45)	(4.4)	(5.2)
Construction	7.39	11.38	19.48	20.97	25.46	26.09	4.3	3.7
Electricity, Gas & Water Supply	0.49	1.40	4.15	5.72	6.63	7.36	10.3	7.4
Sub-total: Secondary Sector	25.38	44.13	76.78	89.50	103.76	110.51	5.2	5.4
Transport, Storage and Communication	6.35	11.03	18.75	24.45	26.50	27.22	5.6	4.8
Sub-total: Tertiary Sector (Including services: banking, defense, trade, hotels, etc.)	45.45	70.43	113.73	139.84	155.25	164.19	4.6	4.7
Sources: GDP at Factor Cost	175.36	255.34	368.66	424.60	467.50	487.09	3.6	3.5

SOURCES: National Accounts Statistics, 1970/71 - 1976/77; and Press Note dated February 7, 1980. Central Statistical Organization (CSO), New Delhi.

2.2 Pattern of Industrial Development

How does energy, particluarly coal and electricity, get used in the various sectors of the economy and in particular various subsectors of industries? This can be seen in Table 2 for coal and Table 3 for electricity. A detailed table for electricity is given in Annex 1. In 1976, out of nearly 25 million tons (mt) of oil products, 3.47 mt of fuel oil was used in the industries. Additional 1.46 mt of fuel oil was used in thermal power plants. Chemicals, textiles, iron and steel and fertilizers were the largest users of fuel oil (see Table 6 for details).

2.2.1 Characteristic industrial mix in India

Within the registered sector, the following industries are large energy-consuming (LEC) industries:

- textiles,
- fertilizers,
- inorganic heavy chemicals,
- pulp and paper,
- non-ferrous basic metals,
- iron and steel; and
- cement.

Although pulp and paper and textiles, if measured in meters, are not by themselves highly energy-intensive industries, the energy consumed by them is high due to the high volume of production. In 1975, these large energy consuming industries consumed 65% of the energy used in the industrial sector and

Table 2. Coal consumption by industry (in million tons)

Industry	1974-1975	1975-1976	1976-1977	1977-1978	1978-1979
Steel	18.51	20.93	22.30	21.54	20.26
Power	20.04	23.44	27.70	27.98	28.72
Railways	13.31	14.30	13.30	13.93	12.39
Cement	3.62	4.44	4.70	5.10	4.94
Fertilizer	0.95	0.93	0.70	1.26	2.66
Bricks	n.a.	n.a.	n.a.	3.36	1.46
Total Consumption	87.14	94.40	99.80	104.51	100.00

Source: Department of Coal, Ministry of Energy, New Delhi (1980)

Table 3. Sector-wise shares of electricity consumption 1953-54 to 1978-79

Sector	1953-1954	1960-1961	1965-1966	1970-1971	1975-1976	1978-1979 Provisional
Household	9.2	8.9	7.7	7.9	8.9	9.1
Agriculture	2.6	4.7	6.2	9.3	13.2	14.2
Industries	65.8	68.7	74.0	70.7	65.6	63.8
Transport	7.9	4.7	3.8	2.9	2.9	3.1
Others	14.5	13.0	8.3	9.2	9.5	9.8
Total %	100.0	100.0	100.0	100.0	100.0	100.0
Total (bkWh)	7.6	16.9	30.6	48.7	66.0	84.4

Source: Report of the Working Group on Energy Policy (1979).

produced 35% of the value-added by the industries sector. Therefore, the LEC industries need to be examined in detail.

Table 4. Characteristics of industrial mix in India showing the percentage share of industries in total value added by industries.

Year	Registered		Unregistered	Percentage LEC to registered sector
	LEC	Non-LEC		
1951-52	34.98	19.91	45.11	63.73
1961-62	32.97	25.33	41.70	56.55
1971-72	33.78	28.27	27.95	54.45
1975-76	34.73	26.89	38.38	56.36

Total of registered and unregistered industries may not be exactly 100 due to rounded figures.

LEC = Large Energy Consuming industries.

SOURCE: National Accounts Statistics, CSO, New Delhi, 1979. Compiled by J. Parikh and A. Chaitanya (1980).

Table 4 shows the percentage share of value added by the LEC industries, non-LEC in the registered sector, and the unregistered sector. It can be seen that over the last 25 years, the share of the unregistered sector has declined from 45% in 1951 to 38% in 1976. The percentage share of the LEC has remained roughly constant, whereas the percentage share of non-LEC in the registered sector has increased (this could be partly due to the fact that some of the LEC industries are in the public sector and their prices are controlled).

To have a better feeling about what industries are included in the registered and unregistered sectors and what is the value added by them, data on value added is presented in Table 5 for the years 1971 and 1976 as well as the corresponding growth rates

Table 5. Growth rates of value added of different industries in the registered and unregistered sector (figures in Rs.100,000 of 1970-71)

Industry Group	Registered Sector			Unregistered Sector		
	1970-71	1976-77	Growth Rate %	1970-71	1976-77	Growth Rate %
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Food Products	26815	29084	1.36	18411	19474	0.94
2. Beverages, Tobacco, and Tobacco Products	9911	14193	6.17	10409	14013	5.08
3. Textiles	59730	76559	4.22	44611	61621	7.10
Cotton Textiles	40139	47591	2.88			
Wool Silk and Synthetics	9378	12635	5.09			
Jute Hemp and Mesta Text.	8780	12294	5.77			
Textile Products	1433	3808	17.69			
4. Wood and Wood Products	3094	2601	(-2.95)	22043	33257	7.10
5. Paper and Paper Products	14959	16124	1.26	5106	5227	0.39
6. Leather and Leather and Fur Products	2260	2010	(-1.97)	6907	7481	1.34
7. Rubber, Plastic, Petroleum and Coal Products	12890	13346	0.58	1820	2966	8.48
8. Chemicals and Chemical Products	36707	52394	6.11	5837	8753	6.99
9. Non-Metallic Mineral Products	11399	12992	2.20	9342	15097	8.33

contd...

