

LANDFILL GAS TO ENERGY- COMBINED ENGINE AND ORC-PROCESS

Dr Petri Kouvo

Helsinki Region Environmental Services Authority

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Helsinki Regional Environmental Services Authority, HSY

- **HSY is responsible for waste and water management of four Helsinki Metropolitan area cities**
- **Turnover over 300 million euros**
- **Number of employees: 750**
- **HSY Waste Management:**
 - **Provides waste management services for over 1 million inhabitants of Metropolitan area**
 - **Owns and operates the largest landfill site in Nordic Countries**
 - **Turnover: 100 million euros**
 - **Number of employees: 140**
 - **Amount of waste received annually: 700 000 tons**
 - **MSW app. 300 000 tons**



Landfill gas

- 1 ton of waste can generate 100 – 200 m³ gas
- The energy content ca 50 % of that of natural gas
- 2 m³ landfill gas corresponds to 1 litre fuel oil
- Main components: CH₄ (55 %), CO₂ (45 %)
- Trace components: O₂, N₂, H₂S, VOC, halogens



Recovery benefits

- Reducing odour annoyance
- Reducing GHG-emissions
- Reducing fire- and explosion risk
- Utilization possibilities of recovered gas

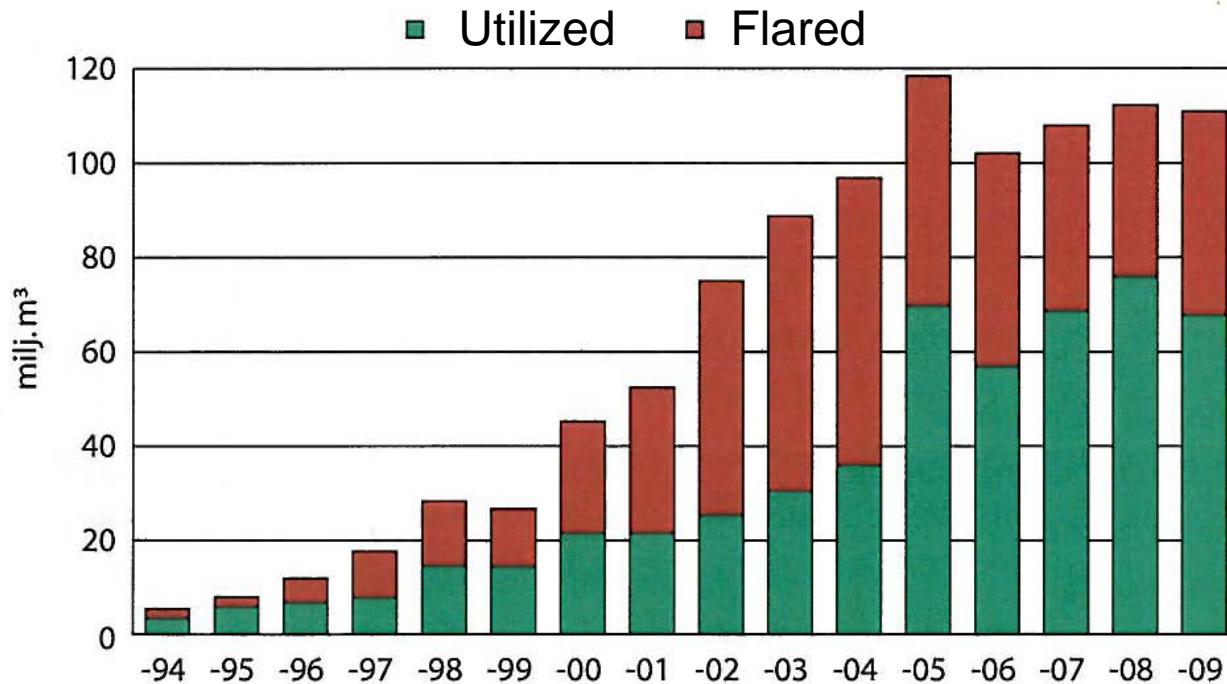
Gas recovery is provided by decision of the Council of State in Finland

