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Cities and Carbon Finance: a Feasibility Study on an Urban CDM

United Nations Environment Programme

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Acronyms and abbreviations

BAU	Business As Usual scenario
BRT	Bus Rapid Transit
C40	C40 is a group of large cities committed to tackling climate change
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CDM EB	Clean Development Mechanism Executive Board
CERs	Certified Emission Reductions
CFL	Compact fluorescent lamp
CMP	Conference of the Parties serves as the meeting of the Parties to the Kyoto Protocol
CO_2e	Carbon Dioxide Equivalent
COP	Conference of the Parties
DNA	Designated National Authority
DOE	Designated Operational Entity
ERs	Emissions Reductions
ERPA	Emission Reduction Purchase Agreement
GHGs	Greenhouse Gases
GEF	Grid emission factor
HVAC	Heating, Venting and Air-Conditioning
ICLEI	International Council for Local Environmental Initiatives
MRTS	Mass rapid transit systems
MRV	Monitoring, Verifying and Reporting
N2O	Nitrous Oxide
NAMA	National Appropriate Mitigation Actions
PoA	Programme of Activities or Programmatic CDM Projects
PECC	Pacific Economic Cooperation Council
PIN	Project Idea Note
PDD	Project Design Document
RES	Renewable energy standards
SWH	Solar water heater
SSC	Small-scale (CDM methodologies)
UNFCCC	United Nations Framework Convention on Climate Change
UEA	United Nations Urban Environmental Accords
VERs	Verified Emission Reductions
WB	World Bank
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Foreword

Cities are home to more than half the global population and are responsible for 60-80 per cent of energy use and more than 75 per cent of carbon emissions. Clearly, cities are key players in addressing critical environmental issues of international and local importance, including climate change. Opportunities for cities to be transformative leaders will only intensify as more than 80 per cent of the world's people are projected to live in urban areas by the year 2050.

Recognizing that cities are increasingly important hubs for social, economic, environmental and technological change, the United Nations Environment Programme (UNEP) and the City of Gwangju, Republic of Korea, joined forces in 2011 to kick-start pioneering work on two critical issues:

1. The need for harmonized metrics to measure and report on sustainability of urban environments to support the reduction of environmental degradation.
2. Improving cities' access to carbon finance mechanisms by supporting their use of Urban Clean Development Mechanisms (CDM).

This report analyses existing CDM methodologies and makes specific recommendations on how cities can improve their access to climate finance through the use of Urban CDM and addresses three important questions:

"Is the Clean Development Mechanism the right instrument to provide carbon finance to carbon emission mitigation activities in cities/urban areas?"

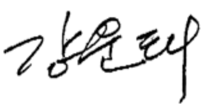
"Under which circumstances can the CDM be best applied for the major emission sources in cities?"

"What is the status of CDM in urban areas? What are the existing barriers and what are the solutions that will offer cities access to carbon finance?"

Preliminary results from this study were presented and validated at the Urban Environmental Accords Summit held in the City of Gwangju on 12-13 October 2011. Signatories to the Urban Environmental Accords upheld the findings of this study in their "Gwangju Cities Declaration". The Gwangju Cities Declaration stated that "ways and means to better access finance mechanisms such as the Clean Development Mechanism and promote advocacy efforts with governments" should be found.

Final results of this important study identify a number of barriers to the implementation of an Urban CDM and at the same time demonstrate the way forward by reforming the existing CDM to allow for methodologies that are geared towards cities and developing a CDM programme of activities for pilot cities to inform the future development of Nationally Appropriate Mitigation Actions.

This report is a key outcome of our joint work over the past year and it is our hope that it will be useful to city managers, policy-makers, and key stakeholders by providing them with a better understanding of the complexity of CDM, supporting their access to international climate finance and providing an additional catalyst for the goal of transition to a Green Economy— one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.



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Chapter 1
Summary

Cities, metropolitan areas, urban and semi-urban areas in developing countries are usually characterized by high populations which increase over time because they are usually important economical hubs. As a result, the demand for resources in general, and especially energy, is high.

The Clean Development Mechanism (CDM) is one of the "flexibility mechanisms" defined under the Kyoto Protocol. Its objective is to assist developing countries in achieving sustainable development and to mitigate the greenhouse gas emissions that cause climate change. In addition, the CDM aims to assist industrialized countries in achieving compliance with their quantified emission limitation (e.g. under the EU Emission Trading Scheme). Despite its great success, with more than 3,300 CDM projects registered within many countries and within many sectors, some important emission sources, sectors and countries are still underrepresented within the CDM.

> *"Is the Clean Development Mechanism the right instrument to provide carbon finance to carbon emission mitigation activities in cities/urban areas?"*
>
> *"Under which circumstances can the CDM be best applied for the major emission sources in cities?"*
>
> *"What is the status of CDM in urban areas? What are the existing barriers and what are the solutions that will offer cities access to carbon finance?"*

These and other questions have been addressed in this feasibility study on urban CDM. A detailed analysis of the current status of CDM in the context of cities includes:

- the CDM rules and procedures and their implications for cities
- latest developments and lessons learned from existing projects.

Answering these questions was vital in allowing us to gather the key lessons learned, identify the eligibility of CDM in an urban context and provide best knowledge recommendations on how cities could best benefit from CDM or alternative carbon finance instruments.

The CDM instrument with its ever-changing and evolving nature has its limitations for wider application in mitigating carbon emission in cities. Mitigation measures in cities that are initiated by city councils or municipalities should cover more than one sector/technology. This feasibility study demonstrates that the CDM has evolved in the right direction by introducing the concept of a Programme of Activities (PoA) that allows for the combination of an unlimited number of emission mitigation activities under a single umbrella using different methodologies.

A relatively high number of approved methodologies are applicable in the urban context and several successes demonstrate that CDM activities are possible in the urban context. However, compared to its global mitigation potential and the fact that carbon emissions in urban areas usually peak for many countries, cities still lag behind. Cities usually attract the highest populations which leads to increased demand for the energy resources that cause high levels of greenhouse gas emissions. Implementing sustainable and emission mitigation measures in cities has great potential to be replicated in other cities and countries and may lead to positive cross effects.

Having said this, the remaining barriers are threefold. Firstly, the regulatory framework for CDM is complex and a number of procedures, guidelines and requirements need to be met for each individual project. Emission reductions are technology-specific (according to the underlying methodology per technology/sector) and standardized approaches (e.g. default values) are almost non-existent (see Chapter 7 for further information) in an urban context.

Secondly, the different sources of emissions may be under different civic controls. There may be varying responsibilities within those sectors (e.g. transport, buildings, energy, water and waste) and some emission mitigation measures may come under different processes (e.g. energy efficiency in buildings is related to energy as well as construction). A CDM project, and especially a PoA, requires clearly defined responsibilities and proper coordination among all the involved institutions and actors.

Thirdly, the demand for emission reduction from CDM is at risk because the European Union (EU) has imposed a time restriction: the only emission reductions generated in Least Developed Countries eligible for the EU Emission Trading Scheme must have been registered before the end of 2012. For those project activities or PoAs that have not yet started, the chances of registration by the end of 2012 are limited.

Despite these barriers, a number of successful CDM projects have already been developed in the urban context. However, most of these activities tackle only a single sector or technology/measure and are very limited in scope. In addition, the United Nations Framework Convention on Climate Change (UNFCCC) is now revising certain rules that may enhance the application of CDM in the urban context: this may affect current progressive approaches to addressing city-wide CDM. Based on those existing approaches and on the lessons learned from working in CDM for many years, this study identifies the following three opportunities for cities to benefit from carbon financing opportunities to mitigate carbon emission and to mitigate climate change in the global context under current market conditions:

a. Reform of the CDM

For the CDM to be better suited to the urban context and a wider approach, e.g. by including different sectors and technologies, further reforms are required. Based on the existing PoA concept, further work needs to be done **to develop suitable methodologies that combine the key emission sources of cities and metropolitan areas** and that allow for some simplification in terms of emission reduction calculation, baseline setting, additionality determination and monitoring. Further work would be required to establish **standardized approaches** in the urban context so that transaction costs are reduced and entry barriers are lowered.

b. From CDM PoA to National Appropriate Mitigation Actions (NAMAs)

By developing **a concrete CDM PoA for one selected city**:

- the major emission sources would be identified
- the institutional set-up to manage and coordinate the different measures would need to be established;
- the design and set up of an appropriate Monitoring, Reporting and Verification (MRV) system would be required.

Such a PoA should **focus on one or two key sectors/technologies with high mitigation potential** within the selected city. This would increase the likelihood of getting the PoA registered and would also provide a straightforward example for other city-wide approaches. The selected city should also be located in a politically stable country (the proposed PoA in Amman city has experienced severe delays due to the political situation in Jordan during recent months). Developing a concrete urban CDM PoA would help identify key lessons learned from the process and help influence the decision-making process at UNFCCC level. Once the PoA is registered, it may generate Certified Emission Reductions (CERs) under the CDM or Voluntary Emission Reductions (VERs). The designed PoA with the identification of emission sources, quantification of emission reduction potential and existing emission levels (sector-specific energy and emission inventory), existing institutional set-up and monitoring procedures could also be transformed into a future Nationally Appropriate Mitigation Action (NAMA) [see Chapter 9 for further explanation about the NAMA concept]. Experience has shown (see case studies in chapter 8), that NAMA development and implementation is much more efficient once certain preliminary tasks have been undertaken. These preliminary tasks could include elements already established under a PoA as described above.

c. NAMA pilot development

A third, rather non-CDM approach would be to start a NAMA from scratch. Given the uncertainty for urban CDM in the context of the post-2012 eligibility, it is advisable not only to build on the existing project-specific concepts of the CDM, but to test innovative solutions on an aggregated level. We suggest that large cities, especially in Non-Least Developed Countries, should get involved in NAMA development (see Chapter 9 for further explanation of the concepts and the differences). The NAMA concept provides more flexibility to address the technological and institutional barriers in the urban context through a top-down approach coordinated by the city administration. The challenge is the municipal government's ability to enforce policy measures and to administer greenhouse gas accounting. Within the NAMA framework, the topic of MRV will have a crucial role and the good work that has started in the CDM, especially with regard to methodologies, standardised approaches and PoAs in the urban concept, can be utilised and adapted to the specific conditions of the NAMA concept.

We further recommend establishing a working group for carbon mitigation action in the urban sector. It is obvious that there is huge interest in the topic of urban CDM and further goal-oriented work is required to increase access to carbon finance for cities whether through CDM, the voluntary carbon market or through new mechanisms like NAMAs.

Chapter 2
Background

The large majority of activities under the Clean Development Mechanism (CDM) are traditionally project-based emission reduction activities that implement one certain specified type of technology and are usually geographically site-specific. Hence, the typical CDM project focuses on implementing one activity/ technology at one site, e.g. methane recovery at one waste landfill or the construction of a wind farm on a single site. The CDM generally allows for project activities that consist of one technology to be applied in different locations, for example energy-efficiency measures in the residential sector. Typical project types might be energy-efficient lighting or improved cooking stoves where the appliances are used at widely dispersed sites (e.g. households).

In recent years, it has become apparent that the CDM concept mainly promotes large-scale projects and processes, e.g. industrial manufacturing or power generation projects where the application of underlying baseline and monitoring methodologies[1] is relatively straightforward and where the yield of carbon emission reductions is expected to be quite high. The specific CDM transaction costs for such "low hanging fruits" are low. Other project types that are relevant from an environmental and social perspective, in terms of rural development and also in terms of multiplying effects, e.g. CDM in highly populated areas like cities and metropolitan areas, but also CDM for dispersed project types, are still underrepresented in the CDM.

In many cases, the underlying CDM methodologies for these project types are complex in terms of monitoring and determination of a baseline emission scenario. Furthermore, data requirements are generally very high and the expected yield of emission reductions is, in many cases, relatively low (specific emission reductions per year or per project activity).

1. CDM methodologies are project-specific. Projects must comply with the requirements given in the applicable methodology for the specific project type.

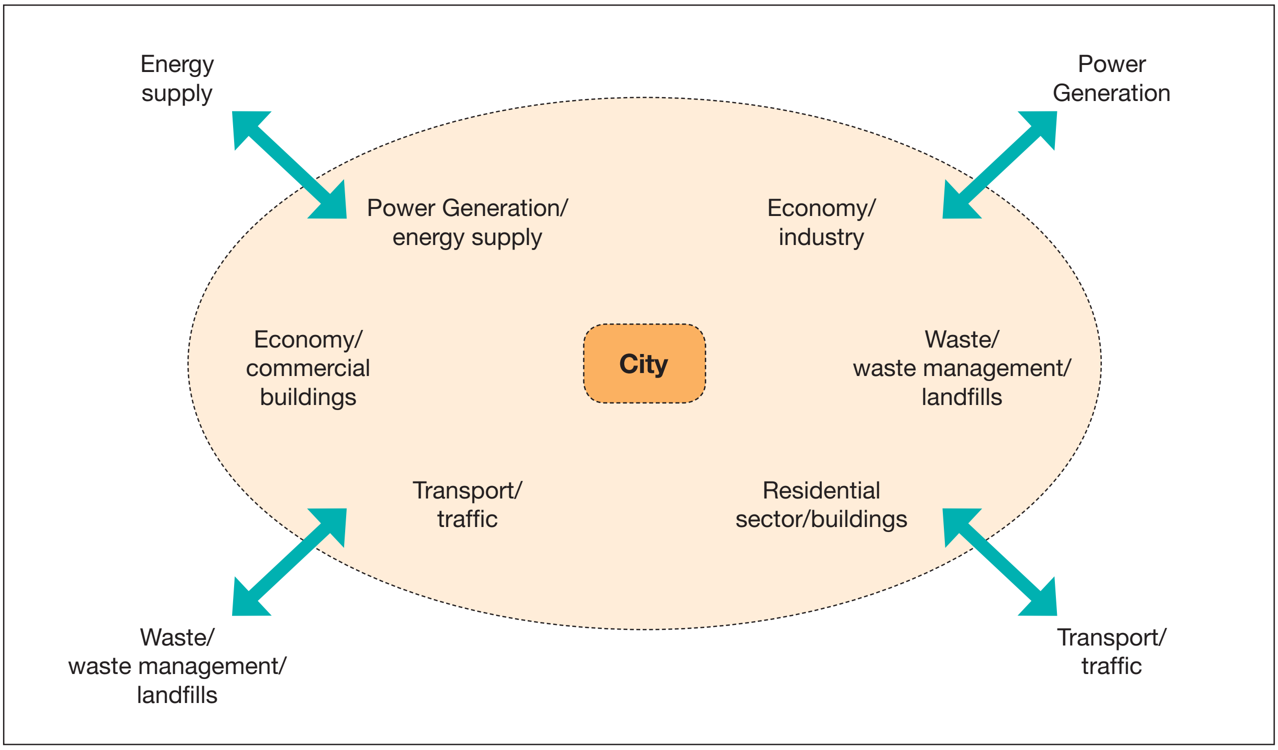
Due to the low frequency of implementation of such projects, the maturity of the underlying methodologies is reduced and these examples usually lead to high transaction costs. The more complex the project setting is, the greater the risk that the project won't reach the final approval stage of CDM registration. Registration by UNFCCC must be achieved if the project aims to generate Certified Emission Reductions (CERs). In many cases, and especially due to the high upfront costs and uncertainties in preparing and implementing such projects, many investors are still reluctant to engage with CDM.

To encourage underrepresented project types to be developed under the CDM and to reduce the overall transaction costs for project developers and investors, UNFCCC introduced the concept of Programme of Activities – PoA (also known as Programmatic CDM) in 2007 (see chapter 5 for further information about the different CDM design options including PoAs).

However, both traditional CDM projects and PoAs are still based on the same CDM methodologies and hence are, in most cases, very technology-specific. There are only a few examples where one CDM methodology allows for its application in different technologies. However, the CDM Executive Board was recently requested by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) to reassess its existing regulations related to PoAs in order to simplify the application of PoAs to activities applying multiple methodologies and technologies, including those for city-wide programmes (UNFCCC, 2011, paragraph 4 (b)).

UNEP's objective is to promote and encourage urban CDM in order to reduce greenhouse gas (GHG) emissions in cities and to provide access to carbon finance in the urban context. The CDM offers potential as an additional funding source for investment and could allow cities to participate in international carbon markets and facilitate an urban economy drawing upon international market mechanisms. City authorities however, have not been able to fully access market

Figure 1: **Typical emission sources in cities**



Source: perspectives, GmbH 2011

mechanisms for carbon credits – less than 1% of projects registered with the CDM are credited to cities.

There are a number of barriers to implementing CDM for typical project types in cities including:

- **technical barriers:** e.g. CDM project activities are traditionally technology and sector-specific; issue of eligibility for CDM post-2012
- **institutional barriers:** policy understanding and capacity of municipalities
- **financial barriers:** relatively high overall transaction costs due to dispersed project characteristics and high up-front costs with uncertain revenues from carbon
- **political barriers:** competing priorities, public support.

From the perspective of emission reduction under the CDM, it may be desirable to address all urban emission sources in one CDM project activity (or one PoA). This would imply that emission reduction activities in the key sectors for reducing carbon emissions in an urban context (e.g. energy production, transport, energy efficiency, waste management), would have to be combined and bundled for the entire city in a single CDM activity.

Alternatively, urban CDM could be defined as an approach to cover a certain sector or technology for the entire city within one CDM project.

This feasibility study assesses to what extent the current CDM rules and procedures allow for an urban CDM project, covering the most relevant sectors responsible for the majority of carbon emission reductions in a city and draws conclusions on what would be required to enable cities to participate further in the CDM. In addition, this study establishes a baseline for further discussions on how the CDM would need to be formed or whether other mechanisms would be better suited to enable carbon finance in the urban context.

Chapter 3
Approach to the work

The results of the study are intended for use by policy makers and for practitioners in decision-making processes for setting up carbon emission reduction activities in an urban context. The Clean Development Mechanism, as the most successful carbon offsetting mechanism in the world and with the UNFCCC as its regulatory body, is a sophisticated and complex instrument with many rules and procedures. Hence, this study needs to go into a reasonable level of technical detail about the underlying sector-specific CDM methodologies, the associated CDM rules and procedures and their implications for the different project types and technologies. This detailed analysis will help practitioners in planning and implementing urban-related carbon mitigation activities and programmes.

In order for the study to be useful for non-CDM experts, policy makers, decision makers and to draw key conclusions and recommendations, the summary on page 4 as well as Chapter 9 “Discussion and recommendations” summarizes the key findings and provides clear recommendations for politicians and decision-makers.

This study uses a step-by-step approach to assessing the feasibility of Urban CDM. Chapter 4 identifies the sources of greenhouse gas emissions in cities using pre-selected cities as examples. Based on these cities, the major emission sources and sectors are identified and discussed. The main purpose of this chapter is to define the major emission sources in the urban context as those emission sources and sectors form the main focus for deeper analysis of urban CDM within this study.

In Chapter 5, the different existing institutional options for developing CDM activities are presented and assessed according to their advantages and disadvantages. This chapter explains the fundamentals of these options within the CDM and sets the scene for subsequent analysis and discussion.

Based on the defined major emission sources of cities, referred to as “priority sectors”, a detailed analysis of all existing and approved CDM methodologies has been undertaken in Chapter 6. The requirements for methodologies and their applicability in the urban context are defined and a set of evaluation criteria has been developed. Each methodology has then been evaluated against these criteria.

Having identified the most appropriate CDM methodologies in the urban context, Chapter 7 outlines the existing barriers for CDM project activities in cities and urban areas.

Based on the identified CDM methodologies, and taking the barriers for urban CDM into consideration, Chapter 8 evaluates the current status of urban CDM projects. Within this chapter, existing CDM project activities and PoAs for the priority sectors in an urban context have been identified and assessed. Based on the definition of an urban CDM project, examples of urban CDM projects currently in progress have been identified. These projects are evaluated with regard to their applicability to urban CDM, the lessons learned and the need to modify existing CDM methodologies for their suitability in an urban CDM.

As part of Chapter 8, four very encouraging case studies of urban CDM activities are presented. The chapter presents the following projects that are relevant for the urban CDM:

- the **Masdar City** CDM project activity on energy efficient buildings
- the **Bus Rapid Transit** (BRT) project in Bogota, Columbia
- the proposed sector-wide approach on new residential housing based on a PoA, a city-wide PoA for **Amman City** (Jordan) and
- a **Nationally Appropriate Mitigation Action** (NAMA) concept in Mexico.

Finally, in Chapter 9 the conclusions from the feasibility assessment are discussed and recommendations given for further enhancing the concept of urban CDM under the CDM framework.

Chapter 4

Major emission sources of cities

The greatest potential for emission reduction in cities is usually in sectors such as transport, waste, energy generation and energy efficiency (e.g. buildings). However, those emission sources can vary from city to city depending on the specific consumption pattern of each one. This study is not meant to analyse the consumption patterns of cities in detail but to assess the feasibility of urban CDM. Hence, this section will identify the major emission sources in an urban context based on a few sample cities in UEA and Korea. The identified emission sources and sectors will form the basis for a further assessment of CDM methodologies and project types suitable in the CDM context. The mapping is based on existing data and identifies the major emission sources within these cities.

To build a representative picture and a wide spread of cities and regions, the following cities were selected:

- **Gwangju, Korea** was selected as a Korean city. In Gwangju the preliminary results of this feasibility study were presented during the UEA Gwangju Summit. Furthermore, sufficient GHG data for Gwangju city was already established and could be provided. The summary of data was also available in the English language.

- **Gauteng**, metropolitan region of Johannesburg, **South Africa**. Recent emission data was available and it was considered necessary to include at least one urban area in Africa, since Africa will be one of the core continents for the future of CDM – due to the decision by the EU Commission to only allow CDM emission reductions into the EU-Emission Trading Scheme after 2012, that are generated from projects in Least Developed Countries). Even though South Africa is not an LDC, most sub-Saharan African countries are.

- **Chiang Mai, Thailand**. This city was chosen to represent the wider Asian context outside South Korea and to include a smaller city.

Other cities could have been chosen that had more detailed and up-to-date information on their carbon emission inventory but this selection does highlight the key emission sources of cities. A further extended assessment of emission sources for other cities was not possible under the scope of this study. The summary of the emission sources of the three sample cities can be found in Annex 1.

4.1 Introductory remarks[2]

Today, half of the world's population lives in cities and generates the majority of greenhouse gas emissions. Depending on definition, the urban share of global greenhouse gas emissions is estimated to be between 30 and 40% and up to 75 or 80% (Dodman 2009, p. 194ff; Satterthwaite 2008, p. 539, 543). As cities in developing countries are starting to catch up economically, they are also catching up in terms of greenhouse gas emissions. In Shanghai, annual per capita CO_2 emissions have grown from 3.8t in 1985 to 16.7t in 2006 (Dhakal 2009). In terms of per-capita emissions, Shanghai, together with Bangkok, Thailand (10.7t) or Cape Town, South Africa (11.6t) have already overtaken Geneva, Switzerland (7.8t), Prague, Czech Republic (9.4t) and London, United Kingdom (9.6t) (Kennedy et al. 2009). This is far beyond the global per-capita emissions threshold of about 2 tCO_2 which climate scientists are calling for. New investments in built structure and infrastructure can lock in vast energy consumption or climate benefits for decades (Sovacool and Brown 2010).

2. This section is based on Sippel and Michaelowa (2009) which has been updated for the purpose of this study.

Understanding local emission patterns, including urban patterns, is a precondition for the development of low-carbon communities (e.g. Kates et al. 1998; VandeWeghe and Kennedy 2007). An increasing number of cities of the world are now reporting their greenhouse gas emissions and recent literature compares the carbon footprint of large cities and metropolitan areas (e.g. Kennedy et al. 2010; Sovacool and Brown 2010).

4.2 Challenges in comparing local GHG emissions data

The authors faced some challenges in comparing local emissions data in this study. Firstly, emissions data is available only for selected cities. Secondly, emission inventories from different cities may be difficult to compare because the underlying methodologies differ significantly. Both issues are discussed in detail below.

Up-to-date local GHG emissions data is not easily available for many cities. There are a variety of reasons:

1. Cities may not have collected emissions data or only do so on an irregular basis. Emission inventories are costly and may not be the top priority in many cities since GHG mitigation is mostly a voluntary policy area in cities

2. Cities may have collected emissions data but do not publish it – either deliberately or because nobody wishes to put the data into the public domain

3. Cities may have collected data and published it – but only in their native language. This makes the use of this data impossible for those not able to understand the language.

When cities publish emissions data, the information needs to be handled with care. Existing research on urban greenhouse gas reporting suggests that comparability of cities' emission data is often limited (e.g. Sippel 2011) – and the authors of this study faced the same difficulty. Some cities report emissions from urban production and thus include emissions that are generated within a city's boundaries ('territorial' approach). This excludes emissions linked to imported electricity but includes emissions from the production of exported electricity (Dodman 2009). Other cities do at least partially report emissions from urban consumption and attribute emissions to end users. This may include emissions from imported electricity or district heating, exported waste or, in some cases, from the production of fuels, building materials or food (Kennedy et al. 2010). Although embodied or indirect energy consumption may be significant (Troy et al. 2003; Schulz 2010), modelling urban carbon metabolism is highly complex and limited to a few case studies worldwide (Sahely et al. 2003; Wackernagel et al. 2006).

Urban GHG inventories often use different sectors to which they attribute emissions. The issue is less ambiguous for the transport and waste sector – though the transport sector may exclude electrical forms of transportation. The division between GHG emissions from residential, commercial and industrial energy use is often less clear. Electricity figures are sometimes presented which include electricity provided to different sectors. Despite these difficulties, this study tries to compare emissions from "buildings", "transport", "energy industry" and "waste" (and in greater detail where data was available).

In order to establish a unified reporting methodology, different networks and institutions have developed a range of protocols or guidelines. An early example, and not targeting cities but companies, is the 'Corporate GHG Accounting and Reporting Standard', developed by the World Business Council for Sustainable Development (WBCSD) together with the World Resources Institute (WRI). City-specific guidelines include an initiative by UNEP, the World Bank and UN-Habitat who have recently presented a standard for urban GHG emission reporting at the World Urban Forum (UNEP et al., 2010). The International Council for Local Environmental Initiatives (ICLEI) and Covenant of Mayors have also independently presented proposals for such a standard (Covenant of Mayors 2010, ICLEI, 2009). Other initiatives also exist but none of these proposed city-specific standards/methodologies have been widely adopted.

Although differences in methodologies, and difficulties in obtaining local GHG emission data, make a comparison of local emission patterns challenging, some conclusions can be drawn: **buildings, transport and waste present the three most**

relevant source sectors for local emissions. See Annex 1 for more detailed information on the different emission sources in this study's three selected cities.

