Analysis of Financial Viability of Energy-Efficient CDM Projects in India: A Case Study

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Abstract

Realising the detrimental consequences of global warming, the industrialised and developed countries around the globe have come together and committed themselves to reduce the emission of greenhouse gases (GHGs) under an international and legally binding treaty coined as 'Kyoto Protocol' in 2005. The Protocol by setting targets on maximum amount of emission of GHGs by the developed countries (Annex I countries) aims at stabilizing the concentration of GHGs in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

However, to serve the purposes of Annex-I countries in achieving compliance with their quantified emission reduction commitments as well as to encourage the non Annex-I countries with no emission reduction target, to contribute towards emission reduction efforts, the Protocol provides three innovative and flexible mechanisms among which Clean Development Mechanism (CDM) is the most stimulating one and the only mechanism relevant to our country at present. Our country, being a non-Annex-I country to the Protocol has emerged as one of the largest beneficiaries of CDM in terms of generation revenues through sale of carbon credits.

In the present paper a case study of an energy efficiency improvement CDM project has been undertaken which demonstrates that the CDM has given birth of an innovative and profitable business model through which an entity as a meritorious corporate citizen can discharge its responsibility towards the environment and society without jeopardizing its own financial sustainability.

Keywords: *Kyoto Protocol, Baseline study, Monitoring interval, United Nations Framework Convention on Climate Change (UNFCCC), Clean Development Mechanism (CDM), Certified Emission Reductions (CERs), Internal Rate of Return (IRR)*

Introduction

Global warming has come to be recognized as one of the most serious environmental challenges ever to face by human race. The Earth's average surface temperature has increased unusually over the past century due to rapid increase in the concentration of greenhouse gases (most importantly carbon dioxide with others like methane, ozone, nitrous oxide, etc.) in Earth's atmosphere predominantly as a result of rising industrial activity, burning of fossil fuels like coal, gas, oil etc. and tropical deforestation. The scientific opinion on the issue as expressed by the 'United Nations Intergovernmental Panel on Climate Change' (IPCC) is that the global average surface temperature rose by about 0.8 degree Celsius in last hundred years and it will increase by another four degree Celsius by the end of 21st century (Summary for Policymakers, IPCC Synthesis Report, November 2007*)*. The expected detrimental consequences of such changes may include severe droughts, heavy rain cycles, coastal and small island flooding, increases in extreme weather, more and stronger tropical cyclone and hurricanes, melting of ice caps and glaciers, biological extinctions, spread of vector-borne diseases, damage to vegetation and reduction in agricultural yields and many others leading fundamental changes to Earth's climate system.

Acknowledging the issue of climate change as a global threat the countries around the globe met together at the United Nations Conference on Environment & Development (informally known as The 'Earth Summit') in Rio de Janeiro in 1992, resulting in the adoption of the 'United

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Nations Framework Convention on Climate Change' (UNFCCC) with the objective of stabilizing the concentration of six greenhouse gases (namely, carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) in the atmosphere at a level that would prevent dangerous human interference with the climate system. Subsequently, to supplement the Convention, an international and legally binding environmental treaty (originally taken at Kyoto in 1997), coined as 'Kyoto Protocol' came into force on 16th February 2005, which sets limits to the maximum amount of emission of greenhouse gases (GHGs) by the developed countries. At present forty one developed countries have ratified the Protocol and committed themselves to reduce their collective emissions of GHGs by at least 5.2% below their 1990 baseline emission levels over the five-year commitment period of 2008-2012. As per the Protocol, however, the prescribed limit of emission level is not applicable to developing and least-developed countries at present, though they emit GHGs in the atmosphere.

Kyoto Protocol and its Mechanisms

The signatories to the UNFCCC are divided into two main groups: Annex I countries- a total of 41 industrialized and developed countries and Non-Annex I countries- all other countries not included in Annex I of UNFCCC, mostly the developing and least developed countries. Under the Kyoto Protocol, countries with binding emission reduction targets (i.e., Annex-I countries) are issued Emission Allowances based on amount of emissions allowed to them. Further, in order to enable the developed countries to meet their emission reduction targets as well as to encourage the private sector and developing countries (Non Annex-I countries) to contribute towards emission reduction efforts, the Protocol provides three innovative and flexible mechanisms – Joint Implementation (JI), International Emission Trading (IET) and Clean Development Mechanism (CDM).

Under Joint Implementation (Article 6), which is a project-based mechanism, a developed country with a relatively high cost of domestic GHG reduction can set up an emission-reduction or emission-removal project in another developed country that has a relatively low cost of GHG reduction. The carbon credits generated by such project, called Emission Reduction Units (ERUs), can be used by the investor developed country to help meet its Kyoto target while the host country benefits from foreign investment and technology transfer.

