Energy Utilisation in Karnataka -Part II: Industries Sector (IISc.)

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INTRODUCTION

Energy resources and their uses were analysed in an earlier study 'Energy utilization in Karnataka Part I : An overview'. The emphasis there was on rural and urban domestic consumption. The close link between energy resources and environment prompts us to continue our studies - this time on energy consumption patterns, especially in the organised industrial sector.

Energy planning in Karnataka is not an integrated activity. The plans for electricity, oil, coal, and firewood are separate exercises. Secondly, the planning activity considers only the demand and projects the demand over a period of years. The efficiency in utilization has scarcely been looked into. This has led to a situation where an input of about 25 units of energy is needed to get a useful output of 1 unit of energy (wasting the remaining 24 units). Even a housewife would not plan her domestic budget merely taking into consideration demands rather than the cost of meeting those demands.

A comparative study of energy use, mainly electrical in industries in Karnataka and in those of some other industrialised countries reveals that Karnataka consumes 5.47 times the energy consumed in the U.S.A. for the same GDP (Gross Domestic Product) and more than 10 times the energy used in Germany and Japan. Sectoral energy values also have been calculated.

A sectoral analysis of users shows that the growth of connected load is mainly in 2 categories- AEH (All Electric Homes) and Small Scale (LT) Industries. The growth rate is 19.46% for the former and 27.33% for the latter. If we look at the annual increases in the number of installations again the LT industries sector has a very high rate of 38.66% followed by AEH with a rate of 19.15%. More than 50% of our industries are clustered in and around Bangalore. Barring a few exceptions there is only limited industrial activity in other parts of Karnataka. Energy consumption patterns show that Bangalore uses 26.67% of HT energy. A few industries like Indian Aluminum at Belgaum, VISL at Bhadravathi etc. show higher energy consumption values for some divisions. Belgaum consumes 21.6% of total HT energy in the State.

Linkages between energy sources and impact of substitution of energy from one source by that from another can be understood only if there is an integrated picture of energy use. Since this type of information was not available this analysis is confined to utilization of energy from only one source. A survey was therefore conducted covering many industries in Karnataka. A questionnaire was prepared and sent to more than 250 industries. Replies received from about 60 industries were analysed for their energy consumptions. It was found that in many industrial sectors energy consumption/rupee of production was higher than the Indian norm. Further, energy consumption varied considerably within a group or sector indicating a distinct possibility for a substantial reduction in energy use by many industries for the same level of production.

Similarly a look at the specific energy consumption by an industry over a five year period shows an increase in some industries and fortunately, a reduction in some others.

Comparisons of Energy Use

Since energy consumption plays an important role in indicating the life style or quality, there are many indicators to compare life styles in various countries. Initially, energy consumption was compared with a country's gross domestic product (GDP). Later on, energy consumptions per capita of many countries were analysed against GDP/capita. It was found that there is a strong multicountry correlation existing between national output per capita and energy per capita. Table 1 gives the energy-output relationships for nine industrial countries and Karnataka State.

The GDP/capita for the industrialised countries varies from 2612 to 5643 dollars for the year 1972, whereas it is only around Rs. 696 for Karnataka for the year 1974-75 (adjusted to 1972 prices). The energy/capita is the highest for U.S. and Canada at the level of 8.35 and 8.38 tons of oil equivalent and lowest for Italy and Japan at the level of 2.39 and 2.9. Karnataka has a figure of 0.4437 for the year 1974-75. Hence this illustrates that Karnataka State has very low energy/capita and GDP/capita values.

But these do not reveal the true state of energy use; one would like to know how the energy is used and what is the level of efficiency. Normally, it is said that since our energy use/person is very low compared to that for advanced countries, we should increase our energy production so as to reach the levels of "advanced" societies. It is wrongly assumed that energy/capita reflects a true state of development in a country. If this argument is accepted, then we should increase energy consumption rates in our country and our State.

Recently, there is a shift in the thinking even in the industrial nations. The index to be used is not energy/person, but energy/GDP i.e. the amount of energy consumed for producing 1 unit of GDP. This index is given in columns 4 and 5 of Table 1. This index also reflects the efficiency of energy use at a macro level. Column 4 gives the absolute values of energy/GDP in tons oil equivalent per million dollars. The value for U.S. is 1,480 and for Canada is 1,772. These two are supposed to be on the high side. Japan, France and Italy with values 849, 795 and 915 respectively are on the low side. Having seen that Karnataka is on the very low side as far as energy/capita is concerned, let us look at the picture for energy/SDP (State Domestic Product).

Karnataka State has an energy consumption/SDP value of 6077.1 tons oil equivalent per crore of rupees for the year 1974-75. This means approximately 7292.5 toe/million dollars. The value for the year 1979-80 adjusted to 72 is 8092.94 toe/million dollars. This means that we are consuming more energy for less output. For a relative picture the help of column 5 of Table 1 is used. Here the energy/GDP is calculated with the U.S. value equal to 100.

Coupled with column 5, we see that Karnataka has an index of 493 for the year 74-75 and 547 for the year 1979-80. This means that we are consuming five times energy consumed by U.S. for the same output. When compared with France or Japan, we consume ten times the energy consumed by them for the same output. This energy consumption does not include the human/animal energy. It these are also included, then the energy/SDP value will be higher (ours is more of an employment oriented society still).

The second factor seen from **Table 1** is that the energy/SDP is increasing from 6077.1 in 1974-75 to 6744.12 in 1979-80. One possible conclusion can be that the energy efficiency (of use) is decreasing and not increasing. Post oil crisis situations saw considerable reductions in

energy/GDP. For instance, West Germany showed a decrease from 1080 to 1010; Similar decreases were evident for UK and Netherlands. United States has shown a steady value for a period of nearly 20 years (1961-1974) varying from 1400 to 1480 (a max. of 5% difference) whereas Karnataka has shown an increase of about 10% in 5 years. Hence, it is desirable to actively pursue the introduction of energy efficient methods. The reasons why U.S. has a flat curve for the 15 years period may be; frequent updating of technology; efficient methods due to competition; stability in the system due to many years of energy use; saturation (?).

Another component in the energy consumption by these countries is the energy required for space heating and conditioning due to weather conditions. We are fortunate in having a good climate and we do not require space heating. Hence, if we adjust the energy/GDP for space conditioning, we get the results as shown in **Table 2**. Here we have subtracted the component for space heating from the total and calculated energy/SDP. The value for U.S. reduces to 1315. If the U.S. value is equal to 100, then the relative value for Karnataka becomes 615.4 (about six times the U.S. energy). Compared to France, it will be 12 times.

In order to see which sector consumes more energy, sectorwise GDP and energy have been calculated. These are presented in **Table 3** for Karnataka. The index here is the energy consumption in tons of oil equivalent per crore rupees of the sector's contribution to SDP. The value for Agriculture is very low - 247. Whereas the value for transport is very high. Industry sector has the energy/SDP values of 10,512 for 74-75 and 6,754 for 79-80. Since the industry sector has a mix of many sources and devices and also it has a higher index, it was chosen for further comparison.

