Methane to Markets

Overview of Methane to Markets

Rachel Goldstein (高 睿 智)

U.S. Environmental Protection Agency

Landfill Methane Outreach Program

27 October 2009

Methane to Markets

Agenda

- Methane to Markets Overview
- Landfill Gas to Energy in China

Methane to Markets

What is Methane to Markets?

- International public-private partnership to reduce greenhouse gas emissions by increasing the capture and use of methane.
- Potential to reach 180 $MMTCO_2$ reductions annually by 2015.

OBJECTIVES

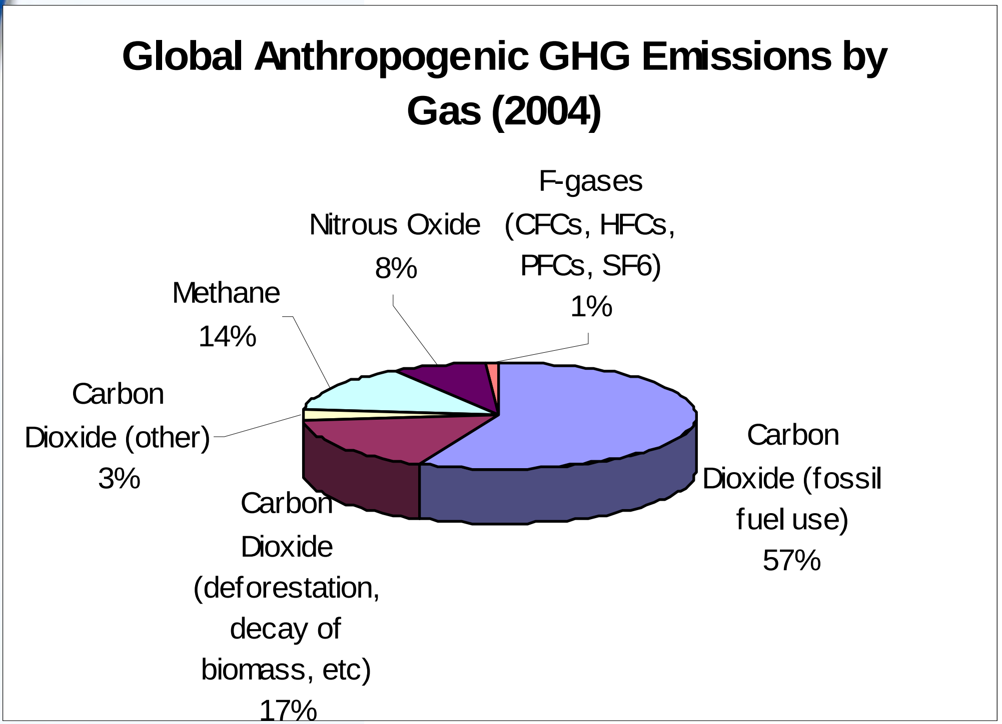
- Advance the recovery and use of methane while:
  - Enhancing economic growth
  - Promoting energy security
  - Improving local air quality and public health.

BENEFITS

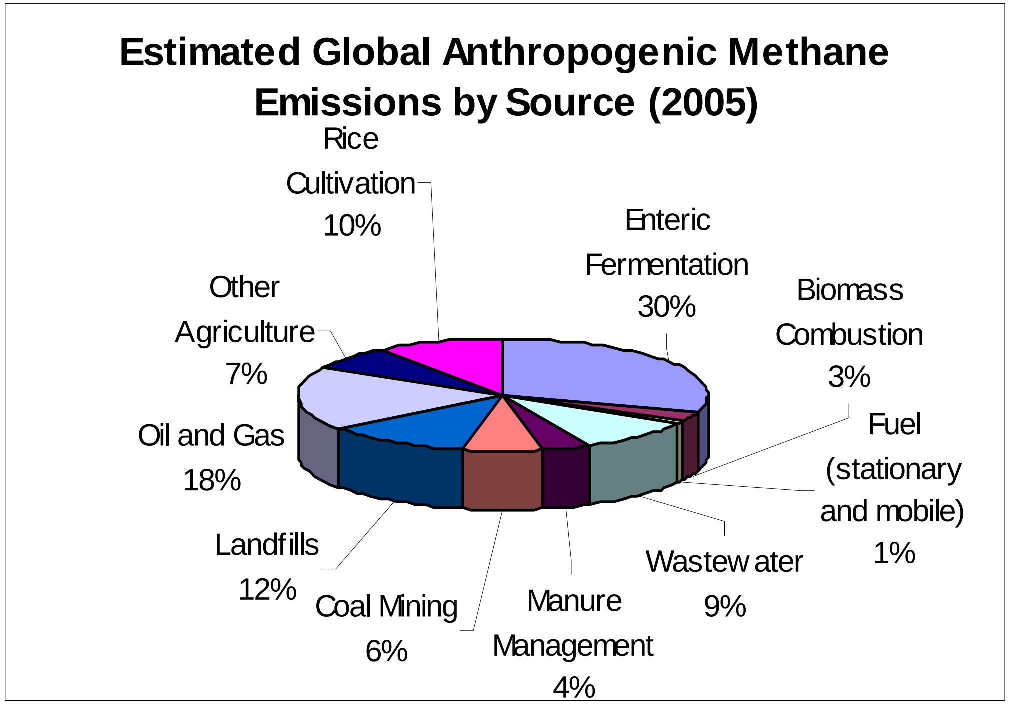
- Stabilization/Decline in Methane Concentrations will result in:
  - Sustainability
  - Energy security
  - Health and safety
  - Profitability

Methane as a Greenhouse Gas

- The 2nd most important GHG, accounting for ~18% of total radiative (climate) forcing, or about one-third of that of CO_2. (IPCC)
- A potent greenhouse gas (GHG) with 100-year global warming potential (GWP) of 23 and atmospheric lifetime of ~12 years



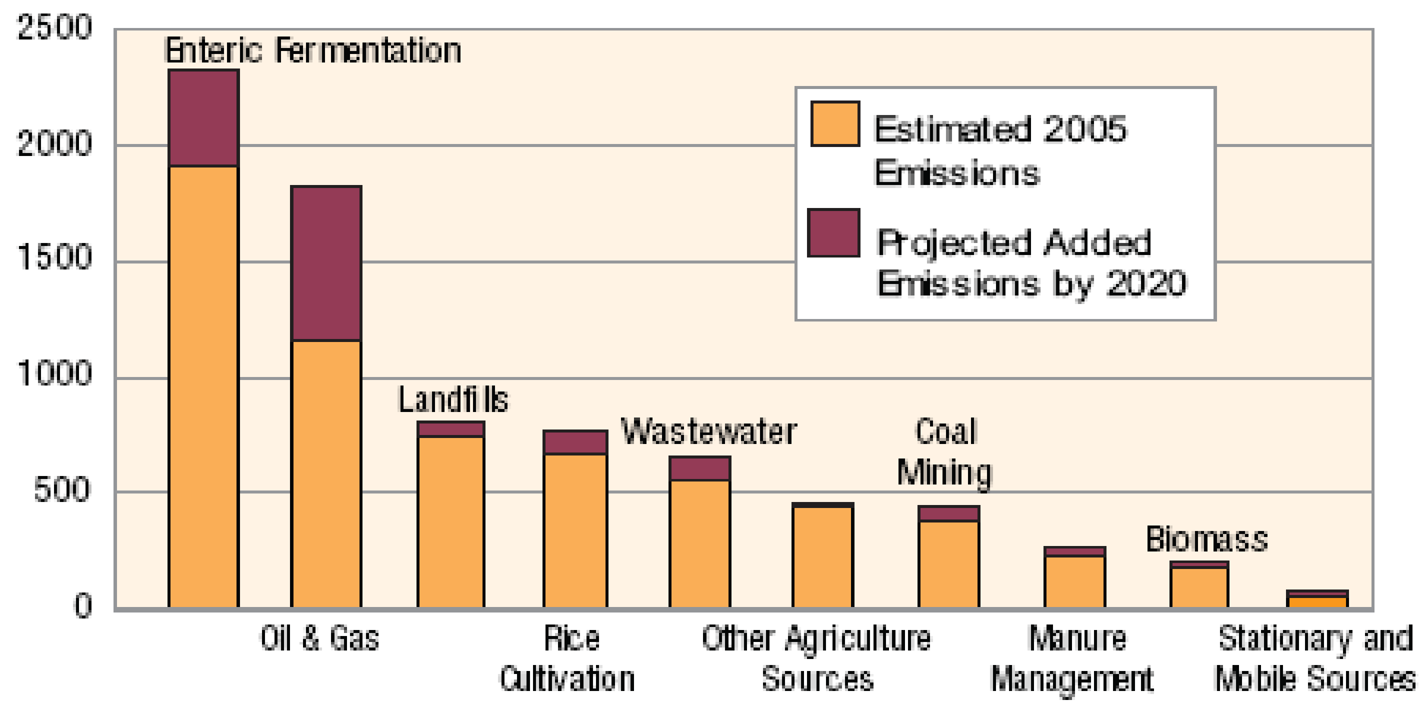
Source: IPCC Assessment Report 4 (2007)