Table 5 continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
10. Basic Metal and Alloys Industry	28451	42429	6.89	462	733	7.98
11. Metal Products and Parts	9454	11292	3.01	11772	14152	3.12
12. Machinery, Machine Tools, etc.	19386	32860	9.19	6375	8679	3.28
13. Electric m/c	18213	29380	8.30	3627	4443	3.44
14. Transport	24396	28832	2.82	5346	7025	4.68
14. Misc. Mfg. Industries	18652	14293	(-4.54)	13258	16530	3.75
16. Repair Services	6397	9769	7.31	10603	13346	3.91
17. Net Value Added Incl. Imputed Bank Charges	296317	392188	4.78	-	-	-
18. Less Imputed	1055	1797	9.28	-	-	-
19. Net Value Added	295262	390401	4.77	175929	232797	4.78

Compiled by J. Parikh and A. Chaitanya (1980) from National Accounts Statistics (1979), Central Statistical Organisation, New Delhi.

over these six years at constant prices. It can be seen that during 1971 to 1976, the registered as well as the unregistered sectors have the same overall growth rates. In 1971, the unregistered sector had a lower share of the total industries sector than the registered sector. Therefore, the percentage share of the unregistered sector has declined further in 1976 because it has the same growth rate as the registered sector. (In other words, in order for the unregistered sector to have the same share in 1976 as in 1971 in total, it would have to grow at a faster growth rate compared to the unregistered sector.)

It can be seen in Table 5 that the individual industries, which are energy intensive, have grown at faster rates than those industries which are not energy-intensive.

2.3 The Developments in the Energy Sector

2.3.1 Energy resources

What are the major energy resources that India has and how are they used? Coal is the major energy resource India has and therefore the economy is structured so as to make the maximum use of it. While India has 100 billion tons of reserves and resources, its annual use is around 100 mt. Only 6 to 10% of oil products (mainly fuel oil) are used for the industries. In the early days natural gas was mostly associated and was often flared away. The recent finds of free offshore gas in South Basein near Bombay is expected to be mostly utilized as non-energy, i.e. for feedstock for fertilizer production. As the best use of natural gas is for the fertilizer production, demand for which grows at more than 9%, it is unlikely that the natural gas will be available for other industrial uses in the near future. However, discoveries of more fields of natural gas cannot be ruled out and to that extent natural gas may be available for purposes other than non-energy uses, however only in the long run. The recent report by the working group on energy policy, therefore, has considered it appropriate not to consider it as a basis for future energy policy for the next two decades at least.

New energy resources also may not contribute much in the next two decades, particularly to industrial development. Nuclear energy is expected to contribute 5 to 10 Gigawatts (GW) at best by 2000 as against the requirements of 100 to 130 GW. Thus, the industries sector would have to be organized so as to make maximum use of energy resources that the country has, viz. coal (direct), and electricity coming from coal, and hydro potential.

Thus, it is expected that the choice of technology in India would be such that coal and electricity provide the necessary energy.

2.3.2 Major energy-using industries in India

What industries are the major users of energy? As indicated earlier, the LEC-industries require detailed analysis. Only then the steps necessary to alter the present situation can be identified.

Table 6 gives relevant data for our analysis. It can be seen that the highest energy consumption is by iron and steel followed by fertilizers and textiles. Iron and steel are the largest consumers of coal and electricity followed by textiles which consume the second highest amount of electricity and second highest amount of fuel oil.

Table 6. Consumption of energy by large energy consuming industries in 1976

Industry	Coal & Coke mtcr (1)	Fuel Oil mtcr (2)	Electricity bkWh (3)	Total Energy mtcr (4)	Output 10^6t (5)
Crude Iron and Finished Steel	22.30	0.96	5.48	28.74	10.2
Textiles	2.60	1.17	5.12	8.89	5.36
Fertilizers	4.70	0.88	4.30	9.88	2.47
Chemicals	0.32	1.57	3.12	5.01	3.5
Cement	4.70	0.09	2.43	7.22	18.68
Aluminum	0.10	0.28	4.01	4.39	0.21
Pulp and Paper	1.47	n.a.	1.33	3.80	8.99

mtcr = million tonnes of coal replacement = 0.5mt fuel oil = billion kWh = bkWh

1kg coal = 5000 kcal

Categorization of industries is not exactly the same as the data source of (1) to (5) are different. Some are for financial year 1976-77 and some for the calendar year. Thus the table is only indicative of approximate magnitudes, ranking, etc.

Sources for (1): Department of Coal, Ministry of Energy, New Delhi (1976);
(2): Statistics by Ministry of Petroleum and Petro-Chemicals, New Delhi (1977);
(3): General Review: Public Electricity Supply (1977), Central Electricity Authority, Ministry of Energy, New Delhi;
compiled by the author.

Energy intensities of these industries have different order of ranking because of the differences in volume of production and in value added by each of the sectors. Here, fertilizers and non-ferrous metals as well as chemicals precede textiles.

