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Full Paper

A LIFE CYCLE ASSESSMENT APPROACH FOR EXAMINING THE FEASIBILITY OF TRANSPORT PROJECTS AS A CDM PROGRAM

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Abstract

This study suggests a methodology to apply Life Cycle Assessment (LCA) as a tool to register transport projects as Clean Development Mechanism (CDM) projects, which reqire reduction of Green House Gases (GHGs) emission. The application of LCA approach introduces one of its methodologies, which can evaluate the whole changes of GHGs emission during the proect's lifetime. However, the lifetime of transport infrastructure is much longer than the credit period determined by Kyoto Protocol. This is a negative rule for validating transport projects as CDM ones. In this study, instead of estimating GHGs emission during only credit period, allocation of lifetime GHGs change by a transport project beyond credit period is proposed for varidation. A suburban railway project in Japan is used as a case study. Certified Emission Reduction (CER) estimated by each method indicates necessity of introducing lifetime estimation. And also, it is proved that the case study could not gain enough CER if compared with energy projects.

KEYWORDS: *climate change, clean development mechamism (CDM), transport project, life cycle assessment (LCA)*

1. Introduction

When Kyoto Protocol was adopted at the third session of the Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, quantitative goals to reduce Green House Gases (GHGs) emission including carbon dioxide (CO_2) were set among the countries listed in its Annex I documents. For Japan, a reduction of 6 % during the period 2008 through 2012 from the level in 1990 was imposed. However, it is not easy to achieve this goal. According to the statement of the Central Council on Environment in April 2004, it was forecasted that GHGs emission would have increased by approximately 4% in 2010 in case there are no technological or social innovation.

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Meanwhile, Kyoto Protocol also introduces a remarkable international system called "Kyoto Mechanism" including Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading (ET). This economic mechanism flexibly works to achieve emission reduction goals. For example, CDM enables Annex I countries to obtain an amount of GHGs reducing through some projects in the non-Annex I countries as reduction credit called "Certified Emission Reduction (CER)". Thus, Annex I countries can earn credits for domestic GHGs emission. The effects of GHGs reduction is site-independent, and CDM can achieve more cost-efficient GHG reduction as well as promotion of innovative projects in developing countries.

The detailed rules and procedures of the Kyoto Mechanism are still under discussion at international panels. The rough framework of the Mechanism was agreed in the COP7 as "Marrakech Accord" in 2001. Now, CDM Executive Board (EB) of UNFCCC collects the proposals of CDM projects. Simultaneously, the interest in the application of CDM to transport sector keeps increasing year by year. Also in Japan, a workshop about the application of CDM in transport sectors was firstly held in March 2003 by the Ministry of Land, Infrastructure and Transport. Projects of the transport sector have received a large portion of the support especially the ones which have been offered for developing countries. However, there are few transport projects that have been proposed as CDM. On June 2004, the only project proposed to CDM EB from transport sectors is "TransMilenio" (Trans Urban Mass Transportation System) in Bogota, Colombia. One of the main reasons why CDM proposals in transport sector are difficult is because the methodology to measure the reduction of GHGs emissions for implementation of such a project has not been established yet.

This study aims to suggest the Life Cycle Assessment (LCA) technique as a tool for estimating GHGs reduction due to transport projects. Moreover, focusing on the suburban railway projects that are now under construction in Japan, for CER estimation it is assumed that the similar projects will be introduced in a developing country. Finally, the feasibility of CDM for transport projects is examined.

2. The procedures and the problems associated with CDM in the transport sector

The procedure agreed in "Marrakech Accord" is outlined in Figure 1. At first, Project Participants (PP) must make a plan. Then, the Designated Operational Entities (DOE) validate to see whether the methodology of the project meets the requirements as a CDM project or not. If all the requirements are satisfied, CDM EB registers the validated project. When the PP implements the project, its emission reduction is monitored and verified. After that, the actual amount of GHG reduction is certified by DOE. Finally, EB certifies and issues CER credits for the reduction.

