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OECD ENVIRONMENT DIRECTORATE
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INTERNATIONAL ENERGY AGENCY

AN INITIAL VIEW ON METHODOLOGIES FOR EMISSION BASELINES: TRANSPORT CASE STUDY

INFORMATION PAPER

FOREWORD

This document was prepared by the OECD and IEA Secretariats in October 2001 at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change. The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations", if appropriate.

This case study is part of a larger analytical project undertaken by the Annex I Experts Group to evaluate emission baselines issues for project-based mechanisms in a variety of sectors. Additional work will seek to address further the issues raised in this and other case studies.

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Executive Summary

The Kyoto Protocol created two mechanisms through which greenhouse gas emission reductions from specific projects around the world could earn credits: Joint Implementation (JI) and the Clean Development Mechanism (CDM). In order to ascertain the tons of greenhouse gas emissions that a project avoids, reduces or sequesters, it is necessary to have a baseline that estimates what the emissions would have been in the absence of the project. Baseline development for potential projects to reduce emissions from stationary sources has been and continues to be examined by a number of organisations, including the IEA. There is little other published work on the topic of mobile source baselines for CDM and JI projects. This report is a first attempt to explore the issues surrounding estimation of greenhouse gas emission baselines for potential JI and CDM projects in the transport sector. As such, the scope of this report is kept broad, leaving the field open for future research and discussion.

Over the past three decades, carbon dioxide emissions from transport have risen faster than those from other sectors. The share of worldwide carbon dioxide emissions that come from the transport sector has grown from 19.3% in 1971 to 22.7% in 1997 (IEA 2000b). Projections of future transport emissions are not encouraging. Under the reference scenario in the World Energy Outlook, emissions of carbon dioxide from transport are projected to grow at an average rate of 2.4% each year for the next twenty years. This growth rate is faster than that of any other end-use sector (IEA 2000c). Reasons for this include the close connections between the transport sector and practically every other part of the global economy, the fact that transport policy is focussed on other problems (i.e. traffic congestion), and the lack of well-developed options for alternative fuel use in the sector. In developing countries and economies in transition, future growth of carbon dioxide emissions from transport is expected to be substantially stronger than the worldwide average (IEA 2000c), making the need for action in these regions even more urgent. The project-based mechanisms in the Kyoto Protocol offer one avenue for this action.

A transport CDM or JI project is a specific action taken with the purpose of reducing greenhouse gas emissions in the transport sector. There are five basic ways that greenhouse gas emissions from the sector can be reduced: vehicle efficiency improvement, fuel switching, mode switching, travel and freight movement reduction, and improvement in capacity utilisation. Action in any of these areas could qualify as a CDM or JI project, but difficulties in quantifying the emissions reduced, particularly for some types of projects, are sizeable.

A baseline is an estimated projection of the greenhouse gas emissions that *would have occurred* if a project were not implemented. To calculate the credits that a CDM or JI project earns, post-project emissions are subtracted from this baseline. A baseline need not be tied to a specific project. Instead, a standardised, or "multi-project" baseline could be established for a subsector of transport in a particular location. Once a baseline exists, any project or set of projects to reduce greenhouse gas emissions in that subsector can use the baseline. In fact, the baseline development process may serve as a tool to help assess which project or projects would be most cost effective to implement in a given situation.

Unfortunately, there are a number of obstacles to accurate baseline development. These include:

- difficulty and expense of data collection due to the dispersed nature of mobile sources;

- institutional incapability to handle either baseline development or project implementation (or both);

- high uncertainty of emissions forecasts; and

- the incentive in the CDM that all project participants have to inflate the baseline.

Some of these obstacles are specific to the transport sector, while others also apply to developing baselines for JI/CDM projects in other sectors.

These obstacles lead some observers to conclude that transport sector projects should be excluded from project-based mechanisms. However, given the projections for extremely high growth in transport-related greenhouse gas emissions, it seems particularly important to use whatever incentives might be available to promote potential emission reduction efforts – and for such programs to start sooner rather than later. Furthermore, overcoming these obstacles, while difficult, does not necessarily present an insurmountable problem. Many can be addressed – either eliminated or reduced – through the creation of standardised baseline methodologies and data collection techniques. Of course, as with CDM projects in any sector, there may still be occasions when specific projects in the transport sector do not meet established criteria, and thus are not feasible.

The main purpose of this report is to identify opportunities to standardise baselines in the transport sector. The discussion here clearly focuses on ways that this can be done within the current framework of the Kyoto Protocol. However, the baseline work done for this report is not specific to this framework and could be used whenever there is a need for projections of greenhouse gas emissions from the transport sector.

Baseline standardisation is important for two reasons. First, standardisation of baselines can streamline the baseline development process, reducing the often-significant cost of creating the baseline. Second, standardised baselines are relatively transparent, making it more difficult for project participants to "game" the system to earn undeserved credits (Ellis and Bosi 1999).

This report outlines two types of baselines that could be used for transport CDM and JI projects: subsector baselines and regional baselines. Subsector technical baselines are estimated using base year emissions data along with projections of future emissions based on technological parameters of the relevant part of the transport sector. This type of baseline is expected to be used most for fuel efficiency and fuel switching projects. Subsector historical baselines are estimated by continuing existing emissions and other relevant trends forward. These baselines may be used for any project that mainly touches only one subsector of transport.

Regional baselines are most appropriate when a project is expected to generate significant secondary effects in many transport subsectors or if a project is implemented as part of a package of policies and investments to reduce greenhouse gas emissions from the transport sector in a region. The advantage of regional baselines is that they take the entire local transport sector into account, reducing concern about secondary emissions effects of projects. Their disadvantage is that, since they are so broad, it may be difficult to say with certainty whether a project reduced emissions from a regional baseline. As such, it is expected that only very large projects will be able to use regional baselines for credit calculation.

From a practical point of view, high uncertainty both in baseline determination (given the inherent hypothetical nature of baselines) and in projections of the emission reduction impact of a project is likely to be the largest obstacle to CDM and JI project implementation in the transport sector. To date, while many initiatives to reduce the greenhouse gas impact of the transport sector have been put into place, few studies have had accurate baseline data or have kept sufficient track of sector changes to monitor the specific effects of projects, and few transport-sector AIJ projects are underway. With additional work on transport baselines, these shortcomings could be remedied, and a greater level of certainty attached to the mitigation effect of specific project-based activities.

Future CDM-related work in the transport sector should focus on two simultaneous efforts. The first is to begin investing in projects that have potential near term benefits (i.e. alternative technology fleet projects and policy actions to promote mass transit) while implementing programs to collect and maintain accurate records. The second is to continue research in this area using the experience of implemented projects so that future project participants will have the information they need to make good decisions about moving toward a sustainable transportation future.

1. Introduction

This paper extends to the transport sector previous IEA and OECD work on greenhouse gas emissions baselines for project-based mechanisms under the Kyoto Protocol. Article 6 of the Protocol provides for the project-based mechanism that operates between Annex I Parties, Joint Implementation. Article 12 of the Protocol defines the Clean Development Mechanism (CDM), a project-based mechanism that includes Non-Annex I Parties. Under both these mechanisms, a Party can invest in a project to reduce emissions of greenhouse gases that are "additional" to any that would occur in the absence of the project activity (UNFCCC, 1997) and receive greenhouse gas emissions reduction credits for doing so.

A baseline is a projection of the greenhouse gas emissions that "would occur in the absence of the project activity". It is important to emphasise that a baseline is a *projection* and *never* corresponds to measurable actual emissions after a project is underway. Once a project is implemented, the system has changed and the actual emissions will differ from the baseline. The amount by which actual emissions differ from the baseline determines the number of Certified Emissions Reduction (CERs) credits or Emission Reduction Units (ERUs) that are earned by the project.[1]

Transport is an understudied sector as far as CDM and JI are concerned. A number of studies have been written about baseline development for emission reduction projects in stationary sources. However, little published work covers the topic of baseline development for the transport sector for the use of CDM and JI projects. This report does not attempt to answer all of the questions associated with this complex topic, nor does it attempt to provide a recipe for creating greenhouse gas emission baselines for the transport sector. The focus of this report is the potential for standardisation of baselines to be used for CDM and JI projects within the transport sector.

There are two main reasons why standardised baselines, or "multi-project" baselines, for JI and CDM projects are attractive. The first is that they reduce the "transactions costs" for project participants of developing a project-specific baseline (Ellis and Bosi 1999). If data are not readily available, it can be extremely expensive to gather the necessary data to determine a baseline for a project. For very large-scale projects expected to produce huge emission reductions, this expense may be justified. However, it is expected that at least at first, the majority of CDM and JI projects will likely be on a smaller scale. For these projects, it will be prohibitively expensive to draw up project-specific baselines using the most precise data available due to the "transaction cost" of baseline development. One way to ameliorate this problem is to standardise baselines, parts of baselines, and/or baseline development methodologies in an attempt to drive costs downward.

The second reason that standardised baselines are desirable is that they make it difficult for players to "game" the system and artificially inflate baselines (Michaelowa 1998, and Ellis and Bosi 1999). This is a potentially significant problem in CDM transactions because both the Annex I party and the host country benefit when the number of credits generated from the project rises. Any baseline calculation has an inherently high level of uncertainty due both to measurement error and forecasting uncertainty. Thus, when baselines are calculated on a project-by-project basis, there are many opportunities for baseline creators to use estimates that are at the high end of the projected emissions scale to make inflated baselines that still appear reasonable. Standardised baseline development protocols will make this much more difficult to pull off and will lead to less biased estimates of emission baselines.

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[1] CER and ERU are the terms used for credits earned through CDM and JI project activities, respectively.

Standardised baseline methodologies may not yield the most precise possible baselines for all projects. The reason for this is that due to the specifics of data availability or other specifics of a certain situation, the standardised methodology may not be the best one to use. However, it is likely that for most projects, the time and money saved by the project participants in avoiding the cost of developing their own methodology and the increased transparency that comes with using a standardised methodology will outweigh the downsides.

The structure of this report is as follows. Section 2 describes the transport sector in some detail and identifies the places where the project-based mechanisms could be used within the sector. Section 3 discusses the difficulties that may be encountered in creating baselines for the transport sector, lays out a generalised baseline creation methodology, and finally describes two types of baselines to be used for transport sector projects. Section 4 presents detailed descriptions of three specific hypothetical baselines. Section 5 outlines conclusions and suggests productive directions for continuing work in this area.

2. Transport projects

In 1999, the last year for which data are available, the transport sector was the source of approximately 24% of global energy-related carbon dioxide emissions. (IEA 2001) This represents an absolute increase of 1017 million tonnes of carbon dioxide and a share gain of 2.4% since 1990. Worldwide, emissions of carbon dioxide from the transport sector are projected to grow at the rate of 2.5% each year through 2020. The growth rates of transport sector carbon emissions in the developing world and in economies in transition are projected to be even higher – 4.0% per year and 3.3% per year, respectively (IEA 2000c). In contrast, the growth rate of greenhouse gas emissions from other major sectors is projected to be lower.

There are many reasons for the unrelenting growth of carbon dioxide emissions from the transport sector. The two main facts that make it very difficult to reduce emissions of carbon dioxide from transport are:

- The transport sector is linked to almost all other economic activity.

- Other large energy using sectors can choose from a variety of fuels that vary in their greenhouse gas emissions. In the transport sector, the only widely used fuel is oil.

These two simple facts make it extremely challenging for transport greenhouse gas emissions to stabilise while both the global economy and population are growing.

Some observers are sceptical of CDM or JI projects in the transport sector due to the difficulties inherent in measuring and forecasting transport sector greenhouse gas emissions. However, due to the current size and the rapid projected growth of the sector, not to consider transport sector projects is to ignore tremendous potential to impact the development path of the single fastest growing major greenhouse gas-emitting sector in the world. In the World Energy Outlook 2000 (WEO), the IEA predicts that carbon dioxide emissions from transport in OECD countries could be curtailed substantially by 2020 relative to their aggregate baseline (the WEO reference scenario) if a mix of policies, measures, and investments were to come together to make this happen. In developing countries, the opportunities for deviation from the baseline may be greater because these countries are making major transport policies and infrastructure investments today. In addition, the transport sector contributes to other environmental problems such as local air pollution, noise pollution, and habitat degradation from the existence of roadways and other transport infrastructure. Reducing carbon dioxide emissions from the transport sector may serve to ameliorate these other problems as well.

