Energy utilisation in rural industries in Karnataka

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ENERGY

SYNOPSIS

Energy is a vital component in rural industries such as the Agro processing industries and the brick and tile industries. In rural areas, population pressure and low agricultural productivity are among factors forcing people into marginal and ecologically fragile lands. Forests are being logged to meet the energy demand of a region in addition to clearing forests for agricultural purposes to meet the demand of food. Soil erosion, siltation and floods are a consequence of the destruction of forests. The low productivity in agricultural lands and the lack of alternative employment opportunities in rural areas has resulted in large scale migration to urban areas in search of jobs. In this context, industries in rural areas would help in arresting rural migration to urban areas and help to improve the economic status of local people in the region. For the sustainable development of a region, industrialisation is to be supplemented with integrated energy planning approaches. It is therefore necessary to look for alternative sources of energy which are renewable in nature and which could be harnessed in a decentralised way. The energy efficiencies of end use devices could be improved and numerous opportunities exist for the development of industrial process with greater efficiencies.

Energy auditing carried out in sample rural industries has revealed a wide disparity in energy consumption to produce the same quantity of similar products. About 60% of the sample units have Percentage Production Capacity Utilisation (PPCU) less than 50% and higher Specific Energy Consumption (SEC) and Energy Intensity (EI). The wide variations in EI in the Cashew Industries from 4.49 kg of fuelwood per kg of kernel to 8.66 kg of fuelwood per kg of kernel reveals the scope for energy conservation to be in the order of 30 to 48%. It has been noticed that optimal utilisation

of installed capacity (better PPCU) would help in energy conservation. The energy analyses carried out reveals that the relationship between SEC and Production (Pr) fits a power law with an exponent less than one. This indicates an improvement of SEC with increase in production which, in turn, implies the optimal utilisation of installed production capacity.

An overview of the Small Scale Industries in Karnataka State, India, is also given in this paper from the point of their spatial distribution, investment costs, industrial growth rate and employment generation. Even though these aspects are not directly connected to the energy consumption patterns, they throw light on developmental aspects and hence indirectly influence energy and the environment.

INTRODUCTION

Our primary needs for energy - heat and light to sustain life on earth - are obtained from the sun. With increasing dependence on acquired forms of energy, energy has become an important need in out life. Generation, transportation/transmission, distribution and usage in end use devices are the main components in the energy system. Energy is obtained from resources, which can be broadly categorised as renewable and nonrenewable or depletable. These resources are converted in to a form desired by the end user. The conversion of energy from one form to another form results in a loss of some useful energy (law of entropy). In a complex system with a large number of conversions, the losses are considerable.

Renewable sources [1] are available all the time, while the depletable resources such as coal, oil, or uranium, were stored over a period of millions of years. Renewable energy can be obtained from the sun either directly (providing light and drying of grain and other materials, heating of earth), or indirectly (wind, hydro, biomass and firewood). Firewood is a renewable resource, only if our annual consumption equals or is less than the annual production. To cater for the needs of a growing population for cooking and rural industries it is necessary to:

- Use alternative sources such as solar devices or biogas.
- Improve efficiency of end use devices, e.g. improve stoves for cooking, improved boilers, driers and other machines which enable sustainable fuelwood production.

Thus the energy has been a dynamic force in accelerating the growth and development of human society. The demand for energy is not an end in itself but for the services such as heating, lighting, mechanical power and other services that satisfy human needs. This necessitates the need for proper energy management taking into consideration the satisfaction of basic human needs through economically feasible, energy efficient, environmentally sound and viable options. These include:

- Promoting energy efficient improvements.
- Beginning a transition to renewable energy sources.
- Optimising energy source - end use matching.

This highlights the need for integrated regional planning [2], based on a detailed look at how energy is used rather than the traditional preoccupation with energy supply and aggregate demand.

Maximum thermodynamic efficiency and maximum cost effectiveness in energy use are the two principles that govern energy conservation policies. The efficiency of energy use depends on thermodynamics, and the cost of energy use responds to the economics of resource allocation. In any region where the energy supply structure is vulnerable, the conservation of energy is a very effective way to alleviate energy constraints.

KARNATAKA'S ENERGY SCENE

Karnataka does not have any coal deposits. It gets its coal from external sources. Electrical energy for Karnataka was purely hydro, but with the commissioning of the Raichur thermal power station, it also gets electrical energy from coal. 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 thereby submerging sizable areas of forest. It is shown by a study that we can obtain a comparable quantity of energy from forest biomass instead of water from the submerged areas. An ideal solution would be to go in for a set of peaking power plants with minimum storage which utilises rain water during the monsoon period and supplemented by firewood-based thermal power plants.

It can be seen that Karnataka State depends both on commercial and non-commercial forms of energy [3]. Non-commercial energy provided over half the supply from sources such as firewood, agricultural residues, charcoal and cow dung. Commercial energy provided the rest, mainly through electricity, oil and coal. Table 1 lists the energy sources meeting the demand for energy during the year 1990-91. The largest single source is firewood. Electricity represented over half the commercial energy demand for 1990-91. Agro wastes are also used for energy purposes. The total share of industries in energy demand is around 44%. The state generated 12,430 million units of electrical

Table 1 Energy in Karnataka during 1990-91 (in million tons of oil equivalent).

Source	Demand (mtoe)	% share
Coal	1.005	5.81
Kerosene	0.445	2.57
Oil (HSD,LDO, etc)	2.014	11.64
LPG	0.130	0.75
Electricity	4.510	26.06
Commercial Energy Total	8.105	46.84
Agricultural Residues	1.510	8.73
Firewood	7.440	42.99
Biogas, Cow dung etc	0.250	1.44
Non Commercial Energy Total	9.200	53.16
Total Energy during 1990-91	17.055	100.00

energy in 1990-91. Irrigation pumpsets used 36.26% of total electrical energy. This was followed by heavier industries with a share of 34.34%, domestic lighting 15.35%, light industries 9.90%, commercial lighting 2.23%, public lighting 1.24% and others (0.68%).

The present study mainly concentrates on the energy use pattern study in rural industries in Karnataka State, India, by collecting secondary data from various government agencies and conducting a primary survey of a sample at Kumta taluk in Uttara Kannada District.

INDUSTRIES IN KARNATAKA

Industry is playing a pivotal role in the development of Karnataka State. The secondary sector in the State accounts for nearly a quarter of the State income (in real terms) of the total output in the economy [4]. The average annual growth rate of industrial production over the period from 1981-82 to 1990-91 was about 6.4% as against 7.9% in the country as reflected in the index of industrial production.

Small Scale Industries: an Overview. The basic framework for the industrial policy of the government was first spelled out in the industrial policy resolution of 1956, with an emphasis on the development of small scale industries. Small, medium and large industries have been assigned a mutually complementary role with a view to facilitate an integrated and harmonious growth of the industries sector as whole and with the objective of economic growth with social justice.

The policy measures, announced in 1991 by the government provided further impetus to the growth of the small sector. The primary objective of the 1991 policy measure was to impart more vitality and growth impetus to the sector to enable it to contribute fully to the economy, particularly in terms of growth of output and employment. As per the recent policy (1991), in small scale industries undertaking the investment in fixed assets in plant and machinery whether held on ownership terms, or on lease or by hire purchase does not exceed Rupees (Rs) 60 lakhs(One lakh = one hundred thousand or 105).

The spectrum of industries ranges from unorganised traditional sectors and modern small scale sectors to large and medium scale industries. The traditional sector and small scale sector provides maximum employment (413.39 lakhs in 1989-90) and constitutes an important component of the economy. In terms of value added it is estimated to contribute 50% of the value added in the manufacturing sector. The uniform distribution and growth in this sector besides resulting in a preponderance of self employment and under dispersal of industrial and economic activities, ensures maximum utilization of both human and material resources. The economics of production is important in small scale industries. Energy consumption plays a key and dominant role in the production economics of these industries. The small scale industries sector plays an important role in the industrial economy of the state. It contributes substantially to the industrial production and in generating employment. These industries are dispersed all over the state, however there is disparity in regional distribution. Table 2 illustrates the growth of small scale industries in Karnataka since 1969-70. The growth in last decade is phenomenal as the number of industries has increased from 37,148 to 129,915 with a percentage annual growth rate of 15.01 % and percentage annual growth in manpower employed of 13.58%. Table 3 gives the cumulative information of SSI' s from 1982-83 to 1991-92 for each district while Table 4 gives percentage yearly increases.