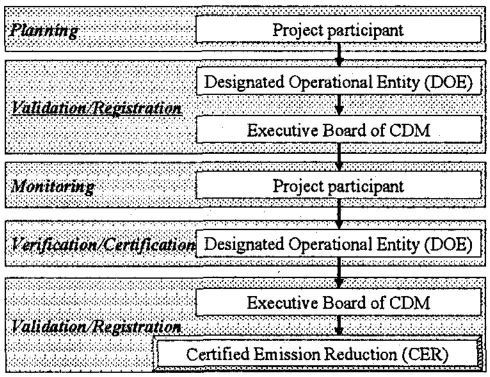


Figure 1 The procedure of CDM

Table 1 shows the requirements for the

registration of a CDM project. However, there are some problems especially in the validation and registration phases. In Table 1, item iv), v) and vi) are called "Technical Issues", which are main obstacles especially in validating transport projects. The associated reasons are summarized as follows:

a) It is difficult to identify rationally system boundary, because the spatial range of influence by infrastructure is wide.
b) It is hard to monitor GHGs emission throughout the wide system boundary.
c) It is difficult to set the baseline and to estimate its GHGs emission.

Table 1 Requirements to be registered as a CDM project

i) Eligibility	: Must contribute to the sustainable development in the developing countries
ii) Emission additionality	: Must gain GHG emission reduction above the current level
iii) Financial additionality	: Must not divert from existing funds to projects
iv) Baseline	: Must validate the emission baseline
v) Monitoring	: Must monitor GHG emission change through projects accurately
vi) System boundary	: Must set a system boundary dynamically and spatially
vii) Risk	: Must grasp expected risks

▒ Technical issues

3. Applying LCA and determining estimated period

3.1 Concept of ELCEL as a methodology to estimate GHGs emission reduction

To tackle the technical issues in previous chapters, this study applies the concept of ELCEL (Extended Life Cycle Environmental Load) as a methodology for estimating GHGs emission

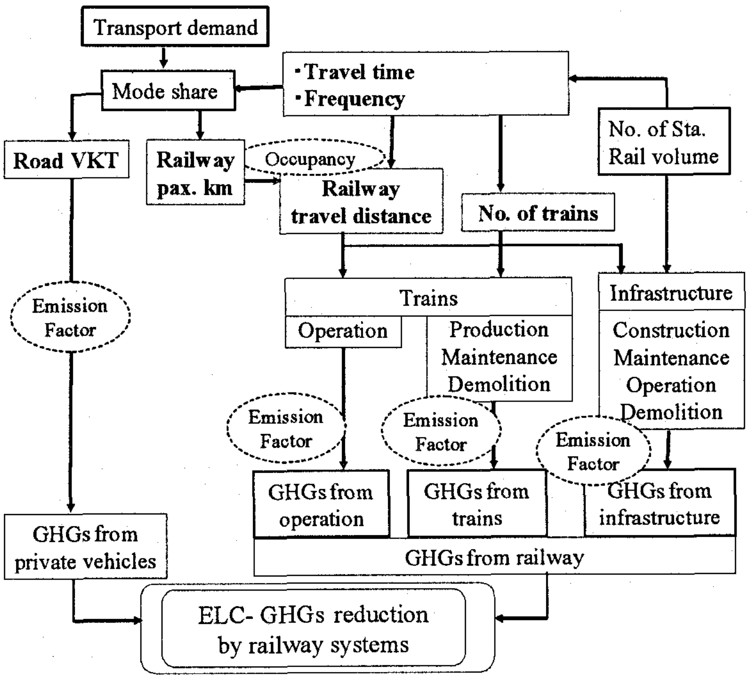


Figure 2 A procedure calculating ELC-GHGs by railway systems

reduction (Kato et al., 2000).

The general procedure of LCA, as standardized by ISO14040, can be used to estimate environmental impacts of products quantitatively from the extraction of their materials to the final demolition. It can be also used to measure the lifetime emission of GHGs. However, in the case of infrastructure, it is hard to consider its spillover effects. Here are some examples such like, shift from private cars to railways, calming of traffic congestion, induced transport demand, and so on. ELCEL concept can be used to estimate the impacts of infrastructure including such spillover effects. This concept enables LCA to apply environmental assessment for transport infrastructure.

Figure 2 illustrates the model system for estimating ELC-GHGs (Extended Life Cycle GHGs) through railway construction (Kato et al., 2001). Total transport demand in study area, the share of each mode, and the data of infrastructure design together with the amount of neccesary materials are input variables. Lifetime GHGs emission from trains and railway infrastructure are endogenously calculated by the model. And also, the GHGs reduction that comes from reduced usage of private cars and from other railways that serve the same travel route is estimated. Finally, ELC-GHGs are estimated by summing up these factors through the lifetime of the railway.

3.2 The ELCEL estimation period considering the CER available period

The Kyoto Protocol defined the first commitment period for reducing the GHGs emission during the period from 2008 to 2012. The reduction credit gained by GHGs reduction in non-Annex I countries from 2000 to first commitment period, can be added into the amount of domestic emission reduction as CER.

