International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

Opportunity of Analysis and Assessment of CDM Potential in Residential Area

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Abstract - *The paper deals with the analysis of CDM in residential area .Its purpose is to spot out and investigate different opportunities like solar heating, energy efficient lighting, air conditioning etc. to reduce green house gas emissions. Retrofitting of Solar water heating proved to be best method to reduce green house gas emissions.(GHG)*

Key Words: **Clean Development mechanism (CDM), Solar water heater (SWH),Greenhouse gas emissions (GHG)**

INTRODUCTION

Due to increase in pollution there is increase of emissions of green house gases, which is the primary cause of climate change. Developing countries are also playing significant part in climate change because of emission of large number of greenhouse gases. The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as 'A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Its main aim is to soothe atmospheric concentrations and sustainable development. Joint implementation, emission trading and clean development mechanism are the three mechanisms for reduction of emission. Out of the three, CDM has been on the top priority for assessment and analysis of emission as it is cost effective. To diminish green house gas emissions, the Kyoto protocol has been employed with the objective to combat global warming. In technologically advanced countries, the protocol is based on the principle of differentiated responsibilities to reduce recent emissions. It has commitment with revelries to diminish green house gas emissions In order to meet the objectives of the protocol; revelries are required to formulate policies and measures for reduction of greenhouse gases. In order to be rewarded with credits it is essential to employ the mechanisms such as joint implementation, the clean development mechanism and emissions trading. CDM consists of a bilateral agreement between two entities to complete a GHG mitigation project. Guidelines for the projects are as:

(i)Project design document: It clearly elaborates all the technology and methodology applicable and also the amount of emissions.
(ii) Approval of report by designated authority.
(iii)Validation.
(iv) Registration.
(v)Final report has to be prepared regarding emissions and submitted to authorities.

Case Study

A residential area of 260 households was taken up for the study. The CDM opportunities defined in the town ship are as follows

(i) Energy efficient lighting
(ii) Replacing electric rods/geysers with solar water heater
(iii) Energy efficient water pumps.

The scope of this paper is to just consider the CDM opportunities which include:

(i)installation of solar water heater
(ii)installation of energy efficient lighting
(iii)installation of energy efficient air conditioners
(iv)installation of energy efficient water pumps

Methodology And Development Of Baseline

The annual energy saving from the CDM project activity is less than 60GWh so the project activity falls under the small scale project activity and there are two baseline methodologies that are applicable for the development of the baseline.

- AMS I.C. Thermal Energy for the user with or without electricity [4].

(For estimating the baseline emission from the installation of SWH).

- AMS II.C. Demand side Energy efficiency programs for specific technology [5].

(For estimating the baseline emission from retrofitting the incandescent bulbs and air conditioners and submersible desert cooler pumps)

Development of Baseline for Solar Water Heating System

electric rods and electric geysers are used for water heating from all the residential chores The activity is to install the energy efficient solar water heating system for heating water for residential chores.. For this system, the baseline emission is the amount of electricity taken from the grid multiplied by the CO2 emission factor of the grid.

The data and assumptions for estimation of baseline emission reductions are given in the Table 1.

In order to calculate the baseline electricity consumption, we need to know the amount of electricity required to deliver the same quantity of hot water from an electric rod/geyser that is delivered by solar water heating system. We therefore need to know the amount of energy needed to heat the available warm water delivered by the project, as well as the efficiency of the electric hot water system.

