Estimation of CO2 Emission in Intercity Road Transportation Sector of I.R.IRAN and presenting emission reduction strategies

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**Abstract.** Climatic changes due to increased earth temperature are one of the most significant challenges in environmental engineering. The temperature increase is the result of increased density of greenhouse gases. I.R Iran country is the tenth producer of greenhouse gases. The energy sector of the country with %77 share of the total, is the biggest producer of greenhouse gases more than %23 (120 million tons per year) of which is due to transportation sector, which is a considerable figure. Also more than %92.6 of emitted CO\(_2\) in transportation sector has been from the road transportation side which in recent years has had an increasing trend. In this paper, after studying the emission of CO\(_2\) as a greenhouse gas in transportation sector, the contribution of intercity road transportation is estimated and some strategies for emission reduction and credit attraction through "Clean Development Mechanism" in that sector are proposed.

**Keywords:** CO2 emission, Intercity Transportation, CDM, Estimation, IRAN

1. Introduction

Climatic changes due to increased earth temperature are one of the most significant challenges in environmental engineering. The temperature increase is the result of increased density of greenhouse gases which, through absorption of too much external energy from the earth, distorts the energy balance between the sun and the earth globes.

Generally in the Kyoto protocol the responsibilities of the members are so designed that the total emission of greenhouse gases in developed countries, called the Annex I members, within the period of responsibility (2008-2012), will be %5 less than that of in 1990. [1].

The high consumption of energy in Iran due to its cheap price, inappropriate utilization and exploitation of energy consuming industries and utilization of old technologies has led to the situation that the energy sector of the country is the main source of greenhouse gas production. The energy sector of the country with %77 share of the total is the biggest producer of greenhouse gases.
As shown in fig. 1, %23.4 (120 million tons), is the share of transportation sector, which is a considerable figure.

The road transportation sector has allocated a higher proportion of emission of green house gases in a way that more than %92.6 of emitted CO₂ in transportation sector has been from the road transportation side which in recent years has had an increasing trend.

Based on the International Energy Organization report, I.R Iran country is the tenth producer of green house gases more than %75 of which is due to the high consumption of fuel- based energy. CO₂ emission of I.R Iran in 2009 was 7.02 ton per capita which is more than one third that of the U.S America and 1.5 times that of china.[6]

In this paper, after studying the emission of CO₂ as a green house gas in transportation sector, the contribution of intercity road transportation is estimated.

2. Methodology

2.1. Estimation of fuel consumption in intercity road transportation sector

Since the used methodology for estimation of fuel consumption (which will be discussed in the next paragraphs) has a direct relationship with the amount of travelling by navigation, therefore the amount of travelling for all types of navigation has been also studied. Calculations were accomplished according to 1998 statistical records and computation for determination of the average consumption of fuel has been in a way that the bus navigations were placed in groups of 5 years old, and for this group an estimation of the average fuel consumption per 100 km was carried out based on research works and relevant standards. Then the average total travelling of each of the bus groups, has been calculated according to 1998 statistical data. For calculation of the total travel navigations with different ages, the correction coefficient has been used in a way that for navigation with smaller age, higher travelling would be considered and also for older navigation which is actually used for short destinations, lower amount of travelling is considered. For example, for bus navigation, the average travelled destination by each bus is obtained.

It should be noted that while the obtained figure is the average travelled destination by each bus, but considering this amount for all the bus navigation groups of any age is not correctly estimated. Therefore the correction coefficients have been determined as table1:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Correction Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 years old</td>
<td>1.085</td>
</tr>
<tr>
<td>6-10 years old</td>
<td>1.065</td>
</tr>
<tr>
<td>11-15 years old</td>
<td>1.042</td>
</tr>
<tr>
<td>16-20 years old</td>
<td>0.9802</td>
</tr>
<tr>
<td>21 – 25 years old</td>
<td>0.8798</td>
</tr>
<tr>
<td>Older than 25 years</td>
<td>0.7811</td>
</tr>
</tbody>
</table>

For calculation of these coefficients, the statistical data taken from some of the travelling agents have been used. The obtained data for amount of annual travelling by buses of all age groups show that there is a reversed relationship between the age of the bus and the travelled destination.

Based on the data available in the field of average travelling [3] and the correction coefficient, the fuel consumption in bus navigation is obtained.

According to mentioned calculation, the annual fuel consumption by bus navigation (Road – passenger), is 1.052 million liters of gasoil. For minibuses and cars the same criteria has been used.

According to the same calculations, the total amount of 1,237 million liters of gasoil and 112 million liters of petrol has been consumed in road passenger transportation in 1998.

For studying the fuel consumption situation in road – transit sector, vehicles have been studied in 3 categories from their load capacity point of view. These categories include road – transit vehicles with less than 8 tons capacity, vehicles with 8-20 tons capacity and vehicles with more than 20 tons capacity. These categories have also been classified by their age groups. The age groups include transit road vehicles with
11 - 15 years old, transit – road vehicles with the age of 21 – 25 years old and finally vehicles more than 25 years old.