International Emission Trading (Article 6) is a market-based Kyoto mechanism under which developed countries with quantified emission reduction targets can simply trade in the international carbon credit market. The allowed emissions of developed countries are divided into 'Assigned Amount Units' (AAUs) and the entities of developed countries exceeding their emission limits can buy AAUs from those who have spare AAUs (i.e., whose actual emissions are below their set limits) at the prevailing market prices.

Like Joint Implementation, Clean Development Mechanism (Article 12) is also a project-based mechanism of Kyoto Protocol. Under CDM, a developed country can invest in an emission reduction project or afforestation or reforestation project in a developing country where the cost of GHG reduction is usually much lower and earn carbon credits on the basis of emission reductions by the project which can be used to meet a part of its Kyoto target. Besides, the entities from developing and least developed countries can also set up a GHG reduction project, generate carbon credits and then earn revenues by selling such carbon credits at prevailing market prices to entities of developed countries having emission reduction targets. The carbon credits so generated and traded under CDM are expressed by the unit 'Certified Emission Reduction' (CER) where one CER is equal to one ton of carbon dioxide equivalent not emitted in the atmosphere (Article 16).

As our country presently belongs to Non-Annex I countries to the Protocol with no emission reduction target, CDM is the only mechanism relevant to our country and India with China and Brazil has emerged as one of the largest beneficiaries of CDM in terms of promoting economic, social and environmental sustainability of the country at large and generating revenues through sale of carbon credits in particular. The Indian CDM sector has been expanding to a variety of sectoral categories like energy efficiency, renewable energy, fuel switching, waste handling and disposal, industrial process etc. and is growing rapidly to become the world leader.

In the present paper, a case study of an energy efficiency improvement project established under the CDM of Kyoto Protocol has been undertaken with the primary objective to analyse its financial viability. As in case of CDM projects revenues streaming from conventional sources of selling products or services are negligible compared to volume of investments, such a project would be commercially viable only when it is able to capitalize successfully the opportunities of CDM in term generation of revenues through sale of carbon credits. The present study analyses how the project generates carbon credits and make itself a profitable business avenue along with methodologies for determining ex-ante and ex-post emission reductions, objective of the project and contribution of the project in promoting sustainable development of the country.

Case Study of Visakhapatnam (India) OSRAM CFL distribution CDM Project:

Name and location of small-scale CDM project activity:
Title of the project is 'Visakhapatnam (India) OSRAM CFL Distribution CDM Project' and the project is located in Visakhapatnam District of the state Andhra Pradesh, India.
Involved Parties and Project Participants:
Host party: India & Project participant: Osram India Pvt. Ltd
Other involved party: Germany & Project participants: Osram GmbH and RWE Power AG
Crediting period: 10 years starting from 12th February, 2009.
Type and Category of the small-scale project activity:
As per UNFCCC categorization the project activity is a Type II: 'Energy efficiency improvement projects' activity as it increases the efficiency of electric lighting in household sector and the project activity belongs to the Category C: 'Demand-side energy efficiency programmes for specific technologies' because it by increasing the efficiency of lighting used in household sector, reduces energy (electricity) demands. Energy efficiency and conservation projects are also treated as eligible CDM projects, as implementation of these projects would also result in considerable energy savings and dislodge CO_2 emissions from grid-connected power plants which otherwise would occur in the absence of such projects. The procedure for establishment, operation and monitoring of this type of project is guided by the Methodology AMS-II.C, Version 9 of the UNFCCC. The project is a small-scale CDM project as the expected energy savings by the project is within the threshold limit for small scale project of 60 gWh per year.

Description of the small-scale project activity:

The project was registered on 12th February, 2009 with the CDM Executive Board of UNFCCC (Reference Number 1754) as a small scale CDM Project under the Clean Development Mechanism of Kyoto Protocol. The project involves the distribution of around 6,50,000 OSRAM Long life (15,000 utilizing hours) and highly energy-efficient (consumes up to 80% less energy compared to traditional incandescent light bulb to produce same level of illumination) Compact Fluorescent Lamps (CFLs) in the district of Visakhapatnam having about 7,50,000 households scattering over an area of 540 sq. km. For the project, CFL components and assembly technology and know-how were imported from Germany to India and the assembly of the components was undertaken in Sonepat factory of OSRAM India Pvt. Ltd. in the state of Haryana. The CFLs were distributed among the members of target group for a minimal price of Rs.15 per CFL i.e., more or less at a price of a traditional incandescent bulb (GLS bulb). The target group of the project comprises of all the households in the district of Visakhapatnam who are registered customers of the 'Andhra Pradesh Eastern Power Distribution Company Limited' (APEPDCL) and have an electricity grid connection. Under the scheme, the households can substitute one GLS bulb of 60 wattage or 100 wattage at the place of maximum usage in their home by one CFL of 15 Wattage or 20 wattage respectively in exchange of Rs.15 and the replaced GLS bulb.

