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## Commercial Sector Energy Consumption Pattern in Madurai and Salem Cities of Tamil Nadu, India

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### **Abstract:**

Energy is a basic and essential need for all kind of works in the Universe and its consumption pattern has been increased steeply due to increase in the population and economic growth. The current world energy consumption primarily depends on the fossil fuels such as coal, petroleum fuels and natural gas. The rate of depletion of these conventional fuels is rapid and therefore it is important to investigate the existing types of energy usage, consumption pattern and demand, especially in cities of developing countries for its efficient utilization. The present work is concentrated on the above said aspect in Madurai and Salem, the second and fifth largest and most densely populated cities, respectively in the state of Tamil Nadu, India. We have focused mainly on energy consumers of commercial sectors in these two cities. The energy consumption pattern of the commercial sector is found out through questioner survey and the energy demand is calculated. The variations in energy utilization are assessed by using cluster sampling method and the results are discussed. Since the energy demand and environmental deterioration are in rising trend, it is necessary to establish the energy conservation measures and utilize the renewable energy sources not only to overcome the energy demand but also to safeguard the health and wealth of the people reside in the Madurai and Salem cities.

**Key words:** Energy; commercial sector; demand and supply; consumption pattern

### **1. Introduction**

Energy is a very essential and basic requirement to perform all kinds of activity in the world. The energy usage pattern in developing countries has been increased steeply in accordance with the population growth (Goldemberg et al., 1988). Especially in India, which is a world's second densely populated country with 1210 million, the energy usage pattern is very high. This creates severe energy and environmental burdens and the most crucial are the fast depletion of fossil fuel reservoirs and the subsequent environmental pollution (Mackay, 1995). According to the predictions, the world primary energy demand will be increased by 50 percent between 2005 and 2030 and around 45 percent of this increase will be due to heavy populated countries of China and India alone.

Based on the nature of energy end-use sectors they are classified as industrial, household, commercial, agricultural, social, service and transportation sectors. Among these the energy use in the commercial sector has gained considerable attention (Leung, 2010). The commercial sector of modern cities in India depends heavily on fossil fuels for all the activities and for powering devices. The energy consumption pattern in commercial sector varies greatly with geographical location, population density, living standards, climate and lifestyles (Winkler, 2006). Therefore, it is the foremost requirement to examine the structure of energy consumption in developing countries like India and that will help to find out the energy demand and formulate measures to compensate the same in the near future. The present study has the following objectives:

- Identifying utilization of present energy sources in the commercial sector
- Quantifying all energies used in the commercial sector
- Analysing and comparing type-wise consumption of energy in commercial sector and its expenditure.

## 2. Materials and Methods

### 2.1. Methodology

Designing a suitable methodology and selection of analytical tools are important for a meaningful analysis of any research problem. This section is devoted to describe the methodology, which includes study area, sampling procedure, period of study, collection of data, method of analysis and tools of analysis.

### 2.2. Study Area

The area selected for the present study are Madurai and Salem, which are second and fifth big cities, respectively in terms of population in the state of Tamil Nadu, India. Both the cities are corporations with major industries and trading centers. Another important feature is the significantly higher work force that the cities are supporting in the non-agricultural sector, 40 percent of this workforce is occupied by this sector as against 45 to 55 percent in the respective cities. However, on the whole, the population and workforce occupied in these two cities indicate the high-energy consumption in the commercial sector. With this background, the energy consumption pattern in the commercial sector was examined for the Madurai and Salem cities.

### 2.3. Sampling Procedure

Madurai city comprises 72 wards. For the purpose of primary data collection, the Madurai city was classified into four zones, namely, north, east, south and west zones. The wards 1 to 21 are in north zone, 44 to 59 are in east zone, 31 to 43 and 60 to 65 are in south zone, and 22 to 30 and 66 to 72 wards are in the west zone. The number of wards in each zone is 21, 16, 19 and 16 in north, east, south and west zones, respectively.