Source: U.S. EPA Report (2006)

Projected Methane Increase to 2020

Global anthropogenic methane emissions are projected to increase by 23 percent to 7,904MMTCO$_2$E by 2020



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M2M Partners

- Grown from 14 to 31 Partner governments
- Represent more than 62% global anthropogenic methane emissions
- 9 of the 10 top methane emitting countries

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Methane to Markets Partnership

- Encourages development of ***cost-effective*** methane recovery and use opportunities in

Coal Mines

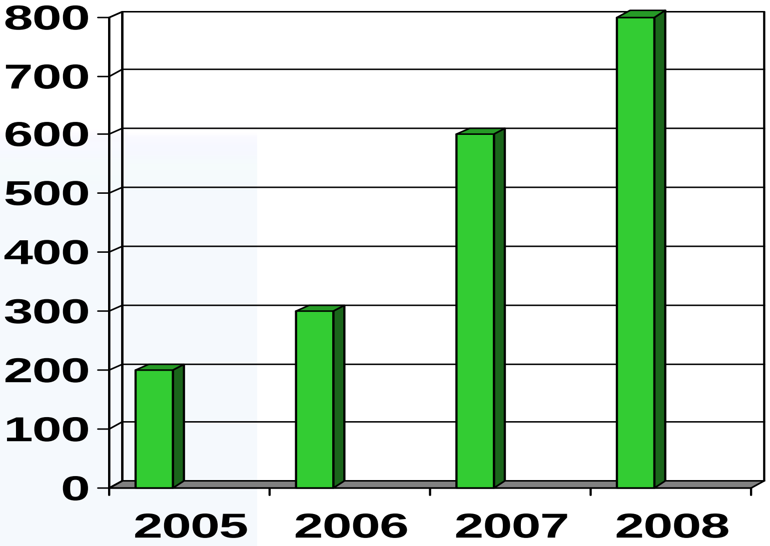
Oil & Gas Systems

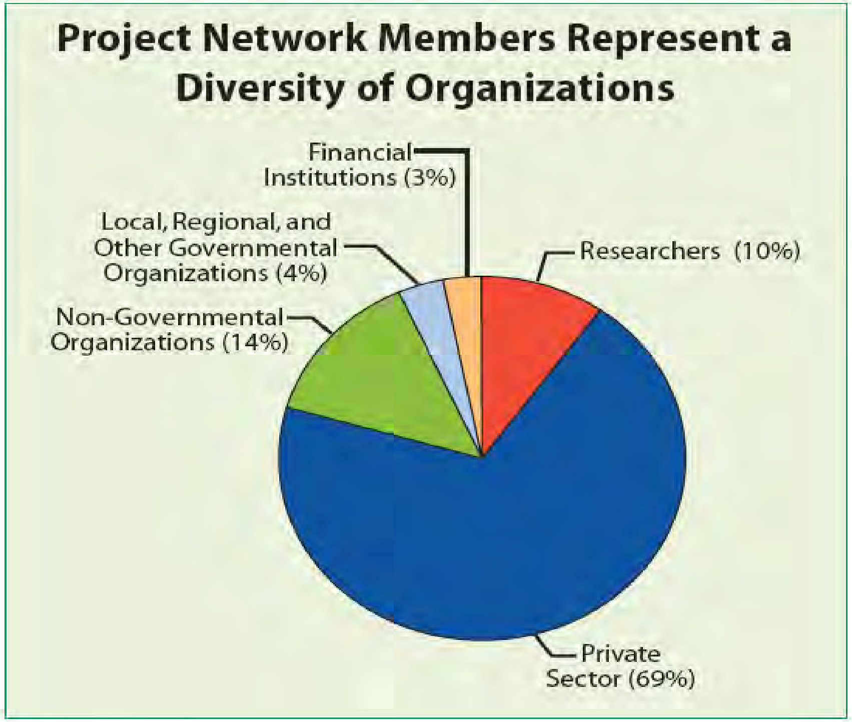
Landfills

Agriculture

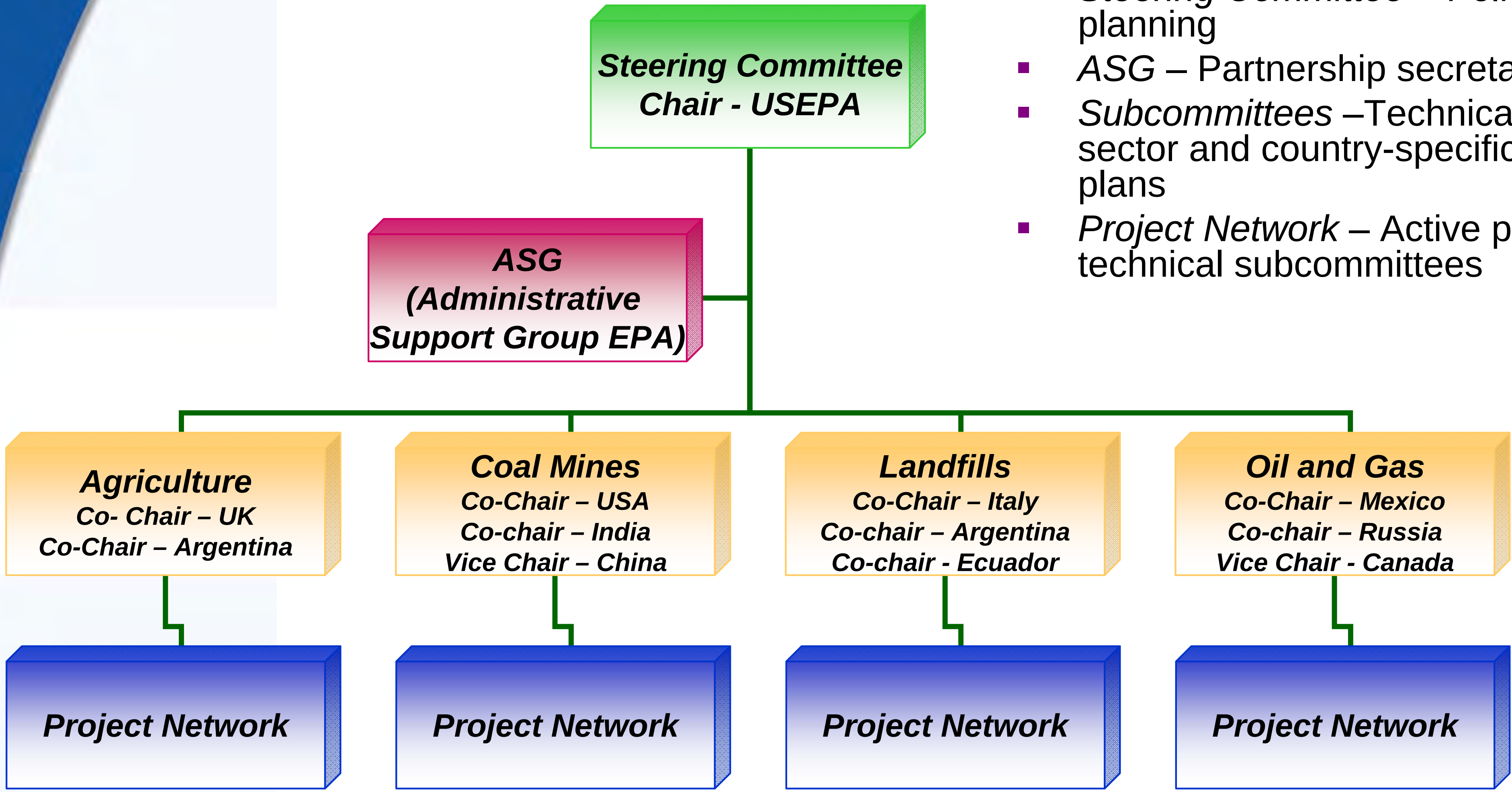
M2M Project Network

- Brings necessary actors together to implement reduction projects
- Over **850** organizations
- Project Network members can:
  - Expand business and increase profits
  - Distinguish themselves in the marketplace
  - Identify financial and technical support for potential projects
  - Build capacity
  - Fulfill strategic goals
  - Mitigate climate change





M2M Partnership Organization



- *Steering Committee* – Policy and planning
- *ASG* – Partnership secretariat
- *Subcommittees* –Technical work, sector and country-specific action plans
- *Project Network* – Active part of technical subcommittees

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Key M2M Accomplishments

- Brought high-level focus specifically on methane
  - Raising awareness within governments of the multiple benefits of methane recovery
  - Demonstrate importance of achieving near-term climate benefits at low cost
- Directly involving the private sector and financing organizations – over 850 in M2M
- Good complement to Kyoto – provides technical assistance and capacity building necessary to ensure long-term project success
- Successful engagement of key developing countries (i.e., Mexico, China, India, Brazil)
- Achieving real reductions – over 91 projects featured at the 2007 M2M Expo in Beijing – potential reductions of 11.5 MMTCO2e

合作机会
Methane to Markets
Partnership Expo
BEIJING, CHINA
30 OCTOBER – 1 NOVEMBER 2007

Global Landfill Methane Emissions Trends

- Industrialized Nations Declining
  - Increased LFG regulation
  - Increased recycling of organics/paper
  - Increased LFG utilization (>1100 worldwide)
- Developing Nations Sharply Increasing
  - Shift from open dumps to sanitary/engineered landfills
  - Increased MSW generation and disposal
  - Lack of LFG regulation and recycling

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Landfill Gas to Energy

- **Project Identification and Assessment**

  EPA has identified and analyzed over ***40 potential landfill gas energy projects*** across the world. These analyses were presented at the 2007 Partnership Expo in Beijing.

- **Tools to Advance LFG Project development**

  EPA is developing a suite of tools that will help landfill owners and operators collect the data they need to determine the feasibility of their sites and market them more efficiently to project developers.

  - Country Specific LFG Recovery Models (Mexico, Ecuador, China, Argentina, Thailand, Philippines)
  - International Landfill Database

- **Training and Capacity Building**

  EPA and its Partners held capacity-building workshops in Brazil, China, Colombia, India, Russia, Ecuador and Turkey. EPA offers technical support and training focused on landfill operations and maintenance, LFG collection systems, gas modeling, and project development

Landfill Sector

- 21 countries are on the Subcommittee, led by chairs from Argentina, Ecuador, and Italy
- 9 countries have developed country specific action plans, and more are being developed.
- More than 300 landfills are now listed in the International Landfill Database.
