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Potential emission reductions from India's transport sector: a view from the green transportation projects under CDM

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Abstract

In most populated countries like India, the need for public and private transportation is much more essential as it one of the crucial sectors that helps in the economic growth. On the other hand, it is responsible for emitting greenhouse gases and causes serious air and noise pollutions. This is due to the lack of sustainable principles and activities in the transportation sector. Hence there is a need for sustainability in the transportation sector, and it is very much essential, and the strive for achieving it should be a continuous activity. In this paper, various green transportation projects (GTP) undertaken for reducing the emissions in India's transport sector were studied. A total of 9 projects were initiated under the clean development mechanism (CDM), contributing to the 760504.69 t CO_2 baseline emission reduction, and causing around 275799.2 t CO_2 project emissions. However, from these 9 GTP's 501952.7 t CO_2 emissions were reduced. Average values of baseline emission, project emission, and emission reduction from 9 GTP's were estimated to be around 84500.52 t CO_2, 30644.36 t CO_2, and 55772.52 t CO_2 respectively.

Keywords: India's transport sector; emission reductions; green transportation projects in India; CDM; electric vehicles for the transport sector

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1. Introduction

India is one of the fastest growing nations that has seen progress in various sectors, among them transportation sector is the one. To facilitate, the transport facilities to people, India had progressively invested in road transport, rail transport, airways, etc. As per the recent statistics, India accounts to be a second largest road transport network in the world [1]. Transport sector serves the nation with different services offering a wide range of benefits that would be responsible for the economic growth. On another side, they are most energy intensive and accountable for the release of greenhouse gas emission [2]. The transport sector is found to consume nearly half of the worlds fossil fuel energy contributing to the one-quarter of greenhouse gas emission [3–5]. However, energy consumption and greenhouse gas emission release would depend on the size of the transportation sector.

India's transport sector is the most complex one comprising various means of transport modes. These modes include the railways, roadways, airways, and waterways. Among these available modes, most used are railways and roads. In recent years India's transport sector has achieved substantial progress in many ways like providing convenient facilities to the public, adopting green project strategies, etc. However, the use of private transport facility primarily in the roadways is increasing day by day apart from the public transport facilities offered by the state or central governments. Due to increased utilization of private vehicles, the average productions levels increased to a total of 21500165.00 (passenger vehicles – 3087973.00, commercial vehicles – 699035.00, three-wheelers – 830108.00, and two-wheelers – 16883049.00) [6]. Due to this, air pollutions levels in India are increasing and accounting to have 13 most polluted cities in India among the top 20 list of most air polluted cities in the world. On the other side, India, being vast transport network including the private and public expected to account for the energy demand, and greenhouse gas emission increase by 5-fold from the 2000 levels by 2020 [5, 7]. At present, few cities are reaching to have a higher amount of particulate matter whose diameter could vary between 10 microns to 2.5 microns. Among all cities of India, Delhi the capital city of India is found to have the air pollutants who size is greater than 2.5 microns [6]. If the trend in energy consumption and emissions increases, that would cause more adverse effects. Hence there is a need for improving the energy efficiency and reducing the emissions in the transport sector. The Indian government had initiated many policies related to the adoption of sustainable practices in the transport sector, also had signed an agreement accepting the targets set by the United Nations Framework on Climate Change Conventions (UNFCCC). As a part of this agreement, India decided to reduce around 20 to 25 % of greenhouse gas emission by 2020 on 2005 levels [5, 8]. Until today, under the clean development mechanism, 9 projects were initiated in India's transportation sector focusing on the developments of new trends in transport including the electrical vehicles, mode shift transportation, clean fossil fuel based, etc. [9]. Whereas in the other sectors, the project initiation under CDM is quite high. This reveals that transportation sector should take this as responsibility in addressing the emission reductions and propose new trends like electric vehicles [10] by using the special benefits like reducing energy costs, proper planning of transport services [11] and polices in any manner.

Hence in this paper, a brief study on the various green transportation projects (GTP) undertaken for reducing the emissions in India's transport sector especially with the CDM registration status was studied and analyzed. Challenges that are responsible for the less progress on CDM projects in the transportation sector are explored.