This report is a first attempt at designing a way for CDM and JI projects in the transport sector to be viable and for the emissions reductions that they represent to count: through standardised baselines. Before embarking on the discussion of the specifics of baseline development and standardisation for transport, this section provides an overview of the transport sector, its greenhouse gas emission sources, and potential CDM and JI projects that would use the baselines.

2.1 Transport sources of greenhouse gas emissions

The transport sector is comprised of a diverse set of activities connected by their common purpose: to move people and goods from one place to another. The sector encompasses such varied activities as walking to the corner store to pick up some milk, driving a car to a theatre, and flying fresh mangoes halfway around the world for consumption by residents of northern countries in winter. While all of the sub-sectors within the transport sector share a common purpose, they do not necessarily share greenhouse gas emissions characteristics. Hence, greenhouse gas emissions reduction solutions for different kinds of transport can be quite varied.

There are five physical elements of the transport sector that can be changed to reduce emissions: vehicle efficiency, greenhouse gas intensity of the fuel used, level of transport activity, mode of transport chosen, and amount of capacity used.[2] All potential CDM and JI projects within the transport sector must thus aim to affect at least one of these five elements. The diversity of projects to reduce potential greenhouse gas emissions in the transport sector is immense. Some of these projects fit well into categories that have already been thoroughly explored in previous baseline studies. For example, fuel efficiency and fuel switching projects in transport are only slightly more complicated than similar projects in the electricity sector (see Violette et. al. 2000 and Bosi 2000).

Other potential CDM and JI projects in the transport sector are quite different from anything that has been explored thus far in OECD/IEA baselines work. These include the use of technological advances to improve the efficiency of freight delivery systems[3], the forming of a car-sharing organisation in a city where car ownership is projected to rise quickly[4], or economic incentives for individuals and companies to use more efficient transport systems and equipment.

Here, the five options to reduce greenhouse gas emissions from transport are identified and examples are given of policies and technologies that would reduce greenhouse gas emissions in each of these ways. It is important to note that often the same goal can be reached using a variety of different policy and investment actions. Sometimes, one of the possibilities stands out as the least expensive or the most politically feasible within a certain country's particular context.

- **Efficiency:** *change the fuel efficiency* of vehicles without changing the type of fuel that the vehicles use. Although increasing the technical fuel efficiency of a vehicle clearly requires some form of physical alteration of the vehicle, there are a number of potential avenues to arrive at this outcome. They include direct investment for a physical change in vehicle design to improve fuel efficiency such as fuel injection engines or more aerodynamically shaped vehicles, refurbishment of vehicle fleets, direct economic incentives for fuel efficient vehicles such as feebates[5] or scrappage programs, and indirect economic incentives for fuel efficient vehicles such as fuel taxes.

- **Fuel:** *change the type of fuel* that vehicles use. As in the case of increasing a vehicle's fuel efficiency, there is only one physical way to change the fuel that a vehicle uses, but there are a number of possible policy and investment avenues. Directly investing in the development and marketing of alternatively fuelled vehicles is one avenue. Others include direct and indirect economic incentives for the purchase of these vehicles such as a feebate system, purchase subsidies for alternatively fuelled vehicles, and differing fuel taxes and subsidies for the different transportation fuels.

- **Mode:** *Mode switching* refers to change in the proportion of transport services provided by the different modes (bicycle, car, bus, train, etc. for passenger travel and truck, rail, ship, etc. for freight transport) without changing the technologies and fuels within each mode. Specific investments that would contribute to this type of change include increasing and improving transit service to induce

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[2] This breakdown closely follows Schipper et. al. 2000.

[3] The use of technological advances to improve the efficiency of freight movement is a matter of improved co-ordination of freight hauling such that two desirable things happen: trucks travel more of the time with full loads, and intermodal hauling is made more reliable such that trains and ships can be used for more freight transport.

[4] See the box on carsharing of this report for an in-depth discussion of this option to reduce greenhouse gas emissions.

[5] A feebate system is a tax-subsidy regulation. First, a level of vehicle greenhouse gas emissions per kilometre is chosen. Consumers who purchase a vehicle that exceed this level pay an extra fee, and consumers who purchase vehicles that have lower emissions than this level receive a rebate.

higher ridership and the creation of more intermodal freight transport centres. Policy incentives for people to switch to lower greenhouse gas emitting modes include transit subsidies, raising parking charges or road-use fees, differentially taxing freight transport by different modes, and implementing land use policies that encourage the use of transit, walking, and bicycling.

- **Activity:** change in the absolute distances that people and freight travel. While this is conceptually the most straightforward of the ways to affect greenhouse gas emissions from transport, it is often the most difficult to put into practice. This is because reducing transport *activity* requires individuals to change their behaviour. Some examples of technologies and policies that could produce activity reductions are optimising logistics for goods delivery, telecommuting, and designing compact towns and cities with mixed-use zoning.

- **Load:** change in the occupancy, or *load factor* of vehicles. Incentives for carpooling such as priority parking and use of less crowded lanes on roadways, optimising logistics for goods delivery, and making public transit vehicles more comfortable so that higher occupancies can be reached are all examples of initiatives that reduce greenhouse gas emissions by optimising vehicle load factors.

Projects that utilise these five physical ways to affect greenhouse gas emissions from the transport sector can be implemented in different subsectors within transport. In order to clearly see where projects are possible, it is useful to subdivide the overall transport sector into smaller pieces. Analysts and governments traditionally subdivide transport in one of two basic ways (see Figure 1). These subdivisions are not necessarily related to the potential for projects. However, thinking about transport in each of these ways in addition to as a whole is useful for envisioning the large range of potential greenhouse gas reducing projects that are possible.

The first way to subdivide the transport sector is by the infrastructure that is needed. Dividing the transport sector in this way, the obvious sub-sectors are road, rail, ship, and air.[6] The benefit for greenhouse gas emissions analysis of subdividing the transport sector in this way is that greenhouse gas emissions characteristics of transport technologies are similar within each of the four sub-sectors.

The second possibility for the division of the transport sector into sub-sectors is to organise the various modes of transport by the service they provide. Using this rule, the sub-sectors are passenger transport, divided into private and public, and freight transport. There are two advantages of subdividing the transport sector in this way. First, this division is the way transport demand is generated and therefore it is convenient for economic analysis. For instance, if there were a price change for freight transport by rail, this way of thinking about the transport sector allows the analyst to explore the effect that this would have on other freight transport modes. The second advantage is that each of these sub-sectors is often overseen by a single company or governing body. For certain potential CDM or JI projects in the transport sector, this existing centralisation of decisionmaking for subsectors within transport may be very useful for data gathering and/or project implementation.

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[6] The examples in this report focus on road and rail transport, with the implicit inclusion of ships in the discussion on freight. It is likely that CDM and JI projects will more often be implemented in countries with a focus on road and rail – although where opportunities exist in ship and air transport for greenhouse gas emission reduction, they should not be ignored.

Figure 1: **Two ways that the transport sector is traditionally subdivided**
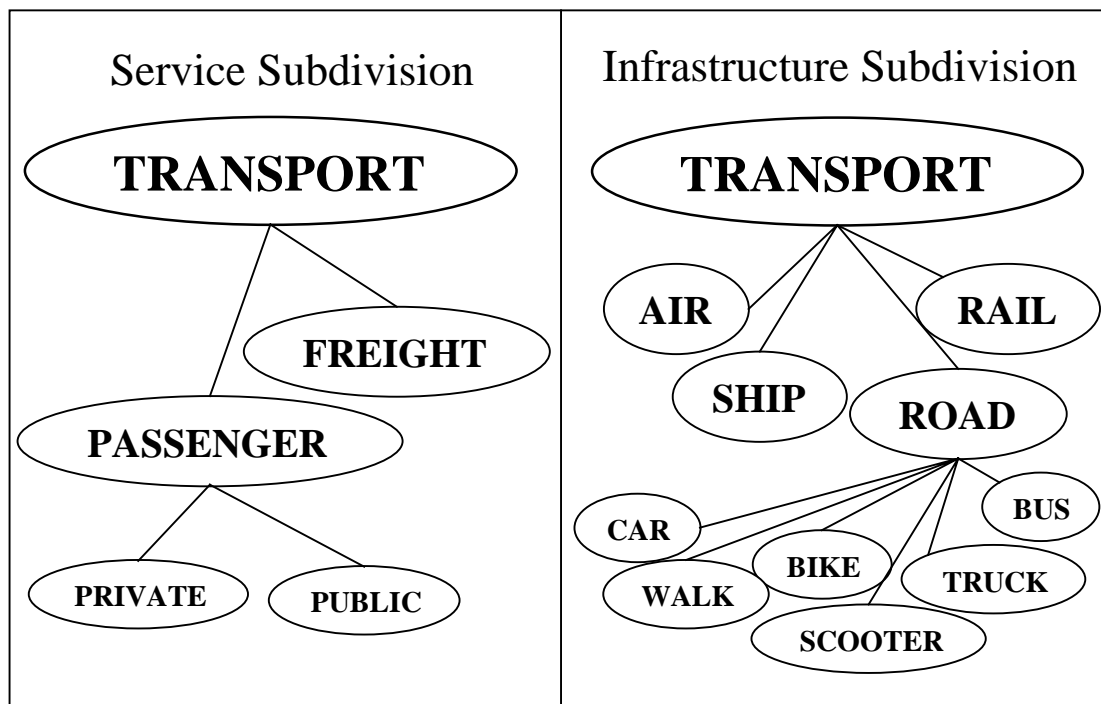
While using this framework and thinking of transport as a number of smaller sectors helps to clearly see the project options, these subsectors interact in complex ways. This interaction often necessitates the consideration of more than one subsector of transport in both baseline generation and project emission measurement. This is because the transport system is like a web – each part is connected to every other part in some way. When an action is taken in one part of the transport system, it often affects greenhouse gas emissions in other transport subsectors.

There are two ways in which a project can affect emissions outside its direct target – through spillover effects and through interaction effects. These effects occur after the project is implemented, and are therefore much more important for post-project emissions measurement than for baseline development and estimation. However, as will become clear, in order to be able to compare the post-project emissions measurements directly with the baseline to determine the CERs or ERUs earned, it is necessary to keep these effects in mind when developing baselines. Also, since these effects will impact the number of credits earned by a project, having a good estimate of the emission implications of spillover and interaction effects will help project evaluation.

2.2   Spillover effects

Many potential CDM and JI projects in the transport sector are likely to cause significant "spillover" effects.[7] This means that an implemented project will not only reduce emissions directly, but it may have other effects on net greenhouse gas emissions that are not so obvious at first glance – positive OR negative. These effects can be either outside the "box" that the original project was planned to affect or they can be secondary effects that are inside the "box".

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[7] Previous OECD and IEA baseline studies have also used the term "leakage" for this idea.

In this report, all of these effects are divided into two types: technical effects and economic effects. Both kinds are extremely challenging to measure. An economic spillover effect occurs when a project causes a price change that affects demand for a good that significantly changes greenhouse gas emissions, but the price change was not the main objective of the project. A technical spillover effect occurs when a project causes an upstream or a downstream physical change that is not the main objective of the project, but that alters greenhouse gas emissions in the system.

For example, a fuel switching project that converted buses from diesel to compressed natural gas (CNG) fuel could lead to the technical spillover effect of additional methane leakage from natural gas pipelines that accompanies increased use of natural gas. The increased use of natural gas may reduce greenhouse gas emissions when it replaces gasoline or diesel fuel, but the spillover effect of the methane leakage increases greenhouse gas emissions. A positive technical spillover effect would occur in a fuel switching project where not only were the tailpipe emissions of the alternative fuel lower than those from the conventional fuel, but the upstream processing emissions for the alternative fuel were also lower. A number of life cycle models have been created to model these types of technical spillover effects in the transport sector,[8] but they are calibrated with detailed data from developed countries. These models could be used to gain an understanding of what types of technical spillover effects tend to be large in the transport sector. However, to use them to actually estimate the size of any particular effect in a developing country, local data would need to be collected.

