

The Global Methane Initiative

*Financing an International Landfill Biogas Project
Mariupol and Chernigov Landfill Gas Energy
Projects in Ukraine*

Yuri Matveev
Renewable Energy Agency
SEC Biomass
Kiev, Ukraine

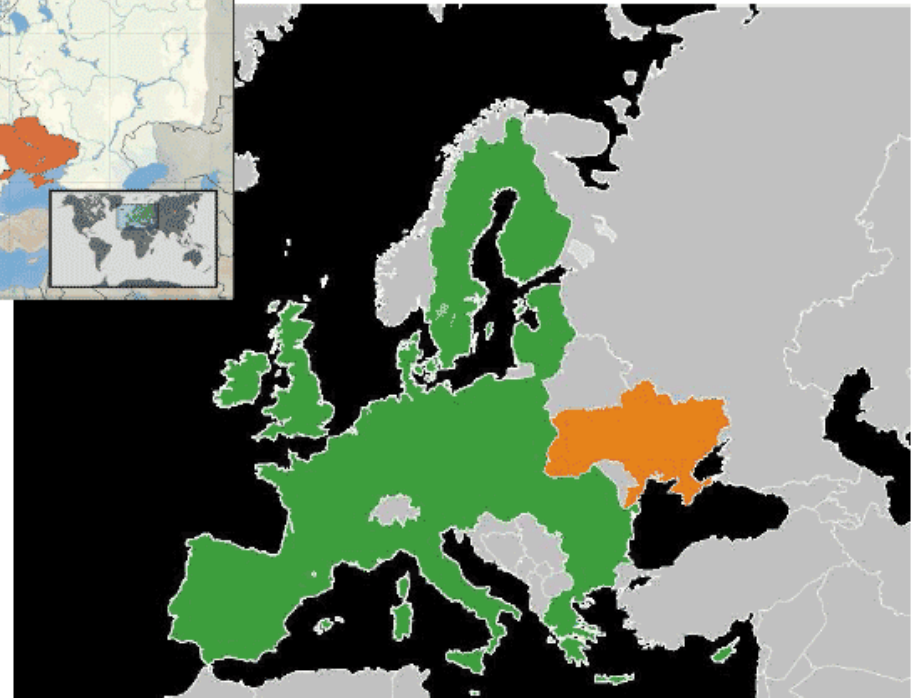
October 13, 2011
Krakow



Presentation structure

- Ukraine – general information
- Ukrainian landfills
- LFG capture and utilization potential
- GMI projects
 - Landfill gas assessment (Khmelnitskiy, Lutsk), LFG generation 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
 - Mariupol landfills
 - Chernigov 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 km²
- Population density – 76 inh./km²
- GDP – 3,050 \$/inh.
- MSW – 10-12 mill t/year

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 landfills 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 landfills and waste dumps



- Steep slopes (up to bottom waste loading)
- Fire events
- Improper covering (big active spot), pure compaction
- 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 **50-100** 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 t CO₂e**

GMI projects

LFG assessment reports

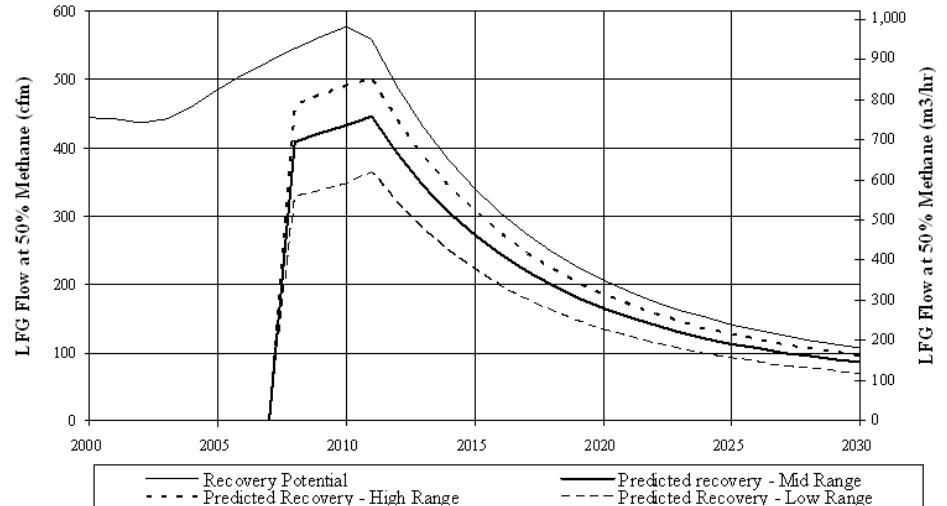
- Khmelnytskyi
- Lviv
- Lutsk
- Chernivtsy
- Mariupol
- Sumy
- etc.

