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CDM Implementation in Domestic Energy Sector : Indian Scenario

K. J. Sreekanth
Department of Mechanical Engineering, National Institute of Technology, Calicut 673601, INDIA,
kj.sreekanth@gmail.com

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K. J. Sreekanth[1], S. Jayaraj And N. Sudarsan

Department of Mechanical Engineering, National Institute of Technology, Calicut 673601, INDIA

Abstract **-** Since the Kyoto protocol agreement, Clean Development Mechanism (CDM) has garnered large emphasis in terms of certified emission reductions (CER) not only amidst the global carbon market but also in India. This paper attempts to assess the impact of CDM towards sustainable development particularly in rural domestic cooking sector. A detailed survey was undertaken in the state of Kerala, in southern part of India to evaluate the rural domestic energy consumption pattern. The data collected was analyzed through standard statistical software yielding insight into the interrelationships of the various parameters that influence domestic cooking energy consumption. The analysis facilitates assessing feasibility of CDM projects in the sector and related prospects pertaining to the Indian scenario..

Key Words: *CDM, Energy Consumption Pattern, Indian Scenario.*

I. INTRODUCTION

One of the important responses of Kyoto Protocol towards mitigation of global warming is Clean Development Mechanism (CDM) that has garnered large emphasis amidst the global carbon market in terms of Certified Emission Reductions (CER). While CDM aims to achieve sustainable development in energy production and consumption in developing countries, the results achieved through its implementation are still uncertain. More than four hundred studies have been undertaken since 1997 with respect to CDM [1]. However, the contribution of these studies towards effective implementation of CDM at regional level and thereby reap the benefits of sustainable development has been ill addressed.

India as a rapidly developing nation has an enormous potential to benefit from CDM. The projects pertaining to CDM implementation, is expected to encourage private investments owing to the high rate of financial returns. Indian economic growth at the present rate points to a huge increase in energy usage in both industrial and domestic sectors.

However, studies and modeling in designing policies to address the related issues needs to be undertaken rigorously. In this study, it is attempted to assess the potential to improvise rural domestic energy efficiency, especially in the lighting sector and investigate measures that can be framed as projects under the CDM. India, a developing nation has long depended on traditional energy resources such as firewood, agricultural waste, animal dung and human power which are still continuing to meet the bulk of energy requirements, particularly in rural India. Presently, these traditional fuels are gradually getting replaced by commercial fuels such as coal, petroleum, natural gas and electricity. With the recognition of fossil fuels being the major cause of climatic change and air pollution, the focus of energy planners has shifted towards renewable resources and energy conservation.

This paper attempts to present the details of the investigation and analysis undertaken in this study with section 1 highlighting the need of the study as Introduction. Section 2 outlines the energy scenario in India, followed by energy scenario in Kerala, the study area, in section 3. Section 4 focuses on an exploratory analysis of the data collection and validation. The CDM implementation analysis is presented in Section 5. The key findings of the analysis are discussed in section 6. The major conclusions drawn from the study are presented in the last section.

II. ENERGY SCENARIO IN INDIA

"India experiencing a GDP growth rate of 8% per annum, putting tremendous pressure on the power sector of the country". The deficiency in the supply of energy is generally met through imports from other countries. The Indian energy scenario shows a float in the energy balance mainly due to the differed energy sources in India. The country confronts fulgurous challenges in meeting its energy needs and providing adequate energy

[1] (Presenting author Email: sreekanthkj@nitc.ac.in)

both in terms of sufficient quality and quantity to users in a sustainable fashion and at tenable costs. If the energy production pattern is analyzed, coal and oil account for about 65% (Table 1). The rest is met by hydro power, nuclear power and natural gas. In the generation sector about 60% is from coal fired thermal power plants and 70% of coal produced every year in India is being used for thermal power generation.

On the consumption side, about 55% of commercial energy consumption is by the industrial sector. Even though the per capita energy consumption in India is one of the lowest in the world, the energy intensity, which is energy consumption per unit of GDP, is one of the highest in comparison to other developed and developing countries (Figure 1).

