



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH  
TECHNOLOGY**

**A Study on Zone-Wise Commercial Sector Energy Consumption in Madurai and Salem Cities of Tamil Nadu, India**

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**Abstract**

Energy, an vital component, is required to perform each and every kind of activity in the Universe and its utilization is depended on the population and economic growth of a country. The present world energy consumption primarily depends on the conventional fuels such as coal, petroleum oils and natural gas. The rapid depletion of these conventional fuels induces a investigation about the existing energy usage, consumption pattern and demand, especially in urban areas for efficient utilization of energy. In this regard, the present study is focused 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 concentrated mainly on zone-wise energy consumers of commercial sector in these two cities. The energy consumption pattern in 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 execute the energy conservation measures and utilize the renewable energy sources not only to overcome the energy demand but also to safe guard the health and wealth of the people reside in the Madurai and Salem cities.

**Keywords:** Energy; commercial sector; demand and supply; consumption pattern.

**Introduction**

Energy is a vital and basic requirement to perform all kinds of activity in the world. The energy consumption pattern in developing countries has been increased steeply in phase with the population growth. India is the world's second densely populated country with 1210 million which has the very high energy usage pattern. This creates severe energy and environmental burdens and the most notable issues are the fast depletion of fossil fuel reservoirs and the associated environmental pollution. According to the predictions, the world primary energy demand will be increased 50 percent between 2005 and 2030 and around 45 percent of this increase will be in the heavy populated countries like China and India [1].

Based on the nature of energy usage in different 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. 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, living

standards, climate and lifestyles. Therefore, it is the foremost requirement to examine the structure of energy consumption in developing countries like India and that helps to find out the energy demand and formulate measures to compensate the same in the near future. The present study has the following objectives:

- [1] Identifying zone-wise utilization of energy sources in commercial sector
- [2] Quantifying all energies used in the commercial sector
- [3] Analyzing and comparing zone-wise consumption of energy in commercial sector and its expenditure

**Materials and Methods**

**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.

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### 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 work force 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 commercial sector. With this background, the energy consumption pattern in the commercial sector was examined for the Madurai and Salem cities.

### 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.

### 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.

### Collection of Data

The survey was based on personal interview. 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, 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.

### Method and Tools of Analysis

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

## Results and Discussion

### Energy sources and consumption pattern in the commercial sector

An attempt was made to analyze the zone-wise (east, west, north and south) energy use pattern in commercial sector in Madurai and Salem cities.

#### Zone-wise energy use pattern

An attempt was made to analyze and compare the zone-wise energy use pattern in Madurai and Salem cities. The various energy sources in commercial sector were classified as charcoal, wood, agro residues, kerosene, LPG and electricity. The energy sources were converted from their quantity to calories of energy. Fig. 1 & 2 gives the details relating to zone-wise energy sources consumed by commercial sectors in Madurai and Salem cities.

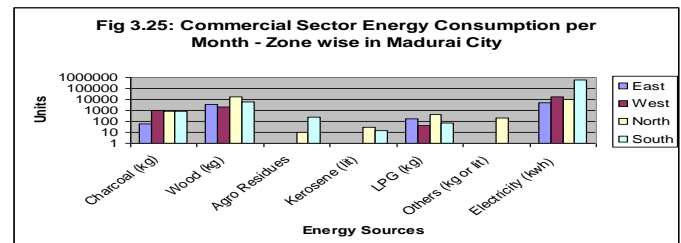
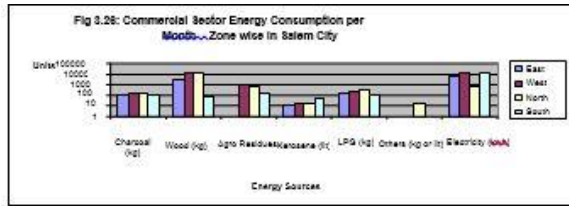


Fig 1. Zone-wise commercial sector energy consumption per month in Madurai city

Fig. 1 shows that in the case of east zone in Madurai, maximum of 4716 kwh of electricity is consumed as a source of energy, followed by 13750 kg of wood, 171.9 kg of LPG and 60 kg of charcoal in the commercial sector. In the case of west zone, maximum of 18182 kwh of electricity is consumed as a source of energy, followed by 2000 kg of wood, 1000 kg of charcoal and 38.2 kg of LPG. Further, it also shows that in the case of north zone, maximum of 16050 kg of wood is consumed as a source of energy, followed by 1252 kwh of electricity, 900 kg of charcoal, 418.7 kg of LPG, 198 kg/liters of other kinds of energy, 30 liters of kerosene and 10 kg of agro residues. In the

case of south zone, maximum of 55373 kwh of electricity is consumed as a source of energy in the commercial sector, followed by 5500 kg of wood, 900 kg of charcoal, 240 kg of agro residues, 76.4 kg of LPG and 45liters of kerosene.



