LANDFILL GAS CDM PROJECTS: CURRENT TRENDS AND FUTURE OPPORTUNITIES FOR DEVELOPING COUNTRIES

C. LEE*, J. BOGNER**, AND A. TOEFY°

** LEE INTERNATIONAL, Westbrook, Maine, USA*
*** LANDFILLS +, INC., Wheaton, Illinois, USA*
° MALLINICKS ATTORNEYS, Cape Town, South Africa

SUMMARY: The Clean Development Mechanism (CDM) of the Kyoto Protocol operates on the premise that the atmosphere is a well-mixed global system, and a reduction in greenhouse gas (GHG) emissions in one country benefits all countries. It also recognizes the need for investment in sustainable environmentally beneficial projects in the developing world. Through the CDM, industrialized countries with GHG reduction obligations under the Protocol can provide financial support for GHG reduction projects in developing countries. Landfill gas (LFG) CDM projects offer the chance to reduce GHG emissions while upgrading landfill management practices using revenue generated by the sale of emission reductions. However, based on recent past experiences in the international marketplace, developers must understand both the challenges and opportunities of LFG CDM projects.

1. BACKGROUND: OVERVIEW OF WORLDWIDE GREENHOUSE GAS EMISSIONS AND THE KYOTO PROTOCOL

There is consensus among the international scientific community that global temperatures are increasing in response to accelerating emissions of greenhouse gases (GHG) to the atmosphere. In particular, CO_2 emissions have increased 130 fold since 1850 and are projected to increase an additional 60% by 2030. In 1992 most countries signed the United Nations Framework Convention on Climate Change (UNFCCC), which provided a framework for future action but did not address mitigation of the problem. In 1997, the Kyoto Protocol was proposed, which imposes a legal requirement on the industrialized countries that are signatories to reduce their greenhouse gas emissions on average by 5% below 1990 levels between 2008 and 2012. The Kyoto Protocol went into force in February 2005 with the inclusion of many large emitters of greenhouse gases—the European Union (EU), Russia, Japan and Canada—in all, 36 industrialized countries that ratified the Treaty have binding targets to reduce emissions; however, developing countries such as China and India do not have binding commitments to reduce GHG emissions. The United States and Australia did not ratify the Protocol. The United States, with only 5% of the globe's population, has contributed 30% of the world's cumulative greenhouse gases since 1850, currently contributes about 25% of worldwide emissions, and has the highest per capita emissions of greenhouse gases in the world. It is anticipated that unless

there is a change in current policies, US emissions will increase by 8% above 2004 levels by 2010, rising to 28% by 2025.

2. THE CLEAN DEVELOPMENT MECHANISM

The Kyoto Protocol is now firmly established and has been an essential tool in encouraging signatory countries to implement policies that will allow them to reduce GHG emissions. It has also helped to keep the world's attention focused on the critical issue of climate change. The reporting required by the Protocol allows us to analyze, for the first time, what is really happening with GHG emissions worldwide. In late October 2006, the UNFCCC summarized current GHG emissions from the industrialized countries that are parties to the Convention showing an upward trend from 2000-2004.

Despite the reported increase, industrialized countries that are signatories to the Kyoto Protocol can still meet their individual emission reduction commitments if they use the Protocol's flexibility mechanisms, including the CDM. Because the Protocol operates on the premise that the atmosphere is a well-mixed global system, a reduction in greenhouse gas emissions in one country benefits all countries. The Protocol also recognizes the need for investment in sustainable, environmentally beneficial projects in the developing world. The Report indicates that greenhouse gas emissions for developed countries in 2004 were 3.3% below 1990 levels. This decrease includes a 36.8% decrease for parties to the Kyoto Protocol. Overall among Kyoto signatories, in the period from 1990-2004, emissions decreased in 22 countries and increased in 19 countries. There were substantial differences among different countries and sectors. For example, emissions increased more than 76% in Turkey but decreased by more than 60% in Lithuania. The greatest increase in sectoral emissions was for transport—up 24%, including a 52% increase from fuels for international aviation.