Salem city contains 60 wards. For the purpose of primary data collection, Salem city was classified into four zones namely east (zone 1), west (zone 2), north (zone 3) and south (zone 4). The number of wards in each zone is 14, 14, 16 and 16 from east, west, north and south zones, respectively.

### 2.4. Period of Study

The field survey was conducted from September 2012 to May 2013 for the collection of primary data. The reference period of the survey was 2012-2013.

### 2.5. Collection of Data

The survey was based on personal interviews. The schedule was a detailed one consisting of the name of the commercial sector, type and quantity of the energy carrier used, etc. During the survey, the commercial sector representative was asked to enumerate the energy carriers used for different end-uses, viz. cooking, water heating, lighting etc. The pattern of end-use of each carrier was studied by disaggregating the consumption in the commercial sector, according to cooking, water heating, lighting etc. Since the survey contained questions only on the sole energy consumption of each energy carrier in the commercial sector (and not for a particular end-use), the desegregations was done while analyzing the results. Except in the case of electricity, other carriers were used for cooking and water heating and these habits hardly change with season (confirmed during the survey). The consumption of electricity was higher in summer because of the extensive use of fan, water heaters, and refrigerators and to some extent bulbs and tubes. The consumption of energy carriers was determined as usage per month. In the case of LPG, one cylinder utilization duration was ascertained.

### 2.6. Method and Tools of Analysis

Keeping in view the objectives of the study, the commercial sector was categorized into type-wise (large, medium and small) energy consumption pattern. In order to examine the difference in energy consumption analysis of variants (ANOVA), one-way test was carried out.

## 3. Results and Discussion

### 3.1. Energy Sources and Consumption Pattern of the House Hold Sector

An attempt has been made to analyze the energy use pattern in commercial sector both type-wise (large, medium and small) and zone-wise east, west, north and south) in Madurai and Salem cities.

### 3.2. Type-Wise Energy use Pattern

An attempt was made to analyze and compare the type wise energy use pattern in Madurai and Salem cities. The various energy sources for commercial sector is classified as charcoal, wood, agro residues, kerosene, LPG and electricity energy sources are converted from their quantity to calories of energy. The following table provides the conversion of energy sources into calories of energy. Table 1 & 2 gives the details relating to type wise energy sources consumed by commercial sectors in Madurai and Salem cities.

Particular	Large		Medium		Small		Total	
	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption
Charcoal (kg)	1	600	NU	NU	9	2260	10	2860
Wood (kg)	NU	NU	1	4000	19	23100	20	27100
Agro Residues(kg)	NU	NU	NU	NU	4	250	4	250
Kerosene (lit)	NU	NU	NU	NU	6	45	6	45
LPG (kg)	3	57.3	3	57.3	30	573	36	687.6
Others (kg or lit)	NU	NU	NU	NU	4	198	4	198
Electricity (kwh)	12	39130	22	24050	75	25043	109	88223

Table 1: Commercial Sector Energy Consumption per Month in Madurai City (Type Wise)  
Source: Survey Data NU- Not in Use

Particular	Large		Medium		Small		Total	
	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption
Charcoal (kg)	NU	NU	1	75	4	400	5	475
Wood (kg)	NU	NU	4	7000	17	22387	21	29387
Agro Residues (kg)	NU	NU	2	550	3	1130	5	1680
Kerosene (lit)	NU	NU	NU	NU	10	97	10	97
LPG (kg)	NU	NU	9	171.9	31	592.1	40	764
Others (kg or lit)	NU	NU	NU	NU	2	17	2	17
Electricity (kwh)	2	7800	31	14104	61	19831	94	41735

Table 2: Commercial Sector Energy Consumption per Month in Salem City (Type Wise)  
Source: Survey Data NU- Not in Use

