EXECUTIVE SUMMARY

Helsinki Metropolitan Council, YTV coordinates the waste management of four Helsinki Metropolitan area cities and owns and operates the largest waste treatment site in Finland. The population of the Metropolitan area is around 980 000 that is approximately one fifth of the population of the whole Finland. Metropolitan area generates 1.2 million tonnes of wastes annually. About one half the waste amount is municipal solid waste. YTV organizes the household waste collection, transport and treatment of the whole Metropolitan area while the waste management of commercial activities area almost fully organized and operated by private companies. The waste management centre, Ämmassuo, consists of two large landfill area and composting plant for biowaste. The landfill area currently in use was established in 1986 and will be closed in the end of year 2007 due to EU landfill directive. From 2008 new landfill area of almost 70 hectares is taken in use. Ämmässuo waste management centre receives over 500 000 tonnes of various fractions of wastes annually. The amount of household waste is 200 000 per year. The landfill area of 50 hectares that is currently in use is equipped with landfill gas collection network. Network consists of 220 gas wells, 23 kilometres of gas pipelines, 3 regulating stations, 4 pumping stations, 3 flares, and drying and boosting unit. Existing landfill is able to produce 9000-10 000 Nm$^3$/h landfill gas with methane content of app. 50-52 %. Today 7500 Nm$^3$/h of gas is collected. The gas production has been estimated to increase for few more years reaching the maximum production level of about 12 000 Nm$^3$/h. From 1998 on all the collected has been treated by flaring. In November 2004 the boosting and drying unit and the pipeline was taken in use. In boosting and drying unit the moisture content of the landfill gas is decreased from 15 g/Nm$^3$ to less than 5 g/Nm$^3$ and gas is pressurized to 1 bar level. Average of 4500 (max. 5200) Nm$^3$/h of treated gas is transferred to the power plant via 11 kilometres long pipe line. Gas is utilised for district heat production in 40 MW heat only boiler (HOB) that has been commissioned also in 2004. Currently with landfill gas only app. 25 MW power production can be reached. In the future it is possible to increase the power production up to 37 MW by additional boosting unit. After the test period both the boosting and drying unit and the power generation unit have been worked without any major problems.
1. INTRODUCTION

Helsinki Metropolitan Area Council (in Finnish, Pääkaupunkiseudun yhteistyövaltuuskunta, or YTV) is a statutory, co-operative organisation operating in the municipalities of Helsinki, Espoo, Vantaa and Kauniainen. YTV was established in 1970 based on specific YTV-law given by Finnish Parliament. YTV works on waste management, especially the household waste, public transport (partially together with City of Helsinki), development planning (land use, population statistics etc.), and in addition monitors the air quality in the metropolitan area.\(^1\)

The YTV Waste Management Department plans and develops waste management and co-ordinates waste transports; it handles waste and composes biowaste, collects in some extent reusable waste, and collects and treats hazardous waste. YTV also gives advice and regulations on waste management in the metropolitan area. In 2004 the annual operational turnover of the Waste Management Department was 50 M€ and in addition to that various investments for the waste management centre infrastructure were done for 20 M€. Currently YTV’s Waste Management Department employees 140 people.\(^1,2\)

The population of the metropolitan area is around 980 000 on an area of approximately 740 km\(^2\). The area is about 95% urban and is made up of 75% high rise apartment blocks. Approximately 450 000 households are covered. The average population density is 1 260 people per km\(^2\), though the density is much greater in the urban centre.

The metropolitan area produces about 1.2 million tons of waste every year. Approximately one half of it is municipal solid waste while the rest of the total amount origins from various sources like industry, construction and demolition and energy production. Over 500 000 tons of the total amount of waste is taken to the YTV waste-handling centre in Espoo. The only landfill site in the metropolitan area is also located at the same site and it receives about 300 000 tons of municipal waste while rest of the received wastes consists of various waste fractions. Some 55% of all the waste produced in the metropolitan area is recycled or reused.\(^3\) For municipal solid waste the average utilization rate is only about 35 %. This is mainly because MSW is not used in energy production than only in very small amounts (as recycled fuel, REF).