4.3 Major emission sources in cities

Not surprisingly, based on the above, the case studies (see Annex 1) identify buildings, transport, waste, industry and energy production to be the main sectors from which urban greenhouse gas emissions arise. This is confirmed by other recent studies on GHG emission patterns in cities (e.g. Kennedy et al. 2009, Sovacool and Brown 2010). However, the carbon footprint of each city is specific, depending – inter alia – on the composition of a city's industry and economic sector, the city layout in terms of settlement patterns, compactness and transport pathways and emission intensity of electricity production.

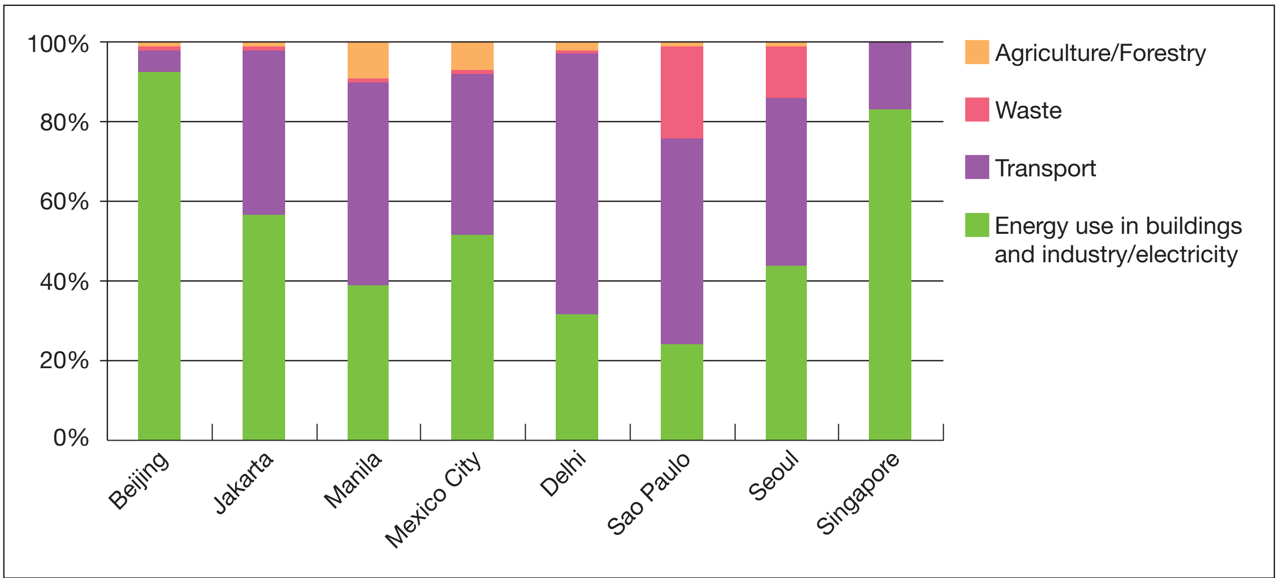
There are further findings from the mapping, and other recent literature on urban GHG inventories. Firstly, urban GHG emissions from a single city vary widely depending on the methodology chosen for reporting those emissions. The decision whether to include emissions from electricity production as well as transport outside city boundaries may have a large impact. The Seoul and the Gauteng cases are both illustrative: imported electricity is a main energy source, also for heating in the building sector (with high emission intensity as coal is the energy source). (See figure 4 below for Gauteng, separating the amount of electricity imported).

Where cities rely on regional or national energy grids, it is subject to debate as to what extent they have influence on energy production (and emission intensity of energy production).

Secondly, industry and agricultural emissions may be higher if a metropolitan area/city region is considered (examples are Gauteng and Chiang Mai), and lower if the boundary of an emission inventory is drawn closely around the city centre. For both Gauteng and Chiang Mai, the boundary was chosen so as to include commuter travel and working relationships in the city. In the case of Gauteng, this led to the inclusion of industrial facilities on the outskirts of the cities of Johannesburg and Pretoria. In the case of Chiang Mai, this led to the inclusion of significant rural areas. Thus, emissions from rice cultivation play a significant (though declining) role in Chiang Mai.

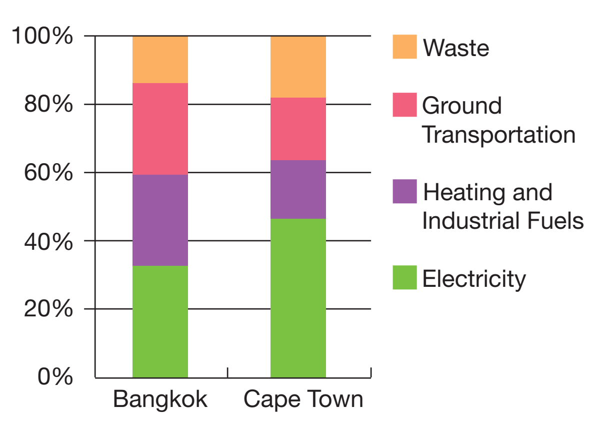
Furthermore, GHG emissions resulting from energy use are likely to increase in cities in developing countries. This is due to the fact that as the population increases, the economy grows comparably quickly. While some of the emission growth is due to the adoption of unsustainable lifestyles (such as dependence on private car use,

Figure 2: **Carbon emission profiles for metropolitan areas**



Source: Sovacool and Brown 2010, p. 4867, Table 3

Figure 3: **Direct greenhouse gas emissions attributable to global cities**



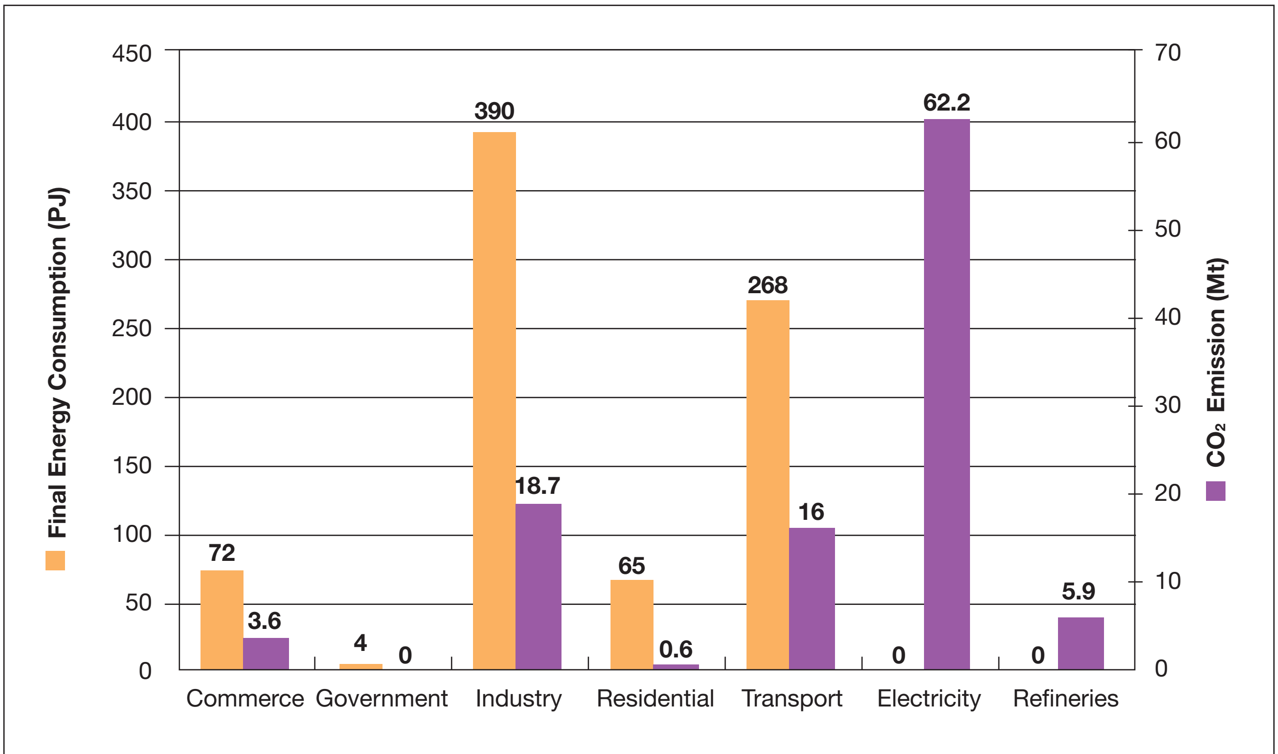
Source: Kennedy et al. 2009, p. 7298, Figure 1

urban sprawl), other emission growth will result from the satisfaction of former deprived needs (eradication of energy poverty). Detailed data for household energy use in Gauteng shows that there are large differences between households depending on their economic status. In many developing countries the demand for carbon-intensive fuel types may increase. For many Least Developed Countries (LDCs), one of the major fuel types is charcoal (for cooking) which is carbon intensive and has other strongly negative environmental effects (e.g. deforestation due to charcoal production). When looking at cities like Nairobi in Kenya, Accra in Ghana and Lagos in Nigeria, those specific emission sources according to the main fuel types used would need to be considered for a best mitigation approach.

Interestingly, there is a major difference in the quantity of GHG emissions presented for the waste sector of different cities (e.g. Sovacool and Brown 2010). This might be due to different waste generation rates and waste management practices in those cities. It may also be due to different reporting procedures.

In the transport sector, private cars are the primary source for carbon emissions in all case studies and in all cities considered by Sovacool and Brown 2010. The number of private cars is rising with people's increased income and their lifestyle choices. Aside from the number of cars, the types of vehicles will also determine the future emission sources in a city. For a detailed analysis in this study on CDM potential, other means of transport will also be considered.

Figure 4: **Energy and CO_2 emission balance for Gauteng 2007**



Source: Tomaschek et al. 2011, p. 2

Table 1: **Priority sectors, emission origin and GHG type**

Priority sector	Major source/origin in the urban context	Type of greenhouse gas
Residential/commercial sector	Buildings, energy demand for heating/ cooling, electric appliances	CO_2
Transport sector	Individual transportation, i.e. cars	CO_2
Waste sector	Landfills, waste handling and management	CH_4 (CO_2)
Energy industry	Power generation, energy supply	CO_2
Industry (excluding heavy industry, i.e. steel, cements, industrial gases etc.)	Inefficient use and supply of process heat; inefficient appliances, e.g. electrical motors, pumps	CO_2

In the context of this feasibility study, heavy industry (cement/steel etc.) and product-specific approaches have been excluded from the major emission sources. Usually, those activities are already covered by a "traditional" CDM. However, when an urban CDM project is planned for a city, all major emission sources should be identified and assessed in detail.

Table 1 summarises the identified priority sectors for further investigation in this study.

Energy efficiency measures at the smaller scale, for example inefficient electric motors and pumps used for manufacturing will be not considered in this study. Conventional and centralised power generation based on fossil fuels is also excluded. Large power plants are often located outside city boundaries, as seen in the analyses above. Even though imported electricity, depending on its origin, is relevant to the carbon footprint of a city, the overall power generation of an interconnected electricity grid is not related directly to a single city. Nevertheless, conventional power plants can be related to the reduction in energy demand and carbon emissions within the city. This is especially true for power plants that are interrelated and connected to the urban surroundings like cogeneration power plants with district heating/ cooling systems and decentralised power generation (e.g. block heat and power plant). Overall, the impact of power generation and its related GHG emissions in an urban context can be reduced and limited in three ways:

1. Avoided energy demand;
2. Enhanced energy efficiency on the demand side;
3. Decentralised and renewable energy supply and generation within cities.

These three priorities refer to an approach which can be applied in general but with different dimensions to each sector when evaluating activities which mitigate emissions. The first priority is to avoid emission forcing activities. Secondly, low carbon alternatives for meeting needs and demand should be employed; and thirdly, methods for satisfying needs and demand must be improved. These general evaluation criteria are considered in the following analysis on the applicability and suitability of CDM methodologies and project types and CDM project examples.

Chapter 5
CDM institutional options

Before starting the more detailed analysis of CDM opportunities in the urban context, this chapter will briefly outline the existing, different institutional options available within the CDM. This will allow the reader to obtain a better understanding of the existing instruments in the CDM, their key features and advantages and disadvantages. This will also set the basis for the detailed analysis in subsequent chapters and will also help readers understand the fundamentals of the discussion on barriers in CDM (Chapter 7) and the final recommendations (Chapter 9).

It should be noted that under the scope of this study, it was not possible to explain all CDM rules and procedures in detail. Since the main target audience for this report has basic knowledge of the CDM regulatory framework, we have limited the information we give on the general aspects of CDM. However, further information on CDM rules can be found at http://www.cdmrulebook.org/.

The CDM currently offers three general approaches for developing CDM project activities:

- Single CDM project (Small-Scale or Large-Scale)
- Bundle of several small-scale projects
- Programme of Activities (PoA), consisting of several single CDM programme activities (CPAs)

A PoA clearly offers maximum flexibility in terms of project boundary definition, the timing for implementing further projects and the inclusion of cities/metropolitan regions and target sectors/groups. However, each of the options mentioned above offers specific advantages and disadvantages depending on the planned scope and underlying project types/technologies.

5.1 Single CDM project

Description

Typically, an individual CDM project is a single activity (measure), realised by one project developer at one location. The monitoring of emission reductions for a single project usually refers to a single project location and will be managed by a single project developer. For some CDM methodologies and some project types there is no limit to the number of participating users (e.g. households, industrial facilities) or the number of technical appliances (e.g. number of chillers, buildings). However, in the case of applying small-scale (SSC) CDM methodologies, an individual project has to stay below certain thresholds (see table below).

Analysis of advantages and disadvantages

The number of registered single CDM projects totals more than 3,300 as of September 2011. There is a lot of experience available regarding the validation and registration process as well as on the pitfalls and challenges. The classical CDM however, failed to lift the emission reduction potential of dispersed sources such as the residential and transport sectors. The main reason is that, for those sectors, the individual emission source is rather small which complicates the participation and especially the monitoring, verification and reporting (MRV). The project size and corresponding emission reductions, e.g. of energy efficiency measures for buildings, are small which results in relatively high transaction costs per project compared to the revenues generated from CERs.

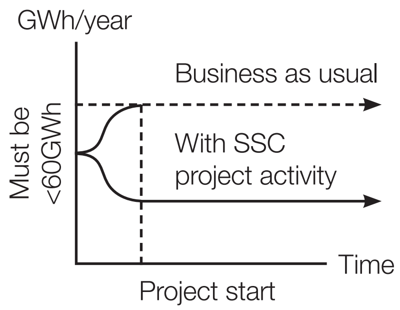
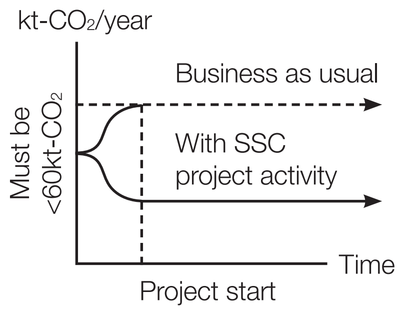
Additionally, for each single project all relevant documentation **(Project Idea Note, Project Design Document**, (PIN, PDD, Host Country Approval) must be developed and each single project must pass the complete CDM project cycle (host country approval, validation, registration, verification and issuance). Projects that do not acquire appropriate documentation risk failing the registration process.

5.2 Bundle of small-scale projects

Description

In the CDM context, bundling means "bringing together several small-scale CDM project activities, to form a single CDM project activity or portfolio without

Table 2: **Eligibility thresholds for small-scale project activities**

Type 1 project activities shall remain the same, such that renewable energy project activities shall have a maximum output capacity of 15 MW (or an appropriate equivalent) (CMP/2006/10/Ad1. p8 para28(a)) • As MW_e is the most common denomination, and MW_{th} only refers to the production of heat which can also be derived from MW_e, the EB agreed to define MW as MW_e and otherwise to apply an appropriate conversion factor. (Glos ver5, p30)	**Type 2 project activities or those relating to improvements in energy efficiency which reduce energy consumption, on the supply and/or demand side, shall be limited to those with a maximum output of 60 GWh/y (or an appropriate equivalent)** (CMP/2006/10/Ad1. p8 para28(b)) 	**Type 3 project activities, otherwise known as other project activities, shall be limited to those that result in emission reductions of less than or equal to 60 kt CO_2 equivalent annually** (CMP/2006/10/Ad1. p8 para28(c)) 

Source: IGES (2011, p. 54)

the loss of distinctive characteristics of each project activity". Bundling aims to facilitate the creation of very small CDM projects for which the transaction costs would otherwise be prohibitive, e.g. residential sector or transportation sector in the urban context. In order to overcome the transaction costs barrier, identical project activities can be bundled together.

This means that PDD development, registration, validation, monitoring, verification and certification would be realised for a group of individual components (e.g. buildings or landfills) instead of a process for each small component (project) individually. Thus, the project developer will benefit from a greater economy-of-scale.

Bundling of small-scale projects is subject to the following conditions:

- The composition of the bundle shall not change over time; this means that the number and timing of projects (e.g. group of users in different regions) has to be known and defined and no projects may be added or removed from the bundle after registration.
- All single project activities must have the same crediting period.
- The total size of the project activities should not exceed the limits for small-scale CDM project activities (see Table 1 above)
- If all project activities are of the same type, of the same category and use the same technology or measure, one single PDD may be developed for the whole bundle.
- The whole bundle must be verified as a single project by the Designated Operational Entity (DOE); only one verification report is required and the issuance of CERs will be made for the whole bundle.

Analysis of advantages and disadvantages

In order to register a bundle of projects under the CDM, all installations (including the geographical location, technical specifications, etc.) are required to be determined ex-ante and would need to be fixed. Additional installations would need extra approvals. Furthermore, the number of installations is limited due to the overall small-scale threshold.

For a city-wide approach, bundling might be an option for addressing similar project activities within the city boundary, for example, landfills or water treatment systems.

5.3 Programme of Activities

Description

A Programme of Activities (PoA) is a voluntary coordinated action by a private or public entity which implements any voluntary or mandatory policy/

measure or stated goal (i.e. incentive schemes and voluntary programmes), which leads to GHG emission reductions. The main characteristics of a programme under the CDM are:

- **Multiple sites:** Depending on the design of a PoA, CDM Programme Activities (CPAs) can occur at different local, regional or national sites. A PoA boundary may extend to more than one country.

- **Two-tiered structure:** There are two types of PoA participants: a PoA coordinator and CPA developers. The PoA coordinator is the key PoA participant. It is not required for the PoA coordinator himself to undertake the CPAs (although it is possible).

- **Unknown number and timing of projects:** In contrast to a bundle, the exact number and time of implementation of CPAs is not known at the time of submission of a PoA. Thus, it is not possible to estimate the overall emission reductions of the PoA with complete certainty.

Once a PoA is registered at UNFCCC, CPAs may be added at any time during the PoA. The addition of new CPAs only requires an assessment of a Designated Operational Entity but does not involve any further registration process and does not involve the UNFCCC CDM Executive Board for approval. The crediting period for each CPA is either 10 years (non-renewable) or 7 years, renewable twice. This is the same requirement as for single CDM projects. However, the overall maximum lifetime of a PoA is 28 years, meaning that within these 28 years an unlimited number of CPAs may be included under the PoA. All crediting periods of the included CPAs end when the PoA ends.

Overall a PoA can be thought of as the registered framework under which individual CDM projects can be included without being individually registered. It is important to understand that these single CDM projects (CPAs) need to comply with all methodological and technical CDM-specific requirements like small-scale thresholds. The PoA can be considered as a regulatory framework that does not achieve emission reductions itself but enables the underlying activities to achieve emission reductions. The advantage of a PoA in terms of CDM transaction costs is that only the PoA itself needs go through the complete CDM project cycle up to UNFCCC registration.

Once it is registered, the individual activities (comparable to single CDM project activities) can be added to the PoA without approval from the UNFCCC CDM Executive Board. If an actor, for example, plans to implement energy-efficiency measures in buildings in Saudi-Arabia, a PoA could be developed that defines the CDM methodology to apply, the type of buildings eligible to participate, measures to be implemented (e.g. insulation, cooling systems, etc.) and the entity that coordinates the whole PoA. In addition, a first real activity (a certain number of buildings defined in the project boundary) needs to showcase the implementability of the PoA and the eligibility of the applied measures. Once the PoA is registered as a CDM PoA, it allows for an unlimited number of CDM Programme activities (projects) to be included under the registered PoA and the individual projects do not need to be defined and known prior to registration of the PoA. This is one of the key differences compared to a CDM project, where all project details (sites, project owners, technology, etc.) need to be known and fixed before registration (see further details on the different CDM institutional options actual PoA concept in Chapters 6 and 7).

Analysis of advantages and disadvantages

A PoA offers a series of advantages that facilitate the realisation of several small CDM project activities:

- Overall, the transaction costs for the registration of CDM projects are usually significantly reduced for project activities under a PoA. The reason for this is that only the PoA itself has to undergo a registration process at UNFCCC level, whereas individual CPAs are only checked by a DOE post-registration and are automatically included in the PoA once the DOE approves that the CPA complies with the eligibility criteria of the registered PoA. This reduces the risk of requests for reviews and rejections for projects during the registration process. Furthermore, Environmental Impact Assessment and Stakeholder Consultation may be realised at PoA level and may be provided at the CPA (project) level. The more it is possible to streamline the procedures at PoA level, the higher the potential cost reductions at CPA level and for the PoA as a whole.

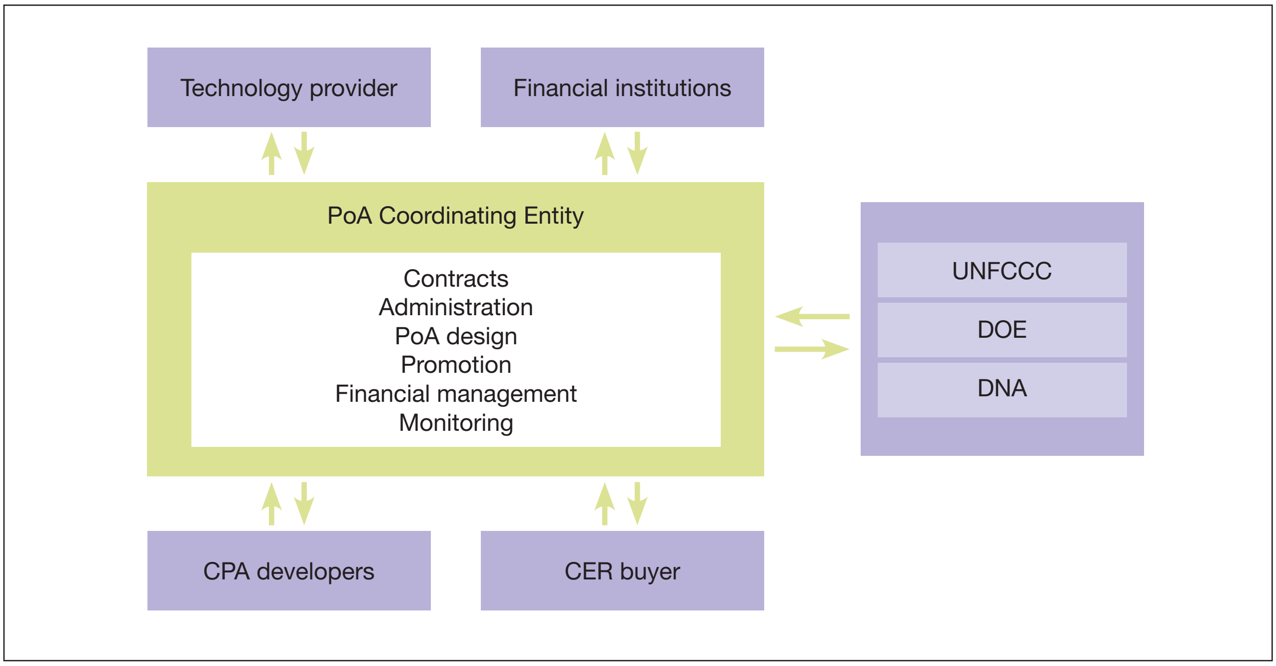
- The PoA itself does not have any limit regarding its size. The PoA applying a small-scale methodology does not need to stay below the small-scale limits. As an example, a PoA that is applying a small-scale methodology on energy efficiency (CDM small scale methodology type II) does not need to stay below the small-scale thresholds for Type II methodologies (60 GWhel/180 GWhth). However, each individual CPA within a PoA needs to fulfil the small-scale limits and hence has to stay below the given thresholds for small-scale.

- Although the monitoring requirements for CPAs under a PoA are the same as for single CDM project(since the same methodological requirements are applied), the PoA rules allow that only a subset of CPAs would need to be verified according to a pre-defined sampling procedure. However, the PoA coordinator has to collect and archive monitoring reports from all CPAs included in the PoA. The PoA coordinator is also responsible for the allocation of issued CERs, if this is applicable to the specific CPA.

- A PoA usually offers more flexibility in terms of designing CDM activities than single projects. This is mainly due to the fact that CPAs may be added at any time during the PoA. This means that – in contrast to single CDM project activities or especially a bundle of small-scale projects –the complete list of projects and project boundaries (e.g. participating end-users) need not be defined in advance. Only each CPA that is going to be included in the PoA needs to specify its project boundary and the participating end-users. This aspect implies that for non-LDCs, a PoA would need to be registered prior to the end of 2012, so that CPAs which are included post-2012 would still be eligible for generating CERs that are eligible for the EU Emissions Trading Scheme post-2012. On the other hand, the PoA concept is the only way to enable projects in those countries to be eligible post-2012, if a PoA is registered for this type of project prior to 2012. Any single project registered after 2012 would not be eligible under current EU-ETS regulations.

- According to the latest "Guidelines for determining the occurrence of de-bundling under a Programme of Activities (PoA)" which was approved at the CDM Executive Board Meeting 47, a de-bundling test is not required for a CPA under a PoA if each of the independent subsystems/measures (e.g. biogas digester, solar home system, light bulb) included in the CPA of a PoA is no greater than 1% of the small-scale thresholds defined by the methodology applied under the PoA. This may be a big advantage for PoAs compared to single projects, at least for some project types/ technologies applied in the urban context (e.g. demand-side energy efficiency).