- M2M held a regional roundtable in November 2008 in conjunction with the International Solid Waste Association's annual meeting in Thailand to discuss regional specific issues in landfill project development.

M2M Landfill Database

http://www.methanetomarkets.com/landfills/#M2M_db


Methane to Markets International Landfill Database

Login: Password: Submit

Help | Forgot your password? | Request an account

The International Landfill Database is an on-line resource to support the Methane to Markets (M2M) Partnership Landfill Gas Technical Subcommittee in its efforts to promote the development of landfill gas energy projects. It serves as a voluntary data reporting tool to amass information critical to project developers, investors, and policy makers. The application is web-based and relies solely on M2M partner countries, its network partners and affiliates to provide landfill specific information.

Country: United States

Login Information

Login: [redacted]@erg.com

Password: ********

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Preliminary Results: From 40 LMOP Landfill Assessments

Country	Number of Landfill Project Sites	Project Life (years)	Average of AnnualAverage Potential Emission Reductions in Metric Tonnes CO_2E	Total Potential Emission Reductions (for 2009 through 2023) in Metric Tonnes CO_2E
Argentina	3	15	1,766,788	39,262
Brazil	11	14	89,793	13,828,134
China	7	15	35,200	3,696,000
Colombia	4	15	293,942	17,636,492
Ecuador	6	15	151,650	11,373,767
India	4	15	54,001	3,240,073
Republic of Korea	3	15	45,123	2,030,516
Mexico	1	15	17,182	257,731
Ukraine	3	15	169,757	5,092,726
Russia	6	15	37,149	3,343,444
TOTALS	**48**		**2,660,585**	**60,538,145**

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Landfill Lessons Learned

- There are serious technical hurdles regarding basic landfill management and landfill gas system O&M that must be overcome in most developing countries.
- Lack of awareness of all LFG uses.
- Contractual disputes (e.g., gas rights) must be addressed.
- M2M Partner Country participation varies widely.
- Political change presents unique challenges.
- Carbon credits are driving almost all projects.

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Why China?

- China is a founding country of the Methane to Markets Partnership
- The population in China is approximately 1,300,000,000
- Estimated refuse generated per person is 0.6-1 lb/day
- Estimated annual waste is between 129,200,000 and 215,400,000 Mg per year
- Estimated methane generation is between 4,800,000 and 13,400,000 m^3/year

U.S. Involvement: China-Landfill Sector

- Hosted the 2007 Methane to Markets Partnership Expo in Beijing
- 11 Chinese landfill opportunities highlighted at the Beijing Expo
- Assessment studies at eight landfills
- Pre-feasibility study at one landfill

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The Future of Methane to Markets

- Terms of Reference up for renewal in 2009/2010
- Growing interest in accelerating global methane efforts due to impacts in the Arctic and near-term benefits (economic-energy-climate) of methane
- Opportunities in expanding scope and commitments
  - New emission sources (wastewater, livestock)
  - New and increased commitments (financial, policies and measures)
  - Enhanced monitoring and reporting
- Possible linkages to a post-2012 agreement
- M2M Steering Committee has developed a process for moving forward
  - ASG seeking input on potential future directions from M2M countries
  - ASG developing white paper assessing different options for moving the Partnership forward
  - Steering committee met in September/October 2009 to discuss future directions

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Possible Sector Expansion

Wastewater

- 9% of global emissions
- Demonstrated capture and use technologies available – consistent with existing M2M charter
- Large potential in Partner countries
- Significant environmental, energy and development co-benefits
- M2M undertaking assessment of potential opportunities

