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Attaining Energy Efficiency through Management of Residential Demand -An Empirical Study of Jaipur City

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ABSTRACT

Energy powers the world's economic engine and there exists a very strong relationship between the quantity of energy used and the development of the economy. It is true that the continuous increase in the per capita consumption of power from 176 KWh in 1980-81 to 1000 KWh in 2011-2012 is considered to be an effective indicator of growth, However this ever increasing consumption has negative impact on the economy such as increased investments in the power sector in order to bridge the gap between demand and supply of power, reduction of finite resources like coal, oil etc., and environmental degradation. It is found that 40% of the electricity produced is consumed by the households as people have increased their stock of electrical appliances in order to lead a comfortable life as well as to have more leisure time to spend with their family members. The present research article focuses on the increasing demand for electricity over the years and suggests some strategies to curb and manage excess demand for power. The paper studies the consumption pattern of residential electricity with specific regard to the increasing usage of electric appliances in the households of Jaipur city. The analysis of stock of electrical appliances has been conducted by taking a random sample of 100 electrified houses in different divisions of Jaipur city.

The supplementary objective of the paper is to analyze the dynamics of energy end-use among the households of Jaipur city and suggest some effective measures to manage the residential demand for power in order to enhance the efficiency in the usage of electricity.

Key words: *DSM, Energy Efficiency, Stock of appliances.*

I. INTRODUCTION

Energy plays a very important role in all walks of our life. No doubt usage of energy in different forms has not only made human life more easy and comfortable but has also paved the way for human development. By using different forms of energy like oil, gas and electricity, human beings are performing their activities quickly and easily which further motivates them to engage in more and more of economic activities which ultimately results in the overall development of the economy. In the past two decades the consumption of energy is increased manifold which is definitely a positive sign of growth but this has given rise to severe energy crisis. Power sector is not able to supply power to meet out the ever increasing demand for power. Since more than 60% of energy requirements are met out from fossil fuels it has resulted into a very serious problem on the economy i.e. Global Warming. Continuous efforts have been made by the government to attain sustainable development in power sector, but all the efforts are in vain. The present research paper is an attempt to find a permanent solution to overcome the power crisis and reduce the emission of Green House Gases by improving the efficiency of electrical appliances among the households in the Jaipur city. Residential sector alone accounts for around 40% of total energy consumption and there is more scope to conserve energy by replacing age old and inefficient appliances by modern energy efficient appliances i.e Star Rated appliances which would not only help us to conserve energy but also help us to have a control over the carbon emission, as energy inefficient appliances not only consume more energy but also emit more CO2 in comparison to energy efficient appliances.

1) Survey of literature

Fisher and Kayson (1962) in their study on residential electricity consumption of USA, established that residential electricity demand is proportional to the stock of appliances. According to Grig B. Smith, and Kelly E. Parmenter (2009) residential demand for electricity is proportional to the stock of electrical appliances. Therefore there is an urgent need to improve the efficiency of electrical appliances to reduce the demand for electricity. To understand the important of energy efficiency in the buildings is the need of the hour. It is cost effective to design a high degree of energy efficiency into new building since the saving on operating and maintenance cost will repay the initial investment many times over.
A significant contribution to the residential demand analysis is that of Parti and Parti (1980) who used regression analysis to disaggregate the total household consumption into appliance-wise consumption. The article on household energy demand estimation by Madlener (1996) uses micro data and econometric single equation models for household demand for electricity, gas and car fuels. It is an estimate of residential demand condition on prices, durable goods, housing and household characteristics. According to Meeta Mehar (2002) there is an urgent need for forecasting demand for electricity through the end use models, with the onset of inflation and rapidly rising energy prices, emergence of alternative fuels and technologies, institutional changes etc. Therefore it has become imperative to use modelling

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techniques which capture the effect of factors such as prices, income, and population and other economic, demographic policy and technological variable on demand for electricity.

2) Objectives

The present paper aims to analyze this impact on the power demand and depict measures to attain DSM. At the same time it targets to assess the impact of old and energy inefficient electricity appliance on consumption of electricity.

3) Methodology

Data pertaining to the consumption pattern of electricity among the households of Jaipur city is collected through a properly designed questionnaire. The questionnaire includes the information related commonly used electrical appliances such as Refrigerators, Geysers and Air Conditioners. Apart from data from primary survey, secondary data has also been collected from various reports of power sector.