GMI projects

LFG assessment - Khmelnytskyi



Figure 2. LFG Recovery Projection
Khmelnytsky 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

GMI projects

LFG projection based on pump test - Chernivtsy



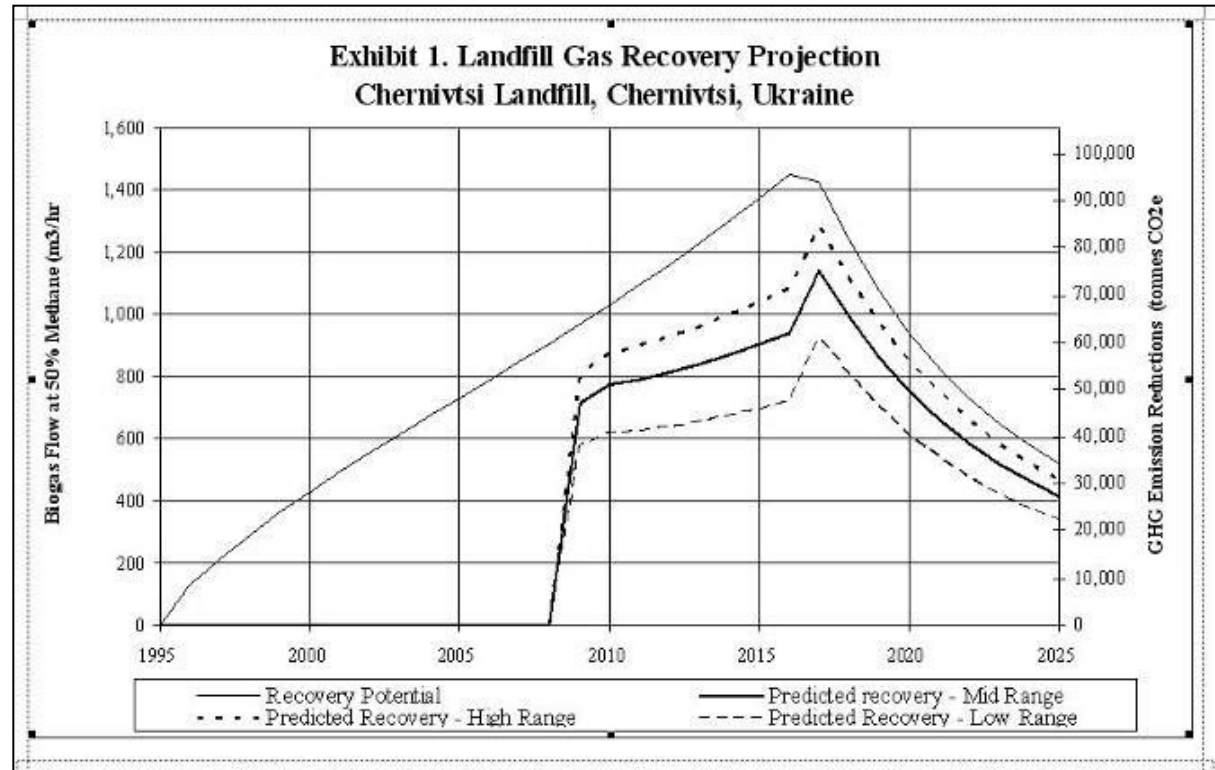
- Landfill
 - Starting year - 1995
 - MSW - 70-80,000 tones/year
 - Area - 25 hectares
 - Depth - 15-18 meters
 - Waste in place – 0.8 mill tones



- Pump test
 - Duration – two weeks in July 2007
 - Three wells and four pressure probes
 - Methane flow – 75-25 m³/h
 - Methane content – 55-40%
 - Oxygen content – < 0.6%

GMI projects

LFG projection based on pump test - Chernivtsy



Lo total = 118.0 m³/Mg

k (fast-decay) = 0.180/year

k (medium-decay) = 0.036/year

k (slow-decay) = 0.009/year

GMI projects

LFG projection based on pump test - Mariupol



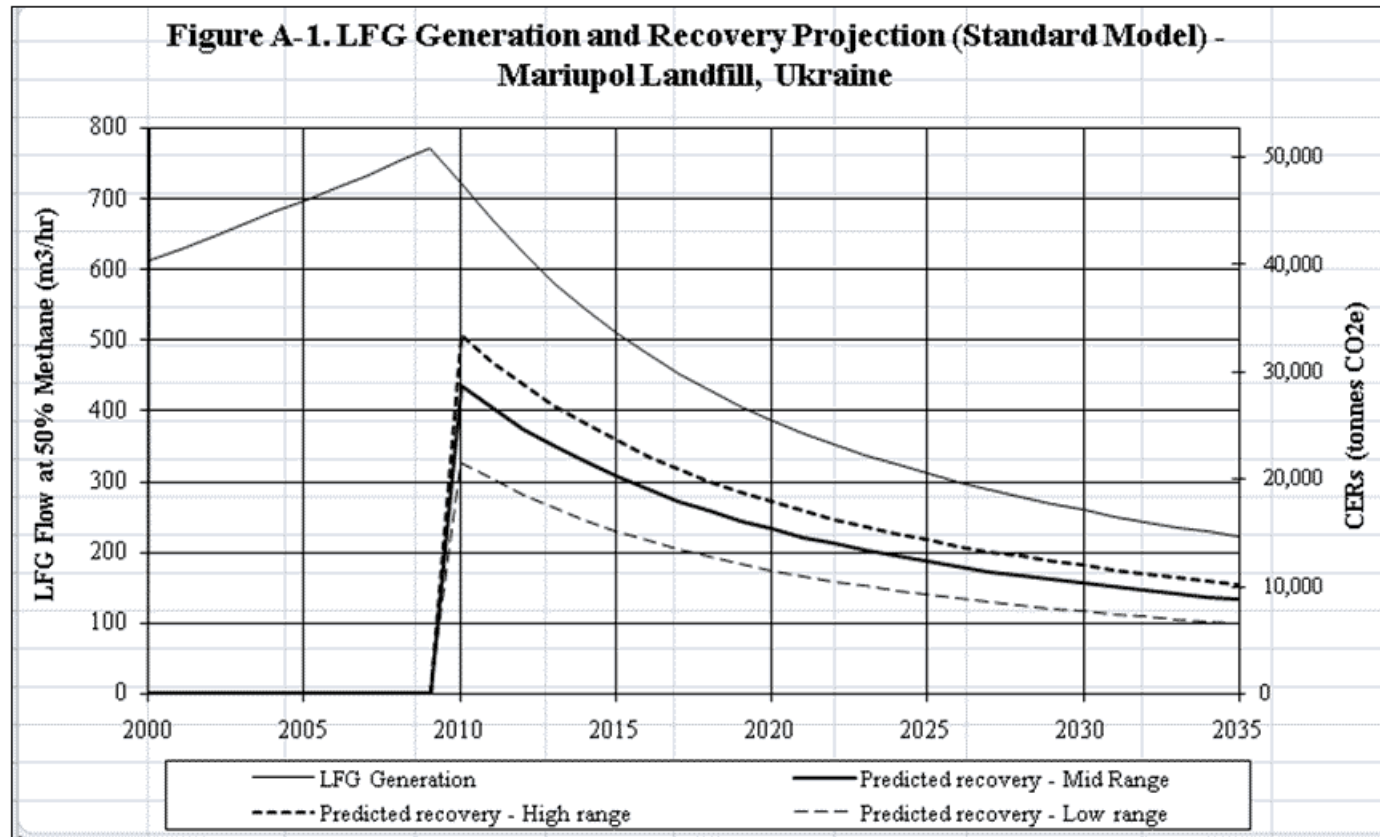
- Landfill
 - Starting year – 1967
 - Closure - 2009
 - MSW – 75,000 tones/year
 - Area - 12 hectares
 - Depth – 25-30 meters
 - Waste in place – 2.5 mill tones



