How can the Clean Development Mechanism contribute to better air quality?

Comment les Mécanismes de Développement Propre peuvent-ils contribuer à une meilleure qualité de l'air ?

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Abstract

Air pollutants and greenhouse gases are to a large extent emitted by the same sources, notably in the industry, transport and residential sectors. However, climate change mitigation is a global issue and is mostly driven by national and international policy. Local governments are in general more interested in improving urban air quality, which is posing serious health hazards across the globe. The Clean Development Mechanism (CDM) was designed to reduce greenhouse gas emissions, helping industrialised countries to achieve their targets under the Kyoto Protocol while contributing to sustainable development in developing countries. As of January 2009 over 4000 projects are in the pipeline.

The CDM could be used by local governments and the private sector to finance projects that contribute to both climate change mitigation and better air quality. However, CDM projects in particularly the transport sector face a number of barriers. We identify the most important issues for such projects, as well as the lessons learnt and some recommendations based on four case studies in Asian cities related to biofuels and bus rapid transit systems. The main conclusions is that successful implementation of CDM projects beneficial for urban air quality depends on the applicability of approved CDM methodologies, the strong cooperation between project developers and local authorities, and the availability of data.

Keywords

Urban air pollution. Synergies. Transport. CDM. Mitigation.

1. Introduction

Climate change and urban air pollution are two of the most outstanding environmental problems of this century. To a large extent, combustion of fossil fuel is the primary source of both greenhouse gases and air pollutants. Therefore, there are opportunities for synergies in policymaking to combat these environmental issues, under the condition to adequately take the differences into them. Urban air pollution is caused by emissions from local or regional sources, and its impacts are felt on the short term. Impacts of climate change will only be seen on long time scales (2nd half of this century and beyond) and greenhouse gases (GHGs) mix throughout the overall atmosphere. Global reduction of GHGs in the short to medium term is therefore required to mitigate it [IPCC, 2007]. The cost and benefits of air pollution reduction accrue to a large extent to the same actors, while the situation is radically different for climate change mitigation and impacts. Therefore, air pollution reduction is a policy priority for megacities in developing countries, while climate change mitigation is generally not.

The Clean Development Mechanism (CDM) is an international climate policy instrument that could benefit both. Designed to generate GHG emission reductions in developing countries that can be transferred to industrialised countries, while contributing to sustainable development in the host countries, it may provide a window of opportunity for financing projects (see Figure 1). In other words, CDM credits might contribute to both better air quality and climate change mitigation.

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Figure 1.
CDM and Air quality.

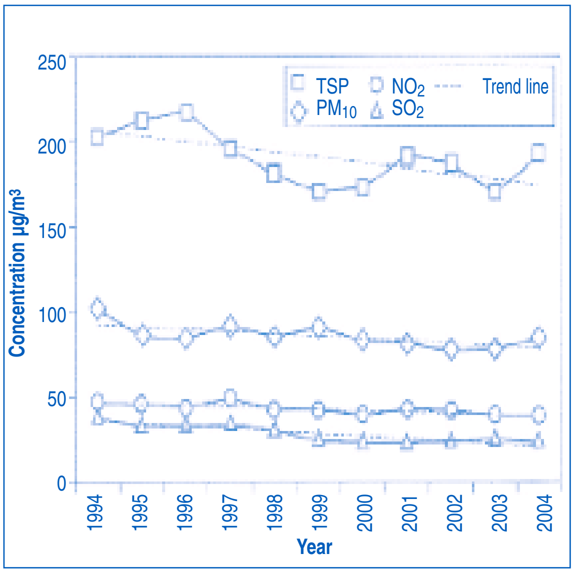

Figure 3.
Trends in air pollution in Asia.
Source: Schwela *et al.,* 2006.