From Table 3 it is evident that the Bangalore district with 27,691 leads all other districts. The increase in the number of industries in the decade is given in Table 5a. Belgaum has annual average growth of 18.61 % while for Bangalore it is 9.31 %. Information regarding the number of industries, investment, and manpower employed in the SSI sector at the end of financial year 1991-92 is listed in Table 5b. The percent number of units varies from a low value of 1.15% (for Kolar District) to a high value of 21.97% (for Bangalore district). Investment per job computed for each district reveals a variation from Rs.9539.20 per person for Dharwad to Rs.22652.09 per person for Dakshina Kannada, indicating that some industries are capital intensive.

Workers in manufacturing and household industries are listed in the eleventh column of Table 5b. The share of manpower in SSI to the total manpower in the industries sector shows a variation of 16.67% for Chitradurga and 18.27% for Dakshina Kannada to 88.34% for Dharwad, 93.74% for Chikmagalur and 97.08% for Raichur. The lower values for Chitradurga and Dakshina Kannada are mainly due to the presence of large number of household industries in these districts. Most of these units are located in rural areas.

Dispersal of small scale units. The second census of registered small scale units [5] conducted by the Directorate of Industries and Commerce of 40,525 industries reveals that 38.14% of total Industries are located in rural areas, while 49.97% in urban area and 11.86% units in metropolitan city of Bangalore as indicated in Table 6a. A look at the employment generated in these industries reveals that 40,525 units have provided employment to 244,039 persons (shown in Table 7). The food products sector (National Industry Code: NIC 20 &21) leads

Table 2 Growth of Small Scale Industries in Karnataka.

Year (1900s)	No of SSI units (Registered)	Investment (Rs. in lakhs)	Manpower employed	SSI units (cumulative)	Investment (Rs. in lakhs) (cumulative)	Manpower (cumulative)	Investment per job (Rs./job)	% annual growth Units	Investment Manpower
69-70	3890	3456.70	47960	3890	3456.70	47960	7207.46		
70-71	1908	2279.43	44295	5798	5736.13	92255	6217.69	49.05	65.94
71-72	2372	1309.39	21343	8170	7045.52	113598	6202.1 5	40.91	22.83
72-73	2272	1350.10	22490	10442	8395.62	136088	6169.26	27.81	19.16
73-74	3043	1638.23	21814	13485	10033.85	157902	6354.48	29.14	19.51
74-75	1907	3991.27	56043	15392	14025.12	213945	6555.48	14.14	39.78
75-76	1562	1642.36	12783	16954	15666.48	226728	6909.81	10.15	11.70
76-77	1420	1482.51	15406	18374	17148.99	242134	7082.44	8.3B	9.46
77-78	1621	1517.11	24750	19995	18666.10	266884	6994.09	8.82	8.85
78-79	1975	1451.46	16957	21970	20117.56	283841	7087.62	9.88	7.78
79-80	2910	3255.01	34376	24880	23372.57	318217	7344.85	13.25	16.18
80-81	2776	3041.83	26164	27656	26414.40	344381	7670.11	11.16	13.01
81-82	3396	4955.16	41375	31052	31369.56	385756	8131.97	12.28	18.76
82-83	6096	6255.29	46420	37148	37624.85	432176	8705.91	19.63	19.94
83-84	7479	6396.51	44282	44627	44021.36	476458	9239.29	20.13	17.00
84-85	11962	6324.31	55849	56589	50345.67	532307	9458.01	26.80	14.37
85-86	11634	3787.09	60796	68223	54132.76	593103	9127.04	20.56	7.52
86-87	11179	9408.47	56883	79402	63541.23	649986	9775.78	16.39	17.38
87-88	10530	10165.19	52498	89932	73706.42	702484	10492.26	13.26	16.00
88-89	9811	10532.77	50448	99743	84239.19	752932	11188.15	10.91	14.29
89-90	9700	11247.02	51521	109443	95486.21	804453	11869.71	9.72	13.35
90-91	9884	11843.16	53568	119327	107329.37	858021	12508.94	9.03	12.40
91-92	10588	18623.11	61903	129915	125952.48	919924	13691.62	8.87	17.35
TOTAL	129915	125952.48	919924				Average	16.26	17.50

with 19.4% of total employment. This is followed by machinery and parts units (8.65%), Non metallic mineral products 8.33%. Table 6b gives information regarding dispersal of units in nature of activities (major activities such as repairing, servicing etc).

The total production of the 40,525 units surveyed was Rs. 2,52,687 lakhs. Out of this 28.32% is by food products, metal products (12.39%), and paper products (11.46%). This is illustrated in Table 7. The food products sector constitutes a major component in the SSI sector and most of these units are located in rural areas of Karnataka. As rural industries are one of the prime actors in the rural energy scene, further study is carried out on industries located in rural areas.

Rural Energy Scenario. Rural energy supply is closely tied in with agricultural and forest production, and with an overall crisis of agricultural productivity and environmental degradation linked to modernisation and changes in land use. The rural community depends mainly on non-commercial energy for domestic and rural industrial needs [6]. If new energy strategies are to be successful, rural energy needs will have to be placed squarely in the context of integrated approaches to rural development, basic needs and general questions of rural poverty, land and other scarce resources. With the emphasis on rural development by the government, rural industries are gaining importance. This paper attempts to focus on the various ecological parameters, such as energy conservation and raw material availability, involved in the successful functioning of rural industries.

The rural industries are important to the stability and growth of the regional economy. They have a significant role in averting migration of rural people to urban areas and cities which in turn cause the start of new slums and hence lead to environmental and ecological problems. The rural industries thus help in the well-being and survival of rural communities. The rural industries process local raw materials, they also tend to rely on local sources such as firewood and agricultural residues for the heat energy they need.

Wood is the traditional domestic fuel in rural areas. With the depletion of forest resources, the financial viability of many industries is threatened due to the increase in fuelwood prices and the lack of technical and financial assistance to switch over to alternate fuels. Although conventional fuels

Table 3 Number of Units, Investment and Manpower details in Small Scale Industries (cumulative for each District).

Year	1982-83			1983-84			1984-85			1985-86		
		Investment	Man-		Investment	Man-		Investment	Man-		Investment	Man-
District	Units	(Lakhs)	power	Units	(Lakha)	power	Units	(Lakhs)	power	Units	(Lakhs)	power
Bangalore	11368	14381.78	156691	13138	15589.10	165515	13127	15248.40	149436	15254	16942.11	158
Belgaum	2010	1856.93	16082	3438	2319.77	20715	4102	2490.98	22693	5283	3329.12	27
Bellary	1530	788.16	8133	2041	1121.29	11271	2135	1222.58	11531	2634	1395.70	14
Bidar	625	400.79	5790	989	703.05	7920	1077	707.17	8036	1330	917.22	9
Bijapur	1282	604.15	12979	1693	799.25	14973	1890	91956	15573	2321	1052.57	17
Chickmagalur	598	380.12	4503	980	636.59	6065	917	492.67	5182	1134	618.78	5
Chitradurga	1638	979.72	11417	1867	1086.13	12221	2024	1293.00	12278	2460	1582.85	14
Dakshina Kannada	2641	2027.17	23989	3984	2444.58	29618	3708	3602.86	29445	4471	4987.61	35
Dharwad	2444	4094.75	64714	3178	4702.68	69050	4094	5092.78	72204	5280	5698.78	77
Gulbarga	850	642.62	7830	1232	775.54	9014	1385	794.71	9100	1793	877.45	10
Hassan	824	550.90	6133	1085	685.31	7476	1155	739.67	7203	1422	1036.12	9
Kodagu	460	959.61	10936	600	986.80	11487	643	962.27	11299	772	1022.28	11
Kolar	1816	1124.05	11672	2170	1298.88	13779	2246	1256.32	15482	2614	1769.74	17
Mandya	1087	624.54	6275	1392	759.36	7580	1293	807.94	7387	1545	952.36	9
Mysore	2871	2619.16	23153	4314	3140.62	30863	5075	3361.04	33320	6241	3919.89	41
Raichur	855	1767.17	19670	1179	1968.01	21106	1372	2088.51	21966	1800	2664.52	24
Shimoga	1904	2022.83	13779	2543	2428.31	15830	2796	2721.31	15832	3379	3216.48	18
Tumkur	1492	1279.13	17737	2243	1900.44	21479	2591	2389.19	23466	3340	2939.23	27
Uttara Kannada	798	537.23	9214	989	619.41	10584	1083	692.74	11010	1274	767.98	11
TOTAL	37093	37640.81	430697	49055	43965.12	486546	52713	46883.70	482443	64347	55690.79	543