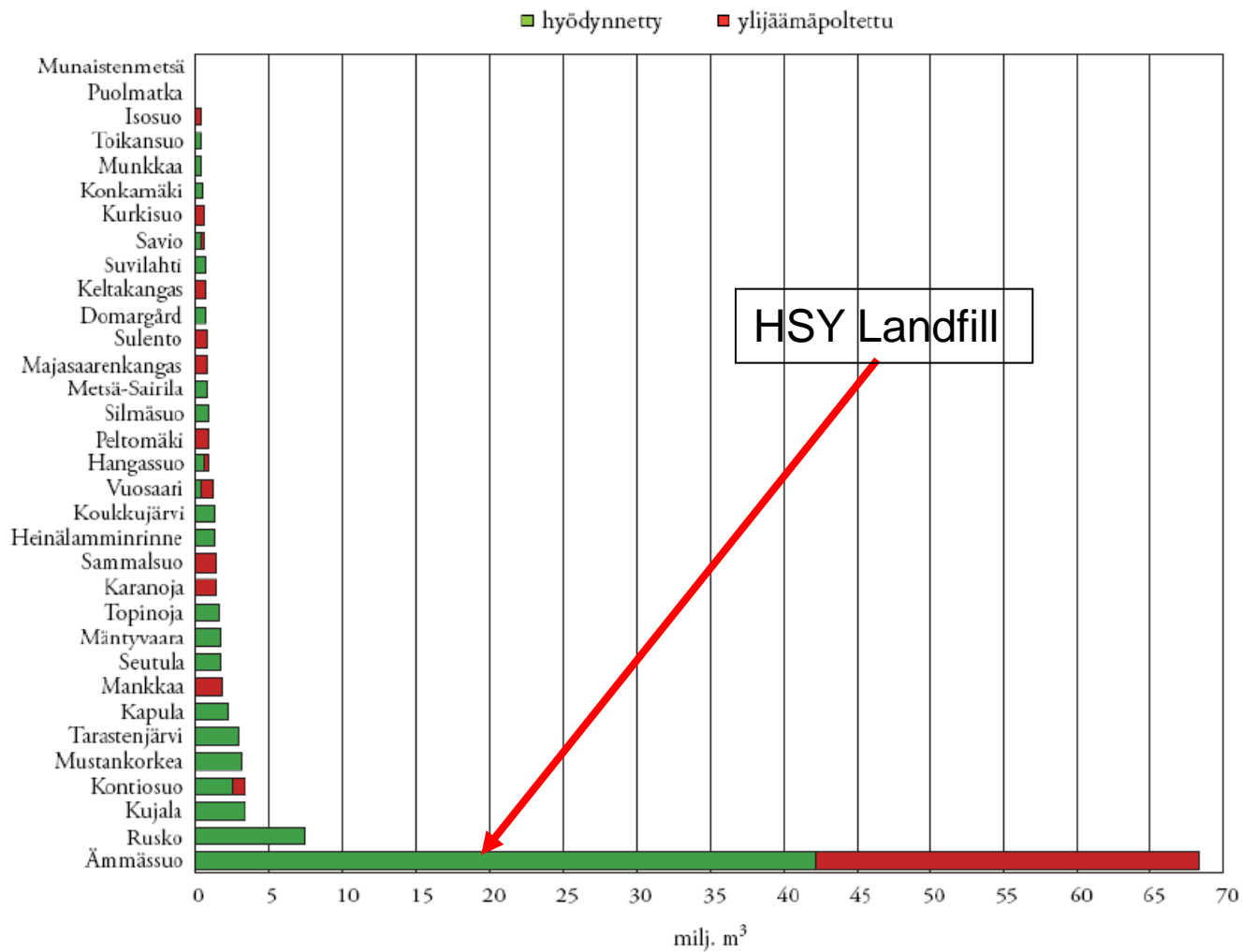
Utilization alternatives of landfill gas

- **Heating**
- **Electricity**
- **Combined heat and power**
- **Industrial processes**
- **Vehicle fuel**

Recovery and utilization of landfill gas in Finland

- 2009 in total **110,9** million m³ gas recovered at 35 landfills
- **67,7** million m³ was utilized producing:
 - 251 GWh district heating
 - 17 GWh mechanical energy
 - 18 GWh electricity





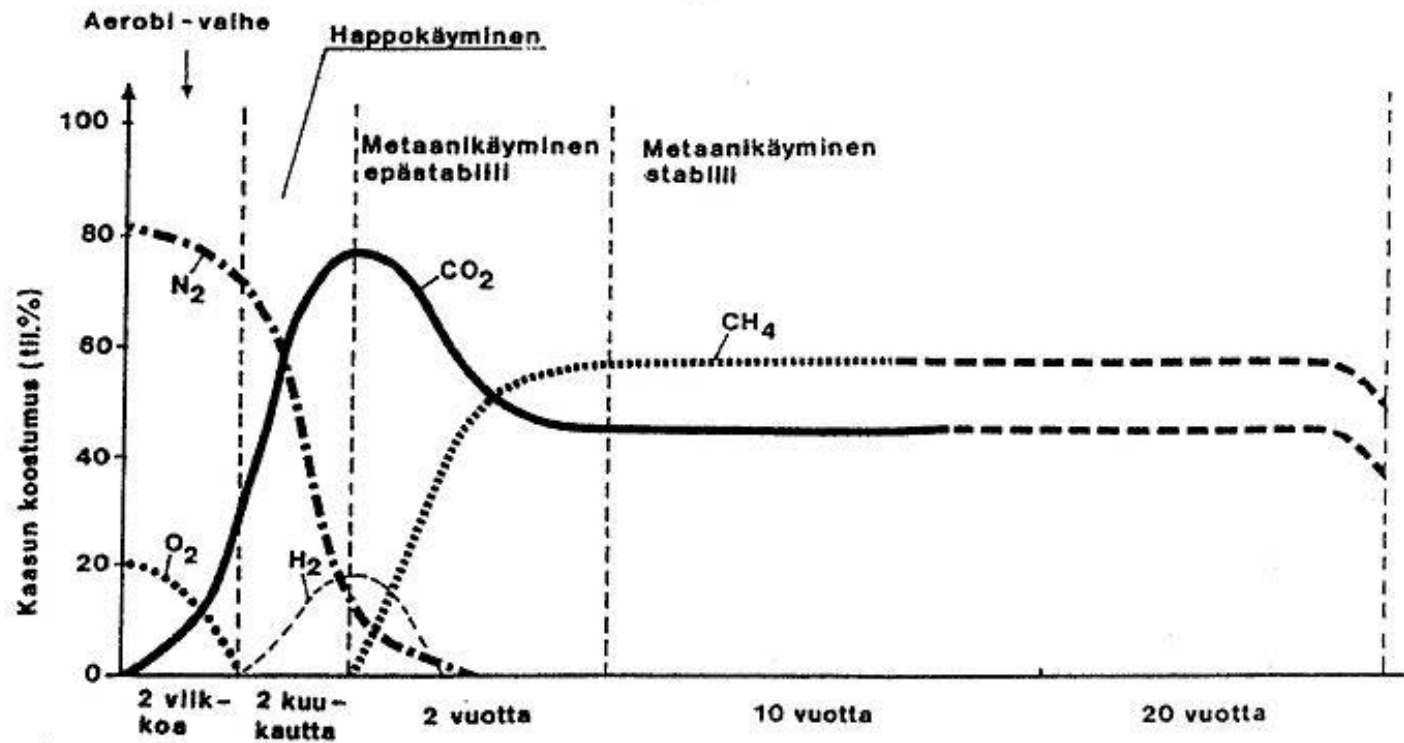
Recovered and utilized landfill gas in 2009

