Analysis of Energy Utilisation in the Small Scale Industries in Karnataka

T.V. Ramachandra & D.K. Subramanian*

A detailed energy analyses was conducted for one of the energy intensive sector of Small Scale Industries in the state of Karnataka. A wide disparity exists in Specific Energy Consumption (SEC) among various units. About 60 units in a sample of 153 units in food grain sector have Percentage Production Capacity Utilisation (PPCU) less than 50%. By shifting units at the lower production range to higher production range would lead to overall energy saving of 23.12% in the food grain sector. Similar exercises in other sectors would help policy makers, funding organisation, etc., in fixing the lower limits of installed capacity of the units as well as making everyone aware of the importance of capacity utilisation in conserving energy.

Introduction

Energy sources are finite non renewable resources like coal, oil, firewood and renewable resources like hydro, agro-wastes, solar, wind etc. An indiscriminate usage of finite resources is resulting in the fast depletion of these resources. The renewable resources are derived from the Sun either directly or indirectly. Firewood or biomass can be treated as a renewable resource if the exploitation rate is less than the growth rate. But, the present usage borders on depleting the biomass potential. This necessitates to restrict our energy needs to the availability of resources.

An energy system consists of three components : (1) Generation or production or extraction of a resource or energy form, (2) transportation or transmission and distribution and (3) usage in enduse devices. Most of the devices we use in day-to-day life are basically energy converters. For example, a cooking stove converts chemical energy to heat energy; whenever we convert energy from one form to another, the full energy content in the input is not converted into the useful form. Only a fraction of the input energy is converted into useful output, the remaining being lost. The term efficiency is used in this context which is the ratio of useful energy content in the output to energy content in the input. The efficiency of most energy consuming processes is very low, often less than 50%. The states of transformation of an energy source can be characterised as:

— Primary energy : energy taken from nature, which is available in the environment such as solar energy, wind energy or form fossil fuels etc.

— Intermediate energy : energy which has undergone, several transformations, convenient for use such as electricity.

— Useful energy : energy in the form wanted by the consumer who uses it, such as mechanical work, heating, lighting etc.

Present Energy Situation in Karnataka

In Karnataka State (of India), both commercial (coal, oil and electricity) and non-commercial (fuelwood, cowdung and agrowastes) forms of energy are being used almost equally. Sectoral energy consumption [1] indicates that 44% of total commercial energy is consumed in industrial sector followed by transport (24.4%) and domestic sectors (18.1%). The gradual increase in the energy consumption in agriculture sector is noticed in

*Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012 (India)

late seventies due to mechanization in agriculture—both for land preparation (use of tractors, tillers etc.) and for lift irrigation (use of centrifugal pumpsets). The industrial sector continues to be the single largest commercial energy consuming sector and is highly energy intensive, with consumption of 1.96 tonnes of coal replacement per Rs. 1000/- of output. Electrical energy generation from hydro and thermal power plants accounts for 10,644 million units (mkWh) (during 1987-88). More than 70% of this goes to industrial sector. Next to the industrial sector comes domestic sector (mostly comprising of AEH (All electric homes) wherein most of this energy is used inefficiently for low quality heating (bath water) etc. The bulk of non-commercial energy consumption is in the domestic or household sector mostly for cooking (predominantly in rural households). The dependence of rural households on firewood is often as high as 90%. Earlier studies conducted by us [2] have revealed that in Karnataka 41.29% of total annual energy consumption is from firewood (11.208 MTCR), while cowdung, agrowastes meet about 10.22% (2.79 MTCR) of the total domestic energy requirement.

Thus, it is clear that we are still heavily dependent on traditional sources of energy. Firewood (11.208 MTCR) contributes three times to energy consumption than that of electricity (4.858 MTCR). The situation is changing fast and to meet the energy needs of growing population, it is necessary to maintain an adequate supply of energy. Demand for electrical energy in industrial as well as urban household sectors has been increasing so fast that the delays in completion of projects involving power generation have created enormous shortages and prolonged power-cuts. Due to the heavy use of firewood, forest lands have been progressively denuded, and require organised replantation. Similarly, the use of cow dung for fuel (in the form of dung cakes) deprives its use as an organic fertilizer. The Karnataka State mainly depends on hydro resources for electricity.

Need for an Integrated Energy Plan

In order to meet the total energy needs, proper planning efforts are needed. Currently, energy planning in our country is not an integrated activity. Since there are many energy sources and enduses, there are many organisations that deal with different aspects of energy. The plans for electricity, oil, coal and firewood are done by respective organisation mostly based on the projection of energy demand. The primary goal seems to go in for energy supply expansions. The approach adopted so far in the planning process links economic growth to energy on the assumption that there is a correlation between energy use and GDP (Gross domestic product, which is taken as measure of economic growth). If this approach is taken, then energy becomes an end in itself, and the focus shifts on meeting increased energy consumption through energy supply expansion alone. This supply and demand based planning for each individual energy form has resulted in problems like more losses, more conversions, and low efficiencies. This is evident from the disappearence of forests, village woodlots, road side trees and construction of giant hydro electric dams, thermal plants and controversial nuclear plants. Our present low energy efficiency levels can be seen form the results of a study conducted by us [3] in a public sector electrometallurgical industry at Bangalore in Karnataka. Table 1 gives efficiencies of various end-use devices.

Table 1 : Energy Efficiencies of some End-Use Devices In a Electro Metallurgical Industry

Weldig sets	14%
Furnace	10.4%
Shearing machine	33.3%
Bending machine	30%
Electroplating process	38%
Diesel Gen sets	36.5%
Press brake	14.06%
Cranes	24.82%

The conflict between the energy demand and environmental quality goals can be solved by having an integrated approach to the problem of energy planning with a view to minimise the consumption of non-renewable resources and maximise the efficiency of usage. Such an approach could lead to zero growth in energy consumption.

Another aspect that has not been looked into in the present energy planning process is that of matching resources to enduses. Currently, because of convenience, high quality energy like electricity are being used for low quality activities like bath-water heating, resulting in low efficiencies. A study on electric load and consumption patterns in large and medium scale industries in Karnataka [2] has revealed that 40% of electrical load in industries is being used for heating purposes-which can easily be obtained from other forms of energy, thereby increasing efficiency of use and relieving the demand on high quality energy (electrical energy) sources. So this aspect of source—enduse matching should be looked at and analysed for the energy planning problem.

There is also a need for an organised approach towards large scale, and optimal use of renewable resources of energy. The present pattern of inefficient useage of biomass energy should not be perpetuated. The biomass energy resources are at present being used predominantly in the domestic sector as fuel for cooking and water heating. Hence, a new role has to be defined wherein there are improvements in the efficiency as well as diversion of biomass use to other sectors.

Hence, strategies for integrated energy planning of our country should include:

1. Improvements in efficiencies of end-use devices and/or conversion equipments
2. optimising energy source-enduse matching,
3. organised approach towards optimal use of renewable resources.
4. proper exploitation of biomass energy resources, and
5. discouraging use of depletable resources (by penalising).

We should also understand that the energy consumption is not an end in itself. Vast possibilities exist for improvement in enduse efficiencies in all sectors. The improvement in the efficiencies of energy use permit significant improvements in the physical quality of life without increase in the amount of primary energy which has to be supplied. When a particular energy carrier is being used very inefficiently, its much more efficient use, or a shift to more efficient energy carrier results in the release of the hither-to inefficiently used source for alternative purposes. Linkages between energy sources and impact of substitution of energy from one source to another can be understood only with the integrated picture of energy use. Study of energy consumption patterns in various sectors, leads to energy analysis. Industries are one of the major consumers of high quality sources. In a study on large and medium scale industries in Karnataka [2], it is noticed that in many application of electrical energy, 25 units of input energy is used to produce one unit of useful output. Hence, we focus our attention to the industrial sector. We have chosen here small scale industries in Karnataka for further analysis and study.

Small scale industries in a group (like biscuits, food grain products, bricks and tiles etc.) manufacture similar products. There are greater degree of similarities in technology, scales of production, raw material used, production processes etc., so it is therefore possible to get meaningful conclusions on energy use. The grain mill products sector (Sector 204) in small scale industries sector is also chosen for futher analysis and comparison.

Present analysis mainly concentrates on energy usage pattern study in small scale industry units and food grain products sector (Sector 204) and compares. This study also looks at linkages between various parameters like energy, energy intensity, Specific Energy Consumption (S.E.C.), manpower, production, per cent installed production capacity utilisation.

The analysis (discussed in the next section) shows that

(1) The energy consumption is related to production.

(2) 30 to 40% energy could be saved in the small scale industries sector by utilising full installed capacity (of motors, etc.)

(3) Industries in the production range less than Rs. 2.5 lakhs consume more energy per unit of output compared to industries in the higher production range.

Objectives of the Study

Our study has the following objectives :

1. To look at general picture of SSI's in Karnataka and compare their energy use in different sectors/ groups and to do districtwise analysis.
2. To analyse energy consumption pattern in different units in food grain products sector of the small scale industries group in Karnataka, so as to identify disparities in the levels of energy consumption.
3. To look at and analyse a homogenous sub-sector (industries wherein dehusking of paddy only is carried out) among food grain products sector.
4. To explore the relationships that exist between different parameters like energy consumption and production, energy and percentage production capacity utilisation, energy intensity (EI) and Production, Specific Energy Consumption (SEC) and Production. Energy intensity and Percent Production Capacity Utilisation (PPCU), Specific Energy Consumption and Percentage Production Capacity Utilisation (PPCU).
5. To compare energy utilisation in these industries in several districts, since these industries are spread all over Karnataka state.

The second objective was accomplished by looking at the index Specific Energy Consumption or Energy Intensity (EI) of each industry.

SEC can be defined as the ratio of energy consumption in rupees to production in rupees and Energy Intensity (EI) is the ratio of Energy Consumption in units (kWh) to production in tonnes. It gives an idea of how much energy has been consumed for a particular level of production. By comparing these factors at different

levels of production or at different points of time. It is possible to see how intensity changes. This in turn gives an idea about energy efficiency.

Another parameter used in this analysis is the Percentage Production Capacity Utilisation (PPCU), which is the ratio of actual production to installed production capacity expressed as percentage. This ratio in turn gives an idea as to the extent of utilisation by an industry of its full installed capacity. Analysis of energy consumption versus percentage production capacity will establish standard norms.

Small Scale Industries in Karnataka

In the process of reshaping and developing the Indian economy under the five year plans, the hither-to neglected and static sector of Small scale Industry came into prominence for the attention of government and the developmental authorities. In this connection it was realised that the Small Scale Industries:

1. provide greater employment opportunities,
2. encourage a gradual progress in the technologies of production in the unorganised sector of industry,
3. would help in better utilisation of local resources leading towards the achievement of local self sufficiency in respect of certain types of essential consumer goods.

Thus, Small scale industries constitute an important component in the Indian industrial scene. Some of the characteristics of small scale industries which prompted us to take up this analysis are :

(1) They are spread all over the state.

(2) Existence of greater degree of similarities in production process within a group. For example, food grain mills, paddy dehusking industries are of great similarity.

(3) Economics of production is much more important in the small scale industries sector. Energy plays a key and dominant role in the production economics in most of these industries.

General picture of the small scale industries in Karnataka is looked at from the point of view of their spatial distribution, investment costs, growth rates and employment generation. Even though, these aspects are not directly related to the energy consumption patterns, they throw light on developmental aspects and hence indirectly influence energy and environment. Compared with india, Karnataka has 5.57% of factories with share of manpower 5.12%, value of output is 4.24%, fuel consumption accounts for 3.55%, Table 2, gives details regarding growth rate, investment and number of persons employed in the small scale sector. The same is displayed pictorially in figure 1. From this we can notice that the small scale industries has an average annual growth rate of 15.77% whereas employment generated has an average annual growth rate of 14.49%.