- Pump test
 - Duration – four weeks in August-September 2008
 - Three wells and nine pressure probes
 - Methane flow – 50-45 m³/h
 - Methane content – 65-35%
 - Oxygen content – < 0.8%

GMI projects

LFG projection based on pump test - Mariupol



Lo total = 84.0 m³/Mg

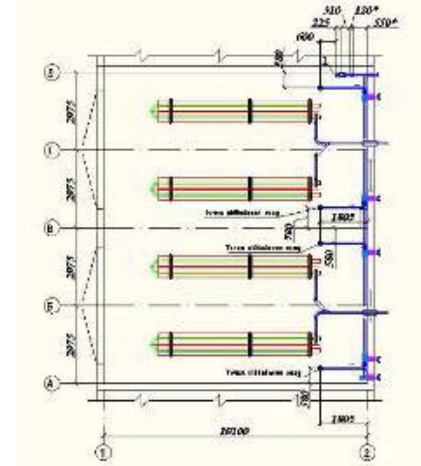
k (fast-decay) = 0.140/year

k (medium-decay) = 0.028/year

k (slow-decay) = 0.007/year

GMI projects

Infrared heaters based on LFG

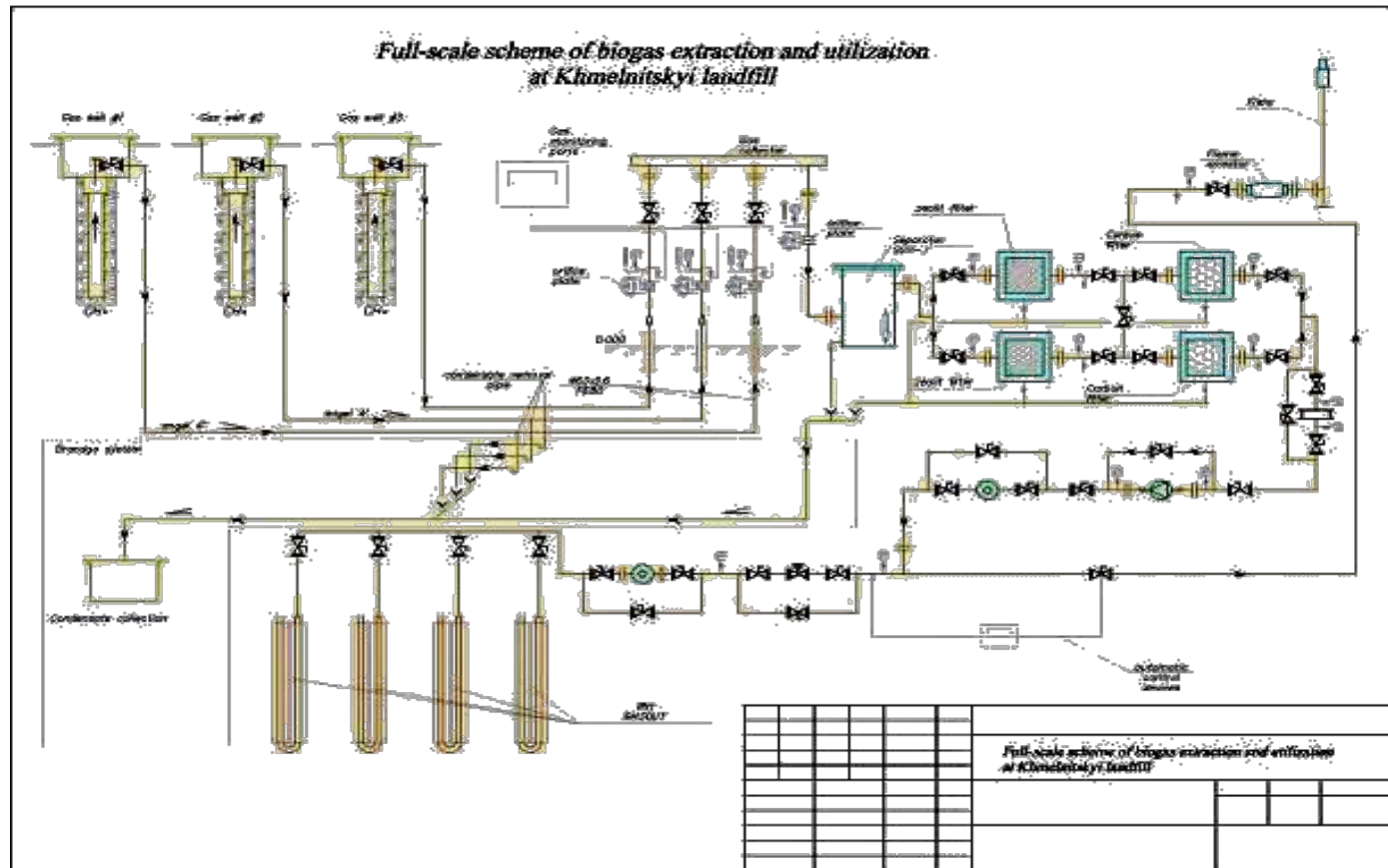


- Heated area – 2 x 126 m²
- Type of IR-heater – *Roberts Gordon Black Heat U30*
- Capacity – 30 kW
- Number of heaters - 4



GMI projects

Infrared heaters based on LFG



GMI projects

LFG recovery and flaring (Rivne/Chernigov 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 m³/h
 - Methane content – 50-35%
 - Oxygen content – < 1.2%

GMI projects

LFG recovery and flaring (Rivne/Chernigov landfill)



Future pump test

- Duration – end of December – April ,2011
- Three gas extraction wells