Landfill Gas formation

- **Gas is produced in anaerobic decomposition of organic waste**
- **The degradation process proceeds from aerobic acid stage to anaerobic methane phase**
- **The main components are methane, carbon dioxide and water vapour**
- **The gas also contains oxygen, hydrogen, nitrogen and small concentrations of impurities such as hydrogen sulphide and halogens**



The degradation process



Factors influencing the degradation rate

- **Quality of waste**
- **Humidity**
- **Oxygen concentration**
- **Sulphate concentration**
- **Nutrients** (optimal $COD_{cr}:N:P = 100:0,44:0,08$)
- **Temperature**
- **pH** (optimal 6 - 8)

Ämmässuo Landfill Site

- **Largest landfill site in the Nordic countries**
 - Old landfill area established in 1987 and closed in 2007, landscaping ongoing
 - New landfill area opened in 2007, currently in active use
- **Approximately 12 milj. ton waste disposed (2010)**
- **Area 52 ha (old landfill) + 62 ha (new landfill)**
- **Filling area height max 100 m from sea level, height of waste fill 40 m**
- **Gas recovery since 1996**
- **Landfill gas recovery over 7000 m³/h (2010)**



Gas recovery system

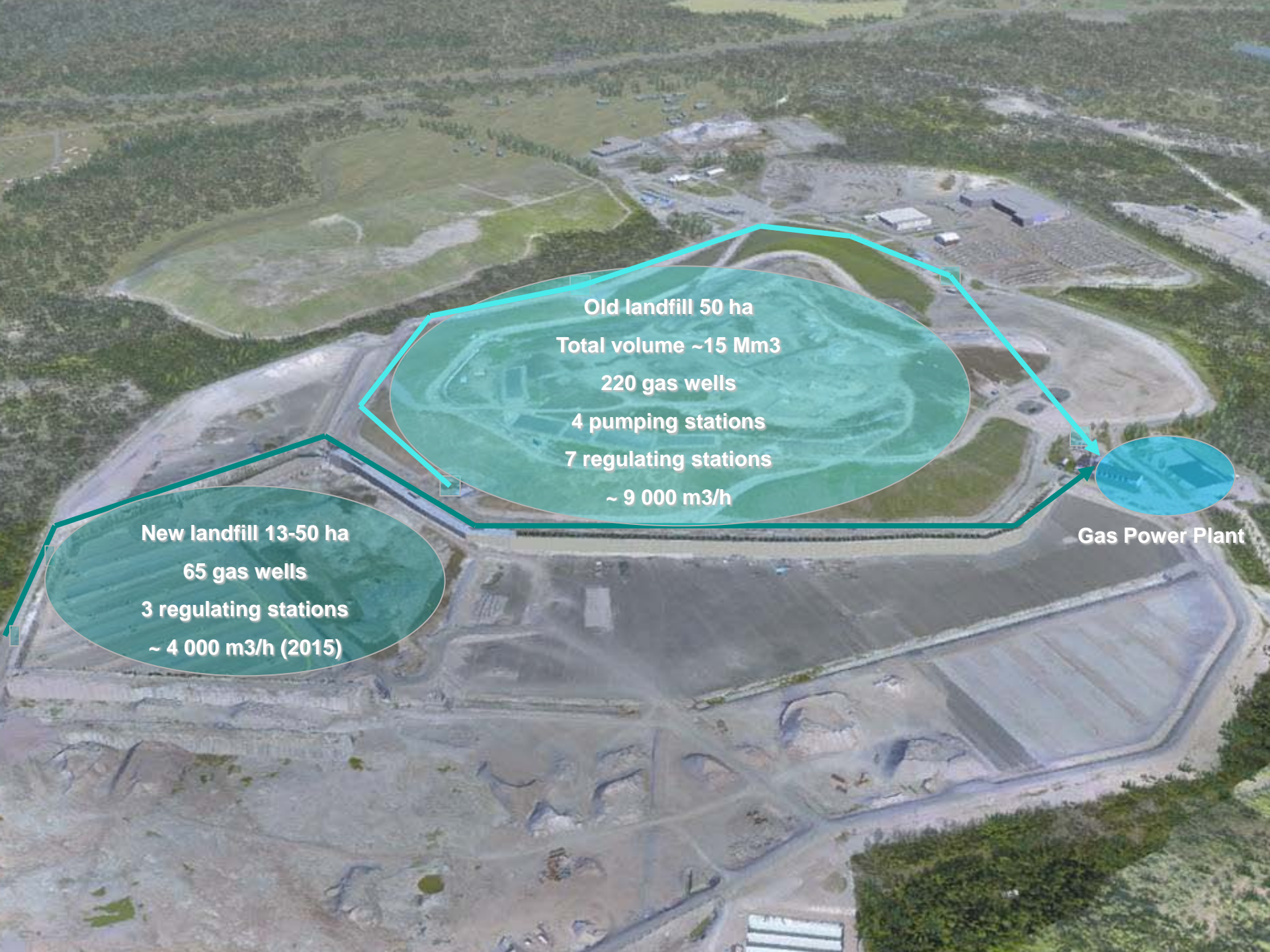
Old landfill

- 220 Gas wells
- 4 pumping stations
- 7 regulating stations
- 4 flares
- Drying and boosting station for the gas to be utilized