Agriculture

- Rice cultivation and enteric fermentation are large sources of emissions, 10% and 30% respectively
- Requires expanding scope of M2M – beyond capture and use
- Significant potential in developing countries
- M2M has performed an initial assessment and is now conducting further work to identify future role for Partnership in these areas
  - Attended the UNFCCC AWG-LCA
  - Developing recommendations for Steering Committee consideration

Methane to Markets Partnership Expo

New Delhi, India • 2–5 March 2010

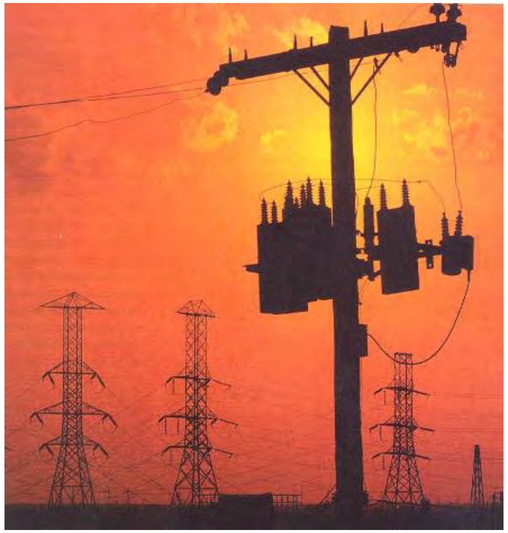
- Premier international forum for promoting methane recovery and use project opportunities and technologies.
- Provides participants with opportunities to:
  - Showcase and learn about methane mitigation projects and technologies.
  - Meet with potential project partners and financiers.
  - Explore key technical, financial, and policy issues.
  - Interact with high-level government agencies from 30 countries.

For more information please visit: www.methanetomarkets.org/expo

For More Information…

www.methanetomarkets.org

- Rachel Goldstein (U.S.EPA)
  - Goldstein.rachel@epa.gov
  - +1.202.343.9391



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Overview of China Landfill Gas Model and Basic Landfill Gas to Energy Project Financing

Jason Leung
Organic Waste Technologies (HK) Limited

27 October 2009

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Methane Basics

- Landfill Gas (LFG) ~ 50% methane gas
- Calorific Value of LFG ~ 18.9 MJ/m^3
- LFG is a Valuable Energy Source
- Emission reductions can be achieved by utilizing LFG as a biofuel or by flaring

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Utilization of LFG

- Landfill Gas – to – Electricity
- Direct Use to provide heat energy / burning fuel
- Other Uses: Vehicle fuel, fuel for leachate evaporation etc.

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Evaluation of LFG Recovery Potential

- Necessary landfill details, including:
  - Waste Composition
  - Waste Inflow Profile
  - Date opened and closed (actual or projected)
  - Waste in place
  - Landfilling Practices
  - Landfill Gas Management
  - Landfill Cover System
  - Surface Water Management
  - Leachate Management

- The above information can be collected conveniently through a landfill questionnaire

Dear Landfill Owner/Operator:

Thank you, for taking the time and effort to provide the following landfill information, which will be useful in evaluating your landfill site for commercially viable gas recovery projects. If space is a constraint, information provided in separate sheets will be welcomed.

Please return the completed Questionnaire through one of the methods:

- Email: info@owthk.com.hk or owten@yahoo.com.cn
- Facsimile: (852) - 2697 2956
- Post: Organic Waste Technologies (HK) Limited, Pik Wan Road, Junction of Lin Tak Road, Lam Tim, Kowloon, Hong Kong

1. GENERAL INFORMATION

1.1 Date of data collection ____________

1.2 Form completed by (name): ____________

1.3 Landfill Name: ____________

1.4 Landfill Address/Location: ____________

1.5 Landfill Contact Person: ____________

1.6 Contact Tel: ________ Fax: ________ Email: ________

1.7 Landfill Status (in operation/ closed) ____________

1.8 Landfill Owner & Person in charge (name / number/ email):

____

1.9 Landfill Operator and Person in charge (name / number / email):

____

____

1.10 What is the approved land use for the site ____________

1.11 Which Bureau approved the land use ____________

1.12 With exception of the landfill operator indicated in Item 1.9, is there any other party working within the landfill site. ☐ Yes ☐ No

If yes, please indicate the name of this party and the nature of their work

1.13 Does the site operate 24 hours a day? (If yes - state number of shifts and shift hours. If no - state work hour, and number of days per week)

____

____

1.14 Site Meteorological Date

a) Average annual precipitation at the landfill: ____________ cm

b) Average winter temperature at the landfill: ____________ C

c) Average summer temperature at the landfill: ____________ C

1.15 Are there any scavenging activities within Landfill? ☐ Yes ☐ No

If yes, please indicate the type of materials that have been recycled

____

2. LANDFILL PHYSICAL DATA

2.1 What type of landfill (sanitary landfill/ pollution control/ open dump)?

____

2.2 What is the landfill's classification in terms of harmless treatment of waste in accordance with CJJ/T107-2005 (Class I, II, III or IV)? ____________

2.3 What is the landfill plan area (i.e. designated area of waste placement)?

____

2.4 What is total landfill waste capacity (cubic meters or Mg)?

____

2.5 Which year did waste filling commence? ____________

2.6 Which year is landfill closure / expected to be closed? ____________

2.7 What is the average waste depth (m) inclosed area ____________

Intermediate covered area ____________ waste tipping area ____________

2.8 Is there any lining system installed at the base of the landfill? ☐ Yes ☐ No

If yes, please indicate type of lining system, ☐ soil ☐ clay ☐ geo-membrane, Thickness of lining ___m

2.9 Is there any lining system installed at the slope side of the landfill? ☐ Yes ☐ No

If yes, please indicate type of lining system, ☐ soil ☐ clay ☐ geo-membrane, Thickness of lining system________m.

Evaluation of LFG Recovery Potential

- Observations and assessment of site operations
  - Review site documents (e.g. waste acceptance logs and LFG monitoring logs)
  - Observe frequency of incoming waste trucks and their waste loads
  - Observe waste composition and waste placement/compaction procedures
  - General observations of the site’s operational practices
  - Sampling of LFG composition

Evaluation of LFG Recovery Potential

- Collection Efficiency:
  - Radius of influence
  - Phasing of LFG system with landfill expansion
  - Area coverage
  - Leachate levels within the landfill
  - Cover conditions
  - Geometry of site (shallow or deep)

- Information above are used to modify the preliminary recovery potential estimation, which was then incorporated into a gas model specific to the landfill

China Landfill Gas Model Version 1.1

Purpose - provide landfill owners, operators, and developers with a realistic tool to evaluate the feasibility and potential benefits of recovering and utilizing LFG for production of energy for various potential end uses.