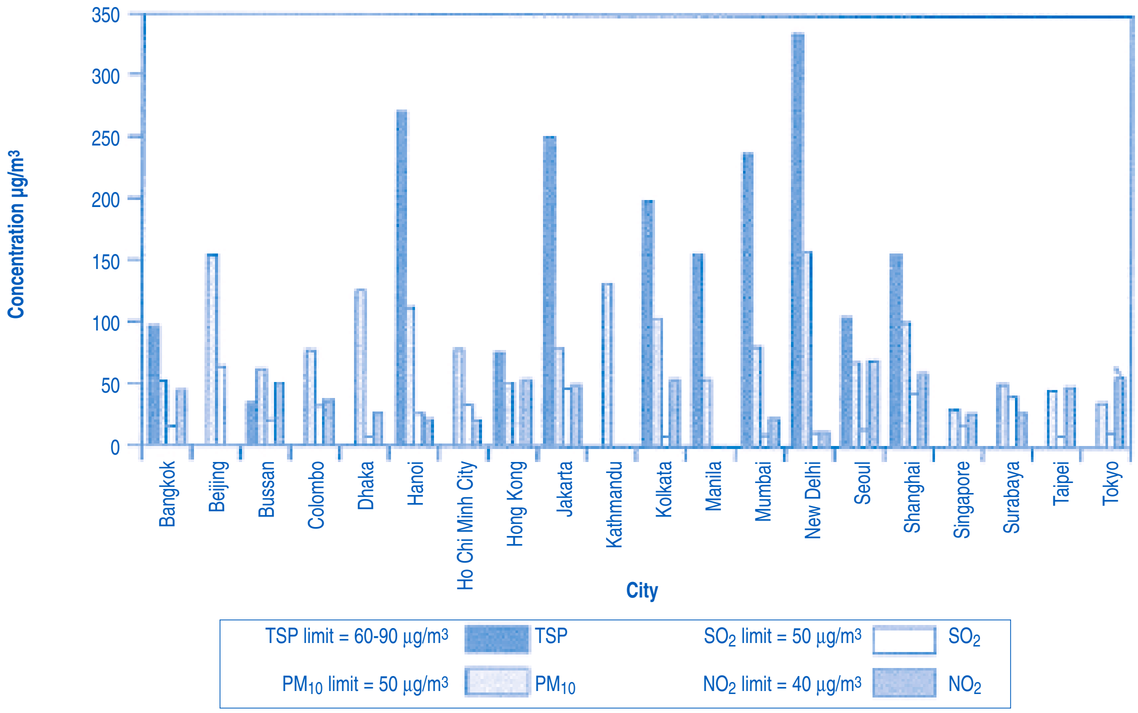

Figure 2.
Air pollution levels in 20 Asian cities in 2000-2004.
Source: Schwela *et al.* (2006).

This paper focuses on the question of how the CDM can be used to improve air quality in megacities. Section 2 deals with air quality, climate change and their interactions. Section 3 focuses on the functioning of the CDM. Section 4 gives lessons learnt from four cases studies in Asia and analyses the barriers and opportunities related to the use of the CDM for improving air quality, and proposes some policy recommendations. Section 5 gives a brief overall summary and conclusions.

2. Capturing synergies between air quality and climate policy

2.1. Air quality

Urban air pollution is a serious environmental risk in many Asian cities. It affects the health, well-being and life chances of each person, including the most vulnerable parts of population – women and children. Exposure to outdoor air pollution is estimated to be is responsible for an estimated 537,000 premature deaths annually with exposure to indoor smoke from solid fuels being responsible for almost double this number of deaths [WHO, 2002].

Air quality measures and policies in both developing and industrialised countries are generally focused on end-of-pipe technologies and emission standards for the industry and household sectors. In the transport sector, fuel quality specifications, engine technology standards and emission standards are common practice.

Schwela *et al.,* (2006) carried out an elaborate analysis of air quality status, policies, and management capabilities in 20 Asian cities. It appears that in most Asian cities, air pollution levels are higher than international standards for particulate matter and NO_2 (Figure 2). On the other hand, on average, a (slowly) decreasing trend is observed for most pollutants (see Figure 3), with the notable exception of ozone, the main substance causing urban smog.