Landfill

- Starting year - 1961
- MSW – 120,000 tones/year
- Area – 14 hectares
- Depth – 15-20 meters
- Waste in place – 2.0 mill tones

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)

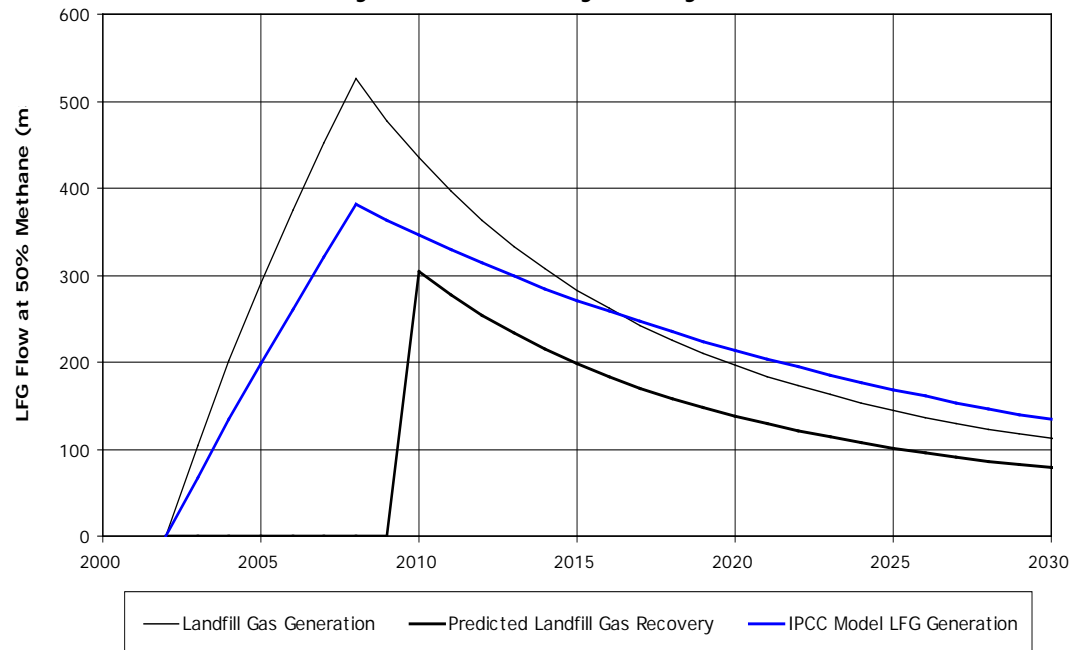
Region 4: 600-699 (blue)

Waste Category:	L ₀ Values (m ³ /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 Waste Company. The Mariupol Waste Company handles and maintains the landfill under the supervision of the Mariupol City State Administration.

The site covers 1,000 ha and contains approximately 1,000,000 tonnes of waste in 2005.

Capacity for site has 4.0 million tonnes of waste in total.

The current landfill area is expected to close in 2010 with an estimated average capacity of 1.2 million tonnes of waste.

Provisional design including preliminary site and/or conceptual site plan is currently available for review and design necessary will take a period of approximately 6 months to complete the design of the landfill to 2010.

