



# Methane to Markets

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## **LFG Projects Development within the Methane-to-Market Program in Ukraine**

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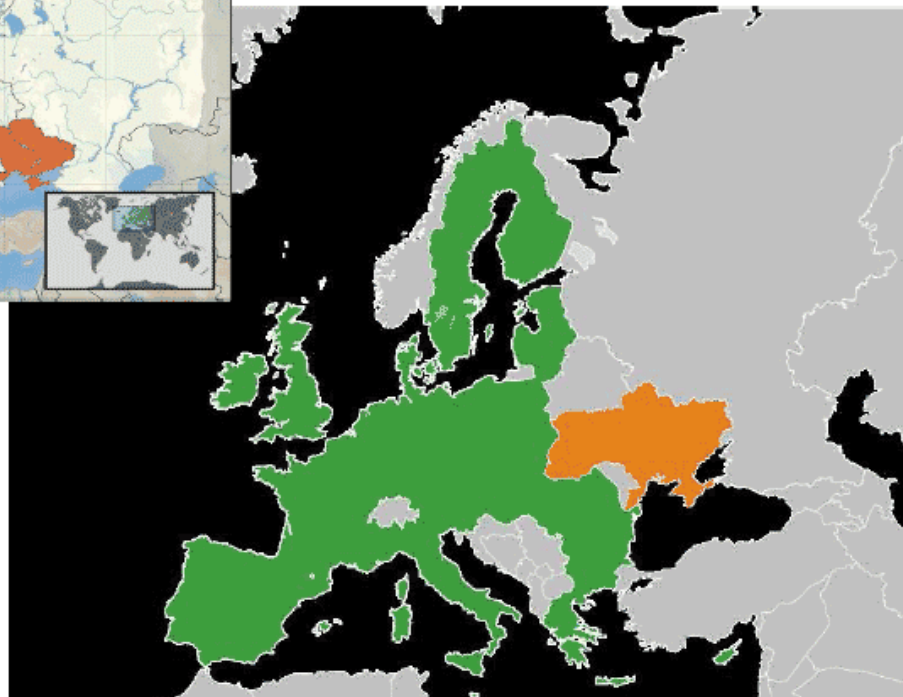
**March 2-5, 2010  
Methane to Markets Partnership Expo, New Delhi**

# Presentation structure

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- Ukraine – general information
- Ukrainian landfills
- LFG capture and utilization potential
- M2M projects
  - Landfill gas assessment (Khmelnitskiy, Lutsk), pump tests (Chernivtsy, Mariupol)
  - Infrared heaters at Ukrainian landfills (Khmelnitskiy)
  - Landfill gas recovery and flaring (Rivne)
  - Ukrainian LFG model. Version 1.0
- Full scale commercial LFG projects
  - Partnership Expo in Beijing, 2008
  - Mariupol landfills
  - Other landfills
- Problems and prospects of LFG technology development in Ukraine

# Ukraine – general information



- Population total – 46 mill
- Population urban – 31 mill
- Area – 603,700 km<sup>2</sup>
- Population density – 76 inh./km<sup>2</sup>
- GDP – 3,050 \$/inh
- MSW – 10-12 mill t/year

# Ukraine – general information

## Urban population in Ukraine

Town size inhabitants	Number	Total population	
		inhabitants	%
50-100,000	56	3 950 000	8.2
100-200,000	17	2 220 000	4.6
200-500,000	22	6 450 000	13.4
500-1000,000	6	4 980 000	10.4
> 1000,000	5	7 670 000	16.0
Total	106	25 270 000	52.6

# Ukrainian landfill and waste dumps

Town	Population	Starting year	MSW, t/year	MSW in place, mill tones	Area, hectares	Depth, meters
Kiev	2,642,000	1986	500,000	7,5	35.5	15-20
Kharkiv	1,622,000	1975	200,000	2.2	20.8	30
Dnipropetrovsk	1,050,000	1998	85,000	0.5	7.5	15
Odessa	1,005,000	1972	250,000	5.3	30	22-25
Donetsk	1,000,000	1991	150,000	2.5	21.5	10-15
Zaporizhzhia	800,000	1952	270,000	8-12	47	25
Lviv	730,000	1959	230,000	8,4	33.3	35
Mariupol	480,000	1967/76	100,000	2.5+2.5	12+12	30/20
Luhansk	450,000	1979	80,000	2.5	8.4	20-25
Khmelnitskiy	250,000	1956	75,000	3,0	8.8	35

# Ukrainian landfill and waste dumps



- Steep slopes (up to bottom waste loading)
- Fire events
- Improper covering (big active spot)
- Leachate flooding