Table 1 : Data/assumptions for solar water heating system

Items	Details
Hot water required for a person to take bath	15 liters
Efficiency of conversion of electrical energy to heat energy	95%
Total number of persons in the township (approx.)	1400
No. of persons taking bath on a day	1260
Winter months	November to February
Efficiency of conversion of electrical energy to heat energy, η_{conv}	95%

Hot water required for a person to take bath =15 liters
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No. of persons taking bath on a day=1260

Winter months=November to February
Efficiency of conversion of electrical energy to heat energy =95%

Calculation of baseline for electricity consumption for water heating:

Heat Energy required for heating water for a person

$$E_{elec} = m \cdot C_p \cdot \Delta T$$

where,

m = mass of water required for a person for bathing (kg)
Cp = specific heat capacity of water (4.18 kJ/kg.K)
ΔT = Temperature difference (K)
The water is required to be heated from 283 K to 338 K, so the heat energy required,
= 15 × 4.18 × (338-283)
= 3448.5 kJ

Electrical energy required = $E_{elec} = \dfrac{m \cdot C_p \cdot \Delta T}{3600 \cdot \eta_{conv}}$ kWh

Therefore,
E_{elec} = 1.008 kWh/person
Total number of persons residing in the township = 1400
Considering 90% persons take bath on a day,
So the no. of persons taking bath on a day
= 0.9×1400 =1260
Considering 4 months (November to February) of winter = 120 days

The institute draws the electricity from the northern grid. The CO2 emission factor (EFy) calculated as per AMSI.D. and published by Central Electricity Authority India is 0.83 tCO2/MWh for the northern grid [7]

For 4 months, total amount of CO2 emitted
= Eelec × No. of persons × EFy
= 1.008×1400×0.9×120×0.83
= 126.499 tCO2/ year

Development of Baseline for Energy Efficient Lighting:

For this project activity, the fluorescent lamp will be replaced by the compact fluorescent lamps (CFLs) to provide the equal lumens. For this project, the baseline technology replaced is a Compact fluorescent lamp (CFL). In each house every 55W fluorescent lamp will be replaced by one CFL of rating 25W (as per market survey approximate cost is $6.27). Every incandescent lamp (bulb) of 60W is being replaced by 13W CFL (as per market survey approximate cost is $ 4.54).

As per the small scale project activity methodology AMS II.C [5], if the energy displaced is electricity, the energy baseline is calculated as follows:

$$E_B = \Sigma_i (n_i \cdot p_i \cdot o_i)$$

where,
EB = annual energy baseline in kWh per year.
Σi = the sum over the group of "i" devices replaced (e.g. 40W incandescent bulb), for which the replacement is operating during the year, implemented as part of the project.

ni =the number of devices of the group of "i" devices replaced (e.g. 40W incandescent bulb) for which the replacement is operating during the year.
pi=the power of the devices of the group of "i" devices replaced (e.g. 40W). In the case of a retrofit activity, "power" is the weighted average of the devices replaced. In the case of new installations, "power" is the weighted average of devices on the market.
oi =the average annual operating hours of the devices of the group of "i" devices replaced.

The energy baseline is multiplied by an emission coefficient (measured in kg $CO2e/kWh$) for the electricity displaced calculated in accordance with provisions under category AMS I.D [6].

For calculation of the wattage of the CFL lamp to be retrofitted, the lumens are equated. The retrofit will be perfect if the lumens provided by the fluorescent bulb are equal to the lumens provided by the CFL. The luminous efficacy of the 40W fluorescent bulb is 35 lumens/W and the luminous efficacy for a CFL lamp is 55 lumens/W. On equating the lumens,

$$W1 \times L1 = W2 \times L2$$

Where,
W1 wattage of existing fluorescent lamp
L1 luminous efficacy of fluorescent lamp
W2 wattage of CFL to be retrofitted
L2 luminous efficacy of CFL
So, 40W × 35 Lumens/W = W2 × 55 Lumens/W
W2 = 25.45W

The data and assumptions used for calculating the baseline emission from retrofitting the CFL is given in Table 2:

(1) There are 260 houses in the township (A-D, F, H, MSH & BSH type). There are total 620 separate latrines and bathrooms, each fitted with 60W Incandescent lamp (bulb), operating for 3 hours daily round the year. These bulbs are being replaced with 620 CFL'S of 13W rating.