An economic spillover effect might occur if private vehicle fuel economy were increased. This fuel economy improvement would cause the per-kilometre price of private transport to drop, leading to an increase in kilometres travelled in private vehicles. While the improved fuel economy reduces greenhouse gas emissions, this "rebound" effect of more private transport drives them back upward. A positive spillover effect in an economic sense would occur if a project raised the cost of passenger or freight transport per person- or ton-kilometre travelled while simultaneously reducing the greenhouse gas emissions per unit. A specific example would be a fuel-switching project in which the alternative fuel emitted fewer greenhouse gases per person-or ton-kilometre travelled, but cost enough so that the price of travelling rose. Not only would there be fewer greenhouse gases emitted per kilometre, but there would also be fewer kilometres travelled in response to the price change.

2.3   Interaction effects

Interaction effects occur when the greenhouse gas emission reduction impact of a project is affected by other, simultaneously implemented projects. Referring back to the five ways that greenhouse gas emissions from the transport sector can be affected, it is interesting to note that there are often a number of ways to reach the same goal. In different countries with differing economies and political systems, different paths to the goal of greenhouse gas emissions reduction from transport may be suitable. However, in each country, one or two of them may stand out as the most economically or politically feasible path. Sometimes, it is easy to see that if more than one strategy were implemented, the resulting emission reduction might be greater than the sum of the reductions due to the separate actions. Other times, two or more actions might overlap and therefore lead to a smaller overall reduction when implemented together than the sum of the two actions would lead to separately.[9]

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[8] Two such models are the GREET model created in the United States at Argonne National Laboratory (Wang, 1999) and Dr. Mark Delucchi's lifecycle greenhouse gas emissions model created at the University of California at Davis (1991).

[9] For a more detailed discussion of interaction effects between potential actions to reduce greenhouse gas emissions from the transport sector, see Schipper et. al. 2000.

To illustrate this point with an example that demonstrates positive interactions between a policy and an investment, imagine a region that aims to reduce greenhouse gas emissions by taking actions that will lead to a mode shift from cars to public transit. The region considers the policy of raising the cost of driving via increasing tolls on common routes and the investment of improving public transit service. If the region implements only the policy or just makes the investment, the resulting mode shift is likely to be relatively small. However, if the region is able to co-ordinate the two strategies to generate a positive interaction effect, the resulting behaviour change may be substantial.

One would expect a negative interaction effect when a project to improve private vehicle fuel efficiency is coupled with a project that attempts to induce travellers to switch from private to public transport. The first project reduces per vehicle emissions, but also reduces the per-kilometre cost of fuel for private vehicle owners, making their private vehicles even more attractive to use. The second project makes public transport more attractive in some way. It is easy to see that, absent the improvement in private vehicle fuel efficiency, the second project would reduce emissions more than in the situation where both projects are implemented simultaneously. The converse is also true.

The situation that necessitates consideration of interaction effects in post-project emission estimation is when two separate investors fund projects that interact with each other. In this case, it becomes necessary to divide the credits between the two investors in a fair way without double counting of emissions reductions. One possibility is to base the total emissions reduced on the amount of money invested that led to the emission reduction. Another is to allocate the total reduction according to some engineering estimate of the per cent contribution of each project to the total number of CERs or ERUs generated. While this would provide clearer encouragement for investors to find the cheapest emission reduction opportunities, it might also increase the cost of implementing the projects due to the likelihood of the need to collect further data.

2.4   Institutional structure and project viability

The ability of countries or communities to dictate their own transport planning – or to make any changes – is dependent on the institutional structure in place. The institutional structure varies significantly from one locale to another. This can become a problem for implementation of some CDM and JI transport projects. For instance, it could happen that a particular city could be a perfect location for a road pricing project, but road pricing for some roads in that city are the jurisdiction of the national government. If the national government is not interested in the project, then it cannot go forward. It is due to situations such as this hypothetical one that the way that policies and investments are institutionally implemented is likely to be a large factor in deciding whether a project is implemented or not.

In many developed countries, economic policymaking has historically been almost entirely in the jurisdiction of national or large regional governmental bodies. Local transport infrastructure – including that of public transit – and traffic management has largely been under the control of local governments. For large infrastructure projects, local governments often co-ordinate with higher levels of government in order to obtain funding assistance. An institutional conflict is most likely to arise when local transport planning projects would be advantageously co-ordinated with changes in economic policies.

In some places, there are political obstacles to data collection and availability. For instance, in certain cities, the fares that buses are allowed to charge are linked directly to the operating costs of the buses. If, for example, it is discovered that the buses are using less fuel per kilometre of travel than had been assumed by the fare-regulating authorities, this discovery of lower operating costs could lead to a mandatory fare reduction. It is for this reason that in cities where this system is in place, private or semi-private bus companies are reluctant to make any fuel use information that they have public. They may also be uncooperative in the collection of fuel use information for baseline creation purposes. As this case

illustrates, it is always important to be aware of the existing political and economic institutions that affect the availability or bias of the data collected.

While institutional structure and politics may be obstacles to project implementation, an even larger obstacle in many places is a lack of institutional experience and expertise. Many of the projects to reduce greenhouse gas emissions in the transport sector are largely untried even in developed countries and are complex to implement without negatively affecting the local economy. Without a competent project host, projects are less likely to be successful. Unfortunately, there is often a positive correlation between more experienced potential project hosts and fewer opportunities for greenhouse gas emission reductions. This is because these prospective project hosts are already co-ordinating their transport sector in such a way that it runs efficiently, fuel is conserved, and therefore greenhouse gas emissions are relatively low.

3. Transport baselines

The following three sections of this report detail the technical and administrative challenges that arise in baseline development for transport projects and identify two categories of baselines that can be used to calculate emissions reductions achieved by transport CDM and JI projects. A baseline is a measure of the emissions that would have occurred in the absence of a project. This means that the baseline for a certain variable does not vary with the project being planned to affect that variable. Thus, baselines need not be tied to specific projects; they could be tied instead to subsectors of transport within a region.

An example may help to further illustrate this point. Consider the first of the five ways to affect greenhouse gas emissions from transport: changing average vehicle fuel economy. There are a number of possible projects that could lead to an improvement in average fuel economy, but there is only one baseline for fuel economy. That is to say, the estimated average fleet fuel economy that would have occurred absent a CDM or JI project does not depend on the project that is implemented. However, when the implemented project is likely to cause secondary effects, the baseline may need to be more complex. Additional baseline information may need to be collected to serve as a reference point for the transport variables that are affected in secondary ways by the project.

In order to standardise baseline development for projects in the transport sector, three categories of standardisation provide a useful framework (Ellis and Bosi 1999):

- standardisation of data needs and measurement techniques,

- standardisation of the methodology used to transform these measurements and forecasts into baselines, and

- standardisation of actual numbers used in baselines across whole regions and many projects.

Before delving further into questions of baseline standardisation, a fundamental aspect of a baseline that must be considered is the units that it is measured in. Baseline units may vary from project to project, depending on the way that the project aims to reduce emissions. In general, however, baseline units should not be in absolute tonnes of emissions, but rather tonnes of greenhouse gases emitted relative to an appropriate index. The reason for this is to ensure that the credits that a project receives are not eroded by an underestimate or inflated by an overestimate of variables such as the growth in the number of people using the transport service or economic growth. This allows baseline creators to focus on measuring and forecasting the variables that the projects might actually affect such as technologies and prices rather than regional populations and economies. For instance, if a project aims to improve the fuel economy of vehicles, it makes sense to measure the baseline in terms of emissions per vehicle-kilometre travelled. If, on the other hand, a project aims to reduce greenhouse gas emissions by reducing passenger travel activity, a kilometres travelled per capita baseline would be appropriate. For a project that aims to reduce freight transport activity, a tonne-kilometre travelled per GDP baseline might be suitable.

3.1 Transport baselines: measurement challenges

Creating a baseline for a CDM or JI project in the transport sector is not a simple proposition. The objective is to estimate the emissions that would have occurred absent the project in such a way that the emissions that actually occur after the project is implemented are directly comparable to the baseline. There are three main technical challenges that must be dealt with in baseline creation:

- historical and current data deficiencies,

- historical and current data uncertainty, and

- forecasting uncertainty.

These challenges are common to baseline development for projects in all sectors, but they are particularly acute for transport sector projects. Transport sector fuel use and emissions data is physically difficult to collect due to the highly dispersed nature of the sector's emissions. Furthermore, because transport is closely linked to practically all other economic activity, it is extremely complex to forecast the trajectory of transport-related carbon dioxide emissions for a given situation. Here, these issues are discussed in detail with examples from the transport sector. Proposed are examples of ways to standardise data requirements, data collection techniques, and forecasting methodologies for transport baseline types that are most likely to be used. The hypothetical case studies later in the report will illustrate how these challenges can be met in a variety of baseline development situations.

3.1.1 Raw data deficiencies and uncertainty

Emissions data gathering in the transport sector suffers from some fundamental difficulties. Transport sources of greenhouse gas emissions are small, numerous, and they move around. In addition, decision making for the use of most transport sources of greenhouse gases is decentralised with billions of individuals around the world choosing transport modes and routes to meet their daily needs. In order to find out the fuel use or emissions from a stationary source, it is usually possible to install a reliable meter to directly measure one or both of these quantities. However, even these basic pieces of data are notoriously elusive in the transport sector. This is true even in developed countries that have been expending substantial resources over many years in an attempt to understand key indicators in their transport sectors. In most developing countries, the data is even spottier.

For example, to calculate carbon dioxide emissions from transport in a region, it is necessary to have *one* of the following information sets.

- The amount of each type of fuel burned for transport purposes in the specified region and time period,

  OR

- The fuel economy of vehicles, the type of fuel they burned, and the kilometres that they travelled in the specified region and time period.

If the first set of information is available, carbon dioxide emissions can be calculated by simply multiplying the amount of fuel burned by the appropriate conversion factor (i.e. carbon per litre) for that fuel type. Gleaning total carbon dioxide emissions from the second information set is slightly more complex, but still easily doable. The appropriate formula is as follows:

$$\# \, kilometres \times \frac{litres \ of \ fuel}{kilometre} \times \frac{carbon \ dioxide \ emissions}{litre \ of \ fuel}$$

All of these pieces of data are difficult to measure accurately in situations where the vehicles are not in a centrally controlled fleet. Fuel use information, when inferred from fuel tax receipts, is systematically underestimated because there is some unknown but likely significant level of tax evasion. Even if total fuel use were known accurately, the portion of this fuel that is used for transport purposes is not always clearly separable from the fuel used for other end-uses. Differences between regions in tax policies on both fuels and vehicles as well as vehicle registration requirement differences can cause huge distortions in the

regional data on fuel use and vehicle ownership. In some cities, survey data indicates that the reported vehicle ownership levels may be substantially underestimated due to the fact that the registration fees in the city are higher than those in the surrounding area.

There are also significant uncertainties in purely technical data such as fuel economy and emissions information for a particular vehicle. These data can be gathered with very high precision in laboratory conditions. However, the driving conditions in the real world may differ enormously from those in the laboratory, and these differences in driving cycle can have huge impacts on actual fuel use and emissions. In some places (mostly in developed countries), estimates have been made in an attempt to convert the laboratory results into on-road fuel use and emission factors, but these estimates are very crude. Knowing that the laboratory data is not correct, but not having reliable ways to make locality-specific corrections, some developing countries are very reluctant to even report the laboratory fuel economy information.

Some additional pieces of data that might be necessary for estimation of certain baselines are simply not available in many potential project host countries. These include relatively basic data such as average trip length, average vehicle occupancy by vehicle type, and average annual kilometres travelled per person. One solution to the unavailability of data is to require project sponsors and/or hosts to collect a certain standardised set of data before a project begins. In Section 4 of this report, the specifics of such necessary data sets are outlined for a small set of sample projects. Future work in this area could further develop this categorisation of project types and specific data requirements for each of them.

Despite these common types of data deficiencies, there are two options to allow CDM and JI projects in the transport sector. The first is to focus projects on centrally controlled and fuelled fleets of vehicles such as buses. Because these fleets are centrally managed, it is likely to be possible to collect reliable information on both fuel used and kilometres travelled, and to use this data to generate a baseline. These types of projects are likely to be the first to be implemented in transport due to data availability, but they leave emission reduction opportunities in most of the transport sector untapped.