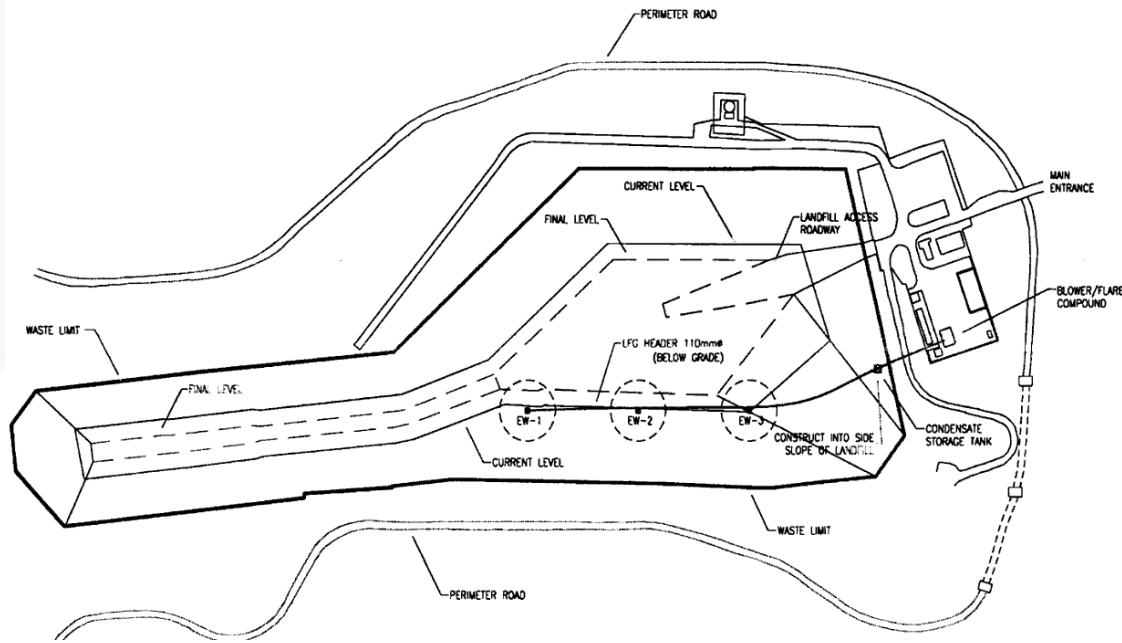
# Landfill gas potential



- Ukrainian towns generate **10-12 mill tones** of MSW per year
- More than **95%** of MSW is disposed at the landfills. There are **700** landfills located around the towns.
- Only **100** of them can be considered as potential candidates for recovery and utilization of landfill gas.

- Based on this facts, potential of landfill gas available for energy production comes to about **400 mill m3/year** that is equivalent to **0.21 mill toe** or **6.0 mill CO<sub>2</sub>e**

# Luhansk landfill



First experience –  
demonstration wells (2003-2006)

60 m<sup>3</sup>/h of LFG (50% of CH<sub>4</sub>)



# M2M projects

## LFG assessment reports

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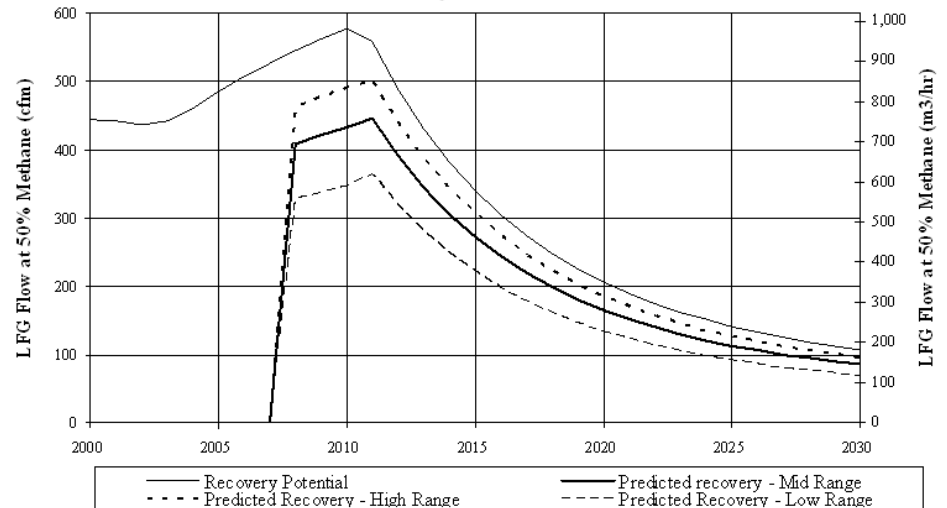
- Khmelnytskyi
- Lviv
- Lutsk
- Chernivtsy
- Mariupol
- Sumy
- etc.

# M2M projects

## LFG assessment - Khmelnytskiy



**Figure 2. LFG Recovery Projection**  
**Khmelnytskiy Landfill, Ukraine**



- Landfill
  - Starting year - 1956
  - MSW – 75,000 tones/year
  - Area – 8.8 hectares
  - Depth - 35 meters
  - Waste in place – 3.0 mill tones