The industrial energy consumption is further compared in **Table 4** This table presents two comparison factors (i) industrial energy in toe/GDP and (ii) industrial energy in toe/industrial GDP Again France is lowest with 40% of the energy/GDP of U.S. Karnataka again shows high values. When industrial energy/industrial GDP figures are looked at, Karnataka consumes 8.8 times the energy needed by U.S. for the same output. This definitely indicated the possibility of improving energy conservation in our industries.

Another factor in the selection of industrial sector is the fact that it is one of the major consumers of high quality energy sources. More than 44% of commercial energy is consumed by industries. **Table 5** illustrates this phenomenon. The percent of industrial energy to total energy is given in this table. As can be seen from this table, whereas many countries consume about 30% of their energy for industrial purposes, we consume 44% and Japan 44.6%. The quantum of electrical energy consumed by industries as a percentage of total industrial energy is also reflected in the table. Even countries like U.S., U.K., West Germany, France etc. resort to electrical energy for a smaller fraction of their requirements, about 15-17% whereas the share of electrical energy in Karnataka's industrial energy needs is about 70%. This is despite power cuts for the past many years. Since electrical energy is a derived secondary energy source, it is inefficient for low quality work - like low temperature or medium temperature heating - applications. Electrical energy is efficient for lighting and static movement applications. As can be shown later, electrical energy finds a lot of use in heating applications in many industries in Karnataka not because it is efficient, but because it is convenient and less expensive than other fuels.

Efficient use of energy implies proper pricing strategies. Subsidies to industries on the tariff or fuel charges or low tariffs result in larger wastage of energy instead of lower costs of production. **Table 6** gives energy prices for various fuels for the same energy content. The electricity tariff for Karnataka is the cheapest (next only to U.S.). Many other countries like West Germany, U.K., France have tariffs which are more than twice our rate. But one cannot say more on this because it also depends on income levels. But one point deserves mention here with low costs of energy charges, labour and raw materials, many of our industrial products - engineering, chemical etc. should be highly competitive in international markets. But it is not so, one of the factors may be inefficient use of energy.

Table 7 shows the prices of various fuels in Karnataka over a period of years. Surprisingly, coal and coke are still cheap. Coal is the least costly resource. Firewood and coke come next. Biogas from a small plant seems to be an attractive proposition with a price/unit of 16-26 paise.

So far we have seen comparisons of our energy usage with that of some industrialised countries. Let us look at the energy scene in Karnataka.

Table 1: Energy/Output Relationships

Country	GDP/Capita (dollars)	Energy Cons/Capita (tons oil equiv.)	Energy/GDP	
			t.o.e million	Indexes U.S.=100
U.S.	5643	8.35	1480	100
Canada	4728	8.38	1772	120
France	4168	3.31	795	54
W.Germany	3991	4.12	1031	70
Italy	2612	2.39	915	62
Netherlands	3678	4.68	1272	86
U.K.	3401	3.81	1121	76
Sweden	5000	5.31	1062	72
Japan	3423	2.2	849	57
Karnataka (74-75) (adjusted to 72)	696.05 (Rs)	0.4437	6077.1/Cr.Rs. (7292.5)	492.7
Karnataka (1979-80)	1345.21 (112.1)	0.4915	3654/Cr.Rs. (4384.8/$m)	296
Karnataka (79-80) (Adjusted to 72)	728.80 Rs.	0.4915	6744.12/Cr.Rs. 8092.94/$m	547

Table 2: Energy/GDP relationships adjusted for space heating

Country	Energy/GDP t.o.e. $ million	Index US = 100
U.S.	1315	100
Canada	1533	117
France	694	52.8
W.Germany	910	69
Italy	801	61.4
Netherlands	1062	80.8
U.K.	985	75
Sweden	858	65
Japan	802	61
Karnataka 74-75	7222.5	554.6
(adjusted to 72)		333.4
Karnataka (1979-80)	4384.8	
Karnataka (79-80)	8092.94	615.4
(adjusted to 72)		

Table 3: Energy/SDP values for sectors in Karnataka

Sector	Energy m.t.c.e.	SDP rupees crores	Energy/Sectoral SDP (t.o.e Rs. crores
Agriculture	0.735	1930.66	247
Household	16.352	-	-
Industry (79-80)	5.798	1031.28	3645.9
(adjusted to 72)			6754
Industry (74-75)	4.476	334.94	8678
Industry (74-75)		276.48	10512.4
adjusted to 72 prices			
Transport	3.215	161.84	12899

Table 4: Energy Consumption in industrial sector/total GDP

Countries (72)	t.o.e. $m. GDP	Index	t.o.e. $m industrial GDP	Index
U.S.	444	100	1427-7	100
Canada	517	116.4	1777.2	124
France	276	62.1	574	40.2
W.Germany	373	84	736.6	51.6
Italy	330	74.3	990.5	69.4
Netherlands	354	79.7	995.5	69.7
U.K.	399	89.9	1146.1	80.3
Sweden	308	69.4	1198.1	83.9
Japan	378	85.1	924.6	64.8
Karnataka (74-75)	1028.6	231.7	10413.1	-
adjusted to 72 prices	1592.1	359	12615	884
Karanataka (79-80)	935.77	210.8	4375.1	-
adjusted to 72	1727.23	389	8105	568

Table 5: Energy consumed by the industrial sector as a percentage of total energy consumption

Countries	Industrial energy as a percent of total	Elec energy as a % of energy in industrial sector
U.S.	30.0	17.3
Canada	29.1	21.8
France	34.7	15.1
W.Germany	36.2	16.0
Italy	36.0	17.1
Netherlands	27.8	13.9
U.K.	35.6	14.8
Sweden	29.0	31.5
Japan	44.6	20
Karnataka (79-80) (excl. non-comml. energy)	44.0	68.99
Karnataka (79-80) (excl. non-comml. energy)	21.36	

Table 6: Energy prices in industry (dollars/m K cals) Prices (1972)

Fuel	U.S.	Canada	France	W.Germany	Italy	Nether lands	U.K.	Sweden	Japan	Karnataka (79-80)
Electricity	11	17.7	21.9	28.7	27.2	26.1	24.9	15	25.4	11.62
Gas	1.7	1.7	3.1	3.3	3.0	2.1	2.3	-	-	-
Coal	1.8	1.9	3.9	3.9	4.7	3.4	3.9	3.6	3.6	3.06
Petroleum	2.8	2.2	3.7	2.9	3.9	2.5	4.3	2.7	2.7	14.91
Kerosene										15.97