The City of Mariupol seeks specific cooperation to:

- Develop a biogas and/or methane project
- The project is asking to consider carbon financing
- The project needs more and have a contract to be signed

ENVIRONMENTAL BENEFITS

Year	2005	2006	2007	2008	2009
CO ₂ (t/year)	10,000	10,000	10,000	10,000	10,000
CH ₄ (t/year)	10,000	10,000	10,000	10,000	10,000

Source: Mariupol City State Administration

LANDFILL BIOGAS PROJECT OPPORTUNITY
L'VIV LANDFILL
L'VIV, UKRAINE

OVERVIEW OF LANDFILL METHANE PROJECT OPPORTUNITY

The L'viv landfill is a sanitary landfill owned by the L'viv City State Administration and operated by the L'viv Waste Company. The L'viv landfill handles and maintains the site under the supervision of the L'viv City State Administration.

The site covers 100,000 sq. m and contains approximately 100,000 tonnes of waste in 2005.

Capacity for site has 10.0 million kg of waste in total.

The current landfill area is expected to close in 2010 with an estimated average capacity of 10.0 million kg of waste.

Provisional design including preliminary site and/or conceptual site plan is currently available for review and design necessary will take a period of approximately 6 months to complete the design of the landfill to 2010.

The City of L'viv seeks specific cooperation to:

- Develop a biogas and/or methane project
- The project is asking to consider carbon financing
- The project needs more and have a contract to be signed

ENVIRONMENTAL BENEFITS

Year	2005	2006	2007	2008	2009
CO ₂ (t/year)	10,000	10,000	10,000	10,000	10,000
CH ₄ (t/year)	10,000	10,000	10,000	10,000	10,000

Source: Mariupol City State Administration

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 State Administration and operated by the Chernivtsi Waste Company. The Chernivtsi landfill handles and maintains the site under the supervision of the Chernivtsi City State Administration.

The site covers 1,000 ha and contains approximately 1,000,000 tonnes of waste in 2005.

Capacity for site has 4.0 million tonnes of waste in total.

The current landfill area is expected to close in 2010 with an estimated average capacity of 1.2 million tonnes of waste.

Provisional design including preliminary site and/or conceptual site plan is currently available for review and design necessary will take a period of approximately 6 months to complete the design of the landfill to 2010.

The City of Chernivtsi seeks specific cooperation to:

- Develop a biogas and/or methane project
- The project is asking to consider carbon financing
- The project needs more and have a contract to be signed

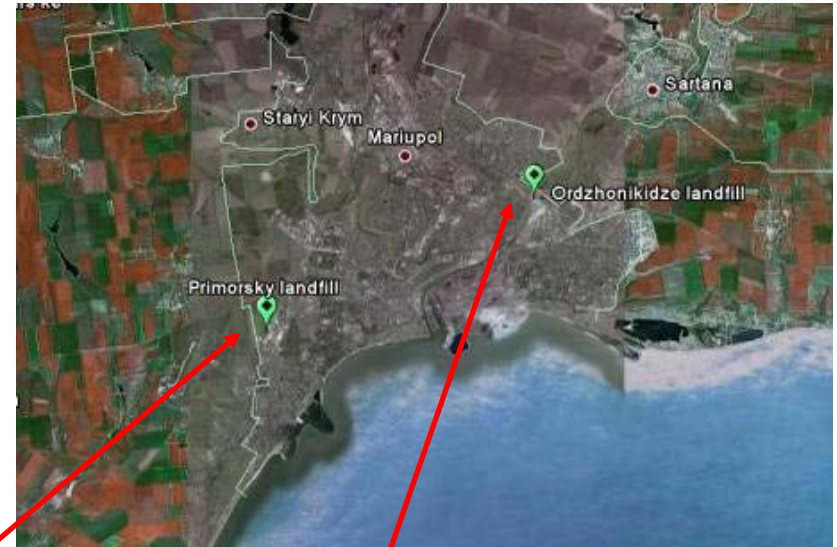
ENVIRONMENTAL BENEFITS

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO ₂ (t/year)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
CH ₄ (t/year)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000

Source: Mariupol City State Administration

- Lviv landfill
- Mariupol landfill
- Chernivtsi landfill

LFG project in Mariupol (Joint Implementation)



LFG project in Mariupol (Joint Implementation)



