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Waste and Climate Change: a Critical Review of Clean Development Mechanism Landfill Gas Projects

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, 7 June 2010

Affidavit

I, **MELANIE BLEWETT**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Waste and Climate Change: a Critical Review of Clean Development Mechanism Landfill Gas Projects", 86 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 07.06.2010

Signature

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Finally, this thesis is for my family, for their ongoing support and patience throughout my years of study.

Abstract

There is growing recognition that improved waste management in developing countries can not only reduce risks to human health and the environment, but also prevent the release of harmful greenhouse gases to the atmosphere and so help to mitigate climate change. Methane (CH_4), the greenhouse gas produced anaerobically within landfills, has a global warming potential 21 times that of carbon dioxide (CO_2) once released into the atmosphere.

The Clean Development Mechanism (CDM), established under the Kyoto Protocol, aims to reduce the release of greenhouse gases, including methane from landfills, into the atmosphere. The CDM enables technology transfer by allowing Annex I (developed countries) to invest in projects in developing countries, including landfill gas projects. However, there has been criticism that this project type allows many Certified Emission Reductions (CER) to be produced rapidly, thus lowering the price of CERs in the market and ignoring the second objective of the CDM which is for projects to lead to sustainable development.

This study looks at three landfill gas projects within the Austrian JI/CDM Programme and aims to establish firstly, whether the dual objective of the CDM can be fulfilled, secondly, can projects benefits CER buyers and developing country communities alike, and finally, do the project methodologies provide an accurate estimation of *real, additional* emissions reductions?

This interdisciplinary thesis critically evaluates from a legal, political and technical perspective, the successes and failures of landfill gas projects, and concludes that estimated CER emission reductions nearly always exceed realistic scenarios for emission reduction. Furthermore, sustainable development benefits can be derived from landfill gas projects, but are limited. In order to make landfilling *'sustainable'* in environmental, economic and social terms, alternative waste disposal strategies such as composting organic waste should be considered and evaluated with regard to their environmental benefits and economic feasibility.

Modern technology

Owes ecology

An apology.

~ Alan M. Eddison

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Abbreviations

Abbreviations:

AF	**– Adjustment Factor**
AMC	**– Aterro Metropolitano do Centro**
BATTRE	**– Bahia Transferencia e Tratamento de Residuos S.A.**
CDM	**– Clean Development Mechanism**
CF	**– Conversion Factor**
CER	**– Certified Emission Reduction**
COP 7	**– Conference of Parties**
DOC	**– Degradable Organic Carbon Content**
DNA	**– Designated National Authority**
DOE	**– Designated Operational Entity**
EDF	**– Methane Efficiency Destruction Factor**
ERU	**– Emission Reduction Unit**
EU ETS	**– The European Emission Trading System**
GHG	**– Greenhouse Gas**
GWh	**– Gigawatt hour**
GWP	**– Global Warming Potential**
JI	**– Joint Implementation**
LFG	**– Landfill Gas**
LPG	**– Liquefied Petroleum Gas**
Lo	**– Potential Methane Generation Capacity**
MDG	**– Millennium Development Goal**
MSW	**– Municipal Solid Waste**
OECD	**– Organisation for Economic Co-operation and Development**
PDD	**– Project Design Document**
T CO_2e	**– a tonne of carbon dioxide equivalent**

Chapter I Introduction

1. Background and Motivation

Fossil CO_2 emissions have increased 130 fold since 1850 and are projected to increase an additional 60% by 2030.[1] This has resulted in a significant increase in atmospheric CO_2 concentrations rising from 280ppm to a current level of over 390ppm.[2] There is now also consensus amongst the scientific community that global temperatures are rising in response to accelerating emissions of greenhouse gases (GHGs) in the atmosphere. Since the pre-industrial era atmospheric concentrations of carbon dioxide have increased by 35% and methane has more than doubled. Moreover, there is scientific consensus that the observed global temperature increase since the mid 20th century is due to an increase in concentration of greenhouse gases, primarily caused by the combustion of fossil fuels.

In 1992, countries signed an agreement under the United Nations Framework Convention on Climate Change (UNFCCC). This recognized a need to address the problem and provided a framework but did not indicate how the problem might be mitigated. In 1997 the Kyoto Protocol was proposed which imposes on industrialized countries the legal requirement that signatories reduce their greenhouse gas emissions on average by 5% below 1990 levels between 2008 and 2012. The Kyoto Protocol went into force in 2005, adopted by many of the large emitters including the European Union as well as Russia, Japan and Canada, a total of 36 countries. However, the United States constituted a notable omission: the nation that with only 5% of the global population has contributed (as at 2007) 30% of the world's cumulative greenhouse gases since 1850 (Lee et al. 2007).

Five years on, climate change continues to impact on many natural and human systems. Furthermore, the effects are predicted to increase in severity as the global

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[1] See Climate Change 101 Overview Pew centre on Global Climate Change http://www.pewclimate.org/docUploads/1114_OverviewFinal.pdf - accessed on 08/05/10.

[2] See Earth's CO2 Homepage http://co2now.org/ - accessed on 08/05/10.

temperature rises. While time to avoid the most damaging impacts of climate change is limited, mitigation measures can still be valuable if the global community takes strong action now.

The question of waste and its contribution to climate change is one aspect that has arisen in recent academic debate and waste has been identified as a major contributor to reducing Greenhouse Gas emissions (GHGs). The estimated global annual emissions from solid waste disposal sites are in the total range of 20-40 million tonnes of CH_4, of which the majority comes from industrialized countries (or Annex I countries as defined under the UNFCCC). This contribution is estimated to be approximately 5-20 percent of global anthropogenic CH_4, which is equal to about 1-4% of total anthropogenic greenhouse emissions. Emissions from developing countries will increase due to an increasing urban population, increased specific per capita municipal solid waste generation due to rising economies, as well as progressively improving waste management systems. Emissions from Annex I countries are expected to remain stable over the next 10-20 years. A compilation of reported emissions to the UNFCCC indicate that 24 million tonnes of CH_4 were emitted by Annex I countries in 1990.[3]

Developing countries are estimated to account for approximately 70% of the increase in global carbon dioxide (CO_2) emissions for the period 2002-2030 (OECD 2002). The Clean Development Mechanism (CDM) conceived under the Kyoto Protocol aims to reduce emissions in developing countries (Non-Annex I countries) on a project basis, and as a flexible mechanism under the Kyoto Protocol, enables developed countries (Annex I countries) to meet their individual emission reduction commitments.

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[3] See Froiland Jensen J.E., Pipatti R. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Background Paper – CH4 Emissions from Solid Waste Disposal http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_1_CH4_Solid_Waste.pdf - accessed on 15/05/2010.

2. Research Questions and Aims of the Thesis

The aim of this thesis is to review the role of the Clean Development Mechanism in light of the conference at Copenhagen in December 2009 which suggested changes in the structure and workings of this instrument.

Between 1990 and 2003, emissions from the waste sector declined 14-19% for the 36 industrialized countries and Economies in Transition listed in Annex 1 of the United Nations Framework Convention on Climate Change. The reduction was mainly due to landfill gas (LFG) recovery (ISWA 2010). Therefore, there is significant mitigation potential in reducing greenhouse gas emissions and allowing the municipal solid waste (MSW) sector in particular, to contribute towards mitigating climate change. Between 1990 and 2007, progress in reducing GHG emissions in the EU was made through policy and regulations. Furthermore, a legislative framework was established, including specific targets and directives regarding packaging waste and diversion of organic waste to landfill. Meanwhile in the US, landfill emissions decreased by 11% between 1990 and 2007 due to increased landfill gas recovery resulting from economic incentives, policies and regulations (ISWA 2010). Developing countries, (or, to an extent economies in transition) which are the hosts of CDM landfill gas projects, do not usually have such national structures to fall back on. The main research question emerging is, therefore, what role can CDM projects play in filling such a gaping hole both in terms of managing the convoluted and troubled waste systems of the developing world, *as well as* reducing GHGs, *and* creating the necessary incentive for developing countries to be able to replicate these individual projects where possible?

The CDM is an enabling mechanism under the Kyoto Protocol through which buyers in industrialized countries can invest in emission reduction projects in developing countries, purchase the Certified Emission Reductions (CERs) and use these reductions to meet their compliance obligations under the Kyoto Protocol. Developed countries are able to reduce their own emissions abroad, given that the Kyoto Protocol is based on the premise that as a well-mixed global system, a reduction in greenhouse gases in one country constitutes a reduction in greenhouse gases in another. A further economic argument for reducing emissions abroad is that those emissions that can be reduced at least cost should be reduced first. As of 1st May 2010, landfill gas projects constituted 6% of all CDM projects.[4]

The aim of this thesis is to test the following hypothesis: can CDM landfill gas projects from the Austrian JI/CDM programme carry additional benefits both in terms of GHG emission reductions and sustainable development benefits?

Furthermore, can the CDM cater for a win-win situation: can it be a low risk opportunity for buyer countries to achieve compliance and an opportunity for economic development for the host country?

Writing in 2007, Ellis et al. affirm: **'CDM /JI programmes (e.g. Austria) have only recently been initiated and have not yet resulted in much project development.'** The motivation behind writing this thesis is to fill precisely this gap in the literature: what can be learnt from waste management projects under the Austrian JI/CDM programme? What successes and failures have resulted from the implementation of waste management projects and ultimately, can landfill gas projects be viewed merely as a 'low cost option' for providing cheap credits in the international carbon market? What sustainable development benefits can be taken from the projects and how many CERs can be attributed to the projects? Are the CERs currently gained from the project a fair measure of the amount of methane generated from the projects?

[4] See UNEP Risoe CDM/JI Pipeline May 1 2010 http://cdmpipeline.org/cdm-projects-type.htm - accessed on 16/05/2010.

Chapter II Research Methodology

In general, it should be noted that specific information additional to that found on the UNFCCC site for each project studied was in most cases not available. Limited information could be gathered directly from Kommunal Kredit Consulting, the body responsible for carrying out the projects together with the Austrian government, by attending a public conference hosted by the Austrian JI/CDM programme for investors, project partners and interested parties. This meant that a combination of data was used; legal documentation made publically available by the UN and available updates on the three case studies, together with primary literature and statistics on the status of the CDM. Finally, there is a large body of secondary literature available on the CDM, and here the challenge was to identify the most recent and relevant pieces for the study of the three case studies in question.

1. Review of legal status of CDM

In order to be able to fill the necessary gap in the literature by focusing on a national programme and its intervention in the international CDM framework, the legislative section of the study will be dedicated at looking first at the origins of the international legal framework, the origins of the Clean Development Mechanism, and giving an explanation of how it works. The dual objective of the mechanism will be highlighted, (which is both for projects to generate CERs *and* to lead to sustainable development) and an initial introduction will be given as to how landfill gas (LFG) projects fit into this classification. The legal overview will then extend to a review of the European Emissions Trading Scheme (EU ETS) which encompasses the Clean Development Mechanism and the particular legal framework of the Austrian JI/CDM programme. Analysis at the international and national level will be necessary to explore in full the initial research questions, including the prospects for buyers on the developed country side, in their purchases of CERs.

2. Literature Review

The literature review will look firstly at primary literature and web updates on the progress of the CDM pipeline and aspects such as the geographical spread of projects to date. Secondly, it will include an overview of the technical dimension of landfill gas extraction and the consequence of diverse operational issues for the resulting CERs. Finally, secondary literature already written on landfill gas CDM projects will be reviewed to determine the current state-of-the-art to which the present case study comparison aims to contribute.

3. Methodology explanation – the Case Study Method

The chosen methodology for this thesis will be the case study method with the purpose of conducting a cross-case comparison and comparing the three projects currently run by the Austrian government together with Kommunal Kredit Consulting. The chosen projects are based in Meizhou, China, Talia, Israel and in Salvador da Bahia in Brazil. Literature with a country-specific analysis of current waste management problems, as well as the implication of political conditions for CDM projects will be considered.

The advantages of conducting a qualitative study are as follows: with the data available, an in-depth study of waste management in the host country as well as the conditions surrounding each of the cases can be explored in detail, allowing a highly valuable insight into each of the respective conditions. Academic literature has also illuminated the benefits of a case study style approach. Firstly, case studies allow one to peer into the box of causality and to locate the intermediate factors lying between some structural cause and its purported effect. Ideally one can then “see” how variables X and Y interact. While it is often difficult to tease out differences between real and spurious causal effects, the link between X and Y can often be readily identified (Gerring 2007). Furthermore, the choice of research design or methodology is often driven by the quantity and quality of information which is available. An evidence-rich environment is where data is relatively precise and rendered in comparable terms across all cases and where one can be fairly confident that the information is accurate. As Gerring (2007) notes:

'If relevant information… is contained in incommensurable formats across a population of cases, then a case study format is almost unavoidable.'

Van Evera (1997) identifies within a 'universe of testing methods', observation using case study analysis. Given that in this thesis, no controlled comparison as such will be undertaken, the aim will be to do precisely what is commonly identified as one of the main criticisms of case studies: generalize case study results to other cases. This can be seen as a weakness, but generally just where single case studies are concerned. The three case studies will be reviewed as representative of studies of this type and in this sense the author will take the liberty of making cross-case comparisons. As discussed above, the scarcity of much of the information available means that each case study will be reviewed separately, based on the information available and a comparison will be made to the extent possible. Therefore a controlled comparison, the most popular case study method, will not be possible as this requires the cases compared to effectively be identical.

Chapter III The Legal Dimension

1. The Legal Framework -The Origins of the Clean Development Mechanism

The Kyoto Protocol was adopted in Kyoto, Japan, on 11 December 1997 and entered into force on 16 February 2005. 184 Parties of the Convention have ratified its Protocol to date. The detailed rules for the implementation of the Protocol were adopted at COP 7 in Marrakesh in 2001, known as the 'Marrakesh Accords.' The target outlined covers emissions of the six main greenhouse gases: Carbon dioxide (CO_2); Methane (CH_4); Nitrous oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF_6) (Bogner et al. 1993).

Article 12 of the 1998 Kyoto Protocol establishes The Clean Development Mechanism (CDM). The central feature of the Kyoto Protocol is that countries should limit or reduce their greenhouse emissions. In setting these targets, emission reductions took on an economic value. As a result, in order to help countries meet their emissions targets and to encourage the private sector and developing countries to contribute to emissions targets, three market-based mechanisms were established: Emissions Trading, the Clean Development Mechanism and Joint-Implementation (JI).

