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An Analytical Approach for Power Energy Management System with Techno-Economic Concept with Small Scale Industries (SSI) For Sustainable Development Strategy

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KEYWORDS

Analytical Approach, Techno-Economic

ABSTRACT:

This research focuses on developing an analytical approach for a Power Energy Management System (EMS) with a techno-economic concept tailored for Small Scale Industries (SSI). The study explores the integration of techno-economic optimization principles to enhance energy management and carbon capture in the context of sustainable development for SSI. Various case studies on optimization projects, including microgrids, Demand Side Management (DSM), liquefied energy chains, and hybrid PV/Wind energy systems, are reviewed to draw insights for small-scale industrial applications. Predictive control techniques are considered for energy use and indoor environmental quality management within the techno-economic optimization process.

The role of Small Scale Industries (SSI) in the Indian economy is emphasized, highlighting their significant contribution to GDP, manufacturing turnover, exports, and employment. The paper discusses the lack of a universally accepted definition of 'small business' and presents diverse definitions from different countries.

The research methodology involves a detailed analysis of the energy sector, emphasizing its vital role in economic growth. Energy resources are classified into primary and secondary categories, encompassing various sources such as nuclear, hydro, solar, wind, and refined fuels. The study delves into energy supply and demand, presenting trends in the production of commercial energy in India. Projections for energy demand up to 2035 are provided, and the estimated energy supply for the years 2014-15 and 2022-23 is outlined.

The paper explores the energy consumption patterns in India across major sectors, including transportation, industry, agriculture, and services. Special attention is given to the industrial sector, where energy consumption is projected to rise, with a focus on natural gas, oil, and coal. The patterns of electricity consumption in India and the state of Madhya Pradesh are analyzed, emphasizing the dominant role of the industrial, domestic, and agricultural sectors.

1 TECHNO-ECONOMIC OPTIMIZATION IMPROVES ENERGY MANAGEMENT, CARBON CAPTURE

Energy Management Systems (EMS) have been deployed for decades in utility control centers to help monitor the electric grid in real time by companies like Alstom Grid, for example. But these EMS systems are now being deployed outside utility control centers and closer to where electricity is ultimately consumed.

Today, there are loads of IRES case studies of optimization projects that have been completed that include energy management focused on the techno-economic optimization of microgrids, load shifting based on Demand Side Management (DSM), the use of

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liquefied energy chains that use liquid CO2 and natural gas, and the optimization of hybrid PV/Wind energy systems with battery storage. The most typical systems include four main energy sources: wind turbines (WT), photovoltaic (PV) solar panels, batteries, and hydrogen fuel-cell systems.[8-11]

Finally, predictive control techniques for energy use and indoor environmental quality management are part of the techno-economic optimization process.

1.1 Small Scale Industry in the Indian Economy Development

Small businesses/small-scale industrial units are playing an important role in the economic development of any nation. Although it is not generally recognized, this segment of our economy includes some of the dynamic, profitable and interesting firms. In India, there are 32.25 lakhs small scale industrial units/businesses in the SSI sector, employing 177.30 lakh persons (1999-2000). The output of this sector is around Rs.5, 78,470 crores. The export amounted to Rs.53, 975 crores. SSIs contribute up to 40 per cent of gross turnover in manufacturing sector, 45% of the manufacturing exports and 35% of the total exports. SSI sector, contributes 7% of the GDP. During this era of economic liberalization, the growth of the SSI sector is rather quite perceptible. [22]

Definition of Small Scale Industry There is no generally accepted definition of a 'small business'. The definitions vary all the way from country to country and Government-to Government in a country. The following are some of the definitions.

In the USA, in the Small Business Act 1953, congress defined a small business as one that is independently owned and operated and which is not dominant in its field of operation.[17]

In India, the Department of Small Scale and Agro and Rural Industries considered small businesses as a sector and given the following definitions.