However, this period is much shorter than the usual infrastructure lifetimes. Since effects of

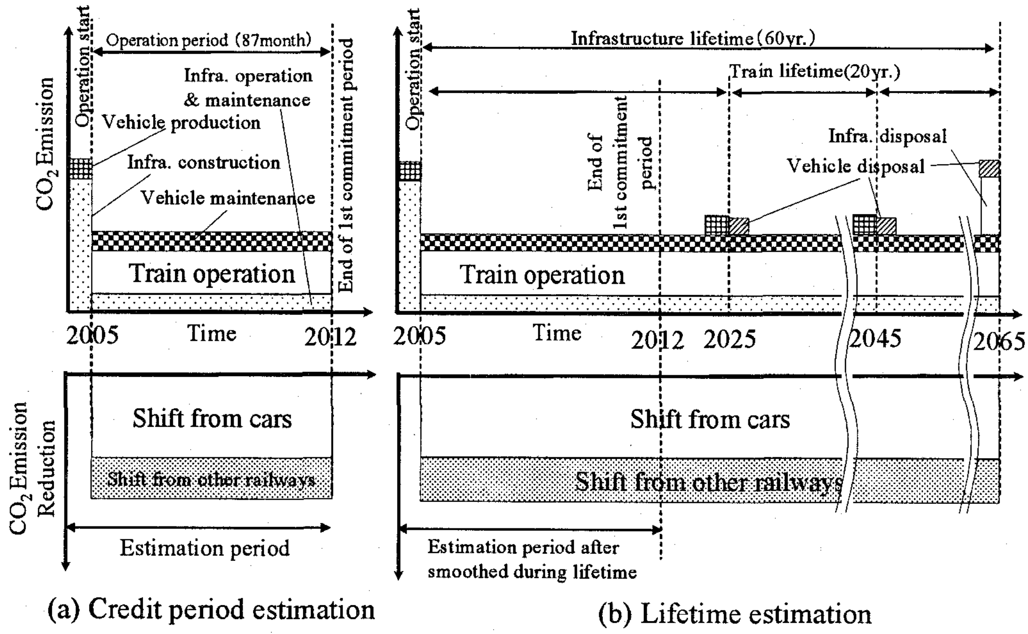


Figure 3 Two concepts to estimate CER

infrastructure supply are generated for a longer time, this shorter period is not enough to evaluate the effects. Therefore, this study proposes following two concepts to estimate CER: (a) Credit period estimation and (b) Lifetime estimation. Figure 3 shows the concepts.

(a) Credit period estimation: calculating the CO_2 emission only until 2012. The CO_2 emission from maintenance and demolition of both infrastructure and trains after 2012 is not considered.

(b) Lifetime estimation: calculating the CO_2 emission through the total lifetime of transport infrastructure and allocate it for the period since construction to 2012. Emissions of the maintenance and disposal of both infrastructure and trains after 2012 should be estimated. Emission from construction is assigned through total lifetime.

For method (a), transport infrastructure usually has larger environmental impact in the construction stage, and there is more underestimated emission reduction. For method (b), it is possible to estimate long-term influence by introducing the proposed project. However, to estimate CO_2 emissions after the first commitment period may have more uncertainty for future forecast and may lower the reliability of the estimated results.