3. TRENDS OF ENERGY USE IN INDUSTRY

It has been observed by the World Bank (1979) and W. Häfele (1981) that in India as well as other developing countries, the energy use per physical output as well as per unit of value added are increasing and are high compared to other developed countries. Table 7 summarizes the reasons for these phenomena. In this section, the reasons listed in Table 7 are elaborated when necessary and quantified where possible. It should be noted that the same reasons which explain increase in energy consumption norms of some of the LEC industries also explain the increase in energy intensities if value added per output is constant and more so if value added per output declines. This is because

$$\text{Energy Intensity} = \text{Energy/Value Added (V.A.)}$$
$$= \frac{\text{Energy/Output}}{\text{V.A./Output}}$$
$$= \frac{\text{Energy Consumption Norm}}{\text{V.A./Output}}$$

It is not possible to quantify all the reasons mentioned in Table 7, such as substitution of human energy by machines, etc. Therefore, a few selected issues for which the data is available are dicussed quantitatively in the following section.

Table 7. Why do the energy consumption norms and energy intensities increase in India compared to the past and compared to the other countries?

Increase compared to the past in India+	Energy/Output (Consumption Norms) (A) a) Improvements in quality of products b) Substitution of human and animal energy c) Substitution of non-commercial energy	Energy/Value Added* (D) a) Wage increase is slow b) Controled prices for some of the outputs c) Increase in consumption norms
Increase relative to other developed countries	(B) a) Technology of production not improving fast enough b) Scale of production c) Capacity utilization not good due to interruptions in production, for a variety of reasons d) Problems of measurement and comparison of energy use between countries e) Increased use of coal instead of gas or oil and decreasing quality of coal	(E) a) Wage - increase in other developed countries is higher b) Corrections for purchasing power of a rupee is necessary
Increase relative to other developing countries	(C) a) Increased use of coal b) Sometimes better quality product	(F) a) Comparatively large production base of energy-intensive industries such as iron and steel, chemicals, fertilizers and metals

*Energy/Value Added = $\frac{\text{Energy/Output}}{\text{Output/Value Added}}$. Therefore, the numerator is the same as in the (A), (B) and (C) blocks given on the left-hand side.

+This is not true of all products.

3.1 Energy-Efficiency in Industries

In order to make international and inter-temporal comparisons of technological progress, norms of energy consumption, i.e. energy consumed per unit physical output are most relevant. This can be treated as an indicator of energy efficiency of a given technology.

We examine whether the energy consumed per unit production (norms) in the LEC-industries are comparable to those in the other countries and whether they have been declining over time within India. The norms of energy consumption for producing a given product depend on three factors:

(i) Production technology and plant capacity

(ii) Capacity utilization

(iii) Quality of products and product mix.

Table 8 shows a comparison of energy consumed per unit production for various countries. Even though international comparisons are always beset with definitional problems, etc.; the message that transpires is obvious. Moreover, Table 8 is indicative of the state of technologies in various countries and may provide an input to the decisions involved in international collaborations. It can be seen that India consumes more energy per unit production of crude steel, aluminium and cement compared to most developed countries. The latter may have already experimented a great deal and possess newer technologies which are energy efficient. Those countries which are high importers of energy, such as Denmark, West Germany, etc., are cautious in their energy use and have more energy efficient technologies.

The fact that the advantages of economies of scale are also less in India compared to other developed countries may also explain part of the difference.

Table 8. International comparison of energy efficiency in industries

Country	Crude Steel	Paper and Pulp		Cement		Aluminum	
Ireland	140			Austria	90	United States	949
	167(x)						
Spain	180(e)	Spain	220	Germany	91	Netherlands	1290
Norway	189(e)	Italy	340	Canada	95(d) 148(w)	Austria	1346
Denmark	236	Austria	344	Italy	96	Japan	1385
Germany	326	Denmark	353	Turkey	98(d) 139(w)	Taiwan	1464
Italy	334	Germany	438	Taiwan	115	Germany	1481-
Sweden	398	Taiwan	476	Norway	115		1503
Austria	450(i)	Sweden	489	Japan	121	Norway	1591(e)
Netherlands	470	Japan	512	Spain	130		
United Kingdom	478	Switzerland	557	Netherlands	131	Sweden	1648
Taiwan	485	United States	579	United Kingdom	138	United Kingdom	2107
Turkey	500	United Kingdom	627	Sweden	140	New Zealand	2165
Japan	513	Norway	659	Ireland	153	India	2295
United States	533	Canada	673	United States	161	Spain	2800
Canada	555	New Zealand	692	Denmark	164(w)		
Luxembourg	701			India	170(w)		
New Zealand	738	India	1130	New Zealand	175		
India	1161(i)						

(e) Electricity only
(i) Pig Iron
(x) Scrap Iron
(w) Wet Process
(d) Dry Process

Source for international data: Energy Management in Selected Asian Countries- Asian Productivity Organization, Tokyo (1977).

Compiled by J. Parikh and A. Chaitanya (1980).

It can be observed from Table 8 that the energy consumption in the pulp and paper industry in India is $1130 \cdot 10^4$ kcal/ton. Some of the pulp is produced outside the paper mill, and is dried before transporting it to the paper mills, and the energy consumption for pulp production is $851 \cdot 10^4$ kcal/ton of pulp.

In the case of crude steel also energy consumption per ton of crude steel works out to be high in India. This may be because India has integrated plants which include coal washeries, iron ore processing, etc. It is possible that, in the other countries, these operations are done outside of the steel plants. Since data on energy consumption at different points of steel production process are not available, it is difficult to say exactly how much of energy is utilized in production of crude steel alone.

In the case of aluminium industry also, India's position is not very good, as it requires $2295 \cdot 10^4$ kcal/ton of production. However, one observes fluctuations from year to year due to changes in capacity utilization in the aluminium industry.