From the table 1, it has been observed that in the case of large size commercial sector in Madurai, maximum of 3913 kwh of electricity is consumed followed by 600 kg of charcoal is consumed and 57.3kg q LPG is consumed. In the case of medium size commercial sector, maximum of 24050 kwh of electricity is consumed by the sector followed by 4000 kg of wood is consumed and 57.3 kg of LPG is consumed. Further, it is also observed that in the case of small size commercial sector, maximum of 25043 kwh of electricity is consumed followed by 23100 kg of wood sector and 2260 kg of charcoal is consumed by commercial sector. It has been observed from the table 2 that in the case of large size commercial sector, total of 7800 kwh of electricity as source of energy is consumed by the sector. In the case of medium size commercial sector, maximum of 14104 kwh of electricity is consumed by the sector followed by 7000 kg of wood is consumed, 550 kg of Agro residues is consumed as source of energy, 171.9 kg of LPG is consumed and 75 kg of charcoal is consumed as source of energy. Further, it also reveals that in the case of small size commercial sector, maximum of 22387 kg of wood is consumed by the sector followed by 19831 kwh of electricity is consumed 1130kg of agro residue is consumed as sources of energy. Further, it also reveals that in the case of small size commercial sector, maximum of 22387 kg of wood is consumed by the sector followed by 19837 kwh of electricity is consumed 1130 kg of agro residue is consumed as source of energy, 400 kg of charcoal is consumed and 97 liters of kerosene is consumed by the commercial sector.

Tables 3 and 4 give the details relating to type wise energy sources in mega joules consumed by commercial sectors in Madurai and Salem cities, respectively.

Particular	Large		Medium		Small		Total	
	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption
Charcoal	1	16800	NU	NU	9	63280	10	80080
Wood	NU	NU	1	59200	19	341880	20	401080
Agro Residues	NU	NU	NU	NU	4	4050	4	4050
Kerosene	NU	NU	NU	NU	6	1530	6	1530
LPG	3	2555.5	3	2555.5	30	25555.8	36	30666.8
Others	NU	NU	NU	NU	4	6272	4	6272
Electricity	12	140868	22	86580	75	90154.8	109	317602.8

Table 3: Commercial Sector Energy Consumption per Month in Madurai City (Type Wise) (in Mega Joules)  
Source: Survey Data NU- Not in Use

Particular	Large		Medium		Small		Total	
	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption	Number of Respondents	Total Energy Consumption
Charcoal	NU	NU	1	2100	4	11200	5	13300
Wood	NU	NU	4	103600	17	331327.6	21	434927.6
Agro Residues	NU	NU	2	9185	3	18871	5	28056
Kerosene	NU	NU	NU	NU	10	3298	10	3298
LPG	NU	NU	9	7666.7	31	26407.6	40	34074.3
Others	NU	NU	NU	NU	2	544	2	544
Electricity	2	28080	31	50774.4	61	71391.6	94	150246

Table 4: Commercial Sector Energy Consumption per Month in Salem City (Type Wise) (in Mega Joules)  
Source: Survey Data NU- Not in Use

From the table 3, it has been revealed that in the case of large size commercial sector in Madurai, maximum of 140868 mega joules of electricity is consumed by the sector followed by 2555.5 mega joules of LPG is consumed by the sector and 16800 mega joules of charcoal is consumed by the sector. In the case of medium size commercial sector, maximum of 86580 mega joules of electricity is consumed by the sector followed by 59200 mega joules of wood is consumed by the sector and 2555.5 mega joules of LPG is consumed by the sector. Further, it also shows that in the case of small size commercial sector, maximum of 341880 mega joules of wood is consumed followed by 70154.8 mega joules of electricity is consumed by the sector, 63280 mega joules of charcoal is consumed by the sector, 25555.8 mega joules of LPG is consumed by the commercial sector on a 4050 mega joules of Agro residues are also consumed by the sector.