Table 7: Equivalent cost of energy from different sources

Source	Cost/Unit of energy in Rs.				
	1979-80	1980-81	1981-82	1982-83	1983-84
Coal	0.0316	0.038	0.046	0.051	0.049
Electricity	0.12	0.19	0.307	0.32	0.371
Kerosene	0.1649	0.17	0.195	0.2182	0.2214
Diesel oil	0.1542	0.25	0.306	0.348	0.372
Furnace oil	0.146	0.218	0.2885	0.3165	0.3312
Fire wood	0.039	0.418	0.0475	0.0572	0.0614
Charcoal	0.112	0.112	0.105	0.105	0.105
Coke	0.049	0.055	0.065	0.0732	0.0617
Biogas					0.16-0.26

Karnataka's Energy Scene

Karnataka does not have any coal deposits. It gets its coal from outside. The electrical energy for Karnataka was purely hydro and with the commissioning of Raichur thermal power station, it may get electrical energy from coal also. the other major source of commercial energy - oil - is also not available in Karnataka. Hence the main source of commercial energy for the state comes from hydroelectric plants. These plants have large reservoirs to store rain water throughout the year, the dams being built in prime forest areas there by submerging sizable areas of forest. It is shown by a study that we can obtain comparable quantity of energy from forest biomass instead of water from the submerged areas. An ideal solution will be to go in for a set of peaking power plants with minimum storage which utilize rain water during monsoon and can be supplemented by firewood based thermal power plants.

But commercial energy sources like coal, oil, electricity provide only a small part of the energy scene of Karnataka. Major energy share comes from firewood. **Table 8** gives the consumption pattern for Karnataka for 1982-83. Electricity represents 40% of commercial energy for 1982-83. There is an increase in the percent share for electricity. Firewood consumption is around 15.5 million tons of coal equivalent. Agro wastes are also used for energy purposes. The share of industries in energy is around 44%. The state generated 6,400 million units of electrical energy in 1982-83. The share of industries in electricity is 4,566 million units.

Since electrical energy is an important component of energy for industrial consumption and as it is a high quality energy, the sectoral and spatial analysis of electrical energy is considered next.

The analysis in the next section looks at it from the supply end. Another analysis follows from the consumer end based on the sample surveys.

Table 8: Energy consumption for Karnataka

Sl. No.	Source	Consumption for 1982-83 in m.t.c.e.
	Commercial	
1	Coal	1
2	Oil	7.4
3	Kerosene	2.3
4	Electricity	6.4
5	Total	17.1
	Noncommercial	
6	Firewood	15.5
7	Others	Not known
	Total	32.6

Electrical Energy Utilization in Industries in Karnataka

There are normally three indices to look at the growth rate of electrical energy (i) number of consumers, (ii) connected load and (iii) energy consumption. A look at these indices can only indicate the primary users and not how they use the energy.

Table 9 gives the number of installation for various categories like domestic, AEH, agriculture, LT industries. HT industries etc. The greatest growth rate is for LT industries (38.66%). This is followed by AEH consumers (19.15%). If we take the increase for three years 1980-83 into account even then the growth rate for LT industries is the highest (72.18%). The next greater growth rate is again the AEH category. The growth rate for HT industries is 4.76% during 82-83 and 23.17% during 1980-83.

Table 9: Number of installations for Electrical Energy

Sector	Total no of installations as on				Percent annual increase	Percent increase 3 years
	31.3.80	31.3.81	31.3.82	31.3.83		
Domestic	1,384,061	1,493,178	1,609,194	1,741,425	8.22	26
Commercial	192,401	209,543	223,208	239,406	7.26	24
AEH	161,340	190,021	225,579	268,775	19.15	67
LT industries	66,405	74,329	82,457	114,335	38.66	72
HT industries	1,161	1,209	1,365	1,430	4.76	23
Water works	2,174	2,560	2,834	3,144	10.94	45
Irrigation pumps	290,308	308,107	332,416	358,113	7.73	23
Street lights	337,558	348,022	361,531	373,206	3.23	11

Table 10 illustrates the profile of connected load in various sectors. The annual increase for the year 1982-83 is greatest for LT industries (27.33) again followed by AEH consumers. When the increase for three years (1980-83) is looked at, the connected load for the AEH category grows faster (67.4) than that for LT industries. HT industries show a small growth rate. The overall annual growth rate is only 11.54. Both AEH and LT industries have growth rates greater than the overall growth rate. In the case of the three years growth rate AEH and LT industries as well as commercial categories have greater increases than the overall value.

Table 10: Growth of connected load in MW in Karnataka (1980-83)

Sector	Connected load in MW			Percent annual increase	Percent increase between 1980-83
	1980	1982	1983		
Domestic	379.5	434.0	463.0	6.68	22.00
Commercial	71.4	85.6	94.2	10.05	31.90
AEH	430.0	602.7	72.0	19.46	67.40
LT industries	428.4	521.5	66.4	27.33	55.00
HT industries	810.3	840.1	871.6	3.75	7.57
Water works	67.8	70.6	72.0	1.98	6.20
I-P sets	962.1	1099.7	1193.0	8.48	2.00
Street lights	25.0	26.0	27.0	3.85	8.00
Total	3174.5	3680.2	4104.8	11.54	29.31

Table 11 continues the profile of connected load. Even though HT industries consume a maximum amount of electrical energy, it is the agricultural load that is the highest from the point of view of connected load; irrigation pumpsets take up 29.06% of the connected load followed by HT industries - 21.23%. AEH category comes third with 17.54%.

Table 11: Increment in the connected load (1982-83)

Sector	Annual 1982-83 increment (MW)	Total (MW)	Total No. of installations	Load/installation, KW/installation	Percent of sectoral load to total
Irrigation Pumpsets	93.26	1193.0	358,113	3.330	29.063
LT industries	52.84	664.0	114,335	5.810	16.176
HT industries	31.46	871.6	1,430	609.500	21.234
Domestic lighting	28.86	463.0	1,741,425	0.266	11.280
AEH	117.56	720.0	268,775	2.680	17.540
Commercial	8.61	94.2	239,406	0.390	2.295
Water works	1.35	72.0	3,144	22.900	1.754
Street lighting	1.00	27.0	373,206	0.070	0.658

Spatial distributions of connected load and the number of installations are given in **Table 12** and 13. Bangalore accounts for 31.55% of the total connected load for LT industries and 26.31% of the connected load for HT industries. Belgaum accounts for 24.04% of the connected load, most of it by one industry. Shimoga division accounts for 14.8% of total connected load for HT. Mysore, Sirsi and Bellary divisions account for about 4% each. All other divisions have low shares of HT. The distribution for LT industries looks better. About 12 divisions have a connected load greater than the average and 14 divisions have a connected load less than the average. (This excludes Bangalore divisions) Bellary II and Madikeri are very poor from the point of view of both LT and HT industries. Bijapur, Chickmagalur, Chitradurga and Chickballapur come next. Their industrial profiles are poor.

