Clean Development Mechanism (CDM) as a Solution for the Indian Energy Problems: A Domestic Perspective

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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 lighting sector. A detailed survey has undertaken in the state of Kerala, in southern part of India to study the rural domestic energy consumption pattern. The data collected was analyzed that throws insight into the interrelationships of the various parameters that influence domestic lighting energy consumption. The analysis also provides a plat form for implementing CDM projects in the sector and related prospects with respects to the Indian scenario.

Key Words: CDM, Energy Consumption Pattern, Indian Scenario

1. 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. 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 [12].

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.

2. Energy Scenario in India

"India experiencing a GDP growth rate of 8% per annum, putting tremendous pressure on the power sector of the country" [7]. 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 [1]. The country confronts fulgurous challenges in meeting its energy needs and providing adequate energy both in terms of sufficient quality and quantity to users in a

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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 [4, 5]. 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 [13].

Table I: Total installed capacity in India, (Source: Ministry of Power, Government of India, 2011)

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**

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). 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. [10].

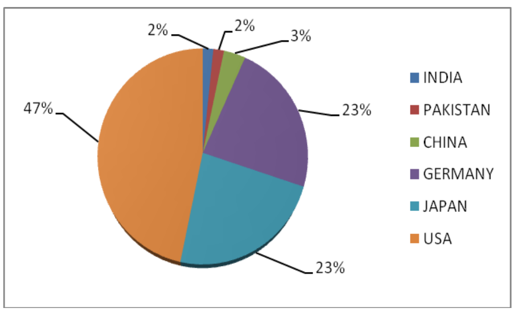

Figure 1: Per capita energy consumption [2]

3. 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 2011. 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 [14]. 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.

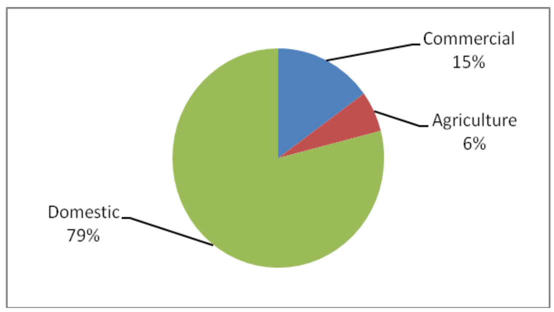

Figure 2: Consumer Profile, Electricity Distribution in Kerala (Source: KSEB, 2010)

4. 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. 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. 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 [3]. In order to verify the sufficiency of the sample size for 95% confidence interval the following equation was employed [11]:

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

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 [9].

5. CDM Implementation Analysis

The National Sample Survey Organization (NSSO), in its sixth survey that is carried out once in five years included coverage of Non-agricultural Enterprises in the Informal Sector additionally. The highlights of the survey particularly applied to lighting sector reveals that at national level, electricity and kerosene accounted for 99% of the households as primary source for lighting in both rural and urban areas. There has been an increase in the proportion of households using electricity as major source of lighting by 11% (from 37% to 48%) in rural areas and by 6% (from 83% to89%) in urban India since 2008-2010[6]. There was decrease in the percentage of households using kerosene as primary source of energy for lighting, from 62% to 51% in rural India, and from 17% to 10% in urban India, since 2008-2010 [8, 9].

One of the previous studies on determinants of energy consumption [13] concludes that income is a weak predictor of residential electricity consumption, explaining only 38% of electricity consumption. The consumption of electricity 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 electricity across all the districts were tested. The results of both these tests indicate that there are significant differences in the average electricity consumed by the households in the different districts and across different slabs of usage. This justifies the sample selection and its purpose. The quantity of electricity and Kerosene used in the rural sector for lighting application in domestic sector in Kerala is given in Table 2.

Table 2: Quantity of Electricity and Kerosene used in Kerala domestic sector for lighting
(Source: NSS Report No. 464: Energy Used by Indian Households, 2007-2010)

Year	Sector	Electricity (GWh)	Kerosene (Tons)
1983	Rural	15	83
1988	Rural	24	74
1993	Rural	37	62
1998	Rural	48	51

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

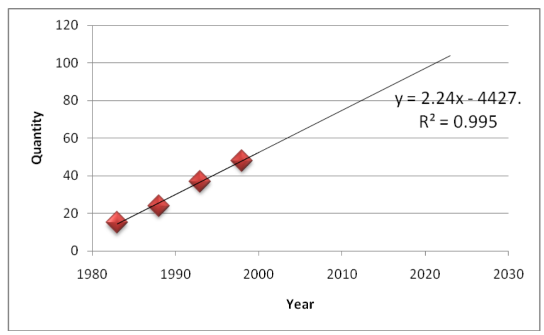

Figure 3: Trend showing the usage of electricity from 1983 to 2030 (Rural sector)