2. Methodology

2.1. Emission reduction evaluation methods as per the CDM

Emission reduction potentials are evaluated as per the applicable methods for transport sector under the clean development mechanism of Kyoto Protocol. For the studied 9 GTP's the following methodologies shown in Table 1 were used. In each methodology shown in Table 1, baseline emissions, project emissions, leakage emissions, and emission reductions were quantified separately [12–15].

$$\textit{Emission Reduction} = (\textit{Baseline Emission} - \textit{Project Emission} - \textit{Leakage Emission}) \quad (1)$$

Emission reduction is referring to greenhouse gas emissions that are reduced due to the execution of any strategic emission reduction project. While executing such projects, one needs to consider the baseline emission, project emissions, and leakage emissions. The expression for evaluating the emission reduction is given in Eq. (1) which subtracts the project and leakage emissions from the baseline emissions [12–15].

Table 1. Methodologies for green transportation projects under clean development mechanism.

CDM methodology	Description
AMS-III.C.	Used for estimating the emission reductions by low greenhouse gas emitting vehicles
ACM0016	Used as a baseline methodology for mass rapid transit projects
AMS-III.C.	Used for estimating the emission reductions with the adoption of electric and hybrid vehicles in the transport sectorial scope
AMS-III.AQ	Can be applied to waste handling projects that could be used for transportation applications. Example: Bio-CNG in transportation applications
AMS-III.G.	Used for evaluating the emissions reduced from the landfill methane recovery in an application with transportation

$$\textit{Baseline Emission} = \textit{Energy} \cdot \textit{Emission Factor} \tag{2}$$

Baseline emissions represent the maximum possible emissions that are possible from the existing project that has not been under any strategies plans of emission reduction norms or schemes. In a simple language, we can define the baseline emissions as the possible greenhouse gas emissions before the execution of green projects. Mathematically it is represented using Eq. (2) as the product of energy produced from the baseline project executed before the introduction of emission reduction or the green projects and the baseline emission factor [12–15].

$$\textit{Project Emission} = \textit{Energy Consumed During Project execution and Operation} \cdot \textit{Emission Factor} \tag{3}$$

Project emissions represent the maximum possible emissions due to the self-consumption of energy after the execution of green strategy project. It is represented in Eq. (3) as the product of energy consumed during the project execution or while in operation to the emission factor [12–15].

Table 2. Green transportation projects under clean development mechanism in India [9].

Project title	Notation	Host country	Supporting country	CDM methodology
Installation of low greenhouse gas emitting rolling stock cars in metro systems	Project-I	India	Japan	AMS-III.C. ver.10
Mode shift from road to train for transportation of cars	Project-2	India		AMS-III.C. ver.11
Mumbai metro one, India	Project-3	India	Switzerland	ACM0016 ver.2
Eko electric vehicles, India	Project-4	India	Switzerland	AMS-III.C. ver.13
Hero electric vehicles, India	Project-5	India	Switzerland	AMS-III.C. ver.13
Electrotherm electric vehicles, India	Project-6	India	Switzerland	AMS-III.C. ver.13
Lohi auto industries electric vehicles, India	Project-7	India	Switzerland	AMS-III.C. ver.13
Mode shift of passengers from private vehicles to MRTS for Gurgaon metro	Project-8	India	Switzerland	ACM0016 ver.2
Landfill closure and gas capture CDM project by GAIL at Ghazipur, India	Project-9	India		AMS-III.AQ AMS-III.G. ver.8