It has been inferred from the table 4, that in the case of large size commercial sector, total of 28080 mega joules of electricity is consumed by the sector. In the case of medium size commercial sector, maximum of 10.600 mega joules of wood is consumed as source of energy by the sector, followed by 9185 mega joules of agro residues is consumed by the sector, 7666.7 mega joules of LPG is consumed as spruce of energy by the sector. Further, it also shows that in the case of small size commercial sector, maximum of 331327.6 mega joules of wood is consumed by the sector flowed by 71391.6 mega joules of electricity is consumed, 26407.6 mega joules of LPG is consumed as source of energy, 18871 mega joules of agro residues is consumed, 11200 mega joules of charcoal is consumed as source of energy by sector. 3298 mega joule of kerosene is consumed as sources of energy. In order to examine the variation in consumption of energy type wise between two cities, ANOVA was applied and the computed results are given in Table 5. It is inferred from Table 5, wide variation in energy consumption in commercial sector was found in Wood, LPG and electricity consumption. That there is no evidence of variation in consumption of energy in commercial sector between Madurai and Salem city

Particulars	Madurai and Salem	Sum of Squares	df	Mean Square	F	Sig.
Charcoal: Cooking, Hot water and Lighting/kg/m	Between Groups	168420.256	2	84210.128	.915	.427
	Within Groups	1104323.077	12	92026.923		
	Total	1272743.333	14			
Wood: Cooking, Hot water and Lighting/kg/m	Between Groups	3850157.077	1	3850157.077	4.984	.031
	Within Groups	301226680.672	39	772478.999		
	Total	33976838.049	40			
Agro Residues: Cooking, Hot water and Lighting/kg/m	Between Groups	9429.365	1	9429.365	.077	.789
	Within Groups	857392.857	7	122484.694		
	Total	866822.222	8			
LPG: Cooking, Hot water and Lighting/kg/m	Between Groups	9.673	2	4.836	7.385	.001
	Within Groups	47.811	73	.655		
	Total	57.484	75			
Electricity Consumption: Average units consumed (kwh)/ Month	Between Groups	116391618.116	2	58195809.058	47.615	.000
	Within Groups	244442290.770	200	1222211.454		
	Total	360833908.887	202			

Table 5: ANOVA Test: Energy Consumption in Commercial Sector Type Wise  
Source: Computed

Tables 3.6 and 3.7, give the details relating to type wise energy expenditure in commercial sectors in Madurai and Salem cities, respectively.

Type of Commercial	Charcoal (kg)		Wood (kg)		Agro Residues (kg)		Kerosene (lit)		LPG (kg)		Electricity (kwh)	
	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)
Large	1	12000	NU	NU	NU	NU	NU	NU	3	138750	12	224350
Medium	NU	NU	1	20000	NU	NU	NU	NU	3	39350	22	168389
Small	9	7885	19	46818	4	395	6	1185	30	74000	75	143194
Total	10	19885	20	66818	4	395	6	1185	36	252100	109	535933

Table 6: Commercial sector Energy Expenditure per Month – Commercial type wise in Madurai City  
Source: Computed  
NU- Not in Use

Type of Commercial	Charcoal (kg)		Wood (kg)		Agro Residues (kg)		Kerosene (lit)		LPG (kg)		Electricity (kwh)	
	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)
Large	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	2	52000
Medium	1	125	4	16000	2	225	NU	NU	9	57400	31	84644
Small	4	685	17	49215	2	220	10	3765	31	105640	61	102682
Total	5	810	21	65215	4	445	10	3765	40	163040	94	239326

*Table 7: Commercial sector Energy Expenditure per Month – Commercial type wise in Salem City*  
*Source: Computed* *NU- Not in Use*

From the table 6, it has been inferred that in the case of charcoal as a source of energy consumed by commercial sector, maximum of Rs. 12000 is spent by large size commercial sector and Rs. 7885 is spent small size commercial sector. In the case of wood as source of energy, maximum of Rs. 46818 is spent kg small size commercial sector and Rs. 20000 is spent kg medium size commercial sector. In the case of Agro residues as source of energy Rs. 395 is spent by small size commercial sector. In the case of kerosene as a source of energy, Rs. 1185 is spent by small size commercial sector. Further, it is also revealed that, in the case of LPG as source of energy, maximum of Rs. 138750 is spent by large size commercial sector followed by Rs. 74000 is spent by small size commercial sector and Rs. 39350 is spent by medium size commercial sector. In the case of electricity as source of energy, maximum of Rs. 224350 is spent by large size commercial sector followed by Rs. 168389 spent by medium size commercial sector and Rs. 143194 is spent by small size commercial sector.