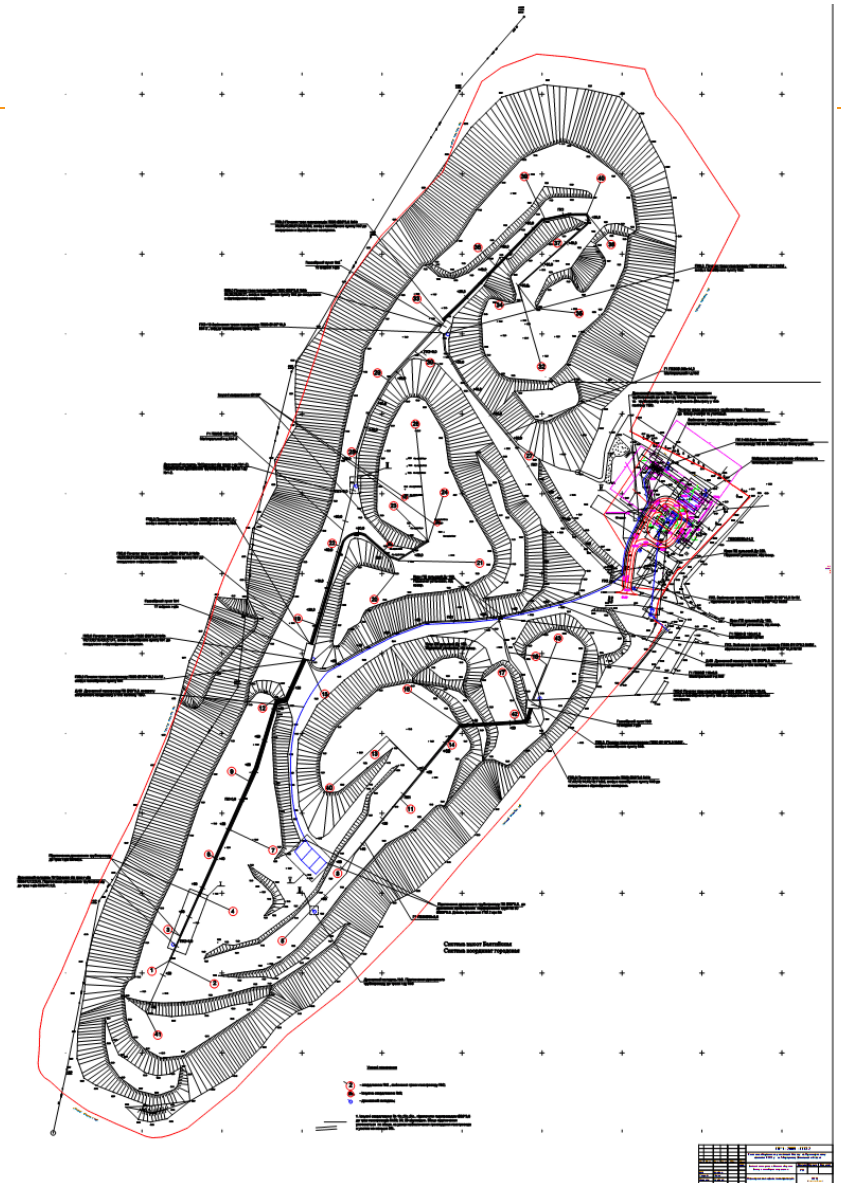
- Population – 480,000
- Starting year – 1967/1976
- Closure – 2009/2011
- MSW – 120,000 tones/year
- Area – 12+12 hectares
- Depth – 30/20 meters
- Waste in place – 2.5+2.5 mill tones

LFG project in Mariupol

Landfill #1 – design



52 wells,
3 gas collection points,
total piping – 6.4 km



LFG project in Mariupol

Landfill #1 - construction



LFG project in Mariupol

Landfill #1 – LFG utilization options

Start up – February 2010

Stage 1 (2010) –
flaring at Hofstetter
Umwelttechnik AG
HOFGAS® – Ready 800



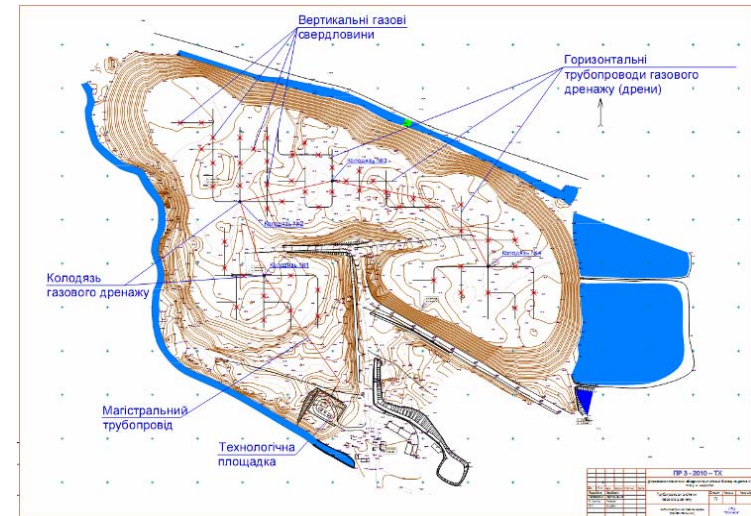
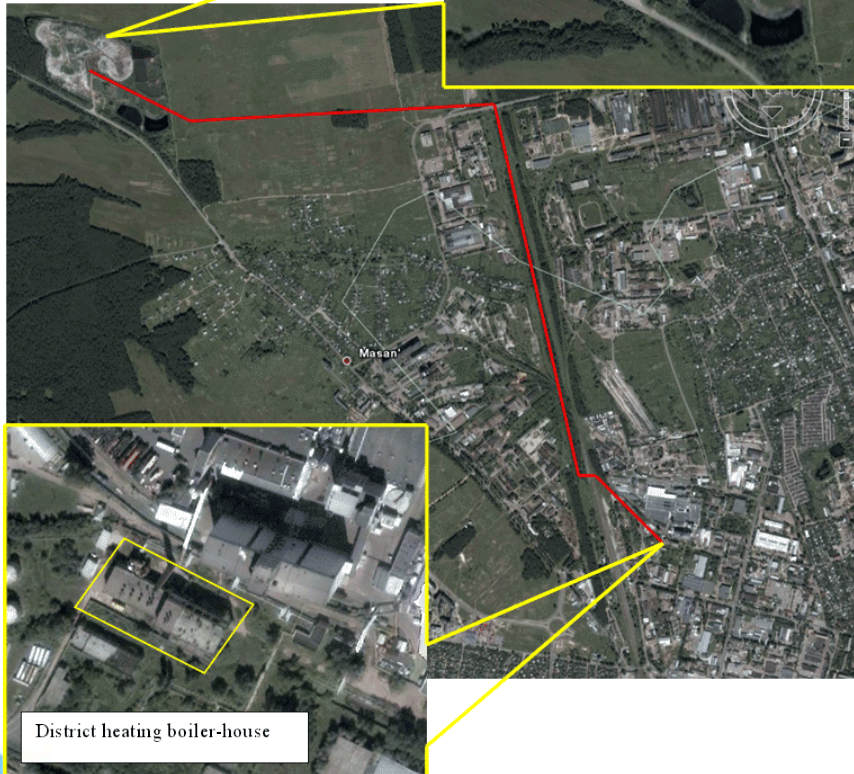
Stage 2 (2011) –
CHP Jenbacher engine or similar