2.2. Climate change mitigation

In order to prevent dangerous human intervention with the earth's climate, global greenhouse gas emissions need to peak before 2025. However, given the current energy and climate policies, GHG emissions are projected to grow over the next decades (IPCC, 2007). Most of this growth in emissions is likely to take place in developing countries. However, average emissions per capita in those countries are projected to be approximately 1/3 of industrialised countries per capita emissions in 2030.

As can be seen in Table 1, energy production is projected to remain the most important sector contributing to global GHG emissions. The transport sector will experience the strongest growth in emissions with 2% per year on average and is project to take almost one-fifth of emissions in 2030.

Compared to these baseline projections, there is a large potential for emission reductions. Globally, reductions in the range of 30 to 50% in 2030 by options up to 100 US$/t$CO_2$-eq are possible, and the largest potential for reductions is in developing countries, except for the transport sector.

2.3. Linkages: which technologies are synergistic?

Climate change and air pollution are to a large extent caused by different substances, with the notable exception of ozone and particulate matter [Amman *et al.,* 2008; Bakker *et al.,* 2004], which are however substances currently not covered by the Kyoto Protocol*. Moreover, the emission sources of CO_2, the main GHG, and air pollutants such as NO_x, SO_2 and particulate matter (PM) overlap to a large extent: the combustion of fossil fuels (see figure 4).

** However, many air pollutants such as NO_2 and volatile organic compounds have an indirect effect on greenhouse gas formation.*

Table 1.
Sectoral GHG emission distribution.

	2004 emissions		2030 baseline emissions		Average growth
	GtCO_2-eq/yr	%/yr	GtCO_2-eq/yr	%/yr	%/yr
Energy	12.7	27%	15.8	28%	0.8%
Transport	6.4	14%	10.6	19%	2.0%
Buildings	3.9	8%	5.9	10%	1.6%
Industry	9.5	21%	8.5	15%	– 0.4%
Agriculture	6.6	14%	8.3	15%	0.9%
LULUCF	5.8	13%	5.8	10%	0.0%
Waste	1.4	3%	2.1	4%	1.6%
Total	46		57		0.8%

Source: IPCC (2007).

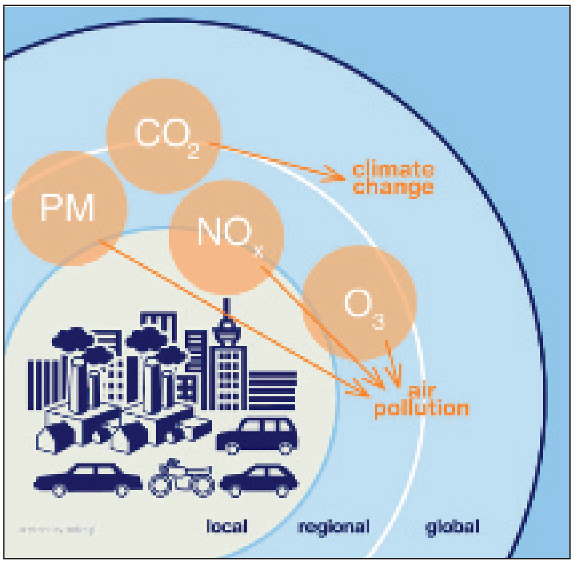

Figure 4.
Interlinkages of climate change and air pollution
Source: CURB-AIR project (www.curb-air.org).
Note: PM and O_3 also have an (uncertain) climate change impact.

Due to the overlap in emission sources, co-benefits from climate change mitigation options in terms of health benefits due to reduced health impacts can be substantial. In fact, they offset a large part of the cost [IPCC, 2007; Amman *et al.,* 2008]. In order to shed light on which options are synergistic, we analysed (sector-wise) air pollution reduction options on their ability of also reducing GHG emissions, based on Bakker *et al.,* (2004) and on a report on best practices in cities [Caldés *et al.,* 2007]. The list below aims to illustrate the variety of options available and is not an attempt to produce an exhaustive set of measures.