Figure 5: **Generic PoA structure**



Source: perspectives, GmbH based on UNEP Risø (2011)

Challenges associated with PoAs are:

- The success of a PoA largely depends on the selected coordinating/managing entity and its organisational and managerial capabilities. Unlike single CDM projects, the design and set-up of comprehensive procedures for preparing, implementing and coordinating the PoA with its individual CPAs is very important and a key factor for successful PoAs. The typical tasks and interrelations with other stakeholders are summarized in Figure 5.
- Identifying institutions that can fulfil the requirements of PoA Coordinating Entities status and that have the appropriate capabilities, experience and capacities have already proven to be one of the main bottlenecks for PoAs, especially in developing countries and even more in LDCs. In addition, most PoAs require that the Coordinating Entity is able to show bankability to potential financial institutions, investors, CER buyers and CPA developers. In many cases it is obvious that those requirements are difficult to meet, especially when considering that solid CDM know-how and experience in the sector for which the PoA is conceptualized would be beneficial to guarantee the success of the PoA. Subcontracting and outsourcing of certain tasks may be an option but would need to be assessed in detail at an early stage of PoA design.
- Due to the current limited experience of validation and registration of PoAs, project developers cannot rely on existing know-how on the validation/registration process for PoAs, and there is limited practical experience of the pitfalls and challenges of PoAs. Accordingly, it might take longer to get a PoA registered than to get approval for a CDM single project.
- The benefit of having more flexibility in terms of CPA inclusion brings another challenge with it. Prior to registration of the PoA and even at the point of registration, it is usually not clear how much emission reduction will be achieved during the lifetime of the PoA or even during the first years, since the number of CPAs that will be included is generally not known at this stage. This may increase the complexity of signing Emission Reduction Purchase Agreements (ERPAs).
- The initial CDM transaction costs are usually significantly higher for a PoA compared to a

Table 3: **Overview of the characteristics of the institutional options**

	Single CDM project	Bundle of projects	PoA
Project Size	**According to SSC limits (e.g.60 GWh/a)†**	**According to SSC limits (e.g. 60 GWh/a for whole bundle)**	**Unlimited (each CPA according to SSC limits (e.g. 60 GWh/a)**
More than one region allowed	no	yes	yes
More than one host country allowed?	no	no	yes
Number of projects allowed	one *(but might include different connected regions/areas)*	limited *(as long as total output is < 60 GWh)*	unlimited
Changes of number of projects allowed?	no	no	yes
Managing entity required?	no	no	yes

† The energy savings created by a single project activity may not exceed the equivalent of 60 GWh per year. A maximum saving of 60 GWh is equivalent to maximum savings of 60 GWhe of electricity consumption or maximum savings of 180 GWhth of fuel consumption. For calculation of maximum savings allowable per year, 1 GWH_e equals 3 GWH_{th}

CDM single project. The main reason is that three instead of one design documents needs to be developed and that the design stage of a PoA involves more preparatory work than for a single project. Covering such up-front transaction costs in combination with uncertainty about the quantity of expected CERs may lead to increased caution in developing PoAs.

5.4 Comparison of the different institutional options

Table 3 provides an overview of the characteristics of the different institutional options for CDM projects applying small-scale methodology for energy efficiency project types (type II).

A general obstacle for urban CDM is that most CDM methodologies for both traditional CDM projects and PoAs are technology-specific. By bundling different types of project, i.e. combining different methodologies into one project boundary, different types can be covered in one project. For instance, a project within the residential building sector could combine different technologies such as insulation and efficient lighting in a building. However, the projects' activities under a bundle and combination of methodologies need to apply the methodologies for each activity in a consistent manner, i.e. all projects need to implement insulation improvements and efficient lighting in a building.

Chapter 6

CDM methodologies available for priority sectors in cities

In this section the key requirements for methodologies applicable in the urban context are outlined in detail. All currently approved and existing CDM methodologies are analysed and then evaluated for their eligibility and suitability in the urban context. We have also included the CDM methodologies that are relevant to the priority emission sectors identified in Chapter 4. Furthermore, those CDM methodologies identified are in general applicable for each of the priorities sectors as defined in Chapter 4.

6.1 Requirements of CDM methodologies for projects for urban CDM

Project boundary

The boundary of CDM project activities must encompass all anthropogenic GHG emissions by source under the control of the project participants that are significant and reasonably attributable to the CDM project. Urban CDM is understood as a city-wide CDM project that covers a specific technology, function or sector within the entire city, based on existing CDM rules. The majority of current CDM project activities being small-scale or large-scale are solely project-based covering one specific technology at one specific site. CDM methodologies have been developed to accommodate these project-based characteristics. The intention to address a technology, function or sector within the entire city cannot be easily addressed with the current CDM methodology characteristics and under current CDM rules and procedures.

Electricity import is treated according to the polluter-pays-principle

Due to the agglomeration of cities, energy demand density is relatively high. Cities use the majority of electricity generation of a country while the generation facilities are usually located outside the city boundaries. There are different approaches for balancing the corresponding GHG emissions, either by allocating the emission to the emitting source or to the electricity user following the **polluter-pays-principle**. For cities the latter is recommended to obtain a real picture of energy consumption and related emissions, since the polluter-pays-principle makes the party/end-user responsible for producing pollution and emissions.

Imported electricity into cities should be accounted for by the emissions related to power generation, i.e. by using the grid emission factor (GEF) of the region or country. The factor, in t CO_2 per MWh_e, can be determined by following the CDM methodological "Tool to calculate the emission factor for an electricity system". CDM projects activities applying energy-efficiency measures on the demand side, for example, need to use the grid emission factor for calculating baseline and emission reduction. According to the tool, the grid/project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity (e.g. the renewable power plant location or the consumers where electricity is being saved) and that can be dispatched without significant transmission constraints. Hence, the project electricity grid for city-wide CDM project activities cannot be limited to the geographical boundary of the city.

De-bundling

De-bundling is defined as the fragmentation of a large-scale project activity into smaller parts. A small-scale project activity that is part of a large-scale project activity is not eligible to use the simplified modalities and procedures that are allowed when applying small-scale methodologies. According to the CDM rules, a proposed small-scale project activity shall be deemed to be a de-bundled component of a large-scale project activity if there is a registered small-scale project activity or a request for registration by another small-scale project activity from the same project participants, in the same project category and technology/measure. It must also been registered within the previous two years and its project boundary must be within 1 km of the project boundary of the proposed small-scale activity at the closest point. According to the latest "Guidelines for determining the occurrence of de-bundling under a Programme of Activities (PoA)" which was approved at the 47th meeting of the CDM Executive Board, a de-bundling test is not required for a CPA under a PoA if each of the independent subsystems/measures (e.g. biogas digester, solar home system, light bulb) included in the CPA of a PoA is no greater than 1% of the small-scale thresholds defined by the methodology applied under the PoA. This may be a big advantage for PoAs compared to single projects, at least for some project types/technologies applied in the urban context (e.g. demand-side energy efficiency).

De-bundling limits the application of small-scale methodologies as single CDM project activities if they are not bundled, or under the PoA. If a municipality, for example, decides to implement energy-efficiency measures in public and institutional buildings it has to consider the de-bundling restrictions when planning to implement the activities. This is a barrier since all project sites need to be known in advance and should be bundled into one project activity if they fall under the bundling restriction criteria.

Baseline scenario and additionality determination

The baseline scenario for a CDM project activity is the scenario that reasonably represents GHG emissions that would occur in the absence of the proposed project activity. The difference between the baseline emissions and GHG emissions after implementing the CDM project activity (project emissions) are the actual emission reductions achieved by the project.

According to the CDM rules (UNFCCC 2005, p. 16) a baseline shall be established:

- In accordance with provisions for the use of approved and new methodologies
- In a transparent and conservative manner regarding the choice of approaches, assumptions, methodologies, parameters, data sources, key factors and additionality, and taking into account uncertainty
- On a **project-specific basis**
- In the case of small-scale CDM project activities, in accordance with simplified procedures developed for such activities
- Taking into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans and the economic situation in the project sector.

Before calculating the baseline emissions, it is necessary to identify the most appropriate baseline scenarios. A baseline scenario shall cover emissions from all greenhouse gases, sectors and emission source categories within the project boundary. A CDM project activity is additional if GHG emissions are reduced below those that would have occurred in the absence of the registered CDM project activity. The project participants must demonstrate how and why the project activity is additional and therefore not the baseline scenario in accordance with the selected baseline methodology. The typical CDM baseline and additionality determination is, under the current CDM framework, performed per project activity, i.e. project-specific.

This represents a barrier for dispersed and distributed projects since the additionality test can be quite complex depending on the project type. Under PoAs, the additionality can be proven on the PoA level and CPAs can be automatically eligible if they meet the additionality and eligibility criteria. If an urban CDM project involves several measures and would apply a combination of baseline methodologies, the determination of the baseline may still be conducted for each sector/measure individually and finally aggregated. Within the CDM, there is no precedent for such an approach yet and it can be assumed that it would not be accepted by the CDM EB.

National or sectoral mitigation policies need to be taken into account for the baseline scenario of CDM projects. The rationale is: the implementation of mitigation policies results in a lower level of emissions. If a CDM project were to use this emission level as its baseline, the mitigation policies would make the CDM project less attractive because the lower level of baseline emissions would result in a lower amount of CERs. This could potentially give perverse incentives to host countries not to implement mitigation policies. Hence, the CDM EB clarified how national or sectoral policies and regulations have to be reflected when determining a baseline scenario of a CDM project. After intensive and lengthy discussions, the EB at its 22nd meeting defined two types of policies (E+ and E-) that should be considered in the context of setting up a baseline scenario.[3]

For policies that give comparative advantages to more emissions-intensive technologies or fuels over less emission intensive ones (E+ policies) implemented after the adoption of the Kyoto Protocol on 11 December 1997, the baseline scenario should refer to a hypothetical situation without the policy. The same applies to policies giving comparative advantages to less emissions-intensive technologies or fuels over more emissions-intensive ones (E- policies) implemented since the adoption of the Marrakech Accords on 11 November 2001.

For projects relevant in the urban context (e.g. energy-efficiency projects), the debate around E+/E- has been less prominent and no energy-efficiency project was reviewed or registered based on the grounds of this rule. In fact, the three CFL distribution projects carried out by the German lighting appliance manufacturer Osram were registered under the CDM although regulation to support CFL existed at that time in India. Osram explicitly stated in the validation report that "following the E+/E- rule of the CDM EB (EB16, Annex 3; EB 22; Annex 3), we only take regulatory requirements for use of CFL lamps into account that were implemented before the Marrakech Accords (2001). We have checked and there are no regulatory or legal requirements on CFL lamps before the Marrakech Accords". In summary, the CDM EB has not been very active in the treatment of policies and regulation. Feed-in-tariff is the only policy that has triggered the E+/E- debate so far and led to rejections of **single** CDM projects.

3. 22nd meeting of the CDM Executive Board, Annex 3: http://cdm.unfccc.int/EB/022/eb22_repan3.pdf.

In general, only mandatory policies already enforced are relevant to baseline emissions and additionality of CDM single projects. In the case of PoAs, a mandatory policy can even be part of a CDM project with a programmatic approach. However, for city-wide approaches under the CDM rules, e.g. initiated by municipalities or city authorities, this implies that in general all programs and regulations in the priority sectors having started after 11 November 2001 should not be considered as part of the baseline scenario for CDM projects. Rather, the baseline scenario of CDM projects could refer to a hypothetical situation without the national or sectoral policies or local regulations being in place. Hence, any program or project implemented in a city after this date in general would not interfere with potential CDM projects nor decrease their economic viability.

However, for certain project types the respective CDM methodologies prescribe the consideration of national legislation in the baseline scenario. This is, for instance, the case for building energy efficiency projects where the methodology AMS-III.AE (Energy efficiency and renewable energy measures in new residential buildings) requires that the latest existing building code needs to be respected. And since the rules of the CDM are under a steady process of elaboration, in particular the baseline and monitoring methodologies, it is essential to apply a case by case assessment for each CDM activity, whether existing policies need to be reflected and where not in the urban context.

Establishment of sector-specific standardized baselines

The framework on sector-specific standardized baselines[4] allows the setting of baselines that are not necessarily specific to one type of project activity in a sector, but can be applicable to most of the possible project activities in a sector. The additionality is not to be demonstrated for each individual project activity ex-post (after its formulation) but rather for types of measures and ex-ante. Standardized baselines can currently be applied to measure activities that comprise a broad class of GHG emission reduction activities possessing common features. Four types of measures are currently covered in the framework (i) Fuel and feedstock switch, (ii) Switch of technology with or without change of energy source (including energy efficiency improvement), (iii) Methane destruction and (iv) Methane formation avoidance.

4. CDM EB62, Annex 8

When setting a standardised baseline (benchmark) a positive list is established that shows emission reduction activities that are considered automatically additional under certain conditions (e.g. location, technology/measure, size). For project activities that include multiple types of independent measures, the additionality of each measure is demonstrated by checking against the positive list of measures.

Since small-scale and highly distributed project activities face relatively high transaction costs and barriers, standardised baselines could help to relieve this handicap. First project activities are currently under implementation applying project type or sector specific baselines. As mentioned above and illustrated in the case studies in chapter 8.3, for instance, AM0091 and the Masdar City project is applying a standardized baseline approach based on the corresponding top performer within the residential housing sector. Other standardized baseline and monitoring methodologies are under development. Perspectives GmbH (the authors of this study) has led a project on developing three standardized baseline methodologies (rural electrification, water purification and efficiency improvement for charcoal production) that are especially suitable for Least Developed Countries. Further work is being conducted by Perspectives for the World Bank and UNFCCC in this field. UNFCCC has placed great importance on further simplifying methodologies and increasing the application of standardized approaches within CDM methodologies.

Emission reductions

Emission reductions are determined by comparing the project's emission, if any, with the baseline emission figures. The baseline approach is the basis for a baseline methodology. The UNFCCC Executive Board agreed that the following three approaches are the only ones applicable to CDM project activities:

1. Existing actual or historical emissions, as applicable; or
2. Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment; or
3. The average emissions of similar project activities undertaken in the previous five years, in similar social, economic, environmental and technological circumstances, and whose performance is in the top 20 per cent of their category.[5]

5. CDM EB08 Annex1, paragraph 4-5

If proposed project activities apply more than one methodology comprising different "sub-activities" and hence requiring different CDM methodologies, the project participant may propose to use one CDM-PDD but complete the methodologies sections in the document for each "sub-activity" separately. This means if a combination of several methodologies is applied for one project activity, the requirements of each applied methodology have to be met which increases the work and complexity of the overall project design document and the monitoring procedures for the project activity since each methodology will require specific and individual monitoring procedures that need to be applied. An alternative approach would be to develop a new methodology that makes use of those methodological elements necessary for the broader approach while combining overlapping elements. Here again it should be stated that the timeline for developing a methodology and getting it approved can take 1-2 years depending on the complexity and innovative character of the approach. Taking into account the 2012 deadline for CDM in non-LDCs, the applicability of this methodology would mainly be limited to LDC countries (see further information in chapter 7).

Monitoring

The monitoring of emission reductions achieved by a CDM activity refers to the collection and archiving of all relevant data necessary for determining the baseline, measuring GHG emissions within the project boundary of a CDM project activity and leakage, as applicable. Accordingly, projects must apply a monitoring methodology that refers to the method used for the collection and archiving of all relevant data necessary for the implementation of the monitoring plan. Projects may propose a new monitoring methodology by identifying the most appropriate methodology bearing in mind proven monitoring practice in relevant sectors. Usually the parameters to be monitored are project-specific, on a continuous basis and being monitored on-site. Emission reductions from dispersed end-users and emission sources that are typical within cities are difficult to assess as the monitoring of all activities is not feasible or efficient, but the monitoring of one single or only a few end-users might not be representative enough. Therefore, at least a sample of the project activities has to be monitored. Hence, monitoring of dispersed projects is complex and costly and imposes a considerable barrier to implementation.

6.2 Evaluation of existing CDM methodologies

For the identification and evaluation of existing CDM methodologies with regards to their applicability in the urban context and on a city-wide level, two different categories of evaluation criteria and indicators have been established:

1. General CDM feasibility of a methodology, and
2. Applicability for the urban context of the methodology.

Table 4 below shows the defined and applied criteria in more detail.

The entire list of analysed methodologies is provided in Annex 2. The methodologies are categorised in the following sectors: residential, service and commercial buildings, waste, transportation, industry and energy industry. By applying the above mentioned criteria, the evaluation matrix provided below reveals CDM methodologies that are widely used and applicable in the CDM on the one hand and methodologies that are especially feasible within the urban city context on the other. Interestingly, methodologies that are

Table 4: **Evaluation criteria of available CDM methodologies for the priority sectors**

Criteria/indicator	Description
1. CDM feasibility	
General sector applicability ('priority sectors')	Does the methodology fall into one of the relevant priority sectors in the context of urban CDM?
Has the methodology been applied to a project?	Some methodologies have been developed top-down or include certain criteria that make them less practical. Those criteria provide an indication if a methodology or project type is applicable in practice and how much experience exists in the CDM on the actual application of the methodology.
Number of times the methodology has been used	In contrast to the first criterion, this criterion allows the evaluation of how much experience exists in the market and how many project types that methodology is able to cover.
2. Urban context applicability	
Applicable for the urban context?	Is the application of the methodology generally applicable in the city/urban context? Urban CDM should be understood as a city-wide CDM project that covers a specific technology, function or sector within the entire city, based on existing CDM rules.
Comprehensiveness	Is the methodology in general contributing to the transformational shift to a low carbon city/low carbon development (instead of "end-of-pipe" quick fixes)? Methodologies and project types can have further different levels of impact for the overall sustainable development of a city. For example, projects within the transport sector can either focus on 1) avoidance of traffic, 2) modal shift of traffic, or 3) the improvement of existing technologies.
Methodology used in more than one sector?	Can the methodology be applied in different sectors, i.e. is the methodology relevant for one or several priority sectors?
Existing combination with other methodologies	Has the methodology been applied in combination with one or several other CDM methodologies already?
Municipality or city-based companies involved in existing projects	Is there a CDM project on-going or in the pipeline addressing municipalities or having a local (city-based) authority as a project participant applying the methodology?
Scalability/city-wide approach (PoA/Bundle)	Is the methodology generally applicable for PoAs or small-scale bundles?
Existing PoA (pipeline)	Do PoAs exist in the CDM pipeline applying the methodology?

broadly applicable and that have often been used in the CDM are also potentially favourable in the urban context e.g. applicable to more than one sector when combined with other methodologies, PoA eligibility and the possibility of bundling. However, there are additional methodologies that are either new or rarely been applied so far, but relevant for the priority sector in an urban context and for the corresponding project types. Hence, alongside the qualitative and quantitative analysis through an evaluation matrix, a closer look at analysing and identifying the most promising methodologies has been undertaken.

Table 5: **Main CDM methodologies applicable for urban projects**

Approved methodology	Sectors covered	No. of projects	No. of PoAs	Available since (year)
Residential sector (energy demand for heating/cooling; electric appliances)				
AMS-II.C	Demand-side energy efficiency programmes for specific technologies	28	12	2002
AMS-II.E.	Energy efficiency and fuel switching measures for buildings	32	2	2002
AMS-II.J.	Demand-side activities for efficient lighting technologies (deemed savings)	43	11	2008
Service and commercial buildings (energy demand for heating/cooling; electric appliances)				
AMS-II.C	Demand-side energy efficiency programmes for specific technologies	28	12	2002
AMS-II.E.	Energy efficiency and fuel switching measures for buildings	32	2	2002
AMS-II.J.	Demand-side activities for efficient lighting technologies (deemed savings)	43	11	2008
Waste sector (waste – municipal solid/liquid – handling and management, landfills)				
ACM1	Landfill gas project activities	245	4	2004
AMS-III.G.	Landfill methane recovery	49	0	2009
AM25	Avoided emissions from organic waste through alternative waste treatment processes	94	0	2006
AMS-III.E.	Avoidance of methane production from biomass decay through controlled combustion	74	0	2002
AMS-III.F.	Avoidance of methane production from biomass decay through composting	87	14	2009
AMS-III.H.	Methane recovery in wastewater treatment	273	1	2009
Transportation (car traffic, public transport, modal shift etc.)				
AMS-III.C.	Emission reductions by low greenhouse emission vehicles	14	1	2002
Industry (energy efficiency measures at manufacturing facilities)				
AMS-II.C	Demand-side energy efficiency programmes for specific technologies	28	12	2002
AMS-II.D.	Energy efficiency and fuel switching measures for industrial facilities	174	2	2002
AMS-II.H.	Energy efficiency measures through centralization of utility provisions of an industrial facility technology	14	0	2008

Approved methodology	Sectors covered	No. of projects	No. of PoAs	Available since (year)
Energy industry (cogeneration with district heating/cooling and decentralised power generation; renewable energies; bio fuels)				
ACM2	Grid-connected electricity generation for renewable sources (no biomass)	2310	2	2004
AMS-I.A.	Electricity generation by the user	46	2	2002
AMS-I.B.	Mechanical energy for the user	4	1	2002
AMS-I.C.	Thermal energy production with or without electricity	516	20	2002
AMS-I.D.	Renewable electricity generation for a grid	2185	11	2002
AMS-I.F.	Renewable electricity generation for captive use and mini-grid	41	3	2010
AMS-I.J.	Solar water heating systems (SWH)	0	1	2011
ACM6	Grid-connected electricity from biomass residues	313	0	2005
ACM18	Electricity generation from biomass residues (co-fired) in power-only plants	22	1	2009
AMS-I.E.	Switch from Non-Renewable Biomass for Thermal Applications by the User	13	5	2008
AMS-II.G.	Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass	7	12	2008
ACM12	GHG reductions for waste gas or waste heat or waste pressure based energy system	331	1	2007
AMS-III.Q.	Waste gas based energy systems (gas/heat/pressure)	122	0	2009
AMS-II.B.	Supply side energy efficiency improvements - generation	26	0	2002
AM29	Grid connected electricity generation plants using natural gas	76	0	2005
AMS-III.B.	Switching fossil fuels	81	1	2002

Source: perspectives GmbH, based on UNEP Risø (2011)

There are a few methodologies that are applicable for more than one sector. For instance, small-scale methodology AMS-II.C for demand-side energy efficiency measures is relevant for the residential, commercial and industrial sectors and is applicable for any small energy efficiency measures like light bulbs, fans, refrigerators etc. AMS-II.E is applicable for various energy efficiency and fuel switching measures in buildings and the methodology AMS-II.J for efficient lightning technologies is applicable for the residential and commercial building sector.

The building sector methodology AM0091, which was approved in 2011, is applicable for residential and commercial buildings and covers electrical and thermal energy savings. Covering more than one sector makes methodologies attractive for application in cities, since a wider range of sectors or technologies could be covered by applying a single methodology. However, most methodologies are quite specific and limited in their applicability conditions to certain technologies or project boundaries. Hence a combination of methodologies might overcome this limitation.

For a city-wide CDM approach that covers a specific technology, function or sector within the entire city, based on existing CDM rules, it is essential to apply

Table 6: **Additional recent CDM methodologies**

Approved methodology	Sectors covered	No. of projects	No. of PoAs	Available since (year)
Residential sector (energy demand for heating/cooling; electric appliances)				
AM91	Energy efficiency technologies and fuel switching in new buildings	0	0	2011
AMS-III.AE.	Energy efficiency and renewable energy measures in new residential buildings	0	1	2009
Service and commercial buildings (energy demand for heating/cooling; electric appliances)				
AM91	Energy efficiency technologies and fuel switching in new buildings	0	0	2011
Transportation (car traffic, public transport, modal shift etc.)				
ACM16	Mass Rapid Transit Projects	8	0	2009
AM31	Baseline Methodology for Bus Rapid Transit Project	14	0	2005
AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1	0	2008
Energy industry (cogeneration with district heating/cooling and decentralised power generation; renewable energies; bio fuels)				
AMS-I.J.	Solar water heating systems (SWH)	0	1	2011

Source: perspectives GmbH, based on UNEP Risø (2011)

methodologies that are not too narrow in their design and scope, i.e. one single technology at a certain project site or sector.

The analysis above has revealed that small-scale methodologies would be most suitable and applicable within the urban CDM context based on existing rules and standards. In all major sectors small-scale methodologies are available now. The advantage of small-scale methodologies is that most of them, especially those focusing on energy efficiency measures, are generally broad in their applicability. For instance **AMS-II.C** is generally applicable for different types of technology (e.g. lighting, refrigerators, etc.). However, the more recent methodology **AMS-II.J** which specifically focuses on efficient lighting technologies by a deemed saving approach (using default values), has been more successful in mobilizing the energy-saving potential of CFL project activities in recent years (43 project activities and 11 PoAs, as of 1 August 2011, UNEP Risø 2011). The reason for this is that even though methodologies might be less specific in their conditions it does not mean that their practicability is always clear. AMS-II.J is therefore deemed most suitable for an urban CDM project for efficient lighting, depending on the size of the city, either as a single project or PoA. Below, key methodologies in the different priority sectors are described.

Residential and commercial building sector

In the building sector (residential and commercial), there are many opportunities to save energy and achieve emission reductions through energy efficiency measures. Listed below are some examples for measures that, if combined, would be tricky under the traditional CDM and worse in one single project:

- Substitution of lighting equipment and application
  - Substitution of incandescent lamps (ICL) with more efficient compact fluorescent lamps (CFL)
  - Substitution of inefficient appliances, e.g. air conditioning and refrigerators
  - Energy efficient lighting system: daylight and occupancy sensors

- Building codes/insulation enhancements
  - Adoption of high efficiency material and advanced control system
  - Enhancement of thermal insulation

  - Enhancements of Heating, Venting and Air-Conditioning (HVAC) systems
  - Retrofit of existing building
  - New building including energy optimized building design

- Employment of renewable energies
  - Solar water heater (SWH)
  - Photovoltaic
  - Solar cooling

AM0091[6] and **AMS-III.AE**[7] are identified as most suitable for a city-wide approach providing a whole-building approach for building programmes including energy efficiency and renewable energy measures as well as measures to reduce leakage from refrigerators and air-conditioners (AC). AMS-III.AE uses a regression analysis on energy savings. Under this methodology the energy savings are estimated based on energy consumption of sample buildings participating in the programme (project buildings) and those outside the programme (baseline buildings). The approach statistically adjusts the energy savings for factors influencing building energy performance (e.g., climate conditions, building size, occupancy, etc.).

In the case of AMS-III.AE, baseline buildings need to be selected from similar locations, climate and socio-economic conditions, with comparable building type, size and vintage. Thus, the level of disaggregation is relatively high. AMS-III.AE sets the baseline as the average of energy performance of the baseline buildings built in the previous five years. Additionality demonstration needs to be carried out following the barrier and/or investment analysis. It requires energy consumption and climate condition data to be updated annually, while other building characteristics can be updated every third year.

AM0091 on the other hand applies a benchmarking approach which has a distinct advantage in streamlining the Monitoring, Verifying and Reporting (MRV) procedures compared to AMS III.AE. Another advantage is that the same benchmark can be used to address both baseline determination and proof of additionality at the same time.

