**MUNICIPAL SOLID WASTE INCINERATOR - ELECTRICITY PRODUCTION AND DISTRICT HEATING**

**Date of factsheet**: 4-12-2018

**Author**: Hiet Nieuwen, Elodie Jego

**Sector**: Built environment

**ETN / Non-ETS**: Non-ETS

**Type of Technology**: CHP

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**Description**

Waste streams can be avoided in a number of ways. These include waste prevention, the re-use of materials and the recycling of materials. When waste streams are no longer available, it is possible to utilise them to generate energy (ECN, 2006), both heat and electricity. Waste incinerators (in Dutch ‘afvalverbrandingsinstallaties’ or ‘AVI’ are defined as any heat and electricity production plant where waste is combusted for energy purposes (Longworth, van Middelkoop, et al., 2017).

**Working of the Technology**

A waste incinerator is a power plant that can be used to generate both heat and electricity. A waste incineration plant can be used to generate electricity using a generator. Cooling water cools down the water that has passed through the turbine. From the drain of the turbine, heat can be fed into a heat network. Heat can be supplied to different sectors such as the built environment, industry or horticulture. This factsheet focuses on a waste CHP plant connected to a heat network. A waste incinerator without CO2 capture and storage (CCS) is considered in this factsheet.

**Technical Lifetime Waste Incinerators**

The technical lifetime of a waste incinerator has been estimated to be around 25 years (ECN, 2011; ETRI, 2014). In some cases, waste-to-energy plants are utilised to burn a mixture of municipal solid waste (MSW) and company waste. The waste incinerator technology generally employs moving grate furnaces (BTR, 2016).

**Main Components**

The main components of a waste incinerator consist of a waste bunker, cranes, furnaces, ash storage bunkers, boilers, fly ash handling equipment, slag handling equipment and wet gas washing equipment. Waste incinerators are also equipped with advanced flue gas cleaners to prevent or limit the emission of various potentially harmful substances, amongst others: PM, VOC, NOx, NH3. Flue gas cleaners are included in the costs presented in this factsheet.

**Energy production related aspects**

The energy production of a waste incinerator is partly determined by the waste mixture which results in a lower CO2 emission factor (kgCO2/GJ heat supplied) compared to a heat produced by fossil fuel-fired CHP plants (ECN, 2017a; CE, 2016).

**Potential In The Netherlands**

Heat networks in the Netherlands produce 1,65 PJe per year (at a capacity factor of 60%). This value is based on the thermal (MWth) and electrical capacities of CHP plants (ETN, 2017b). A CHP plant with a capacity of 87 MWe produces 1,65 PJe per year (at a capacity factor of 60%).

**Heat Capacity Of Waste Incinerators In The Netherlands**

Heat networks provide energy to different sectors such as the built environment, industry or horticulture. This factsheet focuses on waste CHP plants connected to a heat network. A waste incinerator without CO2 capture and storage (CCS) is considered in this factsheet.

**Heat Production and Supply of Waste Incinerators In The Netherlands**

In 2017, waste incinerators in the Netherlands produced about 25 PJe of heat (ECN, 2018). The heat is partly supplied to the built environment, and partly to other sectors. The un-utilised heat is lost. The Central Bureau voor de Statistiek (CBS) does not provide specific figures about the heat supplied by waste incinerators to the built environment. However, based on the statistics from ECN (2015 data) and Rijkswaterstaat (2016 data), it can be estimated that waste incinerators supplied 4 to 4.5 PJ of the final heat demand of the built environment (ECN, 2017a; Vereniging van afvalbedrijven, 2017). In 2016, the final heat demand in the built environment amounted to 435 PJ (ECN, 2017b). Based on the above estimates, this would mean that in that year waste incinerators provided 1% of the total heat demanded by the sector.

**Heat Availability In The Netherlands**

Heat availability can be defined as the amount of heat available for use by a CHP plant. This is the difference between the total thermal output capacity of a CHP plant and the amount of heat supplied to the heat network. Heat availability can vary depending on the season as well as waste and fuel availability.

**Heat Capacity Utilisation Factor**

Heat capacity utilisation factor indicates that the amount of energy produced can be higher or lower depending on waste availability and that the level of energy produced will not necessarily follow energy demand. Last but not least, heat and electricity output can be controlled and vary depending on the season.

**Technical Dimensions**

<table>
<thead>
<tr>
<th>Functional Unit</th>
<th>Value and Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td></td>
</tr>
<tr>
<td>MWe</td>
<td>Current</td>
</tr>
<tr>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Market share %</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>5.262</td>
</tr>
<tr>
<td>Capacity utilisation factor</td>
<td>0.60</td>
</tr>
<tr>
<td>Full-load running hours per year</td>
<td>PJe/year</td>
</tr>
<tr>
<td>Cost of Activity</td>
<td></td>
</tr>
<tr>
<td>Technical lifetime (years)</td>
<td>20</td>
</tr>
<tr>
<td>Progress ratio</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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**Explanation**

Rijkswaterstaat published a report with data on a number of waste incinerators in the Netherlands, including: AEB Amsterdam, AVR Rijnmond, HVC Alkmaar, STA Red Energy Rosenhout and AVI Duiven (Vereniging van afvalbedrijven, 2017). The report provides information on the annual gross electricity production (GWh) of each incinerator and on the heat they supplied (TJ) to heat networks in 2016. The thermal (MWth) and electrical (MWh) of CHP plants are also provided.

**Electrical Capacity Of Waste Incinerators In The Netherlands**

In 2016, the electrical capacity of waste incinerators was about 154 MWe. This includes the five waste incinerators mentioned above (Vereniging van afvalbedrijven, 2017). The main electrical capacity is given as the average capacity of the five waste incinerators mentioned above (Vereniging van afvalbedrijven, 2017). On average, these five waste CHP plants are run on full-load around 5,262 hours per year. This translates to a capacity utilisation factor of 60%. A CHP plant with a capacity of 87 MWe produces 1,65 PJe per year (at a capacity factor of 60%).