The second option to allow CDM and JI projects in transport is to accept a high level of uncertainty in the data and to move forward. Specifically, this would mean creating baselines with relatively high degrees of uncertainty built into them. If the baseline is unbiased, some projects that used it would actually have reduced emissions less than they would get credit for, but other projects would be reducing emissions more than they would get credit for. On average, the net CERs or ERUs awarded would be approximately correct. This strategy is attractive because it would make it possible for more varied types of greenhouse gas emission reducing projects in transport to be implemented. However, there is substantial concern among many observers that some parties might use the high uncertainty to "game" the system and actually contribute to the setting of a baseline that is upwardly biased. This concern can be at least partially addressed through standardised baseline development guidelines along with regular baseline updates.

3.1.2 Forecasting

Apart from the physical difficulties inherent in simply counting the emissions, the baseline is meant to be not what happened in the past, but rather what would have happened in the future absent the project. This means that a baseline for CDM or JI projects involves "business-as-usual" emission projections. Almost any type of forecasting is difficult to do with a high degree of accuracy, and forecasting greenhouse gas emissions from the transport sector is no exception.

There are three basic methodological options for forecasting in the transport sector:

- Continuing a historical trend of local or near-local data,

- Emissions projections using base-year data plus engineering-type parameters and assumptions, and

- Econometric-type analysis of cross-section data to represent a time trend.

Depending on the baseline that is being estimated and the available data, the appropriate forecasting technique will be different. When estimating baselines for mode switching or load factor increasing projects, the first of the methods may be the most appropriate. For fuel economy improvement and fuel switching baselines, the second forecasting technique might be employed. When a suite of projects is planned to be implemented at the same time in one area, a regional baseline is needed and the third type of forecasting method should be used.

All of these forecasting methods are plagued by the simple fact that the future is fundamentally uncertain and the transport system is immensely complex. Even with high quality historical information, forecasts routinely deviate substantially from what actually happens. The next sections of this report describe a way that emission baselines can be estimated in this sector despite the high data and forecasting uncertainties.

3.2   Making a baseline out of a forecast

After the data is collected and the physical baseline is determined through forecasting, there are a few more decisions that must be made in order to use the forecast as a baseline. These include decisions about determining the stringency, timeline, and updating procedure for a baseline, as well as whether a baseline is designed to be static or dynamic. In addition, rules regarding determination of whether or not a project is additional as well as how to deal with the incentives to inflate the baseline in the CDM need to be laid out clearly.

3.2.1   Incentive issues and baseline standardisation

Credits earned by projects via the mechanism of JI are in a sense "double-checked" by the fact that both parties in a JI transaction have emission caps under the Kyoto Protocol. The CDM is different, however, because it involves a transaction of credits between one party that has an emissions cap and one party that does not. For every credit earned via the CDM, therefore, the total emissions allowed in developed countries under the Kyoto Protocol rises by one unit. It is this fact that leads to the incentive problem with the CDM.

Both participants in a typical CDM transaction have an incentive to bias the baseline upwards. The developed country participant is interested in gaining as many credits as possible from the investment, and the developing country participant is interested in attracting as much investment as possible from the developed country participant. This leads to a likely systematic overestimation of the emissions that would occur in the absence of the project activity, which, in turn, forces the number of credits accruing to CDM projects to be higher than they should be, and the global climate to suffer.

A number of strategies have been proposed to ensure that baselines are not overestimated in spite of the incentive problem inherent in the CDM. One proposed strategy is to make a list of acceptable projects with prescribed baseline methodologies and not to allow any credits for projects that do not fit into the specific categories on the list. Due to the necessity of something approaching consensus in international politics, this strategy is likely to rule out many otherwise viable projects. The second strategy is to write the rules about setting baselines so that they are environmentally "conservative" (Lawson and Helme 2000). The last strategy to avert the inflated baseline problem is to standardise baseline creation methodologies and/or specific numbers across multiple projects, leaving little room for gaming (Ellis and Bosi 1999).

Regardless of the strategy pursued, balance is needed to ensure that baselines are not overestimated while also not setting overly restrictive baseline levels. Systematic underestimation of baseline levels through high stringency levels or other rules that restrict project viability can also undermine the usefulness of the CDM. Projects that would actually produce relatively cheap greenhouse gas emission reductions under an accurate baseline would not be implemented. In the transport sector, this could actually have negative implications for greenhouse gas emissions in the long term because major infrastructure investment decisions being made now would not have a chance to be influenced by the mechanism.

Standardisation of baselines is a strategy that attempts to obtain unbiased estimates of what emissions would be absent any project. This is accomplished by setting standardised data requirements, measurement techniques, and baseline development methodologies. While this strategy may be able to effectively bypass the incentive problems with the CDM, it brings with it another problem – reduced baseline precision. Thus, although a standardised baseline is less subject to gaming and is therefore more trustworthy, it is likely to have larger error margins around a central value than a baseline that is more tailored to a specific situation.

This trade-off between baseline standardisation and potential baseline error is a difficult one, especially in sectors such as transport that have very high uncertainty levels in baselines under the best of circumstances. Allowing most transport projects to qualify for CDM and JI credit using standardised baselines requires setting the baseline stringency at a level such that projects that are likely to bring about real greenhouse gas emissions reductions will earn enough credits to encourage implementation. This means accepting the fact that standardised baselines will be imprecise and hoping that they are unbiased so that the lack of precision in credit calculation will basically "cancel itself out" with many projects. As we learn more about the real emissions coming from the various pieces of the transport sector and how the subsectors within transport interact with one another, this emissions uncertainty should be reduced.

3.2.2 Stringency, additionality, and eligibility

Two important baseline terms are stringency and additionality. Additionality is a concept associated with a single project, but stringency is associated with a baseline that can theoretically be used for many projects. Stringency has been defined (Ellis and Bosi 1999) as "a measure of how difficult it is for projects to generate emissions below the baseline level". In the context of this report, additionality refers to the *additional* units of greenhouse gas emissions reduction below the actual baseline that are caused by a project. . Once the baseline and its associated stringency have been established and the actual emissions trajectory has been measured, it is a matter of simple mathematics to quantify the additionality of the project.

In contrast to *quantifying* additionality, the answer to the question "Is a project additional?" is a "yes" or a "no". This question is critical because it is specified in the Kyoto Protocol that in order to be eligible to earn CERs or ERUs, a project must be an action that would not have been implemented in the business as usual scenario. If a project generates positive CERs or ERUs measured from the predetermined baseline, some observers would argue that this means that the project is environmentally additional. Other observers argue that calculated actual emissions below the emission baseline level is not sufficient to determine a project's eligibility.[10]

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[10] Some of these observers have suggested an alternative means of determining eligibility. This alternative approach proposes to determine whether a project is additional or not based on its profitability (absent CER or ERU income) relative to other investment options. In essence, the baseline under this viewpoint becomes the most profitable option and any less profitable option that is implemented is considered additional to what would have happened absent the CDM. Once a project is classified as additional in this way, its

The Bonn Agreement obtained at the resumed sixth Conference of the Parties (COP6-II) in July 2001 includes a provision to fast-track small-scale projects that have a high likelihood of being additional, but for which CDM-process-related costs might be a barrier to implementation, e.g. small renewable energy projects. The rationale for this is that renewable energy projects move developing countries towards a more sustainable future, and that this is one of the goals of the CDM. A parallel in the transport sector might be projects that increase public transport. The argument for this is that any increase in public transport, while it may not actually reduce greenhouse gas emissions from transport immediately, it is a step in the direction of a sustainable transportation system. This suggestion was made in the transport workgroup at the Expert Workshop on Identifying Feasible Baseline Methodologies for CDM and JI Projects held at Risøe, Denmark in May 2001 (UNEP/OECD/IEA 2001).

3.2.3 Putting it together with timelines and updates

It is possible to largely standardise the methodology for estimating the amount of time that a baseline is valid, whether it is fixed ex-ante or revisable during the crediting lifetime, how often it needs to be updated, and the updating procedure.

The timeline for a baseline is defined as the amount of time during which the initial baseline projection is valid to be used for projects. Ideally, the timeline of a baseline should be independent of the projects that use it, decided by technical or economic factors that indicate the number of years that the baseline developers feel that their projection is accurate for. The problem with this is that baselines are rarely very precise, especially in the transport sector. Some baseline developers might feel more comfortable with this imprecision than others, and their baselines would therefore have longer timelines.

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additionality is calculated as above. While this concept is admittedly attractive from a purely economic theoretical point of view, it is not clear that this is a viable alternative for baseline development and additionality determination for projects in the transport sector. This report focuses on the development of baselines, which will be needed regardless of the method for determining whether a project is additional.

Note: On the proposal to use developed country data for CDM and JI project baselines

During negotiations at the Sixth Conference of Parties to the Kyoto Protocol in November 2000, it was suggested that due to difficulties in gathering the necessary data in many developing countries, CDM projects should use developed country data to create baselines. This would means that any CDM project that has lower emissions than this developed country baseline would be eligible to earn CERs. For projects in some sectors, this seems to be a very reasonable suggestion as there is something approaching a global standard for technologies in these areas. In the transport sector, this strategy could be either a boon or an enormous impediment to transport sector projects, neither of which is desirable. The former leads to projects receiving many more credits than they deserve and the latter leads to projects receiving so few credits that it is not likely that they would be implemented. Which it becomes depends on whether baselines are measured in terms of emissions per capita or emissions per vehicle kilometre travelled by vehicle type.

Measuring the baseline in terms of greenhouse gas emissions per capita would lead to many 'projects' producing relatively large amounts of credits. Most developing country transport systems are much less greenhouse gas intensive on a per capita basis than developed country transport systems. This is because the average vehicle occupancy is much higher in developing countries. Even if only truly additional projects earned credit, the number of credits per project would be inflated due to the inflated developed country transport baseline. So, even if all of the projects receiving credit were additional to what would have happened otherwise, the credits would not be.

If instead, the baseline were measured in terms of emissions per vehicle kilometre, the strategy would produce very few projects (if any). Average vehicle efficiencies are generally lower in developing countries for vehicles in the same size ranges because the technologies are simply older. Using transport technology baselines from developed countries as baselines for CDM projects would not only produce very few projects, but it would all but disqualify whole categories of potential projects in the transport sector such as mode switching projects.

Because transport emissions per capita are much lower in developing countries than in developed ones, but transport emissions per vehicle kilometre travelled are higher, it is difficult to imagine a situation where using baselines created from developed country data for CDM transport projects would yield a desirable outcome.

One solution to this is to make the timeline of the baseline depend on the project that uses it rather than on estimates of the longevity of the projection itself. The timeline for some projects could be determined by estimates of the useful lifetime of technologies used or legislative lifetime of policies implemented. For other projects, the timeline of the project could be linked to the baseline in that the project would stop earning credit (and therefore end its life as a project) when the post-project emissions equalled the baseline emissions.

A fixed dynamic baseline can be defined as one that is planned from the beginning to change at a certain rate over time, while a fixed constant baseline is planned to remain at a given level for the entire crediting period. Another possibility could be to have baselines that are revisable during the crediting period, but where the rate of change is unspecified. For situations in which enormous capital outlays are required to change emissions characteristics of a system (i.e. changing the fuel that a power plant uses), it may make sense to use a fixed constant baseline with the baseline level and crediting lifetime determined by technical characteristics of the equipment being replaced. However, in a sector such as transport, where incremental technology and behaviour changes cause incremental emissions changes, fixed dynamic baselines make more sense.

However, there is tremendous uncertainty associated with predicting the rate of change that would have occurred in the absence of a project. An approach that is somewhere in between a fixed constant baseline and a dynamic baseline is a baseline that is revised at regular intervals. The need for revisions or updates could be based on actual data from a "control" location that has similar characteristics to the project location, but where no project is undertaken.

Updating baselines while a project is going on introduces an extra level of uncertainty for the investor because with updating, the investor does not know the baseline for the entire project from the start. Some observers argue that for this reason, updating of baselines after a project is underway should not be allowed (e.g. EnergyConsult Pty Ltd 2001). In certain situations, however, this method may be appropriate to improve baseline accuracy, and it is included as one of the options to be discussed at COP7 to determine crediting lifetimes for CDM projects. .

Standardising calculation methods for the initial baseline and any subsequent revisions or updates for the most common project types would be useful.

3.3   Two types of baselines for the transport sector

In this report, transport baselines are divided into two basic types that correspond roughly to the ways that emissions forecasting can be done in the transport sector: subsector baselines and regional baselines.

