TAMPERE WASTE-TO-ENERGY PLANT

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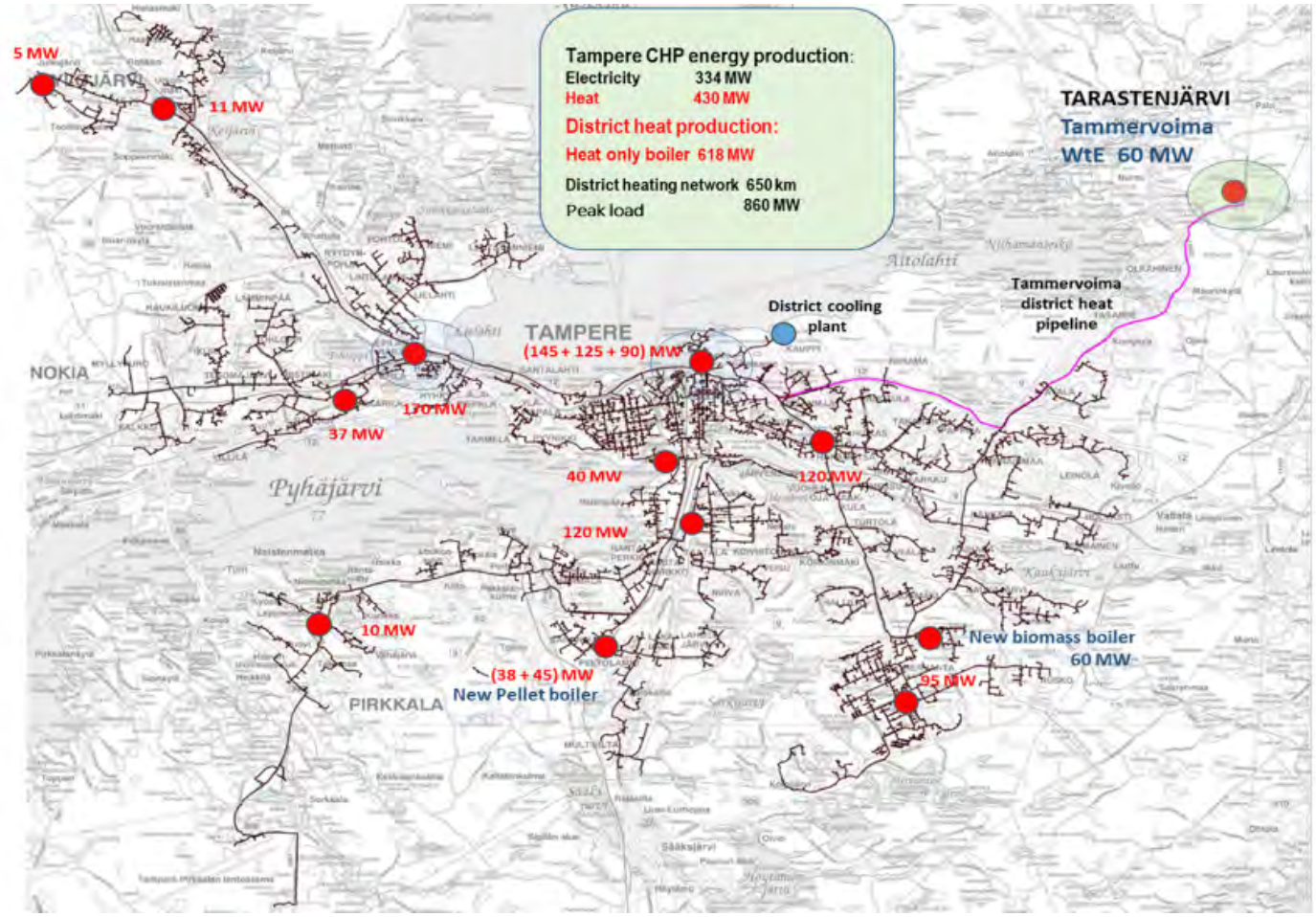
1. TAMPERE WASTE-TO-ENERGY CONCEPT

1.1 PROJECT BACKGROUND

Project implementation was initiated by the revised Finnish Waste Act of 2011 that prohibited, starting from 2016, the disposal of biodegradable and other organic waste to landfills. As a result of the new legislation, Tampere Regional Solid Waste Management Ltd decided to start planning a waste incineration solution together with Tampere Power Utility. The aim was to find a site for the new plant in the area covered by the Tampere district heating network because district heating load is large enough to fully utilize the heat of waste incineration even in summer time. The Tampere district heating network includes 5,700 buildings and more than 230,000 residents live in houses with district heating. Annual consumption of district heat is currently 2,200 GWh.

