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## RESEARCH ARTICLE

### INVESTIGATION ON ENERGY SOURCES, CONSUMPTION AND DEMAND IN SOCIAL SECTOR OF MADURAI AND SALEM CITIES, TAMIL NADU, INDIA

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#### ABSTRACT

Energy is essential for every aspect of our daily life in the Universe and its consumption pattern mostly depends upon population and economy of a nation. The current world energy consumption primarily depends on the fossil fuel resources. The utilization of these conventional fuels is rapid and therefore it is necessary to investigate the existing energy usage, consumption pattern and demand, especially in urban areas of developing countries for efficient utilization of energy. Hence, the present study has focused on the above said aspect in Madurai and Salem, the second and fifth largest and most densely populated cities, respectively in Tamil Nadu, India. We have concentrated mainly on energy consumers of social sectors in these two cities. We have evaluated the energy consumption in the social sector 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 to overcome the energy demand in the Madurai and Salem cities.

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#### INTRODUCTION

Energy is a basic component of a society and plays a vital pivotal role towards its socio-economic development by increasing the living standard and quality of life. The economic development of any region can be accessed from the energy consumption pattern. Energy demand increases as a consequence of economic growth and change in the consumption pattern, which in turn changes with respect to the energy source and its availability, conversion loss and efficiency of end-use (Singh and Bajpai 2010). According to the recent census, India ranks second in terms of population with 1210 million. This large increase in the population creates significant energy and environmental issues such as fast depletion of promising conventional fossil fuel reservoirs and the subsequent environmental degradation. India's energy generation capacity depends mostly on fossil fuels (70%), with coal accounting for 40% followed by crude oil (24%) and natural gas (6%) (Yep 2011). By 2030, India is largely dependent on fossil fuel imports to meet its energy demands and this dependence on energy imports is expected to exceed 53% of the country's total energy consumption. Moreover, according to predictions, the world primary energy demand will be increased by 50 percent between 2005 and 2030 and around 45% of this increase will be occurred in China and India alone (IEA 2007). One of the largest energy consumers in

India is the social sector, which indicates the importance of the social sector in total national energy scenario. Because of the variation in the energy consumption pattern in social sector of India due to climate, living standards and lifestyles, it is essential to analyze the energy sources and their consumption pattern to find out the energy demand and ways to compensate the same in the near future. The energy consumption in India has increased in accordance with the population growth and economic development and as a result India ranks sixth in terms of total energy consumption in the world. Even though, India is endowed with rich coal reservoirs, it is also supplemented with renewable energy resources like solar, wind, hydro and bio-energy. Like many other developing countries, India is a net importer of energy and imports more than 25 percent of primary energy mainly in the form of crude oil and natural gas. The rising oil import bill has been the focus of serious concerns due to the pressure it has placed on scarce foreign exchange resources and is also largely responsible for energy supply shortages. It is worth to mention here that among the 1.6 billion people in the world whose lifestyle is in the absence of electricity (IEA 2004), more than 1 billion people reside in India and China and the predominant them are in India. The energy consumption in social sector mainly depends on electricity generated by using fossil fuels for cooking, water and space heating and lighting applications and moreover the same energy source is used for the maintenance of essential services. However, the drawbacks associated with the fossil fuels such as air pollution, global warming, waste disposal problems, land degradation and the depletion of

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natural resources are changing the reliance on fossil fuels currently. Furthermore, the cheap supplies of oil appear to be running out. These trends are likely to continue and even accelerate throughout the 21<sup>st</sup> century. The consumers in social sector have slowly shifted to adopt alternative energy sources with low-cost and environment friendly. However, the energy consumption is expected to increase in future in phase with the growth in population, economy and rise in per capita incomes. Hence, it is necessary to analyze social sector energy consumption patterns in the cities of developing countries like India to develop policies for promotion of sustainable energy use.

### Objectives

The objectives of the present study are:

- i) Identification of present energy sources in social sector,
- ii) Quantification of overall energy usage in the social sector and
- iii) Analyzing and comparing type-wise energy consumption and its expenditure in the social sector.

### Methodology

Designing an appropriate methodology is essential for a meaningful analysis of any research problem. The methodology followed in this work includes study area, sampling procedure, study period, data collection, method of analysis and tools of analysis.