Objective of the Project

The present CDM project is an innovative initiative undertaken by the private entity 'OSRAM India Pvt. Ltd.' to explore the benefits offered by the Kyoto Protocol to Non-annex I Countries like us. The objective of the project activity is to enhance efficient use of electricity in the household sector of the project area by making CFLs available at prices comparable to that of GLSs and to leverage the high cost of the CFLs through sale of carbon credits (i.e., CERs) generated out of the project. As emission factor for generation of electricity in India is relatively high (as per the latest data published by Central Electricity Authority, India in March, 2011, it is 0.89 i.e., 0.89 ton carbon dioxide (CO_2) is released per mWh of electricity generated in India), the project by reducing consumption of fossil fuel-fired electricity of the Southern Power Grid (which supplies electricity to the project households) considerably reduces emission of GHGs in the grid and on the basis of such emission reductions earns carbon credits which can be sold in international carbon credit market at the prevailing market prices.

Contribution of the project to the sustainable development of the host country:

Like any other CDM projects, the present project also contributes towards promoting sustainable development of the host country in the following way:

- by considerably reducing consumption of electricity (up to 80%), abates CO_2 emissions from the coal-based Southern Power Grid of the country.
- reduces energy demands, most importantly peak demand in a country which faces considerable power outages.
- contributes towards significantly reducing household expenditure on electricity bills and providing access to energy efficient lighting, especially to low-income and rural households. Assuming daily utilization hours of 5 hours and electricity charges @ 4 INR/kWh, a household by replacing one 100 Watt incandescent bulb with one 20 Watt CFL, can reduce electricity bill of (80W x 5 Hours/Day x 365 Days x 4 INR=) 584 INR per year.
- creates employment in CFL manufacturing (assembly) sites as well as in a variety of other jobs associated with project implementation and monitoring activities.

- enables longer evening hours in households (especially in rural areas) allowing for increased social, domestic and educational activities and improves living environment of all, especially of women and children.
- reduces the mercury content in CFLs used in India. The project CFLs have a mercury content of only 2.5 mg. per CFL which is significantly lower than the mercury content in CFLs produced by other manufacturers in our country.
- ensures efficient utilization of natural resources.
- helps to promote technological self reliance in India.

Besides, in the absence of any approved guidelines for disposal of or recycling the used CFLs in our country, the fused CFLs are disposed with the regular waste in landfills. But as its mercury contents may eventually add to contamination of soils and groundwater resources, OSRAM India has addressed the issue proactively and implemented a mitigation plan that would contribute to the prevention of mercury pollution in India.

Methodologies for estimating emission reductions by the project activity:
To be eligible for a CDM project, a project must have the criterion of additionality which means the emission reductions from a CDM project should be additional to that would otherwise occur in the absence of such project and this additionality provides the basis for calculating emission reductions by a CDM project. For the purposes of CDM, emission reductions from a project activity are determined by deducting actual project emission from the counterfactual baseline emission level (i.e., the emission that would occur in the absence of the project).

In order to have an estimate of the number and types of GLS bulbs that could be replaced under the project, OSRAM India Pvt. Ltd. conducted a pre-study by randomly selecting 200 households from the project area in a way that represents all the project participants. The pre-study results revealed that one CFL per household could be installed in 72% of the households in the district and the rest would be ineligible to participate in the project for the reason of either not having eligible GLS bulb to be replaced, absence during conducting the pre-study, unwillingness to participate in the project etc. and out of the total replaceable GLS bulbs 89% would be of 60 Watt and remaining 11% of 100 Watt. For the baseline study, meter equipments were installed in the places where GLS bulbs were in use in the sample households to monitor the daily operating hours of each GLS bulb for 90 days. With the wattage per GLS bulb in the sample and the daily operating hours during the baseline period, the overall power consumption of those GLS bulbs during the baseline period was calculated to find out ‘Baseline energy consumption’**.** These pre-study results and official data regarding average daily operating hours of GLS bulbs and CFL in India (as per data published by ‘The Energy & Resource Institute’, it was 5 hours per day in 2008.) were used in ex-anti emission reduction calculation of the project.