New Landfill

- 65 vertical gas wells with bottom collection
- 3 regulating stations with automatic suction pressure control
- 1 pumping station



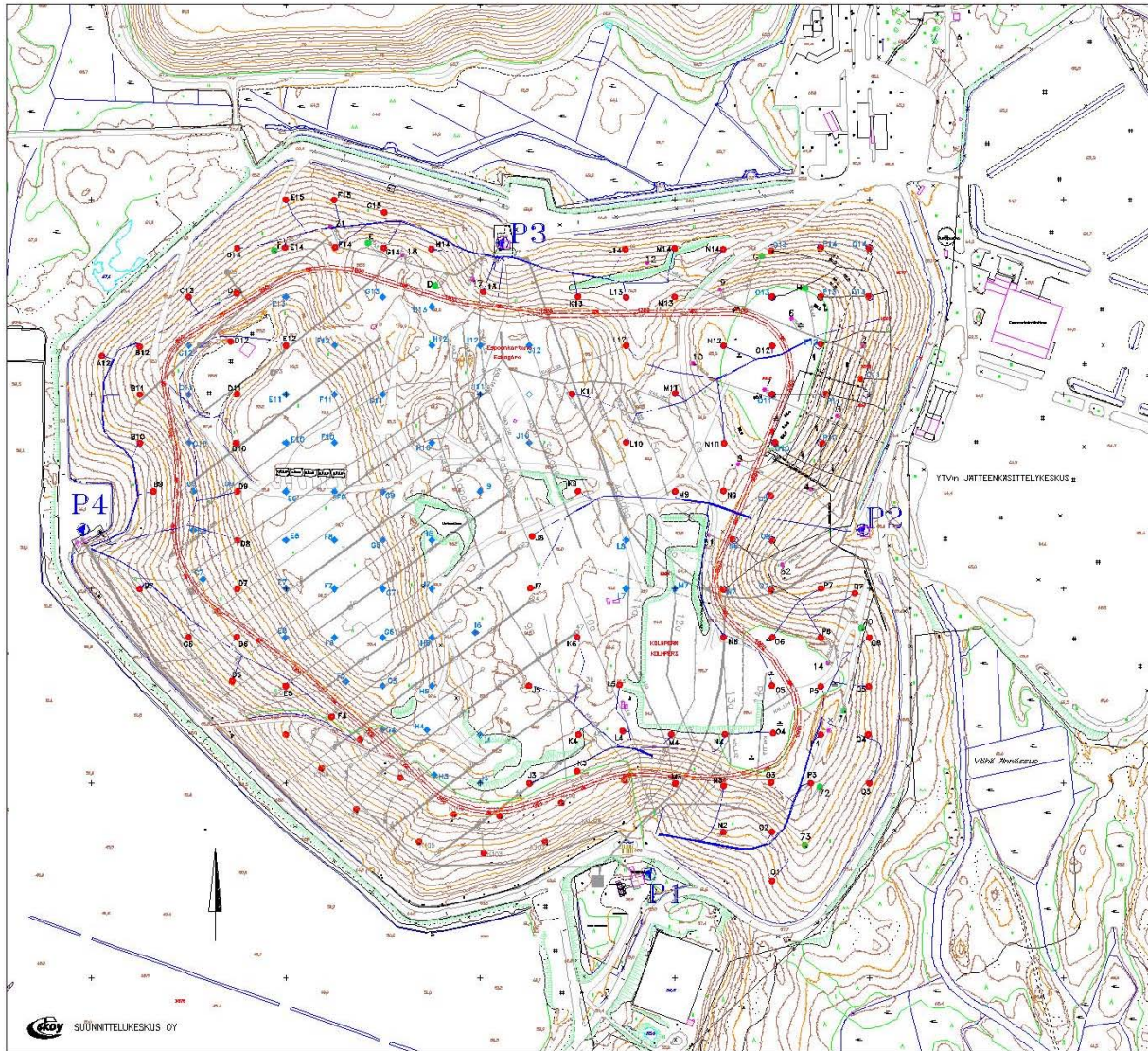


Old landfill 50 ha
Total volume ~15 Mm³
220 gas wells
4 pumping stations
7 regulating stations
~ 9 000 m³/h