The CDM allows emission reduction or emission removal projects in developing countries to earn CERs, each one equivalent to one tonne of CO_2. These CERs were designed to be traded and sold and used by the industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol. The CDM is the first scheme of its kind to provide such a standardized emissions offset instrument. CDM projects must qualify through a rigorous and public issuance and registration process to ensure real, measurable and verifiable emissions reductions that are additional to what would have occurred without the project.

Article 12, paragraph 2 states the dual purpose of the mechanism which is:

'to assist parties not included in Annex I in achieving sustainable development and in contributing to the ultimate purpose of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission and limitation commitments.'

Each project shall be certified on the basis of (paragraph 5):

a) *Voluntary participation approved by each Party involved*

b) *Real, measurable, and long-term benefits related to the mitigation of climate change*

c) *Reductions in emissions that are additional to any that would occur in the absence of a certified project activity.*

The involvement of 'public and/or private entities' is further stipulated.

At the Conference of Parties (COP) 7 meeting in Marrakesh, Morocco, in October-November 2001, the operational details were finalized for emissions trading among parties to the Protocol and for the CDM and Joint Implementation, accounting procedures for the flexibility mechanisms, and a compliance regime that outlines consequences for failure to meet emissions targets, but defers to the parties to the Protocol after it is in force to decide whether these consequences are legally binding.

2. Identifying the dual objective: how to define "sustainable development"?

Literature searching for a clear definition for the term sustainable development has become increasingly extensive in past years, in particular since the 1987 Brundlandt Report 'Our Common Future' proposed the following definition for sustainable development:

'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987).

'Our Common future' further elaborates two key central concepts: the concept of 'needs' of the world's poor as well as the concept of the need for strategic sustainable development which is considered prior to initiating development. Sustainable development is broadly defined as development which should, at a minimum, not endanger the natural systems that support life on Earth: the atmosphere, the waters, the soils and the living-beings (WCED 1987).

Key aspects defined for sustainable development are the conservation of plant and animal species given that development can tend to simplify ecosystems and the propagation of certain specie types. The need for economic growth is highlighted through new modes of technology and in changing the quality of growth; we are called upon to change our approach to development efforts to take also non-economic variables into account. The report therefore points at new criteria for development aside from those driven by economic factors, and calls for the adaption of legal and institutional mechanisms to integrate economic and ecological factors into decision-making systems.

A further seminal legislative document in the development of the term was the Rio Declaration on Environment and Development of 1992 citing (Principle 1) Human Beings to be:

‘at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.’

Environmental protection should be dealt with as an integral part of the development process (Principle 4) and Principle 10 accounts for public participation in the decision-making process as to whether a particular development should go ahead.

At the World summits in the 1990’s during which the Millennium Development goals were compiled, Goal 7 was set to:

‘Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources’ (MDG 7).

2. 1. Do Landfill Gas projects comply with the sustainability principle?

A challenge which has presented itself in some of the CDM host countries is the review of sustainability made by each respective Designated National Authority (DNA). Some DNAs have suggested that landfill gas CDM projects must commit to utilizing the gas and will not be deemed sustainable if they only flare the landfill gas. It is difficult for a project to agree to utilize the gas prior to commencement of the project and project operators that have done this, have found that it can be an expensive mistake to make. The project is still environmentally beneficial, even if the gas is simply flared, though often a project is ‘flare only’ for a particular period of time and then gas quality and quantity are confirmed along with other possible appropriate uses in due course.

Furthermore, the potential of a CDM project in its market must be fully weighed up when considering whether the creation of electricity from a project is financially viable. The widespread availability of low cost coal can mean that project plans for electricity generation can be impeded unless a 'green' or renewable energy tariff is put in place.

3. The Mechanics of the CDM process

The CDM allows developed nations, the so-called 'Annex I parties' to earn Certified Emissions Reductions to contribute to domestic efforts to reduce emissions. (However, according to section F 'Participation requirements' of the Annex to the Report of the Conference of Parties serving as the Meeting of the Parties to the Kyoto Protocol, also a party not included in Annex I may participate in a CDM project activity if it is party to the Kyoto Protocol) (UNFCCC (ed.) (2005) b)).

Participation in CDM projects is voluntary, but all parties are asked to designate a 'Designated National Authority' (DNA) which facilitates the exchange of information between countries participating in the CDM.

The applicant (the industrialized nation) proposes a project through the Clean Development Mechanism Project Activity cycle, submitting a project design document initially detailing the title and purpose of the project as well as the project scenario and describing the activities to be implemented. It is important to include at this initial stage the 'baseline scenario', ie. the scenario prior to commencement of the project. Furthermore, the applicant should include how specifically the project reduces greenhouse emissions, the technology which will be employed, as well as the participant's own view as to how the project activity will contribute to sustainable development. Secondly, the applicant must outline the chosen methodology to be implemented in order to carry out the project. The applicants may either adopt an 'approved methodology' from the guidelines offered for baseline and monitoring methodologies by the Methodology Panel (established by the Executive Board (see UNFCCC (h)), or they may submit a new methodology to be approved by the Board. They should then provide an ex ante calculation of emissions reductions and provide a description of a monitoring plan as well as an outline as to the duration of the project. The environmental impacts envisaged by both project participants and the ‘host parties’ (ie. the developing country host) should be included, supported, if necessary, by documentation of a completed environmental impact assessment. Compiled comments from stakeholders should also be included.

A specific document on baseline and monitoring methodologies adopted should additionally be submitted, showing in detail how the chosen methodology will be applied and why in particular this specific one has been chosen. This is a crucial part of the process given the key importance to the Clean Development Mechanism of ‘additionality’.

3.1. ‚Additionality’

The fundamental idea behind the CDM is to provide a platform for *real* emissions reductions, and not to seemingly represent a reduction in GHG emissions which would have been achieved even without the implementation of the specific CDM project in question. A project is defined as having ‘additionality’ if it goes beyond a ‘business-as-usual project.’ There is a problem of lacking additionality where projects have already been started prior to applying for CDM status. As a result it was decided that projects applying one year after the investment decision should not qualify for CDM status. The key aim is not to give credits to projects which would have happened anyway, in other words to avoid ‘free riders.’

A project is termed ‘additional’ if the emissions reduced by the project are lower than the baseline (the emissions that would have occurred without the project). The baseline is generally measured either through reference to emissions from similar activities or implemented technologies either in the same country or elsewhere, or simply through the actual emissions present prior to the project implementation. Third Party validation is therefore required in order to prevent the establishment of an artificially high baseline in order to make the emission reduction appear greater.

This Third Party validation, verification and certification of the projects is carried out by the Designated Operational Entities (DOEs), independent agencies reviewed by the Conference of the Parties (also known as Meeting of the parties for the purposes of Kyoto – ‘COP/MOP’) which looks at their regional distribution and also makes the decision to promote their accreditation. The DOEs carry out an independent evaluation against the requirements of a project activity (validate the project). In the case of the submission of a new methodology by the participant, the DOE submits this to the Executive Board. Otherwise it can validate the project immediately and submit the project for registration. Once the project has been registered, it has been accepted as validated by the Executive Board. The project participants must then submit a monitoring report to the DOEs, detailing a description of the project, the parameters monitored and the time period of monitoring, and must at this point also include an assessment and description of the social and economic benefits drawn from the project.

Verification is then undertaken by the DOE, which is a periodic independent review and *ex post* determination of the monitored reductions in anthropogenic emissions by sources of greenhouse gases that have occurred.[5] Certification is then the written assurance by the DOE that the reduction in emissions has been achieved as verified. After certification, an issuance request is made to the Executive Board for issuance of the CERs gained.

4. The European Emissions Trading Scheme (EU ETS)

The European Greenhouse Gas Emissions Trading Scheme (EU ETS) began operations as the largest multi-country and multi-sector trading scheme worldwide based on Directive 2003/87/EC which entered into force on 25th October 2003. Allowances traded on the EU ETS are not printed but held in electronic registries set up by the member states. All of the transactions are overseen by a central administrator at EU level who checks each transaction for irregularities. Like a bank keeps ownership of money, the registries system keeps track of the ownership of allowances.

Directive 2003/87/EC accounts for the current trading period (Article 11, paragraph 2):

[5] For further information on the verification procedure, please see 'Verify and Certify ERs (Emission Reductions) of a CDM project activity: http://cdm.unfccc.int/Projects/pac/howto/CDMProjectActivity/VerifyCertify/index.html - accessed on 14/05/2010.

'For the five-year period beginning 1 January 2008 and for each subsequent five-year period, each Member State will decide upon the total amount of allowances it will allocate for that period and initiate the process for the allocation of those allowances to the operator of each installation.'

Article 12 states that Member States shall ensure that allowances can be transferred between:

a) *'Persons within the Community*
b) *Persons within the Community and* ***persons in third countries,*** *where such allowances are recognized in accordance with the procedure referred to in Article 25 without restrictions, other than those contained in, or adopted pursuant to this Directive.'*

Article 25 provides for '**Links with other greenhouse emissions trading schemes'**:

1. *'Agreements should be concluded with third countries listed in Annex B to the Kyoto Protocol which have ratified the Protocol to provide for the mutual recognition of allowances between the Community Scheme and other greenhouse gas emissions trading schemes…'*

Article 30 states that:

'Linking the project-based mechanisms, including Joint Implementation (JI) and the Clean Development Mechanism (CDM) with the Community scheme is desirable and important to achieve the goals of both reducing greenhouse gas emissions and increasing the cost-effectiveness functioning of the Community Scheme. Therefore the emission credits from the project-based mechanisms will be recognized for their use in this scheme subject to provisions adopted by the European Parliament and the Council on a proposal from the Commission, which should apply in parallel to the Community scheme in 2005. The use of the mechanisms shall be supplemental to domestic action, in accordance with the relevant provisions of the Kyoto Protocol and the Marrakesh Accords.'

The Sixth Community Environment Action Plan referred to in the Directive identifies climate change as a priority for action and provides for a community-wide emissions trading scheme by 2005. The programme recognizes that the Community is committed to achieving an 8% reduction in emissions of greenhouse gases by 2008 to 2012, compared to 1990 levels, and in the longer term, emissions of greenhouse gases will need to be reduced by 70% compared to 1990 levels. The ultimate objective of the UNFCCC is highlighted as being to achieve stabilization of greenhouse gas concentrations in the atmosphere which prevents dangerous anthropogenic interference with the climate system.

Furthermore, the following provision in Directive 2003/87/EC, paragraph 23 is given:

'Emission allowance trading should form part of a comprehensive and coherent package of policies and measures implemented at Member State and Community Level.'

Directive 2004/101/EC amending 2003/87/EC made some significant amendments to the latter text, notably in terms of member states allowing operators to use CERs and ERUs (Emission Reduction Units, credits used for JI projects) from project activities in the community scheme up to a percentage of the allocation of allowances, to be specified by each Member State in its national allocation plan for that period (2004/101/EC, Article 11.1.). Moreover, Article 11 a.2 of 2004/101/EC specifies that:

'2. Subject to paragraph 3, during the period referred to in Article 11(1), Member States may allow operators to use CERs from project activities in the Community scheme. This shall take place through the issue and immediate surrender of one allowance by the Member State in exchange for one CER. Member States shall cancel CERs that have been used by operators during the period referred to in Article 11(1).'

Furthermore, the new directive stipulates that member states will report to the European Commission every two years on the extent to which domestic action:

'constitutes a significant element of the efforts undertaken at national level, as well as the extent to which use of the project mechanisms is actually supplemental to domestic action, and the ratio between them, in accordance with the relevant provisions of the Kyoto Protocol and the decisions adopted thereunder. The Commission shall report on this in accordance with Article 5 of the said Decision. In the light of this report, the Commission shall, if appropriate, make legislative or other proposals to complement provisions adopted by Member States to ensure that use

of the mechanisms is supplemental to domestic action within the Community.' (This replaced article 30.3. of 2003/87/EC).

The amendments provide for further detail on the use of operators (whether public or private entities) to participate in project activities generating CERs (as well as ERUs) on behalf of the member state, while the respective country remains responsible for the fulfilment of its obligations under the UNFCCC and the Kyoto Protocol. Interestingly, the amendment of Article 30 above provides for direct intervention of the Commission, should the use of the Kyoto Protocol's flexible mechanisms *not* be additional to domestic action.

5. The role of the CDM on the national level: the legal foundations of the Austrian JI/CDM Programme

The Austrian JI/CDM Programme is regulated under the Environmental Support Act which was first published on 21st August 2003. Austria has completed a number of Memoranda of Understanding with a series of countries. The aim of the programme is to apply the Kyoto Protocol on the use of climate changing flexible mechanisms to a framework for a national goal towards climate protection. In 1997, all European Countries committed themselves to a reduction target to reduce greenhouse gases by a certain percentage. The overall EU reduction target of 8% was split between the countries, based on their differing preconditions for achieving emissions reductions. Austria adopted within the EU-15 a legally-binding agreement to reduce greenhouse gases in the first commitment period 2008-2012 by 13% in comparison to 1990 levels. In order to reach this, the Austrian federal government and federal states adopted a common climate strategy, the most recent version being the climate strategy of 2007. This is based on a broad range of national measures in addition to which, Austria has a purchasing target of 45 million tonnes of emissions reductions to be achieved by the Austrian JI/CDM programme in the time between 2008 and 2012.[6] The proposed aim of the JI/CDM programme (as announced in the Austrian Kyoto Progress Report for the years 1990-2004[7]) is to close the gap

[6] See 'National Climate Policy' of The Austrian JI/CDM Programme: http://www.ji-cdm-austria.at/en/portal/kyotoandclimatechange/nationalclimatepolicy/ (Accessed 14/05/2010)
[7] See Gugele, B., Rigler E., Ritter M., (2006): Kyoto Fortschritt Bericht Österreich 1990-2004 Kyoto Progress Report for the Austrian Ministry of the Environment, Vienna.

between the Kyoto target and the potential greenhouse gas emission reductions which can be made domestically.

The Austrian JI/CDM programme acts as a market participant and has established various opportunities to source emission reductions from single projects, project bundles, funds and facilities. (AMAFEW (2007)[8]) Kommunal Kredit Consulting (KPC) is in charge of the Programme Management and acts on behalf of the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. As well as achieving the aim of a 13% reduction in emissions of greenhouse gases, the programme is obliged by the directive on the JI/CDM programme to include additional information in the 'Austrian Questionnaire' on the ecological, socio-economic and development aspects of the project. Furthermore, the directive obliges the Austrian JI/CDM programme to take into the consideration the objectives and principles of Austrian Development Policy[9] pursuant to Section 1 of the Federal Act on Development Cooperation.