Year	1986-87			1987-88			1988-89		
		Investment	Man-		Investment	Man-		Investment	
District	Units	(Lakhs)	Power	Units	(Lakha)	power	Units	(Lakhs)	Man po
Bangalore	17185	19021.37	167351	18872	21106.14	177084	20520	23851.00	188
Belgaum	6487	4252.23	32022	7610	5150.28	36564	8445	6057.54	40
Bellary	3137	1543.34	16801	3639	1745.10	18889	4085	1965.11	20
Bidar	1596	1065.92	10777	1856	1426.66	12111	2101	1771.19	13
Bijapur	2707	1237.00	19894	3121	1394.67	21507	3516	1652.16	23
Chickmagalur	1357	722.90	7542	1560	819.21	8771	1741	962.18	9
Chitradurga	2872	2007.70	17375	3276	2515.74	19356	3658	3000.97	21
Dakshina Kannada	5745	5935.33	40685	6488	7502.01	45476	7175	899606	49
Dharwad	6109	7097.61	84202	6944	7696.27	88735	7844	8309.61	93
Gulbarga	2226	1198.69	13201	2658	1558.29	15695	3118	2015.43	18
Hassan	1673	1210.40	10125	1930	1404.03	11157	2167	152704	12
Kodagu	872	1149.05	12696	982	1199.39	13058	1084	1246.53	13
Kolar	3003	2123.51	20339	3327	2505.42	22445	3676	2903.63	24
Mandya	1799	1106.78	10948	2008	1267.09	11972	2208	1425.29	12
Mysore	7203	4498.07	45912	8331	5199.00	50848	9129	577 4.33	54
Raichur	2236	3002.03	26507	2695	3397.33	28521	3108	3722.88	30
Shimoga	3892	3573.76	20964	4402	4004.76	22808	4906	4447.87	24
Tumkur	3942	3485.98	29999	4671	441003	33889	5523	5089.36	38
Uttara Kannada	1485	847.59	12787	1686	943.03	13739	1863	105904	14
TOTAL	75526	65079.26	600127	86056	75244.45	652625	95867	85777.22	70307

Table 3 *Continued* - Number of Units, Investment and Manpower details in Small Scale Industries (cumulative for each District).

Year	1989-90	1990-91	1991-92

Table 4 Percentage increase in Industrial Units in Karnataka.

Year	% variation 82-83 to 83-84			% variation 83-84 to 84-85			% variation 84-85 to 85-86		
District	Units	Investment	Manpower	Units	Investment	Manpower	Units	Investment	Manpo
Bangalore	15.57	8.39	5.63	-0.08	-2.19	-9.71	16.20	11.11	6.11
Belgaum	71.04	24.93	28.81	19.31	7.38	9.55	28.79	33.65	21.7
Bellary	33.40	42.27	38.58	4.61	9.03	2.31	23.37	14.16	22.7
Bidar	58.24	75.42	36.79	8.90	0.59	1.46	23.49	29.70	16.5
Bijapur	32.06	32.29	15.36	11.64	15.05	4.01	22.80	14.46	12.8
Chickmagalur	63.88	67.47	34.69	-6.43	-22.61	-14.56	23.66	25.60	14.4
Chitradurga	13.98	10.86	7.04	8.41	19.05	0.47	21.54	22.42	19.4
Dakshina Kannada	50.85	20.59	23.46	-6.93	47.38	-0.58	20.58	38.43	19.9
Dharwad	50.85	20.59	23.46	-6.93	47.38	-0.58	28.97	11.90	7.65
Gulbarga	44.94	20.68	15.12	12.42	2.47	0.95	29.46	10.41	15.7
Hassan	31.67	24.40	21.90	6.45	7.93	-3.65	23.12	40.08	28.7
Kodagu	30.43	2.83	5.04	7.17	-2.49	-1.64	2006	6.24	3.32
Kolar	19.49	15.55	18.05	3.50	-3.28	12.36	16.38	40.87	15.9
Mandya	28.06	21.59	20.80	-7.11	6.40	-2.55	19.49	17.88	29.8
Mysore	50.26	1991	33.30	17.64	702	7.96	22.98	16.63	23.0
Raichur	37.89	11.37	7.30	16.37	6.12	4.07	31.20	27.58	11.7
Shimoga	33.56	20.05	14.88	9.95	12.07	0.01	20.85	18.20	18.1
Tumkur	50.34	48.57	21.10	15.51	25.72	9.25	28.91	23.02	15.5
Uttara Kannada	23.93	15.30	14.87	9.50	11.84	4.02	17.64	10.86	8.29
TOTAL	32.25	16.80	12.97	7.46	6.64	-0.84	22.07	18.78	12.6

Table 4 *Continued* - Percentage increase in Industrial Units in Karnataka.

Year	% variation 85-86 to 86-87			% variation 86-87 to 87-88			% variation 87-88 to 88-89		
District	Units	Investment	Manpower	Units	Investment	Manpower	Units	Investment	Manpo
Bangalore	12.66	12.27	5.54	9.82	10.96	5.82	8.73	13.01	6.26
Belgaum	22.79	27.73	15.90	17.31	21.12	14.18	10.97	17.62	9.92
Bellary	19.10	10.58	18.68	16.00	13.07	12.43	12.26	12.61	10.37
Bidar	20.00	16.21	15.09	16.29	33.84	12.38	13.20	24.15	7.73
Bijapur	16.63	17.52	13.17	15.29	12.75	8.11	12.66	18.46	8.55
Chickmagalur	19.66	16.83	27.14	14.96	13.32	16.30	11.60	17.45	8.20
Chitradurga	16.75	26.84	18.46	14.07	25.30	11.40	11.66	19.29	9.93
Oakshina Kannada	28.49	19.00	15.24	12.93	26.40	11.78	10.59	19.92	8.90
Oharwad	15.70	24.55	8.33	13.67	8.43	5.38	12.96	7.97	5.16
Gulbarga	24.15	36.61	25.38	19.41	30.00	18.89	17.31	29.34	14.85
Hassan	17.65	16.82	9.18	15.36	16.00	10.19	12.28	8.76	8.47
Kodagu	12.95	12.40	8.75	12.61	4.38	2.85	10.39	3.93	2.76
Kolar	14.88	19.99	13.33	10.79	17.98	10.35	10.49	15.89	9.94
Mandya	16.44	16.21	14.10	11.62	14.48	9.35	9.96	12.49	7.63
Mysore	15.41	14.75	11.96	15.66	15.58	10.75	9.58	11.07	8.03
Raichur	24.22	12.67	7.97	20.53	13.17	7.60	15.32	9.58	6.04
Shimoga	15.18	11.11	12.09	13.10	12.06	8.80	11.45	11.06	8.21
Tumkur	18.02	18.60	10.63	18.49	26.51	12.97	18.24	15.40	13.32
Uttara Kannada	16.56	10.37	7.25	13.54	11.26	7.45	10.50	12.30	5.49
TOTAL	17.37	16.86	10.47	13.94	15.62	8.75	11.40	14.00	7.73

Year	% variation 88-89 to 89-90			% variation 89-90 to 90-91			% variation 90-91 to 91-92		
District	Units	Investment	Manpower	Units	Investment	Manpower	Units	Investment	Manpo
Bangalore	9.17	12.29	7.60	8.49	14.19	8.21	13.94	21.32	10.85
Belgaum	10.02	16.63	9.13	9.62	13.20	8.12	8.79	14.69	7.71
Bellary	10.80	6.47	8.20	9.28	6.54	6.55	6.29	16.15	6.19
Bidar	11.66	60.29	11.71	10.53	14.19	13.69	8.99	13.35	7.80

Table 5a Comparative data for the years 1982-83 and 1991-92.