YTV arranges waste (refuse and biowaste) transport for the households. Industrial and commercial property owners are mainly responsible for collection and transport of their own waste.

The "YTV areas" are divided into 60 sub areas covering over 60 000 residential buildings and approximately 5000 commercial buildings. YTV prepares waste transport plans for each sub area and then the plans are sent out for bidding to private companies. A winning company gets a fixed price contract for five years period. The system has proven to cut the collection costs. Simultaneously the quality and environmental impacts of the waste transports has improved due to the challenging and economically encouraging demands set forth in the contracts. Generally, waste is collected and transported by waste collection vehicles equipped with compaction machinery. Over 80% of household waste is collected in 600 – 660 litres waste bins.

The operational strategy of YTV Waste Management has been divided into three substrategies:
- The waste minimisation strategy, which aims at reducing the amount of waste generated and increasing recycling through source separation of waste
- The strategy for safe and customer-oriented waste management services that includes the waste collection, regional waste stations and waste receiving stations for households and small commercial customers, and
- The strategy for treatment and final disposal of waste that covers also the land fill gas utilization.

1.2 Collection and composting of biowaste

Separate collection of biowaste, started year 1993 and is covering the whole area. The collection takes place weekly. All compostable food and garden wastes are collected.

Larger blocks over nine flats/block, which are covering about 75% of the population and larger producers (cafeterias or restaurants with over 50 kg of biowaste per week) have to join the separate collection of biowaste. Small apartment blocks (less than 10 apartments) and one family houses do not participate in biowaste collection but YTV recommends strongly to home composting. Also a wide variety of information material for home composting is available in YTV’s waste advising department.

In 2004, 43 000 tonnes of biowaste were collected. Around 30 000 tonnes originated from households while 13 000 tonnes came from industry. Addition to this about 6000 tonnes of green waste was collected and treated. This material was delivered to the Ämmässuo biowaste composting plant. The capacity of existing tunnel composting plant is 30 000 tonnes/year. Due to continuously increasing biomass amounts the decision on building new composting plant was made in May this year. The construction works were started in June and the new 49 000 tonnes per year of capacity, fully automated composting should be in use in the beginning of 2007. Preliminary plans for anaerobic treatment of biowaste are already on place.

2. LAND FILLING OF RESIDUAL WASTE

The Ämmässuo landfill is the largest disposal site in Nordic Countries. The total area is 150 hectares and the heaping area currently in use covers 50 hectares. The site was taken in use in 1987 and until the end of 2004 the volume of waste disposed was over 8 million tonnes. The current maximum height of the filling area is 65 meters. In 2004, 275 000 tonnes of residual household waste were deposited in Ämmässuo landfill.

Waste deliveries to Ämmässuo are fully controlled. All waste loads are weighed and the amounts and type of materials are registered on computer. Waste tipping on the area is monitored by YTV’s load inspectors, who check the grades of refuse coming into the landfill. After tipping, the waste is crushed and compressed with landfill compactors and covered daily with a layer of soil.

The landfill is built partly on solid rock and partly on 2 mm thick plastic membrane, which protects the groundwater. All leachate waters in the landfill area are channelled through drains to their own balancing basin, where they are pumped over 6 kilometres to Suomenoja sewage works in Espoo for treatment.

The current landfill area’s filling volume would last till 2009-2010. Because of the changes in European legislation the closing of the landfill will be made by the end of the year 2007. Closing the landfill includes a compact multilayer surface structure, leachate recirculation system, efficient collection of landfill gas and water management system. Cost estimation for the whole closing project is about 40 – 50 M€.
Construction will be done phase by phase. Slopes will be closed during the 2003 – 2006. The center area will be affected by the deformations caused by settling, so the first temporary structures will be constructed in 2007 – 2009 and the final structures will be completed as late as 2020.

Quarrying of the new land filling area of approximately 70 hectares was started already in 1992. First parts of new area will be ready for use in the end of 2007. The cost estimation of building the new land filling area with the bottom layer construction meeting the EU-directive demands, gas and waste water collection and treatment systems and with terminals is about 100 M€.