The prerequisites for recognizing a project as a CDM project include the following:

- The project leads to reductions of anthropogenic emissions of greenhouse gases which would not be possible if the project were not implemented.
- The amount of emissions reductions can unmistakably be attributed to the project.
- The project generates verifiable emission reduction units.
- The host country has ratified the Kyoto Protocol.
- The project has been approved by the entity in charge nominated by the host country and meets the CDM criteria of the country if these exist.

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http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0011.pdf (accessed 16/05/2010)

[8] See Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (2007): A Guide to Joint Implementation and Clean Development Mechanism Projects within the framework of the Austrian JI/CDM Programme http://www.ji-cdm-austria.at/blueline/upload/leitfadenenglishlangversion.pdf (accessed 14/05/2010)

[9] See p.49 of Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (2007): A Guide to Joint Implementation and Clean Development Mechanism Projects within the framework of the Austrian JI/CDM Programme http://www.ji-cdm-austria.at/blueline/upload/leitfadenenglishlangversion.pdf (accessed 14/05/2010)

- The project gives due consideration to sustainable development in the host country, ensuring the proper balance of economic, ecological and social impact.

The following are relevant to this study within the range of project types:

- waste management measures which contribute toward the avoidance of greenhouse gas emissions, especially through energy recovery from waste, preferably including thermal waste utilization.

-projects designed to avoid the development of or recover energy from landfill gas.

Contractual provisions for the project state the following: a contract is made between the Federal Minister of Agriculture, Forestry, Environment and Water Management, represented by the programme manager and the offeror, as well as the binding approval of the host country to the project. Alternatively, a contract between the Federal Minister of Agriculture, Forestry, Environment and Water Management represented by the programme manager, the offeror and the host country. The project is concluded once the project has been registered with the Executive Board for CDM projects.

Chapter IV Reviewing the state-of-the-art: the CDM, a solution to waste management challenges in the developing world?

1. The problem of waste mismanagement in the developing world

Many critical works have been written on the problem of waste management for developing countries and possible solutions for managing waste disposal. Furthermore, it has been ascertained that simply importing Western or developed countries systems and waste management standards to the developing world is not a solution (Brunner and Fellner 2007). Their study is based on the premise that the hierarchy 'Prevention-Recycling-Disposal' is a policy which has been keenly adopted in the European Union, but is not one suitable for developing countries. In order to achieve the goals of waste management, which are the protection of human health and the environment, as well as taking economic parameters into consideration, alternative solutions are required. The study concludes that the improvement of disposal systems (full coverage of waste collection service and upgrading of dump sites to sanitary landfilling) is the most cost-effective option of achieving waste management. The developing world has a higher growth in population, and notably an expansion in the size of its cities and increased urbanization, as its peoples emigrate from the countryside to the cities.

The story of Cairo, Egypt, is one which exemplifies this all too well.[10] In 1984, Cairo and Giza created new regulatory authorities (the Cairo and Giza Cleansing and Beautification Authorities CCBA and GCBA) to organize and upgrade the city's waste sector. They aimed to do this by trying to support the traditional collectors (the *Zabaleen)* and to create a system where residents were charged a fixed fee for monthly collection. The money earned by these collectors which was meant to be dedicated to the cost of operating, maintaining or upgrading vehicles was pitiful and even less remained to pay for labour. Such a policy, while aiming to empower the local collectors, failed by creating a multitude of poorly managed, poorly operated,

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[10] Borrowed here is information from the editorial by Iskandar L., and Tjel J.C., (2009) Cairo: A colossal case of waste management to learn from, *Waste Management & Research* 2009: 27: 939 – 940.

poorly maintained plant and facilities which ground to a halt. Some were obsolete, some had never been used. In 2000, the population of Cairo had reached 12 million. 10 000 tons of municipal waste were being created per day and the *Zabaleen* were collecting 30-40% of rubbish and recycling 80% of what they collected. Local Egyptian companies were contracted to collect and transport the waste in the neighbourhoods not being serviced by the collectors and transport it to poorly managed municipal dumpsites. These became sources of dark smoke which hung over the city. Egypt sought a solution to the problem in privatizing their waste services and placing it in the hands of European multinationals. This led to an increased host of socio-economic problems, given that people were now asked to pay more for a lower level of garbage collection and the inhabitants of the city were also the city's scavengers who seek an income from waste pooling sites.

The problem of waste mismanagement is one which quite clearly goes far beyond a preoccupation for its harmful effects on the climate. This is an issue in developing countries which touches the core of each inhabitant in his/her daily life and goes beyond being a greenhouse gas problem, but one of hygiene and of health. The detailed socio-economic and personal impact on developing country citizens merits individual attention and has been discussed in further detail elsewhere. However, this scenario sets a scene that is similar for many of the sites chosen globally to be converted from 'poorly managed municipal dumpsites' to effective landfill gas recovery and utilization projects.

2. Literature Summary – a Review of the CDM to-date

The literature on the CDM is extremely abundant and will be limited in this work to criticism from the most recent years and that which is directly applicable to MSW management. The present section will begin by looking at the status of projects to date in the CDM pipeline and review the technical dimension of the operation of landfill gas projects. The section will conclude with a review of secondary literature specifically focused on landfill gas projects carried out under the CDM. While works on the future of CDM are plentiful, those specifically related to landfill gas projects in depth are somewhat rarer and therefore these will be the focus of this study.

As at Fennhan's study in 2009, the CDM had spurred the development of 4586 projects in 76 developing countries. As at 1st May 2010, landfill gas projects comprised exactly 5.95% of all CDM projects (Fennhan 2009). Projects remain extremely unevenly distributed across regions with projects concentrated in Asia and in Latin America, and with a 68% and 28% share in numbers. Africa and the Middle East are still extremely poorly represented (Boyd el al. 2009). The CDM projects by region were laid out (as at February 2009) as below:

Table 1: CDM projects by region including leading countries. (Data as of February 2009, from UNEP-Risoe).

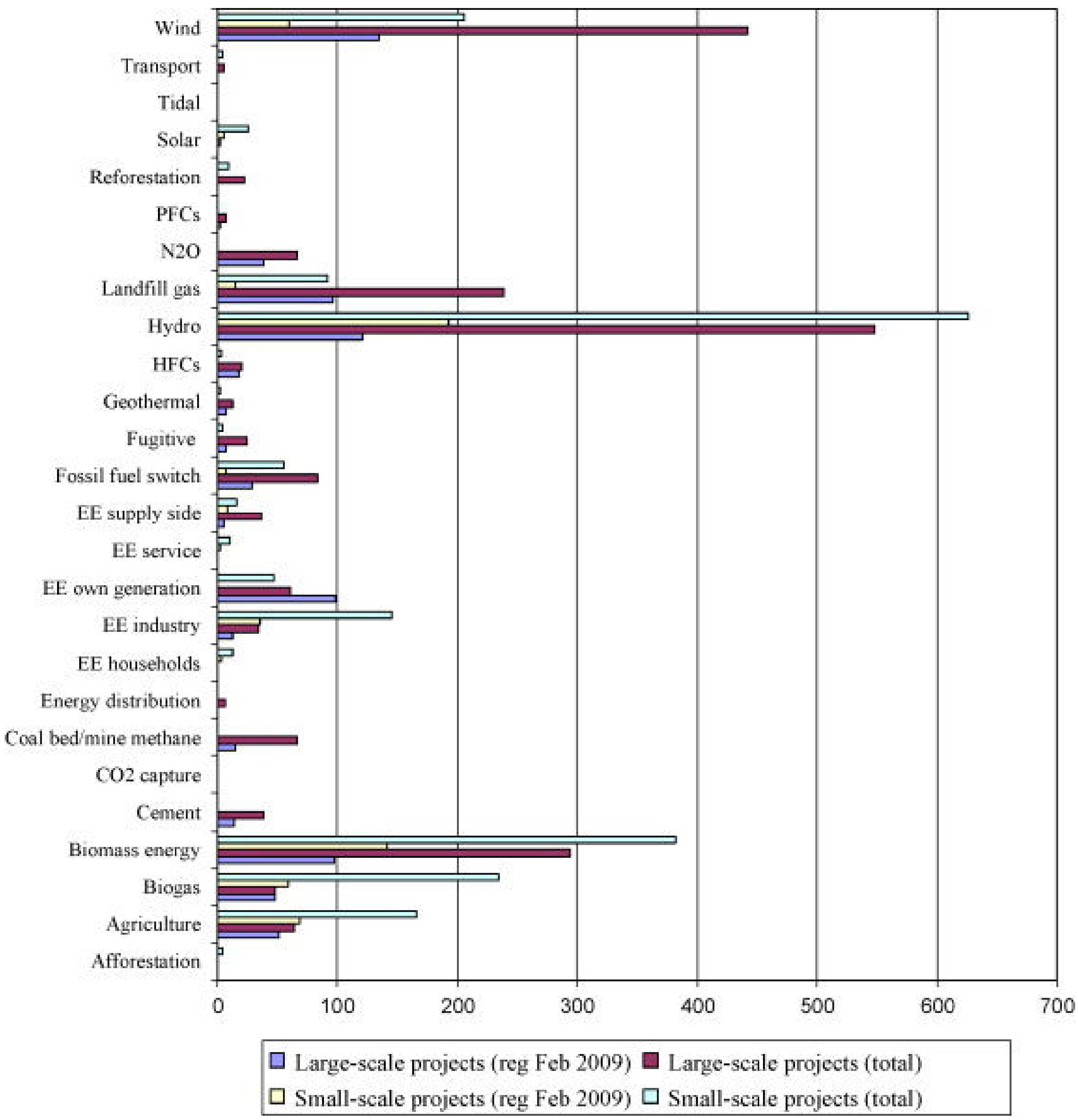
Region and country	**Registered February 2009**	**Requested registration + under validation**	**Total**	**% Share of the region**	**% Share of the CDM portfolio**
Latin America	**394**	**455**	**849**		**19**
Brazil	150	203	353	41.6	7.9
Mexico	110	90	200	23.6	4.5
Asia and Pacific	**923**	**2513**	**3426**		**76.6**
India	392	789	1181	34.5	26.4
China	395	1265	1650	48.2	36.9
Africa and Middle-East	**43**	**103**	**146**		**3.3**
South Africa	14	13	27	18.5	0.6

Region and country	**Registered February 2009**	**Requested registration + under validation**	**Total**	**% Share of the region**	**% Share of the CDM portfolio**
Israel	13	21	34	23.3	0.8
Europe and Central Asia	**10**	**33**	**43**		**1**
Georgia	1	5	6	14	0.1
Armenia	4	4	8	18.6	0.2
Total (all countries)	**1370**	**3104**	**4474**		**100**

Boyd et al. (2009) estimate that Asia would continue to dominate in the market increasing its market share from 67% to 76.6% of the reductions. Latin America was set to diminish from 29% to 19%. The relationship of projects hosted and CERs produced was also addressed and it was highlighted that China hosts 28% of registered CDM projects, yet provides for 51% of global CERs. The contribution of project types to CER emission reductions is shown in Figure 1.

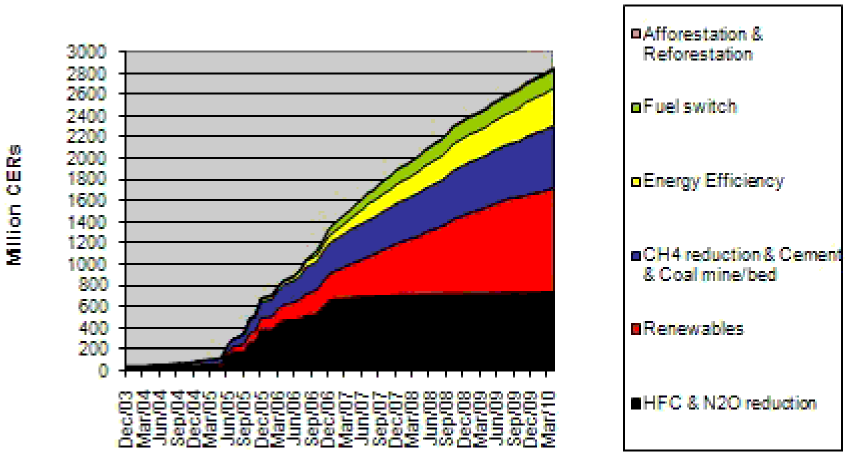
The waste sector represents a significant part of all CDM registered projects. As of October 2009, 18% of the 1834 projects were waste sector projects. These include solid waste activities (landfill gas recovery, composting and incineration) as well as methane avoidance technologies. 138 of the 407 registered waste projects are municipal solid waste projects also referred to as ‘solid waste projects’ (CD4CDM Pipeline – November 2009).

The UNFCCC has set up a body to oversee the CDM – the CDM Executive Board (EB). This Board has established the procedure for project approvals and issuing credits. To date the CDM EB has approved 7 large scale and 6 small scale methodologies which apply to solid waste activities, including landfill gas capture and flaring, LFG recovery, composting, waste-to-energy, anaerobic digestion and refuse-derived fuels. Graph 1 shows the contribution of projects to the number of Certified Emissions Reductions by project type:



Graph 1: Contribution of projects to Certified Emissions Reductions by project type. (UNEP Risoe as at February 2009).

If we now compare the situation just over a year on (1 May 2010), Graph 2 shows the expected amount of CERs to be created before the end of 2012. Since June 2005, these have been growing linearly at the rate of about 1000 million per year. In the Project Design Documents (PDDs) the total amount of 2012 CERs is now 2855 million (as at 1 May 2010.) Table 2 shows the number of CERs allocated to projects by project type.



Graph 2: Growth of total expected accumulated CERs by the end of 2012 (UNEP Risoe 1 May 2010).

Table 2: CDM project with CERs issued by project type. (UNEP Risoe 1 May 2010).

CDM projects in the pipeline	CDM project with CERs issued		
Type (rejected projects excluded)	Projects	Issued kCERs	Issuance success
Afforestation			
Agriculture			
Biomass energy	126	15512	88%
Cement	7	1203	69%
CO2 capture	1	48	123%
Coal bed/mine methane	10	2807	45%
Energy distribution			
EE households			
EE industry	25	1251	86%
EE own generation	51	16762	82%
EE service	1	6	63%
EE supply side	7	395	77%
Fossil fuel switch	23	5616	66%
Fugitive	2	4600	114%
Geothermal	5	684	38%
HFCs	18	213930	107%
Hydro	150	18835	93%
Landfill gas	48	9690	35%
Methane avoidance	61	6219	49%
N2O	21	89943	123%
PFCs and SF6			
Reforestation			
Solar	1	1	18%
Tidal			
Transport	2	201	42%
Wind	150	19332	83%
Total	709	407036	96.8%

The issuance success is the CERs issued divided by the CERs expected for that period of time.