Table 2 : Growth of small scale Industries in Karnataka

Sl. No.	Year	No of SSI Units (Registered)	Investment (Rs. in lakhs)	Manpur employed	SSI Units (Cum)	Investment (Cum)	Man Power (Cum)	Investment /Job Cum (Rs..Job)	% Growth (Yearwise) Units	Investment	Man power
1.	1969-70	3890	3456.70	47960	3890	3456.70	47960	7207.46			
2.	1970-71	1908	2279.43	44295	5798	5736.13	92255	6217.69	49.05	65.94	92.36
3.	1971-72	2372	1309.39	21343	8170	7045.52	113598	6202.15	40.91	22.83	23.13
4.	1972-73	2272	1350.10	22490	10442	8395.62	136088	6169.26	27.81	19.16	19.80
5.	1973-74	3043	1638.23	21814	13485	10033.85	157902	6354.48	29.14	19.51	16.03
6.	1974-75	1907	3991.27	56043	15392	14025.12	213945	6555.48	14.14	39.78	35.49
7.	1975-76	1562	1641.36	12783	16954	15666.48	226728	6909.81	10.15	11.70	5.97
8.	1976-77	1420	1482.51	15406	18374	17148.99	242134	7082.44	8.38	9.46	6.79
9.	1977-78	1621	1517.11	24750	19995	18666.10	266884	6994.09	8.82	8.85	10.22
10.	1978-79	1975	1451.46	16957	21970	20117.56	283841	7087.62	9.88	7.78	6.35
11.	1979-80	2910	3255.01	34376	24880	23372.57	318217	7344.85	13.25	16.18	12.11
12.	1980-81	2776	3041.83	26164	27656	26414.04	344381	7670.11	11.16	13.01	8.22
13.	1981-82	3396	4955.16	41375	31052	31369.56	385756	8131.97	12.28	18.76	12.01
14.	1982-83	6096	6255.29	46420	37148	37624.85	432176	8705.91	19.63	19.94	12.03
15.	1983-84	7479	6396.51	44282	44627	44021.36	476458	9239.29	20.13	17.00	10.25
16.	1984-85	11962	6324.31	55849	56589	50345.67	532307	9458.01	26.80	14.37	11.72
17.	1985-86	11634	3787.09	60796	68223	54132.76	593103	9127.04	20.56	7.52	11.42
18.	1986-87	11179	9408.47	56883	79402	63541.23	649986	9775.78	16.39	17.38	9.59
19.	1987-88	10530	10165.19	52498	89932	73706.42	702484	10492.26	13.26	16.00	8.08
20.	1988-89	9811	10532.77	50448	99743	84239.19	752932	11188.15	10.91	14.29	7.18
									15.77	16.34	14.49

Source : Small Scale Industries Institute, Bangalore.

Table 3a Districtwise Data of Small Scale Industries (From 1982-83 to 1988-89)

Sl. No.	Year / District	1982-83 Units cum	1982-83 Investment cum (lakhs)	1982-83 Persons cum	1983-84 Units cum	1983-84 Investment cum (lakhs)	1983-84 Man Power cum	1984-85 Units cum	1984-85 Investment cum (lakhs)	1984-85 Man Power cum	1985-86 Units cum	1985-86 Investment cum	1985-86 Man Power cum
1	Bangalore	11368	14381.78	156691	13138	15589.10	165515	14908	16796.42	174339	17035	18490.13	183463
2	Belgaum	2010	1856.93	16082	3438	2319.77	20715	4866	2782.61	25348	6047	3620.75	30283
3	Bellary	1530	788.16	8133	2041	1121.29	11271	2552	1454.42	14409	3051	1627.54	17034
4	Bidar	625	400.79	5790	989	703.05	7920	1353	1005.31	10050	1606	1215.36	11378
5	Bijapur	1282	604.15	12979	1693	799.25	14973	2104	994.35	16967	2535	1127.36	18973
6	Chikmagalur	1638	979.72	11417	1867	1086.13	12221	2096	1192.54	13025	2313	1318.65	13775
7	Chitradurga	598	380.12	4503	980	636.59	6065	1362	893.06	7627	1798	1182.91	10017
8	Dakshina Kannada	2444	4094.75	64714	3178	4702.68	69050	3912	5310.61	73386	4675	6695.36	79245
9	Dharwad	2641	2027.17	23989	3984	2444.58	29618	5327	2861.99	35247	6513	3467.99	40773
10	Gulbarga	850	642.62	7830	1232	775.54	9014	1614	908.46	10198	2022	991.20	11627
11	Hassan	824	550.9	6133	1085	685.31	7476	1346	819.72	8819	1613	1116.17	10890
12	Kodagu	460	959.61	10936	600	986.80	11487	740	1013.99	12038	869	1054	12413
13	Kolar	1816	1124.05	11672	2170	1298.88	13779	2524	1473.71	15886	2892	1987.13	18351
14	Mandya	1087	624.54	6275	1392	759.36	7580	1697	894.18	8885	1949	1038.6	11093
15	Mysore	2871	2619.16	23153	4314	3140.62	30863	5757	3662.08	38573	6923	4220.93	46260
16	Raichur	855	1767.17	19670	1179	1968.01	21106	1503	2168.85	22542	1931	2744.86	25126
17	Shimoga	1904	2022.83	13779	2543	2428.31	15830	3182	2833.79	17881	3765	3328.96	20752
18	Tunkur	1492	1279.13	17737	2243	1900.44	21479	2994	2521.75	25221	3743	3071.79	28871
19	Uttara Kannada	789	537.23	9214	989	619.41	10584	1180	701.59	11954	1371	776.83	12867
	Total	37093	37640.81	430697	49055	43965.12	486546	61017	50289.43	542395	72651	59076.52	603191

Sl. No.	Year / District	1986-87 Units cum	1986-87 Investment cum (lakhs)	1986-87 Persons cum	1987-88 Units cum	1987-88 Investment cum (lakhs)	1987-88 Man Power cum	1988-89 Units cum	1988-89 Investment cum (lakhs)	1988-89 Man Power cum
1	Bangalore	18966	20569.39	192254	20653	22654.16	201987	22301	25399.02	213076
2	Belgaum	7251	4543.86	34677	8374	5441.91	39219	9209	6349.17	42845
3	Bellary	3554	1775.18	19679	4056	1976.94	21767	4502	2196.95	23726
4	Bidar	1872	1364.06	12791	2132	1724.8	14125	2377	2069.33	15061
5	Bijapur	2921	1311.79	21288	3335	1469.46	22906	3730	1726.95	24744
6	Chikmagalur	2536	1422.77	15385	2739	1519.08	16614	2920	166.05	17333
7	Chitradurga	2210	1607.76	12724	2614	2115.8	14705	2996	2601.03	16628
8	Dakshina Kannada	5949	7643.08	84626	6692	9209.7	89417	7379	10703.75	93464
9	Dharwad	7342	4866.82	47245	8177	5465.44	51778	9077	6078.78	56359
10	Gulbarga	2455	1312.44	14299	2887	1672.04	16793	3347	2129.18	19123
11	Hassan	1864	1290.45	11741	2121	1484.08	12773	2358	1607.09	13718
12	Kodagu	969	1200.77	13435	1079	1251.11	13797	1181	1298.25	14158
13	Kolar	3281	2340.9	20743	3605	2722.91	22849	3954	3121.02	25080
14	Mandya	2203	1193.02	12446	2412	1353.33	13470	2612	1511.53	14383
15	Mysore	7885	4799.11	51165	9013	5500.04	56101	9811	6075.37	60183
16	Raichur	2367	3082.37	27083	2826	3477.67	29097	3239	3803.22	30821
17	Shimoga	4278	3686.24	23013	4788	4117.24	24857	5292	4560.35	26730
18	Tumkur	4345	3618.54	31754	5074	4542.59	35644	5926	5221.92	40158
19	Uttara Khannada	1582	856.44	13731	1783	951.88	14683	1960	1067.89	15440
	Total	83619	68484.99	660079	94149	78650.08	712582	103960	89182.85	763030

Source : Directorate of Industries and Commerce, Karnataka Government.

Table 3a, looks at districtwise cumulative information from the year 82-83 upto 1988-89. Table 3b gives the districtwise percentage annual growth rate of industries, investment and manpower. Percentage annual growth of Small Scale Industries (districtwise) and percentage variation growth rate for industries for 7 years (from 1982-83 to 1988-89) are given in tables 4a. In last eight years, number of industries in Karnataka have increased from 37,093 to 1,03,960 (180.27%) whereas the employment level has gone up from

4,30,697 to 7,63,030 (77.16%). Number of industries during 1982-83 and 1988-89 is depicted in figure 2.

Figure 3 illustrates percentage variation growth for 7 years while figure 4 shows percentage average annual

Table 3b : Districwise Data of Small Industries, Computation of Percentage of Annual Growth

Sl. No.	Year / District	1982/83 To 1933/84 Units	Investment	Persons	1983/84 To 1984/85 Units	Investment	Man Power	1984/85 to 1985/86 Units	Investment	Man Power
1	Bangalore	15.57	8.39	5.63	13.47	7.74	5.33	14.27	10.08	5.23
2	Belgaum	71.04	24.93	28.81	41.54	19.95	22.37	24.27	30.12	19.47
3	Bellary	33.40	42.27	38.58	25.04	29.71	27.84	19.55	11.90	18.22
4	Bidar	58.24	75.42	36.79	36.80	42.99	26.89	18.70	20.89	13.21
5	Bijapur	32.06	32.29	15.36	24.28	24.41	13.32	20.48	13.38	11.82
6	Chikmagalur	13.98	10.86	7.04	12.27	9.80	6.58	10.35	10.57	5.76
7	Chitradurga	63.88	67.47	34.69	38.98	40.29	25.75	32.01	32.46	31.34
8	Dakshina Kannada	30.03	14.85	6.70	23.10	12.93	6.28	19.50	26.08	7.98
9	Dharwad	50.85	20.59	23.46	33.71	17.07	19.01	22.26	21.17	15.68
10	Gulbarga	44.94	20.68	15.12	31.01	17.14	11.14	25.28	9.11	14.01
11	Hassan	31.67	24.40	21.90	24.06	19.61	17.96	19.84	36.16	23.48
12	Kodagu	30.43	2.83	5.04	23.33	2.76	4.80	17.43	3.95	3.12
13	Kolar	19.49	15.55	18.05	16.31	13.46	15.29	14.58	34.84	15.52
14	Mandya	28.06	21.59	20.80	21.91	17.75	17.22	14.85	16.15	24.85
15	Mysore	50.26	19.91	33.30	33.45	16.60	24.98	20.25	15.26	19.93
16	Raichur	37.89	11.37	7.30	27.48	10.21	6.80	28.48	26.56	11.46
17	Shimoga	33.56	20.05	14.88	25.13	16.70	12.96	18.32	17.47	16.06
18	Tumkur	50.34	48.57	21.10	33.48	32.69	17.42	25.02	21.81	14.47
19	Uttara Khannada	23.93	15.30	14.87	19.31	13.27	12.94	16.19	10.72	7.64
	Total	32.25	16.80	12.97	24.38	14.38	11.48	19.07	17.47	11.21

Sl. No.	Year / District	1985/86 To 1986/87 Units	Investment	Persons	1986/87 To 1987/88 Units	Investment	Man Power	1987/88 to 1988/89 Units	Investment	Man Power
1	Bangalore	11.34	11.25	4.79	8.89	10.14	5.06	7.98	12.12	5.49
2	Belgaum	19.91	25.49	14.51	15.49	19.76	13.10	9.97	16.67	9.25
3	Bellary	16.49	9.07	15.53	14.12	11.37	10.61	11.00	11.13	9.00
4	Bidar	16.56	12.24	12.42	13.89	26.45	10.43	11.49	19.98	6.63
5	Bijapur	15.23	16.36	12.20	14.17	12.02	7.60	11.84	17.52	8.02
6	Chikmagalur	9.64	7.90	11.69	8.00	6.77	7.99	6.61	9.41	4.33
7	Chitradurga	22.91	35.92	27.02	18.28	31.60	15.57	14.61	22.93	13.08
8	Dakshina Kannada	27.25	14.15	6.79	12.49	20.50	5.66	10.27	16.22	4.53
9	Dharwad	12.73	40.34	15.87	11.37	12.30	9.59	11.01	11.22	8.85
10	Gulbarga	21.41	32.41	22.98	17.60	27.40	17.44	15.93	27.34	13.87
11	Hassan	15.56	15.61	7.81	13.79	15.00	8.79	11.17	8.29	7.40
12	Kodagu	11.51	13.93	8.23	11.35	4.19	2.69	9.45	3.77	2.62
13	Kolar	13.45	17.80	13.03	9.88	16.31	10.15	9.68	14.62	9.76
14	Mandya	13.03	14.87	12.20	9.49	13.44	8.23	8.29	11.69	6.78
15	Mysore	13.90	13.70	10.60	14.31	14.61	9.65	8.85	10.46	7.28
16	Raichur	22.58	12.30	7.79	19.39	12.82	7.44	14.61	9.36	5.93
17	Shimoga	13.63	10.73	10.90	11.92	11.69	8.01	10.53	10.76	7.54
18	Tumkur	16.08	17.80	9.99	16.78	25.54	12.25	16.79	14.95	12.66
19	Uttara Khannada	15.39	10.25	6.71	12.71	11.14	6.93	9.93	12.19	5.16
	Total	15.10	15.93	9.43	12.59	14.84	7.95	10.42	13.39	7.08

growth of industries. This shows that annual growth rate for industries vary from a low of 7.49% (Chikmagalur) to a high of 22.32% (Chitradurga).