2 RESEARCH METHODOLOGY

2.1 Energy Sector

Energy is one of the vital factors for economic growth. In modern days, energy is considered as a factor of production like land, labour, capital and organization. Consumption of energy is one of the key indicators of the development of a country. Various studies have proved that there is a direct relationship between the energy and economic growth.

Energy sources are classified according to their characteristics and consumption pattern. Energy resources can be classified into primary and secondary energy resources. Nuclear energy, hydro energy, solar and wind energy come under the category of the primary energy resources, whereas refined fuels such as gasoline, fuel oil, electricity, etc. are the secondary resources.[11]

3 ENERGY SUPPLY AND DEMAND

The sources of supply of energy are categorized into four sources. They are: Coal, Oil, Natural gas and Power. The trend in production of commercial energy is given in Table 3.1.

Table - 3.1 Trend in Production of Commercial Energy in India

Energy	Unit	Production				
		2006	2010	2014	2018	2022
Coal	MMT	114.01	212.73	298.05	330.65	409.63
Oil	MMT	9.51	43.02	34.87	35.03	30.97
Natural Gas	MCM	4.35	3.79	3.29	30.69	32.62
Power	BKWH	5.24	7.14	10.01	17.92	20.3

India's total energy supply is estimated to 2000 MTDE. Experts revealed that the supply of energy would grow exponentially. The energy demand in the years 2025 and 2030 is estimated in Table 3.2.

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Figure - 3.1 Trend in Production of Commercial Energy in India

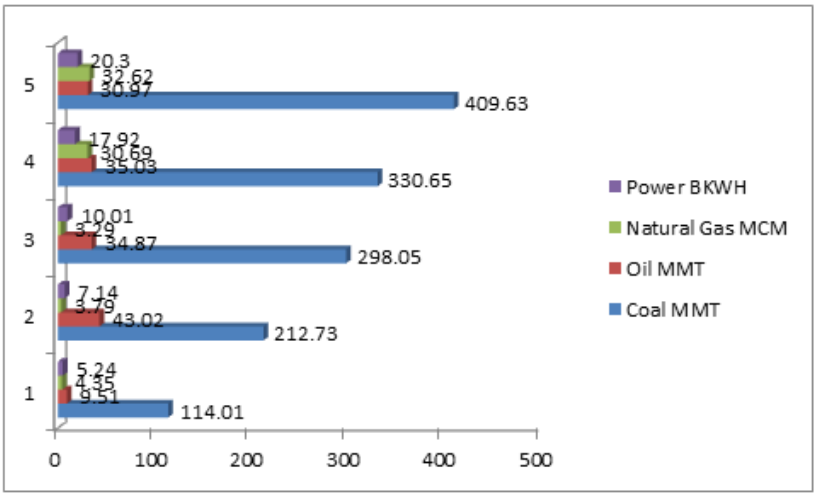

Table 3.2 Energy demand in India

S. No.	Source of Energy	Year			
		2025	2030	2035	Average Annual Growth (in %)
1	Oil (Million Barrels Per day)	2.9	4.1	6.1	4.8
2	Coal (Million Short-tons)	381	455	540	5.2
3	Natural Gas (Trillion Cubic feet)	4.2	3.8	7.7	9.6
4	Electricity (Billion kilowatt hours)	483	811	1300	5.9

The estimated energy supply in India during the periods 2014-15 and 2022-23 is given below in the table.