The table shows the difficulty witnessed by landfill gas operators at issuance stage. While registration is not a problem, only a third of projects registered get to the issuance stage.

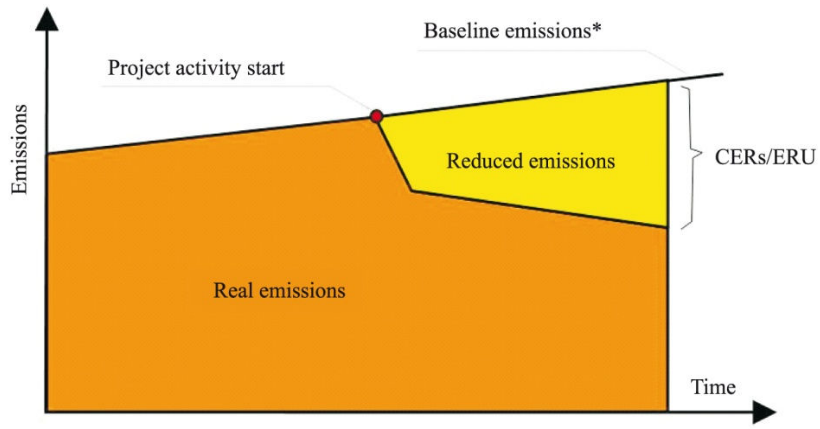
3. Landfill Gas Recovery – the technical dimension

Landfill refers to disposal sites where waste is placed in lined sections and degraded while producing CO_2 and methane, a potent greenhouse gas, currently estimated to have a Global Warming Potential (GWP) of 21 (21 times that of CO_2[11]). Landfill

[11] The GWP of methane has been estimated at 21 times that of carbon dioxide over a 100 year period (see IPCC Second Assessment Report http://www.ipcc.ch/. More recent studies

gases can be stimulated and controlled in order to simulate a biogas reactor, significantly shortening the period over which gas and leachates are produced. The main output of a modern landfill gas system is electricity production from the combustion of biogas which has an average efficiency of 35% of the energy content of the biogas. Compared to anaerobic digestion in vessels or conversion of waste to energy in incinerators, energy recovery rates from landfill gas processes are relatively low. Flaring of landfill gas can reduce GHG emissions but does not offer energy recovery. When calculating GHG emissions, electricity and fuel consumption for running the landfill must be taken into account.

Graph 3 below, taken from the literature, aims to show graphically the reduced emissions realized by CDM LFG projects and the extracted CERs.



Graph 3: Reduction of anthropogenic greenhouse gas emissions due to a CDM project, emissions that would have occurred in the absence of the project activity. (Ploechl, Rassgossnig, 2008).

GHG emission sources include CH_4 from anaerobic decomposition of organic waste, CO_2 from fossil fuel combustion and electricity consumption and N_20 from leachate treatment. Actions to reduce or avoid GHG emissions include installation of active landfill gas and treatment systems, the use of landfill gas as a fuel to produce

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have shown the conversion rate to be 23 times, but according to the UNFCCC, the official conversion rate will remain at 21 times CO_2 until December 2012.

electricity or thermal energy and engineered landfill capping to avoid fugitive emissions.

According to the modalities and procedures for a CDM project (UNFCCC 2005), monitoring includes the collection and archiving of all relevant data necessary for calculating the emissions generated by a CDM project activity. The following parameters have to be monitored in landfill gas activities:

-Amount of landfill gas.

-Quantities fed to the flares and (or power plants or boilers).

-Fraction of methane in landfill gas.

-Temperature and pressure of the landfill gas.

-Operating hours of flares, power plants and boilers.

-Quantities of fossil fuels required to operate the project activity.

-In the case of power production the quantity of exported electricity.

Figure 1 shows part of the monitoring design for calculating the emission reductions from landfill gas destruction and utilization project activities (UNFCCC 2007).

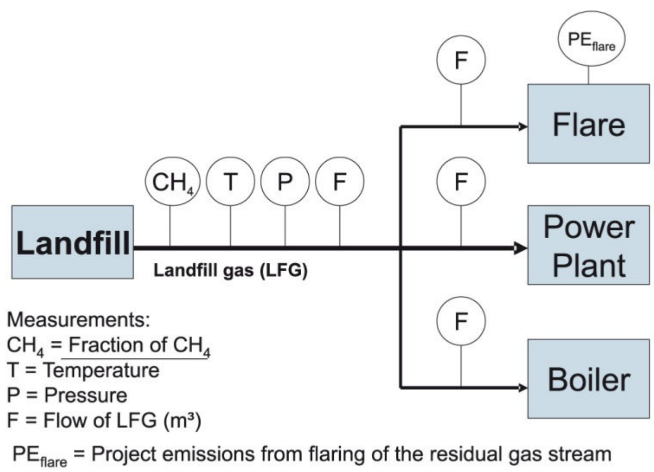

Figure 1: Monitoring Plan according to CCM0001 version 6. (UNFCCC 2007).

A key criticism of LFG projects is that based on monitoring reports from a number of registered landfill gas projects, the projects document under-delivery of CERs in comparison to estimated delivery. There could be many reasons for this, including the use of modelling tools that may over-predict expected CERs and operational issues leading to reduced gas recovery. In order to predict CERs with landfill projects, all of the methodologies approved by the UNFCCC rely on a theoretical model to estimate landfill gas generation. The CERs produced are monitored using a mass flow meter, the percentage of CH_4 in the gas, and CH_4 destruction in a combustion device such as a flare or engine. The reliance on these theoretical models poses a myriad of problems. Firstly, it should be noted that all models assume a well-mixed system with optimum microbial kinetics. Thus there are often significant differences between preliminary modelling of landfill gas generation based on waste in place and the actual landfill gas generation and recovery. Furthermore, all first order kinetic models are optimized theoretical tools; actual site specific gas generation can vary widely between individual sites with similar quantities and a similar composition of waste in place.

Landfill gas is composed of a number of gases that are present in large amounts and a number of trace gases –present in very small amounts. The principal gases are produced from the decomposition of the organic fraction of municipal solid waste and include mainly carbon dioxide and methane as well as ammonia, carbon monoxide, hydrogen and oxygen. Trace gases belong mainly to the VOC family.

Table 3 shows the typical composition of landfill gas.

Table 3: Typical composition of landfill gas. (Lombardi (2007)).

Component	Percent (dry volume basis)	Component	Percent (dry volume basis)
Methane	45-60	Sulphides, disulphides, mercaptans, etc	0-1.0
Carbon dioxide	40-60	Ammonia	0.1-1.0
Nitrogen	2-5	Hydrogen	0-0.2
Oxygen	0.1 – 1.0	Trace constituents	0.01-0.6
Carbon monoxide	0- 0.2		

The microorganisms involved in this conversion, described collectively as non-methanogenic, consist of facultative and obligate anaerobic bacteria. In the following phase, the methane fermentation phase, a second group of microorganisms which converts the acetic acid and the hydrogen to methane and carbon dioxide becomes more predominant. The microorganisms responsible for this phase are strict anaerobes and are described as methanogenic. In this phase both methane and acid formation proceed simultaneously although the rate of acid formation is considerably reduced (Lombardi (2007)). Energy recovery from landfill gas is a means to reduce the environmental impact in terms of greenhouse effect arising from landfills containing biodegradable waste. The anaerobic biological processes produce landfill gas which is approximately composed of 50% methane and 50% carbon dioxide. However, since this CO_2 comes from a biogenic source, it is no longer viewed as a potent greenhouse gas.

3.1. A review of Operational Questions

Operational considerations to deliver optimized landfill gas recovery are an important challenge for CDM projects in developing countries. Sustainable landfill gas recovery can be impeded by insufficient material to prevent air intrusion and poorly maintained piping systems. It is also vital to clarify who owns the landfill gas rights and thus the CER rights early in the assessment of an LFG CDM project at a given landfill site. These can often be resolved directly with the landowner who does not, however, own the landfill. Failure to resolve this issue up front can lead to the resulting CERs being less marketable. As has been pointed out in the literature, (Ploechl and Rasgossnig 2008) additionality is usually straight forward in the standard ACM 0001 methodology normally used for landfill gas projects, given that without the sale of CERs there is no income from flaring landfill gas and utilizing the landfill gas for power production is usually not financially attractive on its own.

However, in certain situations the additionality issue could prove to be problematic. An example would be if in year '*y* ', a project owner has to decide if he should invest in a landfill gas project. In this year ('*y*') there is however, no feed-in tariff or any other incentive for utilizing the landfill gas and he would only invest in degasifying and flaring the landfill gas to sell the CERs. In year *y* + 2, however, some public or private institution offers a feed-in tariff for power which could easily make the degasification or utilization of the landfill gas attractive, even without the sale of CERs. If the project owner decides to invest at this point in time in power production, would the whole project continue to be additional or would it not?

This scenario has yet to be tested in reality, however the scenario once again illustrates that economic incentives play a key role in guiding the realization of CDM projects, meaning these cannot be analyzed or extracted out of their immediate national economic context and be considered in isolation.

Sustainable waste management projects have boomed in response to an international market for CO_2 and the implementation of the CDM, particularly in countries where no national legal framework for such projects is available. Furthermore, the baselines and monitoring methodologies to prove additionality, set standards which need to be applied universally and can, therefore, be difficult to implement practically.

4. Secondary Literature on the CDM to-date

Ellis et al. (2007) give a summary update of the successes of the CDM to-date and consider the pattern of future development for the mechanism, looking at the type of project and its success at achieving the dual objective, both of sustainable development and low GHG emissions. Ellis writes *'the potential for CH_4 reductions from landfills is also significant'* and comments that this type of project is a 'low cost option' where the 'potential for low cost options to generate large amounts of CERs is significant.' Ellis points out that a premium is often paid by developers for the project to take on a sustainable development benefit. Therefore 'low cost options' such as CH_4 gases as well as N_20 projects or F-gas reduction projects would significantly *lower the market price* if these dominated the market. This would increase the project barriers for potential CDM projects such as renewable energy and energy efficiency systems. The latter have higher cost emission reductions but also have a higher long-term value in terms of being able to repeat the project, reduce local pollution, and being able to offer technology transfer benefits and local sustainable development benefits.

Ellis refers to landfill gas projects as an example of 'brownfield sites' and writes that: *'where small changes in existing facilities offer large amounts of cheap reductions,* *brownfield sites will inevitably dominate the market in its early years.'* Projects with a greater number of sustainable development benefits, however, will form a smaller proportion of the market. A further advantage of such 'brownfield' sites are that where there are no requirements stating the contrary, there is no incentive to make an investment to reduce emissions from current levels. Furthermore, they have often already existed for some time and hence have already proved their financial solidity.

As we are approaching the end of the 2008-2012 period, debate is getting progressively livelier as to the future of what is often seen as a declining mechanism. There has been much debate as to whether the CDM should at all be continued beyond 2012 and if so in what form. It has been considered cumbersome and unrewarding as well as 'tangled in red tape.' Various modifications have been proposed for the mechanism from restricting eligibility through to making the CDM a sector-based mechanism. The tension lies between whether the CDM is really succeeding in promoting the development of renewable technologies in developing countries and so aiding the move away from fossil fuels. It has been suggested that country governments and corporations are merely using the CDM to reduce their costs of complying with Kyoto targets and, therefore, seeking projects which yield large volumes of credits. As (Pearson 2007) writes:

'These are the most common projects that capture or destroy gases with high global warming potentials like methane, nitrous oxide and hydrofluorocarbons at existing facilities. These projects merely shift the location at which emissions reductions are made through the Kyoto Protocol without delivering additional sustainable development benefits to host countries and do not help catalyze fundamental shifts in energy production and use.'

These projects have been criticized for their failure to produce CERs, while there remain plenty of landfill gas projects in the developing world which could still benefit from CDM revenues in order to upgrade their waste management practices. The Executive Board responded to this by imposing a number of monitoring requirements. A flaring tool was introduced which require flares to monitor pre- and post combustion for CH_4, CO_2, O_2, N_2 and CO otherwise they must assume a 90% destruction efficiency for CH_4. The default for an open flare, where such monitoring is not possible, is 50%.

In Pearson's review (Pearson (2007)) the trend is summarized as follows*:*

‘a large and rapidly growing portion of the CDM project portfolio has few direct environmental, economic or social effects other than GHG mitigation, and produces few outputs other than emissions credits. These project types generally involve an incremental investment to an already-existing system in order to reduce emissions of a waste stream of GHG (e.g. F-gases or CH_4) without increasing other outputs of the system.’

While there is recognition that landfill gas projects can result in improvements in local air quality due to a reduction in noxious odours, it is precisely this type of project which has received substantial criticism for being an ‘end-of-pipe solution’.

Chapter V Results and Critical Evaluation

1. Case Studies

PREFACE TO CASE STUDIES

The following presents an overview of three case studies on the completed projects of the Austrian JI/CDM Programme, which are based in Brazil, China and Israel. The availability of data differs between the three cases and is dependent on the documents submitted to the UNFCCC. Apart from limited additional data, it was very difficult to find reliable, standardized data on the three case studies which would enable a reliable cross-comparison.

1. Salvador de Bahia Case Study 1

1.1. Background: Current situation of Brazil concerning Waste Management

Current waste problems in Brazil include problems of open dumping where waste which is left near well springs contributes to blocking the urban drainage network. Such problems can not only result in flooding, but also in the spread of diseases.

Furthermore, there is the potential for energy to be produced in Brazil by solid wastes (Oliveira, Rosa 2003). The country has a high potential to use solid wastes to generate electricity, and electricity use extends the life of raw material reserves.

Salvador de Bahia landfill, known more correctly as Aterro Metropolitano do Centro (AMC), is located in a rural area, approximately 20km north east of Salvador, in the state of Bahia, Brazil. The total project area is 2,500,000m^2 with the area reserved for waste disposal 600,000m^2. The landfill has a total capacity of 18,000,000m^3 and receives approximately 850,000 tonnes per year of domestic waste. BATTRE, (Bahia Transferencia e Tratamento de Residuos S.A.), a privately owned enterprise, is the operator of the landfill. While the landfill specifies that there should be landfill gas (LFG) capture, no specific collection efficiency is specified. BATTRE's original proposal to the Municipality suggested a collection efficiency of 19-24% over the life of the landfill. The crediting period for the landfill began in 2004 and the expected operational lifetime of the landfill is 16 years.

1.2. Baseline Scenario prior to Project Emission Reductions

The baseline scenario established by the AM0002 methodology confirms that 5% of the volume of methane collected in 2008 and 2009 at the Salvador landfill gas project would be the amount of methane that would be destroyed in the baseline scenario for this period.