The work method is that, similar to road – passenger sector, first of all the total average traveled destination for this category is calculated according to available statistical data and then considering the age of the navigation, the proportion of each age group is calculated by obtained correction coefficients. The correction coefficients have been obtained on the basis of each group contribution in road – transit transportation and the contribution portion of each vehicle in each age group has been excerpted from the existent age groups. The contribution portion of each vehicle within each of the age groups shows that the younger navigations have larger portion and thus they should accordingly allocate larger percentage of the total traveled destination to themselves. Finally the total fuel consumption in intercity road transportation in 1998 is presented in table 2.

Table 2. Total fuel consumption in intercity road transportation in 2009 million liters

<table>
<thead>
<tr>
<th>Type of vehicle</th>
<th>Passenger travels</th>
<th>Transits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of fuel</td>
<td>Buses</td>
<td>Minibuses</td>
</tr>
<tr>
<td>Gasoil</td>
<td>1052</td>
<td>184</td>
</tr>
<tr>
<td>Petrol</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>Total</td>
<td>1236</td>
<td>112</td>
</tr>
</tbody>
</table>

For the next years the same methodology has been used and the fuel consumption in intercity road transportation (passenger & trans) has been estimated on the same basis [Diagrams 1 & 2].

According to Diagrams 1 & 2 the petrol and gasoil consumption in intercity road transportation within the studied period has had an increasing trend and has been **averagely** and accordingly 75 and 9173 million liters. It is mentioned that the proportion of intercity road transportation within the total consumption of these oil products in the country and within the studied period has been averagely and accordingly % 0.33 and %31.4. It is observed that the proportion of intercity road public transportation has a low contribution in petrol consumption and the highest amount of the consumed fuel is supplied by gasoil.

![Diagram 1](image1.png)

**Diagram1. Movement trends of gasoil consumption in intercity road transportation within the period 2001-2008**

The consumption trend has been increasing and has had an average growth rate of % 15.

![Diagram 2](image2.png)

**Diagram2. The movement trends of petrol consumption in intercity road transportation within the period 2001-2008**

It should be noted that since the registration of formal statistical data such as the number of navigation or the average travelling has encountered some changes after distribution of fuel sharing in the country. This factor is one reason for creation of skewed trend in the estimation diagrams.
2.2. Estimation of CO\textsubscript{2} emission as a green house gas, in intercity road transportation

Considering the diagrams 1 & 2, which are descriptive of the amount of consumed fuel in intercity road transportation and also according to the implemented studies [4 and 5], regarding the emission coefficient of pollutant and greenhouse gases of fossil fuels, it would be possible to calculate the emission of CO\textsubscript{2} due to intercity road transportation. 2.66 And 2.34 kg of CO\textsubscript{2} is emitted per consumption of one liter of gasoil and petrol. The mentioned amounts are just an average of the figures and coefficients of emission because the emission coefficient of CO\textsubscript{2}, per consumption of one liter fuel depends on the technological circumstances of consumption as well as production of energy carriers. Considering these coefficients and according to diagrams 1 & 2, the amount of CO\textsubscript{2} emission of intercity road transportation due to consumption of gasoil and petrol has been calculated. On this basis an annual average of 24 million tons of CO\textsubscript{2} is produced by intercity road transportation per consumption of gasoil. The growth rate for production of CO\textsubscript{2} due to consumption of petrol in intercity roads has been %20, but the amount of emitted CO\textsubscript{2} due to consumption of gasoil is much higher than that of petrol.

The trend for emission of CO\textsubscript{2} due to intercity road transportation has been shown in diagram3. This diagram shows that within the studied period, the CO\textsubscript{2} emission has had an ascendant trend.

![Diagram3. The movement trends of CO\textsubscript{2} emission in intercity road transportation within the period 2001-2008](image)

As shown in diagram4, the intercity road transportation allocates %26 of the total amount of CO\textsubscript{2} production in road transportation sector. This happens while averagely, %6 of CO\textsubscript{2} emission has been due to consumption of energy carriers in intercity road transportation.

![Diagram4. The movement trends of the share of CO\textsubscript{2} emission in intercity road transportation from the total emitted CO\textsubscript{2} in road transportation within the period 2001-2008](image)

3. Conclusions and recommendation

Based on the studies in the paper and the selected methodology for estimation of fuel consumption in long term, and following that estimation of CO\textsubscript{2} emission in intercity road transportation, which is a methodology using surveys and recorded statistical data, it should be claimed that while the society tries to establish a sustainable environmental future, the transportation sector does not show serious challenges towards contribution in improvement of environmental conditions. This is the only sector whose activities regarding the emission of greenhouse gases have had a growing trend since 1990, and the current transportation patterns are clearly unsustainable. In a way that %26 of CO\textsubscript{2} emission has been averagely contributed by intercity road transportation which counts for 30 million tons of CO\textsubscript{2} production per year. With the assumption of %5 reduction of emission in this sector and allocation of commercial price equal to
$20.00 / ton, more than $30 million credit is attracted through Clean Development mechanism for 5% reduction of emission in this sector.

Based on UNFCCC report, the total amount of capital attraction by the non Annex I countries in the field of CDM, is more than $5.0 billion, whereof China with 56%, India with 15%, South Korea with 11% and Brazil with 8.5% have allocated the maximum capital attractions. [7]

Therefore the total Kyoto Protocol may be utilized as an opportunity for modification of transportation policies. The Clean Development Mechanism may also be used for reduction of greenhouse gases.

In fig. 2 some strategies for reduction of greenhouse emission in transportation sector is represented.

4. Acknowledgements

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5. References

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