# M2M projects

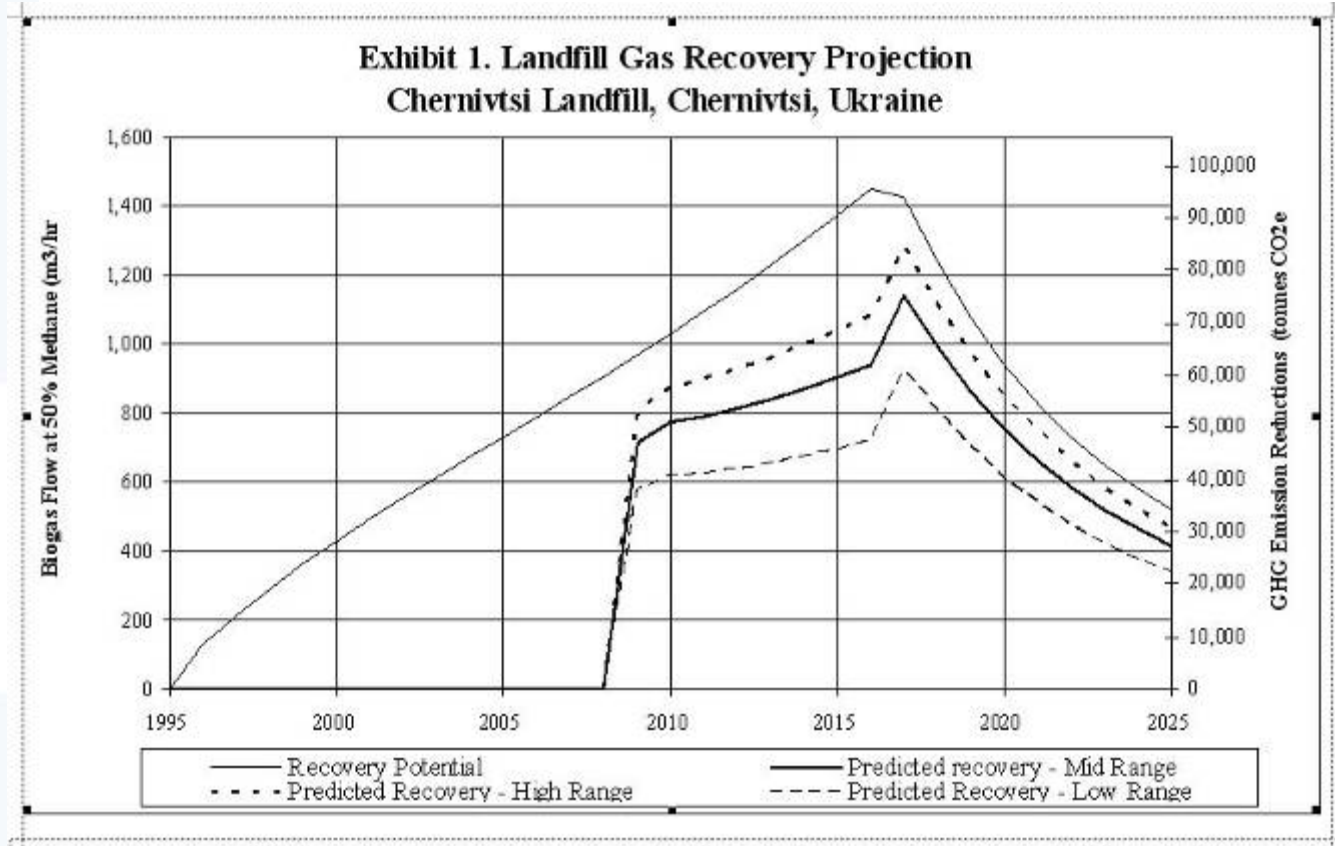
## LFG projection based on pump test - Chernivtsy



- Landfill
  - Starting year - 1995
  - MSW - 70-80,000 tones/year
  - Area - 25 hectares
  - Depth - 15-18 meters
  - Waste in place – 0.8 mill tones
  
- Pump test
  - Duration – two weeks in July 2007
  - Three wells and four pressure probes
  - Methane flow – 75-25 m<sup>3</sup>/h
  - Methane content – 55-40%
  - Oxygen content – < 0.6%