Following Methodology AMS-II.C formulated by the Executive Board of UNFCCC, the emission reduction from the project in a monitoring/crediting period is calculated as:

$$ER_v = (E_{BL,v} - E_{PJ,v}) * EF - LE_v$$

Where:
ER_V stands for emission reductions during the monitoring period v,
$E_{BL,V}$ stands for baseline energy consumption (electricity) for the monitoring period v,

$E_{PJ,V}$) stands for project energy consumption (electricity) for the monitoring period,
EF CO_2 emission factor for generation of electricity in the power grid serving the project households (measured in kg CO_2e/kWh) and remains fixed for the entire crediting period, and
LE_V Leakage emissions for monitoring period v.

The CO_2 emission factor measures the average amount of CO_2 equivalent (in kg.) emission for generating one kWh of electricity and it varies from country to country as well as from power plant to power plant within the country depending on fuel type and technology used in generating electricity. The CO_2 grid emission factor used in calculating emission reductions is the latest ex-ante grid emission factor value published by the respective governmental authority of the host country available at the time of registration of the project. In case of the present project, the factor used is the CO_2 emission factor (combined margin including imports) of Southern Power Grid, published by the 'Central Electricity Authority', India in 2008.

For the project, 'leakage emissions' represents the emissions resulting from potential usage of replaced GLS bulbs somewhere else. For the project, as all the collected replaced GLS bulbs were destroyed under supervision of an independent body, no leakage emission is occurred.

Thus, estimating emission reductions by the project involves mainly determination of baseline energy consumption (EB) and project energy consumption (EP) as under:

$$EB = \sum_{i=1}^{2} (n_i * p_i * o) \quad \text{and} \quad EP = \sum_{k=1}^{2} (n_k * p_k * o)$$

Where:
n_i is the number of incandescent bulbs of type *i* (i.e., 100 W or 60 W),
p_i is power rating of the incandescent bulb of type *i*,
n_k is the number of CFLs of type *k* (i.e., 20 W or 15 W),
p_k is power rating of the CFL of typ *k*, and
o is the average operating hours of the devices for the particular period.

But, for practical purposes, baseline and project energy consumption are measured by constructing sample groups of reasonable sizes and then making statistical estimations of the population parameters based on those sample values. Following methodology AMS-II.C, the baseline and project energy consumptions are calculated in a realistic and precise manner as follows :

A: Baseline energy (electricity) consumption:
The baseline energy consumption of the project (EB) is calculated as:

$$E_{BL,v} = CF_v * \sum_{i=1}^{n} [p_i * \mu_{BL} * d_{k,v}] \qquad \text{(A1)}$$

Where:
$E_{BL,v}$ is the baseline energy consumption (electricity) in monitoring interval v,
CF_v is the correction factor for non-functional CFLs found during cross-check in the monitoring interval. CF_v represents share of functional CFLs in the monitoring interval v
p_i is the power rating of the GLS bulb *i* used before replacement,
μ_{BL} is the average baseline operating hours per day, and

$d_{k,v}$ is the days of operation of each distributed CFL k in monitoring interval v.

The CF_v used in equation (A1) above is defined as:

$$CF_v = 1 - \left\{ p_{cc,v} + z * \sqrt{\frac{p_{cc,v} * (1 - p_{cc,v})}{n_{all,v}}} \right\} \quad \text{(A2)}$$

Where:

$p_{cc,v}$ is the share of CFLs that found non- functional during cross check in the monitoring interval v,

$n_{all,v}$ is the number of checked CFLs during cross check in monitoring interval v, and

z is the standard normal for a confidence level 95% (z =1.96).

The μ_{BL} used in equation (A1) above is calculated as:

$$\mu_{BL} = \frac{\sum_{d=1}^{n} \mu_{BL,d,adj}}{Days_v} \quad \text{(A3)}$$

Where:

$\mu_{BL,d,adj}$ is the mean operating hours for day d in the baseline study interval adjusted by confidence interval and

$Days_v$ is the duration (in days) of the baseline study interval.

$\mu_{BL,d,adj}$ used in equation (A3) is calculated as:

$$\mu_{BL,d,adj} = \mu_{BL,d} - z * \frac{\sigma_{BL,d}}{\sqrt{n_{r,d}}} \quad \text{(A4)}$$

Where:

$\mu_{BL,d}$ is the mean operating hours for day d in the baseline study interval adjusted for daylight hours of different months in the year,

z is the standard normal for a confidence level 95% (z =1.96),

$\sigma_{BL,d}$ is the standard deviation of operating hours (adjusted for daylight hours of different months in the year) for day d in the baseline study interval, and

$n_{r,d}$ is the number of meters r that provide a valid value for day d in the baseline study interval.