3. LANDFILL GAS COLLECTION, TREATMENT AND UTILIZATION

The anaerobic decomposition of organic waste in landfills produces landfill gas which is mainly a composition of carbon dioxide, methane and water vapour. Impurities such as hydrogen sulphide and halogen are present in small quantity. The degradation process of biowaste consists of four sequential steps. In aerobic stage the $O_2$ content of the produced gas lowers down to zero and the $CO_2$ content increases up to 30 %. During the second stage, the acid fermentation, $CO_2$ content increases from 30 % to 70-80 % and at the same time the $N_2$ content decreases closing the zero level. Around in two months the degradation process has reached the third stage, the unstable methane fermentation. In following two years during the methane fermentation the methane content of the gas increases up to 50 % and the $CO_2$ content lowers down to 40-45 %. After two years the methane fermentation has reached the stable stage and the methane formation continues stable for following 20-30 years. The factors influencing the degradation rate are among other things the quality of waste, humidity oxygen concentration, nutrients and temperature. One tonne of municipal solid waste can generate 100-200 normal cubic meter of gas. The energy content of one cubic meter of landfill gas corresponds to $\frac{1}{2}$ cubic meter of natural gas or $\frac{1}{2}$ litre of fuel oil. The degradation process is presented in Figure 1. Since methane is considered as a strong green house gas, around 20 times stronger than carbon dioxide, and because of its easy utilization potentiality in energy production (heat and/or electricity), and because by effective collection of landfill gases the harmful odour problems can be avoided the recovery of landfill gas is ecologically and economically feasible.

The composition of the landfill gas recovered from Ämmässuo disposal area is presented in Table 1.
Table 1. Composition of the Ämmässuo disposal area landfill gas (in 2001 and 2003).

<table>
<thead>
<tr>
<th>Substance</th>
<th>2001</th>
<th>2003</th>
<th>Notes related to utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>%</td>
<td>%</td>
<td>- Fuel and greenhouse gas</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>%</td>
<td>%</td>
<td>- Possible utilization in industrial processes</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>%</td>
<td>%</td>
<td>- Nd decreases the heating value of the gas</td>
</tr>
<tr>
<td>Oxygen</td>
<td>%</td>
<td>0</td>
<td>- 0-3.7 explosive</td>
</tr>
<tr>
<td>TVOC</td>
<td>mg/m³</td>
<td>20-200</td>
<td>- 301-706 partly toxic</td>
</tr>
<tr>
<td>Sulphur (tot)</td>
<td>mg/m³</td>
<td>107-247</td>
<td>- 2600 increases corrosion risk</td>
</tr>
<tr>
<td>Halogenes (tot)</td>
<td>mg/m³</td>
<td>16.2-23.9</td>
<td>- 0 corrosion and dioxine formation risk</td>
</tr>
<tr>
<td>Si-compounds</td>
<td>mg/m³</td>
<td>1.3-2.1</td>
<td>- 7.6 damages in power engines (piston and turbine)</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/m³</td>
<td>&lt; 2</td>
<td>- Nd</td>
</tr>
</tbody>
</table>

3.1 Recovery and Treatment System

The construction of the landfill gas collection system at Ämmässuo landfill started at the same time the filling of existing area was taken in use. Existing land filled waste volume of 9 million tonnes of wastes produces approximately 9 000 - 10 000 Nm³/h of gas. Due to effective collection network over 70 % of gas can be recovered. The gas production is estimated to increase in following years. The collection capacity will be enlarged respectively.

Today the collection system consists of:

- 220 gas wells situate horizontally and vertically
- 4 (5) pumping stations
- 7 regulating stations
- 3 flares and
- drying and boosting station for the gas to be utilised

The gas wells are located around 50 meters from each others building up a network that covers effectively the whole landfill area. Each well is covered with plastic hood and equipped with manual control valve. Gas is transported thorough the suction pipe to regulation station where the gas from separate wells is mixed to meet the quality
demands. The network is presented in Figure 2 and the illustration of the gas well is presented in Figure 3.