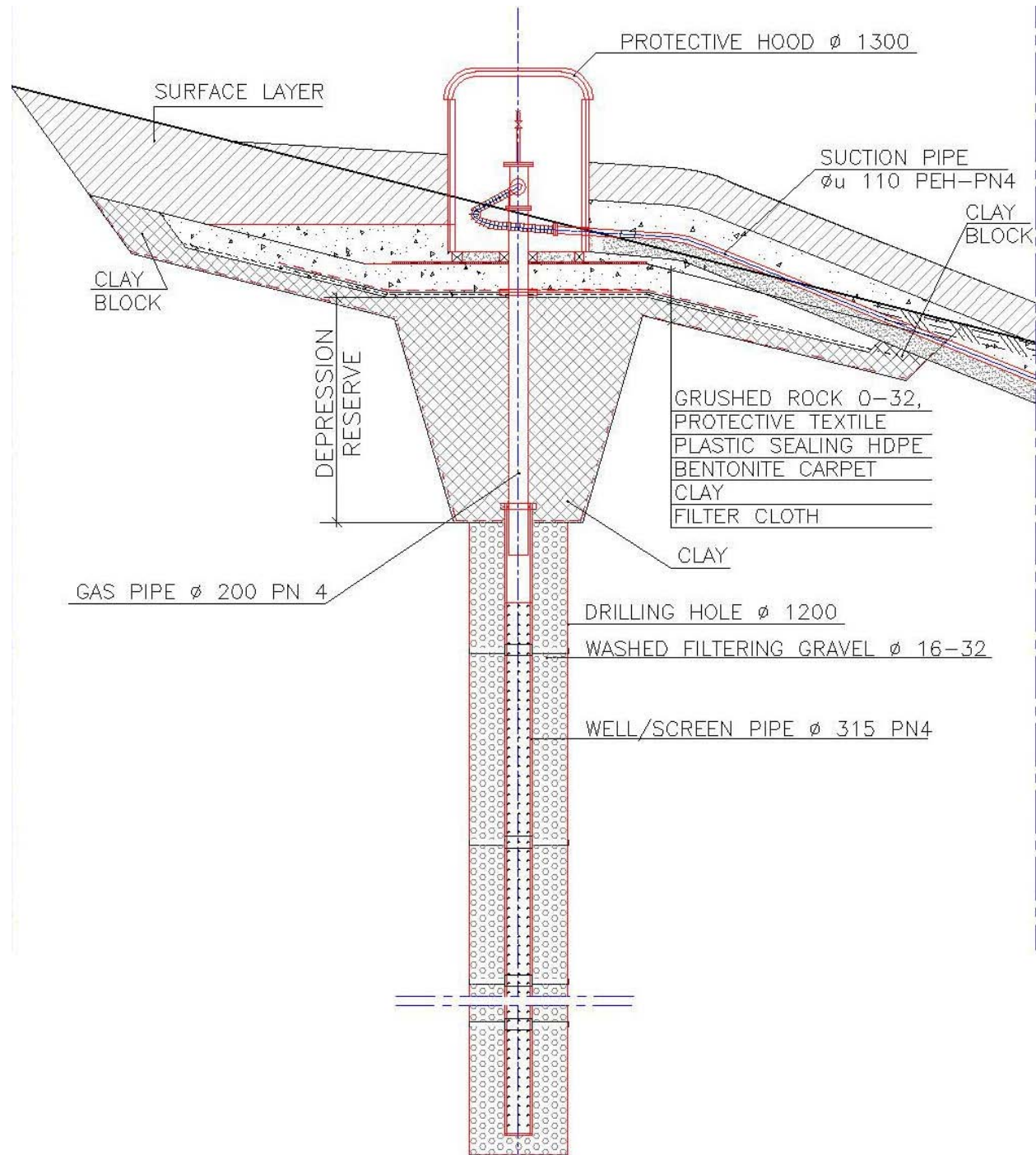
New landfill 13-50 ha
65 gas wells
3 regulating stations
~ 4 000 m³/h (2015)

Gas Power Plant

Gas well network



Gas well



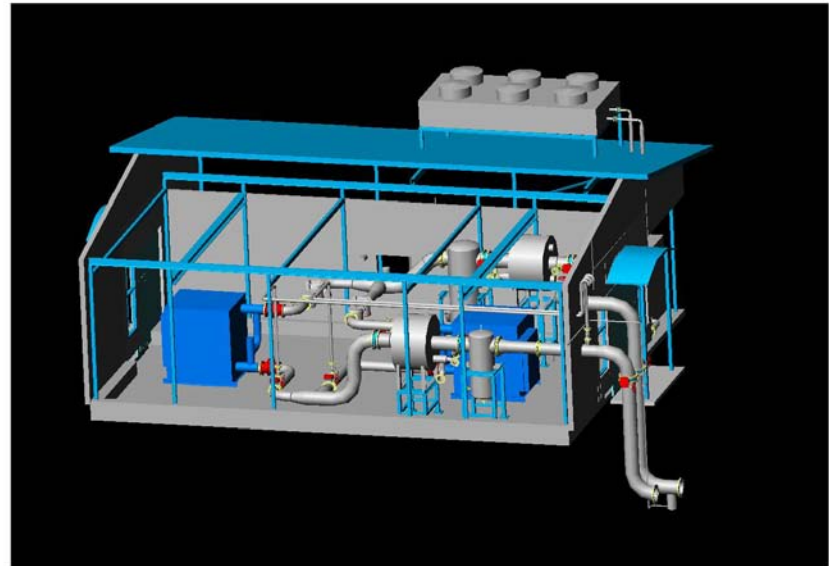
Gas utilization steps 1996-2011

- **1996** collection of the gas for flaring begins
- **2001** first study of utilization possibilities
 - About 15 % utilized in heating of the site buildings
- **2004** Landfill gas drying and boosting station and transfer line buildup
 - Landfill gas utilization in district heating production starts
 - 50 % utilization rate was reached
- **2007** Pumping capacity enhancement
 - Utilization rate 65 % was reached
- **2007** The planning of the Gas fired power plant starts
- **2009** Construction work of the power plant
- **2010** Power plant commissioning and start up in may 2010
 - Electricity and heat production begins, utilization rate nearly 100 %
- **2010-2011** ORC-process construction and commissioning



Drying and boosting station (2004)