# M2M projects

## LFG projection based on pump test - Chernivtsy



Lo total = 118.0 m<sup>3</sup>/Mg

k (fast-decay) = 0.180/year

k (medium-decay) = 0.036/year

k (slow-decay) = 0.009/year

# M2M projects

## LFG projection based on pump test - Mariupol



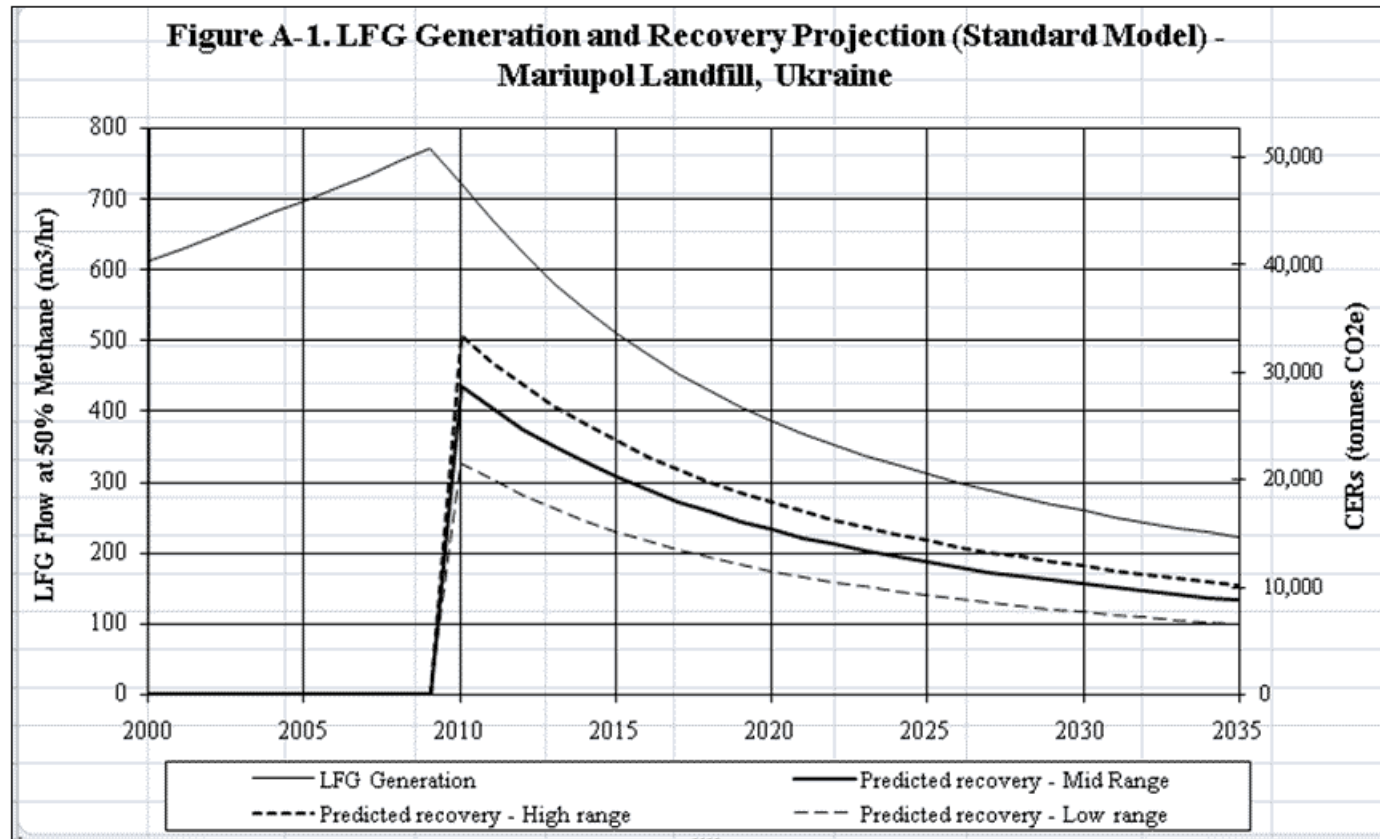
- Landfill
  - Starting year – 1967
  - Closure - 2009
  - MSW – 75,000 tones/year
  - Area - 12 hectares
  - Depth – 25-30 meters
  - Waste in place – 2.5 mill tones



- Pump test
  - Duration – four weeks in August-September 2008
  - Three wells and nine pressure probes
  - Methane flow – 50-45 m<sup>3</sup>/h
  - Methane content – 65-35%
  - Oxygen content – < 0.8%