The consumption of energy in the cement industry is quite comparable to that in the developed countries.

How does energy-efficiency change over time within India? Table 9 shows the changes in norms which have taken place within India. The norms vary with the vintage of the plants, measured by the date of commissioning of the plants. While the crude steel plant commissioned in 1953-54 consumes 1.64 tons of coal per ton of steel, the plant commissioned in 1972-73 consumes only 1.9 tons of coal. Similarly in the case of cement the consumption norms for the wet process have come down from 0.460 tons of coal to 0.300 tons (in spite of low capacity utilization).

Table 9. Changes in energy efficiencies due to vintage of plant and capacity utilization

Name of Plant		Year of the Commission-ing of Plant	Coal Consumed Per Ton of Product	Capacity Utiliza-tion
		Crude Steel		
IISCO		1953-54	1.64	-
Bhilai Steel Plant		1959-60	1.42	-
Bokaro Steel Plant		1972-73	1.19	-
		Cement		
Lokhari	Wet Process	1917	0.460	76
Vijayawada		1940	0.283	90
Sankovidmy		1963	0.220	82
Alangulam		1970	0.300	50
Kistna	Dry Process	1939	0.327	66
Wadi		1968	0.219	96
Udainut		1970	0.208	111

Source: J. Parikh and A. Chaitanya (1980)

It is also interesting to see that when the capacity utilization of the cement industries is 50%, the plant commissioned in 1970 consumes 0.3 tons of coal as against 0.28 tons of coal for 90% utilization commissioned in 1940. In the aluminium industries also fluctuations in the capacity utilization lead to fluctuations in the electricity utilization. As the reasons for interruptions in the production process are many in the developing countries who are just beginning their industrial development, their effects show up in the energy consumption.

3.2 Why Have Energy Intensities in Industries Increased?

It has been observed recently, in published and unpublished reports that:

- Even within India, the energy intensities have increased from 1.267 in 1960 to 1.433 in 1970 measured in tcr per Rs.1000 of value added. The individual energy-resource intensities could be seen in Table 10.
- In India, energy intensities (ratio of energy consumption to value added in the industry) are large compared to other developed and developing countries.

This is rather surprising considering the labor-intensive technologies that are often used. Moreover, 38% of the value added is in the unregistered sector. Let us examine both the aspects concerning the energy intensities.

The first point is concerning increased energy intensities within India over the last 15 years. It is shown in Table 11 that even within the large energy consuming industries sector, growth rates of industries which consume more energy per unit value added (such as iron and steel) are higher than the growth rates of industries which consume less energy (such as paper and pulp, textiles, etc.). Thus, although large energy consuming industries have been contributing roughly 33% of value added for the last 25 years, the composition of the LEC has been changing. Moreover, as already shown in Table 5, the share of the non-LEC, which are more energy-intensive than the unregistered sector, is also increasing.

As far as the second point is concerned, the following points are relevant:

Table 10. Energy/value added in the industries sector for selected years; past and future

Energy Form and Units	1960-61	1965-66	1970-71	1975-76	1984-85	2000*	
						Low	High
Energy Consumed by Industries:							
Coal (10^6t)	20.90	30.10	31.07	51.01	84.58	220.2	317.8
Oil (10^6t)	3.61	4.04	5.45	3.77	3.91	4.78	7.49
Electricity (10^9kWh)	11.60	22.62	34.55	43.35	82.90	188.2	266.05
V.A. in Industries (10^9Rs. in Rs. 1970-71)	31.3	44.6	53.2	62.8	101.40	245	332
Energy Intensities:							
Coal/V.A. (10^6t/10^9Rs.)	0.667	0.675	0.584	0.812	0.834	0.899	0.957
Oil/V.A. (10^6t/10^9Rs.)	0.115	0.0908	0.102	0.0601	0.039	0.019	0.022
Electricity/V.A. (10^9kWh/10^9Rs.)	0.370	0.508	0.645	0.690	0.817	0.768	0.801

Source: J. Parikh (1980)

*The figures for 2000 are used later for the projections for 2000. This point is discussed later in this paper as well as in J. Parikh (1980).

Table 11. Gradual increase of more energy intensive industries. Percentage share of individual large energy consuming industries in total value added by them

	1950-51	1960-61	1965-66	1970-71	1974-75	1975-76
Textiles	64.75	51.83	43.67	37.17	39.85	38.12
Paper and Paper Prod. and Allied Industries	6.90	8.38	9.45	9.31	7.80	7.81
Chemicals and Chemical Products Including Fertilizers	10.19	13.75	15.87	22.84	24.91	23.42
Non-Metallic Mineral Products	4.74	7.22	7.99	7.09	5.60	5.91
Basic Metal Industries and Metal Products	13.45	18.85	23.05	23.58	21.15	24.75

N.B.: The total may not add to 100 due to rounding off.

Source: National Accounts Statistics, 1979 and previous volumes, Central Statistical Organisation, Parliament Street, New Delhi.

- It is well-known that in the developing countries, the major component of the value of the output is raw materials. The cost of labor assumes secondary importance. The wages in the developing countries are so low that the energy requirements per unit value added would be higher in the developing countries than in the developed.
- International comparison of energy intensities in industries is given in Table 12. It can be seen that the industries in India consume very high amounts of electricity and thermal energy per dollar of value added. However, it is necessary to make corrections for purchasing power of the national currency worth a dollar within the country. It has been shown by Kravis et al. (1977) that for a comparable mix of commodities, the purchasing power of a rupee within India is 3.3 times larger than that indicated by the official exchange rate for the traded commodities. This factor, if used, would partly correct for the wage component of the value added (for example, value added generated from a taxi driven for 1 kilometer would be small in India compared to the developed countries and, therefore, energy per value added would be correspondingly high for that activity).
- However, even after corrections for purchasing power, electricity consumption per dollar of value added in India is still high compared to the developed countries. It is especially high in the case of thermal energy use. This may be because of inefficient use of energy due to old, obsolete, technology, bad maintenance and low economy of scale.