The CDM is an enabling mechanism under the Kyoto Protocol through which buyers in industrialized countries can invest in sustainable projects in developing countries, purchase the Certified Emission Reductions (CERs) from these projects, and use the reductions to meet their compliance obligations under the Kyoto Protocol. While the number of CDM projects in the world has increased each year since the Protocol came into force, the clear conclusions one must draw from the data published by the UNFCCC and an analysis of the existing projects in the CDM project pipeline and projects already registered, is the industrialized countries can significantly ramp up their efforts to reduce greenhouse gas emissions and meet their compliance obligations through the Clean Development Mechanism. Using Certified Emission Reductions from CDM projects still offers buyers in industrialized countries the most price competitive and low risk option in the market to achieve compliance. It is also clear that certain regions of the world, notably Africa, have lagged behind in the development of CDM projects. Some CDM project sectors have started to attract attention for their failure to deliver projected CERs. Unfortunately, landfill gas CDM projects sometimes fall into this category but in this paper we will identify some of the reasons for this and provide guidance for avoiding some of the most common pitfalls in the development of landfill gas CDM projects. There is still opportunity for landfills in the developing world to take advantage of the revenue that CDM projects provide to upgrade their current waste management practices.

2.1 Clean Development Mechanism Trends

CDM projects can be counted in several ways and it is important to understand what is being counted in order to have a clear picture of trends. They can be counted in terms of how many projects have been proposed (and so appear in the CDM pipeline) from a given country or sector.

They can be counted in terms of how many projects have been registered from a given country and/or sector. They can also be considered in terms of how many CER sales transactions have taken place in a given country and/or sector or in terms of the total volume of CERs sold. It is important to keep in mind that a CDM project can be developed, appear in the CDM project pipeline and even enter into a contract to sell CERs (and thereby be counted as a CDM transaction) long before it requests registration as a CDM project. Before a project can actually deliver CERs, it must be formally registered by the Executive Board (EB) of the Kyoto Protocol. The EB was established in 2001 and among other responsibilities, it reviews and approves or rejects formal methodologies that must be used to establish baselines and quantify emission reductions. The methodology chosen for a project and periodic revisions of it by the EB can have a significant impact on the number of CERs the project ends up generating, especially for landfill gas projects.

Asia currently leads all other regions by supplying 84% of the total volume of CERs sold through September 2006. In 2005, China was selling 73% of the CERs from CDM projects. Brazil sold 11%; the rest of Latin America was at 8%, and India and Africa had 3% each. By the end of 2006, China's market share had been reduced to 60%, in part reflecting the fact that China's development of very large HFC-23 projects had peaked. India's percentage of total CERs sold had increased to 15%, Latin America to 9%, Brazil down to 4%, and Africa had increased to 7%.