2.2. Description of 9 Green Transportation Projects

A brief description of the 9 projects studied in this paper is given in this section. Overview of the project with the supporting country as well as the methodology adopted for quantifying the emissions are given in Table 2 [9]. Project-1 is about the development of regenerative braking technology for power generation in the Delhi Metro Rail Corporation (DMRC). Here, the proposed project introduces 70 rolling stocks (25 rolling stocks in Dilshad Garden-Rithala corridor lane, 14 rolling stocks in Badli-Jahangirpuri-Huda City Centre corridor lane, and 31 rolling stocks in Noida City Centre-Dwarka Sector 21-Najafgarh and Vaishali-Yamuna Bank). These rolling stocks were introduced with the regenerative braking technology that replaces the traditional rheostatic braking technology works on the electro-dynamo principle [9]. Project-2 is about the transport facility used for shipping the produced automobiles. Here, Maruti Suzuki India Ltd. Developed a project to transport their finished goods under the category of transport mode shift from conventional roadways that are more greenhouse gas intensive to railways from Manesar production plant to Mundra [9]. Project-3 is about the development of mass transport facility for the passengers by eliminating other means of private and individual transport facilities like cars, buses, taxis, etc. which could contribute to higher amounts of greenhouse gas emissions. This sought transport facility was developed by Mass Rapid Transit System (MRTS) Mumbai Metro One in India [9]. Project-4 is about introducing and establishing the productions of electric vehicles. Under this project, EKO vehicles private limited launched EKO Strike, EKO Cosmic, and EV60 two-wheeler models which run on battery and aimed to reduce greenhouse gases [9]. Project-5 is about the two-wheeler electric vehicle production by the Hero Eco-Tech. Ltd., India. Currently, this company developed seven models that run on battery and aimed to reduce greenhouse gas emission [9]. Project-6 also about the electric vehicle development by the Electrotherm India Ltd., currently it has developed eight models that run on battery [9]. Project-7 is also about the development of two-wheeler-based battery-operated vehicles under the brand name Fame and Oma developed by Lohia Auto Industries. This project includes the development of 197,000 units of electric vehicles by 2022 [9]. Project-8 is about the development of mass transport facility for the passengers by eliminating other means of private and individual transport facilities like cars, buses, taxis, etc. which could contribute to higher amounts of greenhouse gas emissions. This sought transport facility was developed by Mass Rapid Transit System (MRTS) Gurgaon Metro in India [9]. Project-9 is about the production of Bio-Compressed Natural Gas that can be used for transportation fuel. In this project, Bio-CNG is produced from the available and safely collected landfill gas at Ghazipur landfill site [9].

3. Results and discussion

This study aims at quantifying the reduced greenhouse gas emissions from the nine green transportation projects that are executed under CDM in India. This study undertook only the carbon dioxide emissions from the transport sector. From the study, it is understood that these nine projects were contributed to reducing a baseline emission of 760504.69 t CO_2 and to cause a project emission around 275799.20 t CO_2. However, from these 9 GTP's a total of 501952.70 t CO_2 emissions were reduced. Average values of baseline emission, project emission, and emission reduction from 9 GTP's were estimated to be around 84500.52 t CO_2, 30644.36 t CO_2, and 55772.52 t CO_2 respectively, and shown in Fig. 1, Fig. 2, and Fig. 3.

The methodology applied to each project is different, and they are clearly shown in Table 1, and Table 2. However, a general mathematical methodology represented using Eq. (1), Eq. (2), and Eq. (3) is used to quantify the emission reductions.

In Table 2, the projects undertaken in this study were shown, and each project is assigned a notation (Project-1, Project-2, …, Project-9). Most of the projects under study were used AMS, i.e., "Approved Methodology for Small-Scale CDM Project Activities" and rest ACM, i.e., "Approved Consolidated Methodology" is used [15]. Some projects registered under the transport sector of CDM in India were categorized as per the year of registration. It is understood that the first project was initiated under this green strategy of the transport sector in 2007, and the last project was registered in 2014. From the period 2007 to 2014, a total of nine projects were registered accounting as 1 GT project in 2007, 2 GT projects in 2011, 5 GT projects in 2012, and 1 GT project in 2014.

Baseline emissions evaluated for each project were shown in Fig. 1. Baseline emissions evaluated for the nine projects were observed as 128710.60 t CO_2 for Project-I, 25233.00 t CO_2 for Project-2, 263705.60 t CO_2 for

Project-3, 35354.00 t CO_2 for Project-4, 60047.30 t CO_2 for Project-5, 65941.90 t CO_2 for Project-6, 41459.00 t CO_2 for Project-7, 135467.14 t CO_2 for Project-8, and 10336.00 t CO_2 for Project-9. However, the average baseline emissions for the nine projects is accounted as 84500.52 t CO_2, and the sum of the baseline emissions for the nine projects is accounted as 760504.69 t CO_2.

Project emissions evaluated for the nine GTP's were shown in Fig. 2. These were observed as 81657.50 t CO_2 for Project-1, 2233.00 t CO_2 for Project-2, 68158.70 t CO_2 for Project-3, 13543.00 t CO_2 for Project-4, 25247 t CO_2 for Project-5, 32665.40 t CO_2 for Project-6, 15940.60 t CO_2 for Project-7, 29604.14 t CO_2 for Project-8, and 1000.00 CO_2 for Project-9. However, the average project emissions for the nine projects is accounted as 30644.36 t CO_2 as shown in Fig. 2 and the sum of the baseline emissions for the nine projects is accounted as 275799.20 t CO_2.