(2) There are 260 houses in the township (A-D, F, H, MSH & BSH type). There are total 260 Porch lights, each fitted with 60W Incandescent lamp (bulb), operating for 10 hours daily round the year. These bulbs are being replaced with 260 CFL'S of 13W rating.

(3) There are 120 houses in the township (A-D type). There are total 230 Main gate pillar lights, each fitted with 60W Incandescent lamp (bulb), operating for 3 hours daily round the year. These bulbs are being replaced with 230 CFL'S of 13W rating.

(4) There are 255 houses in the township (A-D, F, H, MSH & BSH type). There are total 255 Kitchens; each fitted with 55W Fluorescent tube light, operating for 6 hours daily round the year. These bulbs are being replaced with 255 CFL'S of 25W rating.

(5) There are 115 houses in the township (A-D type). There are total 460, 55W Fluorescent tube lights (2 in Dining hall and 2 in Bedrooms being used mostly), operating for 6 hours daily round the year. These Fluorescent tube lights being replaced with 460 CFL'S of 25W rating.

(6) There are 140 houses in the township (F, H, MSH & BSH type). There are total 280, 55W Fluorescent tube lights (2 rooms in each house), operating for 6 hours daily round the year. These Fluorescent tube lights are being replaced with 460 CFL'S of 25W rating.

(7) The average daily operating hours for CFL'S of 13W rating replacing 60W incandescent lamps (bulbs) are 6 hours per day. Life of CFL as per the specifications is 10000 hours (5 years approximately).

(8) The average daily operating hours for CFL'S of 25W rating replacing 55W Fluorescent tube lights are 6 hours per day. Life of CFL as per the specifications is 10000 hours (5 years approximately).

The electricity saved by the replacement of energy efficient CFL'S is:

$$E_{CFL} = 88.85 + 69.64 \text{ MWh/yr} = 158.49 \text{MWh/yr}$$

The CO_2 emission factor for the northern grid is 0.83 tCO_2/MWh.

So, the emission reduction = electricity saved × CO_2 emission factor

$$= 158.49 \text{MWh/yr} \times 0.83 = 131.54 \ tCO_2/yr$$

Development of Baseline for Energy Efficient Air Conditioners:

The air conditioners (ACs) that are currently used in township are overrated than the actual capacity required. In the project activity, the old air conditioners will be retrofitted by the energy efficient air conditioners. The baseline estimation for the electricity consumption for the air conditioner can be done as per the formula stated for the baseline estimation of lighting. The data and assumptions used for calculating the baseline emission from retrofitting the Energy Efficient air conditioners is given in the table

Table 4 : Data/Assumptions for retrofitting the ACs

Items	Details
Number of ACs in township (approx.)	40
Tonnage of existing ACs	1.5 ton
Tonnage of retrofitted ACs	1.0ton
EER of existing ACs	1.1 kWh/ton-hr
EER of retrofitted ACs	3.07 kWh/ton-hr
Operating hours	8 hrs/day for 6 months

The electricity saved by the replacement of energy efficient air conditioner is calculated as:

E_{AC} = No. of ACs × Difference in rating of ACs × Average annual operating hours

$= 40 \times (3.07 - 1.1) \times 8 \times 30 \times 6$

$= 113.47$MWh/yr

So, the emission reduction = Electricity saved × Emission coefficient

$= 113.47 \times 0.83$

=94.18 tCO_2/yr

Development of Baseline for Energy Efficient Desert Cooler Submersible Water Pumps

The data and assumptions used for calculating the baseline emission from retrofitting the Energy Efficient Desert Cool

Table 5: Data/Assumptions for retrofitting the Energy Efficient Desert Cooler Submersible Water Pumps

Items	Details
Number of Desert Coolers in township (approx.)	500
Rated power of existing pumps	35 W
Rated power of retrofitted pumps	10 W
% of pumps to be retrofitted	90 %
Operating hours of existing pumps	16hrs/day for 6 months
Operating hours of retrofitted pumps (with automatic ON/OFF timer)	08hrs/day for 6 months

Automatic ON/OFF timer is an electronic circuit which allows the pump to work intermittently i.e. for a period of 5 minutes the pump works and for next 5 minutes it does not operate. So the actual hours of operation are just halved.