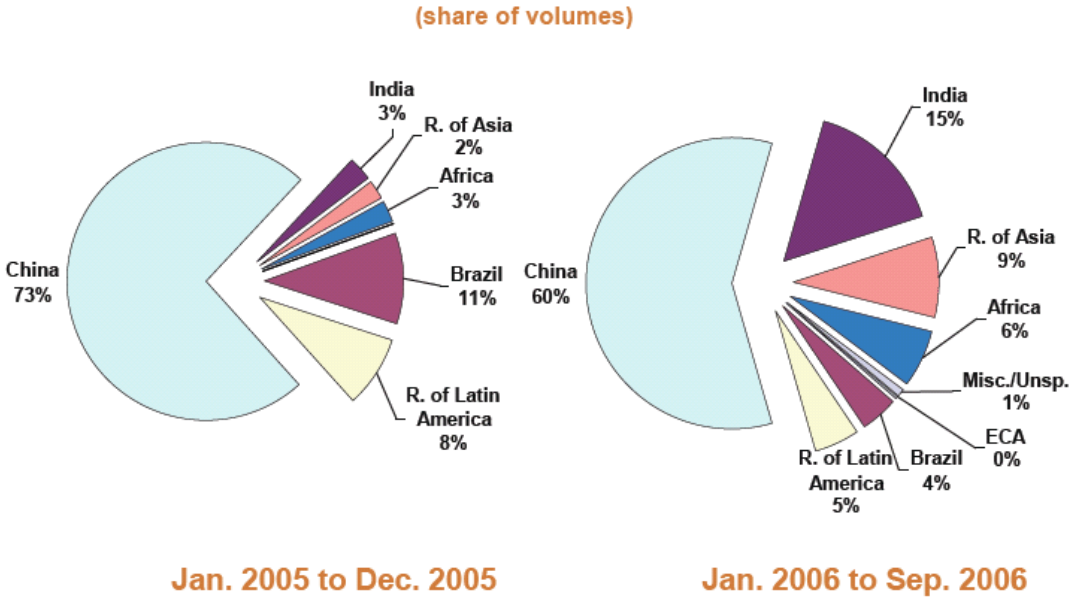

Figure 1. Location of CDM Projects—China and India dominate

A country's market share based on CERs sold is not necessarily reflected in the number of individual CDM projects it hosts. As of April 2007, there were 632 registered CDM projects in the world. India, with only 15% of the CER volume in the market as of September 2006, has by far the largest number of registered projects coming in at 219. Market analysts speculate that some Indian CDM project developers may be registering their projects and holding the CERs to sell later as they believe CER prices will increase. Brazil with only 4% of the volume of CERs sold has 97 registered CDM projects, Mexico has 78, China has 70, Chile has 17, Malaysia has 15 and Honduras has 10, Korea has 12, with South Africa, which has the largest number of registered CDM projects in Africa, at 6.

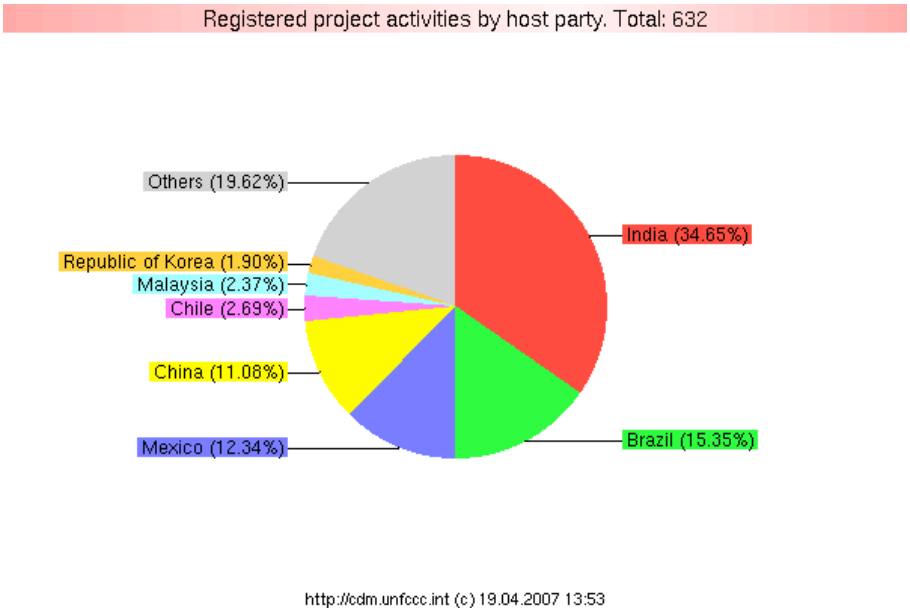

Figure 2. Registered project activities by host party.

2.2 What Sectors are Represented in These CDM Projects?

Of all of the types of CDM projects allowed under the Kyoto Protocol rules, as of the end of 2006, HFC-23 destruction projects were still responsible for more than half of the CERs from registered projects. (This is based on their projections of what they will generate by the end of 2012.) Energy Efficiency and Fuel Switching CDM projects were next at 14%, followed by N_2O projects at 11%. Landfill Gas and wind power projects were tied for fourth with 6% each and other renewable energy projects, animal waste, coal bed methane, hydro and agro-forestry CDM projects came in after that.