Year	1982-83			1991-92			1982/83 to 1991/92					
		Investment	Man-		Investment	Man-	Percent (variation) growth			Percent average annual grow		
District	Units	(Lakhs)	power	Units	(Lakha)	power	Units	Investment	Manpower	Units	Investment	Manp
Bangalore	11368	14381.78	156691	27691	37102.85	242868	143.59	157.99	55.00	9.31	9.94	4.
Belgaum	2010	1856.93	16082	11080	9172.65	51078	451.24	393.97	217.61	18.61	17.32	12
Bellary	1530	788.16	8133	5257	2589.05	25522	243.59	228.49	213.81	13.14	12.63	12
Bidar	625	400.79	5790	2826	3674.88	17864	352.16	816.91	208.53	16.29	24.81	11
Bijapur	1282	604.15	12979	4688	2814.06	28967	265.68	365.79	123.18	13.84	16.63	8.
Chickmagalur	598	380.12	4503	2293	1581.79	11555	196.70	463.11	140.44	11.49	18.87	9.
Chitradurga	1638	979.72	11417	4860	5516.86	27451	283.44	316.13	156.61	14.39	15.32	9.
Dakshina Kannada	2641	2027.17	23989	8955	13458.51	59414	239.08	563.91	147.67	12.99	20.84	9.
Dharwad	2444	4094.75	64714	10506	10134.64	106242	329.87	147.50	64.17	15.70	9.49	5.
Gulbarga	850	642.62	7830	4179	3064.89	23470	391.65	376.94	199.74	17.26	16.91	11
Hassan	824	550.90	6133	2791	1997.74	14778	238.71	262.63	140.96	12.98	13.75	9.
Kodagu	460	959.61	10936	1444	1441.89	14649	213.91	50.26	33.95	12.12	4.16	2.
Kolar	1816	1124.05	11672	4709	4740.34	31262	159.31	321.72	167.84	10.00	15.48	10
Mandya	1087	624.54	6275	2851	2275.39	16154	162.28	264.33	157.43	10.12	13.80	9.
Mysore	2871	2619.16	23153	11374	7550.83	67326	296.17	188.29	190.79	14.76	11.17	11
Raichur	855	1767.17	19670	4287	5144.87	35191	401.40	191.14	78.91	17.49	11.28	5.
Shimoga	1904	2022.83	13779	6410	5769.07	30711	236.66	185.20	122.88	12.91	11.05	8.
Tumkur	1492	1279.13	17737	7437	7784.95	48202	398.46	508.61	171.76	17.43	19.79	10
Uttara Kannada	798	537.23	9214	2410	1675.25	17361	200.88	211.83	88.42	11.64	12.04	6.
TOTAL	37093	37640.81	430697	126039	127490.51	870065	239.79	238.70	10201	13.01	12.97	7.
Average	1952	1981.10	22668	6634	6710.03	45793	273.94	316.57	141.04	13.81	14.49	8.
Maximum	11368	14381.78	156691	27691	37102.85	242868	451.24	816.91	217.61	18.61	24.81	12
Minimum	460	380.12	4503	1444	1441.89	11555	143.59	50.26	33.95	9.31	4.16	2.
Stnd Deviation	2326	3061.92	34133	5795	7858.93	51721	88.62	174.78	54.25	2.68	4.65	2.

Table 5b Districtwise data during the year 1991-92.

Year	1991-92				1991-92		1982/83 to 1991/92						
District	Units	Investment (Lakhs)	Man-power	%881	% Invest- % Man- ment	power	Invest-ment per job	% of population employed in 881	Area 8q. kms	Popul-ation	Workers in manu-facturing & h.hold	No. of persons/ sq. km	% 881/ total mp
Bangalore	27691	37102.85	242868	21.97	29.10	27.91	15277.0	3.73	8213.21	6512356	513755	792.91	47.27
Belgaum	11080	9172.65	51078	8.79	7.19	5.87	17958.1	1.43	13530.92	3583606	128966	264.85	39.61
Bellary	5257	2589.05	25522	4.17	2.03	2.93	10144.4	1.35	9884.87	1890092	44872	191.21	56.88
Bidar	2826	3674.88	17864	2.24	2.88	2.05	20571.4	1.42	5494.8	1255799	20551	228.54	86.93
Bijapur	4688	2814.06	28967	3.72	2.21	3.33	9714.7	0.99	17165.1	2927990	86950	170.58	33.31
Chickmagalur	4860	5516.86	27451	3.86	4.33	3.16	20097.1	2.70	7239.69	1017283	29283	140.51	93.74
Chitradurga	2293	1581.79	11555	1.82	1.24	1.33	13689.2	0.53	10836.08	2180443	69328	201.22	16.67
Dakshina Kannada	8955	13458.51	59414	7.10	10.56	6.83	22652.1	2.21	8509.03	2694264	325131	316.64	18.27
Dharwad	10506	10134.64	106242	8.34	7.95	12.21	9539.2	3.03	13778.61	3503150	120270	254.25	88.34
Gulbarga	4179	3064.89	23470	3.32	2.40	2.70	13058.8	0.91	16215.43	2582169	50233	159.24	46.72
Hassan	2791	1997.74	14778	2.21	1.57	1.70	13518.3	0.94	6895.22	1569684	18009	227.65	82.06
Kodagu	4709	4740.34	31262	3.74	3.72	3.59	15163.3	6.40	4108.6	488455	32705	118.89	95.59
Kolar	1444	1441.89	14649	1.15	1.13	1.68	9842.9	0.66	8268.49	2216889	59567	268.11	24.59
Mandya	2851	2275.39	16154	2.26	U8	1.86	14085.6	0.98	5005.48	1644374	28508	328.51	56.66
Mysore	11374	7550.83	67326	9.02	5.92	7.74	11215.3	2.13	12107.05	3165018	107787	261.42	62.46
Raichur	4287	5144.87	35191	3.40	4.04	404	14619.8	1.52	14049.02	2309887	36249	164.42	97.08
Shimoga	6410	5769.07	30711	5.09	4.53	3.53	18785.0	1.61	10579.46	1909663	49199	180.51	62.42
Tumkur	7437	7784.95	48202	5.90	6.11	5.54	16150.7	2.09	10633.26	2305819	62632	216.85	76.96
Uttara	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table 6a Dispersal of Units.

		Rural		Urban		Metropolitan	
District	No. of Units	Units	Percent	Units	Percent	Units	Percent
Bangalore (Urban)	6051	305	5.04	939	15.52	4807	79.44
Belgaum	2755	1002	36.37	1753	63.63	0	0.00
Bellary	2027	625	30.83	1402	69.17	0	0.00
Bidar	972	459	47.22	513	52.78	0	0.00
Bijapur	1712	875	51.11	837	48.89	0	0.00
Chickmagalur	1002	448	44.71	554	55.29	0	0.00
Chitradurga	2139	685	32.02	1454	67.98	0	0.00
Uttara Kannada	795	513	64.53	282	35.47	0	0.00
Dakshina Kannada	3867	2066	53.43	1801	46.57	0	0.00
Dharwad	4814	2401	49.88	2413	50.12	0	0.00
Gulbarga	1419	500	35.24	919	64.76	0	0.00
Hassan	1164	394	33.85	770	66.15	0	0.00
Kodagu	305	187	61.31	118	38.69	0	0.00
Kolar	1315	424	32.24	891	67.76	0	0.00
Mandya	955	550	57.59	405	42.41	0	0.00
Mysore	2211	709	32.07	1502	67.93	0	0.00
Raichur	1594	745	46.7 4	849	53.26	0	0.00
Shimoga	2928	1425	48.67	1503	51.33	0	0.00
Tumkur	1803	833	46.20	970	53.80	0	0.00
Bangalore (Rural)	697	321	46.05	376	53.95	0	0.00
TOTAL	40525	15467	38.17	20251	49.97	4807	11.86

Table 6b Dispersal of Units by nature of activities.

	Rural		Urban		Metropolitan		Total	
	Units	Percent	Units	Percent	Units	Percent	Units	Perc
Manufacturing/Assembling	5368	31.47	8867	51.98	2824	16.55	17059	42
Processing	5880	54.85	4317	40.27	523	4.88	10720	26
Job work only	789	21.98	1925	53.64	875	24.38	3589	8
Repairing and servicing	1714	33.57	3189	62.46	203	3.98	5106	12
Combined	1716	42.36	1953	48.21	382	9.43	4051	10
Total	15467	38.17	20251	49.97	4807	11.86	40525	100
Energy consumption by location (Lakh Rs.)								
Electricity, Firewood, charcoal etc	1650	34.64	2253	47.30	860	18.06	4763	

are available in many rural areas, their cost per unit of useful energy is usually much higher than that of traditional sources. With the use of conventional fuels, industry becomes more dependent on distribution networks which are liable to interruption and it is not desirable to use high quality energy, such as electricity, for low quality work such as heating. This unreliability in supply and the high cost of conventional sources of energy creates a demand for viable alternatives to meet the needs of rural industries locally. The supply of energy from wood and residues are more flexible and reliable. With increasing industrial demand for wood and residues, both for energy and for other domestic applications, agricultural and industrial purposes puts further pressure on traditional sources, often with adverse effects on other end users, on the stability and productivity of the rural environment. This in turn results in a demand for increasing biomass stocks by raising energy plantations to meet the growing needs of the population for fuel, for domestic use and in rural industries.Rural industries provide the majority of off-farm employment and income generation in rural areas. In Karnataka there are 27,028 villages with

Table 7 Details of number of units, manpower and production.