Table 12: Connected load MW (as on March 1983)

Division	Industries		% for	% for
	LT	HT	LT	HT
1	2	3	4	5
Bangalore E	55	121	8.28	13.88
W	98	85	14.75	9.75
N	33	12	4.97	1.38
S	17	9.3	2.56	1.07
Rural	6.6	2	0.99	0.23
Bangalore (Total)	209.6	229.3	31.55	26.31
Chikballapur	11.9	1.6	1.79	0.18
KGF	16.7	22.8	2.51	2.62
Tumkur	25.8	14.3	3.88	1.64
Hassan	20	3.7	3.01	0.42
Mandya	35	10.6	5.97	1.22
Mysore City	28.7	35.5	4.32	4.07
Rural	23.5	9.8	3.54	1.12
Madikeri	1.7	-	0.26	-
Chikmagalur	10	5.2	1.51	0.6
Mangalore	20.6	11	3.1	1.26
Udupi	12.8	4.2	1.93	0.48
Shimoga	21.8	128.9	3.28	14.8
Bidar	9.2	3.4	1.38	0.39
Gulbarga	20	3	3.1	0.34
Raichur	21.4	18.3	3.22	2.1
Haveri	16	12.1	2.41	1.39
Hubli	36	24.4	5.42	2.8
Sirsi	12.6	36.6	1.9	4.2
Bellary I	19.4	42.8	2.92	4.91
Bellary II	1.3	-	0.2	-
Chitradurga	10.9	5.1	1.64	0.59
Davangere	15	17.4	2.26	2
Belgaum	22.4	209.5	3.37	24.04
Ghataprabha	14.8	12.3	2.23	1.41
Bijapur	9.3	3.1	1.4	0.36
Bagalkot	17.1	7.8	2.57	0.89
Total	664.4	871.6	100	100
Increment for the year 82-83	52.8	31.5	7.95	3.61

Table 13 gives the spatial distribution based on the number of installations. There is a strong correlation between connected load and number of installations for LT industries, but this is not true for HT industries. Hence, a further segregation of HT industries is done. Four categories are defined (i) more than 1000 KVA capacity (ii) those having 501-1000 KVA (iii) those in the range 251-500 KVA and (iv) those in the range 100-250 KVA. The number of installations for these categories in all divisions and their percentages are given in **Table 14**

Table 13: Total number of installations

Division	LT	HT	% of LT installations to total	% of HT installatior to total
1	2	3	4	5
Bangalore E	10280	138	9	9.65
W	17039	74	14.9	5.17
N	3913	157	3.42	11
S	2774	108	2.43	7.55
Rural	1565	31	1.37	2.17
Bangalore (Total)	35571	508	31.1	35.52
Chikballapur	3739	5	3.27	0.35
KGF	3069	12	2.68	0.84
Tumkur	4788	23	4.19	1.61
Hassan	4380	28	3.83	1.96
Mandya	6293	26	5.5	1.82
Mysore City	4772	82	4.17	5.73
Rural	3861	30	3.38	2.1
Madikeri	313	7	0.27	0.48
Chikmagalur	2324	12	2.03	0.84
Mangalore	3936	76	3.44	5.31
Udupi	2398	25	2.1	1.75
Shimoga	3609	58	3.16	4.06
Bidar	1532	27	1.34	1.89
Gulbarga	2744	41	2.39	2.87
Raichur	2701	61	2.35	4.27
Haveri	1961	25	1.71	1.75
Hubli	4940	74	4.32	5.18
Sirsi	1609	46	1.41	3.22
Bellary I	3278	43	2.87	3.01
Bellary II	185	32	0.16	2.24
Chitradurga	2164	16	1.89	1.12
Davangere	2868	37	2.51	2.59
Belgaum	3810	61	3.33	4.27
Ghataprabha	232	34	2.03	2.38
Bijapur	1818	19	1.59	1.33
Bagalkot	3340	22	2.92	1.54
Total	114335	1430	100	100

Table 14: Spatial distribution of HT industries (Figures in brackets give the percentages)

Division	No. of industries			
	1000 KVA capacity	501-1000 KVA	251-500 KVA	101-250 KVA
1	2	3	4	5
Bangalore W	6 (3.16)	6 (4.2)	11 (3.9)	51 (7.4)
E	70 (36.84)	36 (25.2)	33 (11.7)	5 (0.72)
N	17 (8.95)	24 (17)	36 (12.7)	81 (11.74)
S	11 (5.79)	10 (7)	31 (11)	56 (8.12)
Rural	5 (2.63)	0	14 (4.95)	9 (1.3)
Bangalore (Total)	109 (57.37)	76 (53.15)	125 (44.2)	202 (29.3)
Chikballapur	0	0	1 (0.35)	4 (0.58)
KGF	2 (1.05)	1 (0.73)	1 (0.35)	8 (1.16)
Tumkur	3 (1.58)	0	5 (1.77)	15 (2.17)
Hassan	2 (1.05)	0	9 (3.18)	24 (3.48)
Mandya	4 (2.1)	5 (3.5)	3 (1.1)	18 (2.61)
Mysore City	10 (5.26)	10 (7)	14 (4.95)	46 (6.67)
Rural	1 (0.53)	1 (0.7)	8 (2.83)	12 (1.74)
Madikeri	0 (0)	0	1 (0.35)	5 (0.72)
Chikmagalur	2 (1.05)	1 (0.7)	2 (7)	6 (87)
Mangalore	5 (2.63)	4 (2.8)	13 (4.6)	48 (6.96)
Udupi	0 (0)	1 (0.7)	2 (0.7)	20 (2.9)
Shimoga	5 (2.63)	3 (2.1)	2 (0.7)	23 (3.33)
Bidar	0 (0)	0	6 (2.12)	19 (2.75)
Gulbarga	1 (0.53)	2 (1.4)	2 (0.7)	12 (1.74)
Raichur	5 (2.63)	3 (2.1)	6 (2.1)	28 (4.06)
Haveri	1 (0.53)	0	6 (2.1)	11 (1.59)
Hubli	8 (4.21)	2 (1.4)	10 (3.53)	33 (4.78)
Sirsi	5 (2.63)	5 (3.5)	9 (3.18)	22 (3.19)
Bellary I	5 (2.63)	9 (6.3)	8 (2.83)	8 (1.16)
Bellary II	3 (1.58)	0	11 (3.89)	23 (3.33)
Chitradurga	2 (1.05)	1 (0.7)	2 (0.7)	12 (1.74)
Davangere	2 (1.05)	9 (6.3)	7 (2.47)	16 (2.32)
Belgaum	9 (4.75)	4 (2.8)	4 (1.4)	39 (5.65)
Ghataprabha	1 (0.53)	2 (1.4)	13 (4.6)	6 (0.87)
Bijapur	0 0	1 (0.7)	2 (0.7)	14 (2.03)
Bagalkot	1 (0.53)	2 (1.4)	3 (1.1)	16 (2.32)
Gadag	4 (2.1)	1 (0.7)	2 (0.7)	9 (1.3)
Total	190	143	283	690

From **Table 14**, we can see that Bangalore accounts for 57% of very large (1000 KVA) industries, for 53% of large HT industries (501-1000 KVA) for 44% of medium (251-500 KVA) industries and for 29.3% of small HT industries. The figures in brackets in the table give the percentage of the number of installations for that category and division.