II. RAJASTHAN POWER SECTOR-AN OVERVIEW

No doubt the economic development of the state largely depends on the availability of reliable and adequate power. Electricity in the modern era is considered as one of the critical inputs for economic development and the per capita consumption of power is considered as an effective indicator of growth and development. Since the entire development process of the economy is totally dependent on the power, the power sector development was conceived through by the government since independence and government has been continuously making efforts to overcome the problem of power crisis. The percapita consumption of power has increased from 558.84 KWh in 2000-01 to around 1000 KWh in 2011-12, No doubt this is a positive indicator of growth but this has led to one serious problem i.e. widening of gap between demand and supply of power. Studies show that demand outstrips supply by 8-11% in India. The deficit in peak demand and supply met is given in the table 1.

Table 1.1: Rajasthan Power Supply Position

Period	Peak Demand	Peak Met	Peak Deficit	Peak deficit %	Energy Requirement	Energy Availability	Energy Deficit	Energy Deficit%
9 th plan	3700	3657	-43	-1.2	24745	24495	-250	-1.0
2002-03	3880	3820	-60	-1.5	25917	25382	-535	-2.1
2003-04	4134	4134	0	0.0	26611	26486	-125	-0..5
2004-05	4786	4414	-372	-7.8	29207	28974	-233	-0.8
2005-06	5588	4850	-738	-13.2	32052	30879	-1173	-3.7
2006-07	4794	4946	-848	-14.6	33236	31715	-1521	-4.6
2007-08	6374	5564	-810	-12.7	36738	35597	-1141	-3.1
2008-09	6303	6101	-202	-3.2	37306	36898	-408	-1.1
2009-10	6859	6859	0	0.0	44031	42983	-1048	-2.4
2010 march	4798	4790	-8	-0.2	3946	3927	-19	-0.5
2011-12	8482	6644	-1839	-21.7	48916	47152	-1764	-3.6

Source: *As per 17 th Electric Power Survey Report*

In order to overcome the problem of power crisis Rajasthan power sector has been increasing the budget outlay for generation of power. The following table 1.2 shows the plan outlay of Rajasthan power sector.

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Table1.2: Total plan outlay for Rajasthan power sector since sixth plan is shown in the following table

Five year plan	Total plan outlay (in Cr)
6th	641
7th	1069
Annual plan 1990-91	276
Annual plan 1991-92	335
8th	3913
9th	6000
10th	7777*
11th	25205**

*Includes 2145 cr for Distribution Company.
** include 4600 cr for Distribution company.
Source: *compiled from Annual Reports of Rajasthan Vidhyut Prasaran Nigam Ltd*

Rajasthan budget allocates more than 40 % of its total budget outlay for increasing the supply of power so as to bring a balance between demand and supply of power. But even this is not effective since more than 70% of power requirement of state is met out from coal, resulting in emission of Green House Gases. So now the state is confronted with two major problems

a. To overcome the problem of power crisis
b. To reduce the dependence on fossil fuel to protect our environment.

Now the solution to the problem is either to reduce the demand so that the gap between demand and supply of power could be narrowed down, but this would adversely affect the development of state as power is an important infrastructure of development or to supplement the power supply from renewable sources especially solar and wind but this would in turn increase the financial stress on the government as use of solar and wind energy requires huge investment. In this paper an effort has been made to suggest effective Demand Side Management approach which would help us to not only overcome the problem of power crisis but at the same time will not impose any financial burden on the government too.

The need of the hour is to bring a balance in demand and supply of power either by increasing the supply of power or by reducing the demand for power. But increasing the installed capacity would not definitely lead to sustainable development due to cost and environmental factors. This paper highlights the importance of Demand Side Management to overcome the power crisis and achieve sustainable development in the economy.