The electricity saved by the replacement of Energy Efficient Desert Cooler Submersible Water Pumps (with automatic ON/OFF timer) calculated as:

Total energy consumption of existing pumps E_{wpo}

$= 500 \times 0.9 \times 35 \times 16 \times 180$

= 45360 kWh/yr

Total energy consumption of retrofitted pumps $E_{wpn} = 500 \times 0.9 \times 10 \times 08 \times 180$ =6480 kWh/yr

The net electricity saved from adopting the energy efficient pumps $E_{wp} = E_{wpo} - E_{wpn}$

= 45360 – 6480 kWh/yr

= 38880 kWh/yr

= 38.80 MWh/yr

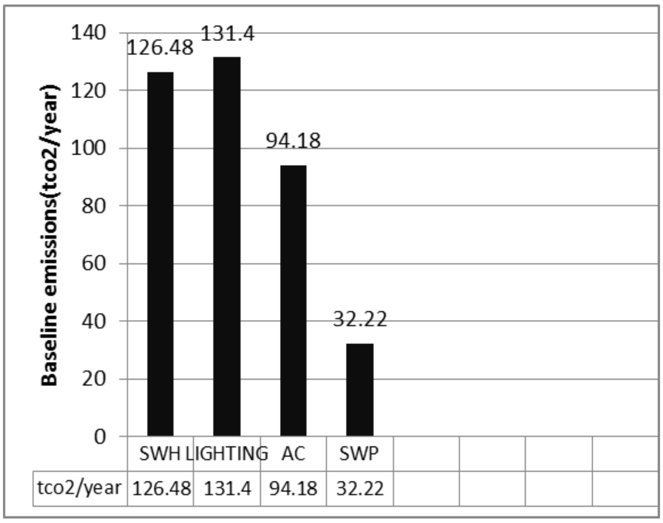
So, the emission reduction = Electricity saved × Emission coefficient

$= 38.80 \times 0.83$

= 32.22 tCO_2/ year

Additionally and Investment Analysis

CDM as such does not reduce the net global greenhouse gas emissions .For every ton of emissions



reduced in a host country, an investor is allowed to emit 1 ton in Annex I country. If a CDM project does not reduce emissions compared to what would have happened anyway (business as usual), then the net effect would be an increase in the global emissions. Therefore business-as-usual projects do not just contribute to overall greenhouse gas emission reduction; they actually will increase the net emissions. The additionally principle is thus of fundamental importance in the CDM context. A CDM project is additional only if greenhouse gas emissions are reduced below those that would have occurred in the absence of the registered CDM project activity. The tool for demonstration of additionally provides a stepwise approach to demonstrate and assess the additionally for the project activity. These steps include:

- Identification of alternatives to the project activity
- Investment analysis
- Barrier analysis
- Common practice analysis

The project falls under the small-scale project activity as annual energy saving is less than 60GWhe so the additionally can be proven by any of these steps. In our case, the additionally has been proved by carrying an investment analysis and common practice test for the project. Under investment analysis, a suitable financial indicator is chosen and compared against the relevant industry regional/national benchmark. The appropriate analysis method chosen for the investment analysis is by conducting a benchmark analysis for each of the project activity wherein a financial indicator (here IRR (internal rate of return)) will be compared against established value for respective technology. The appropriate analysis method chosen for the investment analysis is the Internal Rate of Return (IRR).

In case of solar water heater, the IRR obtained without the CDM revenue is 8 % and with CDM revenue it is 12 % (just above the benchmark of 10%). It can be seen that the technology used by the CDM project is not the economically most attractive option and therefore not the baseline. Therefore, on the basis of economic rationale, the project developers do not install this solar energy technology without the CDM benefit. The financially most attractive option without the CDM is to generate hot water by electric geysers.