Stage ¾ (2012) - Landfill #2



Chernigov landfill

LFG collection and transportation to boiler house (District heating and hot water supply)



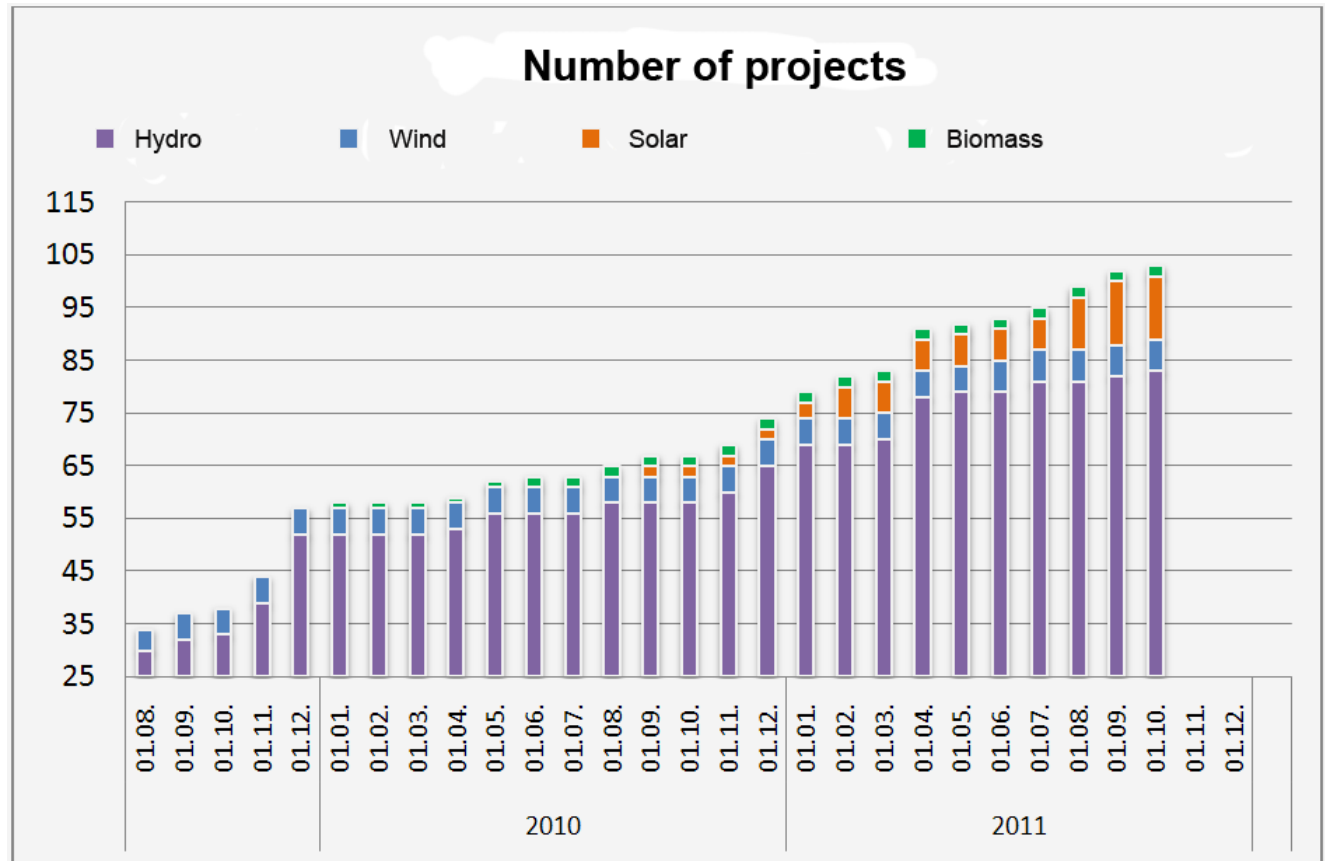
- Population – 300 000
- Starting year – 1961
- MSW – 110 000 - 180 000 t/year
- Area – 14.0 ha
- Depth – 15 - 20 m
- Waste in place -2.0 - 2.5 млн. ТОНН

- Well number - 56
- LFG flow – 300-500 m³/h
- GHG emission reduction – 20-35,000 t CO₂-eqv/year