Available on the web at the following link:

http://www.epa.gov/lmop/international.htm

- Based on USEPA LandGEM and IPCC guidelines
- Excel® spreadsheet - FOD model

China Landfill Gas Model Version 1.1

- Estimates potential LFG generation and recovery potential for existing or future MSW landfills in China
- Estimates available emission reductions
- Provides energy output estimates for either direct use or electrical power generation
- Results assist preliminary financial feasibility analyses

China Landfill Gas Model Version 1.1

- Requires the user to input site-specific data for
  - landfill opening and closure years
  - landfill location (in terms of geographical climate zones)
  - approximate coal ash content of the waste
  - history of landfill fires
  - a number of landfill characteristics that determine collection efficiency
  - waste intake rate

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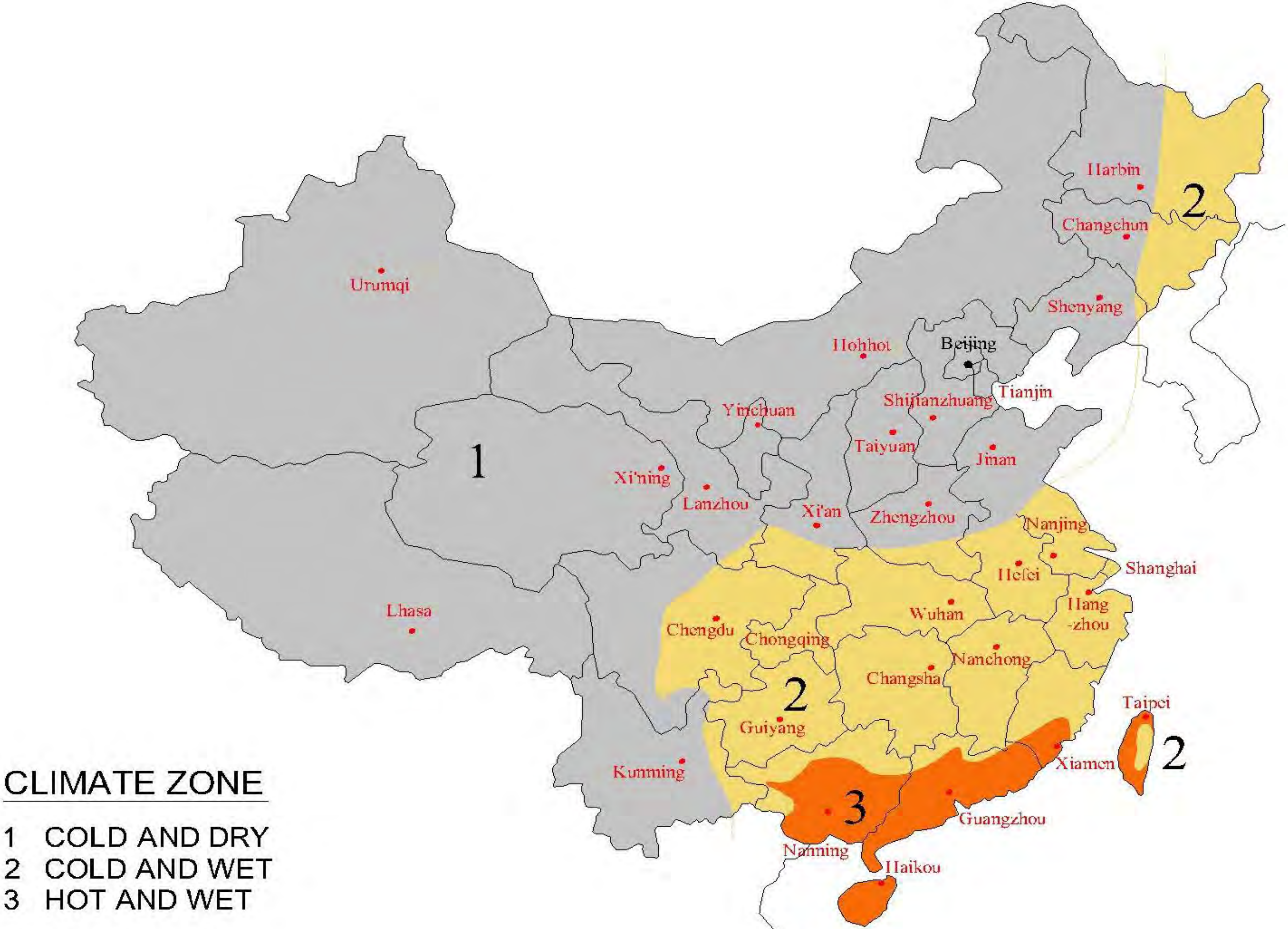
China Landfill Gas Model Version 1.1

- Based on the user's input, the model calculates recommended values for the following parameters:
  - k (Methane Generation Rate)
  - L_0 (Ultimate Methane Generation Potential)
  - Fire Discount Factor
  - Collection Efficiency
- The model estimates LFG generation and recovery rates using waste intake data and either the above model-recommended values for the parameters or user defined values

China Landfill Gas Model Version 1.1

- The recommended values for model parameters were developed using the following data for China
  - Climate regions in China are categorized as “cold or hot” and “dry or wet” (consistent with Table 3.4 in the IPCC 2006 Guidelines)
  - Waste composition from various regions
  - Waste disposal methods and practices
  - Observed landfill operating practices and conditions
- Model allows users to override default parameters


Harbin
2
Changchun
Urumqi
Shenyang
Hohhot
Beijing
Tianjin
Shijianzhuang
Yinchuan
Taiyuan
Jinan
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Xi'ning
Lanzhou
Xi'an
Zhengzhou
Nanjing
Shanghai
Hefei
Hang
-zhou
Wuhan
Lhasa
Chengdu
Chongqing
Nanchong
Changsha
2
Taipei
Guiyang
2
Xiamen
Kunming
3
Guangzhou
Nanning
Haikou
CLIMATE ZONE
1 COLD AND DRY
2 COLD AND WET
3 HOT AND WET

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Methane Generation Rate (k)

- The recommended average k values for the three climatic zones are:

Climatic Zone	k (per year)
Cold and Dry	0.04
Cold and Wet	0.11
Hot and Wet	0.18

Ultimate Methane Generation Potential (L_0)

- The recommended L_0 values for the three climatic zones are:

Climatic Zone	L_0 (m^3/Mg)	
	Coal Ash Content <30% (Non-Coal-Based Landfill)	Coal Ash Content >30% (Coal-Based Landfill)
Cold and Dry	70	35
Cold and Wet	56	28
Hot and Wet	56	42

Fire Discount Factor

- If the user indicates that signs of current or past landfill fires were observed, the model will apply a default fire discount factor (30% reduction) to the LFG recovery estimate

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Collection Efficiency

Collection Efficiency

= (85% - x1 - x2 - x3 - x4 - x5 - x6 - x7) * ACF

Where

- x1 to x7 are discounts based on the landfill's construction and operation characteristics
- ACF, the Area Coverage Factor, is determined by the LFG System Area Coverage Percentage

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Collection Efficiency

No. (i)	Question	Discount x_i (%)	
		Yes	No
1	Is the waste placed in the landfill properly compacted on an ongoing basis?	0	3
2	Does the landfill have a focused tipping area?	0	5
3	Are there leachate seeps appearing along the landfill sideslopes? Or is there ponding of water/leachate on the landfill surface?	10	0

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Collection Efficiency

No. (i)	Question	Discount, % (x_i)	
		Yes	No
4	Is the average depth of waste 10m or greater?	0	10
5	Is any daily or weekly cover material applied to newly deposited waste?	0	10
6	Is any intermediate/final cover applied to areas of the landfill that have reached interim or final grade?	0	5
7	Does the landfill have a geosynthetic or clay liner?	0	5