6. http://cdm.unfccc.int/methodologies/DB/WTEB6W8MP4BQZXOIBS1FO9KXP45C9R; The methodology is based on the proposed new methodology NM0328: Energy efficiency and fuel switching measures in new buildings, prepared by Perspectives GmbH for Abu Dhabi Future Energy Company (Masdar)
7. http://cdm.unfccc.int/methodologies/DB/AWRS1U9S13QBGT2FX236Z2CVTMH44A

Benchmarking is generally defined as a performance comparison against peers. In the case of building efficiency programmes, a benchmark is commonly expressed in GHG emissions or energy consumption per gross floor area of a building. The benchmark is established based on actual energy consumption data obtained from a sample of buildings. As there are numerous factors that influence building efficiency levels, it is commonly required to disaggregate building stocks into several sub-categories so that the performance level of buildings in the sub-category becomes more homogeneous. The most commonly applied dimensions for disaggregation are building type and occupancy, followed by climate condition, building size and vintage.

The stringency level of the benchmark used within AM0091 both for baseline and additionality is set as the average emission performance of building units built in the previous five years, and with the top 20% highest emission performance. A benchmark is commonly established on historical one-year data. Energy consumption and climate conditions are usually based on actual data. AM0091 specifies an updating frequency differentiated by data source. Energy consumption needs to be updated annually but other factors may be updated every three years so as not to inflate the monitoring costs.

For the methodology AMS-III.AE, the project activity boundary is the physical extent of the new residential development(s) where efficiency and/or renewable energy technologies are installed. Under AM0091 on the other hand, the spatial extent of the project boundary encompasses the area covering all the project and baseline building units (baseline is the municipality where the project takes place). In addition, the spatial extent of the energy supply systems that provide energy for the project and baseline building units is included in the project boundary.

For a potential city-wide PoA, the PoA project boundary is defined as the geographical area in which all the CPAs included in the PoA will be implemented.

Transportation sector

For the transport sector particularly, **ACM0016** and **AM0031** address mass rapid transit systems (MRTS) and bus rapid transit (BRT) projects and are deemed promising for cities. The methodologies are applicable to project activities that reduce emissions through the construction and operation of MRTS/

BRT systems within a city or an urban area (e.g. metropolitan area). However, the project activities need to define the exact dimension of the new system in the registration documentation. This applicability condition might be a barrier especially for small-scale activities within cities where only enhancements and organisational changes are undertaken over time. A more flexible methodology or approach like PoA could relieve this barrier.

Waste sector

Depending on the specific situation of the individual waste sector in the city, its waste handling and management procedures (e.g. recycling, landfill and wastewater treatment), could be a relevant source of GHG emissions. Currently all methodologies for the waste sector are end-of-pipe approaches (i.e. landfills or methane avoidance). This means the methodologies do not support and promote the transformation within the waste sector to reduce, reuse or recycle waste. Hence, for cities the sustainable benefits triggered through CDM might be limited, at least with the currently available methodologies. Nevertheless, the methodologies **AMS-III.E**, **AMS-III.F AMS-III.G** and **AMS-III.H** are applicable for PoAs or bundles for emission reductions in cities from municipal waste and waste water. Since many applications include methane capture or methane avoidance, and methane has a much higher greenhouse potential then CO_2, this sector should always be considered in a specific assessment for the carbon emission reduction potential of a city.

Industry

As explained previously, heavy industry (cement/steel etc.) and product-specific approaches have been excluded from the key sectors in cities within this study. Usually, these activities are concentrated facilities covered by the "traditional" CDM. Therefore, only energy efficiency measures at small scale, for example inefficient electric motors and pumps used for manufacturing are considered in the urban context. For these project types, the small scale methodologies **AMS-II.C**., **AMS-II.D**., **AMS-II.H**. are deemed most feasible.

Energy industry

For the energy industry within cities, especially decentralised power generation with or without cogeneration, feeding district heating or cooling systems, as well as the employment of renewable energies are considered most promising. The two most successful CDM methodologies ACM0002 (Grid-connected electricity generation for renewable sources (no biomass)) and **AMS-I.D**. (Renewable electricity generation for a grid) fall into this category. However, in the urban context, large-scale renewable energy facilities, e.g. wind turbines or hydro power plants are usually not the most feasible technologies. Hence, the small-scale methodologies **AMS-I.D**. or **AMS-I.A**. (Electricity generation by the user) are likely to be the most important for power generation like solar PV, small-scale geothermal and micro wind turbines in an urban or semi-urban context.

An enormous amount of energy within cities is used for cooling or heating (depending on the geographical location and the climate zone). In this regard, **AMS-I.C**. (Thermal energy production with or without electricity) has been quite widely applied within the CDM. Another recently approved methodology is solar water heating (**AMS-I.J**.; Solar water heating systems (SWH)). Alongside this, co-generation technologies are covered by several approved CDM methodologies, e.g. **AM0048** "New cogeneration facilities supplying electricity and/or steam to multiple customers and displacing grid/off-grid steam and electricity generation with more carbon-intensive fuels" and **AM0084** "Installation of co-generation system supplying electricity and chilled water to new and existing consumers" as well as the methodologies for industrial co-generation **AM0014** and **AM0049**. Furthermore **AM0058** is applicable for the introduction of a new primary district heating system.

Bundling of small-scale projects

The bundling of small-scale CDM projects in order to cover more measures in one project is deemed as an opportunity to promote an urban CDM approach. However, bundling is not widely applied amongst registered CDM project activities. This is mainly due to its limitation as outlined in Chapter 5.2 (i.e. small-scale threshold, definition of sites and project details prior to registration). In UNEP Risø's CDM Pipeline (Stand August 2011) only about 80 small scale projects could be identified as making use of bundles. Most bundles consist of project types with clearly identifiable project sites (especially wind and hydro power projects). Typical project types in the urban context are not significantly present as illustrated by the following table.

Table 7: **Bundled small scale registered CDM project activities**

Meth/project type	Biomass energy	Fossil fuel switch	Hydro	Methane avoidance	Solar	Wind	Total
AMS-I.A.	1		1				2
AMS-I.C.	1				1		2
AMS-I.D.			35		7	30	73
AMS-I.D.			1			1	2
AMS-III.B.		2					2
AMS-III.D.+ AMS-I.D.				1			1
AMS-III.E.+ AMS-I.C.	1						1
Grand Total	**3**	**2**	**37**	**1**	**8**	**31**	**82**

Source: perspectives GmbH, based on UNEP Risø (2011)

None of the identified bundles are directly implemented in the identified priority sectors for an urban CDM. Apparently bundling of methodologies has so far not promoted CDM projects in complete sectors or cities.

Chapter 7

Barriers for CDM project development in an urban context

Having identified the major emission sources for cities and for applying CDM in the urban context, having described the three CDM instruments available (single, bundle, PoA), and after evaluating the existing CDM methodologies, projects and PoAs for their eligibility in the urban context, this chapter outlines the key barriers for CDM in the urban context. Typical emission reduction activities in cities, e.g. energy efficiency measures in buildings or urban transport projects, face several barriers during CDM project development. These barriers are mainly due to the regulatory framework of the CDM.

Additionality and non-financial barriers

The CDM is an offsetting mechanism, since CERs from developing countries are equivalent to emission allowances in developed countries. This means that a CDM project must provide emission reductions that are additional to what would have occurred in a business-as-usual scenario. In other words: has the CDM project only been mobilized by the revenues from the sale of the CERs or would it have been implemented in their absence? Independent auditors, Designated Operational Entities (DOEs), shall review the Project Design Document (PDD) to check whether a project has less attractive financial parameters than a credible baseline alternative or has encountered prohibitive barriers to its implementation.

In many cases dispersed projects like energy efficiency improvements are financially attractive even without CDM and are in the context of carbon mitigation identified as opportunities with the lowest marginal abatements costs (compare Marr and Wehner 2005). The typical CDM-related barriers for project types relevant in the urban context are of a non-financial nature and are not appropriately addressed under the current CDM regulation for additionality testing. For example, the split-incentive problem (e.g. between the landlord (who installs energy-efficient boilers) and the tenants (who pay the heating bill) prevents investors from taking future avoided costs into account as these costs have to be covered by somebody else. Therefore, they invest in a less efficient technology that has lower upfront costs. Proving these non-financial barriers to energy efficiency projects is more prone to gaming than proving additionality with the help of an investment analysis (Hayashi and Michaelowa 2007). Therefore, dispersed energy efficiency projects in cities typically face a higher regulatory risk making this type of project less attractive for the CDM compared to other project types.

Discrete equipment vs. systems approach

In many cases it makes sense to combine several emission reduction measures, e.g. energy efficient measures or the introduction of mass transportation while promoting bike lanes, in order to achieve substantial GHG emission reductions. However, when several measures are applied (e.g. CFLs, insulation and high-efficient appliances) each of the measures has to be looked at separately under the current CDM structure with project-specific methodologies. Until now, the CDM Executive Board has not allowed for systemic approaches within the CDM, where the overall energy consumption and hence the overall carbon emissions are measured. For understandable reasons, the CDM usually opts for the most accurate and most conservative approach in terms of generated emission reductions. In addition, it seems that due to fears that a more comprehensive approach would not address exogenous effects well enough, this has not so far been accepted. However, this is changing, inasmuch as the new CDM methodology AM0091 “Energy efficiency technologies and fuel switching in new buildings” allows for a whole building approach to monitoring.

PoAs applying the same CDM methodologies

As explained in chapter 6, the PoA concept was established to make underrepresented project types feasible in general and especially in underrepresented countries and circumstances. Even though there clearly are procedural advantages for applying a PoA instead of single projects, one of the main drawbacks is that PoAs are based on the same CDM methodologies as single CDM projects (see Chapter 5.3 – section on PoAs). The result is that in general each project under a CDM PoA, which is called CDM Programme Activity, would need to comply with the same methodological requirements. The methodological barriers (data needs, data availability, complexity of monitoring, etc.) that exist for the key project types in cities and that have been mentioned above would also exist for CPAs under a PoA. To be absolutely correct here, we must mention that some small-scale methodologies have included some specific PoA requirements in existing methodologies. However, in most cases these require even more work than single projects.

The CDM Executive Board clarified that PoAs are generally allowed to apply a combination of methodologies. In the beginning this has led to misinterpretation of the rules among PoA developers. The CDM EB has further stated that a combination of methodologies needs to be approved by the EB and that each individual project under a PoA must apply the same combination of methodologies. This rule was established to allow project types being developed as a PoA that require a combination of methodologies like methane capture projects that also generate electricity. Recently (in EB meeting 59 to 62) the Board also provided certain combinations of methodologies that do not need prior approval after initial approval has already been provided. As a conclusion, only combinations of small-scale methodologies are allowed that have already been applied in registered CDM projects with exactly the same combination of methodologies (CDM EB59 Annex 9, paragraph 11(b)). But change is in the air here as well and it is likely that any combination will be possible, provided the absence of "cross effects" can be proven.

Dispersed end-users: Data availability, monitoring and transaction costs

Experience has shown that monitoring of emission reductions from a high number of appliances and dispersed end-users for emission sources that are typically found in the urban context (e.g. demand-side energy efficiency or transport) is usually harder to assess than the monitoring of a single end-user. Including high numbers of appliances and heterogeneous end-users would increase the difficulty of baseline data determination and monitoring. A sampling approach (based on stratified sampling) would be required, taking into account those differences. In conclusion, data requirements and monitoring project types including dispersed end-users is complex in terms of CDM and would increase the overall CDM transaction costs. This imposes a considerable barrier for implementation of this type of CDM project. However, recently UNFCCC has proposed a new sampling standard which has been open for public comment and which would allow for a PoA sampling approach where not every individual CPA would require a separate sampling. This would be a step in the right direction and a way to reduce CDM transaction costs for PoAs.

Dispersed end-user: Free riders/spill-overs

As soon as a project/PoA targets a larger group of people, free rider and spill-over effects start to affect emission reductions. In other words, not every participant of an energy efficiency PoA can be seen as additional as the participant might have bought the efficient equipment anyway. On the other hand, spill-over effects (publicity) could induce additional emission reductions outside the CDM project. Default values for free-riding and spill-over effects derived from existing projects/PoAs could reduce the monitoring burden considerably. Such default values already exist e.g. in methodology AMS II.J for energy-efficient lighting.

Post-2012 eligibility of CDM

After discussing the technical aspects for CDM projects, PoAs and the underlying CDM methodologies that exist under the current CDM framework, a broader discussion is required about the overall strategy for implementing "urban CDM" projects or PoAs. To ensure the eligibility of generated CERs resulting from urban CDM projects and PoA(s) in Non-Least Developed Countries (e.g. South Korea) into the Trading Phase III of the EU-Emission Trading Scheme (2013-2020), those projects/PoAs would need to be registered before 31 December 2012. From experience of CDM timelines for starting and finishing projects and PoAs, it is too late to bring new projects or PoAs into the CDM pipeline that have a realistic chance of obtaining registration prior to the 2012 deadline. This may be a very important aspect to consider when developing new CDM methodologies and projects/PoAs for urban CDM concepts.

To summarize, typical project activities in an urban context, like demand-side energy efficiency and measures in the transport sector, face several barriers within the current CDM framework. The challenge is to (partly) resolve the trade-off between the environmental integrity and simplicity of CDM methodologies.

Chapter 8

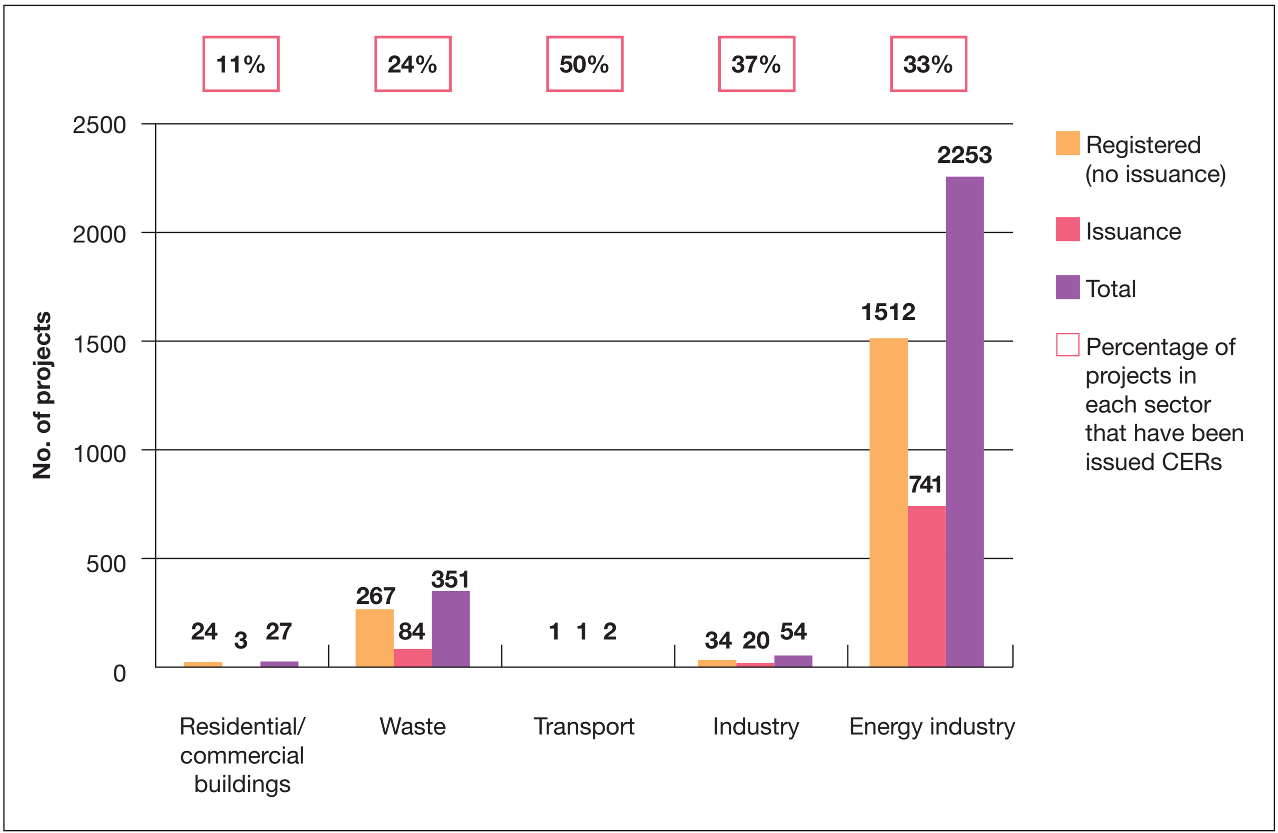
Existing CDM projects in the urban context

The major emission sources of cities is specific and has unique characteristics, depending, inter alia, on the composition of the local industry and economy, the city's design and compactness (dense vs. spread out settlement patterns), transportation needs and modes, the access and price of energy resources as well as the underlying policy and regulatory framework in the country and the city itself (i.e. incentive system/setting). In order to accommodate this in a single urban CDM project for mitigating emission, the approaches and methodologies need to be flexible and broad in order to provide wide applicability and coverage.

8.1 Urban CDM in the current CDM pipeline

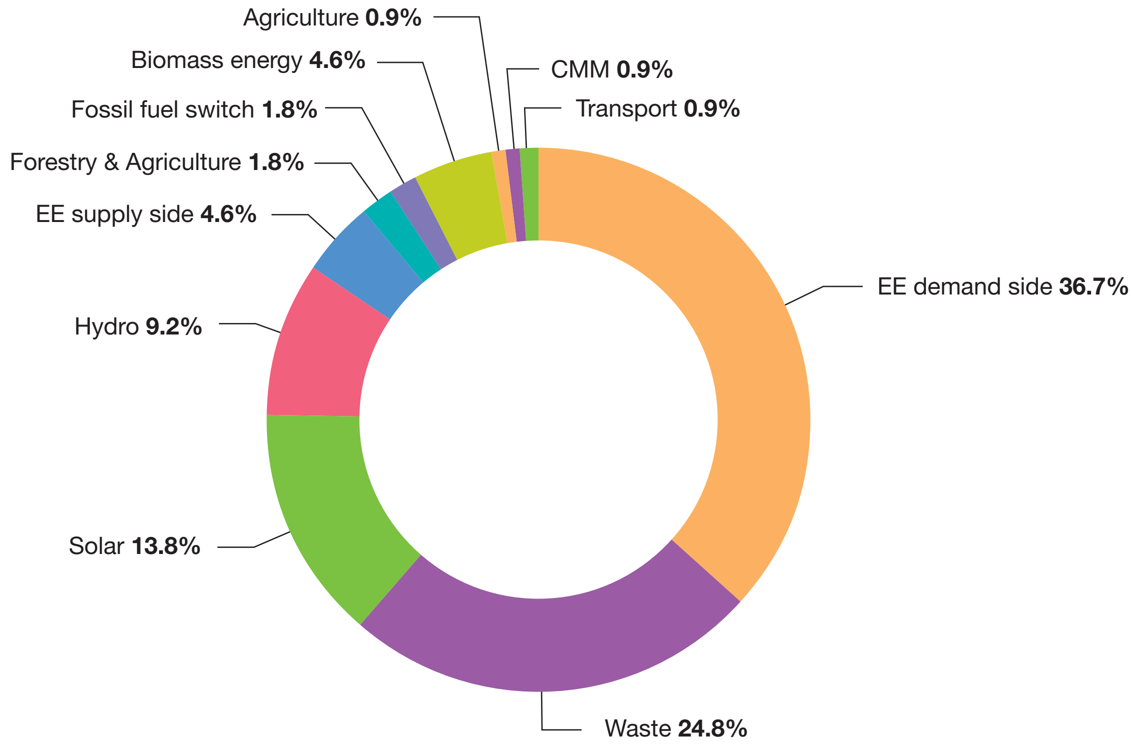
Based on the above definition of urban CDM and the identified priority sectors and methodologies in this section, here we identify and analyse examples of urban CDM projects under implementation in the major sectors/functions. Sample projects and PoAs are discussed and are listed in Annex 3. The projects are evaluated with regards to their applicability to urban CDM; lessons learned are presented and potential need (if any) to modify/optimize existing CDM methodologies to increase their suitability for urban CDM are investigated.

Figure 6: **Registered CDM projects at issuance in priority sectors**



Source: perspectives, GmbH based on UNEP Risø (2011)

Figure 7: **PoA in the pipeline by project type**



Source: UNEP Risø (2011)

Figure 6 shows the number of registered projects in the priority sectors and the projects that have already been issued CERs. In the residential sector (incl. commercial buildings) only 27 projects are registered as of September 2011, with only 11% having at least one issuance of CERs. In comparison the energy sector has more than 2,250 registered projects with about one third having been issued CERs.

At the same time, only 11 CDM PoAs have been registered according to UNEP Risø (2011). One third of all the above mentioned projects and PoAs have a project boundary that is either a city or a municipality. Of all PoAs, registered and at validation, approximately 75% are tackling sectors that are currently underrepresented in the traditional CDM or relevant for cities: demand-side energy efficiency, waste and dispersed renewable energy supply (e.g. solar water heating). This indicates that the PoA concept has the potential to mobilize the potential and relief existing barriers in these sectors due to the existing CDM rules. For example, only 3.6% of ordinary CDM projects are energy efficiency projects on the demand side and only 1.5% of normal CDM projects are solar projects (UNEP Risø 2011). Within PoAs in the pipeline (in validation or beyond) these project types represent 37% and 14% respectively. However, the transportation sector, an important sector in the urban context, is still only marginally represented (<1%).

Table 8 lists currently registered PoAs (incl. CPAs) that have been developed in the context of an urban environment or within a municipality.

As can be seen from the examples listed in Table 8, all PoAs with a city or municipality-wide boundary are initially using small-scale methodologies. The municipal waste composting PoA in Uganda already has eight CPAs included, all applying AMS-III.F. *"Avoidance of methane emissions through composting"*. Each CPA covers one municipality or city in Uganda. In comparison, the low pressure solar water heater programme in South Africa focuses on several municipalities, e.g. Nelson Mandela Bay and Ekurhuleni. The first CPA is limited by the number of installed solar water heaters.

Table 8: **Registered PoAs (incl. CPAs) with a city or municipality-wide boundary**

Ref.	Title	Host country	PoA Boundary and Province / State/ Region	Coordinating Entity	Status	Type	Sub-type	CDM Meth
2956	Uganda Municipal Waste Compost Programme	Uganda	Uganda	National Environmental Management Authority (NEMA)	Registered	Landfill gas	Landfill composting	AMS-III.F.
2897	Egypt Vehicle Scrapping and Recycling Program	Egypt	Egypt	Ministry of Finance	Registered	Transport	Scrapping old vehicles	AMS-III.C.
4302	SASSA Low Pressure Solar Water Heater Programme	South Africa	South Africa	Solar Academy of Sub Saharan Africa	Registered	Solar	Solar water heating	AMS-I.C.

Source: perspectives GmbH, based on UNEP Risø (2011)

Table 9 summarises all methodologies used by PoAs currently in the CDM pipeline within the priority sectors. As can be seen, over 90% of the projects registered or under development are applying small-scale methodologies. However, only about 5% use a combination of methodologies. An entire list of PoAs in the pipeline making use of methodology combinations is provided in Annex 3. One of these projects is "The programme to introduce a renewable energy system into Seoul" in South Korea and coordinated by the Seoul Metropolitan Government. The PoA involves applying a photovoltaic system, solar water heating system and geothermal heating/cooling system in public buildings in Seoul. The PoA that is now under validation proposes to apply the two small-scale methodologies AMS-I.F. and AMS-I.C. This combination allows tackling both electric and thermal energy supply based on renewable energies within buildings under one city-wide programme.

A second example for combining methodologies is the Mexican Housing Commission Sustainable Housing Program of Activities coordinated by the Mexican National Housing Commission (CONAVI). The PoA which is currently in validation is applying the methodologies AMS-III.AE. and AMS-I.C. combining efficient lighting, insulation and solar water heating in new residential buildings.

For energy efficiency measures in households, currently 25 projects are registered as single CDM project activities (UNEP Risø 2011). Of these projects, 18 CDM projects or 72% are tackling energy savings through efficient lighting, e.g. CFLs. Another five projects use more efficient stoves in households. Only one project, the Kuyasa low-cost urban housing energy upgrade project, Khayelitsha in Cape Town, South Africa, is focusing on a broader approach, covering several technologies, i.e. lighting, insulation and solar. Again, this requires a combination of methodologies. In this case, small scale methodologies AMS-II.E., AMS-I.C. and AMS-II.C are used.

Within the commercial building sector there are five registered CDM project activities that implement either energy efficiency measures in new buildings, lighting improvements or energy efficiency measures at public buildings. One example is the combination of small-scale methodologies AMS-II.E. and AMS-II.B. in order to cover both energy efficiency and fuel

Table 9: **PoAs (incl. CPAs) in the pipeline within the priority sectors**

Sector/methodology	At Validation	Registered	Total
EE households	**50**	**2**	**52**
AMS-II.C.	8	1	9
AMS-II.E.	2		2
AMS-II.G.	24		24
AMS-II.J.	14	1	15
AMS-III.AE.+AMS-I.C.	2		2
EE industry	**4**		**4**
AMS-II.D.	4		4
EE own generation	**2**		**2**
ACM12	2		2
EE service	**20**		**20**
AM60	2		2
AMS-II.C.	12		12
AMS-II.E.	2		2
AMS-II.L.	2		2
AMS-III.AV.	2		2
EE supply side	**2**		**2**
AMS-II.K.	2		2
Energy distribution	**4**	**1**	**5**
AMS-II.A.	4	1	5
Fossil fuel switch	**2**		**2**
AMS-III.B.	2		2
Geothermal	**2**		**2**
AMS-II.C.+AMS-I.C.	2		2
Landfill gas	**10**	**1**	**11**
ACM1	4		4
AM53+ACM1	2		2
AMS-III.F.	4	1	5
Methane avoidance	**26**		**26**
ACM1	2		2
AMS-I.C.	8		8
AMS-I.E.	4		4
AMS-III.AO.+AMS-I.E.	2		2
AMS-III.F.	8		8
AMS-III.H.	2		2

Sector/methodology	At Validation	Registered	Total
Solar	**27**	**1**	**28**
AMS-I.A.	2		2
AMS-I.C.	14	1	15
AMS-I.D.	3		3
AMS-I.F.+AMS-I.C.	2		2
AMS-I.J.	2		2
AMS-III.AR.	2		2
AMS-III.AV.	2		2
Solar, Wind, Hydro	**1**		**1**
AMS-I.D.	1		1
Transport		**1**	**1**
AMS-III.C.		1	1
Grand Total	**150**	**6**	**156**

Source: UNEP Risø (2011)

switching measures for buildings as well as energy efficiency improvements of the energy supply system for the building.

As of September 2011 there are two registered Bus Rapid Transport (BRT) project activities (UNEP Risø 2011; see Annex 3). Overall the transportation sector has six CDM projects registered, of which two projects apply BRT (BRT Chongqing Lines 1-4, China and BRT Bogotá, Colombia: TransMilenio Phase II to IV, both applying AM0031) and one cable car system (Cable Cars Metro Medellín, Colombia applying AMS-III.U.). However there are 13 similar projects in the CDM pipeline already at validation stage.