Table 4b displays the districtwise disparity in distribution of industries. The percentage of units varies from a very low value of 0.85% for Kodagu to a very high

Table 4a : Districtwise Data on Small Scale Industries, for the year 1982-83 and 1988-89

Sl. No.	Year / District	1982-83 Units cum	1982-83 Investment cum (lakhs)	1982-83 Persons cum	1988-89 Units cum	1988-89 Investment cum (lakhs)	1988-89 Man Power cum	1982-83 To 1988-89 (Variation) Growth Units	Investment	Manpower	Average Annual Growth Units cum	Investment cum	persons cum
1	Bangalore	11368	14381.78	156691	22301	25399.02	213076	96.17	76.61	35.98	8.79	7.37	3.92
2	Belgaum	2010	1856.93	16062	9209	6349.17	42845	358.16	241.92	166.42	20.96	16.61	13.03
3	Bellary	1530	788.16	8133	3402	2196.95	23726	194.25	178.74	191.73	14.44	13.67	14.32
4	Bidar	625	400.79	5790	2377	2069.33	15061	280.32	416.31	160.12	18.17	22.78	12.69
5	Bijapur	1282	604.15	12979	3730	1726.95	24744	190.95	185.85	90.65	14.28	14.03	8.40
6	Chikmagalur	1638	979.72	11417	2920	1662.05	17333	78.27	69.65	51.82	7.49	6.83	5.36
7	Chitradurga	598	380.12	4503	2996	2601.03	16628	401.00	584.27	269.26	22.32	27.18	17.74
8	Dakshina Kannada	2444	4094.75	64714	7379	10703.75	93464	201.92	161.40	44.43	14.81	12.76	4.70
9	Dharwad	2641	2027.17	23989	9077	6078.78	56359	243.70	199.87	134.94	16.69	14.71	11.27
10	Gulbarga	850	642.62	7830	3347	2129.18	19123	293.76	231.33	144.23	18.69	16.15	11.81
11	Hassan	824	550.9	6133	2358	1607.09	13718	186.17	191.72	123.68	14.05	14.32	10.59
12	Kodagu	460	959.61	10936	1181	1298.25	14158	156.74	35.29	29.46	12.51	3.85	328
13	Kolar	1816	1124.05	11672	3954	3121.02	25080	117.73	177.66	114.87	10.21	13.62	10.03
14	Mandya	1087	624.54	6275	2612	1511.53	14383	140.02	142.02	129.21	11.58	11.68	10.93
15	Mysore	2871	2619.16	23153	9811	6075.37	60183	241.73	131.96	159.94	16.60	11.09	12.68
16	Raichur	855	1767.17	19670	3239	3803.22	30821	278.83	115.22	56.69	18.12	10.05	5.77
17	Shimoga	1904	2022.83	13779	5292	4560.35	26730	177.94	125.44	93.99	13.63	10.70	8.64
18	Tumkur	1492	1279.13	17737	5926	5221.92	40158	297.18	308.24	126.41	18.82	19.22	10.75
19	Uttara Khannada	798	537.23	9214	1960	1067.89	15440	145.61	98.78	67.57	11.89	8.97	6.67
	Total	37093	37640.81	430697	103960	89182.85	763030	180.27	136.93	77.16	14.95	13.45	9.61

Table 4b : Districtwise data on Small Scale Industries, During the Year 1988-89

Sl. No.	Year / District	Units cum	1988-89 Investment cum(lakhs)	Manpower cum	% Units	1988-89 % Investment	% Persons	Investment Per Job	% of Population Employed in SSI
1	Bangalore	22301	25399.02	213076	21.41	28.48	27.92	11920.17	3.64
2	Belgaum	9209	6349.17	42845	11.25	9.95	7.79	14818.93	1.19
3	Bellary	4502	2196.95	23726	2.55	1.50	1.87	9259.67	1.32
4	Bidar	2377	2069.33	15061	1.38	1.43	1.21	13739.66	1.25
5	Bijapur	3730	1726.95	24744	2.20	1.21	2.01	6979.27	0.85
6	Chikmagalur	2920	1662.05	17333	1.76	1.18	1.44	9588.93	1.57
7	Chitradurga	2996	2601.03	16628	1.84	1.87	1.40	15642.47	0.77
8	Dakshina Kannada	7379	10703.75	93464	4.61	7.85	7.97	11452.27	3.25
9	Dharwad	9077	6078.78	56359	5.94	4.84	5.22	10785.82	1.58
10	Gulbarga	3347	2129.18	19123	2.33	1.78	1.87	11134.33	0.76
11	Hassan	2358	1607.09	13718	1.68	1.37	1.37	11715.19	0.84
12	Kodagu	1181	1298.25	14158	0.86	1.12	1.43	9169.73	2.54
13	Kolar	3954	3121.02	25080	2.89	2.72	2.57	12444.26	1.09
14	Mandya	2612	1511.53	14383	1.97	1.36	1.51	10509.14	0.84
15	Mysore	9811	6075.37	60183	7.54	5.53	6.43	10094.83	1.92
16	Raichur	3239	1803.22	30821	2.69	3.66	3.52	12339.70	1.43
17	Shimoga	5292	4560.35	26730	4.52	4.56	3.16	17060.79	1.33
18	Tumkur	5926	5221.92	40158	5.30	5.47	4.91	13003.44	1.68
19	Uttara Khannada	1960	1067.89	15440	1.85	1.18	1.98	6916.39	1.19
	Total	103960	89182.85	763030				11687.98	

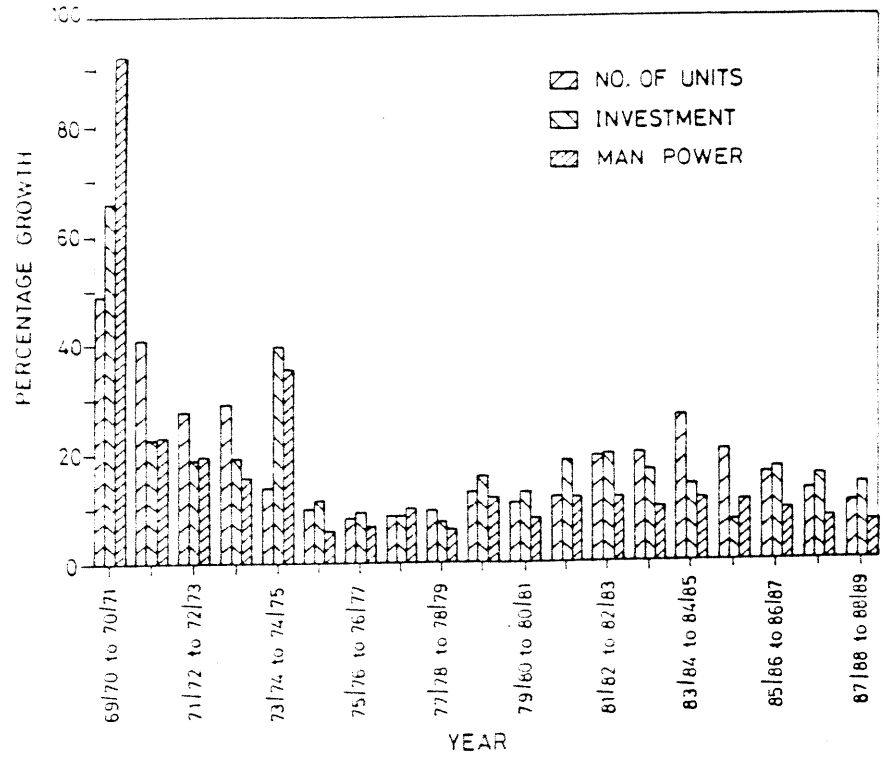

NO. OF UNITS
INVESTMENT
MAN POWER
PERCENTAGE GROWTH
0
20
40
60
80
100
69/70 to 70/71
71/72 to 72/73
73/74 to 74/75
75/76 to 76/77
77/78 to 78/79
79/80 to 80/81
81/82 to 82/83
83/84 to 84/85
85/86 to 86/87
87/88 to 88/89
YEAR

Fig. 1

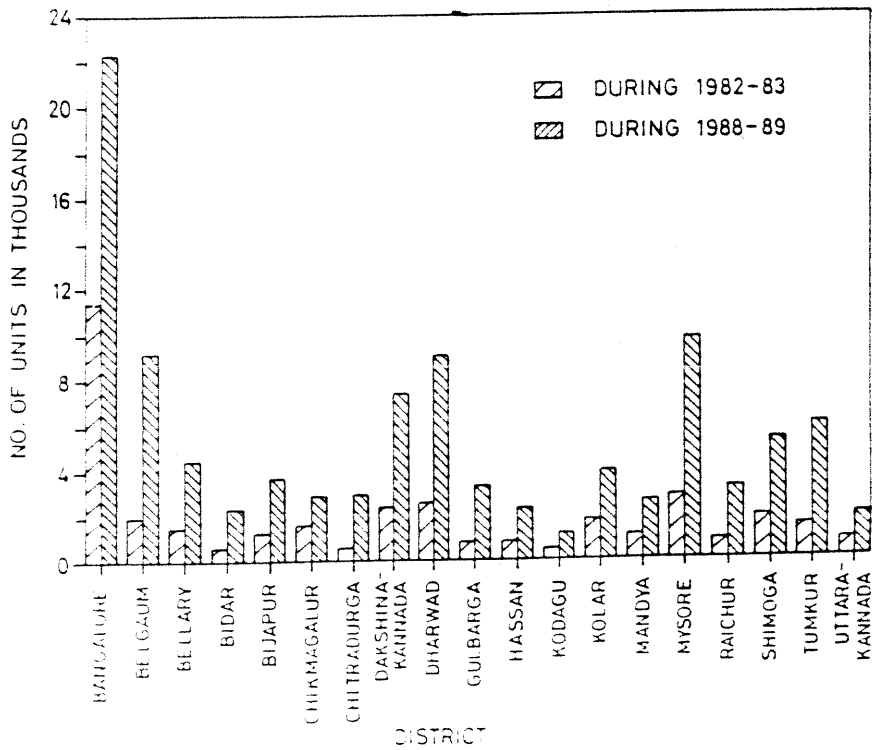

DURING 1982-83
DURING 1988-89
NO. OF UNITS IN THOUSANDS
0
4
8
12
16
20
24
BANGALORE
BELGAUM
BELLARY
BIDAR
BIJAPUR
CHIKMAGALUR
CHITRADURGA
DAKSHINA-KANNADA
DHARWAD
GULBARGA
HASSAN
KODAGU
KOLAR
MANDYA
MYSORE
RAICHUR
SHIMOGA
TUMKUR
UTTARA-KANNADA
DISTRICT

Fig. 2

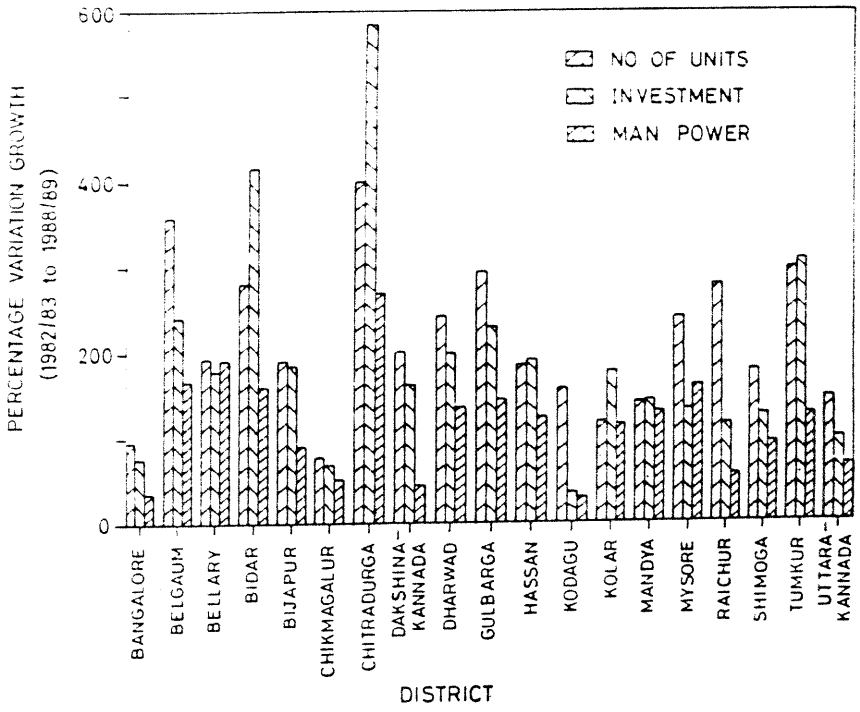

PERCENTAGE VARIATION GROWTH
(1982/83 to 1988/89)
600
400
200
0
NO OF UNITS
INVESTMENT
MAN POWER
BANGALORE
BELGAUM
BELLARY
BIDAR
BIJAPUR
CHIKMAGALUR
CHITRADURGA
DAKSHINA-KANNADA
DHARWAD
GULBARGA
HASSAN
KODAGU
KOLAR
MANDYA
MYSORE
RAICHUR
SHIMOGA
TUMKUR
UTTARA-KANNADA
DISTRICT