The next index is the energy consumption by industries in various divisions. This is given in **Table 15**. Bangalore consumes 20.67% of total HT energy. But it is Belgaum that tops the list - 21.61%, most of it by one consumer.

Table 15: Electrical energy use in industries (HT only)

Division	HT (million units)	Total	HT as a % of total	% of HT energy used
Bangalore East	314	427	73.54*	7.79
West	68	229	29.7	1.69
North	224	401	55.86	5.56
South	122	269	45.35	3.03
Rural	105.2	147	71.56*	2.6
Bangalore (Total)	833.2	147.3	56.56	20.67
Tumkur	69.4	109.6	62.41	1.56
KGF	110.7	144.3	76.72	2.66
Chikballapur	5.8	31.4	18.47	-
Mysore City	104	174.8	59.5	2.48
Rural	11.8	49.6	23.8	0.24
Hassan	9.8	28.7	34.15	0.21
Mandya	78.2	121	64.68	1.6
Madikeri	2.7	18	15	-
Shimoga	477.2	524	90.5	11.73
Mangalore	261.4	335.2	78	6.45
Chikmagalur	102.7	129.9	79	2.51
Udupi	8.7	47.3	18.4	0.21
Raichur	43	81.4	52.8	0.91
Bidar	8	32.2	25	0.15
Hubli	66.4	146.5	45.3	1.65
Haveri	56	82.6	67.9	1.34
Sirsi	301.4	327.6	92	7.44
Belgaum	871	936.3	93.1	21.61
Ghataprabha	30.7	84.6	36.3	0.71
Bellary I	334.8	361.2	93	8.24
Bellary II	17.6	33.6	53.3	0.42
Chitradurga	14.25	38.5	37	0.33
Davangere	64	65	67.8	1.56
Gulbarga	164.6	185	89	4.06
Bijapur	8.7	30.3	28.7	0.19
Bagalkot	28	61.9	46.7	0.64
Total	4030.35	5682.9	70.92	100

Energy Survey in Industries

Since the data available with various agencies dealt with only one aspect of energy use, it becomes necessary to collect data directly from industries. This can be seen from the discussions in the last section. We concentrated on electricity and that too from supplier's end. To understand

the types of fuels used and production, we need to conduct a survey as this type of data is not available or accessible. Hence we decided to conduct a survey of about 250 industries.

Since the survey was done for the first time, we went about it in many stages with help from many authorities like the Director of industries and Commerce, Govt. of Karnataka, and the Chief Inspector of Factories and Boilers. The first questionnaire prepared by us was a simple one requesting for information on the quanta of energy used and production figures for a period of two years. About 80 industries responded to this questionnaire. This was followed by another one sent by the Joint Director of Industries and Commerce, Govt. of Karnataka. This one sought information on energy consumption for one year period. A third questionnaire for one year period. A third questionnaire was also sent to various industries seeking information on their boilers-steam generated, type of fuels used and quanta of use. In spite of the fact that more than 1000 letters were sent, the response was poor.

Analysis of these pilot surveys showed some drawbacks. Many questionnaires were not completed fully. Normally production figures were left blank. It was not possible to draw any conclusions from these survey data. So it was found necessary to generate another questionnaire and get it filled up partly by visiting the industries and partly by sending requests by post.

The questionnaire was an exhaustive one. It requested for the following sets of information;

(i) energy consumption for a period of five years from 1979-80 to 1983-84 for each source like coal, coke, firewood, electricity, furnace oil, LPG, charcoal, kerosene etc., and their values:

(ii) monthly energy consumption (for electrical energy only):

(iii) electrical power and energy details, power cut details;

(iv) production figures - quantity and value - for various products manufactured;

(v) details on connected load for various types of end uses like machinery, heating, welding, lighting, rectifiers etc;

(vi) details of loads for different sections;

(vii) capacity of diesel generating sets; electricity from them;

(viii) consumption of energy by services;

(ix) details for individual types of machines like furnaces, welding units, lighting etc;

(x) conversions;

(xi) future plans;

This questionnaire numbering sixteen pages was sent to more than 250 industries. We received replies from 41 industries. These industries have understood the motive behind our studies and spent considerable amount of their time in filling up this questionnaire. They are of invaluable help to us in our analysis. Despite repeated reminders, the biggest energy guzzler INDAL, Belgaum did not respond to any of our questionnaire - whether to the earlier two simpler ones or to the detailed one.

Table 16 gives the details of the type of industries which responded to our questionnaire. Fortunately, we got a wide canvas of industry types in these responses. We have a number of industries for the groups of engineering, metallurgical, paper, textile and sugar industries. Except for the Aluminium producer, all other major industrial types are to be found in the response. The types also include glass, batteries, watches, oxygen, fertilizers, steel, electronics, tools, tiles, cement, and heavy engineering units. Hence the results will display information on a wide variety of industry types.

Table 16: Types and number of industries surveyed

Sector/type	Produce range	No.of industries surveyed
Engineering	Pistons, valves, pumps	6
Heavy Engg I	Looms, Castings	1
Heavy Engg II	Metallic Products	1
Heavy Engg III	Cylinders	1
Electrical I	Transformers	1
Electrical II	Switchgears	1
Electronics	-	1
Misc.	-	1
Metallurigcal I	Steel Products	8
Metallurigcal II	Ores processing	2
Metallurigcal III	Ores extraction	2
Aluminium	Products	2
Insulators	-	1
Paper	-	4
Textiles	-	7
Sugar	-	8
Chemicals I	Fertizers	2
Chemicals II	-	1
Tiles	-	2
Mines	Gold	2
Agromachines	-	2
Oxygen	-	2
Tools	-	1
Glass	-	1
Batteries	-	1
Cement	-	1
Lamps	-	1
Refractory bricks	-	2
Total		65
No.of industries with 5 years data		41

The questionnaire for nearly half the number of industries which responded were filled up by personally visiting the industries concerned and eliciting their answers to our queries. This involved a number of trips to each industry on timings convenient to them. This process entailed an effort of 4-5 months.

Data pertaining to energy were analyzed and results are presented in a series of tables. **Table 17** shows the energy consumption by these groups during 1983-84. The following points deserve mention. The energy unit used in million kilowatt hours equivalent.