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

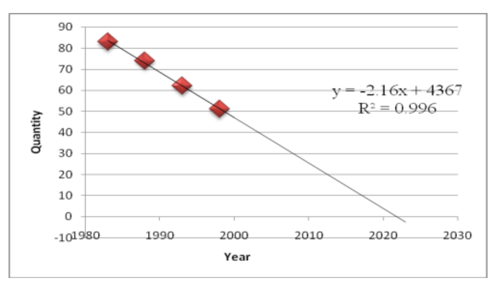

Figure 4: Trend showing the usage of kerosene from 1983 to 2030 (Rural sector)

The trend analysis shows that the usage of electricity is increasing where as the usage of kerosene 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 electricity can be found out by the IPCC guide line 2006 which is as follows:

CO_2 emission from electricity use = [(kWh consumed X Electricity emission factor)/ (Transmission and Distribution .
Efficiency)].

The electricity emission factor for India is 0.0008 to ton of CO_2/kWh and for the Transmission and Distribution Efficiency of 75% [6].

Table 3: Trend equations showing the usage of electricity and Kerosene in Kerala

ENERGY SOURCES	Area	Trend Equations	R^2 Value
ELECTRICITY	Rural	y = 2.24x - 4427	0.995
KEROSENE		y = -2.16x + 4367	0.996

By using the above formula, the CO_2 emission for Kerala from electricity is calculated for both urban and rural sector which is given in table 4. Figure 5 depicts the trend analysis on the variation of CO_2 emission till 2040.

Table 4: CO_2 emission for Kerala from electricity

Year	Electricity (Lighting)	Year	Electricity (Lighting)	Year	Electricity (Lighting)	Year	Electricity (Lighting)
2010	0.080	**2017**	0.0972	**2025**	0.116	**2033**	0.135
2011	0.082	**2018**	0.0995	**2026**	0.118	**2034**	0.137
2012	0.085	**2019**	0.1019	**2027**	0.121	**2035**	0.140
2013	0.087	**2020**	0.1043	**2028**	0.123	**2036**	0.142
2014	0.09	**2021**	0.1068	**2029**	0.125	**2037**	0.144
2015	0.092	**2022**	0.1091	**2030**	0.128	**2038**	0.147
2016	0.094	**2023**	0.1114	**2031**	0.130	**2039**	0.149
		2024	0.1139	**2032**	0.133	**2040**	0.152

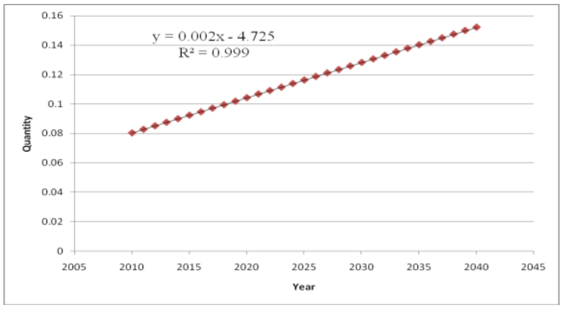

Figure 5: Trend analysis- Electricity for lighting application- Rural sector

6. Key Findings

In all the above cases we can see that the R^2 value is around 0.988 which is very much satisfactory. Also, Kerala households have witnessed dramatic increases in modern fuel use in recent years especially in lighting. Changing patterns of household activity and livelihood underlie this growth. Firewood and Biomass fuels, until recently a dominant household energy source in Kerala particularly for cooking purposes, play only a limited role in current household activities. Even the dominance of kerosene appears to be diminishing as lighting source. The study reveals that this increased reliance on electricity for lighting arises from a preference among consumers for more convenient and availability.

Electricity demand has increased rapidly in Kerala in recent years. Higher appliance saturations and more intensive lighting despite the decrease in household income, have spurred this growth. Electricity availability covers almost all households in Kerala, albeit subject to frequent load shedding. black outs, and voltage fluctuations. The average monthly per household and per capita consumption of electricity has been observed as 120 and 25 kWh, respectively.

One of the major concerns from the Kerala states perspective on energy consumption pattern is the availability of kerosene for poor sections of the society. The Indian government happens to be the sole administrator for the supply of kerosene and other petroleum products and the amount of kerosene available at subsidized prices is limited. Due to the inconsistencies in the policies, essentially the subsidy for kerosene is observed to benefit the regular settlements rather than reaching the target communities.

7. 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 that could form a platform 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 lighting 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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