In most cities, the transportation sector takes the lion's share of the main air pollutants, but also appears the most difficult to address with appropriate policies. In general, it can be said that most measures, with the notable exception of tail-pipe emission abatement devices, also reduce GHGs. Fuel switch is not always synergetic. Most promising options are:

- Fuel switch from petrol/diesel to gas-based fuels.
- Fuel switch from petrol/diesel to (sustainable) biofuels (impact on air pollutants uncertain).
- Promotion of modal shifts thanks to public transportation policies, such as rapid bus systems.
- Traffic management, such as fly-overs, separated traffic lanes, or improved roads.
- Vehicle efficiency improvements.
- Vehicle policies, such as scrap programmes and technical control programmes.
- Fuel cell or hybrid/electric cars or two-wheelers.

One of the most effective measures to reduce urban air pollution from industry and power plants is relocation. The effect on GHG emissions is however nil. Flue gas treatment will reduce energy efficiency and thereby increase CO_2 emissions. Several synergetic measures applying to plants in or near urban areas exist:

- Fuel switch from coal to gas.
- Fuel switch from coal to biomass (reduces SO_2 emissions, and if the baseline is open biomass burning close to city, it also mitigates PM emissions).
- Energy efficiency measures.
- (Non biomass) renewable energy.
- Cleaner coal technology, such as integrated gasification combined cycle or CO_2 capture and storage (where air pollutants are reduced in addition to CO_2).

In the residential and service sector, several synergetic options also exist:

- Fuel switch from coal to gas in building heating (including district heating).
- Fuel switch from coal to (sustainable) biomass for heating/cooking.
- If the baseline biomass utilisation is unsustainable: fuel switch from biomass to gas in cooking stoves or heating.
- Improved cooking stoves.
- Renewable electricity (e.g. solar home systems).
- Energy efficiency measures such as efficient lighting.

3. CDM: capitalising on the synergies

3.1. Clean Development Mechanism

In 1997, the Kyoto Protocol was agreed by the UN Framework Convention on Climate Change. The Clean Development Mechanism (CDM) is a means for developed countries to achieve part of their target under the Kyoto Protocol by purchasing Certified Emission Reductions (CERs) from greenhouse gas reduction projects in developing countries. A prerequisite for a CDM project is that it must contribute to sustainable development in the host country. It is up to each host country government to decide and define their criteria for sustainable development. A UNFCCC body called the CDM Executive Board (EB) decides on the validity of the methodology for generating CERs of each project.

The CDM should contribute to the overall objective of the UNFCCC (preventing dangerous human interference with the climate system) and has a dual goal:

- To help industrialised countries in achieving their GHG target under the Protocol.
- To assist developing countries in achieving sustainable development.

The CDM offers an incentive for developing countries to implement climate-friendly projects. Project developers can implement such projects and sell the generated CERs to governments or companies in industrialised countries that face a shortage in emis-

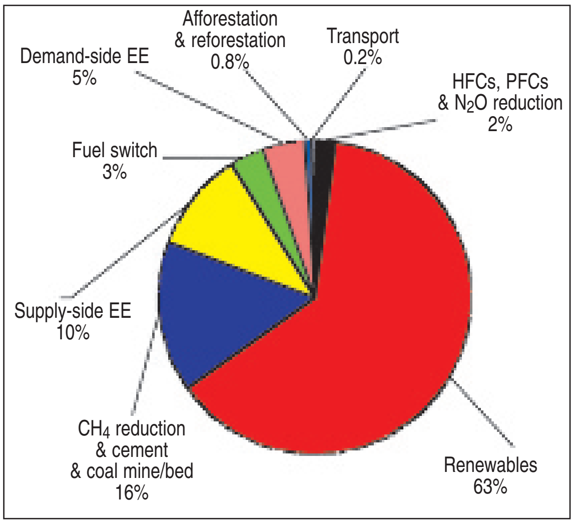

Figure 5.
CDM project portfolio as of January 2009, number of validated projects.
Source: UNEP/Risø, 2009.