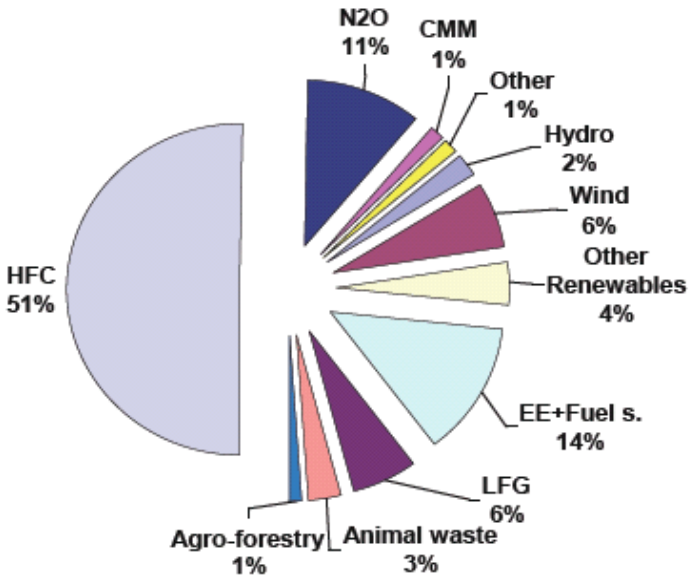

Figure 3. CDM project types—share of volumes of CERs through 2006.

2.3 Who's Buying the CERs?

The World Bank reports that trade in CERs and Emissions Reduction Units (ERUs) which come from Joint Implementation projects has increased by over 4000% since 2001 and is still growing. There have been and continue to be different types of buyers in the market and their characteristics have changed over the past 5 years. We have learned from experience that it can be critical for a seller to understand the differences between the buyers who are out there today. There are compliance buyers who buy to be assured they will meet their compliance obligations in 2012. There are government buyers who want to be certain to have enough credits to cover their emission targets without relying entirely on individual businesses that are busy trying to reduce their emissions or buy emission reductions. There has been a virtual explosion of funds controlled by financial institutions, brokerage houses, and private equity firms that buy CERs either for resale and/or on behalf of country governments or other contributors to their funds who are worried about having sufficient emission reductions to meet their compliance obligations. These buyers have different expectations and varying abilities to pay high prices depending on their goals—compliance or money making and on the funds requirements and restrictions. Some funds have established portfolios of CERs from a wide range of types of CDM projects offering guaranteed CERs to their fund participants rather than CERs from one specific project. Sellers can choose buyers based on a buyer's appetite for risk, willingness to provide advance payment, equity, a high CER price and many other factors. Recent experience has confirmed that buyers in the EU, Japan and the US are clearly competing with each other to purchase CERs from diverse CDM sectors around the world with Africa remaining a high priority.