### Study Area

Madurai and Salem, which are second and fifth big cities, respectively in terms of population in the state of Tamil Nadu, India were selected for the present study. Both the cities are corporations that comprising 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 social sector. Based on these facts, the energy consumption pattern in the social 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 divided into four zones viz., north, east, south and west zones. The wards 1 to 21 are in the north zone, 44 to 59 are in the east zone, 31 to 43 and 60 to 65 are in the south zone, and 22 to 30 and 66 to 72 wards are in the west zone. The number of wards are 21, 16, 19 and 16 respectively in the north, east, south and west zones. Salem city contains 60 wards. For the purpose of primary data collection, Salem city was divided into four zones namely east, west, north and south zones. The number of are 14, 14, 16 and 16 respectively in the east, west, north and south zones.

### Study Period

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.

### Data Collection

The survey was based on personal interview. The schedule was a detailed one consisting of the name of the owner of hospitals, NGOs, noon meal hotels, hostels, old-age homes, etc. During the survey, the representative person of the above said units was asked to enumerate the energy sources used for different end-uses, viz. cooking, water heating, lighting, etc. The pattern of end-use of each energy source was studied by disaggregating the energy consumption in the social sector according to cooking, water heating, lighting, etc. Since the survey contained questions only on the sole energy consumption of each energy sources in the social sector (and not for a particular end-use), the desegregations was done while analyzing the results. Except in the case of electricity, other energy sources used only 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 sources was determined as usage per month. In the case of LPG, one cylinder utilization duration was ascertained. Electricity consumption data was obtained from the Tamilnadu Electricity Board after ascertaining meter reading in a social sector.

### Method and Tools of Analysis

Keeping in view the objectives of the study, the social sector was categorized into zone wise energy consumption pattern. In order to examine the difference in energy consumption analysis of variants (ANOVA), one-way test was followed.

## RESULTS AND DISCUSSION

### Type wise energy use pattern in social sector

An attempt has been made to analyse and compare the type wise energy use pattern in the social sector of Madurai and Salem cities and the results are shown in Table 1 and 2. In the case of large size social sector in Madurai city, maximum of 5508 kwh of electricity and 19.1 kg of LPG were consumed as source of energy whereas in the case of medium size social sector, maximum of 8076 kwh of electricity and 18 litres of kerosene were consumed as source of energy. It also shows that in the case of small size social sector, maximum of 990 kwh of electricity and 5 litres of kerosene were consumed as source of energy (Table 1). It has been inferred from the Table 2 that in the case of medium size social sector in Salem, maximum of 8957 kwh of electricity and 19.1 kg of LPG were consumed as source of energy. Whereas in the case of small size social sector, maximum of 2000 kwh of electricity followed by 1000 kg of wood and 19.1 kg of LPG were consumed as source of energy. Table 3 and 4 indicate the type wise energy use pattern (mega joules) in social sector of Madurai and Salem cities, respectively. It can be understood from Table 3 that in the case of large size social sector in Madurai, Maximum of 1928.8 Mega Joules of electricity and 851.8 Mega Joules of LPG were consumed as source of energy. Whereas in the case of medium size social sector, maximum of 29001.6 Mega Joules of electricity and 612 Mega Joules of kerosene were consumed as source of energy. It also reveals that in the case of small size social sector, maximum of 3564

**Table 1. Type Wise Energy Consumption per Month in Social Sector of Madurai City**

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
Kerosene (lit)	NU	NU	3	18	1	5	4	23
LPG (kg)	1	19.1	NU	NU	NU	NU	1	19.1
Electricity (kwh)	1	5508	7	8056	5	990	13	14554

Source: Survey Data  
NU-Not in Use

**Table 2. Type Wise Energy Consumption per Month in Social Sector of Salem City**

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
Wood (kg)	NU	NU	NU	NU	1	1000	1	1000
LPG (kg)	NU	NU	1	19.1	1	19.1	2	38.2
Electricity (kwh)	NU	NU	4	8957	6	2000	10	10957

Source: Survey Data  
NU-Not in Use

**Table 3. Type Wise Energy Consumption per Month in Social Sector of Madurai City (in Mega Joules)**

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
Kerosene	NU	NU	3	612	1	170	4	782
LPG	1	851.8	NU	NU	NU	NU	1	851.8
Electricity	1	19828.8	7	29001.6	5	3564	13	52394.4

Source: Survey Data  
NU- Not in Use

**Table 4. Type Wise Energy Consumption per Month in Social Sector of Salem City (in Mega Joules)**

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
Wood	NU	NU	NU	NU	1	14800	1	14800
LPG	NU	NU	1	851.8	1	851.8	2	1703.6
Electricity	NU	NU	4	32245.2	6	7200	10	39445.2