A subsector baseline is one that limits itself to a part of the transport sector in a region. This could mean anything from a simple emissions-per-kilometre-travelled baseline for a particular type of vehicle to a more complex, intermodal emissions-per-ton-kilometre freight transport baseline. The level of complexity required of a subsector baseline has to do with the number of transport subsectors that will be significantly affected – directly or indirectly – by projects that use the baseline. This includes subsectors based on both the infrastructure breakout and subsectors based on the transport service division of the larger transport sector.

A *subsector technical* baseline uses base year emissions data together with engineering estimates of future changes in transport technologies over time. A *subsector historical* baseline uses historical data to obtain an emissions trend and continues the trend forward. *Regional* baselines are a more holistic analysis tool for the transport sectors of whole cities or regions. A regional baseline would measure the total greenhouse gas emissions from transport in a region and then use indicators for the region that are not necessarily directly related to transport to project forward. These indicators could include items such as average income, population density, and transport prices. This type of baseline would be used if, for instance, a city were to implement a project that included a package of policies, measures, and investments to reduce greenhouse gas emissions from its transport sector. Using this type of holistic baseline would allow the net effect of the package to be considered as essentially one big project, rather than trying to measure the emissions impact of each piece of the package separately.

Recall the five ways that greenhouse gas emissions from transport can be affected: fuel efficiency, fuel switching, mode switching, activity changes, and changes in vehicle load factors. Either a subsector or a regional baseline could be used to support projects that aim to change greenhouse gas emissions from transport in most of these ways. For instance, a fuel efficiency project implemented alone would probably use a subsector technical baseline. However, the same project, if implemented as part of a regional package of initiatives aimed at reducing greenhouse gas emissions, would probably use a regional baseline.

In most places, the type of baseline for which data is most readily available is a subsector technical baseline. A straightforward fuel efficiency improvement project could use this type of baseline as long as

the rebound effect[11] is not expected to be significant. Base year emissions data is straightforward to collect, and fuel efficiency forecasting based on technical parameters is advanced relative to forecasting in other parts of the transport sector.

Conceptually the simplest kind of baseline is one for which only a single historical trend is needed. These baselines are easy to understand, but may be difficult to estimate with confidence due to the requirement for historical data. Only recently have developed countries started keeping data records of greenhouse gas emissions from transport that are specified to the subsector level. While historical carbon dioxide emissions from the whole of the transport sector in most parts of the world can be approximated by related information such as fuel sales data, it is very difficult to separate out which fuel went to which part of the larger sector. Therefore, precise estimates of subsector historical baselines may be impossible to make at first. Sometimes, current data can be arranged in such a way that it can serve as a proxy for historical data.

Further up the scale of sub-sector baseline complexity come the baselines that can be used for mode switching projects. In this case, the baseline needs to be expressed in terms of emissions per person- or tonne-kilometre. This means that in addition to the information required for the baselines above, it is also necessary to collect either occupancy data for passenger travel or capacity utilisation data for freight transport to transform the emissions per vehicle kilometre figure into emissions per person- or ton-kilometre. Although it would be more complex to estimate, this type of baseline would be applicable to a somewhat wider variety of projects.

Both types of subsector baselines leave projects that use them vulnerable to spillover and interaction effects as only direct effects of a project can be legitimately compared to a technical or a historical trend baseline. It is for this reason that one must exercise care to eliminate the possibility of significant secondary effects of a project before using a subsector baseline to measure earned CERs or ERUs.

The data required to construct these complex baselines may be reused for more than one transport project in a region. Thus, the baselines become modular – once a baseline has been constructed for a transport subsector in a region, it can be built onto or scaled down to make baselines for other projects in that subsector.

When all of the greenhouse gas emission effects of a project are expected to be direct, it is generally clear exactly what baseline pieces are needed so that the full effects of the project can be measured. However, when significant spillover or interaction effects are expected, it is sometimes less clear what to measure to get a good baseline for these indirect effects. In order to identify the full likely effects of a project, a set of key questions may be useful to determine which indicators need to be used as the baseline trends. Three examples of such questions are:

- Does this project directly change a transport price?

- Does this project significantly change upstream transport emissions? and

- Does this project change transport demand in subsectors of transport that are not included in the baseline?

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[11] Raising the fuel efficiency of vehicles reduces the per-kilometre cost of driving, resulting in an increase in the number of kilometres driven. This is known as the "rebound effect". In the United States, this effect has been estimated to result in approximately a rebound of about 20% (Greene 1998). This means that a 10% increase in fuel economy will result in an 8% decrease in greenhouse gas emissions. In order to understand this relationship in the developing country setting, additional research will be necessary.

If the answer to any of these questions is positive, the project has spillover or interaction effects. Secondary effects are often extremely difficult to measure accurately even after the fact, and requiring full baselines for secondary effects adds another level of complexity to the baseline determination process and raises the cost associated with baseline estimation. One way to acknowledge the existence of significant secondary effects in the baseline without significant added cost might be to use a type of "five-point" scale to evaluate the size of the secondary effect (UNEP/OECD/IEA 2001). The "five-point" scale could range from "strongly positive" to "strongly negative", and associated with each level would be a percentage of the emission credits earned by the project (see below)

Secondary Effects Table

Strength of Effect	Adjustment factor
Strongly Positive	+10%
Positive	+5%
Neutral	0
Negative	-5%
Strongly Negative	-10%

In this example, if project developers agreed that a certain project would have a "strongly negative" secondary effect, then credits earned would be calculated as the emission reduction from the project minus 10%. This methodology is clearly ad hoc, but it does have the distinct advantage of very low data requirements, and it does not ignore the reality of secondary effects.

If a project seems likely to have significant effects in many different subsectors within transport (based on the answers to questions like those posed above), it might make sense to use a regional baseline instead of a subsector baseline. Regional baselines are generally less precise than subsector baselines, but they are designed to be used for policy projects that are likely to cause spillover and interaction effects in addition to their direct effects on greenhouse gas emissions. In the case of a regional baseline, the baseline is the total transport greenhouse gas emissions for a region, so these effects are included and do not need to be separately tabulated.

In addition to being used for packages of co-ordinated projects that have numerous interaction and spillover effects, regional baselines are likely to be useful for policy projects. Policy change is a type of project that is somewhat neglected because it is not clear how a developed country investor could finance most policy changes. Even for policy changes that one might imagine financing (such as tax credits for fuel efficiency), the legality of an entity in one country financing a government initiative in another is questionable. However, policy changes have tremendous potential to be effective means of reducing greenhouse gas emissions from a sector like transport where sources are so dispersed. One way out of this situation is to allow policy projects under what are known as "unilateral" CDM projects. The idea of a unilateral project is simple – the entire project is conceived of and implemented by the host country. The project host then owns any credits accruing to the project, and can sell them to an Annex I country Party or entity at the market price for credits (i.e. the contribution of the Annex I Party or entity to the CDM project

is limited to the purchase of credits).[12] A variation of this might be a situation in which an Annex I country Party that would like the option to buy the credits at a predetermined price could serve as an advisor to the project host during the baseline development and implementation phases of a policy project. There are currently divergent views, in the international community, on the eligibility of unilateral projects in the CDM.

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[12] The idea of unilateral CDM projects fits in neatly with one of the potential frameworks under consideration for CDM operation – the portfolio approach. See Yamin 1998 for details.

4. Baseline examples

Until this point, this report has described a detailed framework in which to think about baselines for CDM and JI projects in the transport sector. This section uses concrete examples to illustrate this framework in action. The baseline examples that follow were chosen to be representative of the variety of baselines that will be needed to support the variety of possible transport projects. Namely, a subsector technical, a subsector historical, and two types of regional baselines are presented. Both subsector baseline examples are outlined for the same situation – a bus fleet. Although the following discussion refers almost exclusively to buses, the data needs and baseline development methodologies and concerns would be almost identical in any situation where a baseline is required for a fleet of vehicles.

As actual data was not collected for this report, these examples are not full-fledged sample baselines, but rather specific recipes for creating actual baselines. In the simpler examples, an attempt has been made to fully explore the problems that may be encountered in baseline definition. In the more complex cases that follow, certain potential problems are highlighted, but many problems might arise in practice that are not dealt with in this report.

4.1 A subsector technical baseline for a bus project

One way to estimate a baseline that is likely to be particularly advantageous for use with fuel efficiency or fuel switching projects is to base it on technical parameters. To estimate a baseline for a bus fleet, this procedure would be relatively simple and inexpensive. Although it may not yield the most exact baseline, the baseline that is created is transparent and difficult to artificially inflate. Particularly as CDM and JI projects are just beginning in the transport sector, baselines like this one might be used until adequate data for more complex baseline development can be amassed.

The idea is simple. First, gather base year greenhouse gas emissions data for the bus fleet. There are two basic methods for doing this. The easiest way to directly measure in-use fuel economy is to take odometer readings and fill up all the bus fuel tanks one morning before the buses begin their daily routes. At the end of the day, take odometer readings again, fill up the fuel tanks, and record both the amount of fuel burned during the day and the number of kilometres travelled by the buses. Dividing the fuel used by the kilometres travelled will yield the fuel economy of the buses for that day in kilometres per litre of fuel. Doing this for a sample of a few days should be enough to obtain quite accurate estimates of current bus fuel economy when the baseline is being developed.

For a centralised bus system, this procedure is neither difficult nor particularly costly. However, the bus systems in many developing cities are decentralised. Especially when in-use fuel economy estimates are needed for privately operated buses, one option is to use a model to estimate in-use fuel use. To create such a model, a database of in-use fuel economy in different types of cities would need to be built. Then, generalised on-road degradation factors could be applied to the "rated" fuel economy of each vehicle type for the situation that is being modelled. If gaming is a particular concern, this modelling methodology might be preferable even in the case where the bus system is centralised.

Once base year data is gathered, the baseline is essentially finished. After a technology substitution project is implemented, credits earned would be calculated simply by taking the difference between the greenhouse gas emissions of new technology buses and those of the base year buses. Every few years, this type of baseline would be updated and the process would start over.

4.2 A subsector historical baseline for bus projects

The same baseline that is described above can be estimated as an historical trend as well. In fact, if the data are available, estimating both types of simple subsector baselines may be a good way to check the integrity of the methods. Creating a subsector historical baseline requires only historical fuel use per kilometre travelled information for buses used within a bus system. For most cities in the world, this means diesel bus fuel economy data. This historical trend would be continued forward to create the baseline. Although this seems like it should not be a particularly tall order, it will become quickly obvious that even this "simple" baseline may not be all that simple.

The procedure for estimating a subsector historical baseline begins with gathering base year greenhouse gas emissions data for the bus fleet. This can be done in exactly the ways that are outlined above for the subsector technical baseline. To construct the historical trend upon which this type of baseline is based this data needs to have been gathered historically in the locality for which the baseline is being developed. The data may not exist, and it is physically impossible to collect genuine historical trend data after the fact. However, there are two possible proxies for this type of historical data on bus fuel economy.

Bus fleets are generally composed of some older and some newer vehicles. For financial reasons, it is likely that a bus company would know the historical physical composition of its fleet by make, model, and year of bus. If the current bus fleet were tested for fuel economy, then one could easily readjust the weights of the different makes, models, and years of buses in the average to represent the historical composition of the bus company's fleet, creating a "historical" trend. This method of creating "historical" figures might bias the emission baseline upward because bus fuel economy may go down with bus age. Thus, for those baselines that are constructed in this way, technology deterioration characteristics of the buses should be taken into account to adjust the best guess for the baseline downward.

The second possibility to make "historical" measurements after the fact is to use non-local historical measurements of fuel economy for the makes and models of buses that were historically in the local bus fleet. However, as fuel use varies depending on the driving cycle, which includes the speed, frequency of stops, terrain, as well as the frequency of tune-ups, fuel economy for one make, model, and year of bus might vary considerably from one locality to another. To gain some insight into the appropriate adjustment factor, one could conduct current fuel economy tests in both the locality of the historical data source as well as the locality for which the baseline is being developed.

Both of the proxy methods described above for ascertaining "historical" fuel economy of a bus fleet require that at least the precise makeup of the fleet be known historically. If the historical composition of the local bus fleet is unknown, then the only possibility left is to use the historical average bus fuel economy for a place where the bus system is known to have similar fuel use characteristics. This is clearly the least desirable estimation method for the baseline as it leads to the greatest uncertainty.