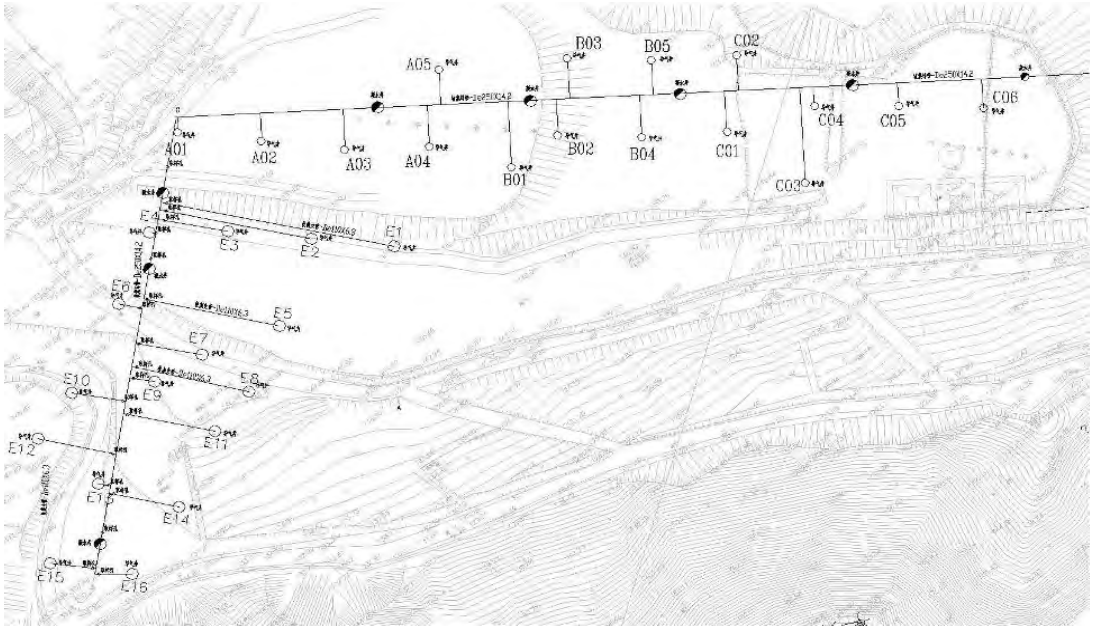
Collection Efficiency


Good / Poor Landfill Cover


Dispersed (large) / Focused Tipping Area

LFG System Area Coverage

- The LFG System Area Coverage Percentage is defined as the percentage of the landfilled area that has a comprehensive and operating LFG collection system.
- Brackets I to V are defined in the table below.
- Area Coverage Factor (ACF) associated with each bracket.



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LFG System Area Coverage Percentage Area Coverage Factor (ACF)

LFG System Area Coverage Percentage	Bracket	Area Coverage Factor (ACF)
80 – 100%	I	0.95
60 – 80%	II	0.75
40 – 60%	III	0.55
20 – 40%	IV	0.35
< 20%	V	0.15

Optional Input

- Optional input:
  - User recommended value for:
    - k
    - L_0
    - Collection efficiency (can vary by year)
    - Supersedes model recommended parameters
    - Input only if reliable data are available
  - Actual measured recovery rate (plotted on output graph only; no calculations performed by model)


China Model V1.1
Methane to Markets
LANDFILL METHANE OUTREACH PROGRAM
China Landfill Gas Model
Version 1.1
March 2009
developed by:
U.S. Environmental Protection Agency
Continue

China Landfill Gas Model (v1.1)

Instructions

Please complete the information in the yellow highlighted cells. This information is the minimum input required for proper model operation.

General Information

Name/Title:	Example Landfill	Edit title at left which feeds into the output table and graph.
Location:	Shenzhen City, Guangdong Province	
Year Opened:	1997	Input year landfill began receiving waste.
Year Closed/Projected to Close:	2010	Input closure year (i.e., the final year in which landfill will receive waste).
Expected Methane Content of LFG:	50%	Please enter the expected methane content of the landfill gas. A value of 50% is recommended unless specific information is available from the site that warrants a different value. This value will be used to calculate the net flow of recovered gas.

Landfill Characteristics:

Region of China where the landfill is located (Identify from the map):	Region 3 (Hot and Wet)
Does coal ash make up a significant fraction (greater than 30%) of the waste placed in the landfill?	No
Are there signs of current or past subsurface fires at the landfill?	No

Show Map of Regions of China

Criteria Determining Collection Efficiency:

1.	Is the waste placed in the landfill properly compacted on an ongoing basis?	Yes
2.	Does the landfill have a focused tipping area?	No
3.	Are there leachate seeps appearing along the landfill sideslopes? Or is there ponding of water/leachate on the landfill surface?	No
4.	Is the average depth of waste 10m or greater?	Yes
5.	Is any daily or weekly cover material applied to newly deposited waste?	Yes
6.	Is any intermediate/final cover applied to areas of the landfill that have reached interim or final grade?	Yes
7.	Does the landfill have a geosynthetic or clay liner?	Yes
8.	In which bracket (I to V) does the LFG System Area Coverage Percentage fall?	II (60 - 80%)

See user's manual for assistance in answering the above questions or for instructions on how to enter a user-specified or default collection efficiency

Modeling Parameters

Based on your inputs, the model will use the "model recommended" values below to estimate the gas potential of the landfill. If you have reliable data that suggest a different value should be used, you may enter it under the user recommended value and it will be used to generate the gas

	Model Recommended Value	User Recommended Value
k (1/yr)	0.18	
L_0 (m^3/metric tonne)	56	50
Collection Efficiency	60%	
Fire Discount Factor	None	Cannot Be Changed

Annual Landfill Activity Data

Input into column 2 the landfill's annual waste acceptance rate. The model recommended or user recommended collection efficiencies have been entered into column 4. You may change these if you have better data for any given year. If the landfill has a gas collection system in place and has measured actual gas recovery for given years, these data may be entered into column 5 (do not enter zeros).

1	2	3	4	5
Year	Disposal Rate (metric tonnes/yr)	Waste-in-Place (metric tonnes)	LFG Collection System Efficiency	Actual Measured Recovery (m^3/hr)
1997	18,000	18,000	0%	
1998	563,774	581,774	0%	
1999	654,106	1,235,880	0%	
2000	712,521	1,948,401	0%	
2001	841,719	2,790,120	0%	
2002	1,047,886	3,838,006	0%	
2003	1,126,419	4,964,425	0%	
2004	1,161,308	6,125,733	0%	
2005	1,265,079	7,390,812	0%	
2006	1,277,500	8,668,312	30%	
2007	1,277,500	9,945,812	40%	
2008	1,380,000	11,325,812	40%	
2009	1,380,000	12,705,812	60%	
2010	1,380,000	14,085,812	65%	
2011	0	14,085,812	65%	
2012	0	14,085,812	65%	
2013	0	14,085,812	65%	
2014	0	14,085,812	65%	
2015	0	14,085,812	65%	