Fig. 3

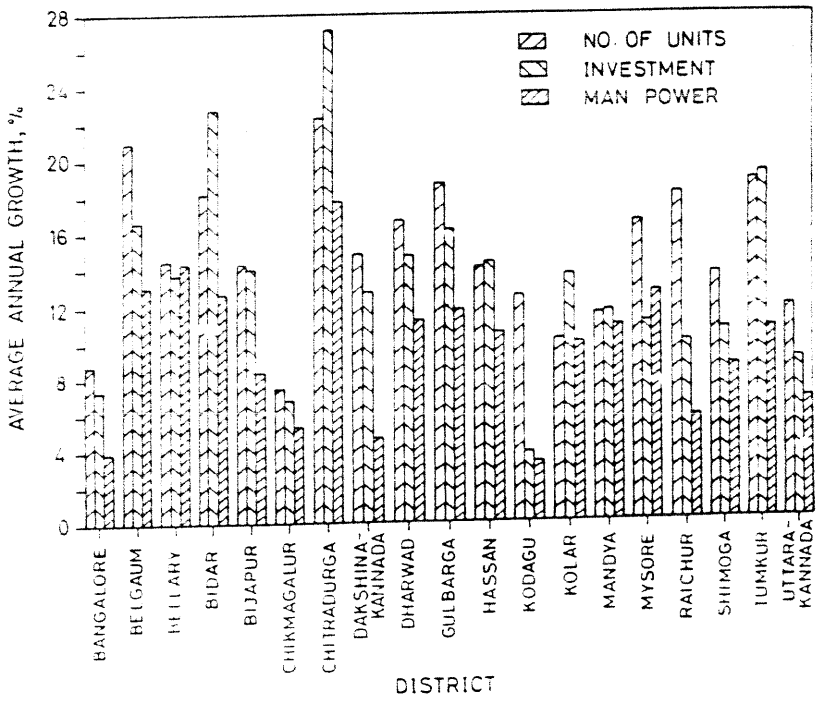

AVERAGE ANNUAL GROWTH, %
28
20
16
12
8
0
NO. OF UNITS
INVESTMENT
MAN POWER
BANGALORE
BELGAUM
BELLARY
BIDAR
BIJAPUR
CHIKMAGALUR
CHITRADURGA
DAKSHINA-KANNADA
DHARWAD
GULBARGA
HASSAN
KODAGU
KOLAR
MANDYA
MYSORE
RAICHUR
SHIMOGA
TUMKUR
UTTARA-KANNADA
DISTRICT

Fig. 4

value of 21.41% for Bangalore. Table 4b also gives districtwise investment/job and percentage of population employed in this sector. Higher values of investment/job for Bangalore, Dakshina Kannada, Chitradurga, Belgaum indicate that some industries are capital intensive. Last column in table 4b is the ratio of the number of persons employed in Small Scale Industries in a district to the total population of that district as percentage. This fraction is quite low for all districts. Chitradurga district provides employment to only 0.76% while the highest is for Bangalore (3.64%).

Table 4c : Total Investment, Employment in Large & Medium Scale Industries

Sl. No.	District	No. of Ind. Studied	Investment (Rs. in lakhs)	Manpower (no's)	Investment Per Job
1	Bangalore	157	79682.27	117685	67708.09
2	Belgaum	19	15363.52	15697	97875.52
3	Bellary	14	9329.97	7323	127406.39
4	Bidar	5	1228.60	1104	102228.26
5	Bijapur	6	3037.62	4702	64602.72
6	Chikmagalur	2	47197.85	2168	2177022.60
7	Chitradurga	15	2731.08	8668	31507.61
8	Dakshina Kannada	21	16794.52	5833	287922.51
9	Dharwad	13	9232.79	10841	85165.48
10	Gulbarga	10	22454.35	8751	256591.82
11	Hassan	4	1343.43	782	171794.12
12	Kodagu	NA	NA	NA	NA
13	Kolar	3	13055.69	20932	62371.92
14	Mandya	7	2456.98	5044	48710.94
15	Mysore	33	22671.73	13476	168237.83
16	Raichur	14	7873.91	7492	105097.57
17	Shimoga	5	28880.60	15089	191401.68
18	Tumkur	9	9531.34	4079	233668.55
19	Uttara Khannada	5	15056.04	5799	259631.66
	Total	342	307822.29	255465	

NA : Not available

Source : Directorate of Industries and Commerce, Karnataka Government.

Table 4c looks at the districtiwise investment per job for large and medium scale industries in Karnataka. Comparison of these values with those for small scale industries (Table 3c) indicates that large industries provide less employment per unit of investment.

Analysis of Energy Use in Small Scale Sector

Since energy plays a vital role, we are looking at energy efficiency studies for these industries. Our enduse energy efficiency study was done in three parts. Initially a survey was done to collect data regarding energy consumption, manpower details, raw material requirements, installed production capacity and actual production of an industry. Since there are 1,03,960 Small Scale Industries, it is difficult to obtain data from all these industries. So data obtained from a sample (2014 industries) were looked at. Even though 147 groups manufacturing different kinds of products were identified in the sample, many groups had a very few sample counts. Hence, from this sample, a secondary sample was derived discarding all sectors with small counts which resulated in 47 groups (1618 industries). Energy analysis is carried out for these 47 groups. Table 5a gives specific energy consumption (Energy consumption in units (kWh) per rupee of production) for these groups. It details mean, standard deviation, maximum value, minimum value, for every group. The maxium value means the maximum energy used by an industry for a rupee of production in the group. From this, we can see considerable variations in each group. This wide variation in some groups show that there is a good scope for improvement in energy use and conservation. In order to see the economic impact with reference to energy use, table 5B is computed. This gives specific energy consumption (in rupees per rupee of production). It also confirms the variations noticed in table 5a. Industries in many groups use more than 30 paise for energy for a rupee of production. Survival of many industries depends on energy conservation as revealed clearly in this analysis especially in the case of those sectors which use more than 25% of cost for energy. Whenever an industry consumes more than 25% of total cost for energy whereas another industry in the same group (producing similar or same products) has much lower energy cost (say 7 to 10%) then energy becomes critical factor in the survival of first industry. Few example groups depicting this situation are listed below :

1.	Food grain milling	— Tumkur district	0.33
		Hassan district	0.43
		Dharwar district	0.01
2.	Biscuits	— Mysore district	0.43
		Chickmagalur	0.017
3.	Cofee powder	— Mysore district	0.4
		Kodagu district	0.01
4.	Bricks and tiles	— Tumkur disctrict	0.34
		Dakshina Kannada dist.	0.33
		Hassan district	0.07
		Uttara Kannada dist.	0.14
5.	Bullock carts	— Dharwar district	0.25
	and parts	— Shimoga	0.006

Hence further detailed analysis is carried out for food grain sector (industry code 204) which is an energy intensive sector consuming more than 30 paise for energy in a rupee of production.

Food Grain Industries

The main operations in this sector are of milling grain products and dehusking of paddy etc. The sample

Table 5a : Energy Analysis of Small Scale Sector : An Overview

Computation of Energy Conumption (Kwh)/Production (rs)							
Sl.No	Product Code	Description	Number of Industries	Maximum	Minimum	Mean	Standard Deviation
1	2018	Ice Candy, Cream, Baby Milkfood	8	0.3264	0.0217	0.1545	0.1142
2	2041	Milling of foodrains	16	0.8654	0.0064	0.0223	0.3055
3	2042	Paddy Hulling, Rice	123	1.9375	0.0027	0.2595	0.3032
4	2043	Fried Gram	14	0.4032	0.0002	0.0749	0.1292
5	2051	Bread, Cake, Biscuits	24	3.8409	0.0077	0.7479	1.0490
6	2053	Biscuits	12	0.4128	0.0268	0.2090	0.1897
7	2110	Oil, Vanaspathy	43	0.3214	0.0052	0.0770	0.0874
8	2132	Coffee Powder	13	1.9365	0.0140	0.2560	0.5140
9	2150	Cold Storage	15	1.4043	0.0500	0.4748	0.4826
10	2641	Ready made Garments	44	0.5158	0.0007	0.0554	0.0980
11	2790	Wood Saving	90	0.1375	0.0050	0.1890	0.1960
12	2721	Wooden Packing	12	0.3545	0.0015	0.0711	0.1031
13	2760	Wooden Furniture	47	0.4000	0.0032	0.0745	0.0812
14	2799	Wooden Photoframes, Articles	15	0.2000	0.0042	0.0648	0.0617
15	2850	Printing & Binding	166	1.0667	0.0037	0.0591	0.0949
16	2890	Commercial Printing	21	0.2616	0.0080	0.0498	0.0676
17	2913	Leather Chappals	15	0.2400	0.0095	0.0612	0.0806
18	3004	J.K. Tyre Retreading	23	3.8923	0.0063	0.7977	0.9518
19	3035	Polythene Bags	11	0.3600	0.0076	0.0676	0.0991
20	3039	Plastic Foam Products, Buttons	35	4.3636	0.0009	0.1843	0.7298
21	3053	Wax Candles	12	0.0511	0.0095	0.0320	0.0223
22	3101	Heavy Inorganic Chemicals	10	1.9751	0.0024	0.2817	0.6043
23	3142	Washing Soap & Powder	10	1.4608	0.0282	0.3463	0.5250
24	3199	Agarbathis, Misc, Chemicals	95	2.2511	0.0007	0.0959	0.3179
25	3209	Non ceramic Bricks, Tiles	12	8.5372	0.1667	3.4434	2.9122
26	3261	Marble Slabs, Stone Polished	14	0.3158	0.0076	0.0630	0.0816
27	3289	Asbestos Cement Products, Glazed Tiles	33	4.2067	0.0032	0.0325	0.0495
28	3291	Concrete Blocks, Hume Pipes	11	0.1200	0.0023	0.0363	0.0384
29	3311	Castings & Forgings	47	3.7017	0.0055	0.7749	0.8853
30	3402	Steel Trunk, Accessories	12	0.6957	0.0068	0.1350	0.2127
31	3403	Moulding-Drums, Tanks, Metal Containers	18	0.3870	0.0088	0.0747	0.0863
32	3410	Structural Metal Products	79	0.6760	0.0052	0.1021	0.1056
33	3420	Iron Furniture, Aluminium Furniture	36	1.6354	0.0029	0.0834	0.2681
34	3435	Agricultural Handtools, Implements	134	5.1120	0.0086	0.7272	0.8173
35	3440	Electro Plating, Polishing, Enamelling	13	0.5255	0.0375	0.2362	0.1654
36	3452	Utensils	35	2.0135	0.0035	0.2538	0.3767
37	3499	Misc. Metal Products including wire mesh, Safety pins	14	0.3742	0.0038	0.0701	0.0967
38	3599	Industrial Machinery	10	0.1981	0.0095	0.0579	0.0556
39	3577	Parts, Accessories of m/c tools	21	0.4248	0.0046	0.0806	0.1307
40	3598	Parts, Accessories	14	0.1060	0.0080	0.0335	0.0274
41	3599	Gen. Engg.	134	1.6867	0.0194	0.1565	0.2026
42	3669	Misc. Electrical m/c Apparatus and Appliances	11	0.0362	0.0023	0.0175	0.0102
43	3748	Automobile parts and Acc.	10	0.2203	0.0093	0.0745	0.0823
44	3781	Bullock carts and Parts	20	1.2070	0.0067	0.2746	0.3087
45	9730	Auto, Scooter, Cycle repairing	36	0.3330	0.0167	0.1120	0.0942
46	9731	Auto, Scooter Servicing	18	0.6113	0.0500	0.1693	0.1378
47	9760	M/c & servicing Pumpsets	12	0.6483	0.0444	0.1659	0.1769