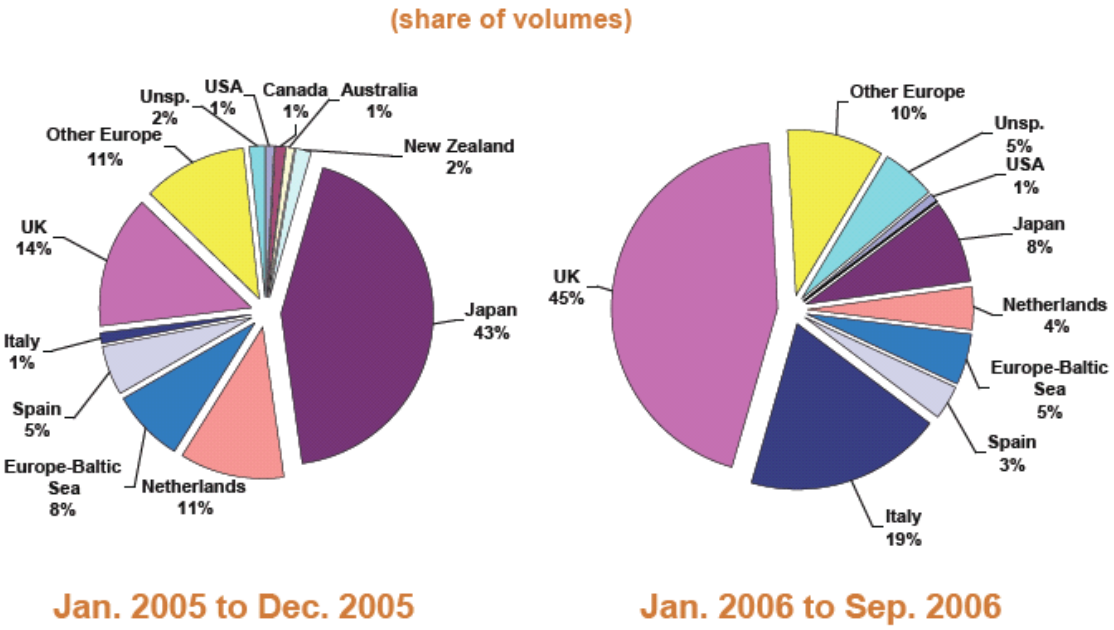

Figure 4. Who's Buying.

In 2005, Japan was responsible for purchasing more than 40% of the total volume of CERs. In 2006, European buyers were far more active than Japanese buyers who led the market the previous year, although this situation is expected to change as Japan gets closer to the Kyoto compliance deadline. The Japanese market share dropped to 8% in 2006. The UK, on the other hand, went from buying only14% of the CERs sold in 2005 up to 45% in 2006. The World Bank in its annual State and Trends of the Carbon Market Report of 2006 attributes some of this

growth in the UK's purchases to the fact that many international financial institutions that have entered the carbon market are located in London. They characterize Japanese trades as dominated by large trading houses in 2006 which buy with the intention to resell to compliance buyers in Japan. However, we know from experience that there are still Japanese compliance buyers active in the market and aggressively seeking projects.

There has been a proliferation of interested US buyers in the past year which has also begun to affect the market. Although the World Bank's report shows that US buyers purchased only 1% of the CERs sold in 2006, off the record comments from brokers and fund managers in New York claim that there is growing interest in acquiring CERs on the part of funds originating from the US. This trend is expected to continued as the US moves toward the inevitable adoption of some form of mandatory cap and trade greenhouse gas program that might eventually link to an international system.

2.4 What are Buyers Paying for CERs?

CER prices have fluctuated in the past year but have continued to bear some relation to EU Allowance prices although they are consistently below those prices. The prices being paid for CERs in the primary and secondary markets have increased but they vary depending on project type, contract terms and various other factors. These other factors include, but are not limited to, how far along in the approval/registration process the project is, the creditworthiness of the seller and the buyer, delivery guarantees, the perceived political and regulatory environment in the host country, the perceived stability of the Designated National Authority in the host country which is responsible for certifying the sustainability of a proposed CDM project before it can seek registration from the EB and the presence of advance payment for the CERs.

In 2005 prices paid for CERs ranged from $2.50 to $12.00 per ton with an average price of approximately $7.00 per ton. This was a 37% increase over prices in 2004. The World Bank reports that prices have ranged from $8.30 to more than $31.00 per ton in the first three quarters of 2006. In April/May of 2006, EU Allowance prices plummeted, losing 70% of their value overnight in what many have characterized as a market correction. They have increased again and become more stable. The same is true of CER prices, which fell when EU Allowance prices fell but have come back up and stabilized some. Current prices for CERs as of April 2007 are in the range of $8-15 per ton, again depending on a variety of risk factors. As the end of the first commitment period for the Kyoto Protocol gets closer (2012), trades may slow and prices remain uncertain.

3. LANDFILL GAS CDM PROJECTS: CHALLENGES AND OPPORTUNITIES

There are now 180 registered landfill gas CDM projects out of a total of 632. They are located in the following countries:

Country	No. of Projects
Argentina	5
Armenia	2
Bangladesh	2
Bolivia	1
Brazil	40
Cambodia	1
Chile	11
China	4

Costa Rica	1
Ecuador	4
Egypt, El Salvador, Georgia, Honduras	1 each
India	10
Indonesia	2
Israel	2
Malaysia	9
Mexico	71
Nicaragua, Peru	1 each
Philippines	6
South Africa	1
Tunisia	2

Figure 5 below shows the current distribution of landfill gas CDM projects by country based on their projected average annual generation of CERs. Note that the majority of the CERs are coming from landfill gas projects in just 5 countries: Brazil, Armenia, Chile, Argentina and China, with 8 additional countries: Mexico, Tunisia, El Salvador, Costa Rica, Israel, Bolivia, Bangladesh, and Malaysia having one registered project each.