Figure 3.2 Energy Demand in India

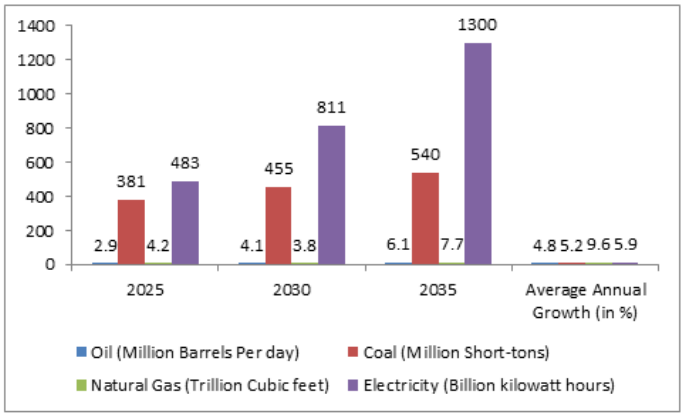

Table 3.3 Estimated Energy Supply in India

S. No.	Type of Energy	Supply (MTOE)		Supply (MTOE)	
		2014-15	%	2022-23	%
1	Commercial Energy	412.91	76.14	544.68	75.72
2	Non-Commercial Energy	146.3	28.86	169.25	28.28
	Total	559.21	105	713.93	104

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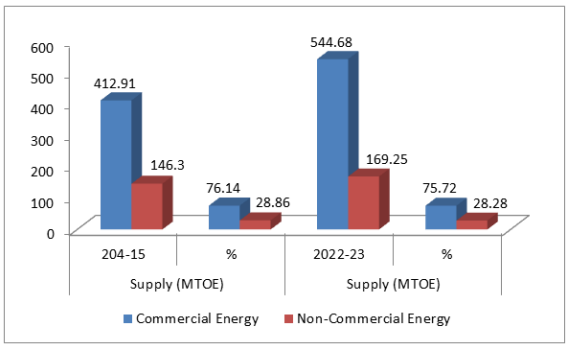
Figure: 3.3 Estimated Energy Supply in India



3.1 Energy Consumption Pattern

Energy consumption in India can be discussed mainly in four major sections namely, transportation, industry, agriculture and services which include household consumption and commercial or public services. In the industrial sector, the role of energy is all prevailing and it is basic to numerous operations of plant and machinery, movement of heavy equipment, material processing, and lighting. 'There is more need for energy in the industrial and transportation sectors.

Energy consumption in industrial sector is projected to rise by 3.9% per year from 2020 to 2025, before slowing down to an average of 2.4% per year from 2025 to 2035. Natural gas and oil consumption accounted for more than one half of industrial energy consumption in most states of India. In India, the coal consumption accounts for 37% in the industries owing to the rich coal resources and also due to lack of other domestic naturally ""available energy resources for development". Power consumption is dominated by three sectors viz. Domestic, Agriculture and Industry and these sectors together accounted for about 82% of the total consumption.

Table 3.4 Pattern of Electricity Consumption in India (Per cent)

Sectors	1980-81	2000-2001	2022-23
Industry	60	62	41
Agriculture	6	13	26
Railway traction	8	4	2
Public lighting etc.	12	11	13
Domestic use	14	10	18
Total Percent	**100**	**100**	**100**

Figure: 3.4 Pattern of Electricity Consumption in India (Per cent)

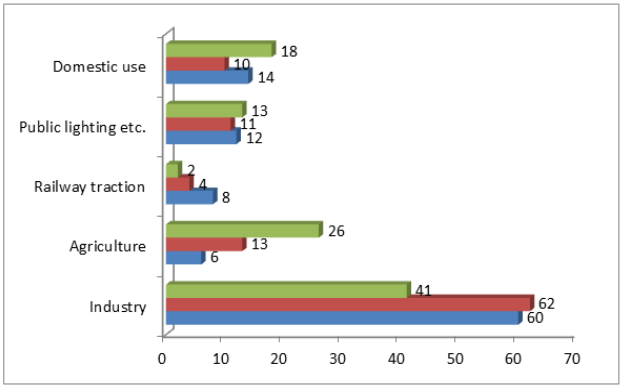


Table 3.5 Pattern of Electricity consumption in MP

Category	2016-17	2018-19	2020-21	2022-23
Domestic	7712 (21.91)	8837 (24.31)	9719 (25.30)	11083 (27.50)
Commercial	3361 (9.56)	3632 (9.99)	3498 (9.10)	3769 (9.40)
Industries	11220 (31.87)	11974 (32.94)	13496 (35.17)	13570 (33.67)
Agriculture	9495 (26.97)	9030 (24.85)	9588 (25.00)	9766 (24.20)
Public Lighting and Water Works	992 (2.82)	1038 (2.86)	1080 (2.80)	1103 (2.70)
Others	2422 (6.88)	1836 (5.05)	993 (2.60)	1007 (2.5)
Total	35202 (100)	36347 (100)	38374 (100)	40298 (100)