Table 5b : Energy Analysis of Small Scale Sector : An Overview

Computation of Specific Energy Consumption (Rupees)							
Sl.No.	Product Code	Description	Number of Industries	Maximum	Minimum	Mean	Standard Deviation
1	2018	Ice Candy, Cream, Baby Milkfood	8	0.1346	0.0161	0.0696	0.0408
2	2041	Milling of foodgrains	16	0.3462	0.0031	0.0111	0.1398
3	2042	Paddy Hulling, Rice	123	0.3886	0.0011	0.1058	0.0993
4	2043	Fried Gram	14	0.1629	0.0002	0.0373	0.0589
5	2051	Bread, Cake, Biscuits	24	0.3000	0.0038	0.0800	0.0804
6	2053	Biscuits	12	0.2700	0.0052	0.0810	0.0846
7	2110	Oil, Vanaspathy	43	0.1583	0.0022	0.0351	0.0416
8	2132	Coffee Powder	13	0.4862	0.0050	0.0802	0.1272
9	2150	Cold Storage	15	0.4667	0.0250	0.0214	0.2232
10	2641	Ready made Garments	44	0.2075	0.0004	0.0248	0.0405
11	2790	Wood Saving	90	0.3750	0.0024	0.0841	0.0784
12	2721	Wooden Packing	12	0.1022	0.0037	0.0251	0.0290
13	2760	Wooden Furniture	47	0.2000	0.0013	0.0361	0.0400
14	2799	Wooden Photoframes, Articles	15	0.1131	0.0017	0.0354	0.0366
15	2850	Printing & Binding	166	0.5503	0.0019	0.0296	0.0489
16	2890	Commercial Printing	21	0.2158	0.0050	0.0257	0.0449
17	2913	Leather Chappals	15	0.1167	0.0019	0.0294	0.0378
18	3004	J.K. Tyre Retreading	23	0.2545	0.0030	0.0873	0.0741
19	3035	Polythene Bags	11	0.1992	0.0010	0.0354	0.0555
20	3039	Plastic Foam Products, Buttons	35	0.0968	0.0029	0.0584	0.0261
21	3053	Wax Candles	12	0.0462	0.0020	0.0144	0.0144
22	3101	Heavy Inorganic Chemicals	10	0.1728	0.0010	0.0649	0.0651
23	3142	Washing Soap & Powder	10	0.0714	0.0042	0.0292	0.0230
24	3199	Agarbathis, Misc, Chemicals	95	0.8657	0.0003	0.0428	0.1306
25	3209	Non ceramic Bricks, Tiles	12	0.3383	0.0667	0.2501	0.1028
26	3261	Marble Slabs, Stone Polished	14	0.1276	0.0036	0.0286	0.0339
27	3289	Asbestos Cement Products, Glazed Tiles	33	0.0260	0.0006	0.0129	0.0143
28	3291	Concrete Blocks, Hume Pipes	11	0.0480	0.0009	0.0174	0.0169
29	3311	Castings & Forgings	47	0.7800	0.0022	0.1422	0.1523
30	3402	Steel Trunk, Accessories	12	0.3478	0.0027	0.0485	0.0885
31	3403	Moulding-Drums, Tanks, Metal Containers	18	0.1400	0.0038	0.0341	0.0343
32	3410	Structural Metal Products	79	0.2000	0.0036	0.0427	0.0362
33	3420	Iron Furniture, Aluminium Furniture	36	0.2900	0.0014	0.0291	0.4820
34	3435	Agricultural Handtools, Implements	134	0.2500	0.0025	0.0639	0.0826
35	3440	Electro Plating, Polishing, Enamelling	13	0.2400	0.0225	0.0982	0.0807
36	3452	Utensils	35	0.1837	0.0015	0.0560	0.0565
37	3499	Misc. Metal Products including wire mesh, Safety pins	14	0.0572	0.0019	0.0245	0.0199
38	3599	Industrial Machinery	10	0.0760	0.0047	0.0307	0.0222
39	3577	Parts, Accessories of m/c tools	21	0.3333	0.0049	0.0513	0.0766
40	3598	Parts, Accessories	14	0.0733	0.0046	0.0233	0.0196
41	3599	Gen. Engg.	134	0.3600	0.0100	0.1003	0.0946
42	3669	Misc. Electrical m/c Apparatus and Appliances	11	0.0234	0.0015	0.0102	0.0064
43	3748	Automobile parts and Acc.	10	0.0748	0.0055	0.0188	0.0209
44	3781	Bullock carts and Parts	20	0.2500	0.0012	0.0552	0.0582
45	9730	Auto, Scooter, Cycle reparing	36	0.2133	0.0083	0.0553	0.0438
46	9731	Auto, Scooter Servicing	18	0.4438	0.0200	0.0963	0.0968
47	9760	M/c & servicing Pumpsets	12	0.2980	0.0178	0.0797	0.0790

survey cover 153 industries from different places within Karnataka State, India. These industries fall in the group 204 (among 3 code group of National Industry Code ; coded by Central Statistical Organization, Govt. of India). The different subgroups and number of industries in our sample are as follows :

Product/Output	No.of Industries	Subgroup (National Industry Code)
Flour mills	16	204.1
Dehusking of Paddy (Paddy hulling)	123	204.2
Fried gram	14	204.3

Industries which carry out dehusking of paddy are located in rural areas (subgroup 204.2). These industries are primarily agricultural. Since subgroup 204.2 has a large number of samples and is homogenous in nature, it is also taken up for further detailed analysis.

Methodology

In this section we discuss the methodolgies used to carryout the energy analysis. The various stages of analysis are :

1. Study of SEC so as to find out whether there are any disparities in the levels of energy consumption within a sector.

II. Establishment of relationship amongest various parameters like En (Energy), Pr (Production), SEC (Specific Energy Consumption), Energy Intensity (EI) and PPCU (Percentage Production Capacity Utilisation).

Techniques adopted for this purpose are :

(a) Principal component analysis,

(b) Linear/Non-linear regression analysis : straight line, quadratic parabola, hyperbola, exponential and power law relationships have been tried.

A. Regression Analysis for Sector 204 was done for the following cases :

(1) All industries in sector 204 (our sample size is 153).

(2) Partial removal of scatter : by removing the industries whose individual energy consumption is greater than the sum of average energy consumption plus twice Standard deviation.

(3) Further removal of scatter : By organising the data into a more compact form without obscuring the essential information contained in the values. This is accomplished by grouping the data : (i) industries are grouped on production range at an interval of Rs. 0.5 lakh in the bin range of 0 to 9 lakhs. (ii) industries are grouped on percentage production capacity utilisation at an interval of 5% in the bin range of 0 to 100%.

B. Homogenous Sector : Subgroup 204.2 (dehusking of Paddy)

Analyses similar to that for sector 204 were carried out for Subgroup 204.2.

(1) Consider all industries;

(2) consider industries using only electricity. Scatter is high even after these operations. Hence, further analyses were carried out by removing scatter through grouping of industries.

(3) Districtwise analysis : regression analysis was carried out for selected districts having samples greater than 12.

III. Finally, possible energy savings in sector 204 and Subgroup 204.2 due to better utilisation of full installed production capacity were also calculated.

Results and Discussions

We have performed the different types of analyses as illustrated in the methodology section. Results are explained below.

ANALYSIS OF ENERGY USE IN FOOD GRAIN PRODUCTS SECTOR

For the food grain products sector, energy analyses were done to explore the variations in individual parameters like (i) Specific Energy Consumption (SEC), (ii) Percentage Production Capacity Utilisation (PPCU).

Table 6a lists the variations in the two parameters—specific energy consumption (S.E.C.) and Percentage Production Capacity Utilisation (PPCU)—for each district. Minimum, maximum and standard deviation values are computed for both. We can see from table 6a that SEC (energy consumed in rupees for a rupee of production) varies from a minimum of 0.01 to a maximum of 0.07 for Raichur, from a minimum of 0.01 to 0.38 for Bangalore, from a minimum of 0.11 to a maximum of 0.43 for Hassan district. The standard deviation computed gives an indication of the variation of SEC and percentage production capacity within a district and for the entire state. About 60 industries out of 153 industries are utilising less than 50% of their installed production capacity.

Apart from this, a look at the type of energy resources (table 6b) shows that industries using energy

Table 6a : Districtwise Data for Sector 204, Computation of Energy INtensity & Percent Production Capacity

District	Number of Industrial Units Studied	Specific Energy Consumption EN. rs/Pr. rs Maximum	Minimum	Average	STD.	Percent Production Capacity Maximum	Minimum	Average	STD.
Bangalore	12	0.38	0.01	0.16	0.16	50.00	30.00	43.33	9.43
Bellary	5	0.16	0.04	0.08	0.04	69.00	5.00	49.40	23.38
Chitradurga	10	0.27	0.02	0.13	0.07	62.12	42.35	52.38	5.89
Dharwad	12	0.38	0.01	0.17	0.14	67.67	7.93	36.89	16.74
Hassan	8	0.43	0.11	0.22	0.11	100.00	47.02	73.31	18.38
Kodagu	8	0.19	0.02	0.06	0.06	81.82	33.33	59.39	14.93
Kolar	5	0.13	0.06	0.09	0.03	67.50	57.60	61.70	4.22
Mandya	17	0.24	0.01	0.08	0.08	80.00	32.00	55.05	13.25
Mysore	15	0.22	0.02	0.06	0.07	93.48	40.00	60.72	17.24
Uttara Kanada	7	0.28	0.02	0.10	0.10	65.00	17.00	44.00	15.62
Raichur	10	0.07	0.01	0.02	0.02	88.89	23.75	57.17	18.60
Shimoga	22	0.35	0.01	0.12	0.10	94.92	8.00	51.56	20.82
Dakshina Kannada	14	0.27	0.04	0.14	0.07	80.00	55.00	65.31	8.46
Tumkur	8	0.28	0.03	0.13	0.09	90.00	60.00	74.50	11.45
Maximum		0.430	0.11	0.22		100.00	60.00	74.50	
Minimum		0.071	0.01	0.02		50.00	5.00	36.89	
Mean		0.259	0.026	0.0111		77.88	32.78	56.05	

Table 6b : Industries Using firewood, Diesel etc.

District	S.E.C.	P.P.C.U.
Uttara Kannada	0.28	37
Shimoga	0.28	43.2
Tumkur	0.28	62.5
Shimoga	0.3	40
Sharwad	0.3234	40
Shimoga	0.35	40
Bangalore	0.375	45
Dharwad	0.3846	57.92
Hassan	0.43	47.01

resources like firewood, diesel etc. (other than electricity) have higher specific energy costs. Their SEC values varies from a minimum of 0.28 to a maximum of 0.43. Whereas for the industries using only electricity, SEC varies from 0.01 to 0.30 (Table 6c). These industries have a uniform technology and the wider range in SEC suggests a possibility of energy conservation in this sector.

QUANTITATIVE RELATIONSHIPS AMONG VARIABLES En, Pr, EI, SEC AND PPCU.

PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (P.A.C.) is tried on our data to obtain a set of independent variables so that we can later identify relationships amongst variable. P.C.A. is a method [4] whereby a set of variables is transformed into a new set of composite variables (components) which are uncorrelated (orthogonal) to one another. The reduction of dimensionality and the ability of the method to remove correlations between variables is often the sole basis for their use. For our set of data, the application of principal component analysis seemed did not yield any conclusive results. Hence, we looked at regression analysis.

REGRESSION ANALYSIS

In this section we apply regression analysis to find out the relationships among

(i) Energy consumption (En) and Production (Pr),

(ii) Energy (En) and Percentage Production Capacity Utilisation (PPCU),

(iii) Specific Energy Consumption (SEC) and Production (Pr),

(iv) Specific Energy Consumption (SEC) and the Percentage Production Capacity Utilisation (PPCU),

Table 6c : Industries Using Only Electicity

District	S.E.C.		P.P.C.U.
Bellary	0.07	(max.)	55.00
Chitradurga	0.04	(min.)	69.00
Dharwad	0.27	(max.)	50.00
	0.08	(min.)	62.12
Dharwad	0.24	(max.)	35.00
	0.02	(min.)	67.67
Hassan	0.19	(max.)	33.33
	0.02	(min.)	80.00
Kodagu	0.19	(max.)	32.00
	0.03	(min.)	60.00
Kolar	0.13	(max.)	50.00
	0.06	(min.)	67.50
Mandya	0.24	(max.)	42.67
	0.03	(min.)	70.00
	0.03	(min.)	67.08
Mysore	0.22	(max.)	45.00
	0.02	(min.)	69.17
Uttara Kannada	0.28	(max.)	47.00
	0.02	(min.)	65.00
Raichur	0.07	(max.)	57.17
	0.01	(min.)	88.89
Shimoga	0.30	(max.)	43.00
	0.01	(min.)	92.55
Dakshina Kannada	0.27	(max.)	45.00
	0.04	(min.)	80.00
Tumkur	0.28	(max.)	42.50
	0.03	(min.)	60.00

(v) Energy Intensity (EI) and Production (Pr),

(vi) Energy Intensity (EI) and Percentage Production Capacity Utilisation,

Energy and Production

To study the effect of energy consumption on the efficiency of production, detailed analyses were carried out.

The correlation between energy consumptin (En) and production (Pr) is found to be 0.83. We now apply regression analysis to find out the type of this relationship - linear, parabola, hyperbola, exponential or powerlaw. The results are given in table 7a. The relationship could be either linear, parabola or powerlaw. Since the percentage error is high in all these cases, we can infer that the scatter is high, and filtering is needed to removal the scatter. The best relationship obtained after partial removal of scatter was powerlaw; Even in this case the percentage error is still high. So the next step was to remove the scatter further by grouping the industries based on (a) actual production and (b) Percentage Production Capacity Utilisation.