Table 12. International comparison of energy intensities in industries

	Western Europe [1]	Eastern Europe[1]	India
Electricity/V.A.(kWh/$)	1.26	2.05	5.52
Thermal Energy/V.A.(kWh/$)	4.48	11.82	43.2
Thermal (useful/final energy, %)	65.4	74.5	30+
	After corrections for purchasing power		
Electricity (kWh/"$")*	1.411	1.414	1.520
Thermal** energy (kWh/"$")	5.02	8.156	11.985

*"$" is corrected $ for purchasing power of a dollar worth of national currency within the country. The representative countries taken are W. Germany and Hungary.

**Thermal energy is converted into kcal and then to electricity using 0.123 tce = 1000 kWh (i.e. the comparison is in the heat units and not in mtcr units, conventionally used in India, e.g. Fuel Policy Committee).

+Approximate figure is guesstimated.

Source: J. Parikh (1980)

[1]A. Khan and A. Hölzl (1981). Forthcoming IIASA Research Report titled "Evolution of Future Energy Demand Till 2030 in Different World Regions - An Assessment made for the Two IIASA Scenarios.

- Poor quality of coal, which is the major energy resource in India, can be also a reason for high energy consumption. Industries based on natural gas or oil--which can be more efficiently used than coal--are much less in India compared to Western and Eastern Europe. Often, when the poor quality of coal having 3000 to 4000kcal per kg (instead of 7000kcal/kg for the standard UN coal) is used, the record of only the quantity, and not the quality, is made in some statistics.

4. EXPECTED STRUCTURAL CHANGES IN THE INDUSTRIES SECTOR

To adapt to high prices or short supply of energy, industries sector may undergo a number of structural changes. They can be broadly classified as follows:

- Changes in the existing production system
- Alternative processes of production
- Changes in the industrial mix and substitution of products
- Changes in the energy supply systems.

The first three relate to reducing demand and the last one concerns alternatives of energy supply system. Each of them is discussed below in the order of their feasibility in the time dimension, i.e. short-term changes are discussed first.

Some changes which are already taking place since long--substitution of human, animal and non-commercial energy which are already mentioned in the preceding section--are not discussed again except to mention that in the case of a steep rise of energy prices these substitutions may slow down.

4.1 Changes in the Existing Industries

As the investment for some of the existing production facilities are already made prior to 1973, it may not be possible to alter them. At best, proper management measures to cut down wasteful uses of energy can be introduced. Some of the very old plants of the LEC industries may close down altogether if the products are not competitive with others on the market.

Steel industries are envisaging a cut in fuel oil consumption at the open hearth furnaces by 5% due to improved operation practices. Efforts are also underway to reduce coking rates of the blast furnaces with increased blast temperatures.

The aluminum industries, which often does not attain full capacity utilization, can reduce 5 to 7% electricity consumption by avoiding breaks in its production.

The representatives of the boiler manufacturing industries also indicate that cuts of 5 to 10% of fuel use can be made by proper maintenance and management.

The biggest dent could be made by the energy industries themselves. Proper maintenance and scheduling of only a few thermal power plants could result in considerable savings of coal. The average coal consumption norm for a thermal power plant is 0.67t/1000kWh and average efficiencies range around 0.26 to 0.30. This is contrasted with 0.35 to 0.37 efficiencies in the countries of Western Europe. Similarly, there is some scope in saving coal and electricity in coal mines and some oil in the refineries.

4.2 Alternative Technologies of Production

What are the implications on choice of technology in terms of (a) selection of processes and (b) determining the appropriate scale of technology? It is well-known that the developing countries use rather outdated technologies in terms of its efficiency and its scale.

4.2.1 Selection of energy efficient processes

While the existing industries gear themselves to achieve energy conservation by merely better management and minor modifications, the new industries have to explore more efficient production processes. The examples of these are Alcoa process in the aluminum industry, natural gas based fertilizer plants which are more energy efficient and economic, chemical process for caustic soda, etc.

In India, 72% of the capacity in the cement industries use wet processes which consume 0.3 tons of coal per ton of cement. As against this, the dry process requires only 0.21 tons of coal. the electricity requirements vary between 96 to 145kWh and 110 to 150kWh, respectively, for the two processes.

4.2.2 Determining appropriate scale of technology

It is well-known that the developing countries and even India,with its massive population,do not benefit from the economy of scale. For example, the unit sizes for power plants are often 50 to 120MW, for fertilizer plants 600 to 900 tons per day (tpd), for cement up to 500 to 700 thousand tons per year, etc. The efforts are underway to increase these sizes to 220 to 500 MW, 1300 tpd, and 1 million tons per year for the same industries respectively. How far does one expect to go on increasing the scale? In most cases, the energy use is lower for industrial production at higher scale. Because of rising population and prosperity, up to a certain point, the demand may not be the constraint in increasing the scale further. But is it an energy-efficient solution? When the scale increases, there are equally formidable problems of transporting the inputs and the distribution of products (i.e. as the demand centers diversify, it may be more desirable to have several medium scale industries than one giant supplier). It is expected* that while the next levels of scale of technologies may get selected, as described above, it is unlikely that this trend would continue indefinitely and in fact for the next two decades the next scale upwards might be the limit.