This article entirely focuses on DSM in the residential sector as it is the one of option to achieve long term reduction in the consumption of electricity. A different approach is presented for residential end users. Residential sector accounts for a major portion of electricity consumption; there lies greater scope of conserving energy by using more and more of energy efficient electrical appliances.
Heating Cooling and Lighting appliances accounts for 80% of energy consumption in residential sector. [Demand Side Management for residential and commercial end users-,Eric Bonneville 2006] It is important to identify the largest energy consuming appliances in order to implement DSM actions. Lighting alone constitutes 20 to 40 percentage of electrical bills therefore it is clear that a large energy saving potential exists for lights if we replace all the inefficient appliances by energy efficient appliances a large amount of energy could be saved.

Table 1.3: Comparison between Energy Efficient and Inefficient lamps.

CFL(Watts)	Incandescent(watts)	Brightness(lm)
5	25	180
7	40	290
9	40+	480
11	60	600
15	75	825
18	100	1015

Source: Carbon Footprint-Household Energy Consumption.htm

The above table shows the energy consumed by CFL and ordinary incandescent bulbs. It is also a well known fact that incandescent bulbs not only consume more electricity but also emit more Carbon Gases. For example a 18 watt CFL gives the same brightness as 100 watts incandescent bulb.
In the present research article information from 100 households were collected regarding their stock of three electrical appliances which are commonly used among households and consume a major portion to electricity consumption i.e. refrigerators, Geysers and Air Conditioners.

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The details of these appliances are given below in the following table.

Table 1.4: Details of Electrical Appliances among 100 Households of Jaipur City

Name of the appliances	Total number of appliances among 100 households	Non Star Rated Appliances	Number of Stars		
			3 star	4 star	5 star
Refrigerator	91	76	5 (5.6%)	3 (3.37%)	7 (7.8%)
Geysers	64	57	2 (3.5%)	4 (7%)	2 (3.5%)
Air Conditioners	46	37	———	4 (8.6%)	5 (13.5%)

Source: Primary Survey

It is seen from the table that 89% of the households use refrigerators out of which 76 are inefficient as they are very old and consume a large amount of electricity as well emit more carbon in the atmosphere. If all these inefficient refrigerators are replaced with the star rated ones a considerable reduction in electricity can be made which is clear from the next table.

Table 1.4: Comparison between Energy inefficient and Star Rated Refrigerators

Star Rating	Energy Consumption KWh	Total savings per year with reference to no star rated
No star	1100	0
1	977	492
2	782	1272
3	626	1896
4	501	2396
5	400	2800

Source: Bureau of Energy Efficiency

This comparison shows that there is a good deal of savings around 60% of energy savings if all the inefficient Refrigerators are replaced with 5 star rated refrigerators but the only drawback in doing so is the energy efficient appliances cost around 30% more than the efficient ones but the saving in electricity bills will help us to even cover the cost in a short time period.

In the case of Air Conditioners even though it is not a commonly used appliances it is found in the survey that 46 % of households use AC out of which only 20% of them use energy efficient AC. It was shocking to observe that people use age old appliances which are not only old but consume energy many times more than star rated ones. The energy savings of efficient and Inefficient AC is given belowtable 1.5.

Table 1.5: Comparison between Energy Inefficient and Efficient Air Conditioners

Star Rating	Cooling Capacity (Watts)	Energy Consumption in KWh*
No Star (inefficient)	5200	9.45
1	5200	9.0
2	5200	8.3
3	5200	7.7
4	5200	7.1
5	5200	6.6

* Energy consumption is calculated assuming the appliance is used for eight hours per day for five months.
Source: Bureau of Energy Efficiency.

The above table clearly indicates that huge amount of electricity could be saved only by improving the efficiency of electrical appliances that are mostly used and contribute a large share to the electricity bills. It is true that one unit of energy saved is equal to two units of energy produced. Improving the efficiency among the end users will help us to overcome several serious problems such as growing demand supply gap, Excessive financial stress towards power production and above all, this strategy would directly result in reducing our dependence on fossil fuels for our energy requirements means reduction in emission of Green House Gases.

III. SUGGESTIONS AND CONCLUSIONS

It has been observed by us that most of the households are really not aware about the problems related to power and they are least bothered to conserve it. In the first instance people should be primarily be educated regarding energy conservation techniques. Secondly people prefer energy inefficient appliances to efficient ones as they are relatively cheaper if considerable reduction in prices in the form of less tax rate or

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subsidies can really help a lot towards the promotion of energy efficient appliances. Energy audits and construction of green buildings also have great potential to conserve energy.

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