The best relationship obtained from these analyses is powerlaw, as the percentage error for powerlaw is low compared to that of linear and parabola cases. The error for powerlaw relationship, in the case of grouping industries on production, is 3.17%. While in case of grouping industries on Percentage Production Capacity Utilisation it is 5.97%. Hence the best fit relationship for Sector 204 is,

$En = 136.20 (Pr)^{0.23}$ (industries grouped based on actual production]

$En = 134.70 (Pr)^{0.22}$ [Industries grouped based on percentage production capacity]

Thus, variation in exponent B is from 0.36 (considering all industries without filteration) to 0.22 (with removal of scatter). Since Sector 204 is not homogenous, we looked at Subgroup 204.2 (dehusking of paddy) next.

Regression analysis was carried out for the Subgroup 204.2, in order to arrive at quantitative estimates of the response of the energy consumption to production in a homogenous Sector. Results are tabulated in table 7b. There are 123 industries in our sample. The relationship between Energy Consumption (En) and Production (Pr) is found to be either linear, or powerlaw. (The error in both cases are high : 18.14 for linear, 16.44 for powerlaws). After the partial elimination of scatter, the best relationship between variables En and Pr was found to be $En=63.06 (Pr)^{0.39}$. But the error of 15.56% shows that the scatter still persists. In order to arrive at uniformity, and thus to remove possible further scatter, we considered only those industries in Subgroup 204.2 which use electricity as the only energy source. There were 118 industries (out of 123 industries in our sample) using only electricity. The least squares analysis was carried out for these 118 industries ; the relationship between Energy consumption and Production was found to be either linear (error 8.40%) or powerlaw (percentage error 6.23). The best relationship obtained from least squares analysis after the partial elimination of scatter is powerlaw (% error 4.86); the equation is given by $En = 55.90 (Pr)^{0.42}$.

For grouped data also the relationship is powerlaw as given by:

$En = 118.56 (Pr)^{0.28}$ [In case of grouping done on actual production]

and

$En = 139.08 (Pr)^{0.26}$ [In case of grouping done on percentage production capacity utilisation].

Table 7a : Regression Analysis of Variables En and Pr for Sector 204

			X : Independent variables = Pr	Y : Dependent variable = En					
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	153	Corr. coef (r)	0.82	0.8366	0.4	0.64	0.83	
			% error of Y est	20.73	21.364	50.34	53.89	20.04	$En = 102.22 (Pr)^{0.34}$
(b)	Removal of scatter Partially	149	Corr. coef (r)	0.67	0.7	0.16	0.41	0.69	
			% error of Y est	9.51	9.28	14.82	15.33	8.99	$En = 122.15 (Pr)^{0.29}$
(c)	**Removal of scatter further by grouping**								
i.	on actual production at a frequency of Rs. 0.5 lakhs	16	Corr. coef (r)	0.83	0.87	0.67	0.84	0.97	
			% eoor of Y est	5.97	4.06	5.28	32.37	3.17	$En = 136.20 (Pr)^{0.23}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.907	0.915	0.397	0.71	0.96	
			% error of Y est	7.04	6.73	22.0	28.3	5.97	$En = 134.70 (Pr)^{0.22}$

The value of exponent varies from 0.43 (considering all industries) to 0.26 (after filtration).

From these analysis, for sector 204 and Subgroup 204.2, the general form of equation linking variables Energy consumption (En) and Production (Pr) is

$$En = A\ (Pr)^{B} \quad \ldots\ldots(1)$$

The value of exponent 'B' is less than unity for Sector 204 and Subgroup 204.2, and from this we can infer that the rate of growth of energy consumption is slower than that of production. This illustrates a possibility of energy savings in these sectors. Fig. 5 gives the plot of Energy with reference to Production on logarithmic scales. Straight line in Fig.5 is the linearised form of equation (1) with slope 'B'.

In order to understand the variations in Energy Consumption with reference to Production and rate of growth, we need to look at the dynamic energy consumption rate. We can get the dynamic consumption by differentiating Engery with reference to Production given by

$$\frac{d\ En}{d\ Pr} = A \times B\ (Pr)^{B-1} \quad \ldots\ldots(2)$$

The value of 'B' is less than unity both for Sector 204 (0.23) and Subgroup 204.2 (0.26); hence dEn/dPr decreases sharply with increase in Production which means, that the Energy Consumption rate slows down with increase in Production.

DISTRICTWISE ANALYSIS

In order to understand spatial variations in energy consumption function, the regression analysis was carried out separately for some selected districts.

Since the percentage error for powerlaw is less compared to other, the best fir for Energy and Production for the districts Shimoga, Mandya, Mysore and coastal districts (Dakshina Kannada + Uttara Kannada) are powerlaw. The variations in the value of exponent 'B' from 0.30 (for Shimoga) to 0.61 (for Dakshin Kannada + Uttara Kannada) means, that there exist districtwise disparities in energy consumption.

Energy and Percentage Production Capacity Utilisation

In the previous section, it was noticed that the energy consumption grows at slower rate with the

Table 7b : Regression Analysis of Variables En and Pr for Subgroup 2042

			X : Independent variables = Pr	Y : Dependent variable = En				
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	123	Corr. coef (r)	0.70	0.7046	0.437	0.508	0.699	
			% error of Y est	18.14	23.03	30.95	30.005	16.445	$En = 51.95\ (Pr)^{0.43}$
(b)	Removal of scatter partially	119	Corr. coef (r)	0.56	0.611	0.485	0.425	0.604	
			% error of Y est	25.09	23.03	40.24	47.31	15.56	$En = 63.06\ (Pr)^{0.30}$
	Considering industries using only electricity								
(c)	Considering all industries using electricity	118	Corr. coef (r)	0.71	0.709	0.439	0.522	0.689	
			% error of Y est	8.405	9.522	45.6	30.64	6.23	$En = 55.90\ (Pr.)^{0.44}$
(d)	Removal of scatter partially	114	Corr. coef (r)	0.571	0.6234	0.4923	0.441	0.62	
			% error of Y est	6.355	5.778	34.6	21.29	4.866	$En = 55.90\ (Pr)^{42.0}$
(e)	(1) **Districtwise regression analysis**								
	Shimoga	29	Corr. coef (r)	0.635	0.6817	0.2756	0.5157	0.602	
			% error of Y est	14.897	14.391	21.4	20.449	9.47	$262.70\ (Pr)^{0.30}$
	Mandya	12	Corr. coef (r)	0.718	0.70	0.35	0.50	0.72	
			% error of Y est	15.38	14.36	67.4	36.44	12.73	$En = 40.68\ (Pr)^{0.42}$
	Mysore	13	Corr. coef (r)	0.96	0.97	0.38	0.74	0.98	
			% error Y est	8.2	6.65	40.0	41.88	3.17	$En = 5.70\ (Pr)^{0.80}$
	Dakshina Kannada + Uttara Kannada + Kodagu	22	Corr. coef (r)	0.529	0.521	0.3827	0.2846	0.509	
			% error of Y est	13.53	12.5	15.94	82.1	6.81	$En = 12.83\ (Pr)^{0.61}$
	(2) **Removal of scatter further(Subgroup 2042) by grouping based**								
i.	On actual production at a frequency of 0.5 lakhs	16	Corr. coef (r)	0.453	0.464	0.381	0.417	0.532	
			% error of Y est	20.03	20.09	15.93	10.24	9.51	$En = 118.56\ (Pr)^{0.25}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.696	0.706	0.70	0.61	0.698	
			% error of Y est	6.72	6.63	18.7	24.68	4.73	$En = 139.08\ (Pr)^{0.25}$

increase in production. The production of an industry normally increases with increased utilisation of installed production capacity. Hence to make a quantitative estimate of the response of percent utilisation of installed production capacity on energy consumption, regression analysis for Energy (En) with Percentage Production Capacity Utilisation (PPCU) was carried out Sector 204 and Subgroup 204.2. Results are tabulated in tables 8a and 8b respectively.

REGRESSION ANALYSIS

SECTOR 204

Initially least squares analysis was carried out for Sector 204 considering all industries. Linear, parabola and power law relationships between En and PPCU have 8.21%, 8.27% and 8.92% errors respectively. Then scatter was reduced partially, and the relationship was found to be powerlaw, with an error 7.91%. In the next step, grouping of the industries based on actual production was done. The best fit in this case in En = 1082.70 $(PPCU)^{0.54}$. In order to look at the role of percent utilisation of installed production capacity on Energy consumption in a homogenous Sector, Subgroup 204.2 is also looked at.

SUBGROUP 204.2

In order to make quantitative estimates of the percent utilisation of installed production capacity on energy in a homogenous sector, both linear and curvilinear equations were tried. The relationship was found to be powerlaw. The results are tabulated in table 8b.

The value of 'B' less than one, 0.54 (for Sector 204) and 0.79 (for Subgroup 204.2), which means that the energy consumption of an industry decreases with

Table 8a : Regression Analysis of Variables in And PPCU for Sector 204.

		X : Independent variables = PPCU		Y : Dependent variable = En					
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	153	Corr. coef (r)	0.109	0.1304	0.048	0.043	0.0272	
			% error of Y est	8.21	8.27	23.5	26.63	8.92	$En = 9749.55 (PPCU)^{0.535}$
(c)	**Removal of scatter further by grouping**								
i.	on actual production at a frequency of Rs. 0.5 lakhs	16	Corr. coef (r)	0.28	0.288	0.57	0.425	0.539	
			% error of Y est	16.23	16.21	16.75	32.5	8.45	$En = 2041.02 (PPCU)^{0.84}$
ii.	on percentage production capacity at a frequency	19	Corr coef (r)	0.38	0.40	0.28	0.33	0.57	
			% error of Y est	15.37	15.37	16.96	28.33	12.84	$En = 2041.02 (PPCU)^{0.34}$

Table 8b : Regression Analysis of Variables En and PPCU for Subgroup 2042.

		X : Independent variables = PPCU		Y : Dependent variable = En					
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	123	Corr. coef (r)	0.11	0.116	0.017	0.013	0.31	
			% error of Y est	9.72	9.72	21.41	23.23	6.24	$En = 9277.18 (PPCU)^{0.667}$
	Considering industries using only electricity								
(c)	Considering all industries using electricity	118	Corr. coef (r)	0.12	0.125	0.012	0.011	0.33	
			% error of Y est	8.9	8.65	20.4	21.99	5.65	$En = 9600.12 (PPCU)^{0.667}$
(d)	Removal of scatter partially	119	Corr. coef (r)	0.142	0.146	0.015	0.015	0.36	
			% error of Y est	7.9	8.34	20.1	21.9	4.34	$En = 9245 (PPCU)^{0.629}$
(e)	**Removal of scatter further(Subgroup 2042) by grouping based**								
i.	on percentage production capacity at a freq. of 5%	16	Corr. coef (r)	0.183	0.3325	0.4067	0.2932	0.439	
			% error of Y est	18.77	19.34	11.97	10.24	9.633	$En = 620.87 (PPCU)^{0.79}$
ii.	on actual production at a frequency of 0.5 lakhs	19	Corr. coef (r)	0.238	0.2387	0.1048	0.1816	0.297	
			% error of Y est	9.10	9.10	10.53	24.68	6.56	$En = 2872.41 (PPCU)^{0.12}$

increased utilisation of installed production capacity. This means increased energy efficiency for higher utilisation of production capacity. This is illustrated further in the next section.

Specific Energy Consumption and Production

The Specific Energy Consumption (SEC) gives an idea of how much energy was consumed for a particular quantum of production. SEC may vary for different production quanta. It can also vary for diferent districts. Hence, regession analysis were carriedout to explore the relationship between SEC and Pr. Fig. (6) gives the plot of variables SEC and Pr and it shows a decline in the value of Specific Energy Consumption with increase in the production. Regression analyses were carried out to find out trends for the Sector 204 and Subgroup 204.2. Results are tabulated in tables 9a and 9b respectively.

REGRESSION ANALYSIS

SECTOR 204

From the regression analysis for Sector 204, it is evident that there exists a relationship between SEC and Pr. Percentage errors for both linear and curvilinear equations are high. With the removal of scatter partially, the relationship is either linear (error of 7.38%) or powerlaw (with an error of 6.87%). Hence, another stage of filteration was carried out by grouping industries

(a) SEC = 130.20 $(Pr)^{-0.78}$, based on actual production

(b) SEC = 134.70 $(Pr)^{-0.77}$, based on PPCU

Thus decline in the value of SEC with the removal of scatter is noticed. That is, SEC varies at the rate of -1/1.56 of production (with scatter) to -1/1.31 of production (without scatter). We now look at homogenous Sector (Subgroup 204.2)

SUBGROUP 204.2

The percentage error is low in the regression analyses carried out for powerlaw. Hence, the best relationship between SEC and Pr is powerlaw as given in table 9b.