![Figure 2. The Gas well network.](image)

![Figure 3. Illustration of the gas well.](image)

Four gas pumping stations sucks the gas from the wells through regulation stations and increases the gas pressure to 1 bar before the gas enters the drying and boosting station. To remove the excess humidity (from 15 g/Nm³ to less than 5 g/Nm³) the gas is cooled.
down to + 2 °C before boosting it. Boosting is done by two root compressors (3500 Nm³/h). The caloric heating value of the gas is analysed and the volume of the gas is measured before gas enters the transfer pipe line. Figure 4 shows the picture of the drying and boosting station.

![Figure 4. The drying and boosting station.](image1)

### 3.2 Utilization for Energy Production

Boosted and dried landfill gas (LFG) is fed to the transfer pipe (DIN400) that leads to the power station located 11 kilometres away from the Åmmässuo waste management centre. The amount transferred is adjusted based on the local district heating capacity needed. Since the recovered gas amount is normally greater than amount needed for district heat production the excess gas is treated by burning it in torches at app. 1200 °C temperature. The aim of flaring is to convert methane in LFG into less harmful greenhouse gas CO₂. The picture of the flaring station is presented in Figure 5.

![Figure 5. The flaring station.](image2)
The district heating power station is owned and operated by energy company E-On Finland Ltd. The station consists of three heat only boilers (HOB). Two of them are older heavy oil fired boilers that are used mainly for peaking periods. Third boiler is fired with LFG or heavy oil. After robust filtering the gas enters the gas burner. The maximum thermal output of the boiler is 40 MW but currently average of 25 MW is reached with LFG due to lower heating value of the gas compared to heavy oil and the gas transfer capacity limitations. The consumption of the gas on full load is app. 4500 (max 5200) Nm3/h. Gas burns in over 1000 °C temperature and the water in district heating network is heated up from 44-55 °C to 77-120 °C. Due to low emission levels of LFG combustion the flue gas treatment is not used but the flue gases are lead into stack directly after the short duct.

Land fill gas utilization system (boosting and drying station, the transfer pipeline and the boiler was taken in use in October 2004. After few months of test run period the system has had no functional problems. Due to well functioning landfill gas utilization system the utilization rate of the gas produced at Ämmässuo landfill area is around 70 % of collected gas.

Figure 6 illustrates the view from the top of the boiler where the gas burner and gas injection system is located.

Figure 6. View from the top of the LFG fired boiler.

**CONCLUSION**

Helsinki Metropolitan Council, YTV coordinates the waste management of four Helsinki Metropolitan area cities and owns and operates the larges waste treatment site in Finland. The waste management centre, Ämmassuo, consists of two large landfill sites and composting plant for biowaste. The landfill area of 50 hectares that is currently in use is equipped with enhanced landfill gas collection network. The network consists of 220 gas well, 23 kilometres of gas pipes, 3 regulating stations, 4 pumping stations, 3 flares, and drying and boosting unit. Existing landfill is able to produce 9000-10 000 Nm³/h landfill gas with methane content of app. 50-52 %. Currently 7500 Nm³/h of gas is collected. From
1998 on all the collected has been treated by flaring. In November 2004 the boosting and drying unit and the pipeline was taken in use. In boosting and drying unit the moisture content of the landfill gas is decreased from 15 g/Nm3 to less than 5 g/Nm3 and gas is pressurised to 1 bar. Average of 4500 Nm³/h of treated gas is transferred to the power plant via 11 kilometres long pipe line. Gas is utilised for district heat production in 40 MW heat only boiler. Currently with landfill gas only app. 25 MW power production can be reached. In the future it is possible to increase the power output up to 37 MW with additional boosting of the landfill gas. After the test period both the boosting and drying unit and the power generation unit have been worked without any major problems.

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6. YTV Waste Management Department, Ämmässuo landfill gas composition, internal research report, Helsinki, Finland 2003 (in Finnish)