$\mu_{BL,d}$ and $\sigma_{BL,d}$ used in equation (A4) are calculated as:

$$\mu_{BL,d} = \frac{\sum_{r=1}^{n} \frac{O_{rd}}{\propto_d}}{n_{r,d}} \quad \text{(A5); and} \qquad \sigma_{BL,d} = \sqrt{\frac{\sum_{r-1}^{n} \left(\frac{O_{rd}}{\propto_d} - \mu_{BL,d} \right)}{n_{r,d} - 1}} \quad \text{(A6)}$$

Where:

$O_{r,d}$ is the operating hours from meter r which provides valid data for day d in the baseline study interval,

$\propto_d$ is the adjustment factor for daylight hours of day d, derived from mean daylight hours of a month (in which day d falls) compared to weighted annual average of daylight hours (Table-1), and

$n_{r,d}$ is the number of meters r that provide a valid value for day d in the baseline study interval.

Table- 1: Adjustment factors for operating hours measured during the baseline study interval

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	**Avg.**
$\propto_d$	0.937	0.921	0.901	0.896	0.871	1.026	1.133	1.153	1.167	1.072	0.983	0.940	**1.000**

B: Project energy (electricity) consumption:

In similar fashion, the energy (electricity) consumption in the project activity in a monitoring interval is determined using the following formula:

$$E_{PJ,v} = CF_v * \sum_{k=1}^{n} [p_k * \mu_{PJ,v} * d_{k,v}] \qquad \text{(B1)}$$

Where:

$E_{PJ,v}$ is the energy consumption (electricity) in the project activity in monitoring interval v,

CF_v is the correction factor for non-functional CFLs found during cross-check in the monitoring interval. CF_v represents share of functional CFLs in the monitoring interval v

p_k is the power rating of the distributed CFL *k*,

$\mu_{PJ,v}$ is the average operating hours per day in monitoring interval v, and

$d_{k,v}$ is the days of operation of each distributed CFL k in monitoring interval v.

The calculation for CF_v has been shown in baseline energy consumption above (Equation A2).

The $\mu_{PJ,v}$ used in equation (B1) above is calculated as:

$$\mu_{PJ,v} = \frac{\sum_{i=1}^{n} \mu_{PJ,v,d,adj}}{Days_v} \qquad \text{(B2)}$$

Where:

$\mu_{PJ,v,d,adj}$ is the mean operating hours for day d in the monitoring interval v, adjusted by confidence interval, and

$Days_v$ is the duration (in days) of the monitoring interval v.

$\mu_{PJ,v,d,adj}$ used in equation (B2) is calculated as:

$$\mu_{PJ,v,d,adj} = \mu_{PJ,v,d} + z * \frac{\sigma_{PJ,v,d}}{\sqrt{n_{m,v,d}}} \qquad \text{(B3)}$$

Where:

$\mu_{PJ,v,d}$ is the mean operating hours for day d during the monitoring interval v,

z is the standard normal for a confidence level 95% (z =1.96),
$\sigma_{PJ,v,,d}$ is the standard deviation of operating hours for day d during the monitoring interval v,and
$n_{m,v,d}$ is the number of meters m that provide a valid value for day d in the monitoring interval v

$\mu_{PJ,v,d}$ and $\sigma_{PJ,v,d}$ used in equation (B3) are calculated as:

$$\mu_{PJ,v,d} = \frac{\sum_{m=1}^{n} O_{m,v,d}}{n_{m,v,d}} \quad \text{(B4); and} \quad \sigma_{PJ,v,d} = \sqrt{\frac{\sum_{m=1}^{n} \left(O_{m,v,d} - \mu_{PJ,v,d}\right)}{n_{m,v,d} - 1}} \quad \text{(B5)}$$

Where:
$O_{m,v,d}$ is the operating hours from meter m which provides valid data for day d in the monitoring interval v, and
$n_{m,v,d}$ is the number of meters m that provide a valid data for day d in the monitoring interval v.

As evident from equations A4 and B3, the population operating hours of lamps both in baseline study and monitoring period, have been estimated statistically from operating hours of respective sample groups assuming operating hours of lamps in the population follows normal distribution. It is to notice that while making such estimations, for a conservative and also realistic approach, the baseline operating hours has been decreased and the project operating hours has been increased by the interval value.