Thus from these analyses, it is evident that the relationship for Specific Energy Consumption and Production is of the type.

$SEC = C\ (Pr)^{-D}$

The negative exponent 'D' indicates a decline in the value of Specific Energy Consumption (SEC) with increase in production. Fig. (7) gives the plot of Specific Energy Consumption with reference to production on logarithmic scales.

The decline in SEC with increase in production gives an idea about the possible energy saving in this sector:

(i) by moving industries in a lower production group to a higher group and,

(ii) by improving utilisation of an industry to its maximum value (closer to optimum value):

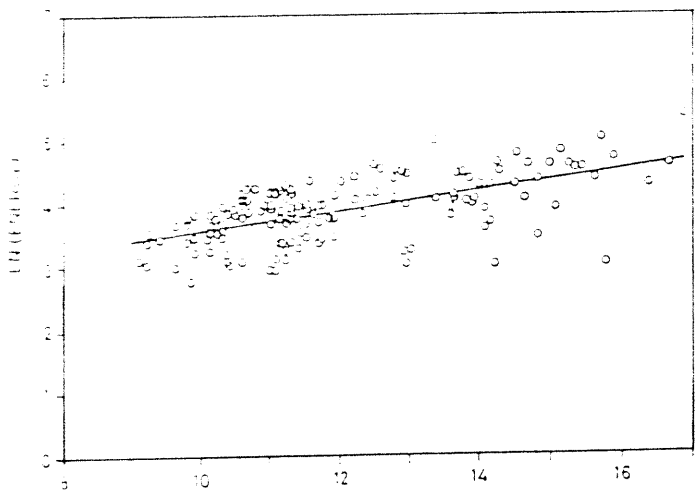
The districtwise analyses were also carried out for the selected districts. It reveals wide variation in the value of the exponent 'D' from district to district from —0.39 for Mysore to -0.69 for Shimoga. This intradistrict variation of 76% gives an idea about the possible better utilisation of energy in these districts.

Specific Energy Consumption and Percentage Production Capacity Utilisation

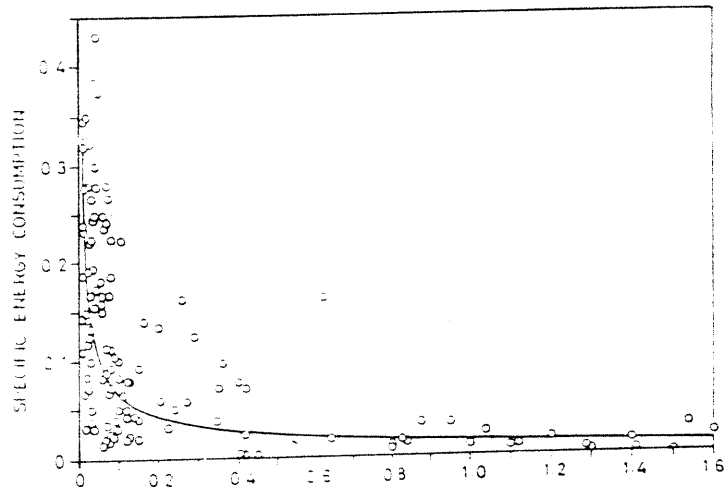
In the previous section, we noticed the decline in the value of SEC with increase in production. The production of an industry increases normally with increased utilisation

Table 9a : Regression Analysis of Variable Sec and Pr for Sector 204

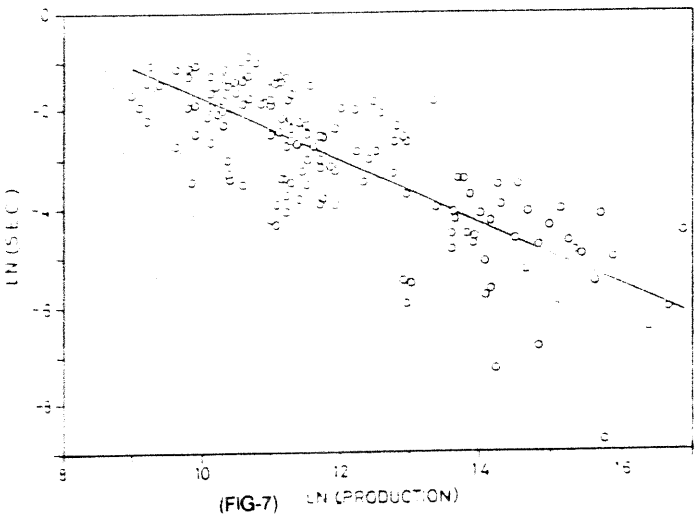
		X : Independent variables = PPCU		Y : Dependent variable = En					
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	153	Corr. coef (r)	0.3	0.44	0.277	0.5057	0.785	
			% error of Y est	9.3	8.86	17.02	9.48	8.67	$SEC = 102.32\ (Pr)^{-0.64}$
(b)	Removal of scatter partially	149	Corr. coef (r)	0.44	0.4462	0.059	0.254	0.468	
			% error of Y est	7.38	7.38	95.83	13.38	6.87	$SEC = 122.15\ (Pr)^{-0.69}$
(c)	**Removal of scatter further by grouping**								
i.	on actual production at a frequency of Rs. 0.5 lakhs	16	Corr. coef (r)	0.4	0.78	0.72	0.6	0.94	
			% error of Y est	26.67	18.03	30.08	102.6	3.67	$SEC = 136.20\ (Pr)^{-0.76}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.42	0.689	0.567	0.563	0.93	
			% error of Y est	26.73	21.37	33.04	53.77	16.73	$SEC = 134.70\ (Pr)^{-0.77}$



(FIG-5) LN (PRODUCTION)



(FIG-6) PRODUCTION (MILLIONS IN Rs.)



(FIG-7) LN (PRODUCTION)

Table 9b : Regression Analysis of Variables Sec and Pr for Subgroup 2042

Sl. No		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
			X : Independent variables = PPCU		Y : Dependent variable = En				
(a)	Considering all industries	123	Corr. coef (r)	0.40	0.5021	0.4657	0.60	0.743	
			% error of Y est	17.82	17.01	19.69	18.79	11.69	SEC = 63.06 (Pr)$^{0.67}$
(b)	Removal of scatter partially	119	Corr. coef (r)	0.423	0.526	0.4618	0.6031	0.734	
			% error of Y est	15.85	15.75	10.36	17.37	11.30	SEC = 63.06 (Pr)$^{0.61}$
	Considering industries using only electricity								
(c)	Considering all industries using electricity	118	Corr. coef (r)	0.4161	0.519	0.4866	0.6023	0.737	
			% error of Y est	16.64	15.83	40.53	48.59	14.81	SEC = 3782 (Pr)$^{0.66}$
(d)	Removal of scatter partially	114	Corr. coef (r)	0.431	0.5338	0.4545	0.6039	0.726	
			% error of Y est	13.54	14.69	48.63	52.58	12.23	SEC = 55.90 (Pr)$^{0.66}$
(e)	(1) **Districtwise regression analysis**								
	Shimoga	29	Corr. coef (r)	0.419	0.577	0.2557	0.6148	0.8352	
			% error of Y est	18.56	10.90	11.38	13.86	9.49	SEC = 256.82 (Pr)$^{0.88}$
	Mysore	13	Corr. coef (r)	0.4	0.58	0.6	0.50	0.81	
			% error of Y est	39.2	41.45	51.21	48.63	25.67	SEC = 6.33 (Pr)$^{0.36}$
	Mandya	12	Corr. coef (r)	0.35	0.54	0.6	0.68	0.82	
			% error of Y est	28.27	25.57	31.58	30.12	11.26	SEC = 40.68 (Pr)$^{0.56}$
	Dakshina Kanada + Uttara Kannada + Kodagu	22	Corr. coef (r)	0.38	0.469	0.5138	0.4552	0.666	
			% error of Y est	15.47	17.35	18.26	98.75	13.29	SEC = 12.83 (Pr)$^{0.49}$
	(2) **Removal of scatter further (Subgroup 2042) by grouping based**								
i.	on actual production at a frequency of 0.5 lakhs	16	Corr. coef (r)	0.56	0.3018	0.7029	0.698	0.847	
			% error of Y est	18.05	21.81	26.29	67.75	13.96	SEC = 118.56 (Pr)$^{0.71}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.6	0.756	0.90	0.814	0.929	
			% error of Y est	20.85	17.19	21.61	60.00	14.10	SEC = 139.88 (Pr)$^{0.73}$

of installed production capacity. Hence to ascertain the role of percent utilisation of installed production capacity on energy efficiency of a industry, the regression analyses are carried out for sector 204 and Subgroup 204.2 respectively.

REGRESSION ANALYSIS

In the method of least squares, both linear and curvilinear equations were tried. The best relationship is powerlaw as given in table 10a for sector 204, and in table 10b for homogenous subgroup 204.2.

Table 10a : Regression Analysis of Variables Sec and PPCU for Sector 204

Sl. No		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
			X : Independent variables = PPCU		Y : Dependent variable = En				
(a)	Considering all industries	153	Corr. coef (r)	0.256	0.3274	0.1	0.236	0.48	
			% error of Y est	10.79	10.75	52.75	74.13	9.65	SEC = 2.46 (PPCU)$^{-0.824}$
(b)	Removal of scatter frequency of Rs. 0.5 lakhs	149	Corr. coef (r)	0.23	0.24	0.03	0.51	0.56	
		16	% error of Y est	10.74	10.76	74.21	31.46	9.25	SEC = 2.20 (PPCU)$^{-0.79}$
(c)	**Removal of scatter further by grouping**								
i.	on actual production at a frequency of Rs. 0.5 lakhs	16	Corr. coef (r)	0.71	0.87	0.31	0.51	0.56	
			% error of Y est	37.41	14.2	26.75	101.01	8.28	SEC = 2.10 (PPCU)$^{-1.32}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.506	0.7523	0.4897	0.702	0.798	
			% error of Y est	25.45	19.45	32.73	42.9	6.12	SEC = 1.25 (PPCU)$^{-0.87}$

Table 10b : Regression Analysis of Variables Sec and PPCU for Subgroup 2042.

			X : Independent variables = PPCU	Y : Dependent variable = En				
Sl. No.		No of industries		Linear	Parabola	Hyperbola	Exponential	Log-Log	Probable relationship
(a)	Considering all industries	123	Corr. coef (r)	0.10	0.14	0.05	0.0118	0.78	
			% error of Y est	8.53	8.53	10.95	18.95	7.24	$SEC = 2.10 (PPCU)^{-0.79}$
(b)	Removal of scatter partially	119	Corr. coef (r)	0.16	0.22	0.057	0.03	0.74	
			error of Y est	8.25	8.31	10.72	20.38	7.21	$SEC = 2.11 (PPCU)^{-0.81}$
	Considering industries using only electricity								
(c)	Considering all industries using electricity	118	Corr. coef (r)	0.15	0.19	0.06	0.003	0.8	
			% error of Y est	7.9	7.65	11.0	19.25	6.54	$SEC = 2.30 (PPCU)^{-0.841}$
(d)	Removal of scatter partially	114	Corr. coef (r)	0.18	0.21	0.07	0.003	0.82	
			% error of Y est	6.54	6.7	10.95	18.9	4.24	$SEC = 2.30 (PPCU)^{-0.82}$
(e)	**Removal of scatter further(Subgroup 2042) by grouping based**								
i.	on actual production at a frequency of 0.5 lakhs	16	Corr. coef (r)	0.71	0.87	0.31	0.51	0.56	
			% error of Y est	37.41	14.2	26.75	10.01	8.28	$SEC 2.15 (PPCU)^{-1.32}$
ii.	on percentage production capacity at a freq. of 5%	19	Corr. coef (r)	0.506	0.7523	0.4897	0.702	0.798	
			% error of Y est	25.45	19.44	32.73	42.9	6.12	$SEC = 1.103 (PPCU)^{-0.97}$

The decline in the value of SEC with increased utilisation of installed production capacity and with increased production. Thus it is evident that energy saving is possible both in sector 204 and subgroup 204.2 with increased utilisation of installed production capacity.

Electrical Energy Intensity and Production

The Energy Intensity is the ratio of energy consumption in physical units (kWh) to Production in tonnes. This gives an idea about the energy consumption for an output of one kg. In nine districts (table 6b), 153 industries in our sample, are using fuel other than electricity. All these sources depending on the quantity used and their heat value are converted to common units of measurement, that is kWh. In order to find out the quantitative relationship among these variables (energy intensity and production), the regression analysis is carried out.

By method of least squares, the relationship is found to be powerlaw;

(a) by considering all industries
The relationship is $EI = 123.88 (Pr)^{-0.54}$
with correlation coefficient 0.748 and % error of 8.43

(b) by partial elimination of scatter ;
$EI = 87.88 (Pr)^{-0.52}$
with correlation coefficient of 0.75 and % error of 6.95

(c) removal of scatter further by grouping based on production of a industry; $EI = 102.81 (Pr)^{-0.709}$
with correlation coefficient of 0.83 and % error of 2.99.