4.3 Changes in the Industrial Mix Through Substitution Processes

The technological changes in the production system, whether in the existing or the new industries, may not be enough. What would be also necessary is a radical change in the industrial mix itself. This would call for massive substitutions of the products using more energy by those products using less energy. Such an industrial mix would have greater shares of demand for:

- Handloom fabrics vs. synthetic materials
- Wood and perhaps even steel vs. aluminum
- Low quality paper vs. highly bleached and fine varieties of paper
- Wood and fiber glass vs. finished steel products of certain types.

It is difficult to quantify the reductions in the total energy demand which can be achieved by this measure; but in general they could be of much larger magnitudes than the conservation.

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*Private communications from several officials dealing with the industries in the Government of India.

In the cases of substitution by products of unorganized sectors, it is important to realize that the developing countries would require indigenous R&D efforts as the like of these industries are either non-existent in the developed world or they are of little interest--particularly those industries which are labor-intensive.

4.4 Changes in the Energy Supply System

It is possible to save energy costs as well as energy merely by switching from one type of energy supply to another. These changes in the energy-mix are discussed below.

4.4.1 Substitution of oil products

Oil-fired boilers by coal-fired boilers are among the promising alternatives. While the coal prices are around Rs.100 to 250 per ton of delivered coal, the fuel oil prices are above Rs.900 per ton.

The ratio of oil-based fertilizer plants to gas-based fertilizer plants is declining rapidly. All the new plants may use natural gas as feedstock.

4.4.2 Substitution of commercial energy by muscular and non-commercial energy

Although, in general, the changes are taking place in the reverse direction calling for more commercial energy, in some isolated cases, it is possible that to a small degree the energy may be substituted by human efforts and non-commercial energy in the rural areas, especially because the supplies of coal and oil have become undependable recently. Some recommend wood-based power plants in the rural areas and charcoal for rural industries. It is, however, expected that while in some industries this may happen, overall trend would be reduced shares of these energy forms; although, in absolute magnitude there may be an increase.

4.4.3 New energy sources for the industries

In addition to natural gas resources, new finds of which are recently being discovered, often solar energy and non-commercial and human energy applications may be relevant, too.

In order to appreciate its possible impact, the energy required in the industries needs to be split into the following components:

(a) Hot water for washing (less than 100°C)

(b) Hot water for boiling, sterilizing (above 100°C)

(c) Hot air for drying (less than 100°C)

(d) Low pressure steam

(e) Hot air for drying or baking (ovens above 100°C)

(f) High pressure steam

(g) Other heat requirements.

Hot water and hot air systems for (a) to (d) and even solar ovens could be made commercially available with payback periods less than 5 years, if suitable tax incentives could be provided. Constraints of the available area in the industries for solar collectors and concentrators in comparison to energy requirements in an industry have to be, however, considered.

In addition, solar boilers and solar furnaces can make important contributions in the small-scale industries.

5. ENERGY DEMAND FOR INDUSTRIES UP TO 2000

What then are the energy requirements for the industrial sector up to 2000? The projections are based on the energy intensity coefficients derived from the past and are varied for future because of the technological changes. In varying them, the structural changes discussed in sections 3 and 4 are taken into consideration. Assumptions for the reference scenarios are given in Table 13. The industrial GDP is expected to grow at 7.2% for the reference scenario and considered by the Working Group on Energy Policy (WEP) as well as in the revised draft 6th plan.

- o Macro Method: Two level disaggregation, viz. LEC and non-LEC industries are considered;
- o End-use Method: 19 level disaggregation for the power sector are considered.

5.1 Discussion of Results of the Macro-Method

Table 13 gives the energy demand for the reference scenario for the period of 1984-2000 discussed in Parikh (1980). It can be seen that for 7.2% industrial growth, the growths required in electricity, oil and coal are 7.5%, 2.3%, and 8.7%, respectively. (The magnitudes of the results given in Table 13 are somewhat similar to the WEP projections in case of electricity and oil and are higher in the case of coal by 43 mt.)

What happens if in a low GDP case high LEC industrial mix policy is pursued (and vice-versa, i.e. high GDP with low LEC)? Then one can analyze the impacts of the industrial policy to encourage high LEC or low LEC. As the difference between the two strategies gets accentuated only with time, the results for only the year 2000 are compared when these differences are large and

Table 13. Energy demand for the industry sector - Reference Scenario

	1978-79	1984-85	1989-90	1992-95	2000-01	Growth 1978-2000
Electricity (10^9 kWh)						
LEC Industries		54.8	77.7	102.2	133.3	
Non-LEC Industries		35.87	54.7	90.4	132.8	
Subtotal	53.9	90.6	132.4	192.6	266.1	7.5
Fuel Oil (10^6 mt)						
LEC Industries		4.1	5.8	6.4	6.7	
Non-LEC Industries		0.3	0.4	0.6	0.8	
Subtotal	4.5	4.4	6.2	7.0	7.5	2.3
Coal, Coke, Charcoal (10^6 mt)						
LEC Industries		60.0	90.0	125.6	185.0	
Non-LEC Industries		32.6	45.5	75.6	132.8	
Subtotal	50.5	92.6	135.5	201.2	317.8	8.7

Scenario Assumptions:

LEC value added growth 7.3% per annum, non-LEC 7.1%

LEC/YIND = 33.4%

YIND = Industrial GDP

Source: J. Parikh (1980)

noticeable. These are given in Table 14. It can be seen that the difference between scenario (1) and (2) is of 10 bkwh, 0.9 mt of fuel oil and 18 mt of coal. This can therefore, be considered as the effect of reducing the share of LEC in the industries sector from 31.3% to 26%. This is low because, due to substantial R&D efforts in the LEC-industries put in not necessarily within India but elsewhere as well the energy efficiency in the LEC industries can be increased by already well-known methods. On the other hand, the measures required for energy conservation are not so well identified in the non-LEC industries.