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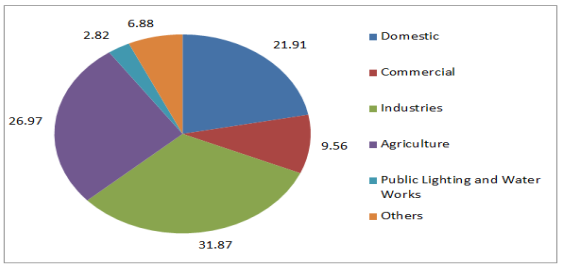
Figure: 3.5 Pattern of Electricity consumption in MP



4 ENERGY MANAGEMENT IN SMALL SCALE INDUSTRIES

Primary data collected from 7 different category of selected small scale industries are analysed in this chapter. The present chapter consists of three sections. The socio-economic status of the 21 sample units and 1050 respondents (50 from each unit) are presented in the first section. The second section deals with the availability of energy sources in small sale industries and their consumption pattern. The third section analysed the testing of few hypotheses with suitable statistical tools.

4.1 Socio-Economic status of the sample respondents

Table 4.1 Age of the Sample Respondents

S. No.	Age Group	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	%
1	21-30	0	10	0	10	0	0	10	30	2.86%
2	31-40	20	40	20	50	20	40	40	230	21.9%
3	41-50	30	50	20	70	40	80	70	360	34.29%
4	51-60	80	20	80	20	60	20	30	310	29.52%
5	61-70	20	30	30	0	3	0	0	110	10.48%
6	71-80	0	0	0	0	0	10	0	10	0.95%
Total		**150**	**150**	**150**	**150**	**150**	**150**	**150**	**1050**	**100%**

Figure 4.1 Age of the Sample Respondents

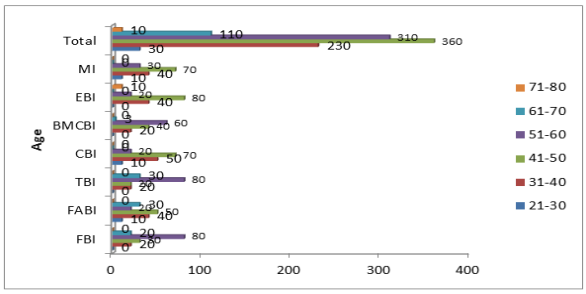


Table 4.2 Gender of the Sample Respondents

S. No.	Gender	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	Percent
1	Male	140	140	140	150	150	150	150	1020	97.14%
2	Female	10	10	10	0	0	0	0	3	2.86%
Total		150	150	150	150	150	150	150	1050	100%

Figure 4.2 Gender of the Sample Respondents

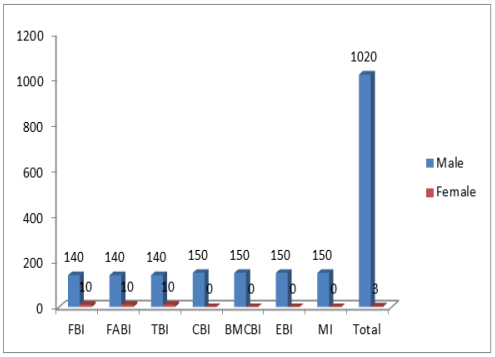


Table 4.3 Educational Qualification of the Sample Respondents

S. No.	Educational Qualification	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	% to Total
1	Below Matric	20	40	0	10	10	10	0	90	8.57%
2	10th	40	10	10	20	0	20	0	100	9.52%
3	12th	10	30	30	20	10	0	30	130	12.38%
4	Diploma	00	20	40	70	60	30	50	270	25.71%
5	Degree	50	50	50	10	40	70	60	330	31.43%
6	Above Degree	30	0	20	20	30	20	10	130	12.38%
Total		150	150	150	150	150	150	150	1050	100%