Description	Units	Percent	Manpower	Percent	Production Lakh Rs.	Perce
Food products	10221	25.22	47363	19.41	71615	28.3
Beverages, tobacco	550	1.36	6812	2.79	6086	2.41
Cotton textiles	52	0.13	659	0.27	641	0.2
Wool, silk and synthetic textiles	28	0.07	197	0.08	101	0.04
Jute, hemp and Mesta tex	9	0.02	47	0.02	28	0.01
Hosiery and garments	1750	4.32	10203	4.18	5824	2.3
Wood products	3779	9.33	17354	7.11	12826	5.07
Paper products	2623	6.47	14541	5.96	28972	11 .4
Leather products	1381	3.41	4926	2.02	3800	1.5
Rubber and Plastic	1570	3.87	11576	4.74	13829	5.47
Chemicals	1587	3.92	17086	7.00	18598	7.3
Non metallic mineral	1422	3.51	20280	8.31	8103	3.2
Basic metal products	546	1.35	8961	3.67	14326	5.6
Metal products	4173	10.30	24920	10.21	31349	12.3
Machinery parts	2915	7.19	21114	8.65	12348	4.8
Electric machinery	699	1.72	9408	3.86	13278	5.2
Transport equipment	808	1.99	5988	2.45	4285	1.6
Miscellaneous manufacture	394	0.97	3222	1.32	2048	0.8
Repair services	5041	12.44	15392	6.31	2833	1.1
Services not else classed	87	0.21	375	0.15	286	0.1
Other services	890	2.20	3615	1.48	1838	0.7
TOTAL	40525	100.00	244039	100.00	253014	100.0

175 taluks (A taluk is a district or tract of proprietary land in India). The population of the state is 44,817,398 with a density of 234 persons per square kilometre and 71.1 % of total population are in rural areas. Deforestation and loss of soil fertility has resulted in a serious reduction in food production by traditional agriculture. Increase in population, leading to fragmentation in land holding, has resulted in further degradation of agriculture land. Fuel shortages are usually tied with environmental deterioration and have also affected food production. Rural industries in this regard are playing a significant role by providing employment to poor peasants especially women. This sexual division of labour has influenced women's ability to produce food and provide the nutrition required for their family.

The cashew processing industries are taken up for further studies among rural industries to explore the role of rural industries in the rural economy and role of traditional fuel in the survival of these industries. Cashew processing industries are mainly located in the rural areas and are labour intensive as well as energy intensive. Cashew processing mainly depends on fuelwood and other agriculture residues for the heat energy required. These industries employ mainly women and hence have helped the village women to attain economic independence and hence self sufficiency. Cashew industries are located mainly in the coastal belts of Karnataka, due to the availability of raw material (namely cashew nuts) in the region. Coastal areas are densely populated and relatively biomass scarce areas. The nonavailability of fuelwood and agricultural residues have often caused serious problems.

CASE STUDY : ENERGY STUDIES IN CASHEW PROCESSING INDUSTRIES

Objectives of the study: The objectives were to:

- Explore the relationship between the energy consumed and production in rural industries based on the data collected from the rural industries.
- Identify the patterns, type and efficiency of energy use in the rural industries, particularly in its more energy intensive processes such as heating.
- Study ecological perspectives of rural industries.
- Identify technical measures for improving energy efficiency.

Methodology: The study was carried out in five stages:

1. Initial information was collected from the Government agencies such as the Department of Industries, Directorate of Economics & Statistics and Districts Industries Centres regarding many cashew industries in Karnataka.
2. A questionnaire-based survey covering firms and units in the Cashew processing industry sector was conducted in Kumta taluk of Uttara Kannada district (of Karnataka State, India) to determine the levels and patterns of energy consumption and the technologies in use.
3. Brief (one to two days) energy audits, management and employees interviews were conducted in representative firms to check and cross verify the data collected from the secondary sources and to identify opportunities for energy efficiency improvements.
4. Computation of Specific Energy Consumption (SEC) and Energy Intensity (EI) to find out the level of disparities among firms.
5. Establishment of quantitative relationship among various parameters such as Energy (En), Production (Pr), Specific Energy Consumption (SEC) and Percentage [percentage installed] Production Capacity Utilisation (PPCU).

Study Area: The primary survey was carried out in industries located in the Kumta taluk of Uttara Kannada district. Kumta taluk is located in the coastal tract of Karnataka [7]. It lies between 74° 24' to 74° 45' east longitude and 14° 17' to 14° 35' north latitude and extends over an area of 582 square kilometres. With a population of 107,963, Kumta taluk is one of the densely populated regions in Karnataka.

Cashew Industries: Cashew processing industries were selected for this study mainly because:

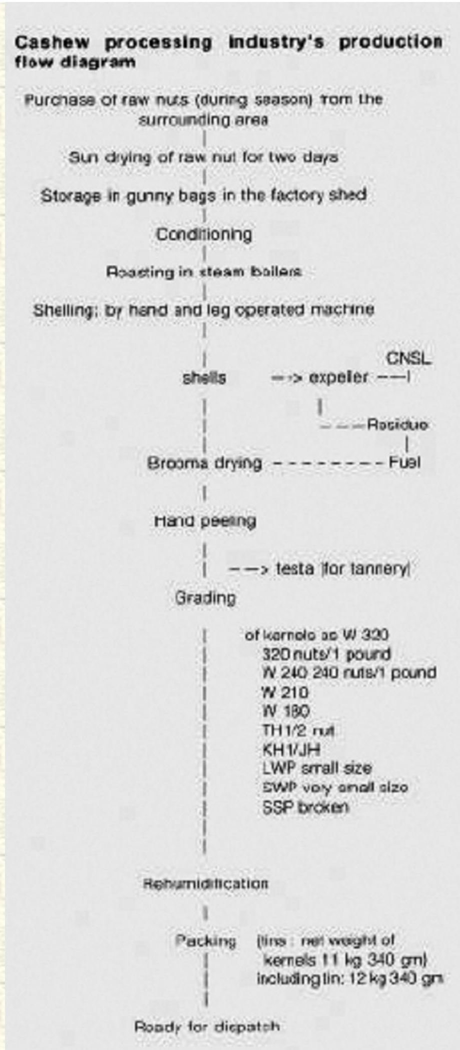
1. The processing industry being mainly located in the rural areas depends on local raw materials, tends to rely on local resources for heat energy needed, and employs local youth. 85% of the labourers are women. Rural women who form the major labour force, also endure the burden of domestic drudgery.
2. Fuelwood is used as main source of heat energy in the processing. The quantity of fuelwood required and its impact on the environment is enormous. The rising cost of fuelwood and scarcity of fuelwood has forced industrial entrepreneurs to think in terms of better processing devices e.g. boilers, improved driers as well as growing fuelwood in the indigenous way.
3. The raw material rquired for the industry could be grown on the barren and already degraded land, unfit for habitation or tillage. The crop does not require any fertilizer or pesticide application or even nursing.
4. Cashew growing provides employment to rural youth.
5. Cashew growing helps in restoring the soil condition.
6. The industry is labour intensive (and helps with rural employment generation), the raw materials are processed by hand which helps in yielding better quality nuts.

The main function of the cashew processing industry is the recovery of the kernel from raw nuts by manual or mechanical means. Processing consists of moisture conditioning, roasting, shelling, drying, peeling, grading and packing. The present study covers 142 sample industries from all districts in Karnataka. Also detailed investigations of processing were carried out for ten industries in Kumta taluk of the Uttara Kannada (North Kanara) district of Karnataka.Some of these processes are illustrated in the flow diagram on the next page and all terms are explained in the text which follows.