- Gas drying by cooling to +2 °C
- Gas analysis and determination of caloric value
- Boosting: 1 bar; 2 rotary compressors a' 3500 Nm³/h
- Gas cooling and quantity measurement
- Basically unmanned plant, which is controlled by the gas demand at the district heating plant (until 5/2010)



Transfer and utilization (2004)

- **Transfer pipe length 11 km,**
- **Utilization in Fortum's 37 MW (maximum gas consumption) district heating boiler**
- **Energy production 140 GWH/a (32 million m³/a gas)**
- **Substitutes the use of fossil fuels and diminishes accordingly emissions from combustion of fossil fuels**
 - 45 ton/a reduction of carbon dioxide
 - 70 ton/a reduction of sulfur dioxide
 - 80 ton/a reduction of nitrogen oxides

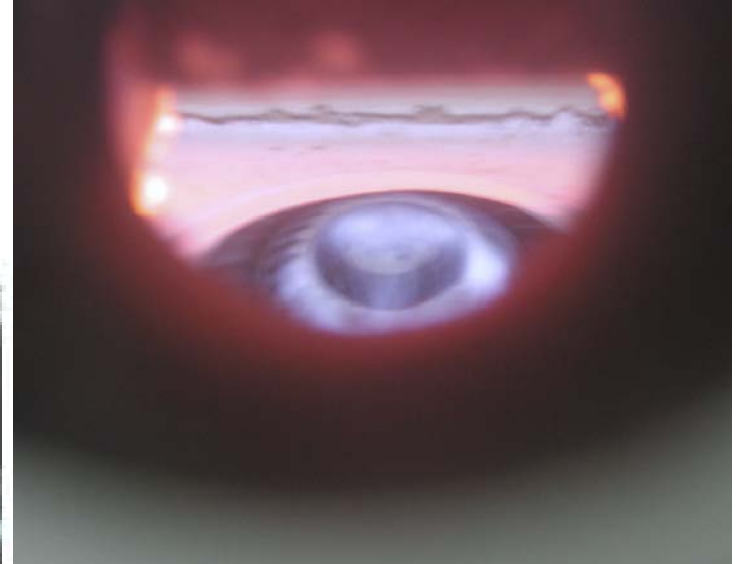
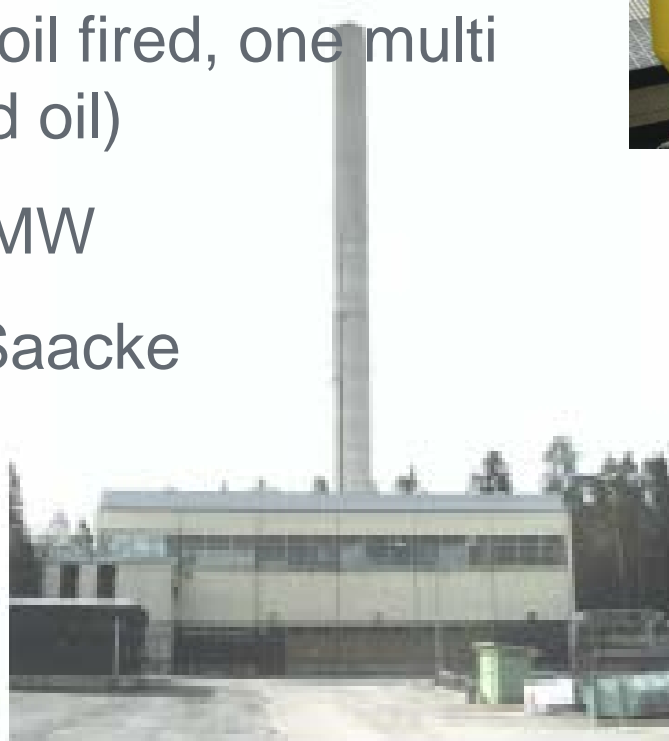


Pipeline installation (Fortum)



District heating production with landfill gas until 2010

- Peak power station
- three boilers, total output 130 MW
- Two heavy oil fired, one multi fuel (gas and oil)
- Noviter 40 MW
- Burner by Saacke



Ämmässuo Landfill Gas Power Plant



Why electricity production?

- Landfill gas utilization studies 2001 - 2005
 - Maximum gas production in 2010
 - Either markets for gas or utilization system must be available
 - District heat production
 - Limited utilization (winter season)
 - Pricing of the gas
 - Upgrading and feed into the natural gas grid
 - Investment cost of the gas cleanup and pressurization system
 - Absence of the pipeline (for upgraded landfill gas = pressurized biomethane)
 - Use in vehicles
 - Lack of gas fired vehicles
 - Vehicle fleet needed: 1000 trucks or 7000 personal cars
 - Bus and waste transportation contracted within Metropolitan
- **Conclusion: electricity production is the most economical and ecological utilization concept for HSY and Helsinki Metropolitan Area**