The proposed project expands the coverage of the LFG capture system at the Salvador da Bahia Landfill by installing additional equipment for LFG collection and flaring. The project aims to reduce methane emissions by improving the original collection efficiency to 80%. This is an extremely high proportion of energy efficiency, given that previous studies on methane extraction have shown that the collection efficiency is normally between 30 – 40%, even for landfills operated in Europe (Fellner et al., 2003). Electricity generation from the methane is currently not considered feasible. Salvador da Bahia is estimated to be the only landfill in Brazil operated according to European standards in terms of the bottom lining system which includes a complete drainage layer. The project also defines a 'contractual' amount of methane to be collected and destroyed, which represents approximately 25% of the projected landfill gas production.

The 'baseline scenario' is, therefore, considered to be 19-24%, while the 'with project' scenario is improving the LFG collection efficiency to 80%. Additional aims of the project are to improve air quality and reduce odour and VOC emissions.

The Salvador de Bahia landfill project calculates the emission reduction through flaring of methane employing Methodology AM0002 which uses the following formula to determine emissions:

$$ER\ y = ER\_CH_4\ y * CF * GWP\_CH_4$$

Where:

ER y = the greenhouse gas emission reduction measured in tonnes of CO_2 equivalents (t CO_2e).

ER_CH_4 y = methane emission reduction measured in cubic meters (m^3 (STP) CH_4) of methane.

The conversion factor (CF) is the tonnes of methane per cubic meter of methane at standard temperature and pressure (0.000662 t CH_4 /m^3 (STP) CH_4). This calculation must be made on the assumption that STP is based on 1 bar pressure and 20 degrees Celsius. Otherwise, using 0 degrees Celsius the following would be calculated: 16 / 22.4 = 0.714 grams / litre (16 being the molar mass of CH_4 divided by 22.4 litres / mol) or 0.714 kg/m^3 which expressed in tonnes would be 0.000714 t CH_4/m^3.

The Global Warming Potential converts 1 tonne of methane to 21 tonnes of CO_2 equivalents (tonnes CO_2e / tonnes CH_4). The Global Warming Potential will remain at 21 until December 31, 2012 (the first commitment period). As established by the contractor, the baseline methane collection efficiency is 20% of the total volume of methane generated.

The methane emissions reduction (*ER_CH_4 y),* due to the project activity, is calculated as the difference between the amount of methane actually captured and flared, less the amount of methane captured and flared in the baseline.

ER_CH_4 y = CH_4flared, y – CH_4 baseline, y

CH_4flared, y is monitoring the quantity of methane actually flared using the approved monitoring methodology. *CH_4flared, y* is measured in cubic metres (Nm^3).

The ***projected*** emissions for Salvador da Bahia are given in Table 4 below.

Table 4: Estimation of baseline and project greenhouse gas emissions and net reductions 2004- 2010. (UNFCCC (b)).

Year	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Waste deposited in that year [tonnes]	860,000	870,000	890,000	910,000	930,000	950,000	960,000
Collection Efficiency -Baseline	23%	24%	25%	25%	27%	27%	27%
Collection Efficiency - Project	80%	80%	80%	80%	80%	80%	80%
Amount of methane produced by the Landfill [Nm3/Year] CH_4*, projected, y*	79,546,203	88,258,626	96,392,920	104,014,460	111,181,228	117,944,649	124,146,799
Amount of methane collected in baseline CH_4*,baseline,y*	18,551,860	21,520,520	24,117,720	25,972,000	29,682,070	31,537, 860	33,393,650
Amount of methane collected in Project Activity CH_4*flared, y*	63,636,962	70,606,900	77,114,336	83,211,568	88,944,982	94,355,719	99,317,440
Amount of methane avoided due to project *ER_*CH_4*y*	40,576,592	44,177,742	47,696,954	51,515,611	53,336,621	56,536,073	59,331,441
Amount of Carbon Dioxide avoided due to project [tCO_2e/year]: *ERy*	**564,310**	**614,392**	**663,335**	**716,442**	**741,768**	**786,263**	**825,139**
Total Carbon Dioxide equivalent: [tCO_2e/year] [2004-2019]	564,310	614,392	663,335	716,442	741,768	786,263	825,139

Actual Emissions Reductions 2009

The actual emissions reduction for 2009 was **473,042 tCO_2e.** The following data is available for working out the total mass and total volume flared for the year 2009, as represented in Table 5.

Table 5: Total mass and volume flared in Salvador da Bahia Landfill 2009. (UNFCCC(x)).

Parameter	Item	Volume [Nm^3 of CH_4]	Mass [t of CH_4]
CH_4flared, 2009	Total amount of methane flared	35,818,559	23,712
	Amount of methane used in energy generation	0	0
CH_4baseline, 2009	Amount of methane to be flared in the baseline	1,790,928	1,186
$ERCH_4$, 2009	Amount of methane emission reduction due to the project activity	34,027,631	22,526

The volume of the CH_4 is multiplied by the density of the methane in order to convert the value to a mass basis (tonnes of CH_4). The values in tonnes of CH_4 can then be multiplied by GWP_CH_4 (21) and by the Methane Efficiency Destruction Factor, or flare destruction efficiency (EDF). This value, (99.9974%), is based on conducted measurements by a third party on the amount of residual methane.

The emission reduction can there be calculated in tonnes of CO_2 equivalent as **473,042 tCO_2e.**

If leakage is then taken into account (emissions due to consumption of grid electricity & liquefied petroleum gas consumption (LPG) by the project activity) then the emissions reductions can be calculated as follows:

Table 6: Emission reductions in Salvador da Bahia Landfill 2009. (UNFCCC (x)).

Emissions reduction [ER2008]	t CO_2e	473,042
EE2009	t CO_2e	-382
ELPG2009	t CO_2e	-1

Therefore the total carbon dioxide equivalent avoided for the year 2009 is:

[ER2009 – EE2009 - ELPG2009] = 472,659 t CO_2e

This is significantly less than the figure projected for the year 2009 as per Table 4: **786,263 t CO_2e.**

Actual Emissions Reductions 2008

For the year 2008, total emission reductions achieved were **544,764 t CO_2e.**

If we make similar calculations for the year 2008, the total volume of methane flared, as well as the total mass of methane can be calculated as shown in Table 7.

Table 7: Total volume and mass of methane flared in Salvador da Bahia Landfill 2008. (UNFCCC(x)).

Parameter	Item	Volume [Nm^3 of CH_4]	Mass [t of CH_4]
CH_4flared, 2009	Total amount of methane flared	41,281,929	27,329
	Amount of methane used in energy generation	0	0
CH_4baseline, 2009	Amount of methane to be flared in the baseline	2,064,096	1,366
$ERCH_4$, 2009	Amount of methane emission reduction due to the project activity	39,217,833	25,962

The volume of flared methane is multiplied by 0.00062 tonnes/Nm^3 (0.00071[12]) (density of CH_4), in order to convert the value for a mass basis (tonnes of CH_4). Total emissions reductions for 2008 are the values in tonnes of CH_4, multiplied by GWP_CH_4 (21) and by the Methane Efficiency Destruction Factor (EDF) at 99.9979% in order to determine the emission reduction for 2008.

Including leakage, emissions due to consumption of grid electricity + LPG consumption by the project activity were as given in Table 8.

Table 8: Emission reductions in Salvador da Bahia Landfill 2008. (UNFCCC (x)).

Emissions reduction (ER2008)	t CO_2e	545,192
EE2008	t CO_2e	427
ELPG2008	t CO_2e	1

Therefore annual carbon dioxide equivalent avoided in 2008 is:

[ER2008 – EE2008 – ELPG2008] = 544,764 t CO_2e

Again, this is significantly lower than the projected amount for 2008, **741,768 tCO_2e**.

1.3. Sustainable Development Indicators - Salvador da Bahia

Sustainable Development Indicators 2009

BATTRE has taken on a commitment to spend 5% of its net income from the sale of CERs to activities that would benefit the local community, environment and economy. These expenditures were initially planned to occur only after issuance and commercialization of the CERs, but BATTRE has already spent R$ 178,798.07 (USD 102,170) on specific projects.

[12] Again, as discussed the density would equal 0.00071 tonnes CH_4 / Nm^3 under the assumption that STP is 1 bar and 0 degrees Celsius.

Economic development indicators:

New jobs generated by the biogas project are 22. Two new jobs were created in 2009.

The salary indicator showed that the LFG collection and destruction project has salaries which are higher in relation to the landfill and waste transfer station and so represents an activity which requires higher qualification.

The total waste density was calculated, based on landfill topographic assessments reaching 1.14 tonne / m^3.

Reforestation activities have been included in the landfill environmental management plan. Reforestation activities in 2009 totalled 0.28ha, according to a report compiled by a selected biologist.

A programme that was hired to supply environmental educational services to children ('Estação das Formas') was extended to educating 3,348 children.

Complaints regarding odour from the landfill (the odour being strong / medium) made up 25% of all odour related comments. This represents a significant decrease on previous years, given that from years 2003 -2008 the corresponding values were 41%, 36%, 29%, 50%, 39% and 23%. Complaints were made in the form of visitors' registries, support centre and regular interviews.

As regards safety, there were 5 registered and notified accidents with dismissal in 2009. The accident frequency indicator is 20.7 (number of accidents per 1 million worked hours).

Air pollution data is measured annually with a set of parameters. The analyzed parameters continue to register not detectable levels or under the equipment low detection level.

Sustainable Development Indicators 2008

Already in 2008 BATTRE had assumed a commitment to voluntarily allocate 5% of the net income of CERs to activities that would benefit the local community, environment and economy. By 2008, BATTRE had spent R$ 170,120-74 (US 97,212) on specific projects.

Economic Development:

Existing jobs (employees of the project): 20

Environmental and Social Development Indicators:

Waste density was based on landfill topographic assessments calculated to be 1.12 tonne / m^3.

Reforestation activities: biologists selected reforestation areas giving priority to the riparian forests. Reforestation activities achieved 0.15 ha (1,501m^2).

Environmental educational services were extended to 2,125 children.

Safety: Accident frequency indicator: 8.46 (number of accidents per 1 million worked hours).

Air pollution data was evaluated annually with a set of analyses and the analyzed parameters continued to register values which were not detectable or under the low detection level of the equipment.

Technology Transfer:

A transfer of technology has been performed via seminars organized and sponsored by BATTRE. In order to make information related to the operation of 'Salvador da Bahia LFG Project' publicly available, BATTRE and the Federal University of Bahia (UFBA) have jointly developed the website www.solvi.com/battre and www.geoamb.eng.ufba.br. These websites aim to support and improve the transfer of technology and knowledge in the field of biogas capture, destruction and utilization.

1.4. Case study Conclusions – Salvador da Bahia

Of the total projected methane emissions avoided for the year 2009, (56,546,073 Nm^3), 34,027,631 Nm^3 was the total volume of methane emission reductions resulting from the project. Total projected methane emissions avoided for the year 2008 are (53,336,621 Nm^3), with 39,217,833 Nm^3 resulting from the project. The total net emissions reduction for 2009, taking into account leakage, amounted to 472,659 t CO_2e, which also represented a decrease compared to 2008, where the net emissions reduction was 544,764 t CO_2e.

2. Meizhou Landfill Site, China, Case Study 2

2.1. Background: the potentials for landfill gas projects in China

The political situation in The People's Republic of China particularly influences the opportunities for CDM projects in the Chinese market. In Chinese government documents, the objective of the CDM is not so much to get financial assistance for Chinese sustainable development, but to gain advanced technology from the Annex I countries and this is clearly the objective that takes precedence (Wang 2010). The stance towards CDM projects is based on the logic that the emission reduction resource belongs to the state. Therefore, the government collects 'royalty fees' from the revenue of CER transfers. CDM projects developed in what are considered priority areas such as energy efficiency improvements, renewable energy and *methane recovery* pay a 2% fee for their CER revenues, while non-prioritized projects can pay as much as 65% (for HFC destruction.) Hence different market conditions do not prevail. The Chinese government creates a carbon price floor for CER contracts between project owners and international carbon traders which means that project owners will have a minimum CER income with which to overcome potentially high technology transfer costs. The price floor has risen to mitigate the disadvantageous position these project owners have in the international carbon market. Moreover, according to national regulations, only Chinese companies or Chinese holding companies are eligible for CDM projects. This ensures that Chinese companies keep a controlling interest and foreign companies, therefore, merely serve as buyers of CER generated by projects carried out by Chinese firms.

Projects where financing plays a major role and which also need foreign technical assistance (landfill gas projects are a prime example) are therefore hampered by the 51% Chinese ownership role.

2.2. Baseline Scenario prior to Project Commencement

The eight landfills at Meizhou are small and separated from each other and due to this, the government has no plan to install facilities to collect the gas at any of the Meizhou landfills. As Meizhou is one of the poorest mountainous regions in Guangdong Province with just a per capita GDP of 8926 Yuan in 2002 (1008 Euro), compared to other cities such as Guanghzhou with 47053 Yuan (5314 Euro) and Schenzhen with 46388 Yuan (5239 Euro), the government neither has the facility to implement LFG collection, nor sanitary landfill technology at the existing sites. The defined alternatives to the project scenario are that the landfill operator could continue the current business of not collecting, utilizing or flaring gas from his waste operations. Uncontrolled LFG emissions are expected to occur from the landfills until the organic component of MSW is completely decomposed. This is expected to continue for at least 30 years after the site is closed and this is the business–as-usual scenario. As LFG collection is relatively new to China, the related technology for gas collection and power generation shall be imported from advanced countries, so the investment and the cost are very high and investors do not like being involved in the landfill recovery business.

The host Party to this project is China with the operator and project developer being Shenzhen Phascon Technologies Co. Ltd, the Austrian JI / CDM Programme, through Kommunal Kredit Consulting, is the Carbon buyer.

There are eight landfills within the Meizhou LFG Project. The biggest is Longfeng landfill in Meizhou city zone (which had two million tonnes of waste capacity in 2004 and projected current levels for 2010 2.5 million tonnes) and seven smaller ones are situated around the outskirts of Meizhou city in the seven counties of Fengshun, Meixian, Xingning, Wuhua, Jiaoling, Dapu and Pingyuan. Meizhou is located in the northeast corner of Guangdong province in the People's Republic of China. These smaller landfills are dug into valleys and made around 35-50 metres deep, encouraging anaerobic decomposition and making more CH_4 than conventional small landfills, due to the high level of food waste and moisture in the waste (UNFCCC e1).The centre of government for Meizhou is located in the Meijang district. A total of 5 million people live in the city. Prior to the commencement of the project, the eight landfills were filled by bad pollution, nauseous odours, gas emission and leachate water.