Table I: Total installed capacity in India, (Source: Ministry of Power, Government of India, 2007)

FUEL	MW	PERCENTAGE
THERMAL	99861.50	64.6
HYDRO	36885.40	24.7
NUCLEAR	4120.00	2.9
RENEWABLE SOURCES	15225.35	7.8
TOTAL	156092.25	100

The energy intensity is about 4 times that of Japan, 1.6 times that of USA, 1.5 times that of Asia and about 1.55 times that of the world average, rendering a large scope for energy conservation.

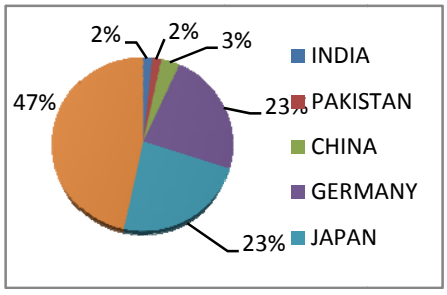

Figure 1: Per capita energy consumption [2]

III. ENERGY SCENARIO IN KERALA

Kerala's energy scenario is inextricably complex as compared with that of the nation. The installed capacity has expanded from 1,362 MW in 1947 to 1, 41,079 MW in January 2008. The per capita consumption of energy has increased from 16 kWh to 650 kWh. With the prodigious increase in world energy prices, the economy of Kerala is struggling to cope with overwhelming increases in production costs. At the same time, due to limited new generation capacity additions and deficient rain fall, Kerala is experiencing severe and chronic energy shortages. The majority of energy in Kerala is consumed by households, which represent about 79% of all energy users and 46% of total electricity use. This is shown in Figure 2. Since, more than 2/3rd of the energy consumed in Kerala is for domestic use; even a minor alteration in the pattern of domestic energy consumption can bring significant changes to the total energy consumption. The important stages of energy transformation in an energy path comprises of generation, distribution, utilization and conservation. Cooking, lighting, heating, food processing and transportation are major energy end uses in Kerala.

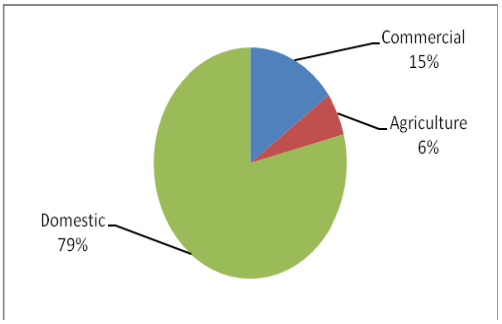

Figure 2: Consumer Profile, Electricity Distribution in Kerala (Source: KSEB, 2010)

IV. DATA COLLECTION AND VERIFICATION

In this study, the state of Kerala, located in southern part of India is selected as the sample space. The region has been divided into 14 districts with a total population of 31,841,374. The survey enveloped the entire state, covering both rural and urban areas. The sampling design was based on a two stage- stratified random sampling procedure with the first stage comprising of rural areas and households forming the second stage units [3]. The households were selected systematically with equal probability, with a random start. The Districts administratively are a collection of panchayats, each of which is further sub divided in to wards each comprising about 1200 households. Data pertaining to randomly selected 120 households was taken to be the representative sample of the District [4]. Data collection was carried out through a questionnaire, prepared for the purpose that provides for gathering minute and precise details regarding the energy usage details [5]. In order to verify the sufficiency of the sample size for 95% confidence interval the following equation was employed [6]:

$$N' = \left(\frac{20\sqrt{N\sum X^2 - (\sum X)^2}}{\sum X} \right)^2 \quad , \quad \text{where}$$

N=1700 and X is the Per capita Income of the people

The value obtained for N' was 764, as compared to the total data collected and hence the sufficiency was verified. For the purpose of data analysis, the state of Kerala was categorized into three regions namely, hilly, coastal and plain region based on geographic considerations. The data collected were also cross verified with data obtained from official statistics and other sources of information.

V. CDM IMPLEMENTATION ANALYSIS

The National Sample Survey Organization (NSSO), as a part of sixth survey, which is carried out once in every five years, was extended to include Non-agricultural Enterprises in the Informal Sector. The highlights of the survey particularly applied to cooking sector reveals that at national level, firewood and chips accounted for 76% of the households as primary source for cooking in both rural and urban areas. There has been an increase in the proportion of households using LPG as major source of cooking by 15% in rural areas and by 40% in urban India since 1993-1994. There was decrease in the percentage of households using kerosene as primary source of energy for cooking, from 24% to 19% in rural India, since 1993-94 [7, 8].