In 2011, a joint undertaking by the name of Tammervoima Oy was established with the task of overseeing the construction of a new waste incineration plant in Tampere. The stakeholders for this new company are Tampereen Sähkölaitos (Tampere Power Utility) and Pirkanmaan Jätehuolto (Tampere Regional Solid Waste Management Ltd). The aim for waste incineration was that it must promote materials recycling, and only the portion of the municipal solid waste (MSW) that is invalid for materials reuse was to be directed to energy production. The reliable grate technology was chosen for the new plant, and incineration capacity was set to 160,000 tons per year.

The collected waste comes from the 17 municipalities and 450,000 residents in the Tampere region for a total of 130,000 tons per year, with an additional 30,000 tons from 150,000 residents in Central Finland. The municipal waste management company in the Jyväskylä region was chosen to complement waste collection, so that we were able to construct an adequately large facility to ensure cost-effectiveness for incineration. The Tampere WtE plant is currently incinerating the MSW produced by 650,000 residents, along with small amounts of hospital waste and commercial waste lots. The maximum waste transporting distance to the new plant is approximately 150 km.



Tampere district heating network

Tampere region waste collection area, 450,000 residents.

1.2 THE TAMPERE WTE CONSTRUCTION PROJECT

Once the building permit for the power plant was granted in the summer of 2013, construction could start right away in early September. The plant was ready for production in two years and the total cost was 111 million Euros. By using the EPCM (Engineering, Procurement, and Construction Management) project model, the construction project was divided into 54 separate procurement packages and contract work assignments. During the construction phase, a total number of 2,300 workers were employed and the entire project size was 350 person-work-years on site.
The first batches of waste were incinerated as early as September 2015, and the commissioning of the whole plant and the warranty tests were successful during the last quarter of 2015. The new WtE plant received acceptance for commercial production right at the start of 2016, at the same time the disposal of waste to landfills was forbidden in Finland.

Tampere WtE plant's building period Sept 2013 – Dec 2015, Status in Summer 2014. In the background the waste pre-treatment plant and closed landfill area.

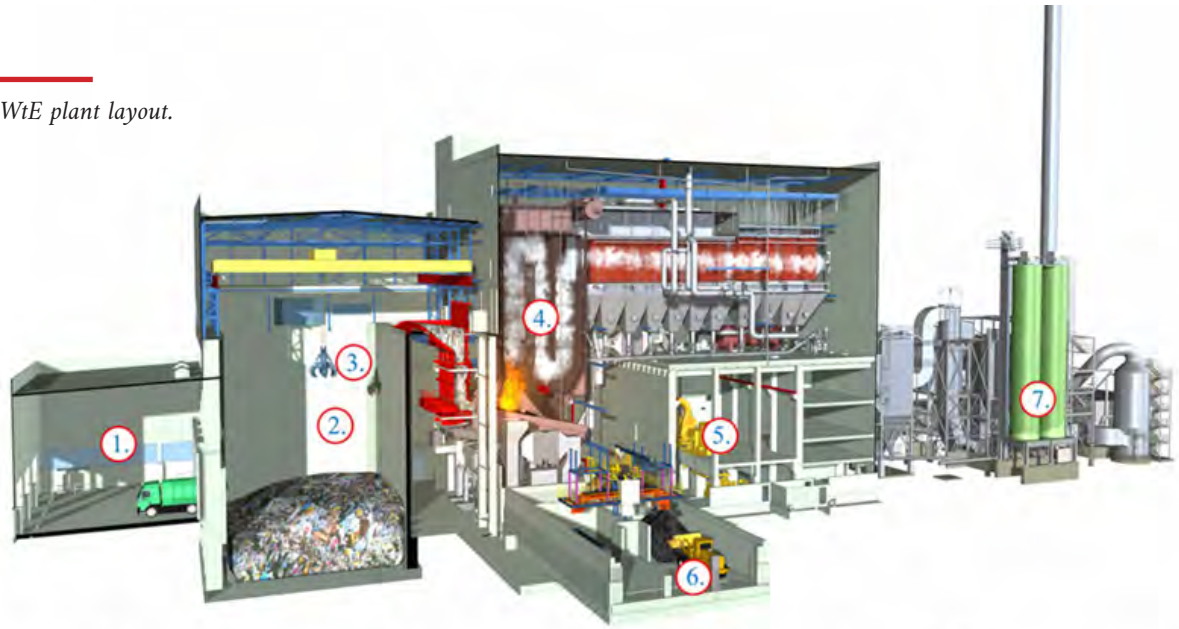
1.3 LAYOUT AND TECHNICAL DATA

As our EPCM consultant, ÅF Consult Oy was responsible for the plant's design, construction supervision, and commissioning. The building's layout is very traditional and compact. The flue gas cleaning system is located outside the boiler house. The turbine hall is built under the boiler facility's horizontal part to save cubic content.