Shenzhen Phascon Technologies Co. Ltd (PhasCon) is an energy and environmental company specializing in energy efficiency service, renewable energy and greenhouse gas mitigation issues and a professional project investor for landfill gas recovery and utilization in China. In 2004, PhasCon was granted 30-year contracts by the Meizhou Environment and Administration Bureau, a government agency responsible for waste collection and disposal, to introduce recycling utilization technologies to collect the landfill gas, and explore potential reutilization and treat leachate water by recycling for all the eight landfills at Meizhou. At each landfill site a gas collection system, leachate recycling system, flaring equipment and modular electricity generation plant were installed. The generators combust the methane in the landfill gas to produce electricity for export to the grid. All landfill gas collected during the periods when electricity is not produced will be flared. Total municipal solid waste collected in 2004 by the eight landfills listed as shown below amounts to 1160 tonnes per day. Information received from Meizhou suggests that the waste was increasing at a rate of 9% per annum.

Table 9 below shows waste deposition rates at the eight landfills at Meizhou.

Table 9: Waste Deposition Rates at Meizhou landfills, China. (UNFCCC (e)).

Landfill Name	Start Fill Date	Waste Deposition Rate [tonnes/day in 2004]	Waste in Place [x,10,000 tonnes at 2004]	Designed End Fill Date	Estimated Final Volume [x10,000 tonnes]	Landfill covered area [x 1000m^2]
Longfeng	1985	350	200.0	2010	250	100.0
Xingning	1994	200	82.0	2016	160	133.0
Wuhua	1998	150	25.0	2008	48	20.0
Fengshun	2001	140	15.0	2031	45	100.0
Pingyuan	1995	80	42.0	2015	62	66.0
Jiaoling	2000	80	15.0	2010	33	24.0
Dapu	1993	80	28.0	2015	57	40.0
Meixian	1995	80	25.0	2010	45	108.0
TOTAL		1160	432.0		700	591.0

Landfills

The total annual CERs estimated in the Project Design Document (PDD) is 286,525 t CO_2e. The emission reduction attributable to the replacement of grid electricity by the project activity was not claimed by the project developer in the PDD of the first seven year period.

The first stage work of Meizhou LFG Project for construction of Longfeng Landfill gas recovery and power generation facilities was completed in January 2006 with 46 landfill gas wells. As at 2009, the LFG power generation system is still under trial use with a local power distribution line. The LFG power transmission line was to be shut down during the maintenance period of the rural power distribution line, therefore part of the gas collected at Longfeng was flared.

To calculate emission reductions, the methodology ACM0001 was used.

The methodology states that:

$ER_y = (MD_{project, y} – MD_{reg, y}) * GWP_{CH4}$

(ER_y) is the difference between the actual amount of methane destroyed / combusted during year 'y' ($MD_{project, y}$) and the amount of methane that would have been destroyed during the year in the absence of the project activity ($MD_{reg, y}$) multiplied by the approved global warming potential for methane, GWP_{CH4}.

In cases where $MD_{reg, y}$ is not defined by any regulatory or contractual requirements, an "adjustment factor" (AF) shall be used and justified, taking into account the project context.

$MD_{reg, y} = MD_{project, y} * AF$

There is no Adjustment Factor for the Meizhou Project.

When applying the formula, the following emissions reductions over the chosen crediting period can be obtained:

Table 10: Estimated Reductions over chosen Crediting Period, Meizhou, China. (UNFCCC (e)).

Years	**Annual Estimation of emission reductions (in tonnes of CO_2e)**
Year 2005	51,440
Year 2006	202,119
Year 2007	266,714
Year 2008	330,639
Year 2009	347,946
Year 2010	350,517
Year 2011	344,500
Year 2012	111,800
Total estimated reductions	2,005,675
Total number of first crediting years	7
Annual average over the crediting period of estimated reductions	286,525

From these estimations, a calculation of the CERs is made with a 20% adjustment contingency factor for the project which moderates the rather high (85%) collection system efficiency.

Table 11: Calculation of CERs generated, Meizhou, China. (UNFCCC (e)).

Year	Methane generated (tonnes/year)	CO_2e (tonnes/year)	Collection System Efficiency (85%)	Project Adjustment (Contingency -20%)	Cumulative CERs estimate
2005	3,602	75,642	64,300	51,440	51,440
2006	14,154	297,234	252,650	202,119	253,559
2007	18,677	392,227	333,393	266,714	520,273
2008	23,154	486,234	413,298	330,639	850,912
2009	24,366	511,686	434,933	347,946	1,198,858
2010	24,546	515,466	438,146	350,517	1,549,375
2011	24,125	506,625	430,631	344,500	1,893,875
2012 (1/3)	7,908	164,414	139,750	111,800	2,005,675
			Subtotal First Crediting Period		

			2,005,675		
2012 (2/3)	15,817	332,150	282,327	225,862	225,862
2013	23,442	492,282	418,440	334,752	560,614
2014	23,038	483,798	411,228	328,982	889,596
2015	22,487	472,227	401,393	321,114	1,210,710
2016	21,781	457,401	388,790	311,033	1,521,743
2017	20,720	435,120	369,852	295,882	1,817,625
2018	19,708	413,868	351,788	281,430	2,099,055
2019	18,747	393,687	334,634	267,707	2,366,762
			Subtotal Second Crediting Period 2,366,762		
2020	17,831	374,451	318,283	254,627	254,627
2021	16,965	356,265	302,825	242,260	496,887
2022	16,137	338,877	288,045	230,436	727,323
2023	15,351	322,371	274,402	219,212	946,535
2024	14,600	306,600	260,610	208,488	1,155,023
2025	13,890	291,690	247,936	198,349	1,353,372
2026	13,212	277,452	235,834	188,667	1,542,040
			Subtotal Third Crediting Period 1,542,040		

2.3. Sustainable Development Indicators – Meizhou

Social and environmental Factors:

The main social and environmental impacts of this project will be a positive effect on health and living conditions in the local area. Contaminated leachate and surface run-off from landfills can affect down gradient ground and surface water quality, consequently affecting the environment. PhasCon uses its own patent technology to return the leachate from the bottom of the landfill to the top. The return of this water has two purposes: firstly, it secures the contaminants on the landfill solids by evaporating the water from the recycled stream, the second, is to promote the generation of landfill gas by the addition of water over the waste in place to evenly supply water to the microbes generating methane from the organic content of the waste. Once LFG recovery operations are instituted, more water is removed from the landfill material and the biological process is slowed unless water is returned to the waste in place.

The uncontrolled release of landfill gas can impact heavily on the health of the local environment and population and can lead to risks of explosions at the site. The risk of explosions and danger to environmental health will be reduced and nauseous odours from the site will disappear, benefiting the local population.

The project also has a modest impact on employment in the local area as a body of staff is required to operate the plant. Social benefits include the project acting as a clean energy demonstration project, encouraging less dependence on grid supplied electricity and better management of landfills throughout China. Interestingly, the PhasCon project will play an important role in demonstrating the use of a new financial mechanism for funding in the renewable energy sector (ie. The Clean Development Mechanism.) Other hazards improved by the appropriate management of the landfill sites are dust, odour, pests, vermin, litter and other unsightliness on- or off-site.

Furthermore, noise will be minimized. Although there will be an increase in noise associated with energy recovery, the engines will be housed in a container to reduce emissions. The impact is marginal in comparison with typical noise at a landfill site.

The vacuum pump and gas engine generators will be housed next to the medical waste incinerator so will only marginally change the visual presence at the site.

2.4. Case Study Conclusions – Meizhou

If 2004 figures are taken into account, the Meizhou landfill sites produce 1160 tonnes of waste per day. For the first seven year crediting period this amounts to a total of 2,005,675 CERs estimated. Interestingly, in the second crediting period, the total amount of CERs rises considerably, only to fall to 1,542,040 in the third crediting period.

3. Talia, Israel, Case Study 3

3.1. Background to waste management in Israel

To facilitate waste management, the government of Israel has formulated a policy on integrated waste management. The overall aim is to reduce the amount of waste that the country generates and the amount which reaches landfills without adversely affecting the environment. Landfilling remains the most prevalent method of waste disposal in Israel today accounting for 80% of the waste produced, however the government has set the target to recycle and recover 50% of waste within the next ten years. In 2007, each person generated an average of 1.58 kilograms of waste per day, amounting to 577 kilos per year. This equals 6.9 million tonnes of solid waste per year. Given a particularly high rate of population growth, (higher than most developed countries) rising at some 2% per year, as well as rising standards of living, municipal solid waste has been increasing in the order of 5% annually. The government of Israel published the following statistics for the waste being generated in each of Israel's major cities per day (as at 2006):

1. Jerusalem – 1.26kg/day
2. Tel Aviv – 2.59 kg/day
3. Ramat Gan – 1.68 kg/day
4. Beersheba – 1.75 kg/day
5. Haifa – 1.03 kg/day
6. Eifa – 3.39kg/day

The significant differences in waste generation between the cities will be due to the extent of tourist activity and population levels in each of the towns (hence a city such as Tel Aviv produces twice the amount of waste as does Jerusalem). Other potential influential factors could be garbage collection rates and the city's share of commercial and industrial waste.

A 1993 government decision mandated the closure of the country's unregulated dumps and their replacement by state of the art regional and central landfills. Today, most of the country's waste is disposed in 15 state-of-the-art landfills, located around the country. However, the capacity for landfills today will soon be exhausted. Israeli landfill regulations require that the methane concentration has to remain below 5%. In the business-as-usual scenario these lead to the construction of safety wells that lead the landfill gas out of the landfill body directly into the atmosphere.

Israel adopted a formal energy policy in 1998 that prepared the way for the promotion of renewable energy. In 2002, the government of Israel prepared a formal policy paper on renewable energy (including landfill gas) that gives a sound legal framework for renewable energy projects. The policy does not provide sufficient financial incentives to implement the projects and, therefore funding through the CDM is a key to enhancing revenues to make landfill gas recovery commercially viable.

3.2. Baseline Scenario prior to Project Implementation

The project baseline is the emission of uncontrolled and unlimited release of landfill gas into the atmosphere. The site was closed in 1999. Currently, there are two complementary activities reducing greenhouse gases in the project: collection and controlled combustion of landfill gas, converting CH_4 into CO_2 and therefore reducing its greenhouse effect; and using landfill gas as an alternative fuel. The expected operational lifetime of the project is 21 years.

Methane Combustion & Electricity Generation

The purpose of the project is to extract landfill gas from an existing landfill and use its methane content for energy production. The project is located in the Jordan Valley near the agricultural community Menahamia. The Talia landfill site was established in 1977 by 5 municipal authorities. The site was closed on 31.12.1999. Two complementary activities reduce greenhouse gases in the project: firstly collection and controlled combustion of landfill gas, converting CH_4 into CO_2 and secondly, utilizing landfill gas as an alternative fuel. The power is then delivered to the national grid where it replaces power generated from fossil fuels. The project baseline or 'business as usual scenario' is the uncontrolled and unlimited release of CH_4 into the atmosphere.

The baseline methodology used is ACM0001 ver.4 'Consolidated baseline methodology for landfill gas project activities.'

Emission reduction per year:

$ER_y = (MD_{project,\,y} - MD_{reg,\,y}) * GWP\ CH_4 + EG_{,\,y} * CEF_{electricity}$

(Where '$EG_{,\,y}$' is the electricity generated per year minus the electricity consumed per year and '$CEF_{electricity}$' is the CO_2 emissions intensity of the electricity displaced – measured in tonnes of CO_2 equivalents per megawatt hour.)

Methane destroyed per year due to regulatory requirements is calculated as follows:

$MD_{reg,\,y} = MD_{project,\,y} * AF$ (in this case AF = zero, as there are no regulatory requirements in Israel (as at 2005)). The methane destroyed per year is expressed as:

$MD_{project,\,y} = MD_{flared,\,y} + MD_{electricity,y}$

The total greenhouse gas emission reduction from electricity production will be:

$CO_{2\ avoided,y} = EGy * CEF_{electricity}$

The following table shows the calculated energy potential of Talia to 2020.

Table 12: Deposited waste and calculated energy potential to 2020, Talia Israel. (UNFCCC (g)).

Year	Deposited Waste to Landfill [tonnes/year]	Collection Efficiency [%]	Produced Gas Quantity [1000 m^3/year]	Collectable Gas Quantity 1000 m^3/year]	Energy Potential of LFG [GWh]
2009	300,000	0	0	00	0
2010	300,000	0	103.72	0	0.0
2011	300,000	50	201.61	100.8	12.1
2012	300,000	60	294.01	176.41	33.3
2013	300,000	70	381.31	266.99	65.3
2014	300,000	70	463.85	324.69	104.2
2015	300,000	70	541.65	379.11	149.7
2016	300,000	70	615.06	430.61	201.3
2017	300,000	70	684.45	477.89	258.8
2018	300,000	70	749.83	524.84	321.7
2019	300,000	70	738.51	568.31	389.9
2020	300,000	70	870.00	609.22	462.9

Direct emissions are avoided due to methane combustion:

Due to the anaerobic conditions present within the landfill, the biogenic fraction of the waste is digested by microorganisms and methane and CO_2 is created. The methane is constantly pressed outwards until it leaves the landfill body to the atmosphere. The project envisages collecting a large part of the methane by a system of landfill gas wells and collection tubes. With the energy of the blower the landfill gas is drawn inside the system and either combusted to CO_2 within the generator facility or within a flare. Without the project, the total amount of methane would be emitted to the atmosphere.

There is **indirect emission reduction** due to displacement of fossil fuel-based electricity generation. The renewable energy produced by the project replaces conventional produced electric power in the national grid which is primarily served by fossil fuel-based power plants.

The estimated emissions reductions over the chosen crediting period are shown in Table 13.

Table 13: Estimated Emissions Reductions to 2013, Talia, Israel. (UNFCCC (g)).

Year	Annual estimation of emissions reductions (t CO_2e)
2007	69,314
2008	66,364
2009	63,353
2010	60,523
2011	74,492
2012	84,427
2013	97,011
Total estimated reductions (tonnes of CO_2e)	515,484
Total number of crediting years	7+7+7
Annual average over the crediting period of estimated reductions	**73,640**

3.3. Sustainable Development Indicators - Talia

Environmental Impacts

Air: the air quality will be considerably increased due to controlled combustion of landfill gas instead of uncontrolled emission. In addition, the operation of the plant will reduce the possibility of fires on the landfill due to better observation. The flare is especially adopted for the combustion of landfill gas and complies with the air pollution requirements in Israel.