Conditioning: Conditioning involves sprinkling of water on dried and stored nuts to bring them to an optimum moisture level of 20% - 30%. To make the shell brittle, roasting is done. The mesocarp of the shell consists of honeycomb like cells containing a viscous liquid called the cashew nut shell liquid (CNSL) which provides natural protection to the kernel against insects. CNSL is a valuable raw material for some polymer based industries such as paints, varnishes, resins and brake linings. Industries in Kumta export and sell these shells to Goa and Ankola where boat manufacturers use the CNSL as paint.

Roasting: Drum roasting is done in most of the industries. The capacity of the drum is 320 kg. Shells are roasted in steam at 100^0C, for about 22 minutes. In most of the industries during the course of our survey, workers were instructed to load nuts to the full installed capacity of the drum. The nuts are kept aside for a day for cooling. Then Shelling is done using hand and leg operated shelling machines. For this purpose female labourers are employed. Normally a worker shells 17 kg/day. The wages paid on pro rata basis at the rate of Rs. 1.5/kg plus Rs. 1.5 towards transport allowance.

One sample industry surveyed had 12 female workers in this section. Most of these workers were in the age group from 15 to 25. The kernel is scooped out by means of a sharp needle. After shelling the kernels are dried in the drier to reduce the moisture (approximately 10%) and to loosen the adhering testa. After drying for 8 - 12 hours the peeling is done by hand, using a knife. 25 female workers were employed in this section. A minimum of 8 kg of kernels is given in the morning for peeling per person, which has to be completed and the same quantity is to be returned, when the worker leaves the work place. Workers were paid on the pro rata basis at the rate of Rs. 1.5/kg to Rs. 2/kg.



The next stage is grading of kernels, depending on the specification for exportable grades. The wholes are size graded based on the number of kernels per pound as W320, W240, W210 and W180 (means 180 kernels/pound). Damaged kernels were graded as TH (1/2 size), KH C/2 TH), LWP (small size) SWP & SSP respectively. This grading is done by the experienced female labourers who were paid Rs. 300 - Rs. 400 per month. Packing is usually done in a tin, which holds 11 kg 340 gms Net, which are subsequently evacuated and filled with carbon dioxide. A rehumidification process is introduced before packing to overcome the possible overdrying. This whole operation has a higher yield rate of 90 to 95% of wholes. The raw materials required for these industries can be grown locally. In the next section cashew plantations are discussed from an ecological perspective in order to assess their ecological viability.

CASHEW PLANTATION: AN ECOLOGICAL PERSPECTIVE

A cashew crop among plantation crops has the unique distinction that it can be cultivated in a wide variety of soils. It can survive on lands of low fertility and can be grown in all soil types from sandy sea coast to laterite hill slopes, but the best soils are deep, triable, well drained sandy loams without a hard pan. It grows and yields well in shallow and impervious soils such as sand hills where no other economic crop generally grows well; it is tolerant of saline and heavy clay soils; it grows on red and laterite soils. It cannot withstand water stagnation, flooding or bad drainage. In Karnataka, cashew is planted mainly in the coastal belt which receives an annual rainfall ranging from 1300 to 3500 mm.

The area under cashew plantation at the end of 1984-85 in Karnataka was 47,442 hectare. The productivity in Kumta tal uk of Karnataka on an average is 13 quintals per hectare. This data regarding productivity was collected by interviewing some farmers randomly selected in the Kumta tal uk. The total production from the Government Horticulture Department estmimates was 22,115 qtl. in Kumta taluk during 1992-93 (the area under cashew cultivation is 1595 hectares). Due to favourable weather and rainfall the scope for increasing the yield is more in the hilly region of the west coast.

Definitions: Specific Energy Consumption (SEC): SEC can be identified as the ratio of Energy Consumption in rupees to Production in rupees. Thus:
SEC = En / Pr (Rs. 1 Rs.)

Energy Intensity (EI): EI is the ratio of Energy Consumption and Production in "per unit" terms. EI would be helpful in industries where the end products of a industry are cash products.

EI = En / Pr (kg/kg) or (kWh/kg)

The intra and inter variation in SEC and EI among the industries producing similar products reveals the extent of inefficient/efficient energy consumption. The higher the variation in the value of SEC and EI for the same amount of Production among industries producing similar product reveals the extent of disparity in energy consumption.

Percent Production Capacity Utilisation

(PPCU) = ratio of actual production to the total production / installed capacity

If Pr is actual Production, P is total Installed Production capacity then PPCU = (Pr/P) * 100. Relationship between variables: Applying standard statistical techniques, the relationship between the variables En and Pr can be represented by any of the following mathematical models depending upon the best fit (least error techniques).

(i)The linear En = A + B Pro
(ii) The parabolic En = A + B (pr) + C (Pr)2
(iii) Exponential En = A Exp (B.Pr)
linearized form: Ln (En) = Ln (A) + B (Pr)
(iv) Power law En = A * (pr)B
l0inearized form: Ln (En) = Ln (A) + B Ln (Pr)
Ln = natural logarithm

The En: Energy mix in rural industries comprises of mainly (a) fuelwood for heat and (b) electricity for lighting purposes [very minimal]. Regression analysis is carried out to look at the role of Energy Consumption and Specific Energy Consumption in this sector.

RESULTS AND DISCUSSION

(1) The rural energy consumption model. To study the dynamics of the energy utilisation patterns in any industrial plant, the SEC (Specific Energy Consumption) and EI (Energy Intensity) would help in predicting minimum energy required to operate an industry efficiently.
(2) Statistical analysis of energy coefficients Energy consumption and production. The relationship between the variables Energy Consumption (En) and Production (Pr) is determined by the least squares method. The best fit is of the form:
En = A. (Pr) C

where "A" is the constant and the coefficient "c" is commonly known as the Energy Elasticity.

Table 8 Regression analysis: Energy & Production.

Equation	r	% error of Y est	A	B
Linear	0.7286	9.26	19.47	0.0135
Parabola	0.7312	9.10	20.70	0.0108
			c = 0.175 x 10-6	
Hyperbola	0.2090	30.20	0.1123	0.0001
Exponential	0.4790	12.24	14.88	0.0019
Power law	0.7544	8.02	2.369	0.3983

Y = dependent variable: En, X = independent variable: Pr

The data collected from both secondary (for 136 industries) and primary sources (energy auditing in six industries) were compiled. The regression analysis was done for this set of data. The probable relationship based on the least % error of best fit is:

En = 2.36 (Pr) O.3983

The 'generalised form of the relationship is written as:

En = A. (Pr) C-------(1) where C = Energy coefficient, A = constant

Equation (1) could be written as: C = (dEn/En) / (dPr/Pr)----------(2)

That is, the Energy Coefficient expressed in terms of the proportionate change in En to the proportionate change in Pro The lower the value of "C", the lower is the change in En for the corresponding change in product. Differentiating Equation En = A (Pr)C with respect to change in production, we get the dynamic consumption rate that is:

d En/d Pr = A x C (Pr) C-1 ------------------(3)

The value of the Energy coefficient "c" being less than one, which means dEn/dPr declines sharply with increase in production in a industry. This might imply better utilisation of the installed production capacity of boilers and driers. Specific Energy Consumption and Production. Specific Energy Consumption is the ratio of Energy Consumption (in Rs) to the Production (in Rs). This ratio would help to predict the minimum

Table 9 Regression analysis: SEC & Production.

Equation	r	% error of Y est	A	B
Linear	0.3947	12.34	0.2923	-0.000108
Parabola	0.4959	11.10	0.3340	-0.000322
			c = 0.596 x 10-7	
Hyperbola	0.4602	11.89	10.34	-0.0205
Exponential	0.6135	8.46	0.188	-0.000855
Power law	0.7673	4.61	2.369	-0.620

X = independent variable: Pr

Y = dependent variable: SEC

energy required to operate an industrial plant efficiently. The relationship between Specific Energy Consumption (SEC) and Production (Pr) for the cashew processing sector is tried by the least square method.A best fit with least % error of Y est is chosen, and is:

The relationship from least square method is:

SEC = 2.35 (Pr)-0.62

The results of the analysis is listed in Table 9. The general form of relationship:

SEC = A' (Pr)-c'-----------(4)

The negative exponent c' shows a decline in the value of SEC with increase in Production. This again may be inferred, as the energy efficiency improves with better efficiency utilisation of the installed production capacity.