Figure 4.3 Educational Qualification of the Sample Respondents

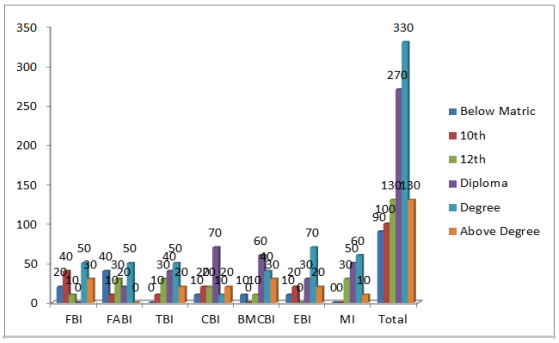


Table 4.4 Father's Occupation of the Sample Respondents

S. No.	Father's Occupation	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	% to Total
1	Business	140	130	130	90	130	80	90	790	75.24%
2	Farmer	10	0	0	20	10	10	00	50	4.76%
3	Govt. Service	0	20	20	30	10	40	30	150	14.29%
4	Private	0	0	0	10	0	20	10	40	3.81%
5	Others	0	0	0	0	0	00	20	20	1.90%
Total		150	150	150	150	150	150	150	1050	100%

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Figure 4.4 Father's Occupation of the Sample Respondents

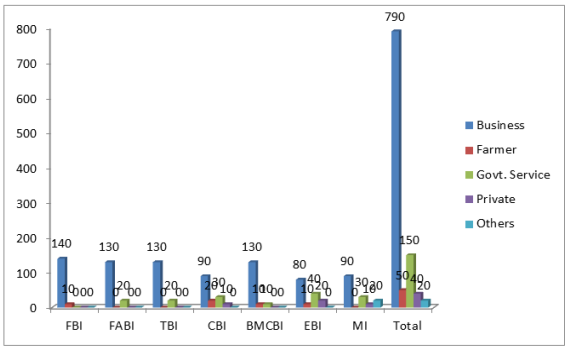


Table 4.5 Family Status of the Sample Respondents

S. No.	Family Status	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	%
1	Joint Family	10	30	30	30	20	0	0	120	11.43%
2	Nuclear Family	140	120	120	120	130	150	150	930	88.57%
Total		150	150	150	150	150	150	150	1050	100%

Figure 4.5 Family Status of the Sample Respondents

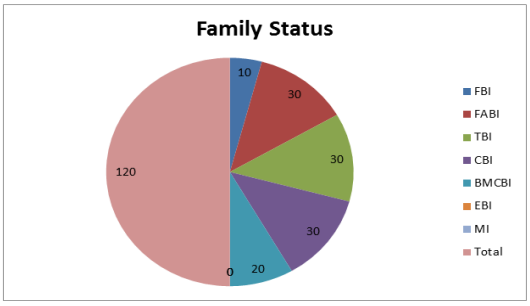
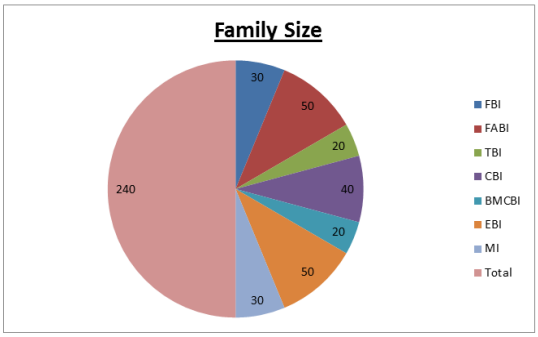