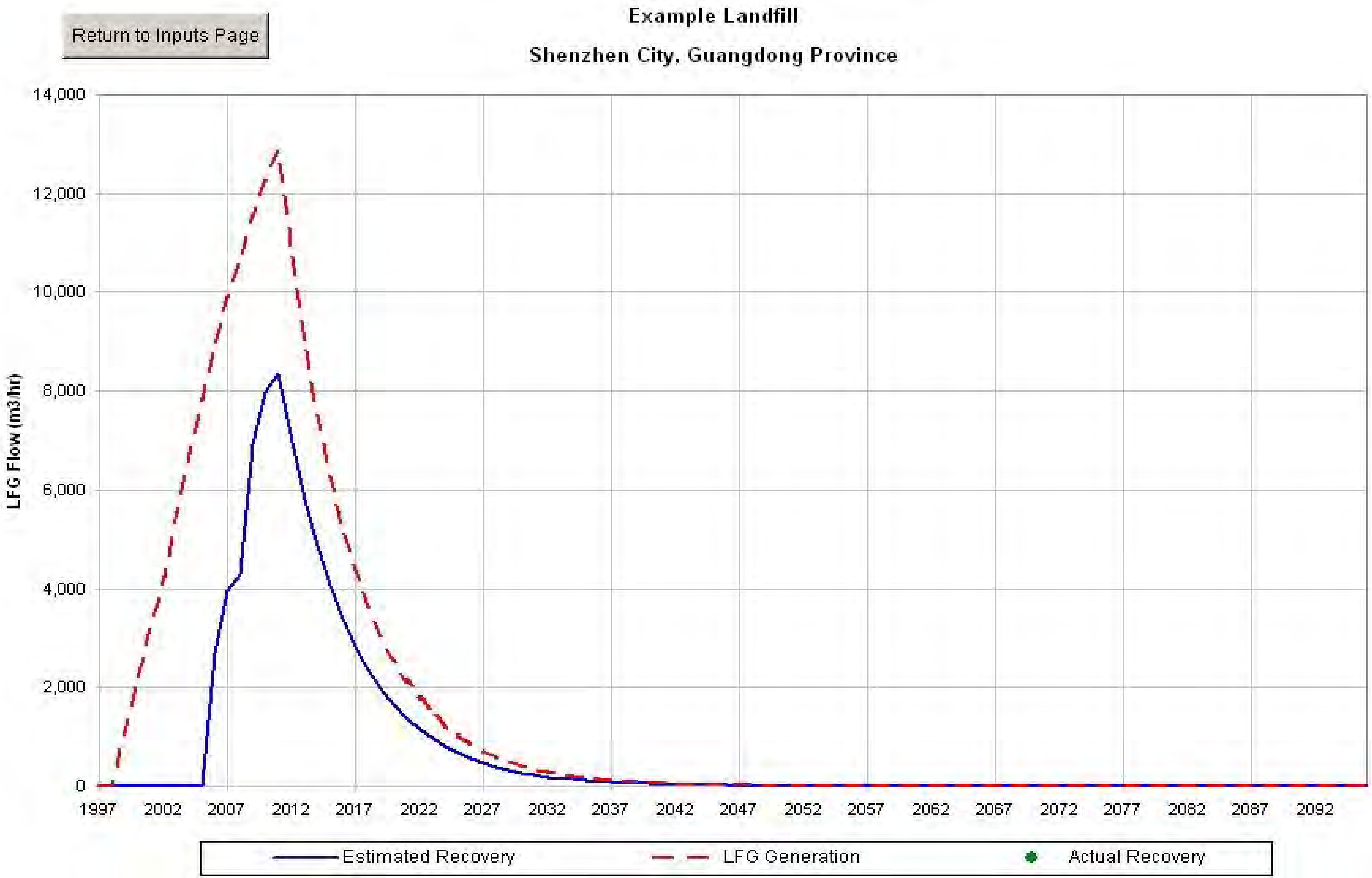
View Output Table

View Output Graph

Return to Inputs Page

Example Landfill
Shenzhen City, Guangdong Province

Year	Disposal Rate	Waste In-Place	LFG Generation Rate		Collection System Efficiency	LFG Recovery from Existing and Planned System			Energy Output From Direct Use Project[1]	Energy Output From Electric Generation Project[1]
	metric tonnes/yr	metric tonnes	(m^3/min)	(m^3/hr)	(%)	(m^3/min)	(m^3/hr)	$MTCO_2e$	(MJ/hr)	(MW)
1997	18,000	18,000	0	0	0%	0	0	0	0	0.000
1998	563,774	581,774	1	34	0%	0	0	0	0	0.000
1999	654,106	1,235,880	18	1,098	0%	0	0	0	0	0.000
2000	712,521	1,948,401	36	2,157	0%	0	0	0	0	0.000
2001	841,719	2,790,120	53	3,153	0%	0	0	0	0	0.000
2002	1,047,886	3,838,006	70	4,230	0%	0	0	0	0	0.000
2003	1,126,419	4,964,425	92	5,520	0%	0	0	0	0	0.000
2004	1,161,308	6,125,733	112	6,747	0%	0	0	0	0	0.000
2005	1,265,079	7,390,812	131	7,838	0%	0	0	0	0	0.000
2006	1,277,500	8,668,312	149	8,945	30%	45	2,684	176,985	45,288	4.320
2007	1,277,500	9,945,812	165	9,894	40%	66	3,958	261,013	66,790	6.372
2008	1,380,000	11,325,812	178	10,687	40%	71	4,275	281,923	72,140	6.882
2009	1,380,000	12,705,812	192	11,543	60%	115	6,926	456,772	116,882	11.151
2010	1,380,000	14,085,812	204	12,259	65%	133	7,968	525,502	134,469	12.828
2011	0	14,085,812	214	12,856	65%	139	8,357	551,115	141,023	13.454
2012	0	14,085,812	179	10,738	65%	116	6,980	460,330	117,793	11.237
2013	0	14,085,812	149	8,970	65%	97	5,830	384,500	98,389	9.386
2014	0	14,085,812	125	7,492	65%	81	4,870	321,161	82,181	7.840
2015	0	14,085,812	104	6,258	65%	68	4,068	268,257	68,643	6.549
2016	0	14,085,812	87	5,227	65%	57	3,398	224,067	57,336	5.470
2017	0	14,085,812	73	4,366	65%	47	2,838	187,156	47,891	4.569
2018	0	14,085,812	61	3,647	65%	40	2,370	156,326	40,002	3.816
2019	0	14,085,812	51	3,046	65%	33	1,980	130,574	33,412	3.188
2020	0	14,085,812	42	2,544	65%	28	1,654	109,065	27,908	2.662
2021	0	14,085,812	35	2,125	65%	23	1,381	91,099	23,311	2.224
2022	0	14,085,812	30	1,775	65%	19	1,154	76,092	19,471	1.858
2023	0	14,085,812	25	1,483	65%	16	964	63,557	16,264	1.552
2024	0	14,085,812	21	1,238	65%	13	805	53,088	13,584	1.296
2025	0	14,085,812	17	1,034	65%	11	672	44,343	11,347	1.082
2026	0	14,085,812	14	864	65%	9	562	37,038	9,478	0.904
2027	0	14,085,812	12	722	65%	8	469	30,937	7,916	0.755


Return to Inputs Page
Example Landfill
Shenzhen City, Guangdong Province
LFG Flow (m3/hr)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1997
2002
2007
2012
2017
2022
2027
2032
2037
2042
2047
2052
2057
2062
2067
2072
2077
2082
2087
2092
Estimated Recovery
LFG Generation
Actual Recovery