Analysis of financial viability of the project:
The purpose of CDM, as stated in Article 12, Paragraph 2 of the Kyoto Protocol, is to assist non-Annex I countries and entities from those countries in achieving sustainable development and to assist Annex I countries and entities from those countries in complying with their quantified emission limitation and reduction commitments under Article 3. This means that besides setting limits on maximum amount of emission of GHGs by the developed countries, it aims to incentivize the companies or countries that emit less carbon vis-à-vis helps to ensure efficient use of the environment and its protection to a great extent.

It is most likely that a business entity would like to set up a CDM project only if the project is financially viable irrespective of extent of its contribution to sustainable development. Acknowledging the reality, the Kyoto Protocol assigned a monetary value to the cost of polluting atmosphere. This means that carbon emission becomes an input cost to those business entities that pollute much and at the same time an important source of revenue to those who pollute less. India, being a non-Annex-I country to the Kyoto Protocol, has emerged as one of the largest beneficiaries of CDM with a great potential and opportunity for government, investors and business enterprises. Osram India, one of the world's leading lighting manufacturers, has undertaken the present project not only as a part of its contribution towards society and environment but also as a profitable and attractive business model.

The expected volume of CERs, commonly termed as carbon credits that would be generated by the project over the crediting period as envisaged in the Project Design Document (PDD) of the project are presented in Table-2. The main cost associated with the project is the fully absorbed cost of CFLs (including duties, taxes, assembly cost in India etc.) distributed under the project and it was comparatively higher than similar types of CFLs produced in India for its high quality (around 4 to 4.5 Euro). Other project costs include overhead charges of OSRAM India Pvt. Ltd., freight and cost of distribution of the CFLs in the project area (ranges between 0.30 Euro to 0.80 Euro per CFL). On the other hand, revenues of the project stream from token selling price of CFLs (which is 15 INR or around .26 Euro per CFL) and sales of CERs generated by the project. The costs and revenues of the projects as well as the numbers of CFLs that would be replaced under the project have been estimated in a very conservative manner for analyzing financial viability of the project.

Table-3 presents anticipated costs and revenues (without considering revenues from CERs) of the project for different years within the crediting period. It is evident from Table-3 that without income from sale of CERs, the project can not be viable as the Net Present Value (NPV) of the project even at a discount rate 0% is negative (1.37 Million Euros). But when we consider CER revenues assuming a CER price of 10 Euros/CER (in a very conservative approach, the CER price of 10 Euros/CER has been taken for estimating CER revenues as the CER prices varied between 11.50 to 18 Euros in the period prior to implementing the project), the NPV of the project becomes positive and the project fetches an Internal Rate of Return (IRR) of 22.66% (Table-4). Thus, the project can financially be viable and attractive only with CER revenues, the main source of revenue for any CDM project.

Further, we have performed sensitivity analysis to judge the financial viability of the project under unfavourable situations by decreasing revenues from CERs by 10% (as revenue from sale of CFL is prefixed) and also increasing costs by 10%. It is seen from Table-5 that when revenue from CERs is reduced by 10% for each year within the crediting period keeping all other figures unchanged, the project still yields an attractive IRR of 18.17%. Likewise, an IRR of 18.27% is generated by the project when the costs associated with the project are increased by 10%, keeping all other figures unaltered (Table-6). The project can also bring a healthy IRR of 14.25% even when both revenue is decreased and cost is increased by 10% i.e., under most unfavourable situation of increased cost and decreased revenue (Table-7).

Again, emission reductions achieved by a CDM project in a monitoring period (normally a year) are monitored and verified by an independent body ‘Designated Operational Entity’ (DOE) appointed by the CDM Executive Board. On the basis of the verification report submitted by the DOE to the CDM Executive Board, the Board issues CERs to the project. But, it has been experienced from other CDM projects in India and also from the first monitoring period of the present project that after actual emission reductions achieved by the project in a monitoring interval, considerable time of nearly a year is required to validate such reductions by DOE and subsequent issue of CERs by the CDM Executive Board. This means that the CERs revenues pertaining to a particular year within the crediting period are actually recognized and received in the next year resulting an upward bias in calculating NPV and IRR of the project. To consider the issue, IRR of the project has been recalculated assuming a time lag of one year between actual emission reductions by the project and subsequent verification and issue of CERs (Table-8). From Table-8 it is evident that the project deserves financial acceptability yielding an IRR of 16.38% even when the delay in receiving the CER revenues is considered.

Thus, the present energy efficient lighting CDM project is nothing but a business project undertaken by Osram India Pvt. Ltd. in the state of Andhra Pradesh. But, its uniqueness lies on the way by which it generates revenues to make the project commercially rewarding vis-à-vis contributes towards the environment and the society in general and conservation of electricity in particular.