The waste sector has a relatively large number of registered CDM project activities. There are currently 202 registered landfill gas projects (mainly applying ACM0001 and AMS-III.G.), 33 project activities avoiding methane through composting (mainly applying AMS-III.F.) and another 143 projects for waste water treatment (mainly applying AMS-III.H.).

8.2 Currently proposed city-wide approaches based on the CDM

Under a PoA the CPAs are single activities, or a set of interrelated measure(s), that are applied within a designated area defined in the baseline methodology and the PoA design. The World Bank's city-wide approach proposed follows the basic principles of a CDM PoA that is based on a multi-sector approach (WB 2010). Under such an approach, the coordinating entity, e.g. municipalities, would have the flexibility to combine relevant technology options across different sectors, given their financial and development abilities. This PoA concept refers to relevant CDM methodologies for quantification of the emissions reductions.

The approach proposed by the World Bank aims to expand the CDM PoA to a multi-sector approach, thus giving cities the flexibility to create their own city-wide GHG mitigation strategies and access carbon finance for those sectors as whole and not technology or sector-specific. The study conducted on this city-wide approach explores alternative opportunities to quantify emission reductions and proposes a two-pronged approach: 'measurement,' based on CDM methodologies, and 'estimation' based on per unit impact of each activity (WB, 2010, page 26). The concept addresses energy efficiency measures in buildings, transport, forestry, water use (i.e. introduction of efficient technologies) and waste management.

The World Bank revealed some regulatory pre-conditions to be fulfilled for a successful implementation of a city-wide PoA (Spors and Ranada 2011): the use of multiple methodologies under a PoA shall be allowed; the PoA-DD format modified and the requirement for generic CPA-Design Document removed.

Initially the concept proposes to restrict the use of multiple methodologies to PoAs that are implemented by a legally distinct entity (e.g., a municipal authority), makes use of approved CDM methodologies, allows the unique identification of each project activity (technology, location), and develops a centralized database system to avoid double-counting (Spors and Ranada, 2011). Each CPA shall have distinct and clear linkage with the municipal authority, i.e., the project is implemented by:

- the municipal authority directly (e.g., Bus Rapid Transit system) or
- through a sub-contractor (e.g., solar water heater for households) or
- by a private investor (e.g., wastewater treatment for the city)

The concept's 'estimation' approach is largely based on energy intensity indicators that are particularly relevant for cities in developing countries given their overall objective of improving and expanding urban services and amenities without limiting their GHG impact on the atmosphere (World Bank 2010, p. 27). However, this concept is not entirely applicable under the current regulatory framework and its related conditions of the CDM and PoAs. The recently introduced possibility of applying standardized baselines for certain project types could solve some of these difficulties. When making use of a PoA the 'measuring' approach based on CDM methodologies has to be applied. This would be possible for project types that are covered under CDM methodologies, like energy efficiency measure in buildings, methane recovery from waste water treatment, efficient lightning etc.

However, some of the described potential technologies and interventions to be applied under a city-wide approach, like labelling building, building codes, certification of building materials, renewable energy standards (RES), and promotion of distributed power generation with feed-in tariffs, changes of land use patterns (see World Bank 2010, p. 25) are policy-based measures. Policy measures are difficult to implement with a project-based mechanism like CDM. Additionally, supportive actions and other interventions, e.g. awareness campaigns, are not directly covered by current CDM methodologies. For policy and regulation based mitigation, then alternative concepts like NAMAs are probably more suitable.

Mexican Housing Commission Sustainable Housing Program of Activities

Photo courtesy of CONAVI

Institutional type	CDM PoA
Priority sector	Residential sector, residential buildings/housings
Host county / city / project boundary	Mexico, country-wide
Coordinating/managing entity and project participants	Mexican Housing Commission (Comisión Nacional de Vivienda – Conavi)
Framework, project design and background	The Mexican Housing Commission Sustainable Housing PoA is a small-scale programme of activities to provide subsidies and/or increase loans ("green financing") for the purchase of residences in Mexico that use energy efficient and/or renewable energy technologies to reduce greenhouse gas emissions. The PoA will be operated and implemented by the Mexican National Housing Commission ("CONAVI, its acronym in Spanish) and will involve the verifiable installation of technological elements and efficiency measures in new affordable housing. The 2007-2012 Mexican Housing Program estimated that during the time period 2005-2030 there will be a need for 16 million new residences. For the time period 2007-2012 the demand for new housing is around 1 million per year. Historically, new housing developments have been characterized not only by the high degree of urban sprawl but also by overexploitation of natural resources. This PoA is a part of the Federal Government's concerted effort to address the strategic problem posed by the pending shortage of natural resources as well the problem of climate change.

	CONAVI is the entity in Mexico responsible of creating, coordinating, evaluating and executing national policies related to housing and it is also given the responsibility of distributing subsidies. CONAVI's program was created in 2007 with the specific purpose of providing subsidies to low income families to purchase affordable houses. The program has evolved since then and has been developed and registered under a CDM-PoA with the same fundamental purpose but also as a tool to promote sustainability and energy efficiency in new residences. CONAVI's subsidies are distributed mainly via mortgages though the large residential mortgage issuers are, to varying degrees, also government entities. These mortgage issuing entities have followed and complemented CONAVI's program with other programs; this is particularly true of the green mortgage program which is operated by the largest originator of residential mortgages in Mexico, the National Fund for Housing (INFONAVIT). This special type of mortgage is an additional credit, above the borrower's approved amount, for the purchase of a home that complies with a series of sustainability measures. These loans are often standalone but they are mainly distributed attached to a subsidy to cover the additional portion of the credit amount either partially or fully. Additionally, the green mortgage program operates under the rules established by CONAVI. CONAVI's program, through its green financing platform, is a very powerful tool to promote sustainability in new residential construction: it allows potential buyers to purchase a sustainable – more expensive – residence through a financial vehicle specifically designed for that purpose. Residences that are eligible for this PoA are built primarily by residential development companies in housing developments or communities that vary greatly in size.
Technologies applied	Energy efficiency • Use of CFL lighting • Thermal insulation Renewable energy generation • Installation of solar water heaters • Solar photovoltaic Bioclimatic architecture (or energy efficient design)
CDM methodologies applied	AMS-III.AE.: Energy efficiency and renewable energy measures in new residential buildings – Version 1.0 AMS-I.C.: Thermal energy production with or without electricity – Version 18.0
Additionality and baseline	The PoA is a voluntary coordinated action and is not implementing a mandatory policy/regulation, thus the assessment and demonstration of additionality of the PoA as a whole is addressing the following points: (i) The proposed PoA is a voluntary coordinated action (ii) If the PoA is implementing a voluntary coordinated action, it would not be implemented in the absence of the PoA.

	Additionality is proven by barrier analysis according to the CDM additionality tool. For the CPA it is assumed that all residences that qualify for green financing in Mexico are eligible under the PoA and hence the CPA is additional.
Annual emission reduction (estimated/realized)	10,067 t CO_2e (first CPA)
Implementation status	Under CDM validation; see CONAVI, 2010
Comments and lesson learned	The advanced planned CDM PoA for new housing by CONAVI is based on the Green Mortgage and "Ésta es tu casa" programmes. Both programmes were developed and are currently financed without considering carbon credits from the PoA and will need to do so in future. Given the current lead times of CDM PoAs the programme can realistically be expected to be registered in 2012 only if it passes validation and registration at the UNFCCC. The CER revenues could then potentially be used to contribute to the refinancing of the two programmes from 2013 onwards. Mexico is interested in the concept of supported NAMAs, as coined during the Bali UN climate negotiations in December 2007 and described within the Copenhagen Accord in December 2009, as an important means for supporting the goals laid out in the Pacific Economic Cooperation Council (PECC) including the "Efficient housing and green mortgages" programme. The enforcement of the already existing building code and norms is voluntary and delegated to local authorities that are often unable to supervise the implementation of the standards. In practice, the ambitious building standards are not implemented or enforced. As effective enforcement and periodical updates are essential for the successful implementation of building codes, Mexico is seeking international support for the enforcement and further enhancement of its existing regulations. Mexico and Germany have initiated a concept study on the 'Supported NAMA Design Concept for Energy-Efficiency Measures in the Mexican Residential Building Sector'. It explores how a supported NAMA could be designed to enhance the 'Efficient housing and green mortgages' programme of the PECC. The NAMA concept was developed in 2010 for the Mexican Environment Ministry (SEMARNAT) and the Mexican National Housing Commission (CONAVI) with the support of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Unless otherwise noted, the analysis in this section is based on the unpublished paper Wehner et al. (2010).

Scope of the supported NAMA:

Item	Description
Sector	Building sector
Sub-sector	New residential buildings
NAMA boundary	Entire country
Measures with direct impact on GHG emission reduction	Substantial up-scale of the Green Mortgage and This is Your House programmes through increased subsidies and more ambitious efficiency standards
Measures with indirect impact on GHG emission reduction	Supportive actions for transformation of the Green Mortgage and This is Your House programmes into a holistic urban planning process: • Building code pilot in one federal state • Promotion and enforcement of building codes across federal states over time • Capacity building • Extension of urban planning criteria and inclusion in the holistic framework
NAMA timeframe	Implementation: 2011-2012 Operation: 2013-2020
NAMA implementation and operation costs	Incremental costs required for the up-scaling of actions until 2020
NAMA type	Supported NAMA (with a possibility of credited NAMA for parts of the actions)
Type of support required under the NAMA	Financial, technical and capacity building

BRT Bogotá, Colombia: TransMilenio Phase II to IV

Photo: Alejandro Navarro

Institutional type	Single large-scale CDM project
Priority sector	Transportation, public transport
Host county / city / project boundary	Colombia, Bogotá
Coordinating/managing entity and project participants	TransMilenio is a public-private partnership (PPP) in which the public sector is responsible for the investment in infrastructure (segregated lanes, stations, terminals, etc.), while the private sector is responsible for investment in the bus fleet, the ticket selling and validating system, and for the operation of the trunk and feeder services.
Framework, project design and background	The goal of TransMilenio is to establish a sustainable mass urban transport system based on a Bus Rapid Transit (BRT) system. TransMilenio Phase II-IV is an extension of Phase I. Phase I is not part of this CDM project. The first crediting period includes Phase II, III and part of Phase IV. All data listed refers to the first crediting period if not mentioned otherwise. Core aspects of TransMilenio are: • A new infrastructure consisting of dedicated lanes, large capacity buses, elevated bus stations that allow pre-board ticketing and fast boarding. Smaller units offering feeder services to main stations are integrated in the system. • A new integrated fare system allowing for free transfers. • Improved bus management system moving from many small independent enterprises competing at bus-to-bus level to a consolidated structure with formal enterprises competing for concessions. • Centralized coordinated fleet control providing monitoring and communications to schedule services and real-time response to contingencies. • Reduction of the existing fleet of buses through a scrappage program. Through scrapping more than 9,000 buses TransMilenio retires more than a third of all conventional buses and reduces the risk of a declining efficiency (load factor) in the remaining system.

	The objective of TransMilenio is to establish an efficient, safe, rapid, convenient, comfortable and effective modern mass transit system ensuring high ridership levels.
Technologies applied	Bus Rapid Transit (BRT) Features of the BRT system of TransMilenio include exclusive right-of-way lanes, rapid boarding and alighting, free transfers between lines, pre-board fare collection and fare verification, enclosed stations, clear route maps, real-time information displays, automatic vehicle location technology to manage vehicle movements, modal integration at stations, effective reform of the existing institutional structures for public transit, clean vehicle technologies and excellence in marketing and customer service. The BRT system of TransMilenio is considered as a model-case for a modern mass urban transit system and is being replicated by other cities world-wide.
CDM methodologies applied	AM0031: Baseline Methodology for Bus Rapid Transit Projects – Version 1.1.0
Additionality and baseline	The baseline alternatives assessed are: 1. Establishment of a rail-based public transport system 2. Complete operational restructuring of the public transport system 3. Continuation of the current system including improvements based on national, regional or local policies. The continuation of the current system includes the continuation of TransMilenio Phase I. 4. Implementing the project (TransMilenio Phase II and following) without CDM The additionality of the project is determined using the CDM "Tool for the demonstration and assessment of additionality (version 2)".
Annual emission reduction (estimated/realized)	246,563 t CO_2e/a (average expected as per PDD); 79,326 CERs issued in 2009
Implementation status	Registered as CDM project activity in December 2006, currently at fifth issuance of CERs
Comments and lesson learned	The Bogotá Transmilenio system has attained a very high productivity level averaging 1,600 passengers per day per bus, reducing travelling time by 32%, eliminating 2,109 public-service vehicles, reducing gas emissions by 40%, and making zones around the trunk roads safer thus decreasing accident rates by 90% throughout the system (C40Cities, 2011). The BRT system, through a combination of advanced Euro II and III technology buses and improved operational efficiencies, has clearly played a major role in reducing traffic congestion throughout the city. Residents and visitors of Bogota now enjoy reduced travel time, cleaner air and fewer accidents. With registration of the BRT system's Phase II-VIII with UNFCCC in 2006, the city expects US$25 million in Clean Development Mechanism (CDM) carbon credits by 2012. The program was a success due to many factors: strong leadership from the City Mayor; careful design and planning; use of state-of-the-art technology; the establishment of a well-managed company; sound investment in infrastructure and an efficient single-fare pricing system (C40Cities, 2011).

Energy Efficiency Improvements in new buildings of Masdar City Phase 1 in Abu Dhabi

Photo: © Foster + Partners

Institutional type	Large-scale CDM project activity
Priority sector	Residential, commercial and institutional buildings
Host county / city / project boundary	United Arab Emirates, Abu Dhabi, Masdar City
Coordinating/managing entity and project participants	Masdar
Framework, project design and background	The project activity is energy efficiency improvements in the new buildings of Masdar City Development. Masdar is Abu Dhabi's multi-faceted initiative advancing the development, commercialisation and deployment of renewable and alternative energy technologies and solutions. Masdar City is part of Masdar development. Masdar City is the first clean-technology cluster located in a carbon-neutral, zero-waste city powered entirely by renewable energy. This free zone in Abu Dhabi seeks to become a global centre for innovation, research, product development and light manufacturing in the fields of renewable energy and sustainable technologies. The purpose of the project activity is to build and operate energy efficient buildings in Masdar City Phase 1. The Masdar City Phase 1 will include construction of the Masdar institute, Masdar head office and residential units. The expected completion of Phase 1 will be in 2012.
Technologies applied	Energy efficiency in buildings will be maintained through: **1. Building load reduction – passive design strategies; reduction in energy consumption compared to Abu Dhabi baseline strategies include:** • Minimize external loads (latent, sensible) by heat transmission, infiltration, ventilation, solar direct and indirect gains and other passive solar design features • Minimize internal loads from equipment and lighting (controlled operation, peak load management) • Optimize natural daylight **2. System optimisation-reduction in energy consumption compared to Abu Dhabi baseline strategies include:**

	• High efficiency equipment and lighting • Low pressure air system with sensible heat recovery • Water-based cooling by radiation or natural convection • Intelligent metering • Peak management
CDM methodologies applied	AM0091: Energy efficiency technologies and fuel switching in new buildings --- Version 1.0.0
Additionality and baseline	The project activity is a greenfield development and therefore no pre-project scenario exists. In the absence of the project activity the Masdar City Phase 1 buildings would have been constructed as a business as usual (baseline scenario) case in Abu Dhabi without considering the building energy efficiency features. A benchmark approach is applied to establish the baseline scenario and demonstrate additionality. The baseline scenario is the construction of new building units. Total baseline emissions correspond to the emissions level of the baseline building units which is derived using benchmark analysis for the respective building unit category. The project will reduce the substantial quantity of emissions (in terms of electricity) with respect to the baseline scenario. In the baseline and project activity buildings only electricity is used for all the applications (lighting, cooling etc.). The electricity is produced in fossil fuel based power plants in Abu Dhabi Grid which emit CO_2. In the project activity the building units will consume less electricity with respect to the baseline scenario. Reduction in electricity will reduce CO_2 emissions in the Abu Dhabi Grid.
Annual emission reduction (estimated/realized)	10,943 t CO2e/a
Implementation status	Baseline methodology was approved in June 2011
Comments and lesson learned	CDM methodology AM0091 is applying an innovative benchmarking approach. Benchmarking is generally defined as a performance comparison against peers. In case of building efficiency programmes, a benchmark is commonly expressed in GHG emissions or energy consumption per gross floor area of a building. The benchmark is established based on actual energy consumption data obtained from a sample of buildings. As there are numerous factors that influence building efficiency levels, it is commonly required to disaggregate building stocks into several sub-categories so that the performance level of buildings in the sub-category becomes more homogeneous. The most commonly applied dimensions for disaggregation are building type and occupancy, followed by climate condition, building size and vintage. AM0091 applies a benchmark to baseline and additionality. For both baseline and additionality, the stringency level of the benchmark is set as the average emission performance of building units built in the last five years, and with the top 20% highest emission performance. A benchmark is commonly established on historical one-year data. Energy consumption and climate conditions are usually based on actual data. Benchmarking is the most popular approach to the whole-building approach. The approach has a distinct advantage in streamlining the monitoring, verifying and reporting (MRV) procedures in that a benchmark can be used to address both baseline and additionality.

Amman Green Growth Program (Amman City-Wide CDM Program)

Construction Work for Amman BRT (April 2011)

Photo courtesy of World Bank

Institutional type	CDM PoA
Priority sector	Urban solid waste management, energy efficiency and the use of renewable energy in streets and residential buildings, urban transport management, urban forestry and urban water management.
Host county / city / project boundary	Jordan, Amman, Greater Amman Municipality
Coordinating/managing entity and project participants	Greater Amman Municipality (Public Entity) International Bank for Reconstruction and Development as Trustee of the Carbon Partnership Facility
Framework, project design and background	**1. General operating and implementing framework of PoA** Greater Amman Municipality (GAM) and the Carbon Finance Unit from the World Bank (WB) signed a Seller Participatory Agreement (SPA); an agreement with the International Bank for Reconstruction and Development, as Trustee of the Carbon Asset Development Fund and the Carbon Fund of the Carbon Partnership Facility, on 27 May 2010. According to the agreement, GAM is committed to sell a portion, as determined in the SPA, of the Emission Reductions (ERs) generated from the project(s) identified under the Amman Green Growth Program (AGGP); where the trustee is also committed to buying ERs even beyond 2012. The AGGP is a program that unifies GAM efforts towards Sustainable Urban and Environmental Development. The program will reduce greenhouse gasses emissions at the city level, aggregating carbon emissions from public transportation (Bus Rapid Transit and Light Rail Transit), energy, and waste sector among others. GAM and the WB have decided that the first phase of the Bus Rapid Transit (BRT) system in Amman will be the first CDM Program Activity.

	This PoA will operate within the framework of the Greater Amman Municipal administration. The Amman Green Growth program will be coordinated by a dedicated team in the office of the Mayor. The municipality works through different departments and in close coordination with different ministries to implement a range of activities broadly categorised in five sectors: I. Energy (energy efficiency and renewable energy) II. Water management III. Solid waste management IV. Transport V. Urban forestry **2. Policy/measure or stated goal of the PoA** In 2008, Amman city embarked on creation of the Amman Plan 2025. This plan is the city's blueprint for sustainable development. It addresses such issues as the built and natural environment, culture and heritage, transportation and infrastructure and community development. The CDM programme, developed as a sub-set of the Amman Plan, will ensure that activities under this plan select lower-carbon technological options thus generating carbon emission reductions. **3. Confirmation that the proposed PoA is a voluntary action by the coordinating/managing entity** There is no government regulation that requires the creation of this PoA by GAM.
Technologies applied	A CPA will include a technology or measure covered under an approved methodology for the following sectoral scopes: 1 Energy industries (renewable / non-renewable) 2 Energy distribution 3 Energy demand 6 Construction 7 Transport 13 Waste handling and disposal 14 Afforestation and reforestation 15 Agriculture CPA can implement different technologies or measures and apply the appropriate baseline and monitoring methodology. As GAM develops and implements its Master Plan, the departments of GAM will identify and discuss potential project activities with the PoA coordinating team. The Amman city-wide program could include the following activities covered by relevant approved CDM methodologies, specified under the sectoral scopes listed above:

No	Sectoral scope	Examples of project activities	List of relevant methodologies
1.	Energy industries (renewable/non-renewable	Solar water heaters	AMS I. C
		Wind power	ACM0002
2.	Energy distribution	Loss reduction	AMS II.A
3.	Energy demand	CFL	AMS II.J
		Street-lighting, water pumping	AMS II.C
6.	Construction	Recycling of building material	If, and as, available
7.	Transport	Bus Rapid Transit	AM0031 or ACM0016
		Retrofit	AMS III.AA
		Electric vehicles and fuel-switching	AMS III.C, AMS III.S
13.	Waste handling and disposal	Landfil gas	ACM0001, AMS III.G
		Municipal waste management, including recycling and waster water treatment	AMS type III methodologies
14.	Afforesttaion and reforestation	Creation of green areas in and around the city	AR-ARMS0002
15.	Agriculture	Manure management system	AMS III.D OR ACM0010

Depending on the scale of the methodology, the CPA may use either the CPA-DD or the SSC-CPA-DD.

CDM methodologies applied

A CPA will include a technology or measure covered under an approved methodology for the following sectoral scopes:

1 Energy industries (renewable / non-renewable)
2 Energy distribution
3 Energy demand
6 Construction
7 Transport
13 Waste handling and disposal
14 Afforestation and reforestation
15 Agriculture

Additionality and baseline

S.No	Eligibility Criteria	Confirmation
1.	The CPA is implemented in Jordan	Yes/No
2.	The CPA fulfills one of the following conditions: (i) the CPA is within GAM's geographic boundary; (ii) the CPA is implemented directly by GAM; (iii) the CPA involves an activity regulated by GAM; or (iv) the CPA is sub-contracted or facilitated by GAM (e.g., through financial or other incentives).	Yes/No (Provide details)
3.	If the CPA falls under condition (i), (iii) or (iv), of criteria 2 above, and is being implemented by an agency other than the departments of GAM, confirm that the agency has signed relevant agreement with GAM	Yes/No (Specify the type of agreement)
4.	The CPA implements a technology or measure covered by an approved (large, small or consolidated) CDM baseline and monitoring methodology, under any one of the following sectoral scopes: 1 Energy industries (renewable / non-renewable) 2 Energy distribution 3 Energy demand 6 Construction 7 Transport 13 Waste handling and disposal 14 Afforestation and reforestation 15 Agriculture *Once approved by the Executive Board, approved combinations of sectoral scopes and methodologies can be used for future CPAs*	Yes/No (Specify the sectoral scope and methodology)
5.	The start-date of the CPA, defined as the date of signing of a contract signifying financial commitment to the activity, is signed after 1/1/2011 or after the date of start of programme validation, defined as publication of PoA-DD documents on the UNFCCC website.	Yes/No (Specify)
6.	The technology or measure implemented by the CPA is not a mandatory requirement in Jordan.	Yes/No
7.	The CPA confirms that the project is not registered or being registered as a stand-alone project or as part of another PoA	Yes/No
8.	The CPA fulfils all specific requirements of the applicable (large, small, consolidated) methodology	Yes/No
9.	The CPA is additional, as per the relevant guidelines, based on the scale of the project activity	Yes/No

Annual emission reduction (estimated/realized)	560,000t CO_2e estimated
Implementation status	Under preparation
Comments and lesson learned	Coordination and consensus is key to successful preparation and implementation later on. Easy access to financing is crucial even before the implementation phase where there is a great need for smooth progress in preparation and buy-in from all parties and stakeholders. Special consideration should be given to the uncontrolled impact of formal approval processes and timelines within the host country and EB on project/program development.

Chapter 9

Discussion and recommendations for further action

As discussed and outlined throughout this study the concept of urban CDM has experienced challenges and barriers for implementation under the current CDM rules and regulations. Urban CDM is understood as a city-wide CDM project covering specific technologies, services or sectors within the entire city or even metropolitan area. As of today, the vast majority of CDM single project activities - be they small-scale or large-scale - are very project-based covering one specific technology usually at one specific site. The project boundary definition of single CDM projects is generally very narrow and fixed. The majority of CDM methodologies have been developed to accommodate these project-based characteristics.

Potential emission mitigation activities in the identified priority sectors within this report however often have dispersed characteristics, as for example in the residential building and transport sectors. Those project types have not been taken up within the existing CDM framework, despite its extensive mitigation potential. The intention to address all applications of a technology, a service (e.g. cooling/heating) or a sector (e.g. transport) within one entire city cannot be sufficiently addressed within the current CDM methodology characteristics and regulatory framework.

The concept of programmatic CDM (Programmes of Activities, PoAs) is a first step to overcoming the barriers that single CDM projects pose to urban emission mitigation activities. In general PoAs offer this opportunity and it can be the best CDM instrument to tackle emission reduction project activities more widely as well as in the urban context. However, PoAs still have to apply existing CDM methodologies (that have been developed for single CDM project activities!) and hence are rather limited in their applicability to an overall city-wide and sector-wide approach including different sectors, technologies and emission sources. PoAs can be designed to address project activities of one sector, if these projects make use of the same methodologies or a certain combination of methodologies and that apply the same type of technology. For example, PoAs for energy efficiency measures in residential buildings or in waste management for landfill sites are currently developed even for the urban context. According to the latest PoA rules, different CDM methodologies may also be applied together under one PoA for pre-defined project types or if approved by the CDM Executive Board. Having said this, it would be recommended that combinations of methodologies should not just be limited to certain project types or technologies, as long as an aggregated target (emission reduction in cities) can be achieved, monitored and verified. Obviously, a conservative approach to emission reductions, additionality and proper monitoring procedures would need to be ensured.