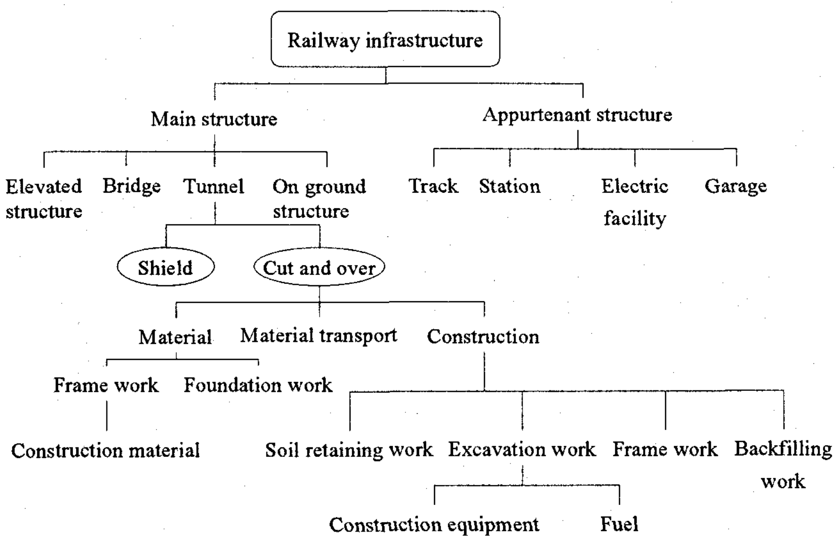


Figure 4 Disaggregation and standardization of railway into elements

3.3 Standardization of the infrastructure element

The case of applying LCA may often occur before the stage of detailed infrastructure design. Hence, it must be presupposed that not all the detail specifications and procedures may be available. To solve this problem, the railway system is divided into many respective parts shown in Figure 4. Then LCI (Life Cycle Inventory) analysis of each respective part is conducted. By aggregating all the parts, the life cycle environmental load of entire system is calculated. Thus LCI analysis of each respective part of railway system would have already been finalized by Japan Railway Construction Public Corporation. This result is compiled in the form of the CO_2 emission per unit length of elements (Shibahara et al., 2003). In this study, such emission factors are used for the estimation. And, only CO_2 emission of all GHGs is estimated.

4. A case study

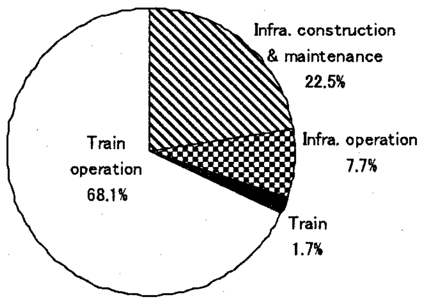
4.1 Outline of the aimed project

As a case study for examining the applicability of a new transport infrastructure construction project as CDM, a railway project in developing countries should be focused on. However, the required data of such projects are not available; so that the authors alternatively examined the case of a suburban railway project in Japan. The railway will connect the suburb to the center of a metropolis. It will be opened in October 2005 and the length is approximately 58 kilometers.

4.2 Some assumptions for estimation

By using transport demand analysis, the number of daily passengers are estimated as 327,000 persons/day. Daily passenger kilometers of the railways and private vehicles in the considered metropolitan area with/without construction of the proposed railway is given in Table 2. The number of passengers with construction is less than that without construction. The reason is that the current alternative line runs a longer distance route than the new line does. The shift from private vehicle and from other railways is set at the present values assuming that the socio-economic background will not changed in the future. The passenger kilometers are assumed to be keeping at the same level in the future. Likewise, technology levels including fuel efficiency, electric power generation are also assumed to be at the same level throughout the whole lifetime of the infrastructure.

1.11 million t-C/60yr.



Lifetime: Infrastructure 60 years
Trains 20 years

Figure 5 Estimated LC-CO_2 of proposed railway

4.3 Estimated Results of LC-CO_2

Life cycle CO_2 of the proposed railway system is calculated to be approximately 1.11 million t-C in 60 years. The emission in each life stage is shown in Figure 5. Train operation stage (electricity consumption for train moving) is the most major factor that constituting the 68.1% of the total.

Table 2 Prediction of total passenger kms of private vehicles and railways in the metropolitan area with/without construction of proposed railway

[thousand pax. km / day]	Private cars	Railway
With railway	333,704	748,600
Without railway	334,682	749,206

Construction and maintenance stages are the second largest one with the 22.5%. This result indicates that additional consideration of the infrastructure part is essential for the comparison with other transport infrastructures.

Based on the data in Table 2, the change of ELC-CO_2 with the new railway is estimated in Figure 6. The total emission reduction is 11.7kt-C per year.

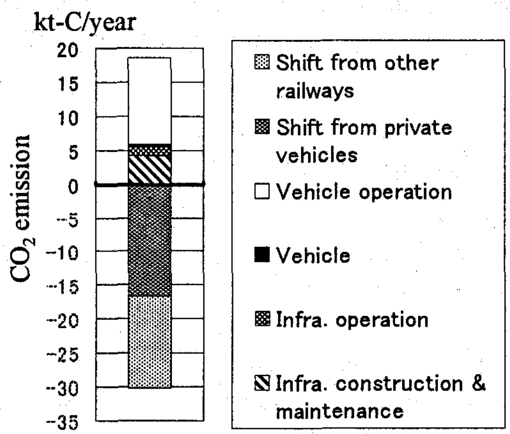


Figure 6 ELC-CO_2 change by proposed railway

4.4 Calculation of CERs and its return

In this case study, it is assumed that CO_2 emission from construction of the railway is generated from January 2000 to October 2005 (the beginning of operation). CO_2 emission from operation is estimated from October 2005 to the end of 2012 (87 months). The estimated result of the CO_2 reduction according to the 2 methods described in section 3.2 is shown in Figure 7. By (a) Credit period estimation, infrastructure construction stage is larger than operation stage because operation period is shorter. As a result, CO_2 emission increases by 68kt-C, and no CER can be gained. On the contrary, by (b) Lifetime estimation, 154kt-C of emission reduction can be expected.