# M2M projects

## LFG projection based on pump test - Mariupol



Lo total = 84.0 m<sup>3</sup>/Mg

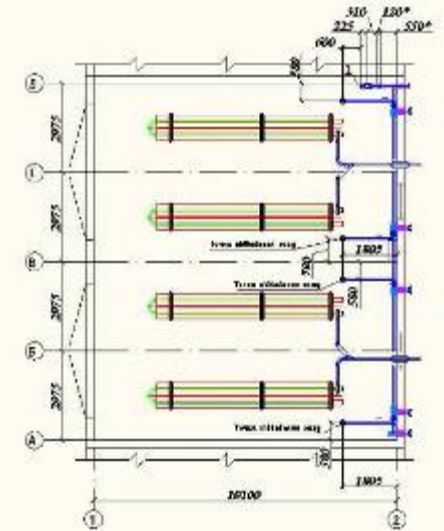
k (fast-decay) = 0.140/year

k (medium-decay) = 0.028/year

k (slow-decay) = 0.007/year

# M2M projects

## Infrared heaters based on LFG

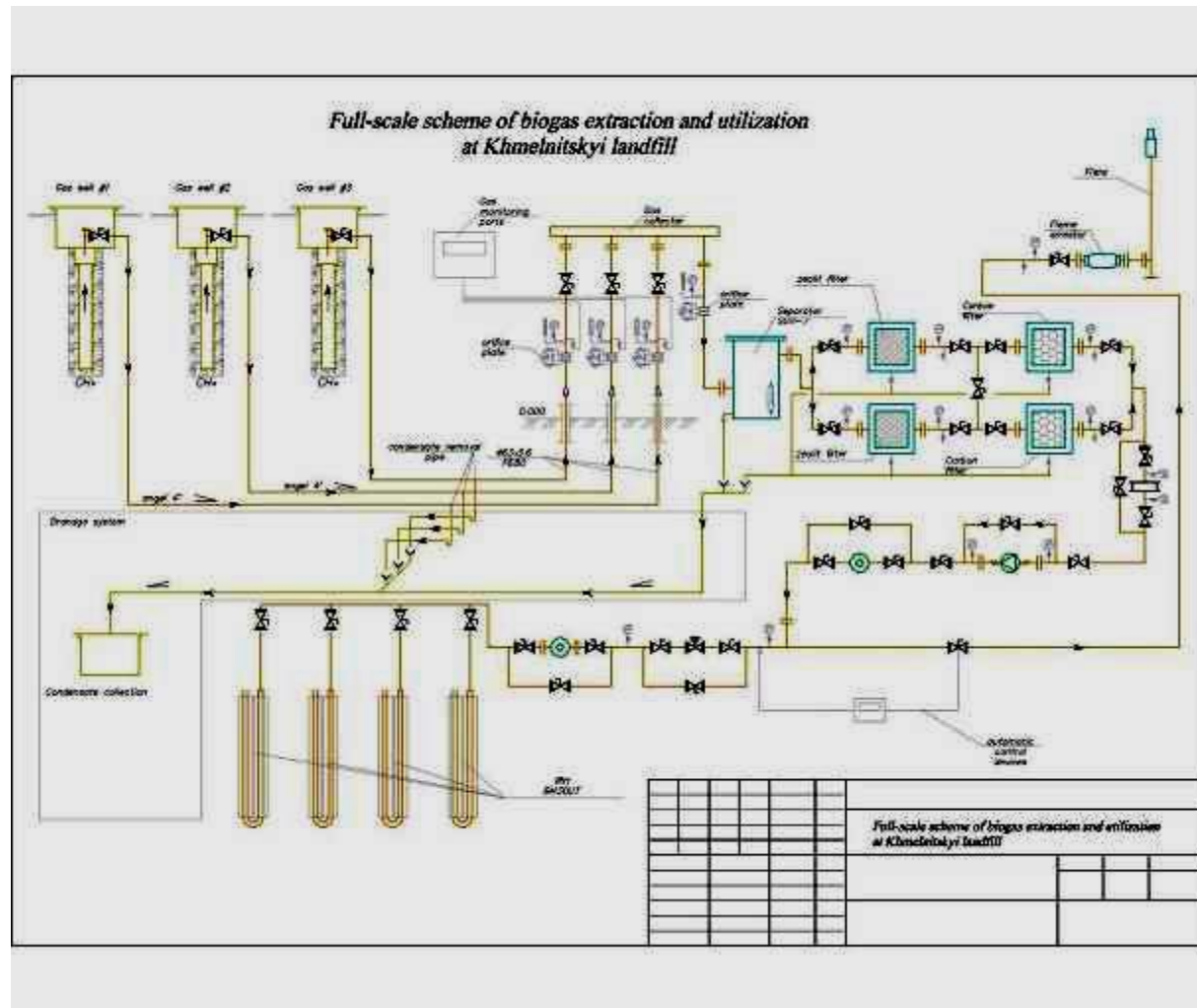


- Heated area – 2 x 126 m<sup>2</sup>
- Type of IR-heater – *Roberts Gordon Black Heat U30*
- Capacity – 30 kW
- Number of heaters - 4



# M2M projects

## Infrared heaters based on LFG





# M2M projects

## Infrared heaters based on LFG



# M2M projects

## Infrared heaters based on LFG

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# M2M projects

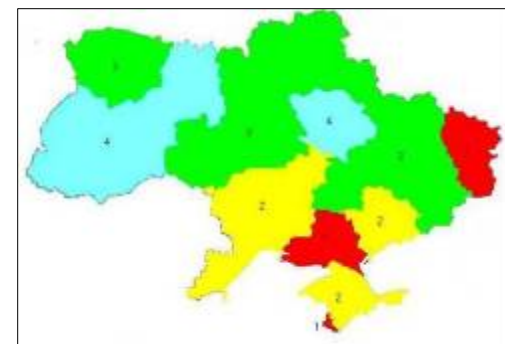
## LFG recovery and flaring (Rivne landfill)



- Landfill
  - Starting year - 1959
  - MSW – 120,000 tones/year
  - Area – 22 hectares
  - Depth – 15-25 meters
  - Waste in place – 2.0 mill tones
  
- Pump test
  - Duration – May 9-20 and July 29-August 05, 2009
  - Three wells and twelve pressure probes
  - Methane flow – 55-20 m<sup>3</sup>/h
  - Methane content – 50-35%
  - Oxygen content – < 1.2%

# Ukrainian LFG model. Version 1.0

$$Q_{CH_4} = \sum_{i=1}^n \sum_{j=0.1}^1 k \cdot L_0 \cdot \left[ \frac{M_i}{10} \right] \cdot e^{-ktij}$$



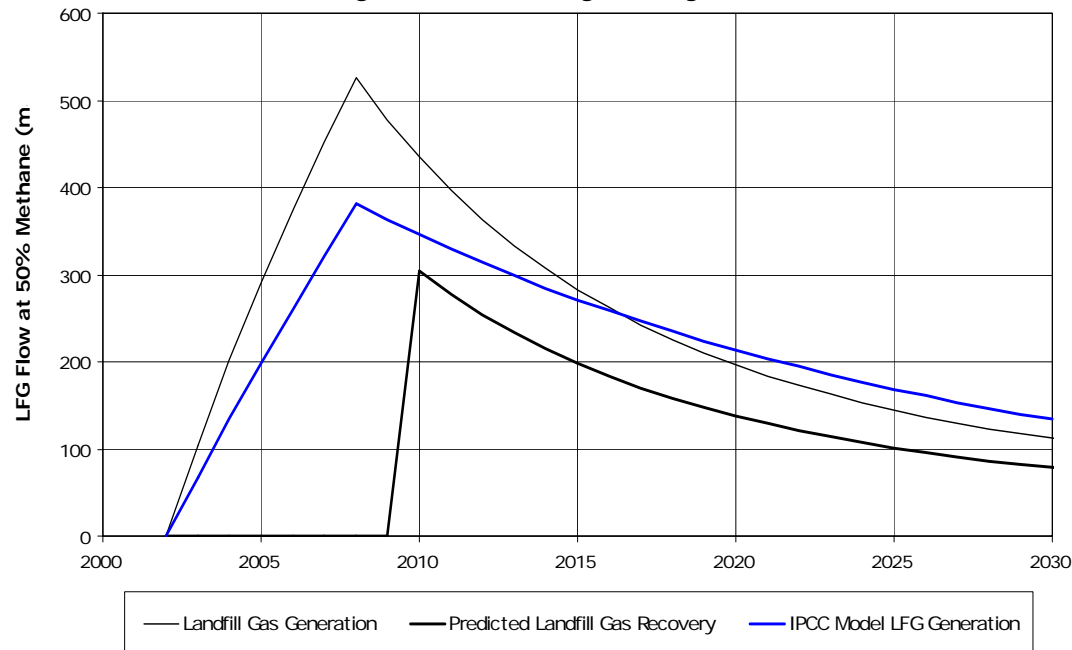
Precipitation (mm/yr)  
 Region 1: 360-429 (red)  
 Region 2: 430-499 (yellow)  
 Region 3: 500-599 (green)  
 Region 4: 600-699 (blue)