Power Plant site in 12.6.2009



Power Plant site in 21.5.2010



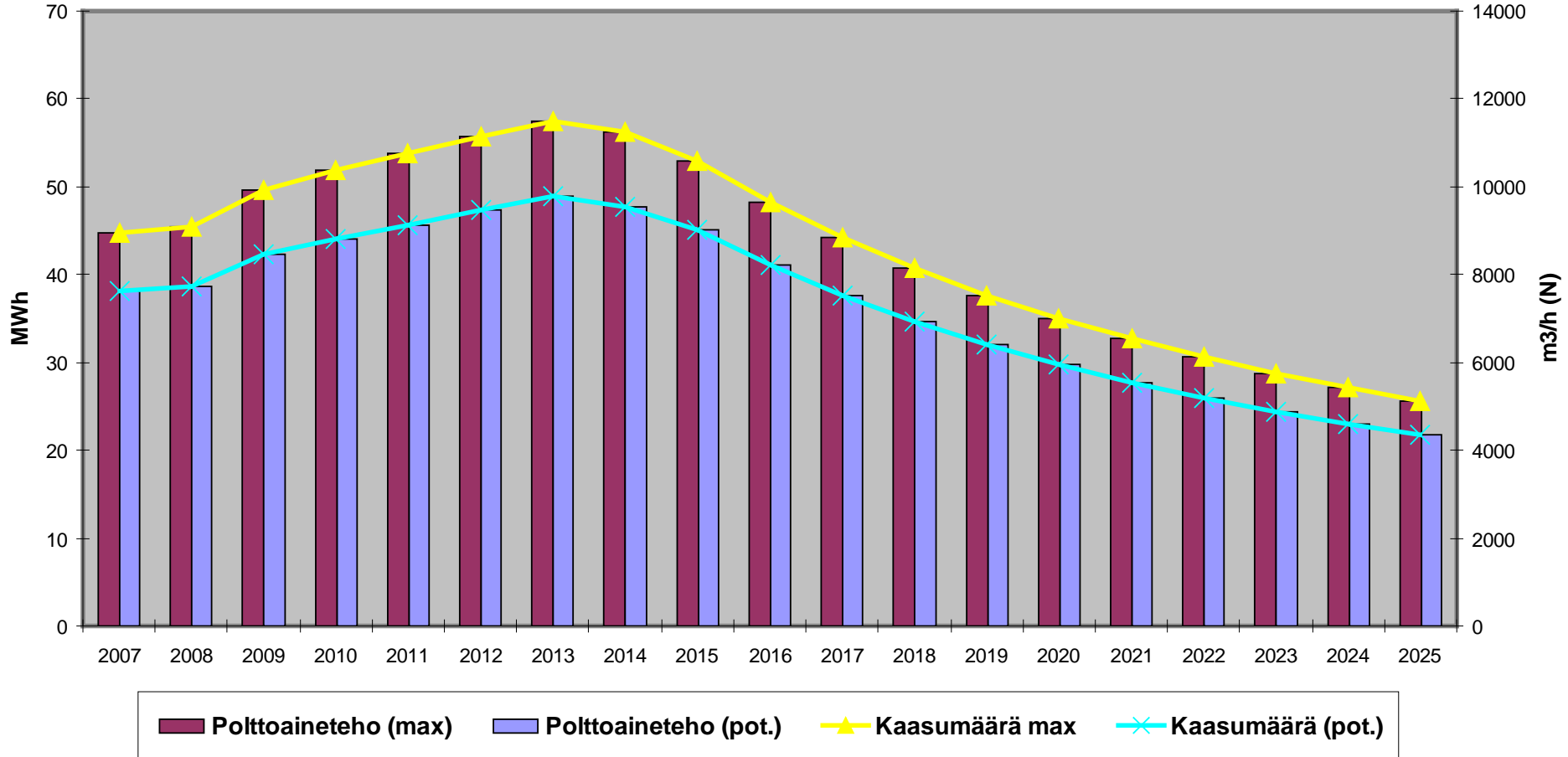
Power Plant

Transfer station

flares

Transfer pipeline 11 km

KAASU- JA ENERGIAMÄÄRÄT 2007-2025



Power plant project steps

- Acceptance of environmental permit 7.11.2007
- Acceptance of the project plan in the Board of HSY 2008
- Application of the investment support 10/2008
- Competitive tendering of the project 10/2008
- Decision on process contractor (Sarlin/MWM) 12/2008
- Design of the power plant building 2/2009
- Competitive tendering of the main contractor of the power plant building 4/2009
- Decision on main contractor (YIT) 5/2009
- Construction work of the power plant 5/2009 – 2/2010
- Electricity production starts 5/2010



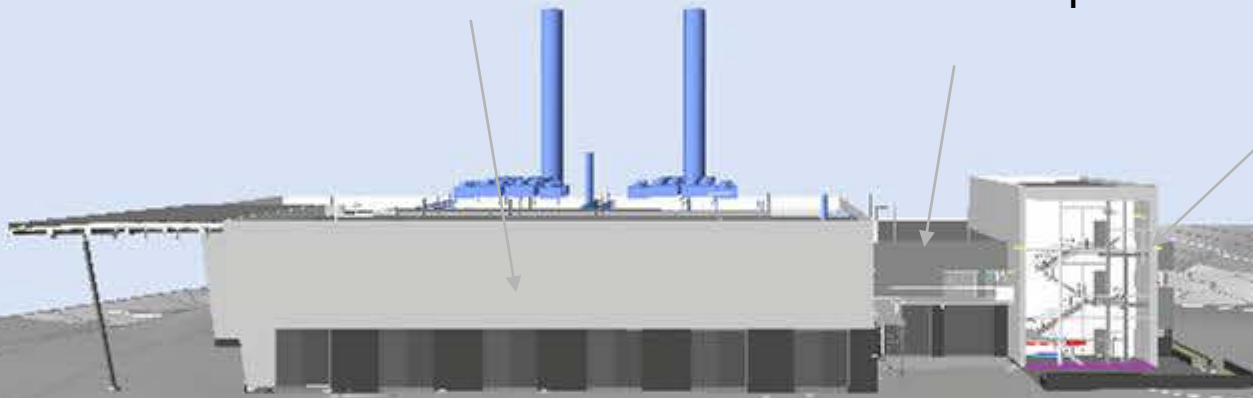
Technical facts

- Based on gas engine technology
- Energy production: max. 17 MW electricity and ~13 MW heat
- Independent 110 kV electricity grid connection
- Fuel: CO₂-neutral landfill gas and biowaste digestion gas (from 2013 on)
- Additional electricity production with ORC process from exhaust gases.
- Investment cost. 15 M€
- Energy investment support from State of Finland 22% = 3,4 M Euros