4.2.1 Estimating the bus baseline

Once the historical trend is estimated, the trend line should be carried forward. The main extenuating circumstance that may make this methodology inaccurate for a particular locality would be an existing plan to significantly change the bus fleet composition in the near future. An example of such a plan would be if a locality were planning to introduce alternatively fuelled or hybrid buses into the fleet. If a plan such as this were in place in the baseline locality, then this plan would need to become part of the baseline, and the baseline determination method would become slightly more complex.

One question that seems logical to ask here is why, if it is possible to reconstruct the historical fuel efficiency of buses from current fuel economy measurements, and if there are plans that indicate what the

bus fleet will be in the future, can't you use the same method to construct the future trajectory of bus fuel economy for a fleet? The answer is that you can, and this would be a subsector technical baseline. However, there is a difference between the two types of baselines in the incentives. The bus company, which has an incentive under the CDM to do what it can so that the baseline is overestimated, could easily tell you that they have no plans to buy more efficient buses or alternatively fuelled ones even if they do have such plans. Although the trendline from the historical data may not really indicate what will happen in the future very precisely, using it avoids the incentive problems that arise when asking bus company decisionmakers what their future plans are for the purpose of creating a baseline. As a rule, when historical data is available or possible to construct and there is no publicised plan by the bus company to introduce lower greenhouse gas emitting buses, then a subsector historical baseline should be used.

There are a number of possibilities for setting the timeline of the baseline. Historical baselines might have their timelines set by estimating how long it will be until significant technological change in vehicle technologies would have taken place. Alternatively, if the project replaces some technology, an estimate of the lifetime of the technology could be used as the timeline for the baseline. In this instance, the timeline of the baseline would be tied to the specific project activity.

4.2.2 Projects that could use this baseline and their characteristics

Although this report mainly focuses on baselines and not projects, it is important to understand the full scope of projects that could use the various types of baselines in order to fully appreciate the standardised baseline methodology laid out here. This section of the report identifies three project types that could make use of a baseline for public bus emissions and discusses their respective measurement and implementation challenges.

There are two main ways to improve the efficiency of a bus system. The first is to reduce the greenhouse gas emissions per kilometre of the buses themselves through bus technology changes. The second is to increase the usage level of the bus system, thereby allowing it to substitute for higher-emitting transportation services. Of the three projects that would use the bus baseline, the latter two fall into the second category.

A project to directly reduce greenhouse gas emissions from bus tailpipes would be to replace diesel engines with compressed natural gas (CNG) or hybrid electric power systems. This type of bus technology project would use the baseline described above in a straightforward manner. Measurements of bus fuel efficiency and greenhouse gas emissions would be taken using a methodology identical to that of the baseline development. These would be compared directly to the baseline in order to calculate the CERs or ERUs earned by the project. One thing that makes this particular type of project special is that there is no reason to expect any negative spillover or interaction effects to result. This means that it is truly feasible to use the simple baseline described here without modifications. There is one AIJ project that falls into this category that is being implemented in the Czech Republic. For the AIJ project, the estimate is between USD 100 and USD 250 per ton of carbon dioxide (UNFCCC, 2000).

The second and third types of projects directly affect bus ridership rather than tailpipe greenhouse gas emissions per bus kilometre travelled. These are mode-shifting projects, moving travellers from other modes into buses. While these types of projects do not affect the emissions per *bus* kilometre, the emissions per *person* kilometre are affected. Projects that would fall into the second category include anything that will make buses a cheaper, more convenient, reliable, safe, and/or comfortable way to travel. Some specific examples are reduced fares, safe and well-lit bus stops with protection from bad weather, improved route design with rights of way for buses so that they do not get stuck in traffic and can be more reliable, and more comfortable seats. The third type of project is one that offers targeted disincentives to use transport modes that are particularly greenhouse gas intensive. An example of such a project might be

tolls for cars on routes that parallel bus lines. These projects would be able to use the baseline outlined above with one modification: it needs to be expressed in terms of emissions per person kilometre travelled rather than per vehicle kilometre travelled.

4.2.3 Historical baseline modification to allow mode-shifting projects

To modify the baseline to allow mode-shifting projects (in which travel is shifted from one mode to another as a result of the project), the baseline developers would need to collect bus occupancy data in addition to the fuel economy information. Data on average bus occupancy is usually collected by directly counting the number of people riding the buses at various locations and times throughout a region. The following equation illustrates exactly how the bus fuel efficiency figure (the first term) can be combined with bus occupancy figures (the second term) to obtain the baseline in terms of emissions per person kilometre.

$$\frac{emissions}{bus \cdot kilometre} \times \frac{bus}{persons} = \frac{emissions}{person \cdot kilometre}$$

If bus service is made more efficient by increasing the number of passengers on buses relative to the baseline, it is clear that the project has had an effect. The bus baseline described above of emissions per person-kilometre can be used to ascertain whether the additionality of the project is positive, but not to actually calculate credits. The amount by which net emissions have dropped is jointly dependent on the number of bus riders who would not have been riding the bus in the baseline scenario and the transport modes that they would be using if they weren't on the buses. Some of these bus riders would have been driving their cars, but others would have been riding their bicycles or walking. The would-be drivers are generating real emission reductions, but those who would be creating no emissions in the baseline world are not. The most direct way to obtain this information is to ask the bus riders themselves via a simple survey. The survey could consist of as few as four questions. The following is a sample survey that could be used to collect the necessary data.

1. Do you ride the bus regularly? If yes, continue to number 2.

2. If [description of the project] had not been done, would you ride the bus regularly? If no, continue to number 3.

3. If you weren't riding the bus now, would you be making this trip? If so, how?

    Choices: private car, carpool, train, van, taxi, scooter, motorcycle, bicycle, walk, no trip, other

4. How long do you spend on the bus each day?

Conducting a survey like this one would yield information about how far those bus riders who would not be riding the bus in the baseline scenario travel and what their alternative transport mode would be if they were not riding the bus. Putting this information together with estimates of the greenhouse gas emissions per kilometre for various alternative transport modes, total emissions actually reduced can be calculated.

While this process sounds complex, it may turn out to be quite cost-effective to put into practice, especially if a number of initiatives are co-ordinated to make the buses truly more attractive than more greenhouse gas intensive modes of transport. For instance, an investor could fund technological improvements to the buses that lower greenhouse gas emissions per kilometre as well as improving bus user comfort by installing cushioned seats on buses and providing for protected and well-lit bus stops. If the investor

worked with the regional government to gain better rights of way for buses and implement disincentives for private vehicle use on bus routes, the emission reductions could be even larger.

While this survey method may be the one that is most precise – there is no other way to obtain the needed information – it does present some risk of gaming. Data from surveys is relatively easy to bias in one direction or another, and emission reductions could be easily overestimated by claiming that most of the new riders on their bus system would otherwise be driving cars or motorcycles. However, with a relatively low level of oversight, this overestimation would not be very large. The reason for this is that the numbers that represent the results of this survey procedure are expressed in easily identifiable percentage of new riders that would be using each of the other modes. A simple monitoring rule could dictate that any time the car or motorcycle percentage is above a certain cutoff for this type of baseline, the transport CDM and JI project monitors would look more carefully at the details of the situation.

Alternatively, a simple guideline based on historical mode shares could be used. Specifically, the new bus riders could be assumed to be drawn from the population in the same proportions as the mode shares. For example, if walking comprised 50% of trips that year, then the assumption would be that 50% of the new riders used to walk; if 5% of trips are in private vehicles, then 5% of new bus riders are assumed to be replacing car trips. While this simple guideline does not attempt to reflect what is actually happening, it does avoid the spectre of gaming and the resulting emissions estimates may not be far off.

Note on organised carsharing as a CDM or JI project

Cars serve a unique purpose for personal transport all over the world. They provide door-to-door transport service (provided that there is a road) for passengers and some cargo in a weather-protected vehicle. The versatility, comfort, and convenience of travelling by car are unrivalled in most parts of the world. Unfortunately, at current average occupancies, cars are also the least efficient way per person-kilometre to get around in most places in terms of energy use and greenhouse gas emissions. Cars also contribute substantially to local air pollution and noise pollution in many urban areas around the world.

One reason that cars are used even in cases where other convenient transport options are available is economic. While cars are expensive, most of the cost of the average car is fixed rather than variable. In the United States, this figure was a whopping 80% in 1996 (USBTS 1999). This means that 80% of the cost of car transport was tied to having the car and *not* to how much it was used. In parts of the world where fuel prices are higher, this percentage is somewhat lower, but the basic problem remains. Because of this, people who choose to purchase a car have a strong financial incentive to use that car for all of their transport needs. They have already paid the fixed costs and the variable costs of car use are usually lower than those of existing transport alternatives. It is largely for this reason, along with the added convenience, that once people own cars, it is extremely difficult to induce them to travel using other modes.

Without reducing the rate of car ownership growth in developing countries and actually reducing car ownership in more developed areas, it will be extremely difficult to obtain substantial reductions in greenhouse gases from ground transportation.

Organised carsharing offers a way out of this dilemma. Organised carsharing is a system where all of the costs of car ownership – fixed *and* variable – are split among many individuals according to their usage. Each participating individual pays a small membership fee and can then reserve and use the car, paying by the hour and the kilometre travelled. This effectively converts the entire cost of car use (with the exception of the membership fee) into variable cost. Mechanisms for gaining access to shared vehicles and recording hours used and kilometres travelled vary in technological complexity, but the economics of the set-up are the same everywhere. Organised carsharing allows other modes of transport to compete on a level playing

field with cars, providing access to cars for more people but economically limiting car use by making the majority of the cost variable.

Because of this, carsharing organisations might be the crucial missing link for creating sustainable transport systems in the long run in developing countries (as well as in industrialised countries). That is to say, with carsharing, use of public transit, bicycles, and walking will also remain high as countries grow and develop. Without carsharing, however, it seems almost inevitable that in all but the largest cities, car ownership will rise sharply with incomes. Despite being promising, there are three reasons why carsharing might be a controversial CDM or JI project.

First, there is a question as to whether carsharing would actually reduce emissions. In fact, there is reason to believe that in the short run, carsharing may actually *increase* people's driving in a developing country setting where most people do not own cars. Although this may contribute positively to their quality of life, greenhouse gas emissions in the short term may go up rather than down relative to a non-carsharing baseline.

Second, separating the greenhouse gas emission reduction impact of a carsharing project from other activities going on in a locality would be nearly impossible. Determining a baseline for a carsharing project would be challenging because carsharing will have spillover effects throughout the transport system. One possibility is to start a carsharing organisation as one aspect of a larger package of policies and investments to reduce greenhouse gas emissions from transport in a locality, and then use a regional baseline to calculate credits earned.

The third aspect of carsharing that may make it a controversial CDM or JI project for some is that in the long run, carsharing is likely to be a profitable activity. Some would argue that profitable activities are by definition not additional to what would have happened otherwise and should not be eligible to receive CERs or ERUs under the CDM or the JI mechanisms. In the case of carsharing, this is easily countered by observing that organised carsharing is not widespread in developing countries and economies in transition. This must mean that, even though this activity may be profitable eventually, the risk involved with this investment is high enough that carsharing organisations are not springing up everywhere. Allowing carsharing projects to receive any credits that they earn for a limited time seems to be a fair trade for the apparent start-up risk involved with this activity.

The example of carsharing was chosen because it demonstrates a number of important points:

- Carsharing provides an example of one way in which the whole paradigm of the personal transport sector could be changed, particularly in developing countries.

- It is extremely difficult to predict the effect that certain types of projects will have on the greenhouse gas emissions in the transport sector. In the case of carsharing, analysts are not even sure the sign of the effect. Interestingly, this tremendous uncertainty does not mean that the effect will necessarily be small.

Carsharing provides a case-in-point for the attractiveness of regional baselines for transport projects. In the case of carsharing, regional baselines avoid the necessity of disentangling the effect of the carsharing program from the effects of complementary projects such as improved transit service and a feebate program for fuel efficient vehicles.

4.3   Creating a regional baseline

Regional baselines are can be based on projections of the transport sector's greenhouse gas emissions per capita for a region. Projects using regional baselines are expected to be larger-scale projects, with packages of specific investments and policies coming together to transform the transportation systems of whole regions. The most significant advantage to the regional baseline approach is that any and all activities in the region, whether their individual effects are measured or not, are included in this baseline. This means that most spillover and interaction effects between project activities do not affect the accuracy of the CERs that a project using a regional baseline will receive (with the notable exception of those effects that are inter-regional). This fact makes it possible to take full advantage of positive synergies between individual actions within the sector. In addition, the opportunities for gaming are largely removed because the data sources used for the baseline are entirely public.