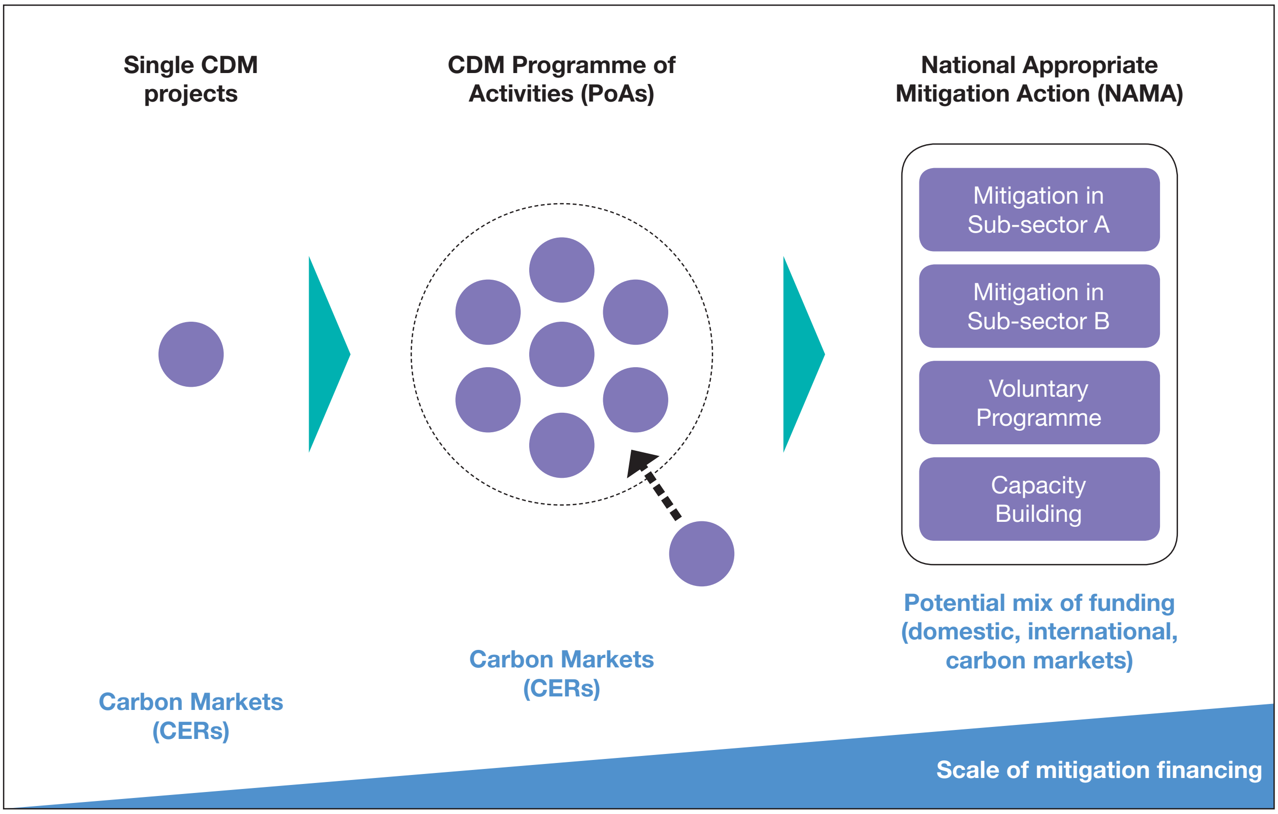
For such city-wide and sector-wide CDM projects and concepts the recently introduced principle of standardized approaches (e.g. standardized baselines, benchmarks and default values) for certain applications/sectors could be relevant and facilitate urban CDM project activities. Especially for distributed and dispersed projects, standardised approaches could make baseline and additionality determination as well as monitoring, much simpler for project developers, and hence reduce CDM-related transaction costs and technical barriers for these mitigation actions. The topic of reduced CDM transaction costs is particularly relevant for small or medium sized cities, where municipalities or city councils must take political decisions within a given budget. For any CDM project activity the revenues from achieved emission reductions only occur ex-post and only when the monitoring has been conducted continuously and according to CDM requirements. Applying several methodologies and addressing different technologies and sectors, which is a relatively innovative approach within the CDM, bears higher risks due to higher front-loaded costs and greater complexity for the monitoring of emission reductions. For enabling urban CDM projects in a wider scope, any risk mitigation option would need to be applied to manage the overall cost-benefits of cities.

One strategy is to further introduce standardized approaches for baseline determination and monitoring. The possibility of proposing standardised baselines has just been opened by the CDM Executive Board and only one standardised baseline has very recently been submitted to the CDM EB.[8] A good example of what standardised baselines can potentially mean for city-wide approaches is demonstrated in the recently approved methodology for energy efficiency measures in buildings (AM0091). It applies a standard baseline for newly constructed buildings which massively reduces pre-registration monitoring needs compared to conventional methodologies. The methodology evolved in the context of the large-scale Masdar City project and also played a key role in the proposed NAMA concept in the Mexican new residential housing sector. Further standardisation of methodologies for baseline and additionality determination will be highly relevant for the further development of sector-wide and city-wide approaches.

However, just as CDM slowly becomes more accessible to cities, the demand for credits from CDM and CDM PoAs in the most rapidly developing cities is likely to falter. The EU, which dominates the CDM market on the demand side, is banning the import of credits from CDM activities registered after 2012, unless projects are located in Least Developed Countries (LDCs). A comparable source of demand for CDM credits from other countries or Emission Trading Schemes is not realistically to be expected within the next few years; or even until the end of the decade. In the short-term, it will therefore be increasingly challenging for UNEP to incentivise partner cities in non-LDC countries to engage in mitigation activities with the argument that those activities could be partially financed through CDM revenues.

8. Standardized Baseline for "Efficiency increase in the production of charcoal" – developed by Perspectives

Figure 8: **Scaling up mitigation and incentives for carbon financing**



In this situation the concept of NAMAs that emerges under the post-2012 climate policy regime could be a promising alternative for UNEP to incentivise cities to take mitigation action and to finance those efforts through such frameworks. NAMAs have the advantage compared to CDM that they target a much higher, either sectoral, regional or country level of aggregation. A second benefit of such frameworks is that they are designed to purposefully integrate the policy dimension which has proven to be difficult to fit into the CDM. Figure 8 illustrates the path of evolution that the UNFCCC mechanisms will take within the next few years: from the project-based CDM as we know it to full-scale sectoral programmes.

When considering NAMA there is also a possible link to new market mechanisms (e.g. sectoral mechanism) currently discussed at the UNFCCC level. The connection between NAMAs and sectoral mechanisms is the following. The Cancun Agreements recognize two type of NAMAs – those which are implemented using only domestic resources and finance, referred to as "unilateral NAMAs", and those with international support, referred to as "supported NAMAs". It is generally recognised that support could be provided through traditional means such as grants, loans and capacity building programmes but could also be provided through carbon markets. A NAMA that is supported by creating and selling carbon credits to industrialised countries is generally referred to as a "credited NAMA" (although not specified in the Cancun Agreements). The two main proposals that have been discussed in the UNFCCC process regarding sectoral mechanisms are commonly referred to as "sectoral crediting" and "sectoral trading". The main proponent of these two models has been the EU, with support from a number of other industrialised countries, as well as some emerging economies. There are a number of similarities between the concepts of NAMA crediting and sectoral crediting. Both envisage credit generation for emission reductions linked to large-scale policy or programme implementation. Both would require high quality emissions data for the setting of appropriate emissions baselines and stringent MRV rules. Both would tend to be most appropriate for financing abatement opportunities further up the cost curve (e.g. in transport), via the sale of the credits generated. From this perspective, the implementation of sectoral crediting could simply be considered a NAMA in itself.

Given the uncertainty for urban CDM in the context of the post-2012 eligibility for many UEA cities (since not situated in Least Developed Countries), it is advisable not to build only upon the existing project specific concepts of the CDM, but to test innovative solutions on an aggregated level. We suggest that large cities should pilot NAMAs. This framework provides more flexibility to address the technological and institutional barriers in the urban context through a top-down approach coordinated by the city administration, but will certainly encounter new challenges, not least the ability of a municipal government to enforce policy measures and to administrate greenhouse gas accounting. It will be crucial for such NAMAs that the local sector strategy is embedded into the overall national country strategy. Since NAMAs are always mitigation actions achieved at the country level, the respective government and ministries in charge need to be involved at an early stage. The measures to generate emission mitigation actions can be on a regional level or be limited to a city or metropolitan area. However, the measures need to reflect the overall policy strategy of the country for being able to obtain support (political, financial, technical). Within the NAMA framework, the topic of MRV will have a crucial role and the good work that has started in the CDM, especially with regard to standardised approaches, PoAs and single projects in most relevant sectors in the urban context (i.e. transport, energy efficiency, waste) can be utilised and adapted to the specific conditions of a NAMA concept for a specific city.

The actual implementation and financing of city-wide actions under such frameworks will require the willingness of industrialized countries to provide, in the long-term, multi-million dollar budgets which will require the development of well-conceptualised NAMA design documents until such budgets might be made available. At the moment, donor funds are available for conceptualising and setting-up NAMA pilots (see case study Mexico in Chapter 8.3.2) but no large amounts of funds have been committed to actually finance the mitigation actions under a NAMA. This is possibly also due to the new character of NAMAs and the willingness of industrialised countries to only provide larger sums of financing to those programmes which have a high probability of success in the long-term. Here could be a role for UNEP to set up sound NAMA programmes and concepts jointly with the partner cities that can be proposed to the various climate financing vehicles that are coming up for long-term support. The work done as part of this study is an excellent point of departure for setting up a robust MRV framework for urban pilot mitigation actions.

Annex 1

Selected case studies of emission sources in cities

a) Gwangju, South Korea[9]

Gwangju, the pivotal city of the southwest area of South Korea, is one of the seven metropolitan cities with an area of 501 km2 and houses some 1,470,000 residents.

For mapping GHG emissions for Gwangju, the GHG-CAPSS (GHG data system) was used by the Ministry of Environment. Due to its industrial structure, the city's tertiary service industry takes up about 92%, whereas agriculture and manufacturing amount to only 8%. Hence, the main source of emissions included the transportation sector. The residence/industry together take up about 80% of emissions. The total GHGs emitted in the energy field such as the industry/ transportation/ residence/commercial/public sector and in the indirect source of emission such as the electricity, water supply and waste was found to be approximately 8,327,692 tCO_2/a in 2007. Among them, the transport sector emitted about 2,269,057 tCO_2/a which indicated that it was the main source of emissions for Gwangju. For comparison of different regions in South Korea, CO_2 emission per capita in the region was divided by Gross Domestic Product (GDP). The results showed that Seoul was the lowest with 0.25 tCO_2/1 million won and Gwangju, the second lowest with 0.44 tCO_2/1 million won.

9. Source: 2010 Comprehensive planning research report on the countermeasure to the climate change in Gwangju

Expected GHG emission for Gwangju

The increase in Business As Usual (BAU) GHG measured using the GEST program provided by the Ministry of Environment showed that GHG emissions are expected to reach 12,989,000 tCO_2/a by 2020. The increase in emissions for Gwangju is created mainly by industry (32%) followed by the commercial sector (24%) by 2020, indicating that the increase is inevitable due to the continuous growth in industry.

Methodological issues

The main causes for the increase in carbon emissions include the population concentration in the capital area and metropolitan cities, the rapid increase in the number of vehicles, in particular diesel and superannuated vehicles, and the increase in energy consumption and urban development.

Figure 9: **Final Gwangju GHG emissions (Unit: tCO_2/yr)**

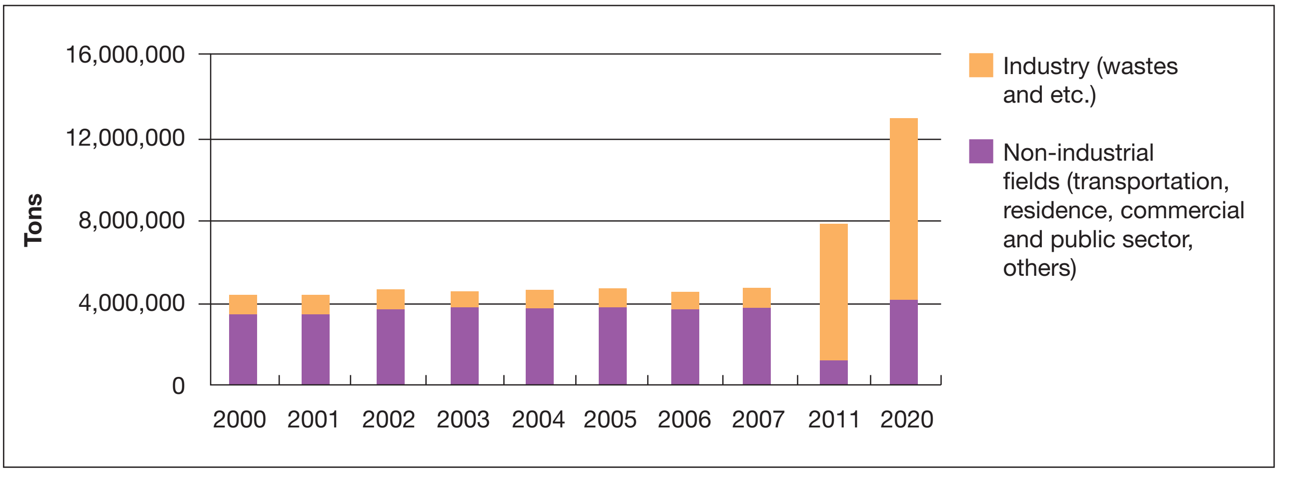
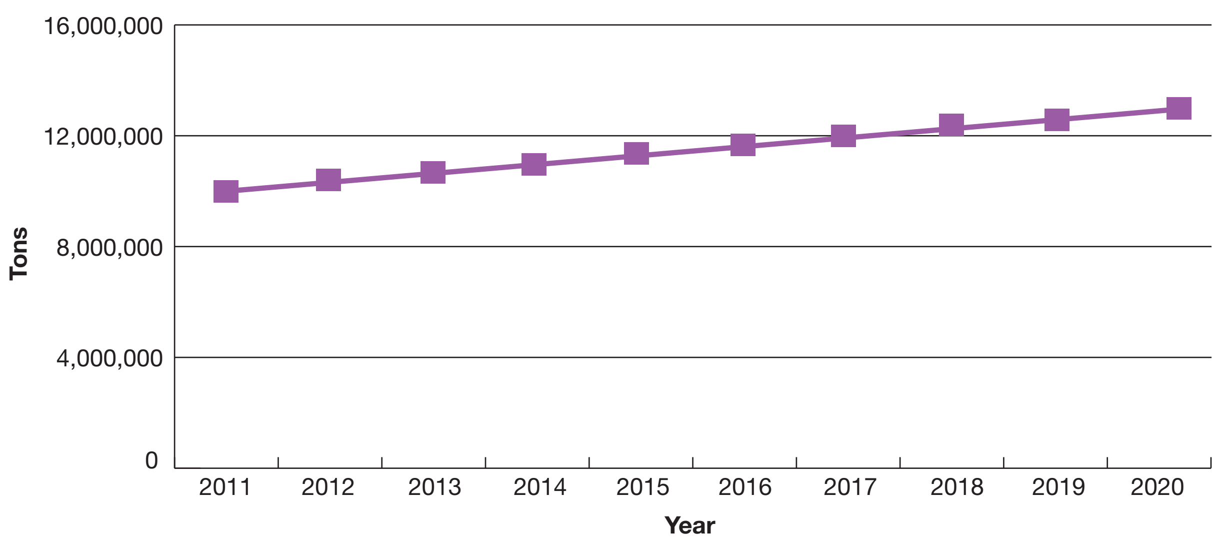


Table 10: **Expected GHG emission for Gwangju in 2020 (Unit: ton CO_2/yr)**

By areas	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total	9,761,018	10,119,349	10,477,680	10,836,012	11,194,343	11,552,674	11,911,006	12,269,337	12,627,669	12,986,000
Residence	3,709,187	3,845,353	3,981,519	4,117,684	4,253,850	4,390,016	4,526,182	4,662,348	4,798,514	4,934,680
Commercial and public sector	1,309,343	1,357,409	1,405,476	1,453,543	1,501,609	1,549,676	1,597,742	1,645,809	1,693,875	1,741,942
Transportation	349,595	362,428	375,262	388,096	400,930	413,763	426,597	439,431	452,265	465,099

Figure 10: **Expected GHG emissions for Gwangju until 2020 (Unit: ton CO_2/yr)**



By 2015, the population in five metropolitan cities is expected to increase by 5.2%, energy consumption by 53.5% and vehicles by 27%. GHG emissions by sector are dominated by transportation (26.9%), followed by the commercial and public sector (23.5%), the residential sector (23.3%); industry (17.6%). Waste (4.2%), agriculture (1.1%) and others (3.4%) are minor sources of GHG emissions.

Building (residential)

GHG emissions by residential buildings are driven by single-family dwellings, multiplex houses and apartments as well as four-person homes with a size of 67-99 m^2 (20 pyeong). The latter form the majority of households in South Korea emitting approximately 371 kg CO_2/month for apartments and 487 kg CO_2/month for single-family houses. For the size of 100-132 m^2 (30 pyeong), apartments emit 442 kg CO_2/month and single-family houses, 540 kg CO_2/month. This shows that for both size ranges the single-family house emits 20-30% more GHG than the apartments.

Transportation

The total GHG emissions in Gwangju caused by the use of energy such as the industry/transportation/residence/commercial/public sectors and that from indirect sources of emission such as electricity, water supply and waste amounted to about 8,284,941 tCO_2/a in 2007. Transportation in particular emits approximately 2,269,057 ton CO_2/a, proving to be the main source of emission in Gwangju. Thus, the final figure for the total GHG emission of Gwangju totalled about 8,324,692 tCO_2/a in 2007 showing that the transportation sector excluding the indirect areas such as electricity, had the highest level of emissions.

Industry

The industrial structure of Gwangju shows that the service industry, which is the tertiary industry, takes up about 92% followed by agriculture and manufacturing (industry) taking up about 8%. It indicated that the industrial structure is very weak. It was found that mining industrial processing such as cement, limestone and glass, the chemical manufacturing process such as organic and inorganic chemistry and metal industrial processing including steel manufacturing such as irons and alloy metals and other industrial processing such as oil, grease and refrigerants, were reported to be none.

Agriculture/Forestry and other land use

GHG emission in the areas of agriculture/forestry and other land use in 2007 amounted to about 8,220 tCO_2/a in livestock and 337,296 tCO_2/a in the integrated source of emission and non-CO_2, with a total emission of about 345,516 tCO_2/a.

Waste

In waste disposal, GHG emissions were 230,227 tCO_2/a for disposal, 134,234 tCO_2/a for incineration, 18,505 tCO_2/a for sewage/waste water processing and 22,400 tCO_2/a for biological treatment, indicating that waste disposal showed the highest percentage in terms of GHG emissions in Gwangju.

b) Gauteng metropolitan region, South Africa

Gauteng is a metropolitan region in South Africa. It includes the cities of Johannesburg and Pretoria and is home to 11 million people (Statistics South Africa 2010). Gauteng is the largest metropolitan area in South Africa and is considered to be the economic hub of the nation – contributing one third of the nation's GDP. The metropolitan region is growing rapidly with a 14% population increase from 2001 to 2007 (Statistics South Africa 2007). A significant share of the population in Gauteng lives in informal settlements and cannot satisfy its energy needs (suppressed demand). Furthermore, the income gap is especially large in South African society, with some parts of the population living in income and energy poverty, and other parts with resource-intensive upper class lifestyles. Johannesburg in the Gauteng region is member to ICLEI and a C40 member.

Methodological issues

The emission data shown in Figure 11 for Gauteng includes CO_2 emissions from energy use. It does not include other GHG emissions and the waste sector is also excluded. The energy sector accounted for 78% of total GHG emissions in South Africa in the last national GHG inventory from 1994 (South Africa 2000). By neglecting emissions from the waste sector, the inventory probably misses a share of less than 5% of local GHG emissions – again derived from national averages from 1994 (South Africa 2000).

Data acquisition for the Gauteng GHG emission balance at the same time followed a top-down and bottom-up approach. Emissions from industry, commerce and government were calculated top-down, based on statistical information on Gauteng sub-sector activities and sub-sector specific energy intensities for 'value added' and 'employees' (South African national average). Emissions from the residential and transport sector were calculated bottom up e.g., for building energy use, factors such as 'typical appliance ownership', 'building type', 'household size' and 'electrification status' were analysed to develop typical energy demand profiles for different housing types, income groups and living standards.

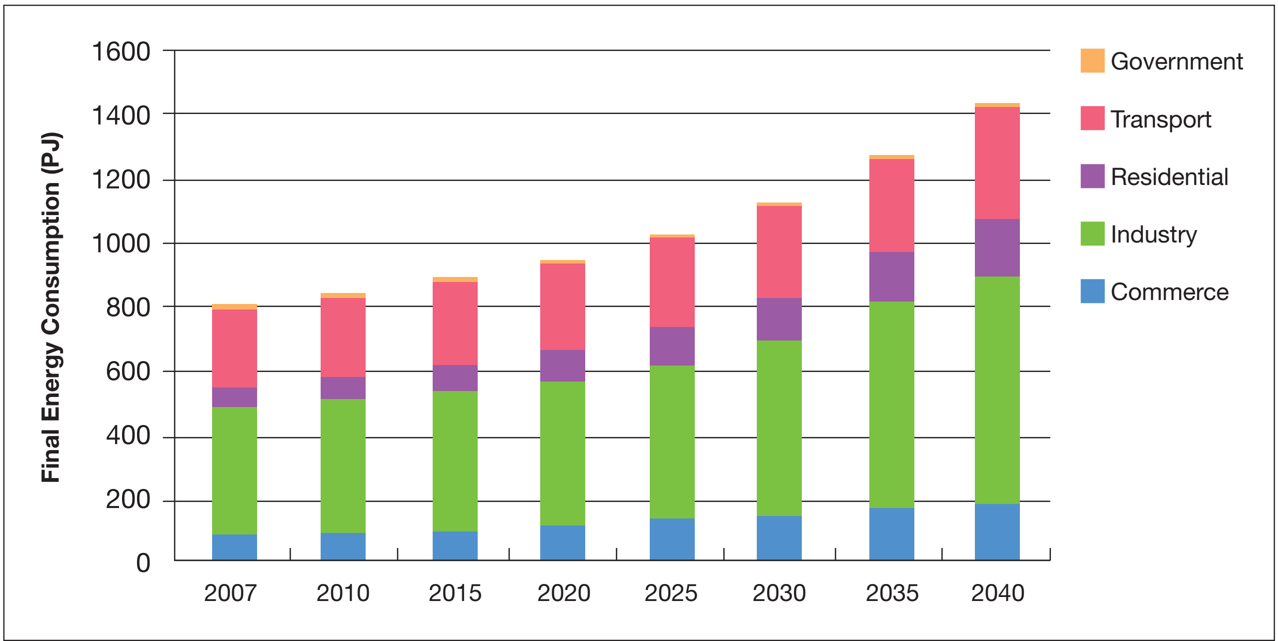
The study of Gauteng's energy-related CO_2 emissions focuses on energy use inside the city region of Gauteng. The city region is a conglomerate of three core cities (Johannesburg, Tshwane/Pretoria, Erkuhuleni) and the surrounding rural areas which are connected to the metropolitan region e.g. by commuting patterns. Thus, it mainly excludes emissions caused by electricity generation which is mainly located outside the Gauteng metropolitan area. However, the study does also provide (less detailed) information on emissions from electricity production.

Transport

Transport emissions in Gauteng were 16 million tCO_2 in 2007. This is 41% of CO_2 emissions from energy generated inside Gauteng's boundaries – or, 15% of CO_2 emissions, if emissions from electricity production outside Gauteng's boundaries are included. Individual transport has a high share (34%), and private cars are the primary source of energy consumption in the transport sector (Tomaschek et al. 2011).

With current policies, energy demand in the transport sector is expected to increase by more than 50% until 2040. The number of cars is projected to increase from 2.2 million in 2007 to 6.1 million in 2040 (Fahl et al. 2010, p. 8). Increased use of bio fuels (especially for buses, BRT and trucks), alternative transport modes (BRT, Gautrain), demand-side management such as Park&Ride, Car sharing, freight logistic hubs, as

Figure 11: **Final energy consumption in metropolitan Guateng**



Source: Tomaschek et al. 2011

well as efficiency standards for vehicles are brought forward by the study as promising means of reducing energy consumption (Tomaschek et al. 2011).

Buildings

Buildings account for about 18% of energy consumed in Gauteng and 11% of Gauteng's CO_2 emissions from energy generated within Gauteng (Tomaschek et al. 2011). This small number does not however reflect primary energy consumption by Gauteng buildings or emissions from electricity production outside Gauteng's boundaries. Electricity is by far the primary choice for building energy use, including heating. Electricity is mostly used in mid and high-income households. High-income households, which make up 12.2% of all households, use 41.3% of total residential energy (see figure 3). Poor and low income households tend to rely on coal and paraffin. Poor households account for 22.2% of all households but for only 4% of residential energy use (Tomaschek et al. 2011, p. 7). Income distribution is disparate in Gauteng with a high Gini coefficient (a measure of statistical dispersion).

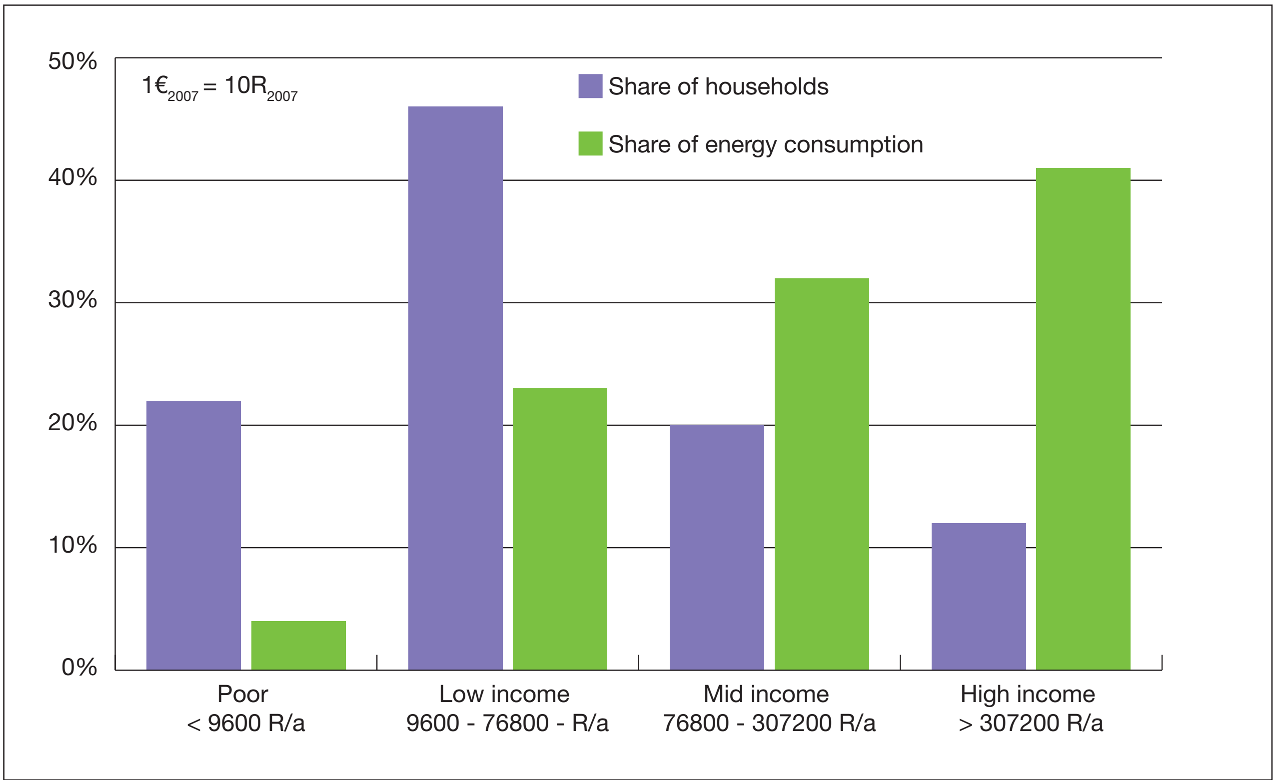
Energy consumption in buildings is expected to grow by about 150% until 2040 and efficiency improvements are projected to compensate for population and household growth. Future income distribution (increase in standard of living) is believed to strongly drive energy demand. Specific mitigation approaches and technologies for different income groups seem necessary (Thomaschek et al. 2010).