Power house

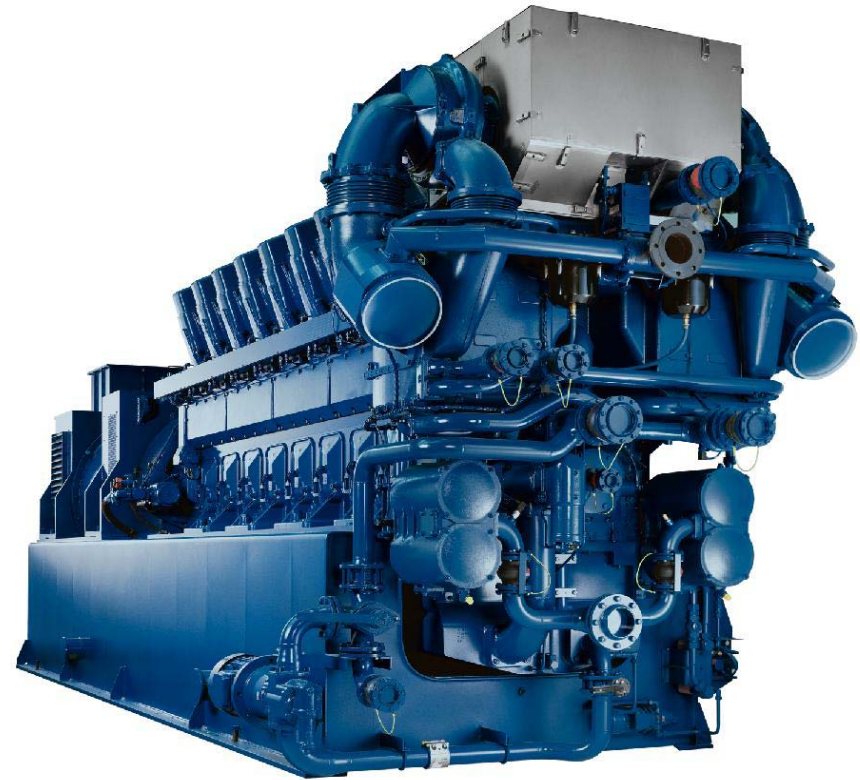
Control room
and workshop

Office wing



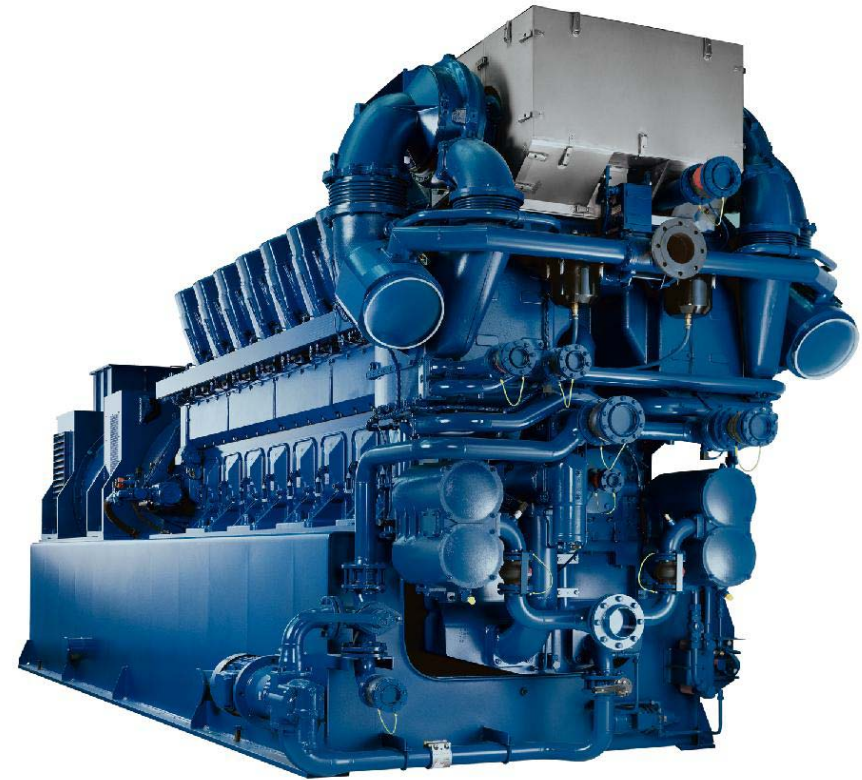
MWM TCG 2032

Engine type	V 16
length	mm 8,900
width	mm 2,750
high	mm 3,800
weight	kg 47,600



MWM TCG 2032

Electricity production		kW 3,917
efficiency (el)	%	42.0
efficiency (th)	%	44.1
Total efficiency	%	86.1



ORC, Organic Rankine Cycle-process

- Utilizes exhaust gas heat for additional electricity production
- Combines
 - Heat exchangers
 - Thermal oil circuit
 - Organic medium (toluene, pentane)
 - Turbine generator set
 - Condenser