How crucial are the policies concerning energy intensities and the assumptions of envisaged changes, values of which are given in Annex 2? They are, of course, crucial. In fact, several scenarios were carried out to gauge their significance. In the absence of any policy and R&D efforts, electricity intensities in the non-LEC industries are expected to increase much more than those assumed in Annex 2. If, in case the electricity intensity of the LEC is increased by 12.5% and of the non-LEC by 25% in 2000, then nearly 50 billion units more would be required for the reference GDP scenarios.

Similarly, coal intensities in the LEC industries are assumed to stabilize; but if they were to increase by 14% because of lack of fuel oil and lower quality expected of coal, then 26 mt more coal would be required for the reference scenario.

The emerging overall intensities of the future need to be compared with the past ones given in Table 10. The intensities in electricity increases 2000 nearly up to 0.8 bkwh per Rs. billion as compared to the present but its growth rates are much lower than they have been in the past. The comparison of the overall

Table 14. Energy demand for the industry sector - comparison of alternative scenarios in 2000

	Low (1)	High* (2)
Electricity (10^9kWh)		
LEC Industries	111.7	133.3
Non-LEC Industries	143.6	132.8
Subtotal	255.3	266.1
Fuel Oil (10^6 mt)		
LEC Industries	5.6	6.7
Non-LEC Industries	0.9	0.8
Subtotal	6.5	7.5
Coal, Coke, Charcoal (10^6 mt)		
LEC Industries	155.0	185.0
Non-LEC Industries	143.6	132.8
Subtotal	298.6	317.8

Scenario Assumptions:

H GDP = High GDP = Rs.1622 10^9 - compound growth for 1982-2000 - 5.8%, YIND growth 7.1%.

H LEC = LEC value added growth 7% per annum, non-LEC 7.1%, LEC/YIND = 31.3%.

*This approximately represents the WEP scenario.

Source: J. Parikh (1980)

intensities with the past given in Table 10, therefore, provide a cross-check at disaggregated levels of industries and an assessment of possible changes on value added per output is necessary. One of the important conclusions from the results is that if the non-LEC path is pursued, then the increase in the energy intensities of the non-LEC industries must be curbed. This would mean that they would require larger R&D support--something that only the LEC industries get at present.

5.2 Discussion of Results of the End-Use Method

In order to have further insights and cross-checks for the simplified macro-method given above, it is necessary to derive the energy requirements for the individual major industries. Unfortunately, the targets of production for individual industries in physical terms are available only up to the year 1992-93 in the revised 6th Plan.+ (It is expected that even in the new Plan for 1984-85, yet to be formulated, targets for energy-intensive industries may not alter drastically.)

The requirements for "other industries" are made on a percentage basis. It has been found that nearly 54% of the electricity consumption is in the production of major commodities described above and the remaining 46% is in the "other industries".

It can be seen that the electricity demand derived by the detailed end-use method agress remarkably well with the projections made by the macro-method given in Table 15, interpolated for the years 1982-83, 1987-88 and 1992-93 as these are the years for which projections are available. If, however, the shares of other industries were to go up, end-use method will agree with the reference scenario of the macro-method.

+See explanatory note on reference page.

Table 15. Electricity demand from the end-use method using long-term plan targets from the revised Sixth Plan

Item	Unit	1982-83		1987-88 (projection)		1992-93 (projection)	
		Production Target	Elec.Cons. in Mkwh	Production Target	Elec.Cons. in Mkwh	Production Target	Elec.Cons. in Mkwh
Sugarcane	10^6t	207	898	250	1085	303	1315
Jute & Mesta	10^6bales (180kg)	8.6	697	10.6	859	12.1	980
Oil Seeds (major)	10^6t	11.2	523	13	601	15.8	730
Coal	10^6t	143	2145	201.2	3018	275	4125
Crude Oil	10^6t	18.0	361	20.52	411	20.60	412
Iron Ore	10^6t	57.5	862	68	1020	84	1260
Petroleum Products	10^6t	33.1	1028	44.9	1392	61.4	1903
Cement	10^6t	28	3360	41	4920	69	7080
Mild Steel	10^6t	11.3	8490	15.3	11475	22	16500
Cloth	10^6mtrs	12200	6603	16000	8659	20000	10824
Paper and Paper Board	10^3t	1350	1890	1945	2723	2800	3920
Newsprint	10^3t	190	399	265	557	370	777
Synthetic Fibres	10^3t	85	428	204	1026	490	2959
Nitrogenous Fertilizers(N)	10^3t	3900	5499	6100	8601	8350	11774

Table 15 continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Phosphatic Fertilizers (P_2O_5)	10^3t	1125	1294	2000	2300	3000	3450
Aluminum	10^6t	300	6000	475	9500	700	14000
Copper Refined	10^6t	35	7	50	10	70	14
Zinc	10^3t	80	336	105	441	150	630
Lead	10^3t	16	8	27	14	45	23
Subtotal			40828		58612		82076
Other Industries			34417		99409		69189
(A) Total			75245		108021		151265
(B) Macro Method							
High (L)			77804		110240		155463
High			77970		113771		165792
(C) WEP Scenario							
Optimal forecast			85000		114500		162300

(A) is from the end-use method; (B) is from the model assuming energy intensities for the two sectors; and (C) gives the projections made by the WEP.