Table 17: Annual energy consumption in industries in 1983-84 Karnataka (million units)

Sector	Electricity	HSD	Furnace oil	LDO	Charcoal	Coal	Fire wood	Others
1	2	3	4	5	6	7	8	9
Engineering	9.384	20.980	5.04	0.58	-	-	-	1.33
Heavy Engg I	0.203	0.135	-	0.09	-	-	1.23	5.42*
Heavy Engg II	6.300	8.070	-	-	-	-	-	-
Heavy Engg III	0.242	0.202	-	-	-	-	-	-
Electrical I	0.477	0.007	-	-	-	-	-	-
Electrical II	0.625	0.343	-	-	-	-	-	-
Electronics	26.800	41.160	-	-	-	-	-	0.70
Misc.	2.750	10.060	-	-	-	-	0.02	0.15
Metallurigcal I	127.700	4.450	58.70	-	-	3.04	2.63	-
Metallurigcal II		49.000	64.80	28.10	192	279.00	8.00	697*
Metallurigcal III	28.700	-	-	0.33	-	20.30	-	-
Aluminium	0.180	-	-	-	-	-	-	-
Insulators	5.400	4.100	2.40	39.60	-	16.70	-	1.30
Paper	120.800	2.900	29.40	-	-	1205.00	-	-
Textiles	45.700	14.800	-	0.10	-	163.00	8.40	-
Sugar	4.100	20.200	-	-	-	3.40	13.20	809**
Chemicals I	154.000	0.650	194.00	-	-	-	-	3.02
Chemicals II	0.500	0.180	6.40	1.80	-	32.20	1.00	-
Tiles	0.500	0.120	-	-	-	-	19.30	-
Mines	109.500	17.500	1.80	0.95	-	0.40	-	-
Agromachines	0.870	0.160	-	-	-	-	0.43	-
Oxygen	8.310	-	-	-	-	-	-	-
Tools	0.286	-	-	0.01	-	-	-	-
Glass	16.900	3.800	23.50	2.40	-	-	-	-
Batteries	2.000	3.900	5.50	0.01	-	-	0.50	-
Cement	53.700	4.400	-	0.17	-	770.00	0.60	-
Lamps	1.800	0.420	16.30	-	-	-	-	16.30
Refractory bricks	0.075	-	4.20	-	-	-	-	-
Total	1198.600	207.540	412.00	74.10	192	2493.00	54.92	1534.20
Percent	19.400	3.400	6.70	1.20	3.1	40.40	0.90	24.90

Grand Total = 6166.35 million units

* - Coke ** - bagasse

(Others include mainly LPG)

(i) Total energy consumed by these industries works out to nearly 6.0 million tons of coal equivalent. This means that we have covered more than 80% of energy consumed in industries.

(ii) But the electrical energy component is only 1,198 million units. This is less than 50% of total electrical energy consumed in the state. But as already stated, the unavoidable exclusion due to non-availability of one aluminium industry has a sizable effect on the total electrical energy. This is because this industry alone consumes about 20% of total electrical energy for industries in Karnataka. Similarly JINDAL also refused to give us information pertaining to their energy use and production despite personal visits.

(iii) Fortunately, there is a balance in the industries consuming different types of fuels. For example, paper, textile and cement industries use coal as their primary fuel; sugar industries consume mainly bagasse; metallurgical industries use coke and charcoal; chemicals and metallurgicals use furnace oil; electricity and diesel are used by most of the industries.

(iv) Electricity constitutes 19.4% of total energy; coal is the maximum with 40.4% others-coke, bagasse, LPG, kerosene - form 24.9% of the total. Firewood use is quite small mainly restricted to sugar, textiles, tiles and metallurgical industries.

Table 18 gives the energy consumption values as percentages. These reinforce the points mentioned above. A look at the total energy consumed by each sector - shown in Table 19 col.2 - reveals that metallurgical iron and steel industries consume the maximum energy followed by paper (1358.4 million units), and sugar (844.2 m. units). Engineering units consume less energy.

Table 18: Energy consumption (in percentage) in Karnataka in 1983-84

Sector	Elect	HSD	FO	LDO	Charcoal	Coal	Firewood	Others
Engineering	25.2	56.2	13.5	1.5	-	-	-	3.6
Heavy Engg I	2.9	1.9	-	1.3	-	-	17.3	76.6
Heavy Engg II	43.8	56.2	-	-	-	-	-	-
Heavy Engg III	54.5	45.5	-	-	-	-	-	-
Electrical I	98.6	1.4	-	-	-	-	-	-
Electrical II	64.6	35.4	-	-	-	-	-	-
Electronics	39.1	60.1	-	-	-	-	-	0.8
Misc.	21.2	77.5	-	-	-	-	0.2	1.1
Metallurigcal I	64.9	2.3	29.9	-	-	1.9	1.3	-
Metallurigcal II	25.4	2.8	3.7	1.6	10.9	14.1	0.5	41.3
Metallurigcal III	58.1	-	-	0.7	-	41.2	-	-
Aluminium	100.0	-	-	-	-	-	-	-
Insulators	7.8	5.9	3.5	56.9	-	24.0	-	1.9
Paper	8.9	0.2	2.2	-	-	88.7	-	-
Textiles	19.7	6.4	-	-	-	70.3	3.6	-
Sugar	0.5	2.4	-	-	-	0.4	1.6	95.1
Chemicals I	43.9	0.2	55.0	-	-	-	-	0.9
Chemicals II	7.8	0.4	14.3	4.1	-	72.0	1.4	-
Tiles	2.5	0.6	-	-	-	-	96.9	-
Mines	84.0	13.4	1.4	0.7	-	0.5	-	-
Agromachines	80.9	15.0	-	-	-	-	4.1	-
Oxygen	100.0	_	-	-	-	-	-	-
Tools	98.0	-	-	2.0	-	-	-	-
Glass	36.2	8.2	50.4	5.2	-	-	-	-
Batteries	16.8	32.8	46.2	-	-	-	4.2	-
Cement	5.8	0.5	-	0.1	-	93.5	0.1	-
Lamps	5.2	1.2	56.8	0.0	-	-	-	36.8
Refractory bricks	1.8	-	98.2	-	-	-	-	-

Since absolute energy consumption patterns do not provide any indication, we used a standard unit and calculated energy consumption in million units equivalent. To understand the significance of the predominant type of fuels consumed, percentages were calculated as in Table 18. Even this provides only this clue. The next stage of analysis is to calculate specific energy consumptions. It is our desire to know (a) how efficiently energy is used by a manufacturing unit, (b) how the efficiency changes with time and (c) how it compares amongst units manufacturing the same product. In order to look at these problems energy consumption/unit of production should be calculated. We call this specific energy consumption. Two indices are possible - energy consumption per rupee of production or energy consumption per unit of production or ton of production. The next section looks at the specific energy consumptions for different industries, their variations with time for some industries and relative figures for total energy and electrical energy uses.