The aims for the plant design were flexible adjustment features for electricity and heat production, as well as high usability for the whole facility. In addition to the main heat exchanger, there are also two reduction heat exchangers that enable continuing incineration at full capacity, even when the turbine is out of use. The district heating system has a heat accumulator to add flexibility to district heat production during fluctuating district heat consumption at different times of the day.

As a technical innovation, the plant features utilizes the condensation water of the flue gas condenser in the power plant processes and flue gas cleaning system. The rest of condensation water is purified for the extra district heat water and fed into the district heat network via the heat accumulator. The plant uses an extremely small amount of clean water and it is only used for boiler water.

Tampere WtE plant layout.



1. Discharge hall
2. Waste bunker
3. Crane
4. Boiler
5. Steam turbine
6. Bottom ash bunker
7. Flue gas cleaning

TAMMERVOIMA WASTE-TO-ENERGY PLANT BUILDING DATA

SITE AND BUILDING

Land area of the site	32 000 m^2
Building volume	144 260 m^3
Total floor area	9 900 m^2
The height of the boiler house	46 m

PRODUCTION CAPACITY	ELECTRICITY / HEAT
CHP operation net	12,5 MW / 45 MW
Heat only mode net	0,5 MW / 57 MW
Heat storage 2300 m^3 / 100 MWh	15 MW

TECHNICAL DATA OF THE MAIN COMPONENTS

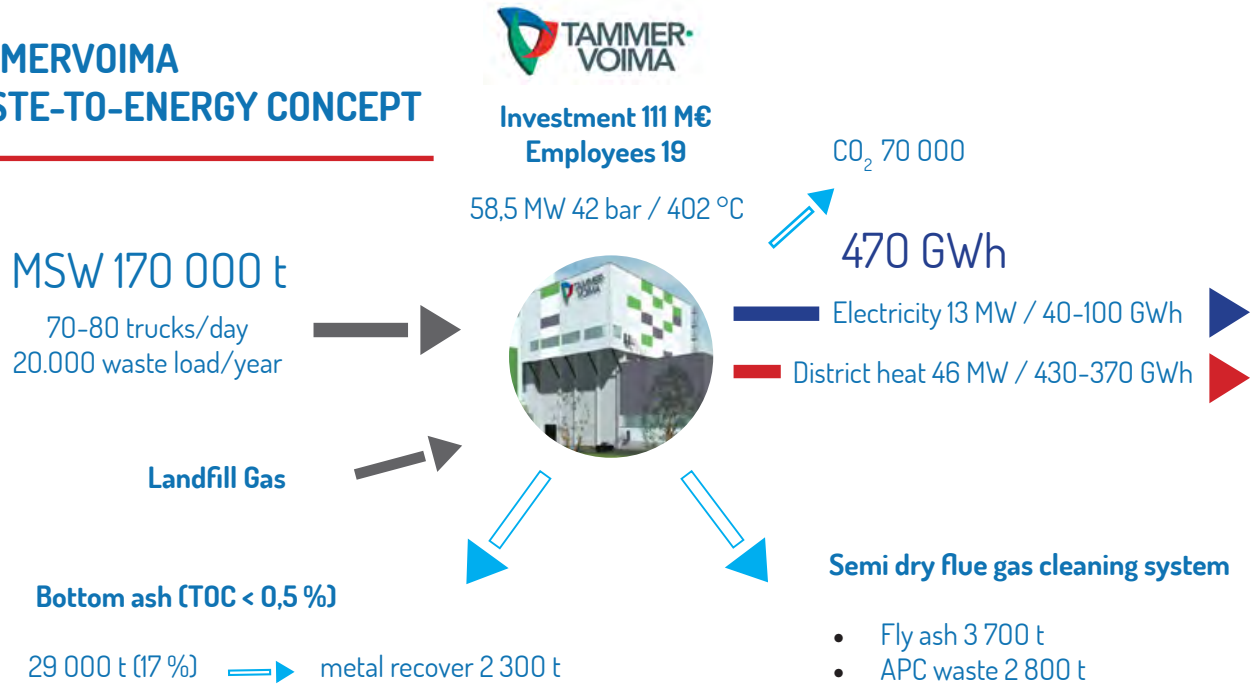
Boiler	STEINMÜLLER BABCOCK ENVIRONMENT GMBH
Number of units	1 UNIT / GRATE SYSTEM, BOILER AND STEAM GENERATOR
Throughput per unit	20 t/h
Total plant	160 000 t/a
Thermal capacity	58,5 MW
Steam parameters	40 bar/402°C,
Flue Gas Cleaning	LÜHR GMBH
Procedure	SEMI DRY SYSTEM SCRUBBER, UPPER AND LOWER CIRCULATION ESP AND SNCR
Turbine - Generator 16 MVA	MAN ENERGY SOLUTIONS SE
Type of turbine	DISTRICT HEATING TURBINE ONE STAGE DH-EXCHANGER
Cranes, 2 units	KONE CRANES OYJ