The drawback to regional baselines is high uncertainty. It is extremely hard to predict what might happen even in the greenhouse gas emissions of the public bus system over ten or fifteen years, never mind what the greenhouse gas emissions of the transport system of a whole region might be! This high uncertainty in baselines leads to a higher likelihood that projects using regional baselines may not produce real emission reductions from that baseline. That is, it may be that only very large projects will be able to push the emissions from a whole region out of the uncertainty margins of the baseline. However, there are some types of policy projects that are very promising in terms of the greenhouse gas emission reductions that they might produce, but simply cannot be implemented using baselines for transport subsectors.

4.3.1   Building a single region transport baseline

A single region transport baseline can be built from the bottom up using current data plus local experts' opinions on what changes may occur in these data pieces in the future for forecasting. A basic methodology for calculating emissions from the transport sector is known as the ASIF methodology (Schipper et. al. 2000). The acronym ASIF stands for the Activity-Structure-Intensity-Fuel data matrix.

The basic ASIF equation is the following:

$$G = \sum_{mode}\sum_{fuel} A_{m,f} \times S_{m,f} \times I_{m,f} \times F_f$$

where: **G** is the total emissions of greenhouse gases in the region
A represents activity in passenger- and tonne-kilometres
S is the structure variable that represents the load factors for the various modes and fuel types, i.e. occupancy of passenger vehicles and an equivalent measure for freight
I measures energy intensity in energy per vehicle kilometre for each mode and fuel type
F is a simple carbon per energy constant for each fuel type

This formula is rather straightforward, but actually calculating carbon dioxide emissions for a region using this equation is difficult due to its high data requirements. Of the pieces of data implied by this equation, only the last two are possible to calculate from relatively simple technical field tests. Activity, modal share, and occupancy data are more challenging to estimate. Sometimes, a city has completed a recent comprehensive travel survey in which much of this information can be found. If this is the case, then a reliable base year estimate can be calculated. If the baseline developer is particularly fortunate, the city has completed a comparable series of travel surveys that can be used to create a regional historical trend for carbon dioxide emissions from transport. This trend can then be continued forward to create the forecast. In the more common case where only one base year of regional emissions data is available, baseline

developers must make educated guesses about the future changes in the various elements of the ASIF equation in order to create a forecast.

In a situation where no travel survey has been completed recently in a city, baseline developers have a choice between using another type of baseline, conducting their own travel survey, or abandoning the project. The next section describes a type of regional baseline that is somewhat less data intensive.

4.3.2 Toward a worldwide regional baseline

Transportation energy use data from the International Energy Agency indicates that on a macro scale, fuel use and greenhouse gas emissions from transport rise linearly with global Gross Domestic Product (GDP) (IEA 2000c). However, city level data indicate that this relationship is more complex and that Gross City Product (GCP) is probably not as good a predictor, especially when one is trying to predict per capita rather than total emissions.

Figure 2: **Carbon dioxide emissions per capita from transport – worldwide cities regression**
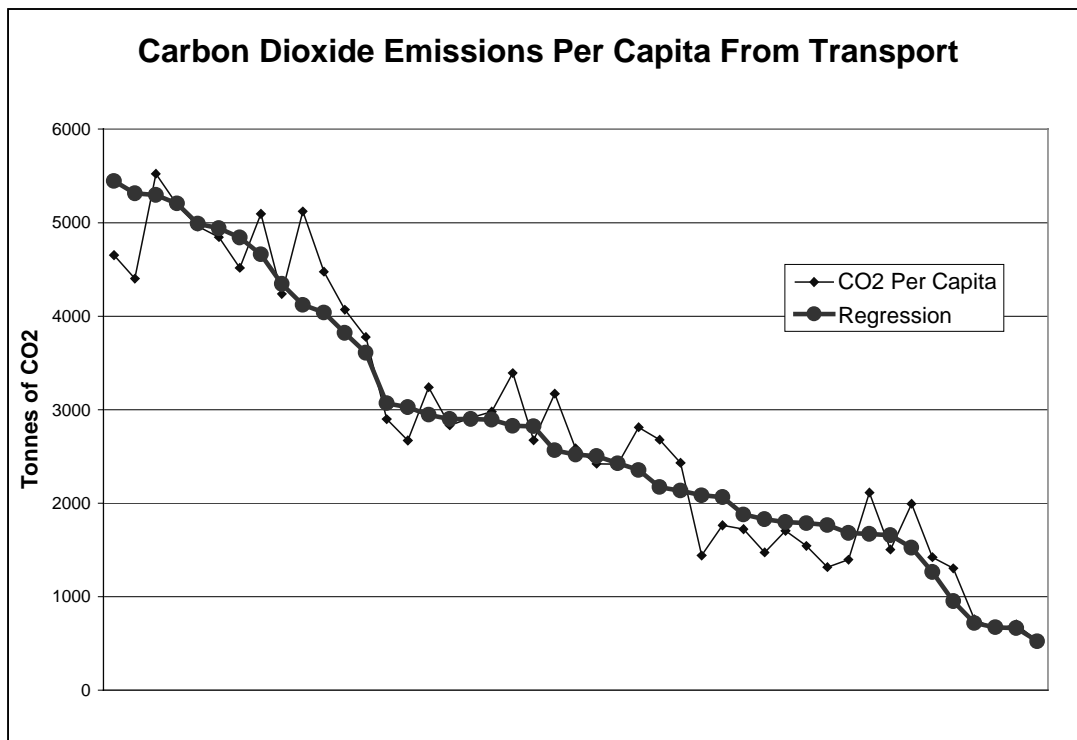
Since many CDM and JI projects in the transport sector are likely to be local in scale, we looked more closely at city level data in an attempt to identify the drivers of greenhouse gas emissions from transport. Using 1990 data from 46 cities worldwide including Gross City Product per capita, transit service level, population density, gas price, and carbon dioxide emissions per capita from transport, a multivariate regression analysis was performed (see Figure 2 and Table 1). The objective of this regression was to try to form the beginnings of a predictive model of city-level transportation greenhouse gas emissions, useful for two reasons. The first is that if causes for changes in greenhouse gas emissions from transport could be identified, then policies to reduce greenhouse gases from the sector could be made with more confidence in their effectiveness. The second is that this pattern identified in the regression analysis could be used as a regional baseline for the entire transport sector in the region, allowing regional packages of policy and

investment to be CDM or JI projects. The problem of needing to account for interaction and spillover effects of individual projects disappears because the emissions from the transport sector of the whole region would be counted as a single big project.

The regression analysis produced extremely promising results. The model fits the data well – the R-squared statistic is 0.89 for the model using only the developed city data and 0.94 for the model that uses the full data set.[13] If this same level of fit could be obtained with additional data, it is possible that this level of precision could be sufficient for use as a worldwide regional baseline.

This would mean that any city that wished to do a citywide project could use the "slope" coefficients from this type of regression to project its total carbon dioxide emissions from transport forward. Creating a regional baseline would consist of three steps:

1. collecting data on the agreed-upon parameters using standardised data collection methods

2. adding this data to the regression (or substituting it for old data if the city was already in the data set) and obtaining slope coefficients

3. adding a correction factor to the regression constant to force the regression line to pass directly through the carbon dioxide emissions per capita of the city

While this process is certainly not costless, it is likely to be considerably cheaper and easier than collecting the necessary data for the full single-region regional baseline.

If this baseline generation technique were refined, it would be a very powerful tool for ascertaining the relationships between different pieces of the transport sector and its greenhouse gas emissions. Whether or not regional baselines are used for CDM and JI transport projects, having a better understanding of these relationships would make all projects more effective in reducing greenhouse gas emissions at low cost and the project-based mechanisms would become more viable for transport projects.

4.3.3 Multivariate analysis for regional baseline demonstration

A multivariate analysis was performed to explain per capita carbon dioxide emissions from the transport sector in cities around the world. The analysis presented here is meant to be an early example of what a regional baseline might look like. The premise is that it is possible to explain per capita carbon dioxide emissions from transport at a city level using a small number of socio-economic and policy variables, and that this relationship is invariant to where in the world the city is located. Assuming no breakthrough technological changes in transport provision, the cross-sectional trend result is therefore representative of the time trend for a single city. This trend can be used as the basis for a standardised regional baseline all over the world.

The variables included in the analysis are carbon dioxide emissions per capita from transport, metropolitan area population density, Gross City Product (GCP) per capita, number of vehicle kilometres of transit service provided per capita, and the gasoline price at the pump. With the exception of the price of gasoline, the data for all of these variables were found in Kenworthy and Laube (1999). Gasoline price data were compiled from a number of additional sources (AIP 1992, APEC 2000, Hong Kong Census 1991, IEA 1991, USEIA 1991, and USEIA 1992).

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[13] There were not enough developing cities in the data set to warrant a regression based only on developing city data.

The data set includes complete 1990 city-level information for 36 cities, 29 of them developed and 7 of them developing. Incomplete information is available for an additional 10 developed cities, with the missing data being either the GCP per capita or the local gasoline price. As both of these pieces of data were available either for similar cities within the same country or at a national level, the missing data were filled in using these data as proxies. As shown below, the results were similar.

Table 1: **Multivariate regression results**

	Model A	Model B	Model C
sample size	29 cities	39 cities	46 cities
ln population density	-0.205 (3.015)	-0.219 (-3.988)	-0.254 (-4.329)
ln transit service	-0.138 (-1.976)	-0.136 (-2.336)	-0.154 (-2.525)
ln GCP per capita	0.330 (2.716)	0.304 (2.883)	0.417 (6.757)
ln gasoline price	-0.584 (-4.366)	-0.575 (-5.058)	-0.507 (-4.509)
ln population density (developing cities)	N/A	N/A	-0.361 (-2.843)
ln transit service (developing cities)	N/A	N/A	0.420 (3.318)
constant	6.212 (5.073)	6.519 (6.180)	5.506 (8.023)
adjusted R^2 statistic	0.8755	0.8870	0.9382

As is clear from the table, the level of fit of the data to the regression line is impressive. All three models presented here were estimated using the technique of ordinary least squares. T-statistics for each estimated coefficient are given in parentheses. These statistics indicate that all of the coefficients listed in Table 1 are significant. The functional form chosen for the estimation is such that the each estimated coefficient on an independent variable represents the elasticity of per capita carbon dioxide emissions with respect to that variable.[14] This means that the functional form used here constrains these elasticities to be constant over the entire range of the data set. This assumption may or may not be a valid one to make. Relaxing this assumption by estimating these parameters using a more general functional form is one area for future work.

Model A is based on those developed cities for which complete information was available. Model B is estimated using data from all of the developed cities, including the 10 cities that were missing either GCP per capita and/or gasoline price data. Model C is estimated using both developed and developing city data. In this last model, the constants for the two types of cities are separated by a dummy variable on the developing cities. This was done because it is thought that there might be a difference between developed and developing cities that is not otherwise captured by the data.

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[14] In Model C, to obtain the elasticities of carbon dioxide emissions per capita with respect to transit service and population density in developing cities, it is necessary to add the developing cities coefficient to the coefficient estimated in that model for the whole data set.

As with almost all such models, there are some reasons to be sceptical of these results. The main weak points of this model are:

- the low number of developing cities in the data set,

- reasons to believe that certain of the variables may be measured with error, and

- the high degree of correlation that exists between some of the independent variables.

As for the first weakness, this model should definitely be estimated again with more developing city data. The results presented here are quite strong for developed cities, but it remains to be seen whether similar patterns can be found among the developing cities which are the main focus of this baselines work.

Potential error in the measurement of per capita carbon dioxide emissions from transport, city population density, and GCP per capita is the second weak point in this data set. City population density varies greatly depending on where city boundaries are drawn. Perhaps there is a measure of density that would avoid this problem such as the land area in each city where the most densely packed one million people live. Unfortunately, this alternative measure was not readily available at the time that this report was being written. As for carbon dioxide emissions from transport and GCP per capita, it is expected that there is some measurement error simply because these two variables are extremely difficult to measure accurately. They cannot be directly measured, and therefore one must rely on calculating these statistics based on various related variables.