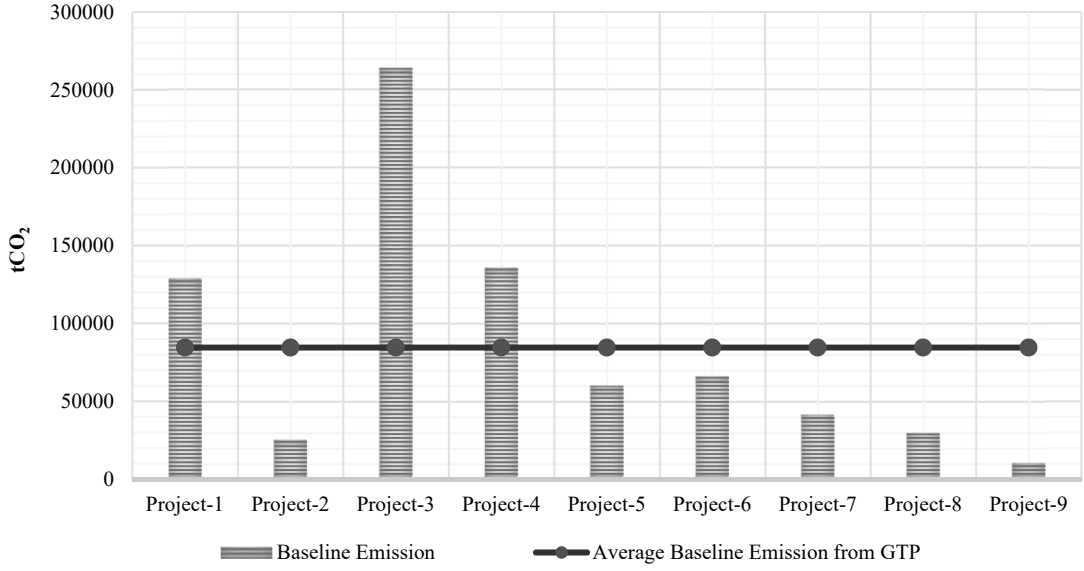

Fig. 1. Baseline emissions from the 9 GTP's in India.

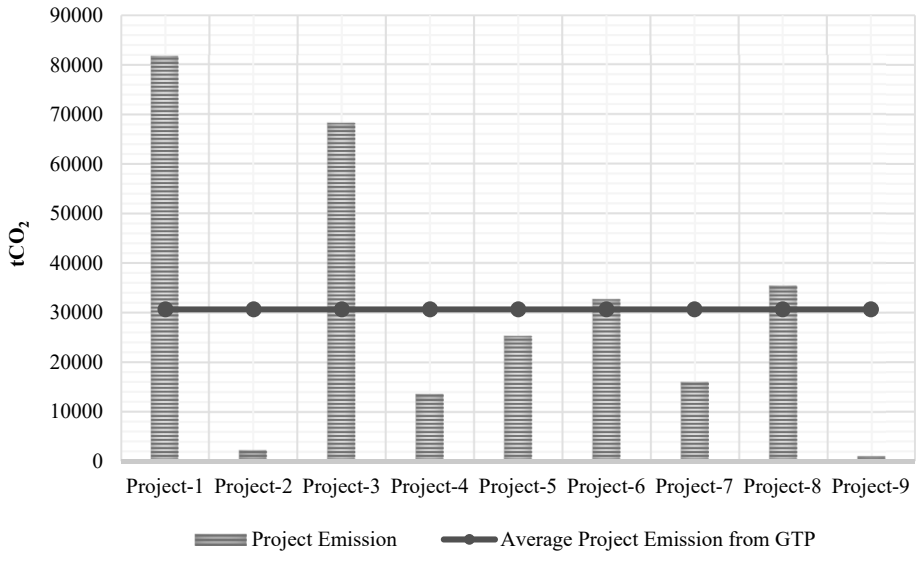

Fig. 2. Project emissions from the 9 GTP's in India.