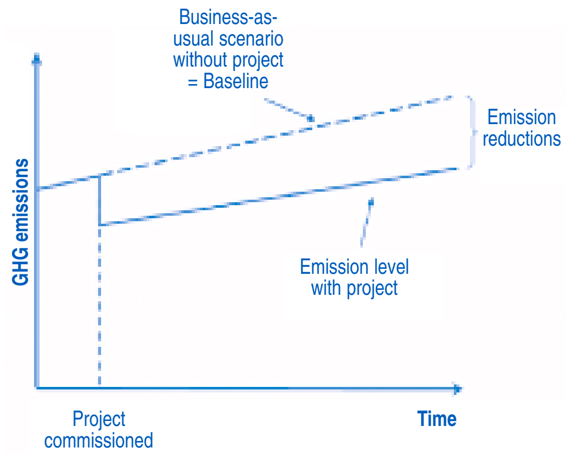

Figure 6.
Baseline scenario and emission reductions of a CDM project [Tyndall Centre, 2007].

sion allowances. In addition to financial benefits, technology cooperation between western and developing countries is an important aspect. For example, biofuel-processing equipment may be supplied by western companies. Using the CDM may help lowering other barriers such as reluctance to use a new technology, increase possibility to attract loans, and cooperation from local and national governments.

As of January 2009, over 4400 CDM projects are in advanced stage of development. More than 1300 of these are registered with the CDM EB. Figure 5 below gives a break-down based on technology. We can observe that renewable energy projects such as wind, hydro and biomass account for almost two-thirds of the number of projects, and energy efficiency (EE) also takes a significant share. However, in terms of CER generation, the non-CO_2 projects, notably HFC, N_2O and methane destruction take approximately half of the total. The transport sector is virtually absent.

For a project to be registered by the CDM Executive Board it requires an approved baseline and a monitoring methodology. A critical element of the CDM is that a project should lead to *real, measurable and long-term* emission reductions. In order to determine how many GHG emission reductions the proposed project achieves, the expected emissions without the project must be evaluated: the baseline emissions. This refers to what would have happened if the CDM projects would not be implemented (e.g. electricity would be produced by using coal rather than wind energy). Then, the GHG emissions related to the project itself must be also evaluated. In a biofuel project for example, these project emissions relate to the production of the biofuel. The emission reductions of the CDM project are obtained by subtracting the project emissions from the baseline emissions over the crediting period(s) of the project, as shown the figure below.

For a project to use an approved methodology (AM) two routes exist:

- *Use an existing AM.* As of 2009 more than 70 methodologies covering different project types have been approved for large-scale projects (see below), and 28 for small-scale projects. CDM projects with similar characteristics can use these baseline methodologies, provided they comply with applicability conditions specified in the AMs. Approved Consolidated Methodologies (ACMs) are those in which several AMs are integrated, broadening the scope and streamlining the methodology process. The latest versions of all AMs can be found at cdm.unfccc.int.
- *Propose a new methodology (NM).* If the proposed CDM project does not fall within the scope of any AM, a new baseline methodology can be proposed, together with a PDD. This NM should be submitted to the CDM EB, which is then scrutinised by experts from the Methodology Panel. These give a recommendation to the EB who then approves or reject the methodology. In most cases a rejected methodology can be resubmitted with the required changes. However the process of getting a NM approved can be long and difficult as proven in recent years.

3.2. CDM & urban air quality

Climate change mitigation is a national and international policy priority. On the local level, urban air quality is of great concern, while GHG reduction is at most secondary. Therefore, it makes sense to focus on where the synergies for reducing both air pollutants and GHGs are.

Indeed, in order to attract the interest of local policymakers, the starting point of the analysis should be urban air quality, and CDM should be seen as a window of opportunity for attracting financial and technical resources in implementing these. However, as the regulations of the CDM are fixed to a large extent, we choose to analyse the current CDM project portfolio in order to determine where the air quality opportunities are the most significant.