Methane to Markets

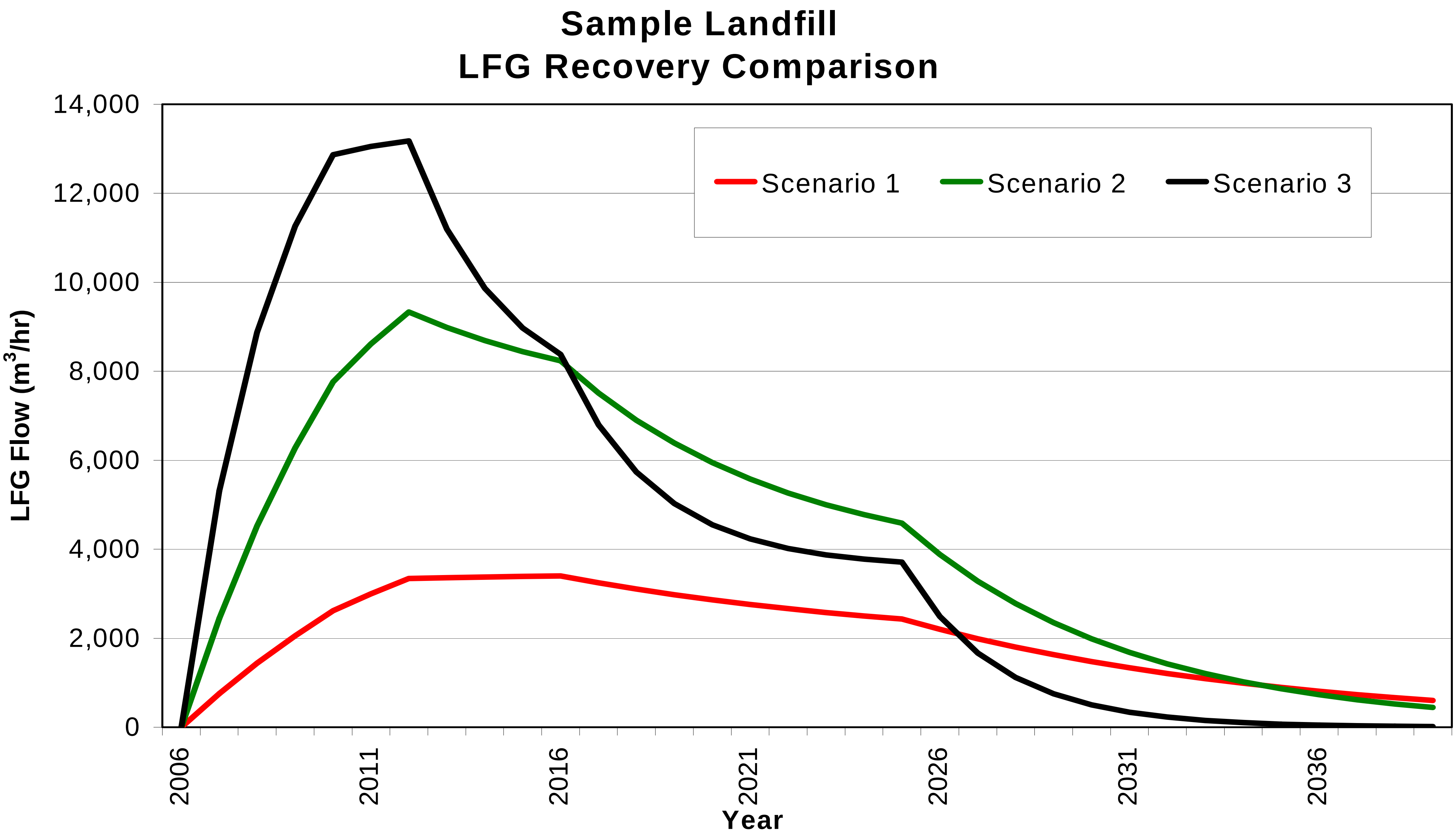
Example: Inputs & Assumptions

3 Different Scenarios Analyzed

Parameter	Scenario 1	Scenario 2	Scenario 3
Waste Input	Per waste input table	Per waste input table	Per waste input table
Waste Composition	60% wet organics @ 40% moisture	Per waste composition table	Per waste composition table
L_o	90	102.7*	102.7*
k	0.10	0.167*	0.40
Collection Efficiency	65%	65%	65%

*Calculated per IPCC Guidelines

Example: Results in Graphs



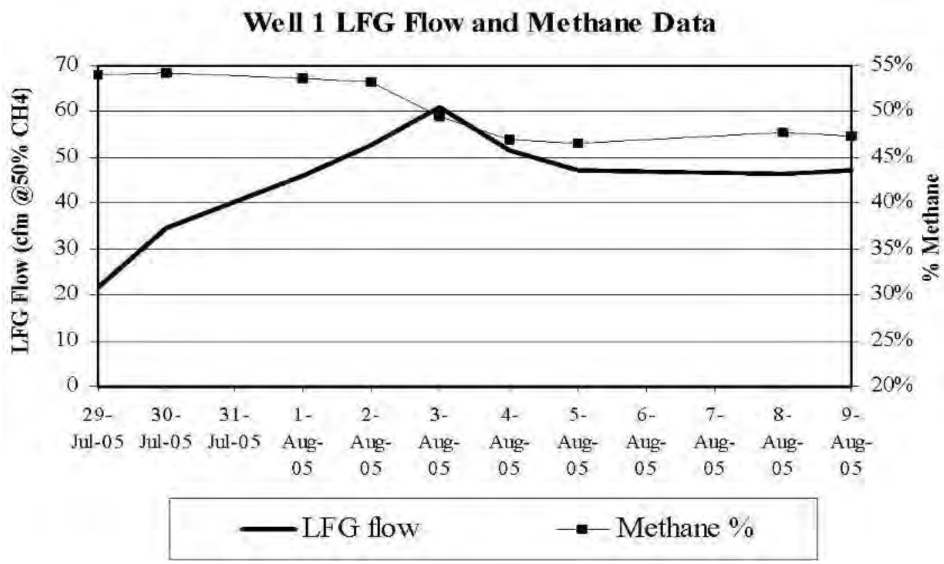
Example: Summary of Results

	Scenario 1	Scenario 2	Scenario 3
LFG Recoverable in 2009 (m^3/hr)	2,057	6,279	11,264
LFG Recoverable in 2012 (m^3/hr)	3,341	9,329	13,177
Max. Engine Capacity (MW)	6.8	16.4	16.7
ERs from 2010 – 2012 (t CO_2 eq.)	~ 590,000	~ 1,690,000	~ 2,580,000

Methane to Markets

Bankable feasibility study – "Pump Test"

- Install LFG extraction wells and pressure monitoring wells
- Mobilize blower and flare system to site
- Monitor extracted LFG from the wells
- Operate the system until the extracted LFG flow and methane content reach a breakpoint



Methane to Markets

Pump Test

- Assess the size of the impacted waste mass in the pump test
- Based on the monitoring data, estimate the potential LFG yield for the entire landfill
- Compare the estimate with results from the LFG model

LFGE Project Cost and Revenue

- All project costs must be considered

CAPEX
- PDD Preparation
- Design
- Permitting
- Construction
- Validation

OPEX
- Operation
- Verification
- Monitoring
- Periodic Maintenance

- Be sure to consider all revenue streams
  - CER / ERU / VER
  - Power or Gas sales
  - Fossil fuel emission offsets
  - Renewable energy credits (RMB 0.25/kWh)
  - Other government subsidies (RMB 0.01 – 0.03/kWh for grid connection, depending on distance to substation)
- Intangibles – Social and environmental benefits

Financial Analyses for LFGE Projects

- All costs and revenues of project must be considered and an economic analyses performed to determine project financial performance. Typical considerations include, but are not limited to:
- NPV
- IRR
- Payback period
- Cash flow
- Sensitivity analyses
- A *LFGCost* Model developed by USEPA can also be used as a screening tool for project financial analysis

Assistance Offered by The M2M Partnership to Landfills

- **Estimation of Available LFG**
  - **Tier 1** - Questionnaire-based preliminary desk-top study with LFG modeling
  - **Tier 2** - Site visit and assessment
    - To account for site conditions not reflected in questionnaire which will impact LFG production
    - To evaluate practical options for LFG energy usage
    - Preliminary economics
  - **Tier 3** - Pumping trials
  - Actual number of tiers will depend on the near-term methane reduction potential of a site as well as other factors

Assistance Offered by The M2M Partnership to Landfills

- **International Landfill Database**
  - Landfill and potential project information on web available to investors & developers

- **Development of Country-Specific LFG Modeling Tools**
  - Central American LFG model
  - Ecuador LFG model
  - China LFG model

Methane to Markets

Advantages of M2M Partnership

- **Unbiased Independent View**
  - No vested interest in project revenue. No conflict of interest
- **Consultation**
  - All desk-top, field assessment services and pumping trials are done at no cost to the landfill / project owner.
  - Help initiate the first step (initial assessment) of the project cycle

Methane to Markets

For More Information

Methane to Markets Partnership

www.methanetomarkets.org

Ms. Rachel Goldstein

goldstein.rachel@epa.gov

Mr. Jason Leung

jason.leung@owthk.com.hk

Methane to Markets

Q & A session:

Thank you for your kind attention!