Emission reductions were evaluated for the 9 GTP's, and corresponding emissions reductions for each project were shown in Fig. 3. The observed emission reductions are 47053.30 t CO_2 for Project-1, 23001.00 t CO_2 for Project-2, 195547.00 t CO_2 for Project-3, 21811.00 t CO_2 for Project-4, 37647.00 t CO_2 for Project-5, 36175.00 t CO_2 for Project-6, 25518.40 t CO_2 for Project-7, 105863.00 t CO_2 for Project-8, and 9337.00 t CO_2 for Project-9. The average emission reductions for the nine projects is accounted as 55772.52 t CO_2, and the sum of the total possible emission reductions with the adoption of these 9 GTP's is accounted as 501952.70 t CO_2.

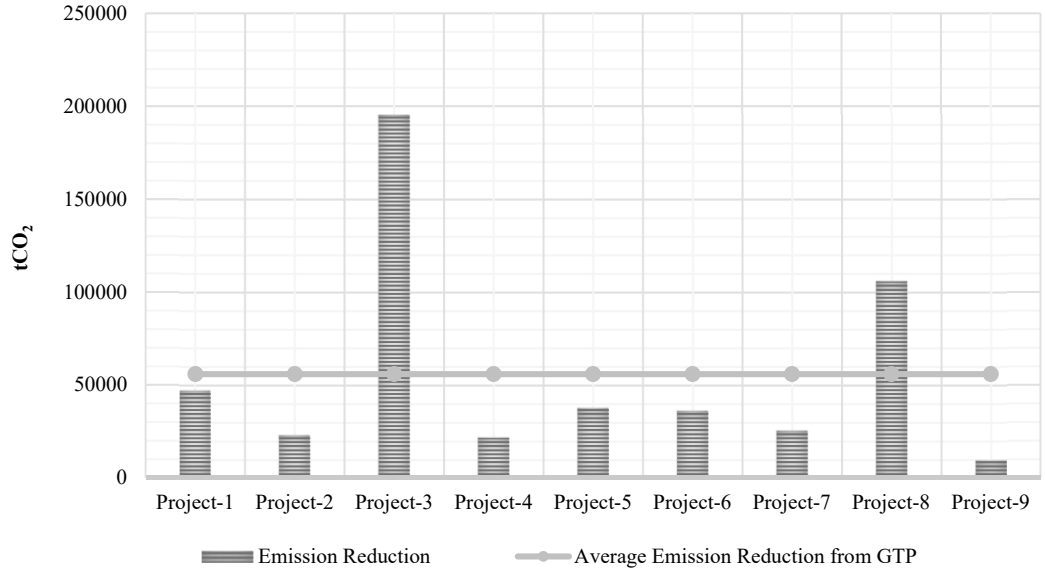

Fig. 3. Emissions reduction from the 9 GTP's in India.

4. Possible challenges for CDM projects in transport sector

Facing challenges is quite tedious to execute projects, however in any sector challenges are to be met. Here also, CDM projects face problems in the transport sector. This can be understood from the number of projects registered and executed under the CDM transport sector in India. Here authors try exploring the various possible challenges from the own perspective as well as from the literature base [16–18]:

- The first and foremost would be lack of sufficient information about the transport sector and the demographics of the nation;
- No control over the private vehicles and no strict rules against the emission release of vehicles as well the automobile manufacturers;
- Less awareness of the carbon trading and finance development option of transport sector;
- Private owned transport sector (individual), this creates less responsibility for the emission release concerns;
- Lack of techno-managerial skills related to the clean development options in the transport sector;
- Limited support from the government and collaborators;
- Transparency, less awareness of the carbon trading policies and price estimations;
- Lack of networking and skills between the workforce that deals such projects;

The possibility of increasing the carbon finance as well the clean development involvement in the transport sector can be increased by overcoming the above-mentioned challenges.

5. Conclusion

The present study shown in the paper examines the various projects undertaken in India's transport sector for improving the green strategy and thereby reducing the greenhouse gas emissions. This study highlights the nine projects registered under the transport sector of CDM in India. How these projects were contributed to emission reduction were also highlighted. From the conducted study it was understood that most of the projects are related to the electric vehicle development and mass transit facilities for the passengers. This study also revealed the potentials of such projects in reducing greenhouse gas emissions. On the other side, demand for these two is also increasing in many of the nations. Hence, more improvements can be made in such projects and can be registered under CDM for the financial benefits.

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