In order to look at the role of installed Per cent Production Capacity Utilisation (PPCU) on the energy utilisation, Specific Energy Consumption and hence on the energy efficiency of the operation, further analysis is carried out between the variables En and PPCU, SEC & PPCU.
From Equation (3) and Equation (4) we noticed that the Energy Efficiency Improves with the increase in Production. Normally with increased production capacity utilisation, production of an industry increases. Regression analyses were carried out to explore the relationship between EI and PPCU, and SEC and PPCU. By the least square method, based on less percentage error of Y est, the best fit relationships are:
EI = 56.34 (PPCU)-0.56 ---------(5)
SEC = (PPCU)-0.76 ---------(6)
These two relationships confirm the earlier conclusions, that to improve the energy efficiency

Table 10 Distribution of Industries in different PPCU range.

PPCU	Number of Industries	SEC
0-5%	1	0.655
5-10%	2	0.342
10-20%	2	0.264
20-30%	6	0.190
30-40%	12	0.120
40-50%	37	0.100
50-60%	39	0.095
60-70%	21	0.093
70-80%	10	0.092
80-90%	8	0.060
> 90 - < 100%	4	0.042
	142	

of an industry, it is very essential to match the production of a industry with installed production capacity.

The next logical question which arises from these analyses is how much energy can be saved by optimal utilisation of the installed production capacity. Table 10 lists the SEC and PPCU in the Cashew processing sector. Out of 142 industries, it is seen that in 99 industries the percent installed capacity utilisation is less than 60%. Examining the two industries with PPCU of 50 and 80, the SEC for respective values would be as shown in Equation (6) as:

SEC = 2.15 (50)-0.76 = 0.109

SEC = 2.15 (80)-076 = 0.076

That means there is 30.27% variation in SEC, which means 30.27% of the energy can be saved by proper utilisation of installed production capacity. Figure 1 gives the plot of SEC and number of firms with Percent Production Capacity Utilisation. A declining trend of SEC with increased PPCU is evident from this Figure. The frequency of the number of firms in each PPCU range is a bell-shaped curve, which clearly shows about 69.72% of the total samples are in PPCU range less than 60%. This gives considerable scope for saving fuelwood with better utilisation of installed production capacity.

Energy Auditing. Detailed energy audits were carried out in six cashew processing industries located in the Kumta taluk of Uttara Kannada (North Kanara) district on the coastal belt of Karnataka, by spending one to two days and measuring actual fuelwood consumption, raw materials etc. The details of energy consumption, raw materials and man-power are listed in Table 11.

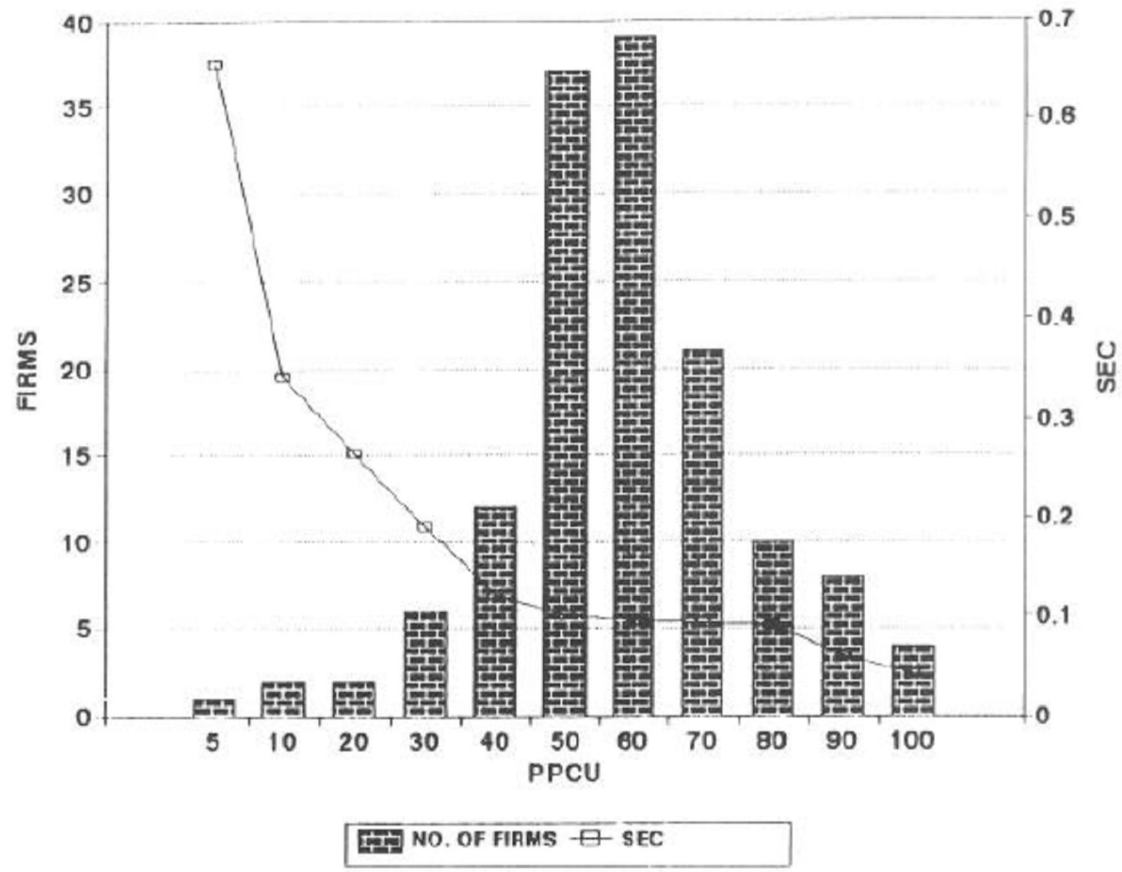


Figure 1 Specific Energy Consumption (SEC) and Percent Production Capacity Utilisation (PPCU).

Table **11** Energy auditing in the cashew processing firms.

Fuelwood/year for (Heat)	Electricity mainly for lighting	Fuelwood	Raw nut	Output kernels production	Employees Male	Female	Wages	Product
Units tonnes	kWh	Rs.	kg	kg	No.	No.	Rs.	Rs.
7.2	180	5400	5914.28	1320	2	8	96000	198000
70	240	49000	31200	8400	4	10	152116	275
120	400	90000	81200	24010	2	25	195000	3601
156	25	120000	61200	18000	2	27	210600	2700
165	600	123750	121200	34200	2	50	267000	5130
692.5	3000*	519375	57720	53900	4	130	619700	21546

* This industry uses electric drier for drying kernels sometimes.

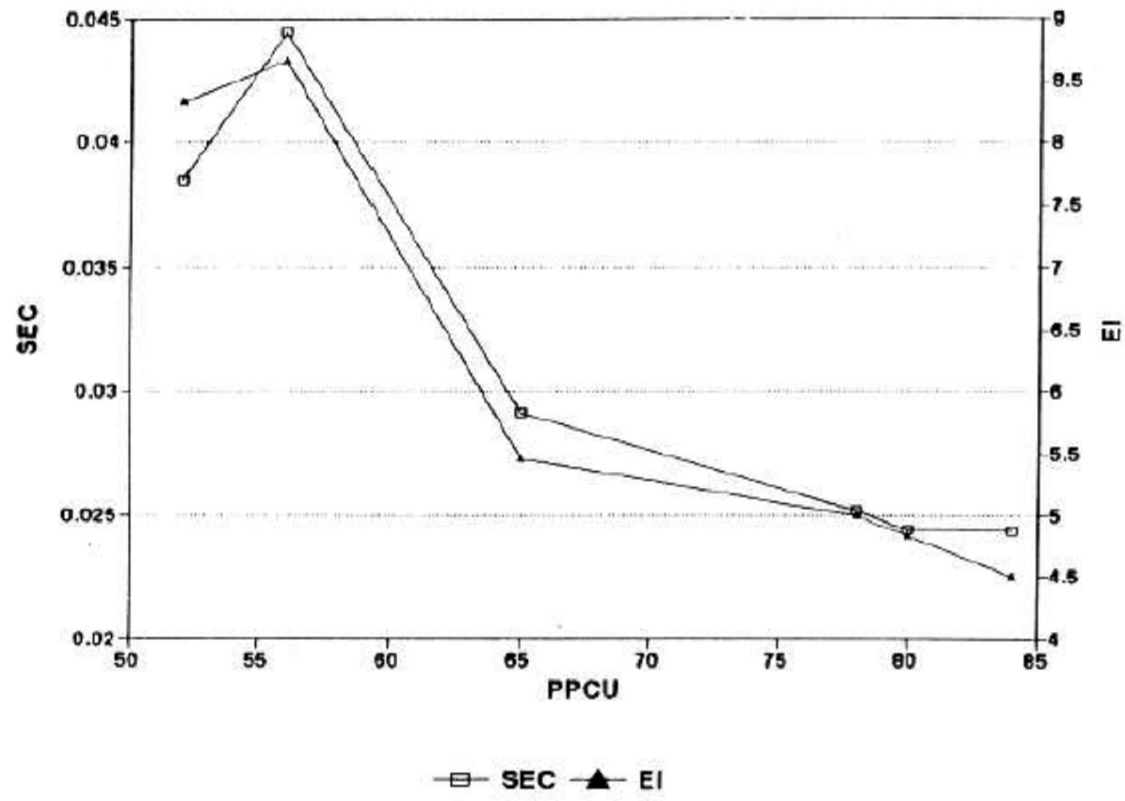


Figure 2 Specific Energy Consumption (SEC) and Energy Intensity (EI) variation for different Percent Production Capacity Utilisation (PPCU).