Specific Energy Consumptions in Different Industries (1983-84)

The study of evaluating various industries on the basis of their energy consumption and production is being done for the first time in the country. One of our main aims in doing this study is to generate norms or existing levels of specific energy consumption. The other aims are (i) to compare similar units (ii) to see this dynamics - change with time SEC for an industries.

Since energy consumption by an industry is an absolute quantity, it cannot be used as an index for comparison. Hence the specific energy consumption is used as an index. In India, there is no integrated study conducted on the SEC for various industrial sectors. Ours is one of the first studies involving all forms of energy sources. There are no norms available for SEC of total energy. But norms are available for the consumption of electric energy/unit of production. Hence one of our intentions is to obtain SECs for some industrial groups. This can be a reference for future use and can also be used for comparison with international norms.

As already stated SEC is defined as energy per unit of production or energy per rupee of production. It has been calculated for all the industries who responded to us, but the values are given only for a sample of this group in **Table 19.** For some groups, energy per rupee is available and for others energy/unit of, production is available. The second category is shown starred in the table.

Table 19: Specific energy consumptions for some sectors

Sector	Total energy (m. units)	Energy in units/R of production				SEC for electricity only (average)
		Avg	Max	Min	Std	
Engineering	37.3	0.22	1.48	0.011	0.65	0.081
Metallurgical I	203.6	0.26	0.36	0.05	0.1	0.164
Metallurgical II	1766	1.73	1.73	1.59	-	0.45
Metallurgical III	49.4	19.4	25	14.4		7.98
Paper*	1358.4	16467	17245	12510	5511	2220
Textiles*	232.1	5567	8102	5345	1865	1450
Sugar*	844.2	9657	11162	5264	3514	44.5
Chemicals I*	351.7	2689	7013	2511	-	1172
Tiles*	19.9	5.05	7.65	4.55	-	0.071
Oxygen*	8.31	0.41	0.46	0.27	-	0.41

* - The SEC values are energy in units/unit of production

The energy consumed/rupee varies from 0.011 to 1.78. Table 19 lists for each sector 4 entries for SEC. The first value gives the average, the second one the maximum value calculated for an industry in that group, the third one the minimum value obtained for an industry in that group and standard deviation. The average values vary from 0.22 to 1.73. The standard deviation gives an indication of the variations in SEC. One way of interpreting SEC is to assume that lower SEC's imply better efficiency because we consume lesser energy for the same amount of production. But looking at SEC's for each industrial group can help us in classifying industries as energy intensive or non intensive. This will be useful in the selection of industries to be nurtured

in future in the state. Instead of concentrating on higher intensity industries, one can look for and select lower intensity industries or at least try to obtain an optimal mix. In this connection, it may be recalled that Karnataka has an overall energy intensity of 1.96 which is higher than the national level.

In the case of energy/unit of production, we can see that it varies from 5.05 to 17245 - a very wide variation (but the lower value is energy/tile).

Since norms are available for electrical energy, we also calculate the electrical energy consumed/unit of production. This is given in the last column of the table. Some industries like sugar use least amount of electrical energy and some have a higher intensity for electricity. The SEC for electrical energy per rupee of production varies from 0.081 to 0.45. From point of view of electricity, an industry like oxygen has become energy intensive whereas from its overall SEC, it is not highly intensive industry. So when we have acute shortages in electricity, then we can use SEC for electricity to characterise the intensity of industries and use this for selection of future industries.

The SEC is very useful to look at individual members in an industrial group and this may reveal interesting information. Some examples are cited below;

(i) In the case of paper, the min. SEC is 12510 and the maximum is 17245 (38% higher). This shows that possibly one industry can reduce its energy consumption by improving efficiency to the scale of the minimum valued industry.

(ii) In the case of sugar also, the minimum SEC is 5264 units/ton and the maximum is 11162 (112% higher). There is a large possibility here also to improve efficiencies of use.

(iii) For tiles, the minimum value is 4.55 and maximum is 7.65 (68% higher).

(iv) For textiles, the difference (in percentage) is 52%.

(v) Oxygen units have a difference (in percentage) of 70%

The above illustrations show that there is a high probability of efficiency enhancements. It is also possible that in some situations the difference in SEC is due to the quality of the product and not due to energy efficiencies. But whenever large differences occur for similar products, it is desirable to look deeper for the maladies.

The intra group variations in SEC may only show a probability of improvement. Actual improvements can be pin pointed only by a detailed study by the industry concerned. Since energy plays an important role in our life, it is desirable to do energy audit and energy budgeting. Many industries do not even have measurement facilities. But it is a very redeeming feature that many industries in Karnataka are aware of the energy shortages and energy environment linkages. Some industries are already initiating steps for increasing the efficiencies of energy use. This can be seen from the study of variations on SEC for five years. **Table 20.** lists SEC's

for some typical industries which show a change in their SEC's. It does not show industrial groups, but an industry in a group, the group identified by column 1.

Table 20: Variations in SEC* in five years in some industries

Type of Industry	SEC for 1979-80	SEC for 1983-84	Percent increase
Engineering I	0.006	0.011	83.3
Engineering II	0.045	0.074	64.4
Engineering III	0.020	0.040	100.0
Heavy Engg*	51.450	131.300	155.2
Electricals	0.019	0.010	-47.4
Metallurigcal I	0.190	0.230	21.1
Metallurigcal II	3.100	1.600	-48.4
Metallurigcal III	126.900	148.000	16.6
Paper	1.020	0.930	-8.8
Textiles	0.570	0.380	-33.3
Textiles	0.510	0.650	27.5
Textiles	1.300	0.900	-30.8
Sugar	14883.000	11162.000	-25.0
Agromachines	0.027	0.034	25.9
Oxygen	0.330	0.460	39.4
Oxygen	0.440	0.270	-38.6
Glass	2.140	0.920	-57.0

* The SEC values are Energy increases/unit of production

From this table, we can see that

(i) The maximum increase is 155% between 1979 to 1984. The heavy Eng. industry should look at this degradation in its efficiency of energy use. The increase is gradual and not sudden.

(ii) An engineering industry has also shown an increase of 100% in 5 years in SEC. This increase is also gradual.

(iii) Surprisingly many of these large increases have occured in engineering industries. Another reason for this increase may be substitution of fuels (like diesel for electricity generation instead of KEB electricity)

(iv) There are some units (8 in number) which have shown a decrease in their SEC values. This might mean (a) increased cost of the product due to demand or (b) better efficiency of use.

We can see from the above that even though general conclusions regarding energy efficiency and SEC can be drawn, we have to go in for deeper studies at the level of individual industries to confirm and pinpoint the lacunae.

Table 21. tries to compare the difference between the ratio of electrical energy to total energy and the ratio of SEC for electrical energy to SEC for total energy. These two ratios should be the same if the industries in the group have similar consumption patterns and efficiencies. A difference (like in the case of paper or tiles or engineering groups) indicates uneven patterns.

