The Global Methane Initiative

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

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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

<table>
<thead>
<tr>
<th>Town size (inhabitants)</th>
<th>Number</th>
<th>Total population (inhabitants)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-100,000</td>
<td>56</td>
<td>3,950,000</td>
<td>8.2</td>
</tr>
<tr>
<td>100-200,000</td>
<td>17</td>
<td>2,220,000</td>
<td>4.6</td>
</tr>
<tr>
<td>200-500,000</td>
<td>22</td>
<td>6,450,000</td>
<td>13.4</td>
</tr>
<tr>
<td>500-1000,000</td>
<td>6</td>
<td>4,980,000</td>
<td>10.4</td>
</tr>
<tr>
<td>&gt; 1000,000</td>
<td>5</td>
<td>7,670,000</td>
<td>16.0</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>25,270,000</td>
<td>52.6</td>
</tr>
</tbody>
</table>
## Ukrainian landfills and waste dumps

<table>
<thead>
<tr>
<th>Town</th>
<th>Population</th>
<th>Starting year</th>
<th>MSW, t/year</th>
<th>MSW in place, mill tones</th>
<th>Area, hectares</th>
<th>Depth, meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiev</td>
<td>2,642,000</td>
<td>1986</td>
<td>500,000</td>
<td>7.5</td>
<td>35.5</td>
<td>15-20</td>
</tr>
<tr>
<td>Kharkiv</td>
<td>1,622,000</td>
<td>1975</td>
<td>200,000</td>
<td>2.2</td>
<td>20.8</td>
<td>30</td>
</tr>
<tr>
<td>Dniproperovsk</td>
<td>1,050,000</td>
<td>1998</td>
<td>85,000</td>
<td>0.5</td>
<td>7.5</td>
<td>15</td>
</tr>
<tr>
<td>Odessa</td>
<td>1,005,000</td>
<td>1972</td>
<td>250,000</td>
<td>5.3</td>
<td>30</td>
<td>22-25</td>
</tr>
<tr>
<td>Donetsk</td>
<td>1,000,000</td>
<td>1991</td>
<td>150,000</td>
<td>2.5</td>
<td>21.5</td>
<td>10-15</td>
</tr>
<tr>
<td>Zaporizhzhia</td>
<td>800,000</td>
<td>1952</td>
<td>270,000</td>
<td>8-12</td>
<td>47</td>
<td>25</td>
</tr>
<tr>
<td>Lviv</td>
<td>730,000</td>
<td>1959</td>
<td>230,000</td>
<td>8.4</td>
<td>33.3</td>
<td>35</td>
</tr>
<tr>
<td>Mariupol</td>
<td>480,000</td>
<td>1967/76</td>
<td>100,000</td>
<td>2.5+2.5</td>
<td>12+12</td>
<td>30/20</td>
</tr>
<tr>
<td>Luhansk</td>
<td>450,000</td>
<td>1979</td>
<td>80,000</td>
<td>2.5</td>
<td>8.4</td>
<td>20-25</td>
</tr>
<tr>
<td>Khmelnitskiy</td>
<td>250,000</td>
<td>1956</td>
<td>75,000</td>
<td>3.0</td>
<td>8.8</td>
<td>35</td>
</tr>
</tbody>
</table>
Ukrainian landfills and waste dumps

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

- **Ukrainian towns** generate **10-12 mill tonnes** 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.
GMI projects
LFG assessment reports

- Khmelnitskiy
- Lviv
- Lutsk
- Chernivtsy
- Mariupol
- Sumy
- etc.
GMI projects
LFG assessment - Khmelnitskiy

- **Landfill**
  - Starting year - 1956
  - MSW – 75,000 tones/year
  - Area – 8.8 hectares
  - Depth - 35 meters
  - Waste in place – 3.0 mill tonnes
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 m$^3$/h
  - Methane content – 65-35%
  - Oxygen content – < 0.8%
GMI projects
LFG projection based on pump test - Mariupol

Lo total = 84.0 m$^3$/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**

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

### Waste Category: L₀ Values (m³/Mg)

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>L₀ Values (m³/Mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Food, Other Organics</td>
<td>69</td>
</tr>
<tr>
<td>2. Garden and Park Waste</td>
<td>126</td>
</tr>
<tr>
<td>3. Paper and Textiles</td>
<td>214</td>
</tr>
<tr>
<td>4. Wood, Rubber, Leather, Straw</td>
<td>201</td>
</tr>
</tbody>
</table>

### Climate Region:

<table>
<thead>
<tr>
<th>Climate Region:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Precipitation Range, mm:</td>
<td>360-429</td>
<td>430-499</td>
<td>500-599</td>
<td>600-699</td>
</tr>
<tr>
<td>Average Annual Precipitation:</td>
<td>389 mm</td>
<td>456 mm</td>
<td>558 mm</td>
<td>645 mm</td>
</tr>
<tr>
<td>Average 24-Hour Temp. (°C):</td>
<td>8.9</td>
<td>9.2</td>
<td>7.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Waste Category:</td>
<td>Assigned k Values (1/year):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Food, Other Organics</td>
<td>0.110</td>
<td>0.120</td>
<td>0.140</td>
<td>0.150</td>
</tr>
<tr>
<td>2. Garden and Park Waste</td>
<td>0.055</td>
<td>0.060</td>
<td>0.070</td>
<td>0.075</td>
</tr>
<tr>
<td>3. Paper and Textiles</td>
<td>0.022</td>
<td>0.024</td>
<td>0.028</td>
<td>0.030</td>
</tr>
<tr>
<td>4. Wood, Rubber, Leather, Straw</td>
<td>0.011</td>
<td>0.012</td>
<td>0.014</td>
<td>0.015</td>
</tr>
</tbody>
</table>
Ukrainian LFG model. Version 1.0

- 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

- 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 км
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

### Financial parameters of electricity/heat production from LFG

<table>
<thead>
<tr>
<th>Main parameters</th>
<th>LFG-to-energy (cogeneration)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NT/ no heat</td>
<td>GT/no heat</td>
</tr>
<tr>
<td>Capacity (heat), kW</td>
<td>1404</td>
<td>1404</td>
</tr>
<tr>
<td>Capacity (power), kW</td>
<td>1250</td>
<td>1250</td>
</tr>
<tr>
<td>Capital cost, UAH</td>
<td>31 958 330</td>
<td>34 213 500</td>
</tr>
<tr>
<td>O&amp;M cost, UAH</td>
<td>1 702 590</td>
<td>1 872 850</td>
</tr>
<tr>
<td><strong>Financial parameters</strong></td>
<td>no ERU/ERU</td>
<td>no ERU/ERU</td>
</tr>
<tr>
<td>NPV, UAH</td>
<td>-10 081 555 / 1 668 565</td>
<td>2 164 602 / 13 914 723</td>
</tr>
<tr>
<td>IRR, %</td>
<td>3% / 19%</td>
<td>20% / 33%</td>
</tr>
<tr>
<td>Simple payback period, years</td>
<td>8,7 / 4,6</td>
<td>4,5 / 3,4</td>
</tr>
<tr>
<td>Discounted payback period, years</td>
<td>- / 5,3</td>
<td>5,2 / 3,6</td>
</tr>
</tbody>
</table>

**Notes:** Discount rate – 17%; Inflation – 10.2%; ERU – 100 UAH/tCO$_2$-equiv

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

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