Waste Category:	L <sub>0</sub> Values (m <sup>3</sup> /Mg)
1. Food, Other Organics	69
2. Garden and Park Waste	126
3. Paper and Textiles	214
4. Wood, Rubber, Leather, Straw	201

Climate Region:	1	2	3	4
Annual Precipitation Range, mm:	360-429	430-499	500-599	600-699
Average Annual Precipitation:	389 mm	456 mm	558 mm	645 mm
Average 24-Hour Temp. (°C):	8.9	9.2	7.3	7.7
Waste Category:	Assigned k Values (1/year):			
1. Food, Other Organics	0.110	0.120	0.140	0.150
2. Garden and Park Waste	0.055	0.060	0.070	0.075
3. Paper and Textiles	0.022	0.024	0.028	0.030
4. Wood, Rubber, Leather, Straw	0.011	0.012	0.014	0.015

# Ukrainian LFG model. Version 1.0

Landfill Gas Generation and Recovery Projection  
Sumy Landfill, Sumy, Sumy Oblast



- Model accounts for fires by applying a “fire adjustment factor”
- Collection efficiency calculated by model based on site management practices, waste depth, well field coverage of waste area, soil cover type and extent, bottom liner, waste compaction, focused tip area, leachate presence

# M2M projects

## Partnership Expo in Beijing, 2007

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
**MARIUPOL LANDFILL**  
MARIUPOL, UKRAINE

**OVERVIEW OF LANDFILL METHANE PROJECT OPPORTUNITY**

The Mariupol Landfill is a sanitary landfill owned by the Mariupol City State Administration and operated by the Mariupol Municipal Enterprise. The Mariupol Municipal Enterprise handles and maintains the Mariupol Landfill and the surrounding area.

- The site opened in 1987 and located approximately 11,000 tonnes of waste in 2005.
- Capacity for about 4.0 million tonnes of waste in total.
- The current landfill area is expected to close in 2008 with an estimated average capacity of 1.4 million tonnes of waste.
- Provisional design including methane gas capture and conversion to electricity and heat is a part of the preliminary design. Detailed design will be started in 2008.

The E.ON of Mariupol seeks specific cooperation to finance, build, own, and operate project.

- The project is asking to consider partner financing.
- The project needs more and more a contract to be signed.

**ENVIRONMENTAL BENEFITS**

Year	2008	2009	2010	2011	2012
Electricity (MWh)	18,000	30,000	42,000	54,000	66,000
Heat (MWh)	18,000	30,000	42,000	54,000	66,000

Source: Mariupol From Yang Institute

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
**LVIV LANDFILL**  
LVIV, UKRAINE

**OVERVIEW OF LANDFILL METHANE PROJECT OPPORTUNITY**

The Lviv landfill is a sanitary landfill owned by the Lviv City State Administration and operated by the Lviv Municipal Enterprise. The Lviv landfill handles and maintains the surrounding area.

- The site opened in 1988 and located approximately 10,000 tonnes of waste in 2005.
- Capacity for about 3.0 million tonnes of waste in total.
- The current landfill area is expected to close in 2008 with an estimated average capacity of 1.0 million tonnes of waste.
- Provisional design including methane gas capture and conversion to electricity and heat is a part of the preliminary design. Detailed design will be started in 2008.

The E.ON of Lviv seeks specific cooperation to finance, build, own, and operate project.

- The project is asking to consider partner financing.
- The project needs more and more a contract to be signed.

**ENVIRONMENTAL BENEFITS**

Year	2008	2009	2010	2011	2012
Electricity (MWh)	18,000	30,000	42,000	54,000	66,000
Heat (MWh)	18,000	30,000	42,000	54,000	66,000

Source: Mariupol From Yang Institute

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
**CHERNIVTSI LANDFILL**  
CHERNIVTSI, UKRAINE

**OVERVIEW OF LANDFILL METHANE PROJECT OPPORTUNITY**

The Chernivtsi landfill is a sanitary landfill owned by the Chernivtsi City Municipal Administration and operated by the Chernivtsi Municipal Enterprise. The Chernivtsi landfill handles and maintains the surrounding area.

- The site opened in 1992 and located approximately 10,000 tonnes of waste in 2005.
- Capacity for about 3.0 million tonnes of waste in total.
- The current landfill area is expected to close in 2008 with an estimated average capacity of 1.0 million tonnes of waste.
- Provisional design including methane gas capture and conversion to electricity and heat is a part of the preliminary design. Detailed design will be started in 2008.