**Heat Capacity Of Waste Incinerators In The Netherlands**

Heat capacity utilisation factor is the ratio of the actual heat sold to the total heat produced by a CHP plant. Heat capacity utilisation factor indicates that the amount of energy produced can be higher or lower depending on waste availability and that the level of energy produced will not necessarily follow energy demand. Last but not least, heat and electricity output can be controlled and vary depending on the season.

**Heat Production and Supply of Waste Incinerators In The Netherlands**

In 2017, waste incinerators in the Netherlands produced about 25 PJe of heat (ECN, 2018). The heat is partly supplied to the built environment, and partly to other sectors. The un-utilised heat is lost. The Central Bureau voor de Statistiek (CBS) does not provide specific figures about the heat supplied by waste incinerators to the built environment. However, based on the statistics from ECN (2015 data) and Rijkswaterstaat (2016 data), it can be estimated that waste incinerators supplied 4 to 4.5 PJ of the final heat demand of the built environment (ECN, 2017a; Vereniging van afvalbedrijven, 2017). In 2016, the final heat demand in the built environment amounted to 435 PJ (ECN, 2017b). Based on the above estimates, this would mean that in that year waste incinerators provided 1% of the total heat demanded by the sector.

**Waste Availability In The Netherlands**

Waste availability is the amount of waste available for use by a CHP plant. This is the difference between the amount of waste available for use by a CHP plant and the amount of waste supplied to the heat network. Waste availability can vary depending on the season as well as waste and fuel availability.

**Potential In The Netherlands**

ECN (2011) indicates that, in the Netherlands, the amount of heat supplied by waste incinerators can increase by 11 PJe (ECN, 2011). Some of this potential has already been utilised since total installed capacity has already increased over the last years.

**Technical Lifetime Waste Incinerators**

Waste incinerators have relatively higher costs compared to other power plant technologies. This is mainly because of the advanced flue-gas cleaning systems they require (ETRI, 2014). The implementation of such systems, and possibly additional operational costs, but can reduce treatment costs (European Commission, 2016b). In addition to this, high fuel-handling costs should also be considered (ETRI, 2014). Different approaches and regulations on the treatment, recovery and disposal of ash residues fly ash and bottom ash, and also influence implementation access and minimise costs.

**Overview**

Waste incinerators commonly discussed in literature, namely: fly ash (from flue gas), bottom ash and air pollution control residues (APC). New technologies have considerably decreased the emission or release of these components in the environment. Some emission remain but it is minimum, and varies as a result of local regulation.

**Solid waste incinerators** include the following by-products emissions of:

- Fly ash (from flue gas)
- Bottom ash
- Air pollution control residues (APC)

Waste incineration generates harmful emissions, including dust, odours, fumes, heavy metals, SOx, NOx and HF (Faggiola A. and Gentile G. 2012). There are three by-product emissions of solid waste incinerators currently discussed in literature, namely: fly ash from flue gas, bottom ash and air pollution control residues (APC). These technologies have considerably decreased the emission or release of these components in the environment. Some emission remain but it is minimum, and varies as a result of local regulation.

**Material flows**

Material flows explanation

<table>
<thead>
<tr>
<th>Substance</th>
<th>Current</th>
<th>2020</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly Ash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom Ash</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Emissions**

Emissions explanation

The fly ash content of flue gas is minimised (from >150 mg/Nm3 to <50 mg/Nm3) thanks to wet and dry multi-stage flue gas cleaners systems (Brunner P.H., Rechberger H., 2015). Poggio A.

**Material Flows (Optional)**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Current</th>
<th>2020</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fly Ash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottom Ash</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**ENERGY IN- AND OUTPUTS**

Energy centers (per unit of main output)

<table>
<thead>
<tr>
<th>Energy center</th>
<th>Unit</th>
<th>Current</th>
<th>2020</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>PJ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste (biogenic)</td>
<td>PJ</td>
<td>1.50</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Waste (non-biogenic)</td>
<td>PJ</td>
<td></td>
<td>1.22</td>
<td>1.22</td>
</tr>
<tr>
<td>Coal</td>
<td>1.45</td>
<td>0.83</td>
<td>0.83</td>
<td></td>
</tr>
</tbody>
</table>

**Energy in- and Outputs**

The National Energy Outlook (2016) projects that waste incinerators will have an electrical efficiency of 16% and a thermal efficiency of 27% by 2020 (ECN, 2016a). In 2030, the electrical efficiency is expected to reach 20% and the thermal efficiency 20%. The biogenic waste fraction is assumed 55% in all years.

**Materials**

**Material Flows (Optional)**

<table>
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<tr>
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<td></td>
<td></td>
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</tbody>
</table>
A downside of utilizing heat for district heating is that it lowers the electrical conversion efficiency of the CHP plant. For each GJth of drain-heat supplied to district heating, there is a 0.2 GJe loss of electricity production (ECN, 2016a). Thus, the higher the heat temperature, the higher the losses. ECN (2011) indicates a loss of 0.18 GJe/GJth for drain-heat at 120 °C and a loss of 0.09 GJe/GJth at 80 °C (ECN, 2011).

According to ETRI the water withdrawal is equal to 3.3 liters per kWhe and the water consumption to 2.1 liters per kWhe in case of usage of cooling towers (ETRI, 2014). Water consumption refers to the water that is not returned to the water system.

### REFERENCES AND SOURCES

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- PBL (2017). Functioneel ontwerp VESTA 3.0