1.4 ENERGY PRODUCTION AND ASHES

The production targets set for the plant have been easily achieved. In the first three years of operation, waste incineration usability has been at a high level of 99.0 – 99.5 % with annual operation of 8000 - 8100 hours. The plant has had normal summer revision with a duration of 3 – 4 weeks. The plant's annual production has been on the level of 450 – 470 GWh, and the received amount of waste is 165,000 – 170 000 tons.

The utilization of bottom ash from the incineration process has also been resolved already during the first year of plant operations. After metals have been recovered from the bottom ash, the remaining ash is sieved. The separated mineral fractions can be utilized as auxiliary material in concrete and the coarser fractions in foundation engineering for street construction. The materials utilization rate of the ashes produced in the waste incineration process is 96 %. Air pollution control residue (APC waste) and fly ash are taken to a landfill.

TAMMERVOIMA WASTE-TO-ENERGY CONCEPT



1.5 EMISSIONS

Thanks to the efficient flue gas cleaning system, the plant's atmospheric emissions have been realized at a very low level. Compared to the plant's environmental permit, the realized emissions in 2017 have been only 1 % of the allowed discharge standard excluding nitrogen oxides and carbon monoxide. The level of NOx emissions is 66 % and that of carbon monoxide is 16 % of the allowed discharge standard. The plant's carbon dioxide emissions are around 70,000 tons per year.

The flue gas purification equipment was built by utilizing the best available technology (BAT) while also taking into account the new BREF Waste Incineration Draft.

TAMPERE WTE PLANTS EMISSION VERSUS THE ENVIRONMENTAL PERMIT AND THE NEW WTE BAT

PARAMETER	UNIT	ENVIRONMENTAL PERMIT 2013	MEASURED VALUE	REALISATION	NEW BAT-AEL FOR EXISTING PLANTS
NO_x	mg/Nm³	200	132	66 %	50-180 (SNCR)
SO_2	mg/Nm³	50	0,3	0,6 %	5-40
Dust	mg/Nm³	10	0,1	1,0 %	< 2-5
CO	mg/Nm³	50	8,0	16%	10-50
TOC	mg/Nm³	10	0,1	1,0 %	< 3-10
HCl	mg/Nm³	10	0,1	1,0 %	< 2-8
HF	mg/Nm³	1	0,001	0,1 %	< 1

2. WASTE AND ENERGY MANAGEMENT AT THE TAMPERE WTE PLANT

2.1 ORGANISATION OF OPERATIONS

The production operations of the waste incineration plant are carried out in a cost-effective manner by utilizing its owners' core competencies. The waste incineration company does not have its own staff and it purchases all the resources and services from its owners or from external service providers. Tammervoima WtE business concept is to incinerate waste at cost price and to produce affordable district heat and electricity for power utility.

The resources and services produced by the owners can be summarized as follows:

Services produced by the waste management company:

- Waste transport and collection
- Waste acquisition and intermediate storing if required
- Waste classification and weighing services
- Operation of the waste pretreatment plant
- Reclamation of materials in bottom ash and recovery of metals
- Public relations and consumer advice on waste management issues

Services produced by the energy company:

- Power plant running and maintenance
- Company's administrative and financial services
- Environmental reporting and reports to authorities

The plant has 19 employees, with 12 operators working in pairs in 12-hour shifts. The plant manager is responsible for production operations and the maintenance manager takes care of maintenance with four maintenance technicians. The cleaning services and maintaining the outside areas are subcontracted. The disposal services for the fly ash and APC waste are also outsourced.