The E.ON of Chernivtsi seeks specific cooperation to finance, build, own, and operate project.

- The project is asking to consider partner financing.
- The project needs more and more a contract to be signed.

**ENVIRONMENTAL BENEFITS**

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Electricity (MWh)	18,000	30,000	42,000	54,000	66,000	78,000	90,000	102,000	114,000	126,000
Heat (MWh)	18,000	30,000	42,000	54,000	66,000	78,000	90,000	102,000	114,000	126,000

Source: Mariupol From Yang Institute

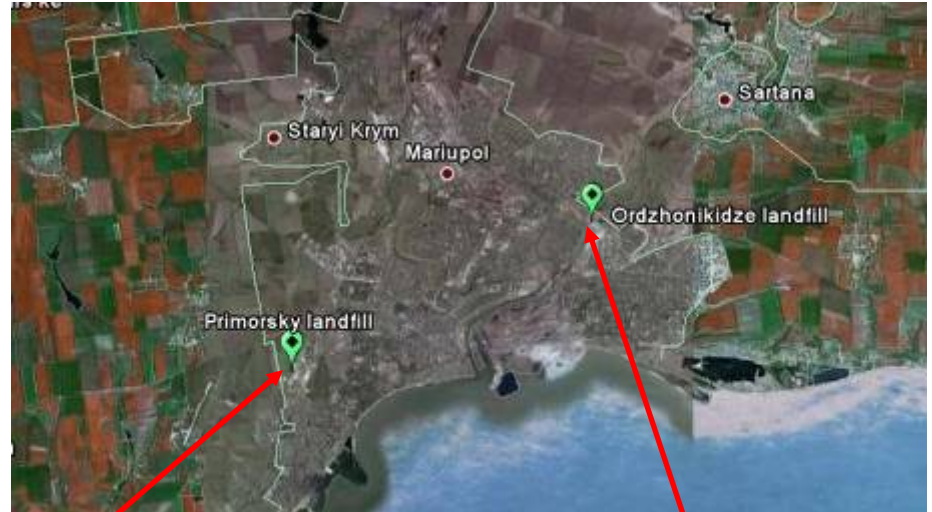
- Lviv landfill
- Mariupol landfill
- Chernivtsi landfill

## LFG project in Lviv (Joint Implementation)



LFG recovery and flaring, August 2009  
2000 m<sup>3</sup>/hour of LFG  
(Gafsa/CMM)

# LFG project in Mariupol (Joint Implementation)





# LFG project in Mariupol (Joint Implementation)



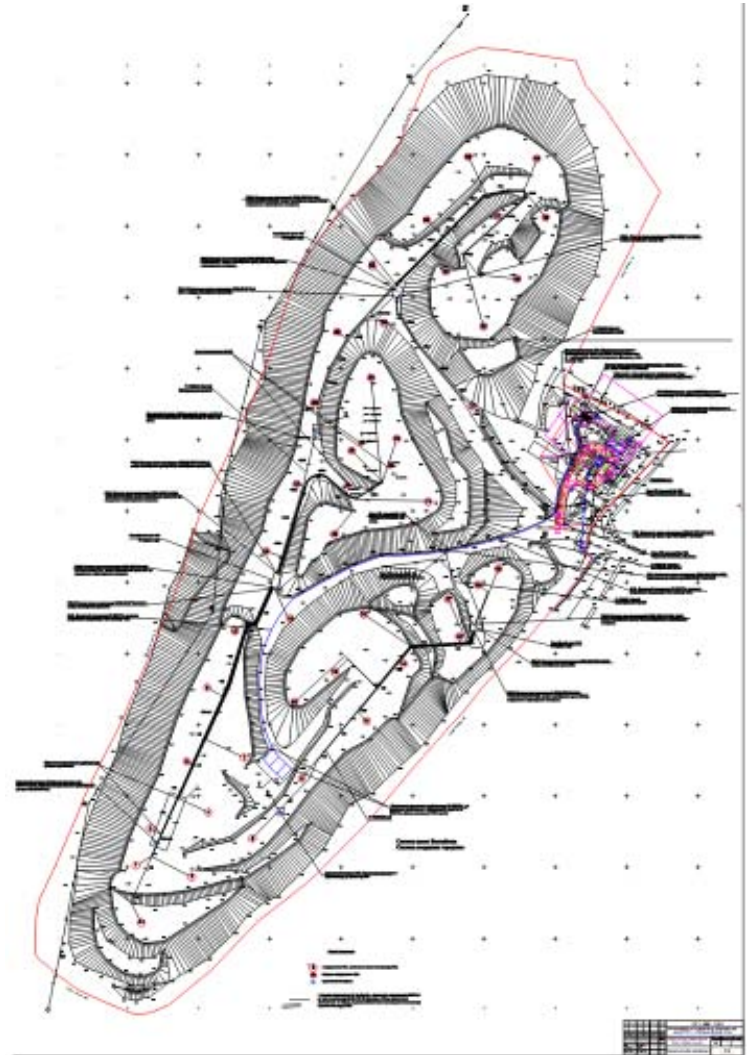
- Population – 480,000
- Starting year – 1967/1976
- Closure – 2009/2011
- MSW – 120,000 tones/year
- Area – 12+12 hectares
- Depth – 30/20 meters
- Waste in place – 2.5+2.5 mill tones