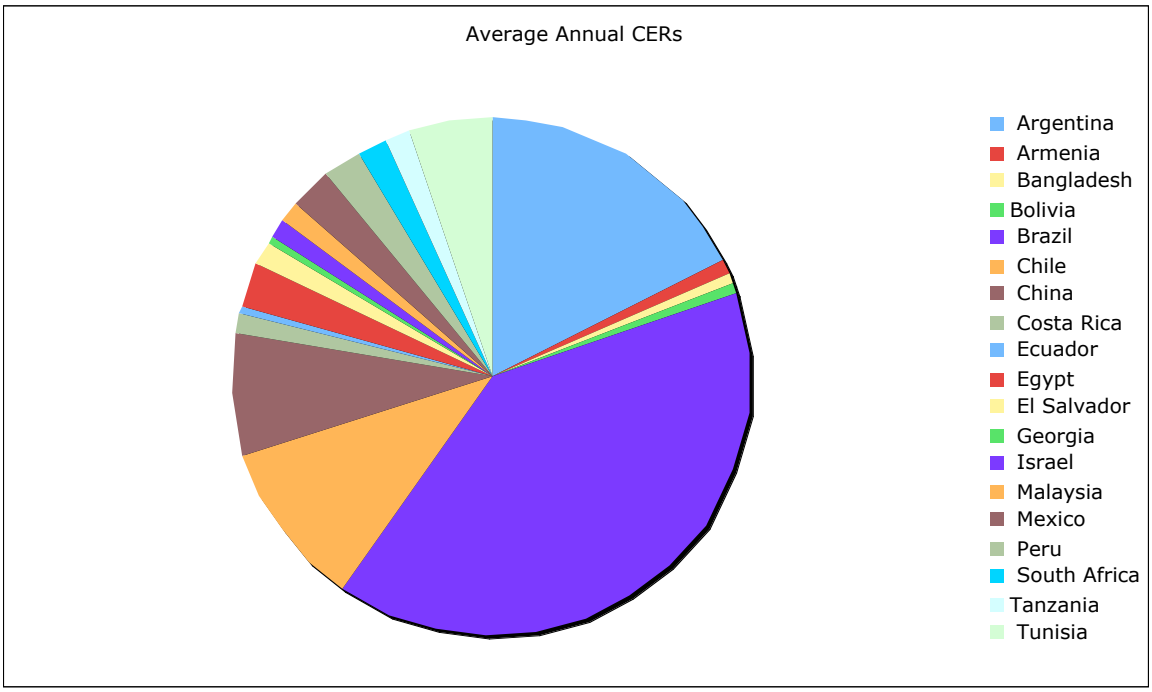

Figure 5. Distribution of Landfill Gas CDM Projects by Country based on Projected Average Annual Generation of CERs as of 20 April 2007

3.1 Projecting and Delivering CERs from Landfill Gas CDM Projects

In recent months, monitoring reports from a number of registered landfill gas CDM projects have documented under-delivery of CERs in comparison to projected delivery. There are several possible reasons for this, including the use of modeling tools that may over-predict expected CERs and operational issues leading to reduced gas recovery. With respect to prediction of CERs, all of the approved methodologies for landfill gas projects rely on a theoretical model to estimate landfill gas generation. The actual CERs produced are monitored using a mass flow meter, the % CH_4 in the gas (v/v), CH_4 destruction in a combustion device (flare, engine, or

turbine). It is important to emphasize that all of the theoretical models assume a well-mixed system with optimum microbial kinetics; therefore, there are often significant differences between preliminary modeling of landfill gas generation based on waste in place and the actual landfill gas generation and recovery. Moreover, because all first order kinetic models are optimized theoretical models, actual site-specific gas generation can vary widely between individual sites with similar quantities of waste in place.