Table 4.6 Family size of the Sample Respondents

S. No.	Family Size	FBI	FABI	TBI	CBI	BMCBI	EBI	MI	Total	%
1	0-3	30	50	20	40	20	50	30	240	22.86%
2	4-6	110	70	110	100	120	100	120	730	69.52%
3	7-9	10	10	10	10	10	0	0	50	4.76%
4	Above 10	00	20	10	0	0	0	0	30	2.86%
Total		150	150	150	150	150	150	150	1050	100%

Figure 4.6 Family size of the Sample Respondents



4.2 Energy Management in SSI Sector

The present study attempts to analyse the energy management in terms of energy utilisation pattern and cost incurred for energy for production and lighting activities in the SSI sectors. In order to compare the energy utilisation pattern in various categories of the SSI sectors, the energy equivalent of different fuels are also analysed in this section. The size of the SSI sample unit and the type of energy used in the sector varied from unit to unit and category to category. Hence, the category wise analysis of the energy utilisation and energy cost is presented in the study.

Energy consumption in sample SSI units

Table 4.7 Average Annual Consumption of resources in Food Based Industry

Resources	Rice Mill		Bakery		Vermicelli		Total			Average per unit
	Production	Lighting	Production	Lighting	Production	Lighting	Production	Lighting	Total	
Electricity (Units)	49752	2622	57066	3028	28539	1564	135357	7214	142571	47524
Firewood	183		16		6		205	0	205	68
Paddy Husk (Ton)	78						78	0	78	26
Groundnut Shell (Ton)	3						3	0	3	1

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Petrol (Ltr)	726						726	0	726	242
LPG (Nos)			483				486	0	483	161
Kerosene (Ltr)			126				126	0	126	42
Men	6		29		11		46	0	46	15
Women	16				14		30	0	30	10

Figure 4.7 Average Annual Consumption of resources in Food Based Industry

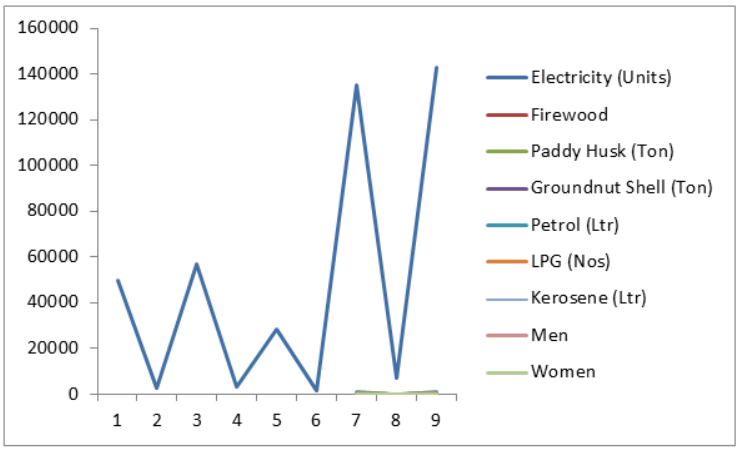

Table 4.8 Average Annual Consumption of resources in Forest and Agro Based Industry

	Corrugated Boxes Mfg Unit		Saw Mill		Coir Rope Mfg Unit		Total			Average per unit
	Production	Lighting	Production	Lighting	Production	Lighting	Production	Lighting	Total	
Electricity (Units)	96192	24048	19956	3522	4326	1088	120474	28658	149132	49711
Diesel (Ltr)	489		129				618	0	618	206
LPG (Nos)	8						8	0	8	3
Kerosene (Ltr)			25				25	0	25	8
Crude Oil (Ltr)			186				186	0	186	62
Men	17		11		13		41	0	41	14
Women	9				13		22	0	22	7