Proposed measures to reduce energy consumption in buildings include increased building standards (differentiated by income groups), more energy-efficient design for government-funded social housing (semi-detached instead of single houses, including ceiling insulation), the promotion of CFL and LED lighting, low-flow shower heads, and widespread use of solar water heaters for medium and high income households. Behavioural and lifestyle changes are also important as they heavily influence hot water and space heating demand (Tomaschek et al. 2011, p. 25; Tomaschek et al. 2010, p. 32).

Industry

Energy and mining are key branches in the industrial sector in the Gauteng metropolitan region. The 'Iron & Steel' and the 'Chemical & Petrochemical' industry make up almost 60% of industrial energy consumption (Ward and Schäffler, 2008. page 9). While industry is responsible for almost half of energy consumption in the metropolitan region (Tomaschek 2011), it presents a share of only 14% of energy consumption of the three cities in the Gauteng area. (Ward and Schäffler 2008). Industries either use electricity or generate their own energy. In both cases, coal is used as a primary energy source. Low-grade coal is used in these operations (Ward and Schäffler, 2008, p. 4).

Figure 12: **Comparison share of household and share of energy use**



Source: Hector et al., 2009 and Fahl et al. 2010 in Tomaschek et al. 2010

Energy industry

Electricity import to the Gauteng region is mainly fossil fuel-based. Coal fired power plants in Mpumulanga, operated by ESKOM, provide electricity. They are fired by low-grade coal with a heavy carbon load (Ward and Schäffler, 2008).

Waste

No figures for GHG emissions from waste in the Gauteng region are available. It can be assumed that Gauteng waste emissions are not smaller than national average waste emissions which make up 4.4% of South Africa's total GHG emissions (1994 figures, South Africa 2000).

c) Chiang Mai, Thailand

With nearly a million inhabitants, Chiang Mai is an intermediate-sized city region in the north of Thailand.[10] **Since the 1980s, economic growth and massive infrastructure development have led to wealthier and more mobile lifestyles.**

Most new growth is taking place outside the inner city and the city now takes a much less compact urban form. Local air pollution is a environmental priority. The city has a rich history and is a primary tourist destination in Thailand. Chiang Mai is member of ICLEI's Cities for Climate Protection campaign.

Methodological issues

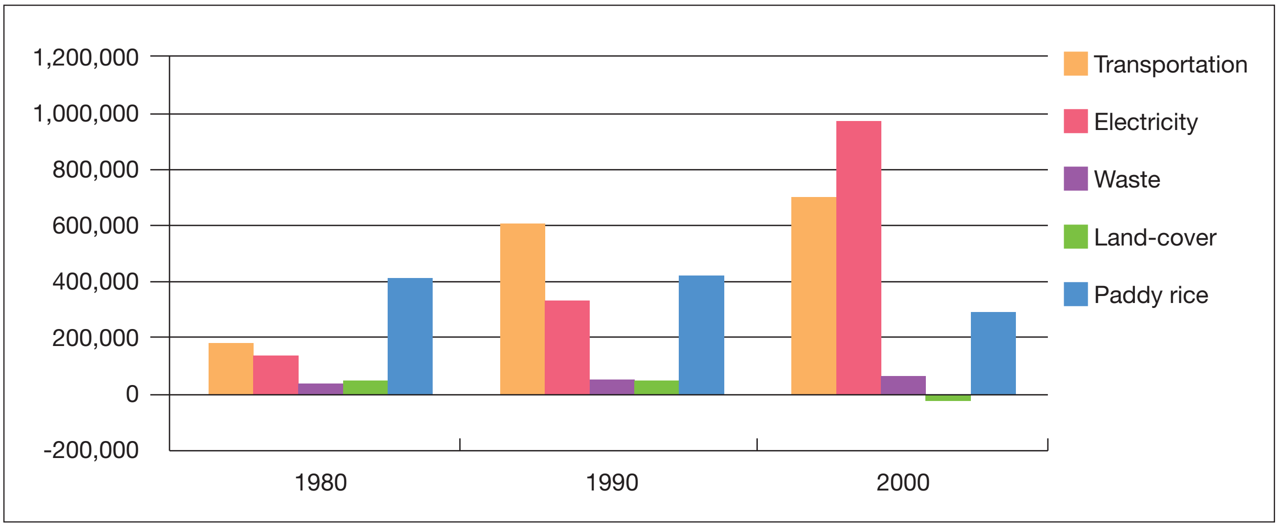
Chiang Mai was chosen for this report as it is an intermediate-sized city. The emission data for Chiang Mai may however include some uncertainties, as disaggregation of national data was found to be difficult by Lasco et al. (2004). They decided to give a range for emissions in each sector. Figure 13 shows the lower range of carbon equivalent emissions given in this study. Emissions include CH4 emissions from waste. Emissions from the wet lands in the city region were however not included (Lasco et al. 2004).

Transport

Transport emissions were estimated to be between 120,000 and 250,000 tCO_2eq in 1980 and between 450,000 and 960,000 tCO_2eq in 2000 (Lasco et al. 2004). Emissions from the transport sector have been rising steadily since the 1980s. In 2000 they

10. The city region of Chiang Mai in the study includes all districts and includes at least some built up areas of Chiang Mai / Lamphun cities or those immediately adjacent (Lebel et al. 2007).

Figure 13: **GHG emission in Chiang Mai (% of CO_2eq)**



Source: Lebel et al. 2004

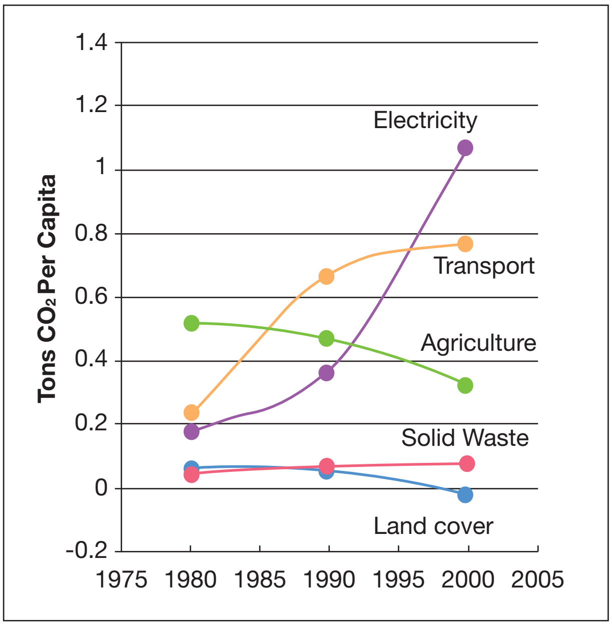
accounted for 35% of overall GHG emissions. The rise is due to an increase in motorized vehicle use: the number of registered passenger cars and motor-cycles increased 20-fold between 1970 and 2000, while population only doubled in the same period (Lebel et al. 2004). Between 2002 and 2008, the number of in-use vehicles was increasing at 7% annually. Public transport has a mode share of only 9% (ASEAN and GTZ 2009). Studies found integrated urban and transport planning, as well as new route structures and quality of public transport, to be key areas for mitigation in the sector (Lasco et al. 2004; ASEAN and GTZ 2009).

Buildings

Residential and commercial electricity consumption has grown even more rapidly than transport fuel consumption. Between 1990 and 2000, Chiang Mai faced a 21% annual increase in electricity consumption (Lebel et al. 2004). With 46-53%, electricity is now the largest source for GHG emissions in the city (Lebel et al. 2004). This is due to an increase in the acquisition and use of electric appliances. Electrical appliances do not play a role in cooking where a shift from small-scale combustion of bio fuels to bottled natural gas has taken place. The use of microwaves or air conditioners is believed to be growing fast (Lasco et al. 2004). Furthermore, household sizes are decreasing with higher rates of single occupants or small family dwellings.

A way to reduce energy consumption in the building sector is seen by better siting, orientation and

Figure 14: **Trends for per capita carbon emissions in Chiang Mai**



Source: Lebel et al. 2004, p.65

construction of buildings. Better insulated buildings that allow for natural ventilation reduce the need for electric fans or air conditioning (Lasco et al. 2004). Until the 1980s, economic growth in Chiang Mai was mainly based on agriculture and tourism. Since then, the Chiang Mai – Lamphun twin city was established which has created an urban-industrial corridor. Emissions related to commercial and industrial activities have "become a significant contributor to overall emissions budget of the region" (Lasco et al. 2004, p. 110).

Waste

Waste emissions are a minor source of GHG emissions, accounting for only 3% in Chiang Mai.[11]

Land-cover

The Chiang Mai GHG inventory also includes adjacent rural areas. Changes in land-cover also resulted in GHG emissions or sequestration, and are included here. Conversion of forest land to agriculture and the conversion of forest land and agriculture to urban use were both similar in scale from 1974 to 2000 (Lebel et al. 2004). With a ban on logging, emissions have become negative for 2000. Overall, the role of GHG emissions related to land use change is declining, as other emission sectors become more important.

Agriculture

GHG emissions from rice cultivation caused the majority of emissions in 1980. Meanwhile, their share has decreased both relatively and absolutely. They now account for less than 20% of overall GHG emissions in Chiang Mai. This is mainly due to a decline in rice-growing areas which is partly a consequence of a shift to less labour-intensive cultivation such as orchards. The boundary for Chiang Mai city considered in the study by Lasco et al. (2004) also included rural areas adjacent to Chiang Mai inner city which may explain the large share of agriculture emissions.

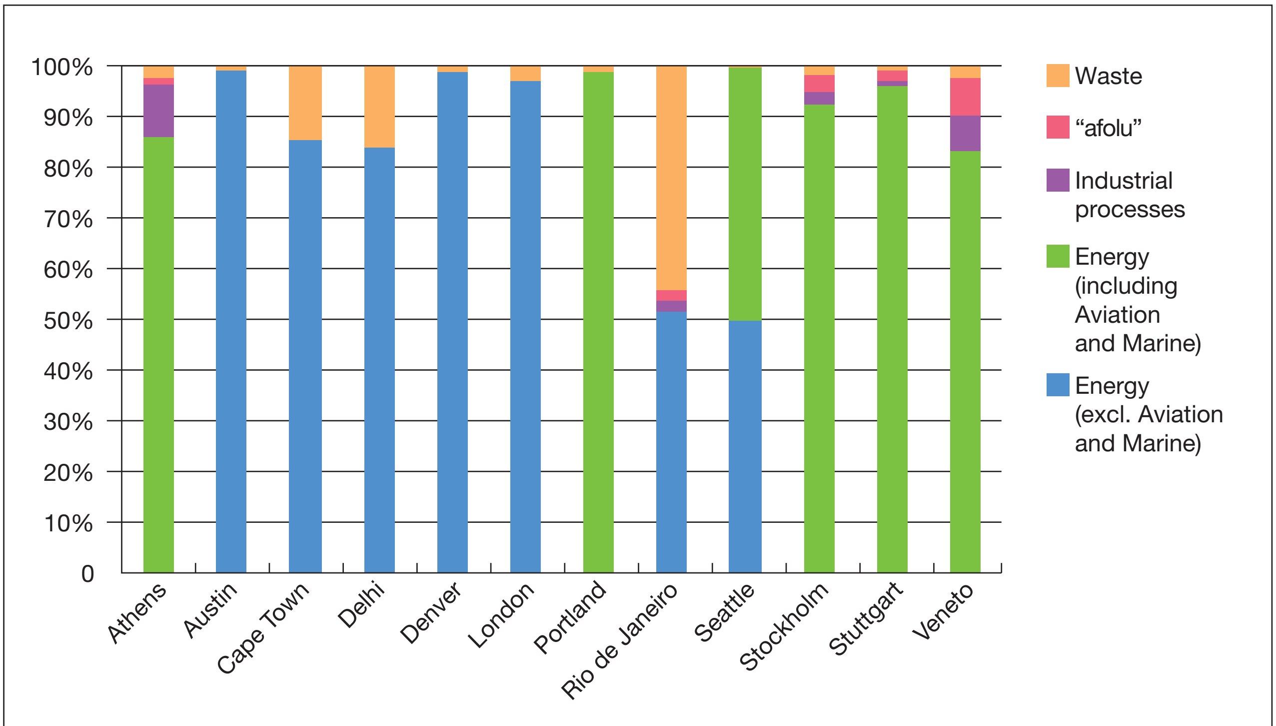
11. From the data presented by Lasco et al. (2004), one would conclude that GHG emissions from waste have seen a more than ten-fold increase between 1990 and 2000. However, the same research group present per-capita emissions which do not show this increase in Lebel et al. (2004). It was assumed that waste figures for 2000 in Lasco et al. 2004 are wrong by a factor of 10.

d) Supporting facts from UEA cities

In addition to the detailed analysis of emission data from the sample cities Gwangju, Gauteng and Chiang Mai, some less specific data was collected from literature comparing carbon emissions from global cities. This data is presented in the categories used in the literature cited, and these categories may differ from the categories chosen here (buildings, transport, waste etc.).

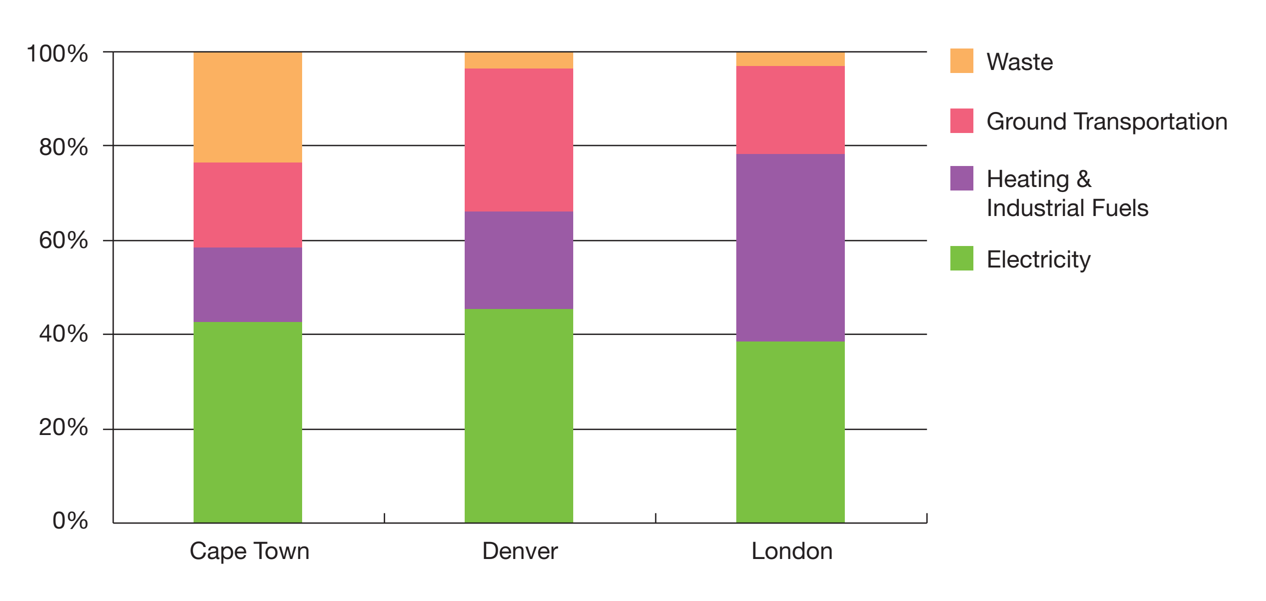
A study by Kennedy et al. (2011) included a list of UEA cities (see Figure 15). Not surprisingly, the study also found energy emissions to be the dominant emissions in cities. However, the study does not split up energy emissions in more detail (transport, buildings, etc). An interesting conclusion can however be drawn from the data on waste emissions:

Figure 15: **Emission sources of selected UEA cities**



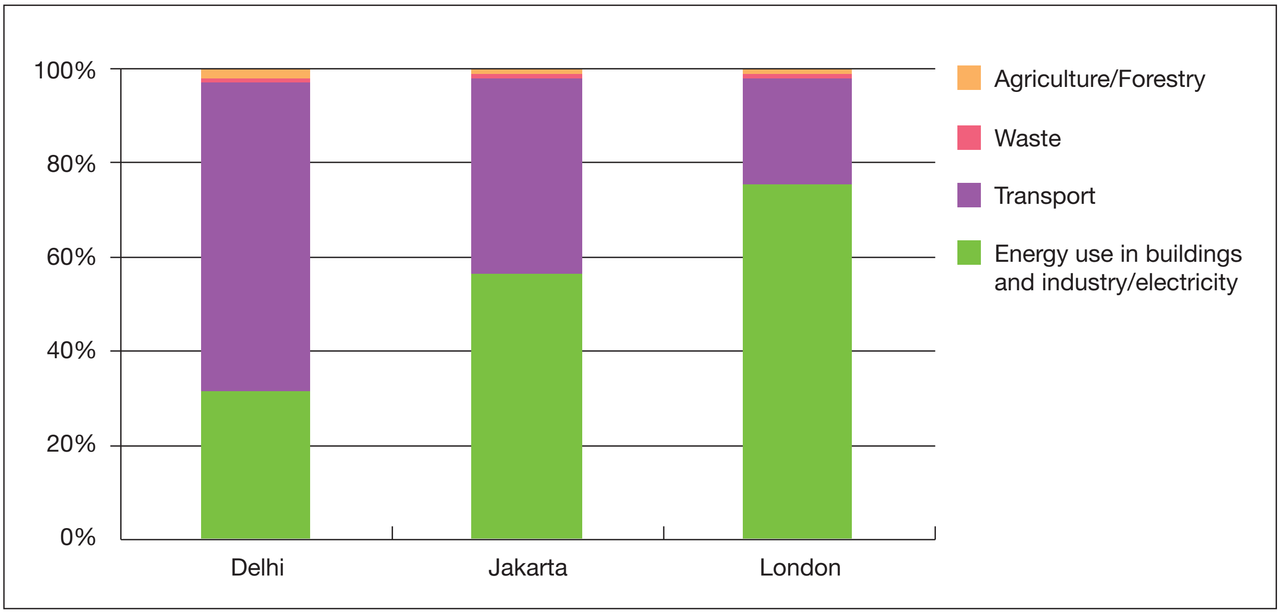
Source: Kennedy et al. 2011, p42ff

Figure 16: **Emission source categorisation of selected cities**



Source: Kennedy et al. 2009, p7298, Figure 1

Figure 17: **Emission source categorisation of selected cities**

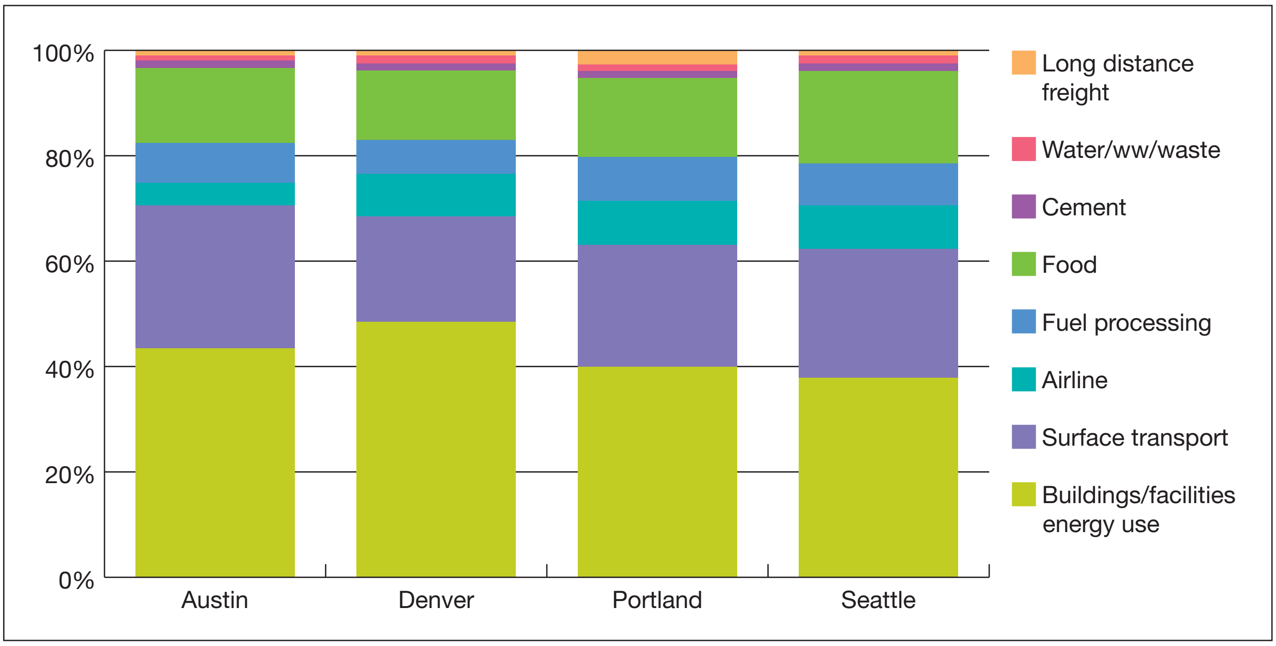


Source: Sovacool and Brown 2010, p. 4867, Table 3

according to the study, waste emissions present a significant part of GHG emissions in Rio de Janeiro, and also in the two other developing country UEA cities included in the study – Delhi and Cape Town.

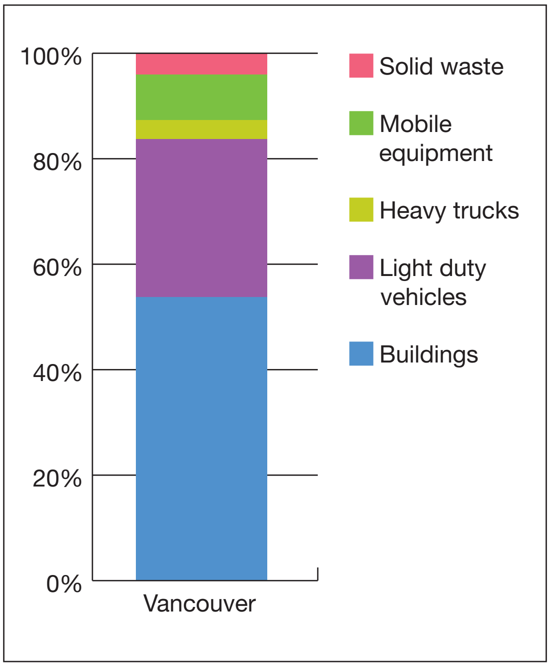
Another study by Kennedy et al. 2009 also includes three UEA cities – Cape Town, Denver, and London (see Figure 16). Emissions are categorized into 'electricity', 'heating & industrial fuels', 'ground transportation' and 'waste'. The category of 'transport emissions' was also used for the sample cities in this report. Transport can thus easily be identified as a significant emission source in the three UEA cities dealt with in Kennedy et al. 2009. Emissions in the building sector include both emissions from heating and electricity, though these two categories used by Kennedy et al. also include other uses of heat and electricity (e.g. industrial). Nevertheless, it can be assumed that in UEA cities in this study, buildings are responsible for an important

Figure 18: **Emission source categorisation of selected cities**

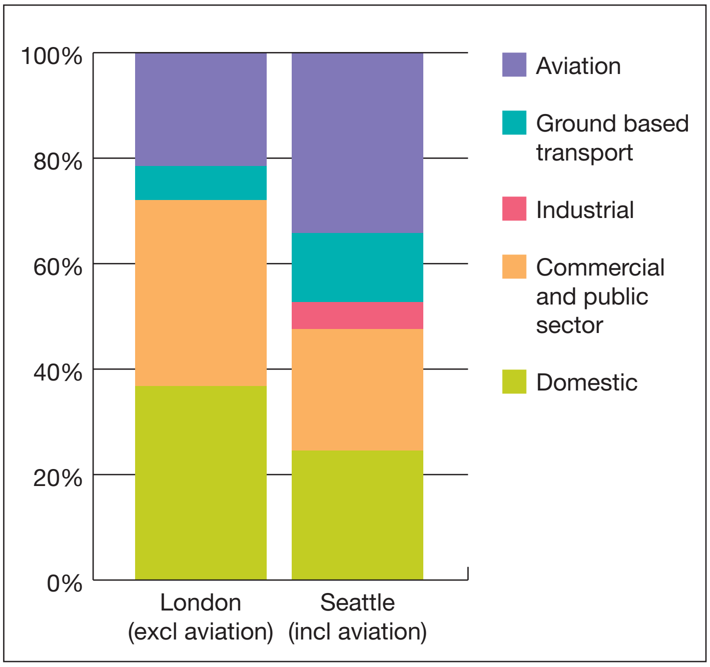


Source: Hillman, Ramaswami, 2010. P. 1906, figure 1

Figure 19: **Emission source categorisation of selected cities**



Source: City of Vancouver 2007, p. 10, figure 2



Source: Mayor of London 2007, p. xii, figure i

part of emissions from these two categories, too. And again, waste emissions are largest (as a proportion of overall emissions) in Cape Town, a developing country city, while they present a less significant share in Denver and London, as industrialized cities.

A study by Sovacool and Brown (2010) includes three UEA cities – Delhi, Jakarta, and London (see Figure 17). It confirms findings from the sample cities, that energy use in buildings and transport are the two dominant sectors for local GHG emissions. Waste emissions play a minor role according to Sovacool and Brown in all three UEA cities, and interestingly the figures for waste emissions from Delhi differ significantly between Kennedy et al. and Sovacool & Brown (compare Figure 15 and Figure 17).

Another study by Hillman and Ramaswami (2010) analysed GHG emission patterns of eight American cities. Among them were four UEA cities, namely Austin, Denver, Portland and Seattle (see Figure 18). The study chose a consumption-based approach and included emissions such as for food and cement production or fuel refinery. This gives a good overview of the magnitude of these emission sources. Again, the findings from the sample cities are confirmed. Emissions from the building and the ground transport sector are dominant, with emissions from the building sector still larger than transport emissions. Emissions from waste are summarized under the category 'water / ww (waste water) / waste', and together only represent a small share of overall emissions. Emissions for food production and fuel processing are significant.