It has been revealed from the table 7 that in the case of charcoal as source of energy in the commercial sector, maximum of Rs. 685 is spent by small size commercial sector and Rs. 125 is spent by medium size commercial sector. In the case of wood as source of energy, maximum of Rs. 49215 is spent by small size commercial sector and Rs. 16000 is spent by medium size commercial sector. In the case of Agro residues as source of energy, maximum of Rs. 225 is spent by medium size commercial sector and Rs. 220 is spent by small size commercial sector. In the case of kerosene as source of energy, Rs. 3765 is spent by small size commercial sector. Further, it also inferred that in the case of LPG as source of energy, Rs. 105640 is spent by small size commercial sector and Rs. 57400 is spent by medium size commercial sector. In the case of electricity as source of energy, maximum of Rs. 102682 is spent by small size commercial sector followed by Rs. 84644 is spent by medium size commercial sector and Rs. 52000 is spent by large size commercial sector.

To test whether there is any variation in energy consumption cost in Type wise between Madurai and Salem cities, ANOVA test was carried out. The results are given in Table 8.



Particulars	Madurai and Salem	Sum of Squares	df	Mean Square	F	Sig.
Charcoal: Purchase Cost (Rs)	Between Groups	121113031.026	2	60556515.513	39.023	.000
	Within Groups	18621792.308	12	1551816.026		
	Total	139734823.333	14			
Wood: Purchase Cost (Rs)	Between Groups	90191222.561	1	90191222.561	11.258	.002
	Within Groups	312440425.000	39	8011292.949		
	Total	402631647.561	40			
Agro Residues: Purchase Cost (Rs)	Between Groups	150.000	1	150.000	.043	.843
	Within Groups	21100.000	6	3516.667		
	Total	21250.000	7			
LPG: Purchase Cost (Rs)	Between Groups	5458611824.094	5	2729305912.047	24.678	.000
	Within Groups	8073623149.590	73	110597577.392		
	Total	13532234973.684	75			
Electricity Consumption: Average Bill Amount/2 month (Rs)	Between Groups	4146784019.465	2	2073392009.732	44.597	.000
	Within Groups	9298251334.515	200	46491256.673		
	Total	13445035353.980	202			

Table 8: ANOVA Test - Energy Consumption Cost in Commercial Sector: Type wise

It is seen from Table 8 that there exists a significant variation in cost of charcoal, wood, LPG and electricity energy consumption between two cities. There is no evidence of variation of cost of purchase of Agro – residues between two cities.

#### Conclusions

In Commercial Sector the analysis of energy use pattern in commercial sector type wise showed that large size units have consumed a maximum have consumed followed by charcoal. Medium size units have consumed a maximum LPG in Madurai city. In the case of Salem city, electricity as a major source of energy for large size units and medium size units. Wood is a major source for small size units.

The ANOVA test revealed that there is no evidence of significant difference in type wise consumption of commercial sector between Madurai and Salem cities.

Regarding the cost of consumption, large size units spent a maximum of Rs. 224350 for energy consumption in Madurai city and in the case of Salem city; small size units have spent a maximum of Rs. 102682 for energy consumption.

In order to examine the variation in energy expenditure different type of commercial sectors between Madurai and Salem cities, ANOVA test is carried out. The results revealed that there existed a significant variation in cost of charcoal, wood, and LPG and electricity consumption between Madurai and Salem cities.

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