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Figure 4.8 Average Annual Consumption of resources in Forest and Agro Based Industry

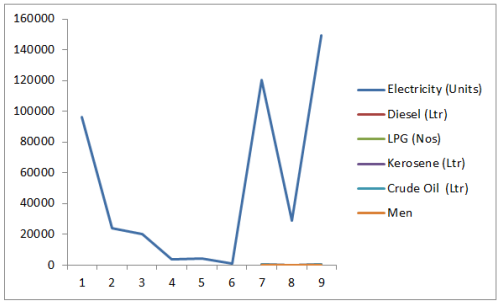


Table 6.9 Average Annual Energy Equivalent of different resources consumed in Food Based Industry

Resources	Rice Mill		Bakery		Vermicelli		Total			Average per unit (kwh)	Percent
	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Total (kwh)		
Electricity	49254	2596	56495	2998	28254	1548	134003	7142	141145	47048	8.95%
Firewood	896700	0	78400	0	29400	0	1004500	0	1004500	334833	63.70%
Paddy Husk	267540						267540	0	267540	89180	16.97%
Groundnut Shell	14220						14220	0	14220	4740	0.90%
Petrol	6636						6636	0	6636	2212	0.42%
LPG			49382				49382	0	49382	16461	3.13%
Kerosene			1154				1154	0	1154	385	0.07%
Men	7920		38280		14520		60720	0	60720	20240	3.85%
Women	16896				14784		31680	0	31680	10560	2.01%
Total	1259166	2596	223711	2998	86958	1548	1569835	7142	1576977	525659	100.00%

Figure 6.9 Average Annual Energy Equivalent of different resources consumed in Food Based Industry

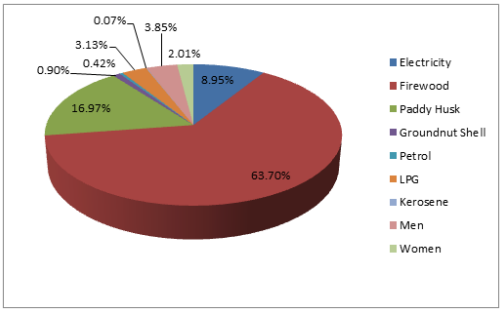
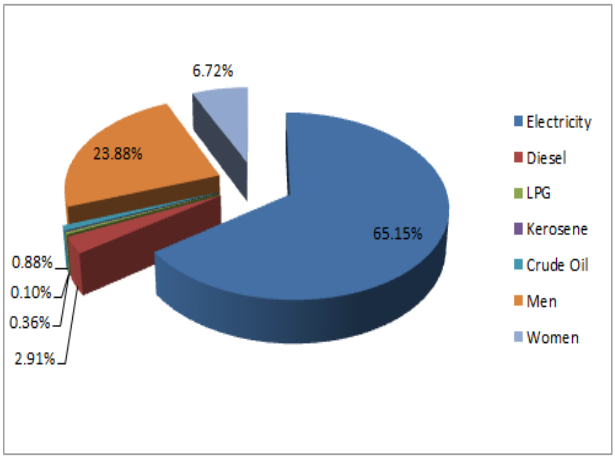


Table 6.10 Average Annual Energy Equivalent of different resources consumed in Forest and Agro Based Industry

Resources	Corrugated Boxes Mfg Unit		Saw Mill		Coir Rope Mfg Unit		Total			Average per unit (kwh)	Percent
	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Production (kwh)	Lighting (kwh)	Total (kwh)		
Electricity	95230	23808	19756	3487	4283	1077	119269	28372	147641	49214	65.15%
Diesel	5232		1359				6591	0	6591	2197	2.91%
LPG	818						818	0	818	273	0.36%
Kerosene			229				229	0	229	76	0.10%
Crude Oil			1988				1988	0	1988	663	0.88%
Men	22440		14520		17160		54120	0	54120	18040	23.88%
Women	1504				13728		15232	0	15232	5077	6.72%
Total	125224	23808	37852	3487	35171	1077	198247	28372	226619	75540	100.00%