Typically, a number of readily available first order kinetic models are widely used, however, it is important to point out that often these have not been developed specifically for short-term projection of CERs through 2012. For example, the US EPA LandGEM model was primarily developed to bring most of the large US landfills into an air quality regulatory program (under Clean Air Act (CAA) amendments) and extended for regional emission inventories. Typically, the LandGEM model over predicts landfill gas generation when applied to US sites using default values, is not routinely used in the US for site-specific gas generation for landfill gas recovery projects, and is run primarily for regulatory baselines and for risk assessments. It is probably best applied to long-term modeling for worst-case regulatory scenarios because small differences in input values or model parameters can drastically affect shorter-term predictions. When total landfill gas generation is projected over 2-3 decades, these modeling differences would be smaller than for shorter-term projections.

As an example, Figure 6 compares predictions for cumulative 2007-2012 CERs for an African landfill using LandGEM (with CAA defaults) to a customized site-specific multicomponent first order model (based on Van Zanten and Scheepers, 1994). The site-specific model takes into account the waste composition (modeling only the biodegradable fractions); it also takes into account the fraction of the waste in place in any given year which can be welled for gas extraction using either vertical wells or horizontal collectors.

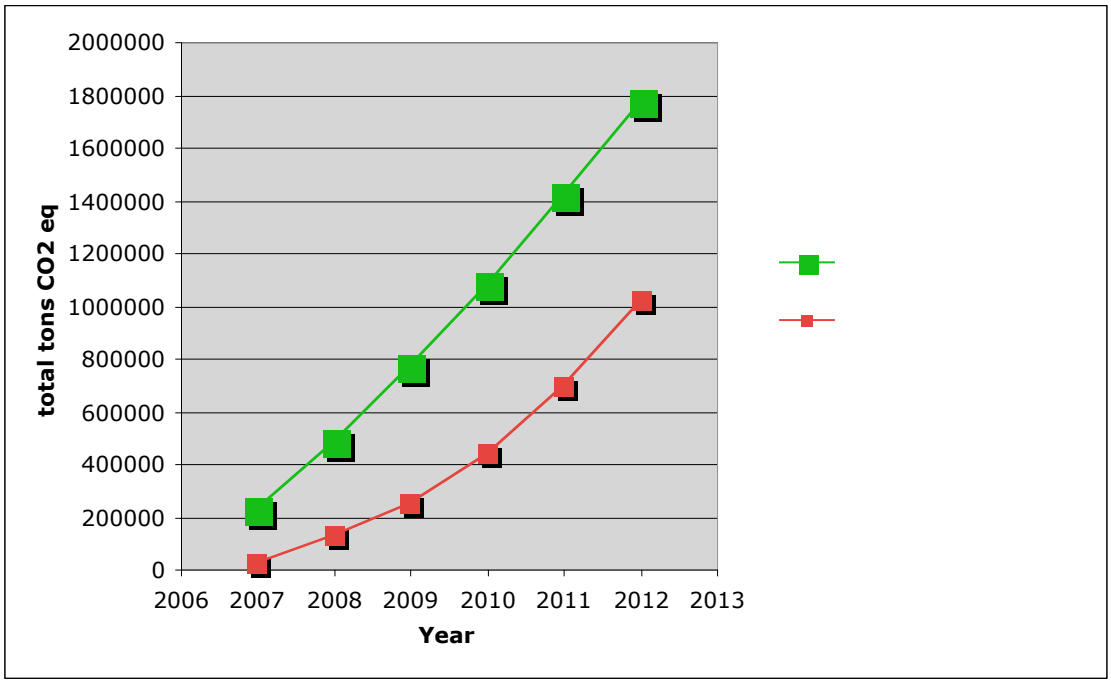

Figure 6. Comparison for an African landfill between LandGEM (using US Clean Air Act regulatory defaults) to multicomponent site specific model (which considers historic waste composition and site operational issues, including waste in place that can be "welled" in specific years using either vertical wells or horizontal collectors).

Note that by 2012, the projected cumulative CERs using LandGEM are almost double those from the site-specific model. Therefore, it is important to validate and fine-tune any theoretical modeling using site-specific landfill gas production. For projects where only the theoretical modeling is used to estimate CERs for contract negotiations, one must add additional conservative assumptions to make the results appropriate for financial commitments.