A brief look at some individual UEA cities' emissions inventories – Vancouver, London, Stuttgart (see Figure 19) – again highlights buildings and transport as the largest source categories for urban GHG emissions. Emissions from the waste sector play a minor role in these industrialized cities or sometimes do not show up in the inventories.[12] The London case further reveals the dimension which emissions from aviation can take, if they are included in an urban emission inventory, and in an international aviation hub like London.

12. In the London case, buildings are not a specified source category but come as 'domestic' and 'commercial & public sector'. The same applies for Stuttgart where buildings come as 'domestic' and 'commercial & industrial' – while it must be noted, that 'industrial' also includes emissions for industrial production.

Annex 2

Relevant CDM methodologies for the priority sectors

	Approved metho-dology	Sectors covered	Number of projects	Number of PoAs	CDM feasibility: Available since (year)	CDM feasibility: General sector applicability ('priority sectors')	CDM feasibility: Has the metho-dology been applied?	CDM feasibility: Number of times used: 1<5	CDM feasibility: Number of times used: 6<20	CDM feasibility: Number of times used: >20	CDM feasibility: CDM scoring	Urban context applicability: Applicable for the urban context	Urban context applicability: Comprehen-siveness (avoid=3; shift=2; improve=1)	Urban context applicability: Methodology used in more than one sector?	Urban context applicability: Existing combination with other methodology	Urban context applicability: Municipality or city company involved in projects	Urban context applicability: Scalability / city wide approach: PoA	Urban context applicability: Scalability / city wide approach: Bundle	Urban context applicability: Existing PoA (pipeline)	Urban context applicability: Urban context scoWring	Overall scoring
	Residential sector (energy demand for heating/cooling; electric appliances)																				
Energy efficiency households	AM46	Distribution of efficient light bulbs to households	2	0	2006	1	1	1			3	1	1				1			3	6
Energy efficiency households	AM70	Manufacturing of energy efficient domestic refrigerators	2	0	2008	1	1	1			3	1	1				1			3	6
Energy efficiency households	AM71	Manufacturing and servicing of domestic refrigeration appliances using a low GWP refrigerant	0	0	2008	1					1	1	1				1			3	4
Energy efficiency households	AM91	Energy efficiency technologies and fuel switching in new buildings	0	0	2011	1					1	1	2	1			1			5	6
Energy efficiency households	AM94	Distribution of biomass based stove and/or heater for household or institutional use	0	0	2011	1					1	1	2				1			4	5
Energy efficiency households	AMS-I.I.	Biogas/biomass use for thermal application for households/ small users	0	0	2011	1					1	1	2				1	1		5	6
Energy efficiency households	AMS-II.C	Demand-side energy efficiency programmes for specific technologies	28	12	2002	1	1			3	5	1	1	1	1	1	1	1	1	8	13
Energy efficiency households	AMS-II.E.	Energy efficiency and fuel switching measures for buildings	32	2	2002	1	1			3	5	1	2	1	1	1	1	1	1	9	14
Energy efficiency households	AMS-II.J.	Demand-side activities for efficient lighting technologies (deemed savings)	43	11	2008	1	1			3	5	1	1	1	1		1	1	1	7	12
Energy efficiency households	AMS-II.M.	Demand-side energy efficiency activities for installation of low-flow hot water savings devices	0	0	2010	1					1	1	1				1	1		4	5
Energy efficiency households	AMS-III.AE.	Energy efficiency and renewable energy measures in new residential buildings	0	1	2009	1	1	1			3	1	1				1	1	1	5	8
Energy efficiency households	AMS-III.AR.	Substituting fossil fuel based lighting with LED lighting systems	0	1	2010	1	1	1			3	1	1				1	1	1	5	8
	Service and commercial buildings (energy demand for heating/cooling; electric appliances)																				
Energy efficiency, Service	AM20	Water pumping efficiency improvement	0	0	2004	1					1	1	1				1			3	4
Energy efficiency, Service	AM60	Power saving through replacement by efficient chillers	0	1	2007	1	1	1			3	1	1				1		1	4	7
Energy efficiency, Service	AM86	Installation of zero energy water purifier for safe drinking water application	0	0	2010	1					1	1	2				1			4	5
Energy efficiency, Service	AM91	Energy efficiency technologies and fuel switching in new buildings	0	0	2011	1					1	1	2	1			1			5	6
Energy efficiency, Service	AMS-II.C	Demand-side energy efficiency programmes for specific technologies	28	12	2001	1	1			3	5	1	1	1	1	1	1	1	1	8	13
Energy efficiency, Service	AMS-II.E.	Energy efficiency and fuel switching measures for buildings	32	2	2002	1	1			3	5	1	2	1	1	1	1	1	1	9	14
Energy efficiency, Service	AMS-II.J.	Demand-side activities for efficient lighting technologies (deemed savings)	43	11	2008	1	1			3	5	1	1	1	1		1	1	1	7	12
Energy efficiency, Service	AMS-II.K.	Installation of co-generation or tri-generation systems supplying energy to commercial buildings	1	1	2010	1	1	1			3	1	1				1	1	1	5	8
Energy efficiency, Service	AMS-II.L.	Demand-side activities for efficient outdoor and street lighting technologies	0	1	2010	1	1	1			3	1	1				1	1	1	5	8
Energy efficiency, Service	AMS-III.AV.	Low greenhouse gas emitting water purification systems	0	2	2011	1	1	1			3	1	1				1	1	1	5	8

	Approved metho-dology	Sectors covered	Number of projects	Number of PoAs	CDM feasibility							Urban context applicability									Overall scoring
					Available since (year)	General sector applicability ('priority sectors')	Has the metho-dology been applied?	Number of times used			CDM scoring	Applicable for the urban context	Comprehen-siveness (avoid=3; shift=2; improve=1)	Methodology used in more than one sector?	Existing combination with other methodology	Municipality or city company involved in projects	Scalability / city wide approach		Existing PoA (pipeline)	Urban context scoWring	
								1<5	6<20	>20							PoA	Bundle			
	Waste sector (waste – municipal solid/liquid – handling and management, landfills)																				
Landfill	ACM1	Landfill gas project activities	245	4	2004	1	1			3	5	1	1		1	1	1		1	6	11
Landfill	AM83	Avoidance of landfill gas emissions by in-situ aeration of landfills	1	0	2009	1	1	1			3	1	1			1	1			4	7
Landfill	AM93	Avoidance of landfill gas emissions by passive aeration of landfills	0	0	2011	1					1	1	1				1			3	4
Landfill	AMS-III.G.	Landfill methane recovery	49	0	2009	1	1			3	5	1	1		1	1	1	1		6	11
Landfill	AMS-III.AF.	Avoidance of methane emissions through excavating & composting of partially decayed municipal solid waste (MSW)	0	0	2009	1					1	1	1				1	1		4	5
Methane avoidance	AMS-III.AO	Methane recovery through controlled anaerobic digestion	4	1	2010	1	1	1			3	1	1		1		1	1	1	6	9
Methane avoidance	ACM10	GHG emission reductions from manure management systems	18	0	2006	1	1		2		4	na	1		1		1			3	7
Methane avoidance	AM25	Avoided emissions from organic waste through alternative waste treatment processes	94	0	2006	1	1			3	5	1	1		1	1	1			5	10
Methane avoidance	AM39	Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting	23	0	2006	1	1			3	5	1	1				1			3	8
Methane avoidance	AM53	Biogenic methane injection to a natural gas distribution grid	1	1	2007	1	1	1			3	1	1		1		1		1	5	8
Methane avoidance	AM57	Avoided emissions from biomass wastes through use as feed stock in pulp and paper production	1	0	2007	1	1	1			3	1	2				1			4	7
Methane avoidance	AM69	Biogenic methane as a feedstock and fuel for town gas production	2	0	2008	1	1	1			3	1	2			1	1			5	8
Methane avoidance	AM73	GHG emission reductions through multi-site manure collection and treatment in a central plant	3	0	2008	1	1	1			3	na	1				1			2	5
Methane avoidance	AM75	Collection, processing and supply of biogas to end-users for production of heat	0	0	2009	1					1	na	2				1			3	4
Methane avoidance	AMS-III.D.	Methane recovery in animal manure managements systems	277	7	2002	1	1			3	5	na	1		1	1	1	1	1	6	11
Methane avoidance	AMS-III.E.	Avoidance of methane production from biomass decay through controlled combustion	74	0	2002	1	1			3	5	1	1		1	1	1	1		6	11
Methane avoidance	AMS-III.F.	Avoidance of methane production from biomass decay through composting	87	14	2009	1	1			3	5	1	1		1	1	1	1	1	7	12
Methane avoidance	AMS-III.L.	Avoidance of methane production from biomass decay through controlled pyrolysis	0	0	2009	1					1	1	1				1	1		4	5
Methane avoidance	AMS-III.O.	Hydrogen production using methane extracted from biogas	1	0	2009	1	1	1			3	1	1		1		1	1		5	8
Methane avoidance	AMS-III.R.	Methane recovery in agricultural activities at household/small farm level	21	3	2009	1	1			3	5	na	1		1		1	1	1	5	10
Methane avoidance	ACM14	Mitigation of greenhouse gas emissions from treatment of industrial wastewater	32	0	2007	1	1			3	5	1	1		1		1			4	9
Methane avoidance	AM80	Mitigation of greenhouse gases emissions with treatment of wastewater in aerobic wastewater treatment plants	2	0	2009	1	1	1			3	1	1			1	1			4	7
Methane avoidance	AMS-III.H.	Methane recovery in wastewater treatment	273	1	2009	1	1			3	5	1	1		1	1	1	1	1	7	12
Methane avoidance	AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems	12	0	2009	1	1		2		4	1	1		1		1	1		5	9
Methane avoidance	AMS-III.Y.	Methane avoidance through separation of solids from wastewater or manure treatment systems	3	0	2008	1	1	1			3	na	1				1	1		3	6

	Approved metho-dology	Sectors covered	Number of projects	Number of PoAs	CDM feasibility: Available since (year)	General sector applicability ('priority sectors')	Has the metho-dology been applied?	Number of times used: 1<5	6<20	>20	CDM scoring	Urban context applicability: Applicable for the urban context	Comprehen-siveness (avoid=3; shift=2; improve=1)	Methodology used in more than one sector?	Existing combination with other methodology	Municipality or city company involved in projects	Scalability / city wide approach: PoA	Bundle	Existing PoA (pipeline)	Urban context scoWring	Overall scoring
	Transportation (car traffic, public transport, modal shift etc.)																				
BRT, MRTS	ACM16	Mass Rapid Transit Projects	8	0	2009	1	1		2		4	1	2			1	1			5	9
	AM31	Baseline Methodology for Bus Rapid Transit Project	14	0	2005	1	1		2		4	1	2			1	1			5	9
	AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1	0	2008	1	1	1			3	1	2				1	1		5	8
Other transport	AM90	Modal shift in transportation of cargo from road transportation to water or rail transportation	1	0	2010	1	1	1			3	1	2				1			4	7
	AMS-III.C.	Emission reductions by low-greenhouse emission vehicles	14	1	2002	1	1		2		4	1	1			1	1	1	1	6	10
	AMS-III.S.	Intro of low-emission vehicles to commercial vehicle fleets	0	0	2009	1					1	1	1				1	1		4	5
	AMS-III.AA.	Transport energy efficiency using Retrofit Tech.	0	0	2009	1					1	1	1				1	1		4	5
	AMS-III.AP.	Transport energy efficiency using post-fit Idling Stop device	0	0	2010	1					1	1	1				1	1		4	5
	AMS-III.AQ.	Introduction of Bio-CNG in transportation applications	0	0	2010	1					1	1	1				1	1		4	5
	AMS-III.AT.	Transportation energy efficiency activities installing digital tachograph systems to commercial freight transport fleets	0	0	2011	1					1	1	1				1	1		4	5
	Industry (energy efficiency measures at manufacturing facilities)																				
Energy efficiency, Industry	AM17	Steam system efficiency improvement by replacing steam traps and returning condensate	0	0	2004	1					1	na	1				1			2	3
	AM18	Baseline methodology for steam optimization systems	14	0	2004	1	1		2		4	na	1		1		1			3	7
	AM38	Improved electrical energy efficiency of an existing submerged electric arc furnace used for the production of SiMn	1	0	2006	1	1	1			3	na	1				1			2	5
	AM44	Energy efficiency improvement projects: boiler rehabilitation or replacement in industrial and district heating sectors	1	0	2006	1	1	1			3	na	2				1			3	6
	AM54	Energy efficiency improvement of a boiler by introducing oil/water emulsion technology	0	0	2007	1					1	na	2				1			3	4
	AM56	Efficiency improvement by boiler replacement or rehabilitation & optional fuel switch in fossil fuel-fired steam boiler systems	0	0	2007	1					1	na	2				1			3	4
	AM68	Improved energy efficiency by modifying ferroalloy prod. facility	0	0	2008	1					1	na	2				1			3	4
	AM88	Air separation using cryogenic energy recovered from the vaporization of LNG	0	0	2010	1					1	na	2				1			3	4
	AMS-II.C	Demand-side energy efficiency programmes for specific tech.	28	12	2002	1	1			3	5	1	1	1	1	1	1	1	1	8	13
	AMS-II.D.	Energy efficiency & fuel switching measures for ind. facilities	174	2	2002	1	1			3	5	1	2		1	1	1	1	1	8	13
	AMS-II.H.	Energy efficiency measures through centralization of utility provisions of an industrial facility technology	14	0	2008	1	1		2		4	1	2		1	1	1	1		7	11
	AMS-II.I.	Efficient utilization of waste energy in industrial facilities	0	0	2008	1					1	1	2				1	1		5	6
	AMS-III.J.	Avoidance of fossil fuel combustion for carbon dioxide production to be used as raw material for industrial processes	1	0	2009	1	1	1			3	na	2				1	1		4	7
	AMS-III.M.	Reduction in consumption of electricity by recovering soda from paper manufacturingprocess	4	0	2009	1	1	1			3	na	1				1	1		3	6
	AMS-III.V.	Decrease of coke consumption in blast furnace by installing dust/sludge recycling system in steel works	1	0	2009	1	1	1			3	na	1				1	1		3	6
	AMS-III.Z.	Fuel switch, process improvement and energy efficiency in brick manufacture	9	1	2009	1	1		2		4	na	2				1	1	1	5	9
	AMS-III.AI	Emission reductions through recovery of spent sulphuric acid	0	0	2009	1					1	na	1				1	1		3	4
	AMS-III.AJ.	Recovery and recycling of materials from solid wastes	0	0	2010	1					1	1	2				1	1		5	6

	Approved metho-dology	Sectors covered	Number of projects	Number of PoAs	CDM feasibility: Available since (year)	CDM feasibility: General sector applicability ('priority sectors')	CDM feasibility: Has the metho-dology been applied?	CDM feasibility: Number of times used 1<5	CDM feasibility: Number of times used 6<20	CDM feasibility: Number of times used >20	CDM feasibility: CDM scoring	Urban context applicability: Applicable for the urban context	Urban context applicability: Comprehen-siveness (avoid=3; shift=2; improve=1)	Urban context applicability: Methodology used in more than one sector?	Urban context applicability: Existing combination with other methodology	Urban context applicability: Municipality or city company involved in projects	Urban context applicability: Scalability / city wide approach PoA	Urban context applicability: Scalability / city wide approach Bundle	Urban context applicability: Existing PoA (pipeline)	Urban context applicability: Urban context scoWring	Overall scoring
Fuel switch	ACM9	Industrial fuel switching from coal or petroleum fuels to natural gas	15	0	2006	1	1		2		4	na	2				1			3	7
Fuel switch	AM50	Feed switch in integrated Ammonia-urea manufacturing industry	2	0	2006	1	1	1			3	na	2				1			3	6
Fuel switch	AMS-III.AN.	Fossil fuel switch in existing manufacturing industries	0	1	2010	1	1	1			3	na	2				1	1	1	5	8
	Energy industry (cogeneration with district heating/cooling and decentralised power generation; renewable energies; biofuels)																				
Renewable energy (zero emissions)	ACM2	Grid-connected electricity generation for renewable sources (no biomass)	2310	2	2004	1	1			3	5	1	3		1	1	1		1	8	13
Renewable energy (zero emissions)	AM19	Ren. Energy project replacing the electricity of one single fossil plant (excl. biomass)	0	0	2004	1					1	1	3				1			5	6
Renewable energy (zero emissions)	AM26	Zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid	8	0	2005	1	1		2		4	na	3				1			4	8
Renewable energy (zero emissions)	AM72	Fossil Fuel Displacement by Geothermal Resources for Space Heating	1	0	2008	1	1	1			3	1	3				1			5	8
Renewable energy (zero emissions)	AMS-I.A.	Electricity generation by the user	46	2	2002	1	1			3	5	1	3		1		1	1	1	8	13
Renewable energy (zero emissions)	AMS-I.B.	Mechanical energy for the user	4	1	2002	1	1	1			3	1	3				1	1	1	7	10
Renewable energy (zero emissions)	AMS-I.C.	Thermal energy production with or without electricity	516	20	2002	1	1			3	5	1	3		1	1	1	1	1	9	14
Renewable energy (zero emissions)	AMS-I.D.	Renewable electricity generation for a grid	2185	11	2002	1	1			3	5	1	3		1	1	1	1	1	9	14
Renewable energy (zero emissions)	AMS-I.F.	Renewable electricity generation for captive use and mini-grid	41	3	2010	1	1			3	5	1	3		1	1	1	1	1	9	14
Renewable energy (zero emissions)	AMS-I.J.	Solar water heating systems (SWH)	0	1	2011	1	1	1			3	1	3				1	1	1	7	10
Biofuels	AM89	Production of diesel using a mixed feedstock of gasoil and vegetable oil	0	0	2010	1					1	na	2				1			3	4
Biofuels	ACM17	Production of biodiesel for use as fuel	10	0	2009	1	1		2		4	na	2				1			3	7
Biofuels	AMS-I.G.	Plant oil production and use for energy generation in stationary applications	0	0	2010	1					1	na	2				1	1		4	5
Biofuels	AMS-I.H.	Biodiesel production and use for energy generation in stationary applications	0	0	2010	1					1	na	2				1	1		4	5
Biofuels	AMS-III.T.	Plant oil production and use for transport applications	1	0	2009	1	1	1			3	na	2				1	1		4	7
Biofuels	AMS-III.AK.	Biodiesel production and use for transport applications	1	0	2010	1	1	1			3	na	2				1	1		4	7

	Approved metho-dology	Sectors covered	Number of projects	Number of PoAs	CDM feasibility							Urban context applicability									Overall scoring
					Available since (year)	General sector applicability ('priority sectors')	Has the metho-dology been applied?	Number of times used			CDM scoring	Applicable for the urban context	Comprehen-siveness (avoid=3; shift=2; improve=1)	Methodology used in more than one sector?	Existing combination with other methodology	Municipality or city company involved in projects	Scalability / city wide approach		Existing PoA (pipeline)	Urban context scoWring	
								1<5	6<20	>20							PoA	Bundle			
Renewable biomass	ACM3	Emission reduction through partial substitution of fossil fuels with alternative fuels in cement manufacture	34	0	2004	1	1			3	5	na	2				1			3	8
	ACM6	Grid-connected electricity from biomass residues (includes AM4 & AM15)	313	0	2005	1	1			3	5	1	2		1	1	1			6	11
	ACM18	Electricity generation from biomass residues (co-fired) in power-only plants	22	1	2009	1	1			3	5	1	2			1	1		1	6	11
	AM7	Analysis of the least-cost fuel option for seasonally-operating biomass cogeneration plants	0	0	2004	1					1	1	2				1			4	5
	AM36	Fuel switch from fossil fuels to biomass residues in boilers for heat generation	21	0	2006	1	1			3	5	1	2				1			4	9
	AM42	Grid-connected electricity generation using biomass from newly developed dedicated plantations	2	0	2006	1	1	1			3	na	2				1			3	6
	AM82	Use of charcoal from planted renewable biomass in the iron ore reduction process through the establishment of a new iron ore reduction system	2	0	2009	1	1	1			3	na	2		1		1			4	7
	AM85	Co-firing of biomass residues for electricity generation in grid connected power plants	0	0	2009	1					1	1	2				1			4	5
	AMS-I.E.	Switch from Non-Renewable Biomass for Thermal Applications by the User	13	5	2008	1	1		2		4	1	2		1		1	1	1	7	11
	AMS-II.G.	Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass	7	12	2008	1	1		2		4	1	2				1	1	1	6	10

Annex 3

Programme of activities in the CDM pipeline apply a combination of CDM methodologies

Title	Host country	PoA Boundary and Province/ State Region	Coordinating Entity	Status	Type	Sub-type	Methodology
Methane abatement and household biogas utilization programme in India	India	India	Managing Emissions	At Validation	Methane avoidance	Domestic manure	AMS-III.R.+AMS-I.E.+AMS-I.C.
Caixa Econômica Federal Solid Waste Management and Carbon Finance Project	Brazil	Brazil	Caixa	At Validation	Landfill gas	Switch from fossil fuel to piped landfill gas	AM53+ACM1
Sichuan Rural Poor-Household Biogas Development Programme	China	Sichuan	Chengdu Oasis Science and Technology Co.	At Validation	Methane avoidance	Domestic manure	AMS-III.R.+AMS-I.C.
Mexican Housing Commission Sustainable Housing Program of Activities	Mexico	Mexico	Mexican National Housing Commission (CONAVI)	At Validation	EE households	Lighting & Insulation & Solar	AMS-III.AE.+AMS-I.C.
Biogas Utility Programme to Households by Grameen Shakti in Municipalities of Bangladesh	Bangladesh	Bangladesh	Grameen Shakti	At Validation	Methane avoidance	Biogas from MSW	AMS-III.AO.+AMS-I.E.
The programme to introduce renewable energy system into Seoul	South Korea	South Korea	Seoul Metropolitan Government	At Validation	Solar	Solar water heating	AMS-I.F.+AMS-I.C.
Renewable energy utilization in the new and exiting buildings in Henan Province	China	Henan	Henan Provincial Academy of Building Research	At Validation	Geothermal	Geothermal heating	AMS-II.C.+AMS-I.C.
Hebei Animal Manure Management System (AMMS) GHG Mitigation Programme	China	Hebei	Hebei Green Agriculture Co.	At Validation	Methane avoidance	Manure	AMS-III.D.+AMS-I.C.+AMS-I.F.
Programme of Activities (PoA) for Sustainable Renewable Energy Power Generation in Papua New Guinea (PNG)	Papua New Guinea	Papua New Guinea	PNG Power	At Validation	Hydro	Run of river	AMS-I.F.+AMS-I.D.+AMS-I.A.

Source: UNEP Risø, CDM Pipeline, August 2011

Sample CDM projects in the urban context

Ref.	Title	Region	Sub-region	Host country	State	Status	Type	Sub-type	Methodology
Residential sector (energy efficiency)									
79	Kuyasa low-cost urban housing energy upgrade project, Khayelitsha (Cape Town; South Africa)	Africa	Sub-Saharan Africa	South Africa	Western Cape	Registered	EE households	Lighting & Insulation & Solar	AMS-II.E. +AMS-I.C. +AMS-II.C.
Commercial building sector (energy efficiency)									
686	Improvement in Energy Consumption of a Hotel	Asia & Pacific	Southern Asia	India	West Bengal	Registered	EE service	EE new buildings	AMS-II.E. +AMS-II.B.
1794	Energy efficiency measures in “Technopolis”.	Asia & Pacific	Southern Asia	India	West Bengal	Registered	EE Service	HVAC & lighting	AMS-II.E.
159	Moldova Biomass Heating in Rural Communities (Project Design Document No. 1)	Europe & Central Asia	Europe	Moldova	Many	Registered	EE service	EE public buildings	AMS-II.E. +AMS-I.C. +AMS-III.B.
160	Moldova Biomass Heating in Rural Communities (Project Design Document No. 2)	Europe & Central Asia	Europe	Moldova	Many	Registered	EE service	EE public buildings	AMS-II.E. +AMS-I.C. +AMS-III.B.
173	Moldova Energy Conservation and Greenhouse Gases Emissions Reduction	Europe & Central Asia	Europe	Moldova	Many	Registered	EE service	EE public buildings	AMS-II.E. +AMS-III.B.
Transportation sector									
3760	BRT Chongqing Lines 1-4, China	Asia & Pacific	East Asia	China	Chongqing	Registered	Transport	Bus Rapid Transit	AM31
672	BRT Bogotá, Colombia: TransMilenio Phase II to IV	Latin America	South America	Colombia	Bogotá	Registered	Transport	Bus Rapid Transit	AM31
3224	Cable Cars Metro Medellín, Colombia	Latin America	South America	Colombia	Antioquia	Registered	Transport	Cable cars	AMS-III.U.
1351	Installation of Low Green House Gases (GHG) emitting rolling stock cars in metro system	Asia & Pacific	Southern Asia	India	Delhi	Registered	Transport	Rail: regenerative braking	AMS-III.C.

Source: UNEP Risø, CDM Pipeline, August 2011

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Set up in 1975, three years after UNEP was created, the Division of Technology, Industry and Economics (DTIE) provides solutions to policy-makers and helps change the business environment by offering platforms for dialogue and co-operation, innovative policy options, pilot projects and creative market mechanisms.

DTIE plays a leading role in three of the six UNEP strategic priorities: **climate change, harmful substances and hazardous waste, resource efficiency.**

DTIE is also actively contributing to the **Green Economy Initiative** launched by UNEP in 2008. This aims to shift national and world economies on to a new path, in which jobs and output growth are driven by increased investment in green sectors, and by a switch of consumers' preferences towards environmentally friendly goods and services.

Moreover, DTIE is responsible for **fulfilling UNEP's mandate as an implementing agency for the Montreal Protocol Multilateral Fund** and plays an executing role for a number of UNEP projects financed by the Global Environment Facility.

The Office of the Director, located in Paris, coordinates activities through:

> **The International Environmental Technology Centre** – IETC (Osaka), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.

> **Sustainable Consumption and Production** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.

> **Chemicals** (Geneva), which catalyses global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.

> **Energy** (Paris and Nairobi), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.

> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.

> **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies. This branch is also charged with producing green economy reports.

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The Clean Development Mechanism (CDM) is one of the "flexibility mechanisms" defined under the Kyoto Protocol. Its objective is to assist developing countries in achieving sustainable development and to mitigate the greenhouse gas emissions that cause climate change.

Despite its great success, with more than 3,300 CDM projects registered within many countries and within many sectors, some important emission sources, sectors and countries are still underrepresented within the CDM.

"Is the Clean Development Mechanism the right instrument to provide carbon finance to carbon emission mitigation activities in cities/urban areas?" "Under which circumstances can the CDM be best applied for the major emission sources in cities?" "What is the status of CDM in urban areas? What are the existing barriers and what are the solutions that will offer cities access to carbon finance?"

These and other questions have been addressed in this feasibility study on urban CDM.

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