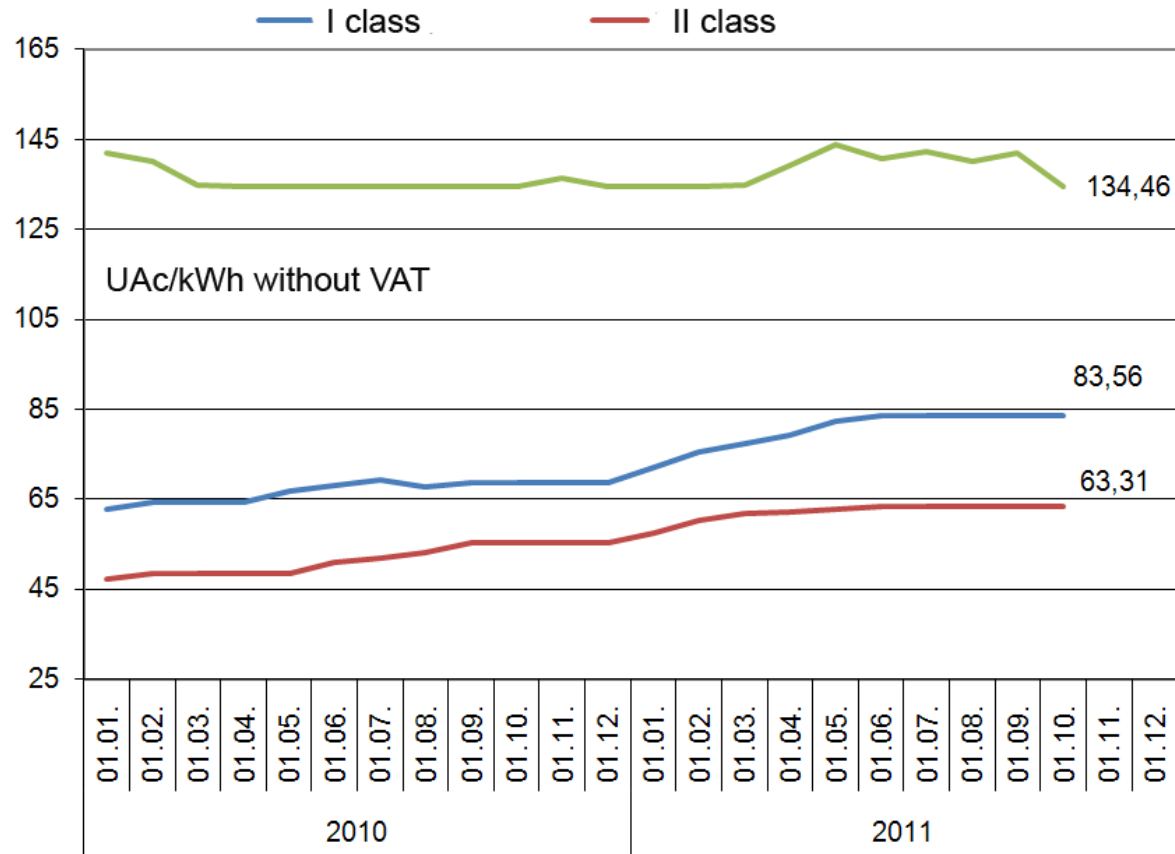
Joint Implementation Projects in Ukrainian landfills



Green tariff in Ukraine



Electricity tariff in Ukraine



Source: HKPE <http://www.nerc.gov.ua/>

Financial parameters of electricity/heat production from LFG

Main parameters	LFG-to-energy (cogeneration)			
	NT/ no heat	GT/no heat	NT/heat	GT/heat
Capacity (heat), kW	1404		1404	
Capacity (power), kW	1250		1250	
Capital cost, UAH	31 958 330		34 213 500	
O&M cost, UAH	1 702 590		1 872 850	
Financial parameters	no ERU/ERU	no ERU/ERU	no ERU/ERU	no ERU/ERU
NPV, UAH	-10 081 555 / 1 668 565	2 164 602 / 13 914 723	-9 074 071 / 3 345 414	3 172 087 / 15 591 572
IRR, %	3% / 19%	20% / 33%	6% / 21%	21% / 34%
Simple payback period, years	8,7 / 4,6	4,5 / 3,4	7,5 / 4,3	4,4 / 3,3
Discounted payback period, years	- / 5,3	5,2 / 3,6	- / 4,9	5,0 / 3,5

Notes: Discount rate – 17%; Inflation – 10,2%; ERU – 100 UAH/tCO₂-eqv

Normal electricity tariff – 0,82 UAH/kWh; Green electricity tariff – 1,34 UAH/kWh;
Heat tariff – 113,6 UAH/Gcal

Problems and prospects of LFG technology development in Ukraine

- 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 LFG projects
- Ukraine is not big. Ukrainian landfills are relatively small
- The main GHG emission reduction potential is connected to the towns with population more than 200,000 – 33 towns
- 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

Problems and prospects of LFG technology development in Ukraine

- Previously LFG projects at old landfills could hardly be implemented without Kyoto Protocol
- Today LFG projects are supported by Green Tariffs (0,13-0,15 Euro/kWh)
- Implementation of the strategy of new regional landfill erection and old landfill closure will stimulate LFG technology development
- The usual method of LFG utilization can be power generation by IC-engines
- Condition would improve:
 - price for natural gas goes up
 - support of the government by green tariffs for electricity, taxes and custom exemption etc.
 - New landfills are going to be constructed.

Thank you for your attention

Yuri Matveev

E-mail: mtv@biomass.kiev.ua

www.biomass.kiev.ua

Tel./Fax: +38 (044) 223 55 04
p/o box 66, Kiev, 03067
Ukraine