Source: J. Parikh (1980)

6. HIGHLIGHTS AND RECOMMENDATIONS

In this section, highlights of the preceding sections are given and emerging recommendations are discussed. What is true for India also holds for other developing countries, unless otherwise stated.

6.1 Highlights

1. In the case of India, the growth of industrial GDP was (and will be) higher than the total GDP (5.2% vs. 3.5%). Therefore, in the past, energy growth had to be higher than the growth of the economy and even higher than that of the industrial GDP because of structural changes taking place in the industries sector as well.
2. The industries sector consumes nearly 60% of commercial energy and therefore it is important to consider energy itself as one of the most important industries and not merely an infrastructure facility. In India, it would continue to require nearly 30% of the plan allocations for the next two decades.
3. Due to substitution of human, animal and non-commercial energy by commercial energy, and also due to increases in quality of the outputs, energy consumption norms have increases in some industries. The consumption norms are high compared to the developed countries because of old technologies, low scale of production, interruptions in capacity utilization and in case of India high use of coal, rather than gas or oil which are more efficient. Energy-intensities also appear to be high because of the same difficulties described above and because of the necessity of corrections for purchasing power of a rupee vs. U.S. dollar.

4. The structural changes necessary to meet the new challenge would require careful analysis of alternatives for industrial production, for energy consumption and for energy supply. It is indicated that conservation measures on the existing industries may lead to 5 to 10% savings, 20% savings from alternative production processes and considerable savings from changing industrial mix, if the appropriate R&D efforts are put in. Changes in the energy-supply mix in India may be towards more utilization of coal and the beginning of solar alternatives for industrial heat.

5. In the next two decades, for 7.2% growth rate in the industries sector, India may require 7.5%, 2.3% and 8.7% growths in electricity, fuel oil and coal consumption, respectively, if substantial conservation measures are considered.

6.2 Recommendations

1. Conservation measures in the industries sector are extremely necessary but even so, they can barely offset the increase in consumption norms likely to arise due to a number of reasons discussed above. Thus, conservation can at best be a partial solution.

2. Due to a variety of reasons, the developing countries are not availing themselves of the best of technologies available elsewhere in the world. The issue of technology transfer, particularly in the LEC industries to the developing countries needs to be examined very carefully considering the associated energy requirements. This requires cooperation between developing and the developed world.

3. Non-LEC industries produce 67% of the value added in industries while consuming 35% of the energy consumption in India. Selection of the kind of technology, such as handloom vs. synthetic textiles etc., needs careful consideration and requires different kind of R&D efforts not carried out so far either in the developed or developing countries.
4. In addition to the efforts for conservation in the LEC and non-LEC industries, efforts for solar furnaces, solar boilers, hot water and steam systems using solar energy may be relevant.
5. Energy-efficient production processes may require to be adapted from the developed countries for which information systems may be helpful.
6. Some of the measures would require investment. Thus there would be competition for the investment for the new energy facilities, energy saving measures and new industries themselves. Foreign investment and aid to the developing countries for this transformation may be most helpful so as to foster industrial development.

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+Explanatory note to pages 1 and 36

The Planning Commission, Government of India, printed a "Revised Draft 6th Plan" in 1979, where the targets for the 6th, 7th and 8th plans were indicated for the periods 1977-78 to 1932-83, 1982-83 to 1987-88 and 1987-88 to 1992-93, respectively. The new Government took over after the election in 1980 and decided to revise the plan for which figures are not yet available. The new Government also decided to shift the plan periods by two years, i.e. 1980-81 to 1984-85, etc. In this paper, the reference to the 6th plan is made according to the printed version available. It is, however, expected that the growth rates for the energy sector and the LEC industries will not change drastically in the new plan.

ANNEX 1

Electricity Consumption by Major Industries and Their Percentage Shares in 1977-78+

Industry Category	Electricity Consumption Mkwh	Percentage Shares
Aluminum*	3552	10.65
Cement*	2345	0.04
Chemicals	3377	10.13
Colliery	786	2.36
Fertilizers	3888	11.67
Iron and Steel*	5480	16.45
Crude Oil and Petroleum	707	2.12
Paper	1487	4.46
Plastic and Rubber	448	1.34
Sugar	795	2.38
Textiles	5255	15.77
Non-Ferrous Metals	1643	4.90
Miscellaneous	3568	10.77
Subtotal**	33321	100

+Source: Abridged from General Review of Public Electricity Supply. All India Statistics 1977-78. Includes energy generated by captive plants, energy used in auxiliary and energy purchased. Percentage may not add up because of rounding off errors.

*Includes primary and secondary consumption.

**Other minor industries with individual use below 150Mkwh all together consumed 9314Mkwh giving a total of 42635Mkwh in industries sector.

ANNEX 2

Energy Consumption Norms Used for the Industry Sector of the Model

	1976-77	1984-85	1989-90	1992-93	2000-01
Electricity (10^9kWh per Rs.10^9)*					
LEC Industries	1.39	1.521	1.439	1.355	1.200
Non-LEC Industries	0.390	0.486	0.557	0.607	0.600
Fuel Oil (10^6mt.per Rs.10^9)					
LEC Industries	0.1126	0.113	0.108	0.085	0.060
Non-LEC Industries	0.0037	0.0037	0.0037	0.0037	0.0037
Coal, Coke, Charcoal(10^6mt.per Rs.10^9)					
LEC Industris	1.648	1.666	1.666	1.666	1.666
Non-LEC Industries	0.421	0.442	0.463	0.508	0.600

*Includes contribution from non-utlities.

Source: J. Parikh (1980)