It is worthwhile to mention here that till the end of the year 2011, 26,532 CERs have been issued by the CDM Executive Board to the project for the actual emission reductions achieved by the project during the first monitoring interval Feb. 2009 to Mar. 2010. Again, as per monitoring report, the project has achieved an emission reductions of 45,954 tCO_2 (meaning 45,954 CERs) during the second monitoring interval of Apr. 2010 to Aug. 2011, though that has to be verified by DOE. Thus, though the project could not able to achieve planned emission reductions during the first monitoring interval mainly due to unexpected early failure of the project CFLs, it successfully achieved the target in the next monitoring interval resulting achieving average annual emission reductions in line with what was anticipated in registered PDD.

Conclusion:

Fossil fuels such as coal, gas and oil are extensively used as the primary source of energy in India with more than 65% of the electricity generated in the country comes from burning of fossil fuels at present (2010-11). But, apart from depletion of precious and non-renewable natural resources, it leads to harmful emission of GHGs responsible for global warming. Moreover, in spite of increasing proportion of various non-conventional energy sources, there exists a continuing gap between demand and supply of energy in the country (the energy shortage and peak demand shortage were about 8.8% (55904 million unit) and 10.2% (12151 MW) respectively in the year 2010-11). With significant growth of population (1.34% p.a.), rapid urbanization (2.4% p.a.), very low per capita electricity consumption compared to other developed and emerging countries as well as global average (only 478 kWh compared to 12,365 kWh for USA, 6,788 kWh for Japan, 2572 kWh for China, 1,987 kWh for Brazil etc. and global average of around 2900 mWh), multidimensional developmental approach and rapid stride towards economic self-reliance, the country's appetite for energy is increasing substantially day by day while energy sources are becoming scarce and costlier than before. Thus besides augmenting power generation capacity, conservation of energy through efficient utilization of energy resources has emerged as one of the major issues in recent years. Apart from being environmentally benign, it is the quickest, cheapest and most practical way of bridging or at least narrowing the gap between requirement and availability of energy of the country in short term.

The 'Visakhapatnam (India) OSRAM CFL Distribution CDM Project', a landmark demand side energy efficiency project, by improving energy efficacy contributes toward saving electricity of the country which despite significant growth in generation over the years, has been suffering from considerable energy shortages and supply constraints, ensuring energy security to its population and trimming down CO_2 emission from fossil fuel-based power plant serving the grid. As per an estimate of Bureau of Energy Efficiency (BEE), India, if the present project could be replicated throughout the country with replacing only one incandescent bulb per household by CFL, then it would result in reduction of electricity demand by around 3000 MW (where peak demand shortage of electricity was 12151 MW in 2010-11) with a potential saving of INR

12,000 crores per annum and CO_2 emission by ten million tones from grid-connected power plants.

India, being a non-Annex-I country to the Kyoto Protocol having no emission reduction target at present, has emerged as one of the largest beneficiaries of CDM with a great potential and opportunities for business enterprises, government and investors. The government and private entities of our country can successfully capitalize the benefits and opportunities offered by the CDM in promoting economic growth and well-being of the nation in a sustainable manner vis-à-vis generating revenues through sale of carbon credits. The financial analysis of the present project demonstrates that the government and entrepreneurs from developing and least developed countries can utilize the benefits of CDM to combat challenges faced by global environment in an innovative and profitable way as well as promote social, economic and environmental sustainability in line with national sustainable mission of the country. In fact, CDM has given birth of an emerging and innovative business model through which an entity as a meritorious corporate citizen can discharge its responsibility towards the environment and society without jeopardizing its own financial sustainability. But, as the registration and operation of a CDM project involves a lot of technical and non-technical complexities with substantial investment risk, the government has to play a more proactive role in exploring and capitalizing the benefits of CDM to promote economic growth and well-being of the nation at large and capacity-building at both private and public sector levels, risk management and project financing through banks and financial institutions in particular.

Table- 2: Estimated emission reductions by the project in tones of CO_2e or estimated volume of CERs generated by the project over the crediting period of the project

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Avg.
CO_2e (in tons) /CFRVolume*	28,664	31,982	31,370	30,694	29,849	28,731	26,893	24,801	22,189	19,102	**274,275**	**27,428**

* *After deducting the fee levied by the CDM Executive Board for small scale project @ 2% of CERs generated by the project.*

Table- 3: Costs and Revenues of the project without CER revenues (in 1,000 €)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
CFL Cost [1]	1,351	0	0	0	0	0	0	0	0	0	1,351
Other Project Costs [2]	135	0	0	0	0	0	0	0	0	0	135
Total Cost (A)	1,486	0	0	0	0	0	0	0	0	0	1,486
CFL Sales	116	0	0	0	0	0	0	0	0	0	116
Total Revenue (B)	116	0	0	0	0	0	0	0	0	0	116
Net Revenue (B-A)	-1,370	0	0	0	0	0	0	0	0	0	-1,370

Note1: Fully absorbed cost including freight, duties, taxes etc.
Note2: Such as overhead, distribution cost etc.)