This indicates the decline in the value of Energy Intensity with increase in the Production of industry. This may be due to the better utilisation of installed production capacity. Hence the regression analysis of variables Energy Intensity and Percentage Production Capacity Utilisation is carried out to explore the quantitative relationship and effect of better utilisation of installed production capacity on energy consumption.

By the method of least square, the relationship is powerlaw:

(a) considering all industries;
The relationship is $EI = 4.95 (PPCU)^{-0.74}$
with corelation coefficient of 0.311 and % error of 9.79,

(b) with the partial elimination of scatter (119 industries), the relationship is $EI = 4.30 (PPCU)^{-0.72}$
with correlation coefficient of 0.311 and % error of 8.37.

Energy Saving in Sector 204 and Subgroup 204.2

In the regression analyses pertaining to Specific Energy Consumption and Percentage Production Capacity Utilisation, SEC & PPCU, we noticed that considerable energy saving is possible by:

(i) Shifting industries to a higher production group and,

(ii) Improving installed capacity utilisation to maximum value.

Industries are grouped on actual production range at a frequency of 0.5 lakhs. Table 11a gives SEC and PPCU for grouped data. Since, the SEC decreases with production (Fig. 7), shifting of industries from one range to a higher range is adopted to find out the possible energy saving in sector 204 and subgroup 204.2. Shifting the industries in the production range of less than 0.5 lakh rupees to 0.5 - 1 lakh rupees group (hence tyrying to use installed production capacity at higher level than the existing level) yields an estimated energy savings of 49%. Last column in table 11b gives the cumulative saving in sector 204 by the method of shifting. Thus the average energy saved in this sector is 23.12%

If the industries are shifted by two group up (since the industries in the range less than 0.5 lakh rupees has only PPCU of 28.52%), the possible saving would be 62% and the overall average saving in sector 204 would be 38.46%. These results are tabulated in table 12a.

Table 11a : Computation of Sec & Percentage Production Capacity Utilisation (Sector 204).

Production Range	Number of Industries	PPCU	SEC
0.0-0.5 lakhs	44	28.52	0.2056
0.5-1.0 lakhs	37	53.59	0.1040
1.0-1.5 lakhs	13	47.95	0.0780
1.5-2.0 lakhs	2	69.46	0.0580
2.0-2.5 lakhs	3	68.16	0.0464
2.5-3.0 lakhs	3	57.60	0.0380
3.0-3.5 lakhs	2	69.50	0.0320
3.5-4.0 lakhs	2	46.06	0.0280
4.0-5.5 lakhs	5	54.65	0.0210
5.5-6.5 lakhs	2	63.00	0.0140
6.5-8.0 lakhs	2	64.00	0.0095
8.0-8.5 lakhs	4	56.14	0.0092
G.T.8.5 lakhs	34	63.26	0.0085

Table 11b : Possible Saving in Sector 204 (By Utilising full installed Capacity)

Sl No.	Pr range lakhs	SEC	EN (Act)	EN (act)cum	EN (EST)	EN(est) cum	By one Shift % Saving	Saving (cum)
1	0 To 0.5	0.205						
2	0.5 To 1	0.104	20563.42	20563.42	10401.28	10401.28	49.42	49.42
3	1 To 1.5	0.078	15601.93	36165.35	11700.00	22101.28	25.01	38.89
4	1.5 To 2	0.058	15600.00	51765.35	11600.00	33701.28	25.64	34.90
5	2 To 2.5	0.046	14500.00	66265.35	11601.79	45303.08	19.99	31.63
6	2.5 To 3	0.038	13922.15	80187.51	11400.00	56703.08	18.12	29.29
7	3 To 3.5	0.032	13300.00	93487.51	11200.00	67903.08	15.79	27.37
8	3.5 To 4	0.028	12800.00	106287.50	11200.00	79103.08	12.50	25.58
9	4 To 4.5	0.021	12600.00	118887.50	9513.20	88616.28	24.50	25.46
10	4.5 To 5	0.019	10570.22	129457.70	9500.00	98116.28	10.12	24.21
11	5 To 5.5	0.018	10450.00	139907.70	9900.00	108016.20	5.26	22.79
12	5.5 To 6	0.016	10800.00	150707.70	9600.00	117616.20	11.11	21.96
13	6 To 6.5	0.014	10400.00	161107.70	9100.00	126716.20	12.50	21.35
14	6.5 To 7	0.130	9800.00	170907.70	9100.00	135816.20	7.14	20.53
15	7 To 7.5	0.012	9750.00	180657.70	9000.00	144816.20	7.69	19.84
16	7.5 To 8	0.0095	9600.00	190257.70	7650.00	152466.20	20.31	19.86
17	8 To 8.5	0.0092	8128.12	198385.80	7820.00	160286.20	3.79	19.20
18	GT 8.5	0.0085	8280.00	206665.80	7652.47	167938.70	7.58	18.74
				210665.00		161621.00	23.13	

Table 11c Possible Energy Saving in Subgroup 2042 (by utilising full installed capacity)

Sl No	Pr Range lakhs	S.E.C	By Single shift method Energy	% Saving	% Saving (cum)
1	0 To 0.5	0.204	10208		
2	0.5 To 1	0.085	8500	58.37	58.37
3	1 To 1.5	0.064	9600	24.71	45.43
4	1.5 To 2	0.052	10400	18.75	38.00
5	2 To 2.5	0.046	11500	11.54	32.17
6	2.5 To 3	0.042	12600	8.70	27.71
7	3 To 3.5	0.038	13300	9.52	24.66
8	3.5 To 4	0.034	13600	10.53	22.57
9	4 To 4.5	0.032	14400	5.88	20.40
10	4.5 To 5	0.028	14000	12.50	19.46
11	5 To 5.5	0.027	14850	3.57	17.82
12	5.5 To 6	0.026	15600	3.70	16.44
13	6 To 6.5	0.022	14300	15.38	16.34
14	6.5 To 7	0.020	14000	9.09	15.78
15	7 To 7.5	0.019	14250	5.00	15.02
16	7.5 To 8	0.017	13600	10.53	14.72
17	8 to 8.5	0.015	13006	9.99	14.44
18	GT 8.5	0.013	11532	16.26	14.53
					18.68

Similar picture of inefficient energy consumption do exist in the case of the homogenous subgroup also (subgroup 204.2). To find out the possible saving in subgroup 204.2, similar computations were done for this case also. By utilising full installed production capacity in the range less than 0.5 lakh rupees and at Specific Energy Consumpton of 0.085, the energy saved would be 58.76%. The overall energy saving in subgroup 204.2 would be 18.67%. The results are tabulated in tables 11c and 12b respectively.

Actual production of paddy in Karnataka was 23,61,146 quintals that is Rs. 6,13,897,960. For hulling this quantity, we need 184.169 million units of electricity. By adopting the energy saving measures as mentioned above, we can save 55.25 million units in subgroup 204.2. This means a saving equivalent of 12.62 Mw generating capacity which is quite significant (in 6600 industries of subgroup 204.2 out of a total of 1,03,960 small scale industries in Karnataka).

Table 12a : The Possible Energy Saving in Sector 204 (shifting ind by two ranges)

Sl No	P-Range	S.E.C. Lakhs	Energy (act)	Energy (act. cum)	Energy (est)	Energy (est.cum)	% Saving	% Saving (cum)
1	0 To 0.5	0.205						
2	0.5 To 1	0.104						
3	1 To 1.5	0.078	30845.14	30845.14	11700	11700	62.07	62.07
4	1.5 To 2	0.058	20802.57	51647.71	11600	23300	44.24	54.89
5	2 To 2.5	0.046	19500.00	71147.71	11601	34901	40.50	50.94
6	2.5 To 3	0.038	17400.00	88547.71	11400	46301	34.48	47.71
7	3 To 3.5	0.032	16242.51	104790.20	11200	57501	30.05	45.13
8	3.5 To 4	0.028	15200.00	119990.20	11200.79	68701.79	26.32	42.74
9	4 To 4.5	0.021	14400.00	134390.20	9513.200	78214.99	33.94	41.80
10	4.5 To 5	0.019	14000.00	148390.20	9500	87714.99	32.14	40.89
11	5 To 5.5	0.018	11627.24	160017.40	9900	97614.99	14.86	39.00
12	5.5 To 6	0.016	11400.00	171417.40	9600	107214.9	15.79	37.45
13	6 To 6.5	0.014	11700	183117.40	9100	116314.9	22.22	36.48
14	6.5 To 7	0.013	11200	194317.40	9100	125414.9	18.75	35.46
15	7 To 7.5	0.012	10500	204817.40	9000	134414.9	14.29	34.37
16	7.5 To 8	0.009	10400	215217.40	7650	142064.9	26.44	33.99
17	8 to 8.5	0.0092	10200	225417.40	7820	149884.9	23.33	33.51
18	GT. 8.5	0.0085	8606.30	234023.70	7652.5	157537.4	11.08	32.68
				2338095		1438799	38.46	

Table 12 b : The Possible Energy Saving in Subgroup 2042 (two shift method, by utilizing full installed capacity)

Sl	Production Range	No. of Industries	S.E.C. Rs	Energy Rs.	% Saving	% Saving (cum)
1	0 To 0.5	35	0.204	10208		
2	0.5 To 1	34	0.085	8500		
3	1 To 1.5	11	0.064	9600	68.65	68.65
4	1.5 To 2	2	0.052	10400	38.82	58.01
5	2 To 2.5	3	0.046	11500	28.13	50.49
6	2.5 To 3	3	0.042	12600	19.23	44.34
7	3 To 3.5	2	0.038	13300	17.39	39.79
8	3.5 To 4	2	0.034	13600	19.05	36.68
9	4 To 4.5	3	0.032	14400	15.79	33.91
10	4.5 To 5	0	0.028	14000	17.65	32.02
11	5 To 5.5	0	0.027	14850	15.63	30.26
12	5.5 To 6	0	0.026	15600	7.14	28.11
13	6 To 6.5	0	0.022	14300	18.52	27.26
14	6.5 To 7	0	0.020	14000	23.08	26.91
15	7 To 7.5	0	0.019	14250	13.64	25.97
16	7.5 To 8	2	0.017	13600	15.00	25.26
17	8 to 8.5	4	0.015	13006	19.46	24.91
18	GT. 8.5	22	0.013	11532	24.63	24.89
						30.42

Conclusions

1. Out of 146 groups considered, the SEC values are higher for 34 groups. This means that there is a great potential for energy saving in these sectors.
2. Karnataka's map of small scale industries reveals uneven distribution of the industries amongest the various districts. Bangalore's share is very high, It has 21.41% of total number of industries and investment is 28.48% of total.
3. Districtwise, groupwise analysis of specific energy consumption show wide variations in every group. About 33 groups reveal ratios of maximum to minimum SEC greater than 10.
4. There exist a wide variation of energy intensity within a district and for the entire state.
5. Industries using energy resources like firewood, diesel etc. (other than electricity) have higher specific energy values in the order of 0.35 to 0.43. And industries using only electricity have specific energy consumption in the order of 0.1 to 0.3. Since these industries are homogenous, and have a uniform technology, the wider range in SEC values suggests a possibility of energy conservation in this sector.
6. Variation of En vs Pr, En vs PPCU, SEC vs Pr and SEC vs PPCU are all given by power law relationship.
7. By method of least squares, the best fit relationship for Energy and Production for food grain products sector and dehusking of paddy industries is powerlaw given by, Energy = A x (Production)^B.
8. Computation of dynamic Specific Energy Consumption (dEn/dPr) reveals that the rate of energy consumption is less than the rate of production. Also Energy Consumption rate slows down with the increase in production of a industry.
9. The exponent B in the relationship Energy = A x (Production)^B is an index of energy consumption. Wide disparity in value of exponent B (varies from 0.61 for Dakshina Kannada to 0.30 for Shimoga) from one district to another reveals intradistrict disparity in energy consumption and possible energy saving in this sector.
10. The rate of change in Energy Intensity or SEC of an industry decreases with increase in production.

    The negative exponent in power law relationship of SEC/EI vs Pr indicates decline in value of SEC with increase in production of a industry.
11. From the relationship SEC = C' x (PPCU)$^{-d}$ it is evident that Specific Energy Consumption of a industry decreases with better utilisation of installed production capacity.
12. A close look at the energy intensive industries in Sector 204 and Subgroup 204.2 reveals that these

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industries are utilizing only 50% of installed production capacity. The motor runs at lower power factor when it is underloaded. This leads to low efficiency. Utilisation of full installed capacity at improved energy efficiencies leads to a possible energy saving of 23 to 38% in this Sector, which is significant.

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