There is minimal impact on biodiversity due to the construction of landfill gas wells and a tube system. After the construction is finished, conditions for wildlife will be improved due to reduced methane emissions. Due to the operation of the flare, birds and insects could be attracted to the flare and perish. It has to be taken into consideration to build extra shields on the flare to prevent both light emission and birds coming too close.

Noise: the operation of blowers, engine and flare will produce considerable noise. However noise pollution should not be a problem given there are no nearby settlements.

Social issues and Safety:

The plant will create 2-3 jobs and then up to a permanent 15 jobs. Odours will also be reduced.

Due to the regular observation of the landfill the likelihood of fires will be reduced and therefore the emission of especially harmful products of uncontrolled combustion. The employees of the landfill gas plants will also receive suitable immunizations.

3.4. Case study Conclusions – Talia

The case study of the landfill gas project in Israel shows that the annual average over the crediting period of estimated reductions came to 73,640 t CO_2e. The estimated reduction for the period is 515,484 tonnes of CO_2. Deposited waste for each year is 300,000 with which projections for 2020 come to 462.9 GWh of energy potential.

2. Critical Evaluation of Landfill Gas Projects

1. Calculating a benchmark for annual tonnes of Carbon Dioxide Equivalent (t CO_2e)

As has previously been discussed, the disparity within both the projects and within the relevant information available means that a clear-cut cross comparison will rely on several critical assumptions. However, the three case studies taken from the Austrian JI/CDM programme enable an insight into landfill gas projects without regional bias, but taking into account regional differences affecting the operational modus of the projects. As there is no comparison available to compare projected emissions and actual emissions for the second and third case studies (Meizhou, China and Talia, Israel respectively), this section will calculate a total amount of reductions realistically expected from these projects, courtesy of a toolkit provided by the World Bank Carbon Finance Unit, (hereinafter the 'toolkit').

With this instrument, emissions reductions coming from projects with an installed landfill gas capture system can be estimated. This study will not be needed for Salvador da Bahia landfill, given that with the data available for this case study it was possible to compare projected emissions with actual emissions achieved.

Calculations using the toolkit are made based on the length of the crediting period, the landfill gas collection efficiency and waste composition, as well as energy generated in the case that electricity is produced from the project.[13] Waste composition plays a significant role in the decay process given that different types of waste decay at differing rates. Already in 1977, Rovers et al. suggested that food and garden wastes decompose within 1-5 years, paper has an intermediate rate of breakdown between 5 and 20 years and the non-lignin fraction of wood may last 20-100 years. However, faster rates have been calculated since then (Bingemer 1997).

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[13] However given that a number of assumptions are made, an error margin of up to 20% should be expected compared with approved methodologies. (siteresources.worldbank.org/.../Simplified_LFG_flaring_toolkit_v2.xls)

Notably Bingemer (1997) writes that paper is the main organic component of waste in the developed world. As will become evident below, food waste is still the largest fraction of organic waste in the *developing* world, meaning the municipal solid waste of the developing world has a higher percentage of rapidly degrading waste. This difference between developed and developing world is even more acute where tropical climates are concerned (which are by far more predominant in the developing world). Here default methane generation rates are higher due to the fact that all waste decays significantly faster in moist and tropical climates, as Table 14 below shows.

Table 14: Decay rate for the waste type j. (UNFCCC/CCNUCC (i)).

Waste type j		**Boreal and Temperate (MAT≤20°C)**		**Tropical (MAT>20°C)**	
		Dry (MAP/PET <1)	Wet (MAP/PET >1)	Dry (MAP< 1000mm)	Wet (MAP> 1000mm)
Slowly degrading	Pulp, paper, cardboard (other than sludge), textiles	0.04	0.06	0.045	0.07
	Wood, wood products and straw	0.02	0.03	0.025	0.035
Moderately degrading	Other (non-food) organic garden and park waste	0.05	0.10	0.065	0.17
Rapidly degrading	Food, food waste, sewage sludge, beverages and tobacco	0.06	0.185	0.085	0.40

NB: MAT – mean annual temperature, MAP – Mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration

In the same document an assumption for a universal fraction of organic content in MSW is given, by waste type, taken originally from the IPCC 2006 Guidelines for National Greenhouse Gas Inventories (adapted from Volume 5, Tables 2.4 and 2.5).

Table 15: Fraction of degradable organic carbon (by weight) in waste type j. (UNFCCC/CCNUCC (i)).

Waste type j	**DOCj (% Wet waste)**	**DOCj (% dry waste)**
Wood and wood products	43	50
Pulp, paper and cardboard	40	44
Food, food waste, beverages and tobacco (other than sludge)	15	38
Textiles	24	30
Garden, yard and park waste	20	49
Glass, plastic, metal and other inert waste	0	0

1.1. Meizhou, China

For the projects in Meizhou, China, the waste composition percentages for East Asia can be extracted from the toolkit, and are given in Table 16.

Table 16: Waste Composition Figures for East Asia. (Source: World Bank, Carbon Finance Unit).

Type of Waste	% of Waste
Wood and wood products	3.5
Pulp, paper and cardboard (other than sludge)	18.8
Food waste, beverages and sewage sludge	26.2
Textiles	3.5
Garden, yard and park waste	0.0

If we aim to work out the fraction of organic carbon content with the formula advised by the 1996 IPCC guidelines, the result is as follows:

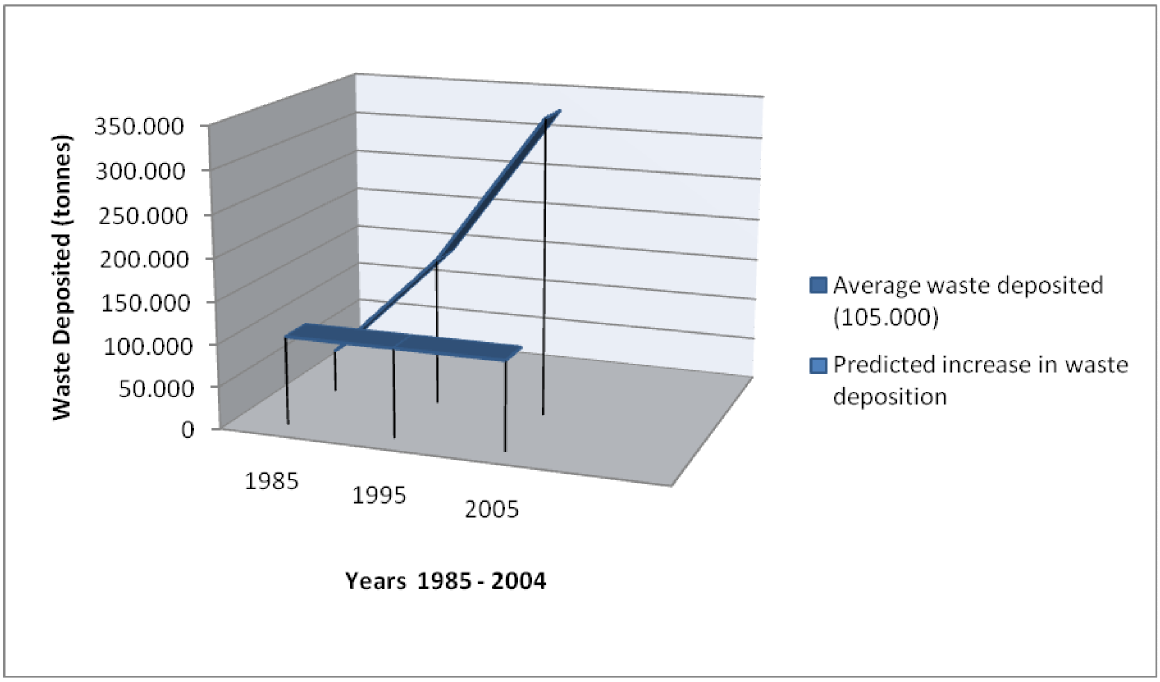
DOC = (0.4 x A) + (0.16 x B) + (0.3 x C)

DOC = (0.4 x 0.223) + (0.16 x 0.262) + (0.3 x 0.035) = 0.142

DOC = 0.142 Gg carbon per Gg waste

In the case of Meizhou, there are eight individual landfills in the area to be taken into consideration. At 2004, 4,320,000 tonnes of waste were present at Meizhou from the eight different landfills, the oldest originating back to 1985, the most recent only back to 2001.

The oldest landfill of the eight, Longfeng, has been in existence since 1985 and collected a total of 2 million tonnes of waste over the course of 19 years. As the graph below shows, the average disposal rate for this period is 105,000 over the course of the 19 years, however if we were to factor in an exponential growth rate for waste deposition, this would range from approximately 50.000 tonnes in 1985 to 350.000 tonnes in 2004.



Graph 4: Waste Deposition rate at Longfeng landfill, Meizhou, China 1985-2004. (Source: Author).

The crediting period began from the end of 2005 onwards (the first whole year being 2006) and, as stated in the results, this allowed annual emission reductions to be estimated through to 2012. While waste deposition data for these years is not available, if we take the liberty to assume similar waste deposition rates for 2005 as for 2004 *at all landfills*, we can compare the 51,440 tCO_2e of emissions reductions estimated from that year with a benchmark figure from the toolkit's calculations.

The table below aggregates the annual waste deposition rates for each of the landfills, both for the period prior to 2004 and for the crediting period from the end of 2005 onwards, for which the 2004 deposition rate is held constant for the years until the end of the crediting period 2012, or the end fill date of the landfill if this is sooner. Finally, the annual average emission reductions are totalled, as are the average annual project emissions to give a figure for all of the Meizhou landfills combined.

Table 17: Average annual deposition rates and estimated annual emissions reductions for the eight landfills in Meizhou, China. (Source: Author).

Landfill	Start fill date (SFD)	Daily Waste Deposition rate in 2004 x 365 (tonnes / year)	Average annual amount deposited from SFD – 2004 (tonnes)	Average annual amount deposited 2005 – end fill date* (tonnes)	Average annual emissions reduction as per toolkit (t CO_2e)	Average annual project emissions (baseline emissions- project emissions) as per toolkit (t CO_2e)
Longfeng	1985	127,750	105,263	127,750	**31,157**	3,462
Xingning	1994	73,000	82,000	73,000	**16,850**	1,872
Wuhua	1998	54,750	35,714	54,750	**6,216**	691
Fengshun	2001	51,500	37,500	51,500	**5,349**	691
Pingyuan	1995	29,200	42,000	29,200	**7,701**	856
Jiaoling	2000	29,200	37,500	29,200	**4,659**	518
Dapu	1993	29,200	23,333	29,200	**5,519**	613
Meixian	1995	29,200	25,000	29,200	**37,670**	4,186
	TOTAL	**423,800**			**115,121**	121,98

*** = In a number of cases the end fill date is prior to the end of the crediting period (for the individual end fill dates, please refer to Table 9 of this chapter).**

The table shows firstly, the yearly waste disposal rate of all combined landfills if we are to assume 2004 deposition rates. Secondly, the average annual emission reductions combined, give an idea of the combined potential of all landfills. At 115,121 t CO_2e however, this is still significantly lower than the annual average of emission reductions over the crediting period as given in Table 10 of this chapter, estimated at 286,525 t CO_2e.

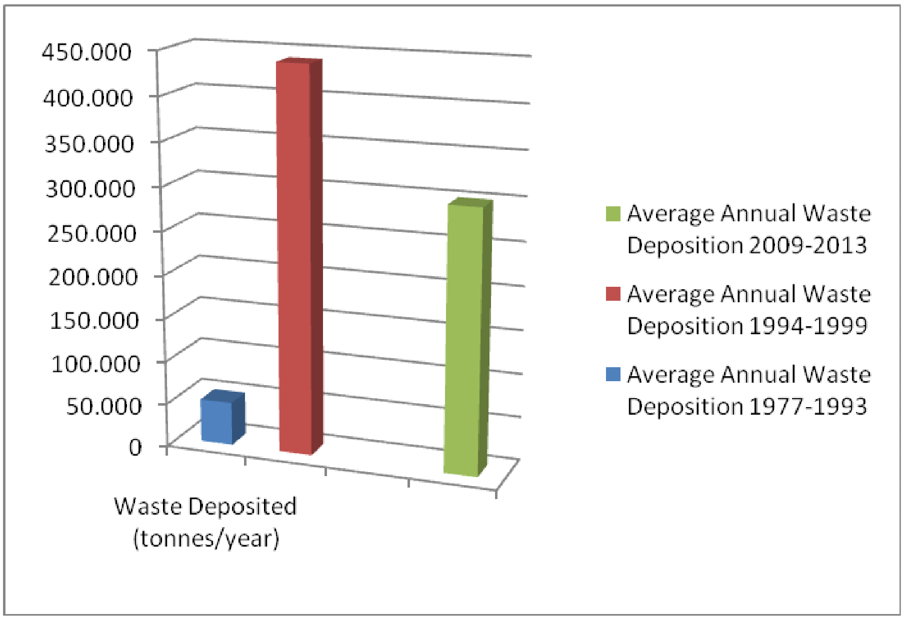
1.2. Talia, Israel

The results of the Talia landfill, Israel, similarly to those of the Meizhou landfills, make future predictions of methane generated based on a deposition rate of 300,000 tonnes of waste per year starting from 2009 with an upward trend in the quantity collected and also the gas produced and the potential energy yield from this, as shown in Table 12 of this chapter.

For the project at Talia, Israel, the amount of waste deposited is available for 1978 – 1999 which totalled 2,800,600 tonnes of waste. The landfill is planned to be reopened as of 2009 in order to generate electricity from the landfill gas. The methane for this will in fact come from the Hagal landfill, south of Talia. The landfill gas will come by pipeline to Talia for joint utilisation of the landfill gas.

Data is also available for 2009 up to 2024 in order to predict future gas availability, 300.000 tonnes of waste will be generated annually from 2009 onwards. However, 2007 is the start of the crediting period for which no waste deposition figure is available. If we multiply the annual 300 000 x 5 for 2009-2013 (the crediting period) we reach 1,500,000 tonnes.

Using the toolkit, we can put in an annual average for the period 1977-1993 for which the total was 800,000 tonnes. Divided by 16 this gives an annual average of 50,000 tonnes. For the period 1994-1999, 2,200,000 tonnes of waste were deposited giving an annual average of 440,000 tonnes. For the period 2009-2013, 300,000 tonnes of waste are estimated to be produced annually. The graph below shows the average annual waste deposition figure for the three periods during which waste was deposited at Talia.



Graph 5: Average Annual Waste Deposition at Talia, Israel for the years 1977-1993, 1994-1999 and 2009-2013. (Source: Author).