One of the previous studies on determinants of energy consumption concludes that income is a weak predictor of residential energy consumption, explaining only 45% of energy consumption [9]. The consumption of energy by a household essentially depends on the location and the socio-economic factors of the household. Using the SPSS regression analysis and EXCEL trend analysis, the differences in the average consumption of energy across all the districts were tested. The results of both these tests indicate that there are significant differences in the average energy consumed by the households in the different districts and across different modes of usage. This justifies the sample selection and its purpose. The quantity of firewood and LPG used in the rural sector for cooking application in domestic sector in Kerala is given in Table 2.

Table 2: Quantity of Firewood and LPG used in Kerala domestic sector for cooking

(Source: NSS Report No. 464: Energy Used by Indian Households, 1999-2000)

Year	Sector	Firewood (Tons)	LPG (Tons)
1983	Rural	79	0.2
1988	Rural	79	0.8
1993	Rural	77	1.9
1998	Rural	75	12

The variation in firewood usage for cooking pertaining to rural sector from the year 1983 to 2000 and trend in energy usage established through data analysis is depicted in Figure 3.

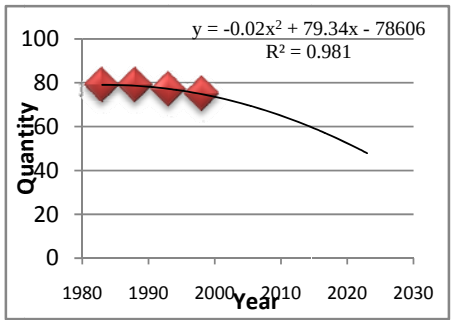

Figure 3: Trend showing the usage of firewood from 1983 to 2030 (Rural sector)

The variation of LPG usage for cooking in rural sector from the year 1983 to 2000 and trend in LPG usage established through data analysis is depicted in Figure 4.

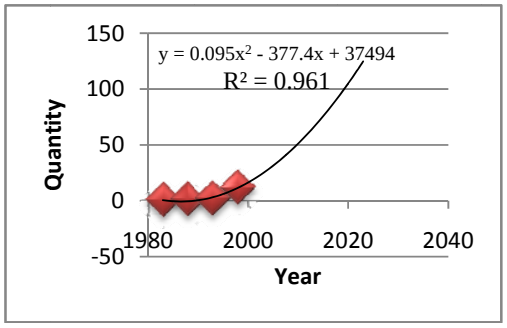

Figure 4: Trend showing the usage of LPG from 1983 to 2030 (Rural sector)

The trend analysis shows that the usage of LPG is increasing where as the usage of firewood are decreasing in the rural sector. The various trend equations for these two applications are given in the Table 3. The CO_2 emission from fossil fuels can be found out by the IPCC guide line 2006 which is as follows:

CO_2 emission from fossil fuel use = fuel consumed X Net Calorific Value (NCV) X CO_2 Emission Factor.

By using the above formula, the CO_2 emission for Kerala from firewood and LPG is calculated for rural

sector pertaining to cooking sector, which is given in table 4 and 5. Figure 5 and 6 depict the trend analysis on the variation of CO_2 emission till 2040.

Table 3: Trend equations showing the usage of firewood and LPG in Kerala

ENERGY SOURCES	Area	Trend Equations	R^2 Value
FIREWOOD	Rural	$y = -0.02x^2 + 79.34x - 78606$	0.981
LPG		$y = 0.095x^2 - 377.4x + 37494$	0.961