**Fig. 2. Zone-wise commercial sector energy consumption per month in Salem city**

From Fig. 2, it has been inferred that in the case of east zone in Salem city, maximum of 350 kg of wood is consumed as a source of energy in the commercial sector, followed by 133.7 kg of LPG, 100 kg of charcoal and 12 liters of kerosene. Whereas, in the case of west zone, maximum of 14700 kg of wood is consumed as a source of energy by the commercial sector, followed by 1000 kg of agro residues, 248 kg of LPG, 150 kg of charcoal and 20 liters of kerosene. Further, it also shows that in the case of north zone, maximum of 11100 kg of wood is consumed as a source of energy by the commercial sector, followed by 550 kg of agro residues, 267.4 kg of LPG, 125 kg of charcoal and 20 liters of kerosene. In the case of south zone, maximum of 130 kg of agro residues is consumed as source of energy, followed by 1140.6 kg of LPG, 100 kg of charcoal, 87 kg of wood and 97 liters of kerosene.

ANOVA Test was carried out for the zone-wise energy consumption in commercial sector. The results are given in table 1.

Particular	Madurai and Salem	Sum of Squares	df	Mean Square	F	Sig.
Wood: Cooking, Hot water and Lighting/kg/m	Between Groups Within Groups Total	5608756.529 29722108.447 35330864.976	3 38 41	1869585.510 782160.749	2.390	.084
Others: Cooking, Hot water and Lighting/kg/m	Between Groups Within Groups Total	1456.033 14364.800 15820.833	1 4 5	1456.033 3591.200	.405	.559
LPG: Cooking, Hot water and Lighting/kg/m	Between Groups Within Groups Total	6.469 52.579 59.049	3 73 76	2.156 .720	2.994	.036
Kerosene: Cooking, Hot water and Lighting/Lit:m	Between Groups Within Groups Total	26.036 217.714 243.750	3 12 15	8.679 18.143	.478	.703
Electricity Consumption: Average units consumed (kwh) Month	Between Groups Within Groups Total	73600704.432 287234811.549 360835115.980	3 200 203	24533568.144 1436174.058	17.083	.000
Charcoal: Cooking, Hot water and Lighting/kg/m	Between Groups Within Groups Total	307672.500 965070.833 1272743.333	3 11 14	102557.500 87793.712	1.169	.366
Agro Residues: Cooking, Hot water and Lighting/kg/m	Between Groups Within Groups Total	718033.556 148786.667 866822.222	2 6 8	359017.778 24797.778	14.478	.005

It is found from the table 1 that the zone-wise variation in energy consumption in commercial sector was found in agro– residues, LPG and electricity. There is no evidence of variation in energy consumptions of charcoal, wood, kerosene and others including hot water, light etc. between two cities.

Fig 3 and 4 gives the details relating to zone-wise energy expenditure in commercial sectors of Madurai and Salem cities, respectively.

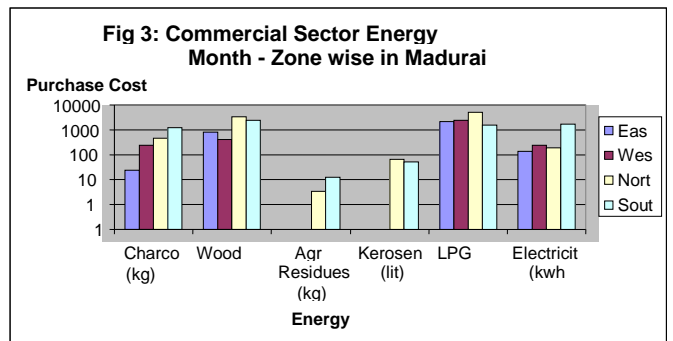


Fig. 3 shows that in the case of charcoal as source of energy in Madurai, maximum of Rs. 12720 is spent by commercial sector in south zone, followed by Rs. 4425 is spent in north zone, Rs. 2500 is spent in west zone and Rs. 240 in spent in east zone. In the case of wood as source of energy, maximum of Rs. 32340 is spent by commercial sector in north zone, followed by Rs. 23100 is spent in south zone, Rs. 7875 is spent in east zone and Rs. 4000 is spent in west zone. In the case of agro residues as source of energy, maximum of Rs. 120 is spent by commercial sector in south zone and Rs. 3335 is spent in north zone. Further, it also shows

that in the case of kerosene as source of energy, maximum of Rs. 660 is spent by commercial sector in north zone and Rs. 525 is spent in south zone. In the case of LPG as source of energy, maximum of Rs. 53600 is spent by commercial sector in north zone followed by Rs. 25000 is spent in west zone, Rs. 21000 is spent in east zone and Rs. 15566 is spent in south zone. Whereas, in the case of electricity as source of energy, maximum of Rs. 16610.60 is spent by commercial sector in south zone, followed by Rs. 2527.53 is spent in west zone, Rs. 2015.62 is spent in north zone and Rs. 1387.29 is spent in east zone.