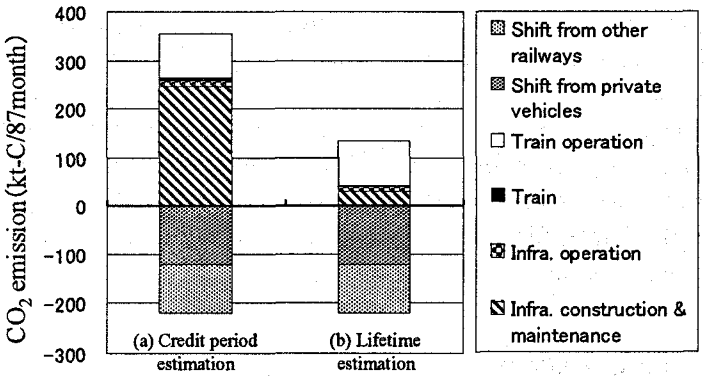


Figure 7 CO_2 emission change converted to CER

To convert CERs to the monetary term of profit, the tentative price of carbon trading in the UK, i.e. 14.7US\$/t-C, is adopted. By (b) Lifetime estimation, approximately 1.24 million US\$ worth of emission credit can be gained.

Initial cost of targeted project is approximately 7.84 billion US\$. CER-RR (CER Rate of Return, which is defined by the ratio of CER return and initial cost) is about 0.0159%.

As a comparison, for a CDM project in energy sector, or a power station using recyclable energy with a capacity of 140GWh per annum can be used, it is reported that its CER-RR amounts to about 10%. This shows that the case study railway project, it is far less feasible than an energy field project for a CDM project. To make matters worse, the return from the CER may be offset by the transaction costs at each stage in Table 1. That is one of the main reasons why transport sectors draw little attention for potential CDM projects. However in the case of developing countries, CER-RR in some projects can be much higher because the initial cost of railway infrastructure is usually much lower than that of Japan. Also, because the energy efficiency of transport would be expected to improve further.

5. Other problems

Validation of transport projects holds other problems which can not be solved by only the former methodology. Among the technical issues shown in Table 1, the methods of setting the baseline and monitoring GHGs, which will be introduced by the proposed transport project is specifically examined here.

Firstly, for setting the baseline, it is necessary to estimate the GHGs emission attributable to the transport activities in relevant regional areas without the transport project. For this purpose, transport demand analysis or traffic simulation is necessary.

Secondly, in order to monitor GHGs emission after the implementation of the project, the usage of each transport mode within the system boundary needs to be measured. Actually, it is possible to estimate the GHGs emission by using the person trip survey or the sectional traffic volume survey. This way is, however, not practical due to the huge cost of the mentioned surveys. Thus, the utilization of existing basic data and the coordination with other survey projects for transport planning will be issues in the future. And also, fundamental statistical data by national or local government, such like the number of railway passenger and gasoline sales, will be useful for continuous monitoring. ITS technologies like probe vehicles will make monitoring easier and cheaper in the future. Similarly, progression of monitoring technologies are promoting CDM projects in transport sector.

6. Conclusions

This study proposed a methodology to register transport projects as CDM projects by introducing LCA concept to solve the technical issues regarding the requirements. And, instead of estimation during credit period which is in general for validation of CDM, allocation of CO_2 change by a transport project to credit period was proposed. The estimations in a considered case study shows that the results of credit period estimation cannot achieve enough CO_2 emission reduction. Therefore, project participants under the method of the credit period estimation are not able to get CER from the CO_2 emission reduction without considering the whole lifetime of infrastructure after the first commitment period. Thus it is recognized necessary for applying the method which calculates the whole CO_2 emission during the lifetime of transport infrastructure. To encourage CDM projects in transport sector, this concept should be introduced to more detailed CDM procedure. It is easy to guess that, however, this method causes uncertainty by estimating CO_2 emission after the first commitment period, and some additional method should be developed.

A Japanese railway project is taken as a case study and it is proved that the CER obtained from the implementation of the project can not reach an economically viable level. In the future, in order to evaluate the feasibility of transport improvement as CDM projects, further case studies especially in developing countries need to be examined.

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