Table 21: Comparison of percent electrical energy to SEC ratios

Sector	Ratio of elec. energy to total	Percent ratio of SEC for elec. to total
Engineering	25.2	36.80
Metallurgical I	64.9	63.10
Metallurgical II	25.4	26.00
Metallurgical III	58.1	41.10
Paper	8.9	13.50
Sugar	0.5	0.50
Chemicals	43.9	43.60
Tiles	2.5	0.36
Oxygen	100.0	100.00

The effect of power cut is seen from **Table 22.** Energy generated by captive diesel sets was very small in 1979-80. The percent ratio between self generation and purchased energy from KEB was only 0.22; but this ratio has gone up to 17.08 in 1983-84. Since the cost of electricity from diesel generators is very expensive of the order of 2 rupees - compared to purchased electrical energy from KEB, this shows that the cost of energy is not an important criterion. In fact lower costs result in wastages. Hence the planners should consider proper costing of energy including replacement costs for generating stations - thereby doing away completely with subsidies. Subsidised energy may not result in lower manufacturing costs. It results definitely in decreased efficiencies and unnecessary use of energy. Same is the case with capacity. Self generation capacity is equal to 69% of the maximum demand.

Table 22: Electricity consumption ratios for some industries

Year	Energy from KEB (m. units)	Self generation (m. units)	Percent to self gen. to KEB supply	Max demand (KVA)	Capacity of self gen.	Percent of self gen. capacity
1979-80	1575.2	3.49	0.22	18,579	7563.5	40.7
1983-84	892.6	152.46	17.28	114,451	7931.2	69.3

Proper costing of energy will have the following benefits;

a) Energy consciousness will increase leading to greater energy conservation

b) The anamalous situation that exists now - like people installing diesel/petrol/kerosene generators in their shops factories etc and thereby paying higher costs for energy will be alleviated especially because capital can be generated for additional power plants.

In the beginning it was said that the ratio of electrical energy to total energy consumed by the industrial sector in Karnataka is very high when compared with many countries. Since electrical energy is high quality energy and as it is a derived form of energy, it is desirable to use it mainly for high quality of work - movements and electrolysis etc. It will be appropriate to find out the percent of use of electrical energy for the higher quality of work and the percent used in lower quality activities like heating. Since energy consumption statistics are not available for each end use in each industry, we decided to look at the connected load distribution. The distribution of connected load for various end use activities like heating, lighting, welding, machinery etc was collected from the responding industries. Hence we analysed the connected load figures. **Table 23.** gives the percentages of load in each category. It shows that 46.55% of electrical load is in the heating category.

Table 23: Percentage distribution of connected electrical load in KW in some industries

Type of load	Percent
Heating	46.55
Machinery	47.25
Welding	1.10
Lighting	1.33
Others	3.77
Total	100.00

Electrical energy need not be used for heating activities. To a large extent substitution of lower quality energy is desirable in all these cases. Such a substitution will not only match source with end uses, but also increase the efficiency of use. This is true in other sectors also.

Table 24. gives SEC for total energy and electricity for some industries based on surveys conducted by students in various engineering colleges in Karnataka for their projects. In the case of coffee curing, the SEC varies from .002 to .0044 a variation of more than 100%. For tiles, the SEC is 6.771. This is between the minimum and the maximum values for SEC calculated in Table 19.

Table 24: Specific energy consumptions for some industries

	Unit	SEC	SEC elec.
Tile industry	Tiles	6.7710	0.2200
Mosaic industry	tile	0.0060	0.0060
Coffee			
curing 1	kg	0.0044	0.0044
curing 2	kg	0.0040	0.0040
curing 3	kg	0.0020	0.0020
Boards	sq.m.	0.3800	0.1580
Steels	tons	42.2760	38.5800
Silk fabrics	mtrs	0.8600	0.0590
Sandal oil	kgs	68.2200	0.7000

Energy Conservation Measures

Even though some industries have begun looking at their energy problem to find measures to save energy the effort is very insignificant compared to the magnitude of the problem of inefficiency. Some examples are;

(i) Proper maintenance of electric motors in textile industries brings down energy consumption considerably; about 3% of power consumption can be saved by improved maintenance. This also reduced repairs as shown by the fact that burnout of motors varies in frequency from one in three months/10,000 spindles to 8-20 in three months/10,000 spindles. The increase is 8-20 fold in the second case. Similarly burnout frequency varies from 1-7 to 60 for six months for 25,000 spindles.

(ii) Waste heat recovery in boilers can reduce energy use by about 10%. It is shown that the payback period is a few months.

(iii) Use of polyster cotton tapes etc. in textile mills will reduce consumption by about 10%.

(iv) Replacement of old boilers with high efficiency boilers and introduction of turbines and generators can reduce total energy requirements by more than 20-30%.

(v) Spindle speed is an important factor in energy consumption in textile industries. Proper speed can reduce energy use. In the survey the energy consumption varies from 60% to 165% (with the base of 100 chosen for one mill). This shows that proper speeds can reduce consumption.

(vi) In many industries, machine shops use lathes and other machines. There are thousands of these machines in our industries. Introduction of computer numerical control machines will reduce energy consumption and increase productivity.

Conclusions

1. Even though energy consumption/capita is low, energy/SDP for Karnataka is quite high. This is true specially for the industrial sector. The energy/SDP for industrial sector in Karnataka is 10-20 times higher than that for some of the industrialised countries. This shows that there is great room for improvement of the efficiencies in energy consumptions in our industries.

2. Electrical energy forms a major component in the industrial energy use. The percent of electrical energy to total energy is also higher for Karnataka when compared with this index for the industrialised countries. Electrical energy being high quality energy involving more energy conversions it should be used in high quality work.

3. Energy consumptions per rupee of productions for various industrial groups have been calculated. These will serve as indicators for industries in the same group. Some of these when compared with international norms look quite high.

4. Electrical energy consumption per rupee of productions for various industrial groups has also been evaluated. This can again be used as an indicator.

5. The specific energy consumption within a group varies very widely - in some cases a variation of about 100% or more exists. This shows that we can definitely reduce energy use through conservation measures.

6. The specific energy consumptions have been calculated for a period of five years. These variations show an increase in SEC in many industries. In some cases, there is a decrease, a welcome measure.

7. Electricity production is shifting towards diesel captive plants because of power cuts in the grid electricity. This increases the cost and decreases the efficiency of energy use. This has not induced industries to go in for reduced consumptions of energy.

8. A study of electric load patterns indicates that about 40% of the load is for heating. Hence these can be easily converted to use other forms of energy, thereby increasing efficiency of use and relieving the demand on electrical energy.

9. A study of electrical energy and power distribution throughout the state reveals a large spatial disparity in energy use with most of the use being concentrated in Bangalore and one or two singular points.

10. This study only reveals the possibilities of energy conservation. Actual measures depend on studies in individual industrial units. Hence energy budgeting and auditing measures in many major industries should be initiated.

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