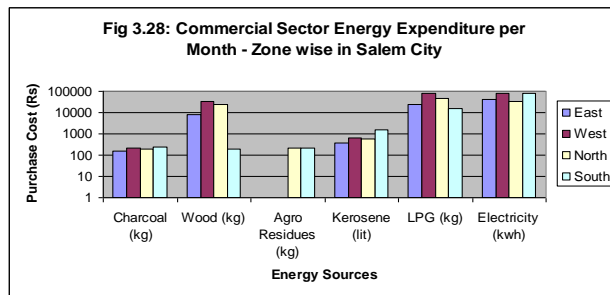


Fig. 4. Zone-wise commercial sector energy expenditure per month in Salem city.

It has been observed from the Fig 4 that in the case of charcoal as source of energy in Salem, maximum of Rs. 240 is spent by commercial sector in south zone, followed by Rs. 220 is spent in west zone, Rs. 200 is spent in north zone and Rs. 150 is spent in east zone. Whereas, in the case of wood as source of energy, maximum of Rs. 32250 is spent by commercial sector in west zone followed by Rs. 24530 is spent in north zone, Rs. 8250 is spent in east zone and Rs. 185 is spent in south zone. In the case of agro residues as source of energy, maximum of Rs. 225 is spent by commercial sector in north zone and Rs. 220 is spent in south zone. Further, it also shows that in the case of kerosene as source of energy, maximum of Rs. 1575 is spent by commercial sector in south zone, followed by Rs. 650 is spent in west zone, Rs. 570 is spent in north zone and Rs. 370 is spent in east zone. In the case of LPG as source of energy, maximum of Rs. 76040 is spent by commercial sector in west zone, followed by Rs. 46400 is spent in north zone, Rs. 2460 is spent in east zone and Rs. 16000 is spent in south zone. Whereas, in the case of electricity as source of energy, maximum of Rs. 84452 is spent by commercial sector in south zone, followed by Rs. 80888 is spent in west zone, Rs. 40845 is spent in east zone and Rs. 33141 is spent in north zone.

**ANOVA test for zone-wise energy consumption expenditure in commercial sector**

In order to examine the variation in zone-wise energy consumption expenditure in commercial sector between two cities, namely Madurai and Salem, ANOVA was applied. The computed results are given in table 2.

Particulars	Madurai and Salem	Sum of Squares	df	Mean Square	F	Sig.
Charcoal: Purchase Cost (Rs)	Between Groups	12380472.500	3	4126824.167	.356	.788
	Within Groups	127354550.833	11	11577668.258		
	Total	139734823.333	14			
Wood: Purchase Cost (Rs)	Between Groups	38654837.282	3	12884945.754	1.319	.282
	Within Groups	371200353.214	38	9768430.348		
	Total	409855190.476	41			
Agro Residues: Purchase Cost (Rs)	Between Groups	19636.667	1	1613.333	.493	.509
	Within Groups	21250.000	6	3272.778		
	Total		7			
Kerosene: Purchase Cost (Rs)	Between Groups	29823.750	3	9874.333	.441	.728
	Within Groups	268720.000	12	22393.333		
	Total	298543.750	15			
LPG: Purchase Cost (Rs)	Between Groups	1762857608.947	3	587522536.318	3.643	.017
	Within Groups	11774809422.222	73	161298759.209		
	Total	13537467031.169	76			
Electricity: Consumption: Average Bill Amount (Rs)	Between Groups	3114771324.807	3	1038257108.269	20.101	.000
	Within Groups	10330307917.114	20	51651539.586		
	Total	13445079241.922	23			

**Source: Computed**

It is inferred from the table 2 that there exists a variation in energy consumption expenditure in the case of LPG and electricity alone between two cities. There is no significant variation in cost of energy consumption in the case of charcoal, wood, agro residues and kerosene.

**Conclusion**

In commercial sector, the analysis of zone-wise energy use pattern in commercial sector showed that electricity was a major source of energy in all the four zones in Madurai and Salem cities. It was followed by wood and LPG. The results of ANOVA test showed that there existed a significant difference in agro-residue, LPG and electricity between Madurai and Salem cities.

Regarding the energy consumption expenditure, a maximum amount was spent by commercial sector in south zone followed by north zone in the case of charcoal and wood in Madurai city. The expenditure was found high in north zone. In the case of Salem city, the expenditure on wood was found high in north zone, followed by south zone. In the case of LPG, south zone was spent a maximum amount followed by north zone.

The ANOVA test revealed that there existed a significant difference in energy consumption cost in the case of LPG and electricity between two cities.

*Reference*

- [1] IEA (2007), "World energy outlook 2007,"  
Paris, France: OECD/IEA 2006.