As mentioned above, Figure 5 shows a technology-wise breakdown of the 4475 CDM projects in the pipeline as of January 2009, i.e. those CDM projects that are in validation stage or are registered with the CDM Executive Board. All of these projects use an approved baseline and monitoring methodology, accounting for over 2.8 $GtCO_2$-eq reduction up to 2012. If CER generation would have been the basis (rather than the number of projects), the major difference would be that HFC and N_2O projects would increase their share to 25%. Fuel switch projects only refer to those in industry and power production. Of the renewable energy projects, most are biomass, followed by hydro, wind and biogas, with small shares of solar, geothermal and tidal. The energy efficiency projects are mainly large industrial projects, while the service and household sector take up the remaining part. Of the 13 transportation projects, the Bogotá Transmilénio is the most relevant to urban air quality, as it implements a rapid bus transit (BRT) system in the Colombian capital. There are four more BRT projects in validation stage, using the same methodology (AM0047), which was approved in mid-2006. Another BRT methodology (Insurgentes, Mexico-city) is under consideration after a previous rejection. The other projects are activities related to biofuel from waste oils and ethanol, a mass transport systems based on cable cars, efficient metro cars and fuel switch in vehicles.

There are several methodologies related to biofuel and other transport-related activities under consideration by the CDM EB. Table 2 gives an overview of the status with respect to methodologies for potentially important projects for air quality in the transport sector.

It appears that especially in the industry/power sector, several options exist to implement CDM project improving air quality by using already approved methodologies, while a significant number is waiting for approval. In the transportation sector six methodologies have been approved (out of which four are for small-scale projects) and another six are in the pipeline. For the buildings sector four approved methodologies exist, while three are pending.

It can be concluded therefore that in order to enable more air quality – CDM project, there is a need for more approved baseline and monitoring methodologies. In the next section, we will highlight these issues in more detail.

4. Barriers and opportunities for CDM and air quality projects

The current CDM project portfolio (as shown in Figure 5) contributes to urban air pollution reduction, but only to a limited extent. The large number of renewable energy and efficiency projects only have a significant impact to the extent they displace coal utilisation in or near urban areas. The same argument is valid for the fossil fuel switch projects.

Table 2.
Transport sector CDM methodologies as of January 2009.

Mass rapid transit systems	
AM31	Baseline Methodology for Bus Rapid Transit Project
NM258	Metrobus Insurgentes BRT, Mexico City
NM266	Mumbai Metro One, India
SSC-NM6	Cable Cars for Public Transit
Biofuels	
AM47 (v2)	Production of biodiesel based on waste oils and/or waste fats from biogenic origin for use as fuel
AMS-III-T	Plant oil production and use for transport applications
NM228	AGRENCO Biodiesel Project in Alta Araguaia
NM233	Palm Methyl Ester – Biodiesel Fuel (PME-BDF) production and use for transportation in Thailand
Improving vehicle efficiency or modal shift	
AMS-III-C	Emission reductions by low-greenhouse emission vehicles
AMS-III-S	Introduction of low-emission vehicles to commercial vehicle fleets
AMS-II-U	Cable Cars for Mass Rapid Transit System (MRTS)
NM279	Transit Oriented Development
NM287	Methodology for Increasing Rail Based Mass Rapid Transit Ridership
SSC-NM19	Transportation Energy Efficiency Activities using Retrofit Technologies

Source: *cdm.unfccc.int*

In order to get more insight in the barriers and opportunities for CDM projects improving urban air quality, the CURB-AIR project initiated and investigated four potential projects. Here we give a brief overview of the results. For a more elaborate description and analysis see Dass *et al.,* (2008). These four projects represent promising opportunities for measures that improve air quality and can potentially be developed as a CDM project. Also these may be replicated in their respective countries or around the world for reduction of air pollutant and greenhouse gas emissions.