The last cause for concern is the high degree of correlation that exists between some of the independent variables. Particularly between the variables of gasoline price and transit service, the correlation is extremely high – 0.74. This makes sense because both of these variables indicate some concern in the area about reducing fuel use. People who live in areas where gasoline prices are extremely high are likely to demand more transit service than people who live in areas of low gasoline prices. Despite this high degree of correlation, as all of the coefficients of regression are estimated with high significance, this multicollinearity may not be a serious problem.

5. Conclusions and recommendations

The prospect of transport CDM and JI projects presents a sort of paradox. Transport is the fastest growing fossil fuel using sector in the world. Many transport infrastructure investments are very expensive and, once made, are extremely long-lived. Transport behaviour patterns are similarly difficult to change, especially after a population begins to rely on private vehicles for a large portion of its transport needs. In many parts of the world, the infrastructure investments have not yet been made and people generally use low greenhouse gas emitting modes of transport. However, if substantial effort is not made to upgrade public transport systems and to continue to encourage other climate friendly ways of getting around, people will begin to turn to the more greenhouse gas intensive modes as they get wealthier.

The project-based mechanisms in the Kyoto Protocol present an opportunity to influence the evolution of the transport sectors in these regions to the benefit of both the users of the affected transport systems and the global climate. Unfortunately, there are some significant hurdles that must be cleared before transport sector CDM and JI projects can move forward.

Probably the largest obstacle to CDM and JI projects in the transport sector is that the effect on greenhouse gas emissions of most potential policies and investments are not known with certainty. Although many initiatives have been put into place with the intention of reducing (or reducing growth in) greenhouse gas emissions from the transport sector, baselines for these initiatives were not usually prepared, and the actual greenhouse gas emission reductions compared to the baseline scenario were not measured. This uncertainty lends a high level of risk to a CDM or JI investment due to the uncertainty regarding the actual reductions that will result. However, it seems likely that certain projects may be profitable for investors should a market value be associated with reductions in greenhouse gas emissions. Whether a CDM or JI transport project goes ahead will depend critically on two currently unknown factors: whether a clear baseline can be constructed against which the transport project effects can be measured, and the price of a greenhouse gas credit on the market.

It also seems likely that transport projects with more significant results tend to be either policy-based or to have high start-up costs. The problem is exacerbated in that emission reductions from these projects are spread over long time periods. Infrastructure investments made today are expensive, but can last for decades, and policies may be expensive to draw up and to change, but their emission reducing effects often increase over time. The long term results of such projects mitigate against private sector investment – which commonly uses a discount rate of approximately 20%. For a limited set of transport projects such as bus technology projects, short-term greenhouse gas emission reduction credits may be sufficient to justify the project financially, especially when ancillary benefits such as local pollution reduction and reduced fuel costs are taken into consideration. However, a large portion of the potentially climate-friendly transport projects would not be financially justifiable in the short term.

In light of these obstacles, two paths that can be taken, and it is recommended that both be pursued simultaneously. The first is to begin implementing investment projects that appear to be good investments in the short term such as alternative technology fleet projects as well as low-cost policy projects. The second is to work toward removing obstacles that currently stand in the way of larger scale and longer-term projects, including the uncertainty in how emissions credits will be awarded.

Baseline development is the first step toward identifying CDM and JI projects in transport that can work. For all projects, standardised baselines will be important to ensure the transparency of the baselines as well as to keep the cost of baseline development as low as possible. This report has laid out a general framework for baseline standardisation for transport sector CDM and JI projects. While baseline-setting in the transport sector is admittedly difficult, it can be done and the long run payoff in terms of both climate

and sustainable development of transport systems could be large. Actually beginning to implement projects under a framework such as this one will not only reduce some emissions directly due to the projects that are implemented, but will also give transportation planners all over the world better information about the real emissions changes that are or are not being caused by specific activities. Due to the initial lack of experience with baseline setting and evaluating the effects of specific actions in this sector, it is expected that there will be some projects that receive more credits than they deserve and others that receive fewer. Based on this experience, however, baseline standardisation protocols can be improved and these start-up problems should dissipate.

5.1 Future work

There is a long way to go between where this report ends and where a "how-to" manual for creating standardised baselines for CDM and JI transport projects begins. This work suggests a number of different elements that will need to be pursued to provide a more reliable set of transport-related baselines for CDM and JI projects, including:

- further development of specific baseline/project examples such as the freight logistics example mentioned earlier in this report,

- cost analysis, both for baseline development and for actual project implementation,

- development of specific recommendations for data needs for different types of baselines, and

- further work to develop usable regional baselines.

This work would have clear applications not only for CDM and JI projects, but also for countries that are implementing policies or making investments to reduce greenhouse gas emissions from their transportation sectors.

Glossary

additive (or extender)	material(s) added to clinker to make cement
AEEI	autonomous energy efficiency improvement
AIJ	activities implemented jointly
AIXG	Annex I Experts Group on the United Nations Framework Convention on Climate Change (UNFCCC)
audit-based programmes	Programmes that rely on the systematic collection of data on building and energy system performance characteristics at the customer site. The goal of these programmes is typically to identify and quantify energy efficiency improvement opportunities in combination with an implementation plan.
baseload	The minimum amount of electric power delivered or required over a given period of time at a steady rate.
BAU	business as usual
bench tests	Tests of equipment performance characteristics conducted in a controlled environment such as a laboratory or manufacturer's test facility.
BF	blast furnace
blast furnace slag	One of the common additives used in cement. It is the by-product of iron and steel manufacture and grinding this additive for use in cement is energy intensive.
BOF	basic oxygen furnace
CDM	Clean Development Mechanism (project-based mechanism introduced in Article 12 of the Kyoto Protocol)
CFL	compact fluorescent lamp
CH_4	Methane
CHP	Combined heat and power. A plant that is designed to produce both heat and electricity
cli	Clinker
clinker	The key component of cement and the most GHG-intensive.
CO	coke oven
CO_2	carbon dioxide
combined cycle	An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. This process increases the efficiency of the electric generating unit.

conversion efficiency	Efficiency at which a thermal power plant converts input fossil fuel (*i.e.* coal, gas, or oil) into electricity.
crediting lifetime	Length of time (in years) during which a project can generate emission credits.
demand-side management (DSM)	Utility programmes designed to control, limit or alter Energy consumption by the end user. DSM objectives may include energy conservation, load management, fuel substitution and load building.
diversity factor	The ratio of the peak demand of a population of energy-consuming equipment to the sum of the non-coincident peak demands of the individual equipment.
DR	direct reduction
DRI	direct reduced iron
dry process	A process whereby the raw materials for cement production are ground and then mixed (as a dry powder).
EAF	electric arc furnace
EEI	energy efficiency index
EIT	countries with economies in transition
EJ	exajoule (= 10^{18} Joule)
emission credits	Unit used for the measurement (*e.g.* in tonnes of CO_2-equivalent), transfer and acquisition of emission reductions associated with JI and CDM projects.
end-use indices (EUI)	The ratio of the energy use of a building, system or end-use over a given time period to a commonly recognised index of size or capacity. Examples include lighting energy use per square foot of floor area and motor energy use per unit of production output.
environmental credibility	Quality of a baseline with respect to realistically reflecting the emission level that would likely occur without the JI or CDM project(s).
environmental effectiveness	Extent to which the project-based mechanisms result in maximum emission reductions and maximum participation through JI and CDM projects, thereby contributing to achieving the objectives of the Kyoto Protocol.
EU or EU15	The 15 members states of the EU.
fluorescent lamps	A discharge lamp whereby a phosphor coating transforms ultraviolet light into visible light. Fluorescent lamps require a ballast that controls the starting and operation of the lamp.

free riding	A situation whereby a project generates emission credits, even though it is believed that the same project would have gone ahead, even in the absence of JI or CDM. The emission reductions claimed by the project would thus not really be "additional". Free riding therefore affects the number of projects obtaining credits under JI and CDM.
gaming	Actions or assumptions taken by the project developer and/or project host that would artificially inflate the baseline and therefore the emission reductions. Gaming therefore affects the amount of emission credits claimed by a JI or CDM project.
GHG	greenhouse gas
GJ	gigajoule (= 10^9 Joule)
greenfield projects	New projects (as opposed to existing plants that are refurbished)
grid	The layout of an electrical distribution system.
GWh	gigawatt hour, *i.e.* 10^9 Wh.
GWP	global warming potential
hp	horsepower
HPS	High pressure sodium lamps.
HVAC	Mechanical heating, ventilating and air-conditioning of buildings.
IEA	International Energy Agency
incandescent lamps	A lamp that produces visible light by heating a filament to incandescence by an electric current.
ISP	integrated steel plant
JI	Joint implementation (project-based mechanism introduced in article 6 of the Kyoto Protocol).
kWh$_e$	kilowatt hours of electricity use
leakage	Leakage occurs if actual emission reductions (or sink enhancements) from a CDM or JI project lead to increases in emissions (or sink decreasing) elsewhere.
load curve	A plot of the demand placed on an energy system during an hour, day, year or other specified time period.
load factor	Number of hours in a year during which a power plant is generating electricity.
market segment	A segment of a customer or end-user market identified by common demographic, firmographic or energy use characteristics. Examples include the single-family detached home segment in the residential sector; and the office building segment in the commercial sector.

MJ	megajoule (= 10^6 Joule)
Mt	million metric tons
mtoe	million tons of oil equivalent
multi-project baselines	Emission baselines (also referred to as "benchmarks" or "activity standards" in the literature) that can be applied to a number of similar projects, *e.g.* to all electricity generation CDM or JI projects in the same country.
nameplate data	Data provided by equipment manufacturers that identify the make, model and performance characteristics of the equipment. These data are published in the manufacturer's product literature and key data elements are affixed to the equipment on the nameplate. Often the equipment nameplate itself does not provide sufficient information for energy analysis.
N_2O	nitrous oxide
OECD	Organisation for Economic Co-operation and Development
off-peak load	The demand that occurs during the time period when the load is not at or near the maximum demand.
OHF	open hearth furnace
peak load	The maximum demand or load over a stated period of time. The peak load may be stated by category or period such as annual system peak, customer class peak, or daily peak.
peaking plants	Power plants normally reserved for operation during the hours of highest daily, weekly, or seasonal loads.
PJ	petajoule (= 10^{15} Joule)
PJe	petajoules electricity
PJp	petajoules calculated back to primary energy
PJf	petajoules final energy
Pozzolana	A natural cementious material that can be ground and used as a cement additive.
Process emissions	For cement production this refers to the CO_2 emitted from decarbonisation of limestone. It takes place during the pyro-processing step.
Production process change	Refurbishment of an existing plant that would change the process by which clinker is manufactured to a more efficient process (*e.g.* wet to dry, or semi-dry to dry)
Pyro-processing	This is the process of turning the raw materials into clinker (and takes place in the cement kiln).
Refurbishment projects	Projects in which existing equipment/processes are upgraded or replaced.

rpm	revs per minute
Run-time monitoring	Recording equipment or system runtime over a specific monitoring period. Often conducted with devices specifically designed for recording operating hours.
SAE	statistically adjusted engineering analysis
SEC	specific energy consumption
shaft kiln	The kiln, where clinker is produced, is vertical (whereas in other cement processes the kiln is slightly tilted, *e.g.* 1-3 degrees from the horizontal).
spot-watt measurements	One-time or instantaneous measurements of input wattage to a system or piece of equipment.
tcs	tonne of crude steel
thermal power plant	Power plants that burn fuel directly to produce steam.
TJ	terajoule (= 10^{12} Joule)
transaction costs	The costs associated with the process of obtaining JI or CDM recognition for a project and obtaining the resulting emission credits. Transaction costs would include, for example, costs of developing a baseline and assessing the "additionality" of a project, costs of obtaining host country approval, monitoring and reporting, *etc.* Transaction costs would not include the direct investment, maintenance and operational costs of the project.
UNFCCC	United Nations Framework Convention on Climate Change
update of baselines	Updating multi-project baselines, at regular intervals, in order to continue to reflect business-as-usual electricity investments. CDM or JI electricity projects would need to use the most recently updated multi-project baseline.
USAID	US Agency for International Development
USEA	US Energy Association
wet process	A process whereby the raw materials are ground, with water added, and mixed (as a slurry). The wet process is more energy-intensive than the dry process as energy is needed to evaporate the water in the raw material mix.

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