Source: Survey Data  
NU- Not in Use

**Table 5. ANOVA – Test: Type Wise Energy Consumption in Social Sector**

Particulars	Madurai and Salem	Sum of squares	df	Mean Square	F	sig
Kerosene: Cooking, hot water and Lighting/Lit/m	Between Group	.750	1	.750	.250	.667
	Within Groups	6.000	2	3.000		
	Total	6.750	3			
Electricity Consumption: average units consumed (kwh)/m	Between Group	29167589.123	2	14583794.561	12.361	.000
	Within Groups	23596112.182	20			
	Total	52763701.304	22			

Source: Computed

**Table 6. Type Wise Energy Expenditure per Month in Social Sector of Madurai City**

S. No.	Sector type	Kerosene		LPG		Electricity	
		Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs.)	Number of Respondents	Total Purchase Cost (Rs./ month)
2	Large	NU	NU	1	15300	1	33354
	Medium	3	540	NU	NU	7	46765
	Small	1	150	NU	NU	5	5691
Total		4	690	1	15300	13	85810

Source: Survey Data  
NU- Not in Use

Table 7. Type Wise Energy Expenditure per Month in Social Sector of Salem City

S.No	Sector type	Wood		Kerosene		LPG		Electricity	
		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./ month)
1	Large	NU	NU	NU	NU	NU	NU	NU	NU
2	Medium	NU	NU	3	540	1	800	4	44337
3	Small	1	2500	1	150	1	850	6	10388
	Total	1	2500	4	690	2	1650	10	54725

Source: Survey Data  
NU- Not in Use

Table 8. ANOVA Test: Type Wise Energy Expenditure in Social Sector

Particulars	Madurai and Salem	Sum of squares	df	Mean Square	F	sig
Kerosene: Purchase Cost (Rs)/m	Between Group	675.000	1	675.000	.250	.667
	Within Groups	5400.000	2	2700.000		
	Total	6075.000	3			
Electricity Consumption: average Bill Amount(Rs)/m	Between Group	1031799791.731	2	515899895.866	12.361	.000
	Within Groups	500940363.D.182	20	25047018.309		
	Total	1532740157.913	22			

Source: Computed

Mega Joules of electricity and 170 Mega Joules of kerosene were consumed as source of energy. It has been inferred from the Table 4 that in the case of medium size social sector in Salem, maximum of 32245.2 Mega Joules of electricity and 851.8 Mega Joules of LPG were consumed as source of energy. Whereas in the case of small size social sector, maximum of 14800 Mega Joules of wood followed by 7200 Mega Joules of electricity and 851.8 Mega Joules of LPG were consumed as source of energy. To examine the variation in type wise energy consumption in social sector between Madurai and Salem cities, ANOVA Test was used and the results are given in Table 5. It is inferred from Table 5 that the variation in consumption of kerosene in social sector between Madurai and Salem was not statistically significant. Whereas in the case of electricity consumption, there was a significant variation in consumption of electricity between Madurai and Salem cities. From the Table 6, it is observed that in the case of kerosene as source of energy in Madurai, maximum of Rs. 540 was spent in medium size social sector and Rs. 150 was spent in small size social sector. Whereas, in the case of LPG as source of energy, total of Rs. 15300 was spent in large sized social sector. Further, it also revealed that in the case of electricity as source of energy, maximum of Rs. 46765 was spent in medium size social sector followed by Rs. 33304 was spent in large size social sector and Rs. 56791 was spent in small size social sector. Table 7 shows that in the case of wood as source of energy in Salem, total of Rs. 2500 was spent in small size social sector, whereas in the case of kerosene, maximum of Rs. 540 was spent in medium size social sector and Rs. 150 was spent in small size social sector. Moreover, in the case of LPG as source of energy, maximum of Rs. 850 was spent in small size social sector and Rs. 800 was spent in medium size social sector. Whereas in the case of electricity as source of energy, maximum of Rs. 44337 was spent in medium size social sector and Rs. 10388 was spent in small size social sector. In order to examine the variation in type wise energy consumption cost in social sector between Madurai and Salem cities, ANOVA was applied. The computed results are given in Table 8.

It is inferred from Table 8 that the variation was found in electricity consumption cost in social sector between Madurai and Salem cities. There is no significant variation in cost of kerosene between two cities namely Madurai and Salem.

### Conclusion

The analysis of energy use pattern in social sector reveals that a maximum of electricity was consumed by medium size units in both Madurai and Salem cities which was followed by small size units. The ANOVA test showed that there existed a variation in consumption of electricity alone in social sector between Madurai and Salem cities. Regarding the energy expenditure, medium size was spent high for kerosene and electricity in Madurai city. Whereas in the case of Salem city, small size social sector was spent a maximum amount for wood and medium size was spent for electricity. The ANOVA test revealed a significant variation in electricity consumption expenditure between Madurai and Salem cities.

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