- *Bangalore (India):* Utilisation of an ethanol/diesel blend in the bus fleet in the South Indian state of Karnataka. The ethanol will be sourced from molasses, a sugarcane by product and mixed with diesel by using an additive. This technology is still in demonstration phase.
- *Bangkok (Thailand):* Establishment of new Bus Rapid Transit lines, complementing existing public transport routes.
- *Jakarta (Indonesia):* Extension of the existing Bus Rapid Transit (BRT) network by five new corridors, the implementation of which is uncertain due to financial constraint and decreasing political support.
- *Jinan (China):* 5 × 2 MW biomass gasification for power generation, using a new 2-stage gasification technology currently in demonstration. The biomass will be obtained from agricultural waste in villages in Shandong province, which otherwise would have been burned in the open and causing substantial seasonal dust pollution over the city.

As mentioned before, key requirements for a project to be registered as a CDM project are: utilisation of an approved baseline methodology, proving project additionality, contribution to sustainable development in the host country, and compliance with monitoring conditions. These aspects are summarised for the four case projects in the Table 3.

Based on these case studies and considerations given in Grütter (2007), several barriers can be identified for developing underrepresented projects beneficial for urban air quality:

- Determining the baseline scenario and baseline emissions.
- Data required to establish the baseline scenario and calculate GHG reductions.
- Limited financial contribution from CERs, compared to project investment.
- Difficulty and/or high cost for monitoring.
- Interaction with other policies (the perverse incentive of the CDM).
- Additionality proof (other aspects than the policy interaction).

Table 3.
CDM viability assessment of CURB-AIR case studies.

	Bangalore (ethanol/diesel)	Bangkok (BRT)	Jakarta (BRT)	Jinan (Biomass)
Baseline methodology	NMS required; experience of AM47 and AMS.III-T can be used	AM31 not applicable; NM229 more applicable but needs approval	AM31 likely to be applicable, as situation is similar to TransMilénio; No AMS exists	ACM6 or AMS.I-D can be used
GHG reduction estimate ($ktCO_2$-eq/yr)	18	10 (first line)	20	60
Additionality	Can be proven by common practice analysis; without CERs it's not likely to be financially attractive	1st line likely to go ahead without CDM; next six lines likely to be additional	Can be proven based on financial and political constraints	IRR increases from 7% to 13% due to CER revenues; project is also far from common practice
Monitoring	Not analysed	High data requirement	High data requirement for AM31 might be limiting factor	Can be done using ACM6 or AMS.I-D
Sustainable development contribution	Significant AQ improvement; local income generation; reduced oil dependency; technological advancement	Improved AQ by displacing private vehicles and introducing more efficient mass transport; increased comfort; reduced congestion	Improved AQ by displacing private vehicles; increased comfort; reduced congestion	Substantial reduction of seasonal air pollution; technological development; reduced fossil fuel use; local income.
Final remarks on CDM viability	Very promising CDM option if NMS is developed and approved	CDM implementation depends on NM229 approval and perhaps development of more applicable methodologies	Promising, but data requirement likely to be bottleneck; NMS could be an option	Promising option with potential for replication; current demonstration plant will provide proof of technology

AM: Approved Methodology;
NM: New Methodology;
AMS: Approved Small-scale methodology;
NMS: New Small-scale Methodology;
AQ: air quality;
CER: Certified Emission Reduction;
GHG: greenhouse gases; kt: 1000 tonnes;
IRR: internal rate of return.

Table 4.
Barriers to CDM projects beneficial for urban air quality.

	Baseline	Data availability	Low CER contribution	Monitoring	Other policy	Additionality
Fossil fuel switch	x			x	x	x
Biofuel in transport	x		x	x	x	
Infrastructure	x	x	x	x	x	x
Vehicle programmes	x	x		x		x
Cleaner coal technology	x		x			x
Cooking stoves		x		x		x
E-efficiency programmes	x	x	x	x		
RE in buildings			x	x		

Table 4 shows which barriers are considered relevant to the technologies identified in the beginning of this paper. They have to be addressed case by case, as they are different in each potential CDM project (as shown in Table 3). However, we can make some general remarks*.

Baseline and monitoring methodologies

If there is no applicable methodology already approved, a new methodology needs to be developed, submitted and approved by the CDM Executive Board, which may be the largest barrier for successfully CDM developing projects, as shown by the case studies. Current experience with developing baseline methodologies for different project types is increasing rapidly. Consequently, there is a pool of knowledge from which valuable lessons of how things should or should not be carried can be drawn. Specialised consultants may provide the required expertise.