Table- 4: Costs and Revenues of the project at a CER price of 10 €/CER (in 1,000 €)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
CFL Cost	1351	0	0	0	0	0	0	0	0	0	**1351**
Other Project Costs	135	0	0	0	0	0	0	0	0	0	**135**
Total Cost (A)	1486	0	0	0	0	0	0	0	0	0	**1486**
CFL Sales	116	0	0	0	0	0	0	0	0	0	**116**
CER Revenue	287	320	314	307	298	287	269	248	222	191	**2743**
Total Revenue (B)	403	320	314	307	298	287	269	248	222	191	**2859**
Net Revenue (B-A)	-1083	320	314	307	298	287	269	248	222	191	**1373**
Internal rate of return (IRR) = 22.66%											

Table- 5: Costs and Revenues of the project at a CER price of 10 €/CER (in 1,000 €) reducing revenues from CER sale by 10%

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
CFL Cost	1351	0	0	0	0	0	0	0	0	0	**1351**
Other Project Costs	135	0	0	0	0	0	0	0	0	0	**135**
Total Cost (A)	1486	0	0	0	0	0	0	0	0	0	**1486**
CFL Sales	116	0	0	0	0	0	0	0	0	0	**116**
CER Revenue	258	288	283	276	268	258	242	223	200	172	**2468**
Total Revenue (B)	374	288	283	276	268	258	242	223	200	172	**2584**
Net Revenue (B-A)	-1112	288	283	276	268	258	242	223	200	172	**1098**
Internal rate of return (IRR) 18.17%											

Table- 6: Costs and Revenues of the project at a CER price of 10 €/CER (in 1,000 €) increasing cost by 10%

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
CFL Cost	1486	0	0	0	0	0	0	0	0	0	**1486**
Other Project Costs	149	0	0	0	0	0	0	0	0	0	**149**
Total Cost (A)	1635	0	0	0	0	0	0	0	0	0	**1635**
CFL Sales	116	0	0	0	0	0	0	0	0	0	**116**
CER Revenue	287	320	314	307	298	287	269	248	222	191	**2743**
Total Revenue (B)	403	320	314	307	298	287	269	248	222	191	**2859**
Net Revenue (B-A)	-1232	320	314	307	298	287	269	248	222	191	**1224**
Internal rate of return (IRR) 18.27%											

Table- 7: Costs and Revenues of the project at a CER price of 10 €/CER (in 1,000 €) reducing revenues from CER sale and increasing cost by 10%

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
CFL Cost	1486	0	0	0	0	0	0	0	0	0	**1486**
Other Project Costs	149	0	0	0	0	0	0	0	0	0	**149**
Total Cost (A)	1635	0	0	0	0	0	0	0	0	0	**1635**
CFL Sales	116	0	0	0	0	0	0	0	0	0	**116**
CER Revenue	258	288	283	276	268	258	242	223	200	172	**2468**
Total Revenue (B)	374	288	283	276	268	258	242	223	200	172	**2584**
Net Revenue (B-A)	-1261	288	283	276	268	258	242	223	200	172	**949**
Internal rate of return (IRR) 14.25%											

Table- 8: Costs and Revenues of the project at a CER price of 10 €/CER (in 1,000 €) and Internal Rate of Return (IRR) generated by the project considering the time gap between generation of CERs and subsequent issue of CERs

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
CFL Cost	1351	0	0	0	0	0	0	0	0	0	0	**1351**
Other Project Costs	135	0	0	0	0	0	0	0	0	0	0	**135**
Total Cost (A)	1486	0	0	0	0	0	0	0	0	0	0	**1486**
CFL Sales	116	0	0	0	0	0	0	0	0	0	0	**116**
CER Revenue	0	287	320	314	307	298	287	269	248	222	191	**2743**
Total Revenue (B)	116	287	320	314	307	298	287	269	248	222	191	**2859**
Net Revenue (B-A)	-1370	287	320	314	307	298	287	269	248	222	191	**1373**
Internal rate of return (IRR) 16.38%												

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