The energy analyses were carried out to explore the variation in SEC, EI and PPCU in these industrial units and the results are listed in Table 12. From Table 11 it is evident that these industries are labour intensive and mainly employ women. Since the wages paid are based on the amount of work done (that is quantity of nuts dehusked/peeling of kernels, etc.), these labourers seem to be one of the most efficient. The employment opportunity in these industries has created a new kind of social awareness among the women.

Since cashew is a cash crop, the SEC computed shows very small values. The discussion based on SEC seems to be insignificant. Hence EI (Energy Intensity) is computed which reveals distinctly the disparities in the level of fuelwood consumption in the other sector. It is noticed that the variation ranges from a minimum of 4.49 kg fuel wood per kg of cashew kernel processed to the maximum of 8.66 kg. The PPCU computed reveals that the high level of fuelwood consumption is related to the lower installed production capacity utilisation. Figure 2 is the pictorial representation of SEC/EI with the PPCU of firms where the detailed survey was carried out.

As listed in Table 12, it is evident that an industry with PPCU 52% consumes 8.32 kg of fuelwood while an industry with a PPCU of 84% consumes 4.49 kg of fuelwood. This means there is a 46% variation in the quantity of fuelwood consumed for processing cashew. This is mainly due to the non-utilisation of installed production

Table 12 Computation of SEC/EI and PPCU.

SEC Rs./Rs.	EI kg./kg.	PPCU %
0.02435	4.824	80
0.02438	4.499	84
0.02521	4.997	78
0.02909	5.454	65
0.04446	8.666	56
0.03843	8.324	52

capacity. Roasting of raw nuts and drying of the kernel are the two energy intensive operations in these industries. The drier is used mainly to remove the moisture (in the order of 10%) in the kernel. High thermal efficiency could be achieved by the combustion of fuelwood in an enclosed chamber over a suitable grate with a proper opening for primary and secondary air to generate the highest combustion temperature and thus maxi mise the heat transferred to the trays. Proper insulation of the drier doors and a chimney of suitable height and diameter to create a draught and disperse smoke are the other essential components in cutting down the fuelwood consumption. In two out of six firms, the combustion was done in an open chamber and the drier doors were poorly insulated. Apart from these, the drier is not loaded fully in these firms.

(a) The fuelwood cost is relatively small in the processing of cash crops such as cashew compared to the value of the end product. This is one of the reasons for not taking up energy conservation measures in these industries.
(b) Easy access and availability of fuelwood both on a commercial and non-commercial basis are the main reasons for the rural industries to use fuelwood. However, the fast depletion of forests has caused a fuelwood scarcity which affects the domestic consumer severely while these industries continue to get fuelwood at higher or increased cost. Nevertheless, the cost of fuelwood in the total production cost is very small in this sector. The inefficient usage of fuelwood, in the order of 46 to 50%, could be conserved by proper maintenance of equipment, better utilisation of installed production capacity and use of renewable sources of energy such as solar energy for steaming raw nuts.

CONCLUSIONS

1. The wide variations in EI from 4.49 kg of fuelwood/kg of kernel to 8.66 kg of fuelwood/kg of kernel reveals the scope for energy conservation to be in the order of 30 to 48%.
2. The relationship between SEC and Pr being a power law with an exponent less than one indicates an improvement of the SEC with increased production in a industry. Computation of the dynamic SEC (dEn/dPr) reveals that the rate of energy consumption is less than the production. The relative energy consumption rate decreases as the firm's production increases.
3. The use of fuelwood for domestic and rural industries applications will continue in this region for at least another decade. This study and earlier studies in the domestic sector have revealed that the present usage is very inefficient in these sectors. About 40-45% of fuel wood is saved in domestic cooking and water heating purposes. This necessitates a wider use of energy efficient end use devices to conserve energy. This helps in meeting the growing demand of energy in a region.
4. Fuelwood consumption in cashew processing industries could be brought down by: (a) use of solar water heating devices for roasting the raw nuts, and (b) the use of insulated, properly designed driers for drying the kernels.
5. Encouraging enterpreneurs to grow energy plantations on already degraded and unused lands to meet the fuelwood requirement for the industry in a sustainable way (while setting up energy intensive rural industries), could help to improve the soil condition by avoiding further

degradation and generate employment to rural youth.

6. Decision makers should take into account the energy requirements of the industries while emphasising the industrialisation of a region. The decentralised way of meeting the energy requirements of industries, e.g. solar, wind (depending on availability of source), small hydro and energy plantations, would be the most appropriate way of handling the energy situation in a region.

APPENDIX

Cashew (Anacardium occidentale L.), is a small tree, crooked; originally introduced from South America. Every part of the cashew is useful to man. The kernels are of high nutritive value. It is rich in carbohydrate (22%), unsaturated fats (47%), minerals such as Calcium (0.55), Phosphorous (0.45%), Iron (5.0 mg/100gm), Vitamins (Vitamin B, 630 mg/100gm) and Riboflavin (190 mg/100gm). A kernel supplies about 6000 calories of energy per kg as against 3600 by cereals, 1800 by meat and 650 by fresh fruit. The cashew apple juice is rich in vitamin C (261.5 mg/ 100gm) content and contains 10.15 to 12.5 per cent sugar and about 0.35% acid (as Malic). The mesocarp of the shell contains black, caustic, oil juice which is rubefacient and vesicant. It contains phenolic compound cardol, anacardic acid and an ether soluble substance. It is a valuable raw material for a number of polymer based industries e.g. for paints, varnishes, resins, industrial and decorativelaminates, brake linings and rubber compounding resins. Cashew nut shell liquid (CNSL) is used extensively in boat manufacturing industries and carved wood works as it effectively prevents white ants. The delicious and nutritious kernel is commonly eaten roasted, a process which improves the flavour. Coating on the kernel yields tannins (24-26%) which is used in the leather industries. The cashew apple and its juice has a medicinal value for scurvy, cough and colds and is an excellent purgative. The juice is used as an antiscorbutic and diuretic; given in kidney troubles and cholera. The bud and young leaf is used as a vegetable and as green manure; the leaf contain tannins (23%) used in skin diseases; the alcoholic extract shows hypoglycemic and anticancer activity [8].

In addition, cashew trees are used for firewood or charcoal. The pulp from the wood is used to fabricate corrugated and hard bound boxes. The bark of the tree yield& tannins (9%), and possesses an antihypertensive and hypoglycaemic properties; the milky sap, on exposure becomes black, useful in indelible ink. Gum from the bark, has insecticidal properties useful in book binding and pharmaceutical industry.

Cashew is familiarly known as "money spinner" among plantation crops due to the various uses of the tree ranging from land reclamation to medicinal purposes, and finds a unique place in our ecosystem. In Karnataka 4.04 lakh hectares of land are barren, sandy, slightly alkaline and poor in nutrients. Of this, 14,000 hectares is in the Uttara Kannada District. This could be used for cashew plantation and energy plantations. Casuarina equisetifolia, Acacia auriculiformis, Anacardium occidentale are best suited for this soil. Cashew because of versatility, and its ability to survive on saline land, laterite and red soils, is a very important tree in Agro and social forestry because of its distinctive role in land reclamation. It is usually closely planted for effective wide breaks for orchards and as soil binders.

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