Table 4: CO_2 emission for Kerala from Firewood

Year	Firewood (mT)	Year	Firewood (mT)	Year	Firewood (mT)	Year	Firewood (mT)
2010	0.0769	**2017**	0.0671	**2025**	0.0529	**2033**	0.0375
2011	0.0756	**2018**	0.0654	**2026**	0.0509	**2034**	0.0334
2012	0.0743	**2019**	0.0637	**2027**	0.0489	**2035**	0.031
2013	0.0729	**2020**	0.0621	**2028**	0.0468	**2036**	0.0287
2014	0.0715	**2021**	0.0603	**2029**	0.0448	**2037**	0.0263
2015	0.0701	**2022**	0.0586	**2030**	0.0426	**2038**	0.0237
2016	0.0686	**2023**	0.0568	**2031**	0.0403	**2039**	0.209
		2024	0.0548	**2032**	0.0381	**2040**	0.0186

Table 5: CO_2 emission for Kerala from LPG

Year	LPG (mT)	Year	LPG (mT)	Year	LPG (mT)	Year	LPG (mT)
2010	0.1537	**2017**	0.2591	**2025**	0.4063	**2033**	0.599
2011	0.1677	**2018**	0.2782	**2026**	0.4304	**2034**	0.6306
2012	0.1794	**2019**	0.2958	**2027**	0.4603	**2035**	0.6647
2013	0.1925	**2020**	0.3139	**2028**	0.4898	**2036**	0.6871
2014	0.2065	**2021**	0.3318	**2029**	0.5112	**2037**	0.7077
2015	0.2271	**2022**	0.3486	**2030**	0.5354	**2038**	0.7438
2016	0.2421	**2023**	0.3752	**2031**	0.5527	**2039**	0.7661
		2024	0.3889	**2032**	0.5793	**2040**	0.7802

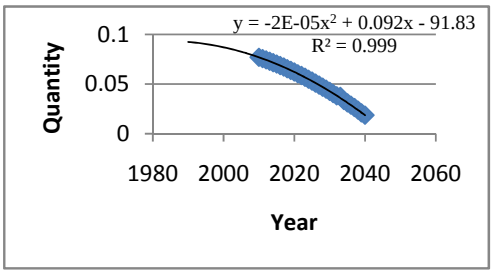

Figure 5: Trend analysis- Firewood for cooking application- Rural sector

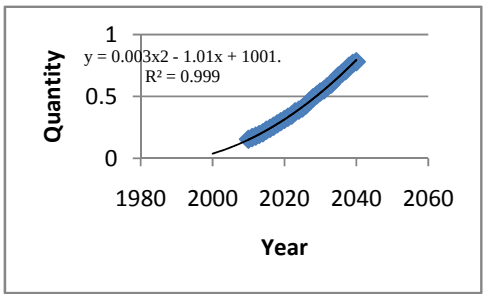

Figure 6: Trend analysis- LPG for cooking application- Rural sector

VI. KEY FINDINGS

In all the above cases we can see that the R^2 value is around 0.971 which is very much satisfactory. Also, Kerala households have witnessed dramatic increases in modern fuel use in recent years especially in cooking. Changing patterns of household activities and livelihood underline this growth. Firewood and Biomass fuels, until recently has been dominant household energy sources in Kerala particularly for cooking purposes, however, play only a limited role in present household scenario. Even the dominance of kerosene appears to be diminishing as cooking source. The study reveals that this increased reliance on LPG for cooking arises from a preference among consumers for more convenience and availability.

LPG demand has increased rapidly in Kerala in recent years. Higher appliance saturations and more intensive cooking despite the decrease in household income, have spurred this growth. One of the major

concerns from the Kerala states perspective on energy consumption pattern, is the increased availability of LPG to the poor sections of the society. Hence any attempt to implement CDM in this sector would essentially be addressed through replacement of LPG with alternative energy resources such as Bio gas or Bio mass.

VII. CONCLUSIONS

The study results presented herein is a pilot attempt in modeling energy consumption patterns and trends in the state of Kerala in India, identifying the various factors influencing energy usage, especially in the cooking sector, that could form a basis for energy planning in not only in the state but also for India as a whole. The models envisaged to be developed is expected to aid in planning adaptation of CDM in the energy sector, which could go a long way in contributing to reduction in Carbon Emission Reduction through implementation of alternative energy potentials particularly in rural India. The study presents only minor area concerning the energy requirement patterns for cooking in rural sector. However the study methodology can be extended to other areas of energy applications encompassing equally both rural and urban areas. The study results are a part of research work being pursued by the authors towards a wholesome solution to global sustainable development.

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