# LFG project in Mariupol (Joint Implementation)

- Number of wells – 44;
- Total piping – 6 km
- Maximum flow – 800 m<sup>3</sup>/h



- Two options – flaring or power production



# LFG project in Mariupol (Joint Implementation)



# Possible LFG projects

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- Landfill gas capture and flaring (< 100,000 inhabitants);
- Landfill gas capture and directly utilization in a boiler/kiln/ furnace etc. (Odessa, Mariupol);
- Landfill gas capture and combustion for electricity production (green tariff);
- Landfill gas capture and combustion for combined heat and electricity production;
- Landfill gas use for vehicle
- Leachate evaporation (Kiev)

# Problems and prospects of LFG technology development in Ukraine

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- Local project structure and decision making – bottleneck
- Key point - financial conditions and level of interest of the owner/operator of the landfill site
- Low waste management tariffs. Co-financing from owners (municipalities) and operators can hardly be expected
- Bad technical conditions and a lack of reliable technical data at some landfills restrict practicability of potential JI projects
- Ukraine is not big. Ukrainian landfills are relatively small

# Problems and prospects of LFG technology development in Ukraine

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- Currently LFG projects at old landfills can hardly be implemented without Kyoto Protocol
- The main GHG emission reduction potential is connected to the towns with population more than 200,000 – 33 towns
- The usual method of LFG utilization can be power generation by IC-engines
- For smaller town with population less than 100 thousands inhabitants LFG can be captured and flared without utilization. For JI project it can be recommended to joint 3-5 landfills in the certain region under one project umbrella
- Condition would improve:
  - price for natural gas goes up
  - support of the government by green tariffs for electricity
  - implementation of the strategy of new regional landfill erection and old landfill closure

# M2M projects

## Partnership Expo in New Delhi, 2010

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
ORDZHONIKIDZEVSKY LANDFILL  
MARIUPOL, UKRAINE

**DESCRIPTION OF LANDFILL BIOGAS PROJECT OPPORTUNITY**

The Ordzhonikidzevsky Landfill is a sanitary landfill owned by the Municipality of Mariupol.

- The site covered is 350 and access facility - includes supply of water network.
- The landfill is expected to close in 2016 and estimated capacity of 2.2 million tonnes of waste.
- Potentially biogas including methane 250 m<sup>3</sup> of biogas of 60% methane with 40% carbon dioxide can be recovered for power and use as DNG.
- Biogas recovery will rise to a peak of approximately 300 m<sup>3</sup> in 2012.

The Municipality of Mariupol seeks a partner to develop:

- Techno-economic
- The project to bring a complete facility financing.
- The project to invest and have a complete set-up.

**ENVIRONMENTAL BENEFITS**

Year	2011	2012	2013	2014	2015	2016
Equivalent CO <sub>2e</sub> Saved	63,241	125,572	188,903	252,234	315,565	378,896

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
DONETSK LANDFILL  
LARGO SETTLEMENT DONETSK CITY, UKRAINE

**DESCRIPTION OF LANDFILL BIOGAS PROJECT OPPORTUNITY**

The Donetsk Landfill is a sanitary landfill owned by the Municipality of Donetsk.

- The site covered is 350 and access facility - includes supply of water network.
- The estimated annual waste is expected to reach by 2012-2013 - around estimated capacity of 2 million tonnes of waste.
- Potentially biogas including methane 250 m<sup>3</sup> of biogas of 60% methane with 40% carbon dioxide can be recovered for power and use as DNG.
- Biogas recovery will rise to a peak of approximately 300 m<sup>3</sup> in 2012.

The Municipality of Donetsk seeks a partner to develop:

- Techno-economic
- The project to bring a complete facility financing.
- The project to invest and have a complete set-up.

**ENVIRONMENTAL BENEFITS**

Year	2011	2012	2013	2014	2015	2016
Equivalent CO <sub>2e</sub> Saved	20,241	39,272	58,303	77,334	96,365	115,396

**LANDFILL BIOGAS PROJECT OPPORTUNITY**  
DNEPROPETROVSK LANDFILL  
DNEPROPETROVSK OBLAST, UKRAINE

**DESCRIPTION OF LANDFILL BIOGAS PROJECT OPPORTUNITY**

The Dnepropetrovsk Landfill is a sanitary landfill owned by the Dnepropetrovsk City State.

- The site covered is 350 and access facility - includes supply of water network.
- The estimated annual waste is expected to reach by 2012-2013 - around estimated capacity of 2 million tonnes of waste.
- Potentially biogas including methane 250 m<sup>3</sup> of biogas of 60% methane with 40% carbon dioxide can be recovered for power and use as DNG.
- Biogas recovery will rise to a peak of approximately 300 m<sup>3</sup> in 2012.

The Municipality of Dnepropetrovsk seeks a partner to develop:

- Techno-economic
- The project to bring a complete facility financing.
- The project to invest and have a complete set-up.

**ENVIRONMENTAL BENEFITS**

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Equivalent CO <sub>2e</sub> Saved	63,241	125,572	188,903	252,234	315,565	378,896	442,227	505,558	568,889	632,220	695,551

- Mariupol landfill (2)
- Donetsk landfill
- Dnepropetrovsk landfill

# Thank you for your attention

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