Table 6.10 Average Annual Energy Equivalent of different resources consumed in Forest and Agro Based Industry



5 SUMMARY OF FINDINGS

Findings of present research study can be summarized as follows:

- From technical aspect, It is evident from the findings of all 7 categories of SSI that common major resources of energy consumption are Human Energy (i.e. Men and Women), Commercial source of energy (Electricity) and Natural sources of energy (Firewood, Paddy husk and diesel).
- From economic aspect of, it is evident from the findings of all 7 categories of SSI that common major resources of energy cost are Human Energy (i.e. Men and Women) and Commercial source of energy (Electricity).
- Since human energy is major contributor in terms of energy consumption and energy cost, its minimization can be highly beneficial for major small scale industries. Its minimization can be achieved by awareness and adaptation of

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technological advancement and automation of machines and processes.

- Another major contributor of energy consumption and energy cost is Electricity. It is produced in various forms, among which coal based thermal power plant are only non-renewable energy source based facility. Development of hydro, solar and wind energy based power plant can minimize the cost of electricity generation and its demand in small scale industries can be fulfilled and economic advantage can be achieved.
- Other natural resources i.e. firewood, diesel etc. can be alternated by biogas power generation and bio fuels production in view of environmental protection and sustainability.

6 BARRIERS AND ENERGY CONSERVATION POLICIES

The barriers to energy conservation are many. Some of the important barriers are as follows.

- High cost of energy saving devices and equipment.
- Lack of adequate financial facilities to purchase energy saving equipment.
- Low price of energy is also a barrier of energy conservation. It does not create enough motivation for introducing energy conserving measures.
- The time required for switching over from energy consuming equipment to a more efficient one.
- Lack of knowledge about the scope of energy consumption
- The high level investment required for the production of energy conserving equipment.
- Uncertainties about the future also tend to discourage investment in energy conservation industry.

7 SUGGESTIONS

The following are the suggested tips for energy conservation.

- The electricity may be saved by the use of sodium vapour lamps for area lighting in place of Mercury vapour lamps.
- The treated water may be used in boilers. A scale formation on the waterside increases fuel consumption.
- A properly maintained injection pump decreases fuel consumption.
- Government can provide concessions in tax to the industries under various energy conservation programmes.
- Electricity and oil consumption can be reduced to a greater extent by fixing the ball bearings in appropriate places of the machines.
- Adopting suitable economic, energy efficient fuels, e.g. using cashew nut shells as fuels in brick kilns instead of firewood may provide the efficient energy management.
- Trained people should be employed in the industries. So that they may be able to achieve maximum production with minimum consumption of man power, power and machine power.

8 CONCLUSION

The study has identified some problems and constraints involved in implementing energy conservation measures and suggested some suitable measures for the effective energy management systems in the SSI sector. Energy conservation is the need of the hour. If dedicated and concerted efforts are made to save energy in industrial sector, significant breakthrough could be obtained through energy conservation, by providing driving force for more industrial units thereby raising the overall industrial production in the country.

The core of the research centers on energy management in Small Scale Industries (SSI). Primary data collected from seven different categories of SSI are analyzed, covering socio-economic aspects, energy sources, consumption patterns, and testing hypotheses using statistical tools. The findings underscore the significance of human energy, electricity, and natural resources in energy consumption and cost. Recommendations for minimizing human energy through technological advancements and optimizing electricity generation through renewable sources are proposed.

The study concludes by addressing barriers to energy conservation in SSI, suggesting policies to overcome these barriers, and providing practical tips for

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energy conservation. The importance of government incentives, technological advancements, and the training of personnel for effective energy management in the SSI sector is emphasized. The research highlights the need for dedicated efforts in energy conservation to drive overall industrial production and contribute to sustainable development.

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