These days, CER buyers may provide financial resource to cover part of the upfront costs to design projects. In addition, several international programmes by the World Bank, European Commission and UNDP could assist in development of methodologies.

The CDM Executive Board acknowledges problems of monitoring for certain projects types and allows sampling methods (e.g. to determine the functioning of efficient light bulbs or the number of passengers using a BRT) in order to reduce monitoring cost.

Programmatic CDM, under which a set of measures in a region as part of a programme is carried out under the same baseline, may provide interesting opportunities for energy efficiency projects, including transportation [Ellis, 2006]. It has the potential to significantly reduce overall transaction costs. An important advantage is also that new activities can be added at any time, allowing for a flexible approach. An example may be to start with three BRT projects in a country, and other BRT projects are added later.

Additionality and economics

For proving additionality, it is very beneficial if it can be shown that considerations for CDM have been taken into account and had a prominent role in the early phases of the project (e.g. signing of contracts). Regarding policy interactions, additionality can be made plausible if it is shown that current policies in place (e.g. mandatory ethanol blend) are not enforced properly and that the CDM project overcomes this.

If the investment analysis cannot be carried out, the barrier analysis may provide an alternative to prove additionality. However recent practice has shown that project developers are rather creative in providing barriers without being able to substantiate those, and the CDM Executive Board is becoming stricter in the application of this part of the additionality assessment [Schneider, 2007].

In many cases, the CER revenues are only the 'icing on the cake', i.e. small compared to the total investment needed. In case of infrastructure projects, the financing structure can be such that a municipality takes only part of the cost but acquires the full CER revenues. This has been the case in the Transmilénio BRT project, where the CDM income provided 10% of the investment cost of the total project but ca. 1/3 of the cost for the municipality [Grütter, 2007].

Partnerships between local authorities and private sector

The CDM is a market mechanism and leaves it up to project developers to come with new CDM activities. Until now, initiatives were taken mainly by the private sector, and in many countries rather successful. In addition, national government bodies, including Designated National Authorities, have assisted in providing the CDM approval procedures and sometimes trainings. Local governments are generally much less active in the CDM market, even though they could benefit significantly from these projects, notably due

** A report on CDM in the transport sector [Grütter, 2007] covers several of the issues in more detail.*

to improved air quality. Therefore, more partnerships between the private sector, and national and local governments are required.

In addition, partnerships between cities in different regions or countries could also be conducive to more air quality – CDM projects. E.g. strategic cooperation between different cities across South Asia to implement the promising technology of ethanol/diesel blend could help to harness its significant short term potential.

5. How can the Clean Development Mechanism contribute to better air quality?

On the one hand, climate change is a global environmental problem, which is mainly the concern of national governments. On the other hand, urban air quality is a priority for local governments. In the CURB-AIR approach, the CDM could provide a window of opportunity for promoting air quality measures that also reduce GHG emissions, thereby connecting these two important environmental issues.

Opportunities for projects in the industry and power sectors could be very significant, in particular for fossil fuel switch or biomass projects. A new technology currently in demonstration phase – biomass gasification – could be used, in the future, within the CDM framework to reduce air pollution and provide electricity in rural areas where open-field biomass burning is common practice.

In the transport sector, the opportunities are less straightforward. Only few large and small scale baseline methodologies have been approved, which is a key barrier. There are inherent difficulties in establishing the baseline scenario, proving additionality and monitoring of emissions. However, with the approval of the first bus rapid transit system and biofuel methodologies, there is scope for expansion of the transport sector in the future. In addition, opportunities may increase further thanks to the development of Programmatic CDM. However, data availability for public transportation projects remains a crucial issue.

Finally, the promotion of the concept of improving air quality by utilising CDM requires a more intensive cooperation between different stakeholders, particularly the involvement of local governments in partnerships with the private sector and the national government, as well interregional cooperation between cities.

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