The waste deposition figures for Israel, based on averages for Western Asia and the Middle East given by the World Bank, are as follows:

A: Paper / Cardboard and textiles – 18.0% + 2.9% (0.209)

B: Food: 41.1% (0.41)

C: Wood: 9.8% (0.098)

Again, to work out the fraction of organic carbon content, we can assume the following:

DOC = (0.4 x A) + (0.16 x B) + (0.3 x C)

DOC = (0.4 x 0.209) + (0.16 x 0.41) + (0.3 x 0.098) = 0.179

DOC = 0.179 Gg carbon / Gg waste

Using the given data, the toolkit produces the following results:

Average Annual emissions reduction: **54,463 t CO_2e**

Average Annual Baseline emissions: 60,515 t CO_2e

Average Annual Project emissions: 6,051 t CO_2e

The average annual emissions reduction is somewhat lower than the average estimated for the crediting period by the project operators (73,646 tonnes). However, it is not very much below the lowest annual estimate for the crediting period which is 60,523 in 2010.

Furthermore, a concession is made for the fact that the arid environment and 'imperfect technology of deposing waste' will mean actual reductions are lower than estimated ones. The latter are still somewhat optimistic however, especially given that for the second and third crediting periods, emissions reductions of over 100,000 tonnes are expected to be possible, due to future delivery of waste and expansion of the system.[14]

2. Results of Sustainable Development Indicators in Comparison

The Sustainable Development Indicators of all three case studies show positive steps towards fulfilling the objective of the Clean Development Mechanism, however they differ significantly in scale and nature. In the case of the Salvador da Bahia project the aid was formalized into a commitment to spend 5% of income made by operator BATTRE from the sale of CERs on activities that would benefit the community, environment, and economy. This initiative supports the argument that LFG projects are not simply end-of-pipe solutions, but provide sustainable development benefits for the community, as well as working towards better conditions of sanitary landfills in a country where open dumping is in many areas still the norm. Steps such as providing environmental education for children were similar in 2008 and 2009 and progressively improved as well as reforestation. It should not

[14] (See PDD Talia, p.6 – UNFCCC (g).)

be ignored however that accidents did occur as a result of landfill operation, with 8 deaths occurring in 2008 and 5 in 2009.

The sustainable development benefits of the Meizhou landfills are less quantifiable and the main benefits detracted are that the project will have positive effects on the health of the surrounding inhabitants and on the surrounding environment. However, little is done beyond the logical benefits gained directly from improving waste deposition at a landfill which are noise and pest reduction as well as a decrease in odours. The mentioned fact that the project will serve as a worthy example for general waste management trends in China is certainly important in serving an example to other regions with potential landfill gas extraction potential, however this is rather a consequence of the project than an actively pursued sustainable development benefit.

Again, the sustainable development indicators of the project at Talia, Israel are rather more ‘passive’ than ‘active’ with 2-3 jobs created by the plant. Furthermore, a reduction of odours was achieved, as was increased air quality.

Overall therefore, the latter two projects offer no more in terms of sustainable development benefits than those proceeding in any case from the project which unfortunately supports the criticism that end-of-pipe technologies offer little in the way of additional socio-economic development or environmental benefits for the surrounding community and environment. However, the Brazilian project shows that additional steps such as educational activities for children can be financed through the initiative of the operator to donate a percentage of profits. It might therefore be fair to say, that while improved waste management should be a natural consequence of CDM landfill gas extraction and reutilization activities, there is further potential for exploiting other potential avenues for sustainable development.

VI Conclusions and Summary

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1. Project conclusions

A review of the projects has allowed a comparison of trends in waste deposition and methane generated from this, as well as assessing the credibility of estimation for future CERs to be generated. A critical evaluation of the three case studies showed that even with the toolkit used for calculations for the latter two case studies, it was difficult to make a direct assessment to suggest ‘real’ CER outcomes of the Salvador da Bahia, Meizhou and Talia projects. However, with the data available and the figures calculated with the toolkit, it is possible to conclude that all three project scenarios for future CER generation are probably too optimistic. While the model used in this study to calculate emissions reductions was simplistic and allowed margin for error, the methodologies used for each CDM project also allow a significant margin for error, given that individual project influences (such as the particularly arid environment discussed in the project in Israel) need to be taken into consideration.

For both the Meizhou and the Talia projects, the amount of CERs estimated through the World Bank toolkit were significantly lower than estimated in the project scenario. This may of course be because in the critical evaluation, constant waste deposition was assumed for the last two case studies, where individual annual waste deposition data was not available. However, the Brazil case study estimated an annual increase of 20,000 tonnes for the future crediting period, which together with an extremely high efficiency level (despite the 20% correction factor which meant that efficiency levels still remained at 60%), projected tonnes of CO_2 emissions, which even for the year 2004 at 564,310 tonnes, remained still higher than the amounts calculated from *actual* project emissions.

We can therefore conclude, that calculations based on the methodology tools and over-optimistic efficiency levels in particular, mean that CO_2 reduction levels and hence CER production levels are far higher than the actual reductions eventually achieved by a project. Such a conclusion therefore supports criticism that end-of-pipe solutions such as landfill gas projects produce an excess of CERs (given that due to the difficulty of measuring methane emissions and therefore tonnes of CO_2 equivalents coming directly from a project *precisely*, operators *must* rely on the models and methodologies available). The larger quantities of CERs coming from this type of CDM projects inevitably could further dominate the market and lower the overall cost of CERs. This has occurred to the extent that landfill gas projects have risen in popularity, while there have been complaints from the local community that due to the CDM, landfills have been kept in operation far longer than would in fact have been necessary (Ellis et al. 2007[15]).

What could be a possible solution? The inherent problem lies in the 'estimated' nature of the calculations applied. The number of CERs attributed to a project is based on calculations made by according to standardized methodologies not prepared for regional disparities, and on calculations made well in advance of any actual emissions reductions achieved by the project. A solution would be to set the estimated targets and then follow up directly with empirical data of methane recovery from recent years (e.g. methane extracted from the project during the last five years). By basing the future five years on those just past, projects would ensure that emissions reductions achieved are real and additional and relevant to the project: projecting emissions 10, 20 years in advance or even more, simply distances estimates from *real*, achievable targets.

Therefore, to return to the initial research questions, there is an apparent conflict between producing CERs in abundance and achieving these as a result of real genuine emissions reductions. Furthermore, seeking only to produce CERs from the project endangers the realisation of the second objective of the CDM, which is for projects to lead to sustainable development. The Salvador da Bahia project showed, that additional effort on the part of the private sector operator, can lead to additional sustainable development benefits. Furthermore, as previously discussed, these are a prerequisite stipulated in the information required by the additional questionnaire from the Austrian Ministry of Environment. However, the lack of more general evidence of the original dual objective to the CDM leads to the apparent imbalance between creating a so-called 'win-win' situation for buyers and for the developing country communities. Firstly, an impediment to sustainable development within communities may be that sustainable development benefits are defined locally by the DOEs in the respective countries and in this sense there is no international

[15] Ellis et al. 2007 (p24) make the point that while LFG projects create cheap emissions reductions, they can in some cases face opposition from the local communities who are opposed to the extension of the life of the sites as was the case at a LFG project in Durban, Australia.

‘benchmark’ to define success as we have with the CER ‘common currency.’ However, it is clear that in being provided with an opportunity to purchase CERs at relatively little cost (hence increasing supply beyond demand), buyers are focusing on this type of project (and so therefore are the project operators) in order to achieve low-cost emissions reductions, without regard for the sustainable development dimension.

Finally, it is clear that Ellis’ comment (Ellis et al. 2007) may certainly be refuted now that national CDM/JI programmes ‘have not resulted in much project development.’ The Austrian JI/CDM programme has since its conception in 2003 taken on a broad portfolio of projects of which landfill gas projects constitute a majority, based on Memoranda of Understanding completed with several countries, providing a platform for political cooperation as well as merely economic incentive. However, based on the conclusions made in the critical evaluation, it is not possible to support the hypothesis that these projects bring *significant, additional* benefits in terms of CERs and sustainable development.

It would naturally require further studies to consider the case of Austria in parallel to other existing programmes supporting landfill gas projects. However, the conclusion can be drawn, that embedding CDM projects within an official national programme can streamline this activity with a country’s development policy. However, perhaps more crucially, it must be concluded that there is a problem with over-estimation of CERs which is central to *all* CDM projects of this type.

2. Commentary on suggestions for post-2012 frameworks

There has been general consensus that there is a need to look ahead as to how the CDM will evolve in coming years. As well as the impetus given to the subject at Copenhagen, CDM practitioners have at various international conferences made reference to the cumbersome procedures of the CDM and made clear that the CDM is no longer sufficient as an offset mechanism.[16] The disappointment of Copenhagen is evident given that there was hope for what might have at least been a substantial political agreement; however the resulting ‘Copenhagen Accord’ is at

[16] Reference here is made to the Austrian JI/CDM Workshop held in Vienna 27-29 January 2010.

best a non-binding political declaration. The EU was most active in pushing for proposed CDM reform prior to the summit and at the Conference. The US, theoretically supportive of a multilateral framework, did not prioritize creating a market for CERs by means of a trading scheme and hence follow in the European Union's footsteps. Practitioners have been keen to highlight the practical problems in implementing the CDM, notably that each project operator wishes to extract the *maximum* CERs out of the portfolio. The market created by the CDM has shaped itself as demanding high numbers of CERs, which then naturally lose value as supply drowns demand in an unbalanced market.

CH_4 reduction is one of the project types subject to this specific criticism and LFG projects have been highlighted in particular. Projects can take up to one year to move from validation to registration, and from registration to issuance, waste projects take the longest time. Furthermore, monitoring is a key challenge. Landfill gas projects do not allow for an easy quantification of the amount of waste disposed and the resulting methane which can be avoided.[17] While the density and type of waste must be taken into account, LFG appear to become more problematic, the more effort is made to quantify or reutilize the methane extracted to create electricity for example. This is because *additionality* (the key aim in every CDM project) is most easily proven if projects just flare landfill gas. While LFG projects are easily registered and a popular project type, only 50% of registered projects get to the issuance stage and 50% is also the average volume delivery from projects at the issuance stage. The problem therefore lies in proceeding past the issuance stage. The hurdles of a bureaucratic CDM are still a significant obstacle to the realization of projects and project operators hope that in view of the fact that Copenhagen failed to provide significant improvements to the existing mechanism, or a replacement, there will be further progress at the COP16 in Cancun in November 2010.

3. Potentials for alternative types of waste management project?

As initially stated, Annex I countries were responsible for 24 million tonnes of CH_4 emissions in 1990. However in the year 2008, these emissions had been reduced to about 20 million tonnes. This is due to recycling initiatives and other treatments as

[17] Independent CDM consultant cited at conference of Austrian JI/CDM Programme January 2010.

well as to increased implementation of landfill gas extraction and recovery systems.[18] The question therefore remains, which alternative treatments could be transferred from the north to the global south *as well as* landfill gas extraction and recovery facilities? Alternatives to landfill gas include anaerobic digestion of MSW from which the resulting biogas can then be tapped, as well as separating the waste prior to dumping in order to separate the organic matter which can be composted. The example of composting is elaborated upon below.

3.1. Considering alternatives: Composting

While landfill gas projects are by far the leading type of waste management project under the mechanism, the CDM has progressively included new methodologies for procedures such as the composting of municipal solid waste in order to fully utilize and exploit the potential to recycle the different fractions of MSW. Using the composting method means, that rather than simply combusting waste or the resulting emissions, waste can be rendered a marketable substance. As the Revised Framework Directive (Directive 2008/98/EC) imposed by the European Union, states, waste ceases to be waste when:

'(*a*) *the substance or object is commonly used for a specific purpose*

(b) a market or demand exists for such a substance or object

(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and

(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."[19] (Directive 2008/98/EC, Article 6).

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[18] See Froiland Jensen J.E., Pipatti R. Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Background Paper – CH_4 Emissions from Solid Waste Disposal http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_1_CH4_Solid_Waste.pdf (accessed 15/05/2010)

[19] See 2008/98/EC Directive 2008/98/EC of the European Parliament and the Council of 19th November 2008 on waste and repealing certain Directives for further specifications.

For example, a project of this type is being carried out in Urumqi, China. The project aims to avoid CH_4 emissions by not sending all the fractions of waste to landfill. It highlights the following 'sustainable development' benefits: the project will dispose of 219,000 tonnes of MSW by composting, 'a harmless treatment' and thus improve local living conditions by not sending the waste to landfill. Furthermore, compared to landfill treatment and other MSW treatment alternatives, it will reduce land occupation and pollution emission. Additionally, the project will produce manure to be sold, and given this project is 'a first-of-its-kind' in its region, it will be promoted regionally, even nationally, within China. The MSW is separated into inorganic matter, organic matter, recyclable material and combustible material. The organic matter is composted to manure for market and the inorganic matter (ash, stone, and slag) as well as the composting waste is then transported to landfill.

The benefits of composting projects in comparison to landfill gas extraction projects have been highlighted for the African continent. Africa continues to be regionally underrepresented by the Clean Development Mechanism and projects with new methodologies have been slow to commence given the caution of funders towards Africa and the bureaucracy of the CDM process. It is in particular the waste of urban areas that goes straight to landfill and with an urban population of 0.4 billion people, GHG emissions from landfill result in 66 M t CO_2e per year (Couth R., Trois C., (2010)). In their paper, Couth and Trois propose that if all landfills in Africa were able, with LFG extraction systems, to capture and combust 50% of the gas emissions, then GHGs from LFG could be reduced to around 33 M t CO_2e. In comparison, composting schemes would effectively increase the capture rate to *100*%, by pre-treating biogenic waste prior to landfill which can then be used as a soil improver or organic fertilizer. Furthermore, the *sustainable development* benefits in relation to landfill gas projects are greater. Firstly, the environmental benefits would be greater in avoiding any land contamination, leachate production and potential hazardous air emissions. Secondly, the economic benefits would be greater with a greater CDM income. Thirdly, the social benefits would be greater with an increased number of jobs in the local community and reduced health risks to the neighbouring communities (Couth R., Trois C., (2010)). Nevertheless, in addition to green house gas reductions, composting projects need to be critically evaluated regarding their impact on soil quality (e.g. the dispersion of heavy metals contained in MSW into the soil).

Given the high fraction of organic waste in developing country landfills, this could certainly be a viable alternative to landfill gas projects for communities, both in providing income through the manure generated and limiting methane emissions. Moreover, perhaps most importantly, public awareness is raised, that by improving the management of MSW, not only is health protected and odours eliminated, but communities are given the opportunity to develop *sustainably.* This means that producing compost from biogenic waste for vegetation, their waste can be recycled, so not to leave it, and its harmful effects on the environment, on the shoulders of future generations.

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