4. OPERATIONAL, GAS OWNERSHIP, MONITORING AND SUSTAINABILITY/GAS UTILIZATION ISSUES

Operational considerations to achieve optimized landfill gas recovery are also very important, especially in developing countries. Insufficient cover material to prevent air intrusion, piping systems which are poorly maintained, and inadequate condensate knock-outs can greatly reduce sustainable landfill gas recovery.

As the CDM has become better known, landfill owners have begun to realize the value of their LFG asset. It is essential to investigate who owns the gas rights and subsequent CERs early in the assessment of an LFG CDM project at a given landfill site. These issues can often be negotiated and need to be resolved in advance with land owners who are not the landfill operators. If gas/CER ownership issues are not resolved up front, they will surely negatively affect the marketability of the CERs from the project.

The EB has the responsibility to review and approve all methodologies that are used to calculate a CDM project's baseline and anticipated emission reductions. Recently, the EB Methodology Panel, apparently responding to CH_4 projects under-delivering CERs, has started to impose a number of additional monitoring requirements. For example, a new flaring "tool", which is referenced in all of the approved methodologies for LFG projects, will require enclosed flares to monitor pre-and post- combustion for CH_4, CO_2, O_2, N_2, H_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 feasible, is 50%.

Another issue that has presented challenges in some countries is the sustainability review by the host country 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. If a project is required to commit to a certain gas utilization before gas quality and quantity can be confirmed in the field, this can lead to expensive mistakes with respect to gas utilization hardware. We have been successful in reasoning with DNAs that a landfill gas CDM project should be allowed to "flare only" for a period of time in order to confirm gas quality and quantity and identify appropriate local uses, if they exist. Even "flaring only" has clear environmental benefits for reducing greenhouse gas emissions.

In many developing countries, low cost coal is still the primary fuel used to generate electricity. Many countries have begun to debate the value of green energy tariffs, to discuss the development of a renewable energy market, and to implement incentives for renewable power production. However, in countries where the debate is very recent and incentives are not yet in place, it may not be possible to generate electricity on a financially viable basis. Thus, project developers must investigate the current financial feasibility of electricity generation and, in addition, consider the potential impact of renewable energy incentives. In some regions, such as Southern Africa, there is still no meaningful green energy tariff, however, government has readily acknowledged that a power shortage is imminent and expectations are that a green energy tariff will be forthcoming. It is important to know the status of these issues to fully evaluate the CDM potential in a given market.

5. CONCLUSIONS – 2012 IS AROUND THE CORNER

Opportunities for LFG projects under the Kyoto Protocol still exist, and these opportunities are expected to continue beyond 2012, the end of the first Kyoto commitment period. Developers of LFG emission reduction projects are urged to proceed with caution, consider the experiences of existing LFG CDM projects, and avoid costly mistakes as discussed above with respect to prediction and recovery of CERs.

Uncertainty about a post Kyoto system is expected to slow the market for CERs until a post 2012 system has been put in place. However, even in the US, there has been some significant movement toward a mandatory national cap and trade system after a Democratic US Congress was elected in late 2006. There are currently (April 2007) at least 5 proposed legislative bills being debated in Congress, including proposals for the US to enter the global marketplace for GHG emission reductions trading. This could significantly expand the market for CERs or their post 2012 equivalent. In addition, the EU Emissions Trading Scheme has no fixed end date and the EU has recently announced its intention to develop a Phase Three of the Scheme for 2012-2020. Phase Three is expected to require a 20% reduction in CERs by 2020. This announcement has already led to some trading in EU Allowances post 2012. Lastly, the parties to the Kyoto Protocol will begin to negotiate the post-Kyoto mandates and mechanisms at the next meeting of the parties in Bali in December 2007. Experts agree that some form of continued trading and recognition of existing CDM projects is extremely likely to emerge eventually, thereby extending this important opportunity for developing countries. The message is that significant opportunities for LFG CDM projects are likely to extend into future decades.

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