In case of energy efficient lighting, the IRR for installing the energy efficient lighting is calculated which is 125% without CDM revenue and 149% with CDM revenue. So it can be said that adopting energy efficient lighting is highly profitable as is seen by the higher value of the IRR and does not require the additional revenue from the CDM. The project activity is viable even without the CDM.

The IRR for installing the AC of 1.0 ton capacity is calculated as 92 % without CDM benefits and 109 % with CDM benefits. In this case also, the IRR is high enough to make the project activity attractive without the benefit from the CDM. Also the sensitivity analysis is done with the retrofitting of 1.5 ton AC. In this case the IRR obtained from the project activity is 84% and 103% without CDM benefit and with CDM benefit respectively. The IRR in this case is less because of the less saving of electricity by adoption of AC with higher rating.
The IRR for installing the SWP is calculated as 123 % without CDM benefits and 147 % with CDM benefits So it can be said that retrofitting of SWP is highly profitable as is seen by the higher value of the IRR and does not require the additional revenue from the CDM. The project activity can go ahead even without the CDM.

Conclusions

Assessment of CDM potential was carried out considering the adoption of renewable energy technology and energy efficiency measures.

Out of the four cases analyzed for the CDM opportunities, the solar water heating system requires the CDM benefits to go ahead. The adoption of energy efficiency measures through the lighting and air conditioning and submersible desert cooler water pumps does not require the CDM revenue as is seen from their higher rates of return

S.no.	Type of house	Place where retrofitting is being done	No. of incandescent lamps to be replaced	Average Operating hours	Electrical Energy saved by retrofitting (kWh)	Cost involved with retrofitting ($)	Emission reduction = Electricity saved × Emission factor (tCO_2 per year)
1	A-D,F,H,MSH&BSH	Latrine & bathroom	620	3	=620 x (60 – 13) x 3 x 365 =319083.00 kWh =31.90 MWh	= 620x 4.54 = 2814.8	= 31.909 x 0.83 = 26.47
2	A-D,F,H,MSH & BSH	Porch light	260	10	=260 x (60 – 13) x 10 x 365 =446030 kWh =44.60 MWh	= 260 x 4.54 =1180.4	= 44.60 x 0.83 = 37.01
3	A - D	Main gate pillar lights	240	03	=240 x (60 – 13) x 3 x 365 =123516 kWh =12.35 MWh	= 240 x 4.54 = 1089.6	= 12.35 x 0.83 = 10.25
		Total	**1120**		**= 88.85MWh**	**= 5084.8**	**= 73.73 (tCO_2 per year)**

Table 2 : Number of Incandescent lamps to be retrofitted and energy saved

S.N.	Type of house	Place where retrofitting is being done	No. of fluorescent lamps to be replaced	Average Operating hours	Electrical Energy saved by retrofitting (kWh)	Cost involved with retrofitting ($)	Emission reduction = Electricity saved × Emission factor (tCO_2 per year)
1	A-D,F,H,MSH&BSH	Kitchen	260	6	=260 x (55 – 25) x 6 x 365 =170820 kWh =17.08 MWh	= 260 x 6.27 = 1630.2	= 17.08 x 0.83 = 14.17
2	A-D	Dining hall, Bed rooms	500	6	=500 x (55 - 25) x 6 x 365 =32850kWh =32.85MWh	= 500x 6.27 = 3135	= 32.85 x0.83 =27.26
3	F,H,MSH & BSH	Rooms	300	6	=300 x (55 - 25) x 6 x 365 =197100kWh =19.71 MWh	= 300x 6.27 = 1881	= 19.71 x0.83 = 16.35
4		**Total**	**1060**		**= 69.64 MWh**	**= 6646.2**	**= 57.78 (tCO_2 per year)**

Table 3 : Number of Fluorescent Tube Lights to be retrofitted and energy saved

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BIOGRAPHIES

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