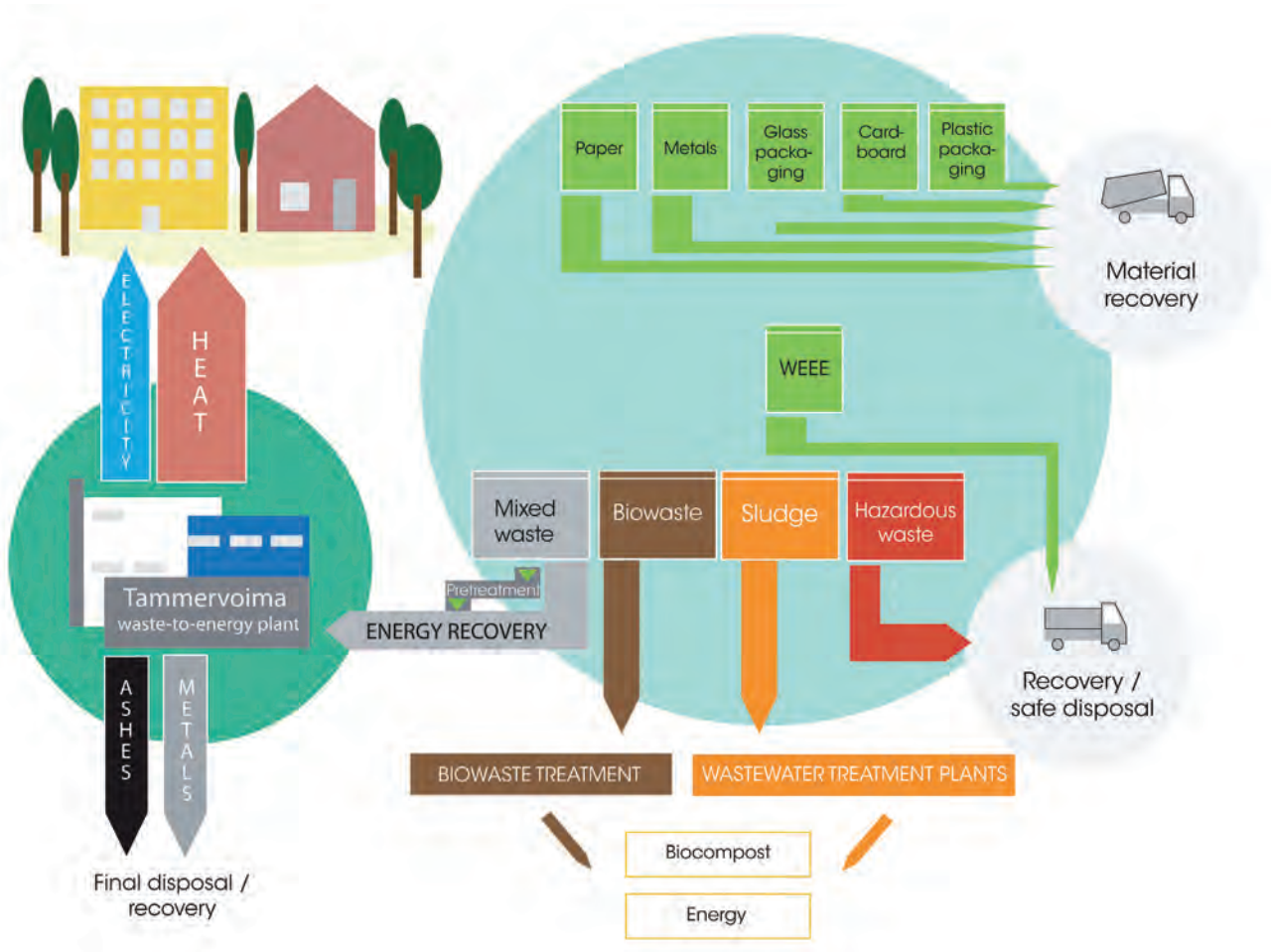
Presentation at the power plant are handled by the owner companies' communications staff. 10,000 guests have already visited the new Tampere WtE plant in its first three years of operation.

Bottom ash treatment.

2.2 DEVELOPING THE WASTE COLLECTION SYSTEM INCREASES RECYCLING AND ACCELERATES INCINERATION

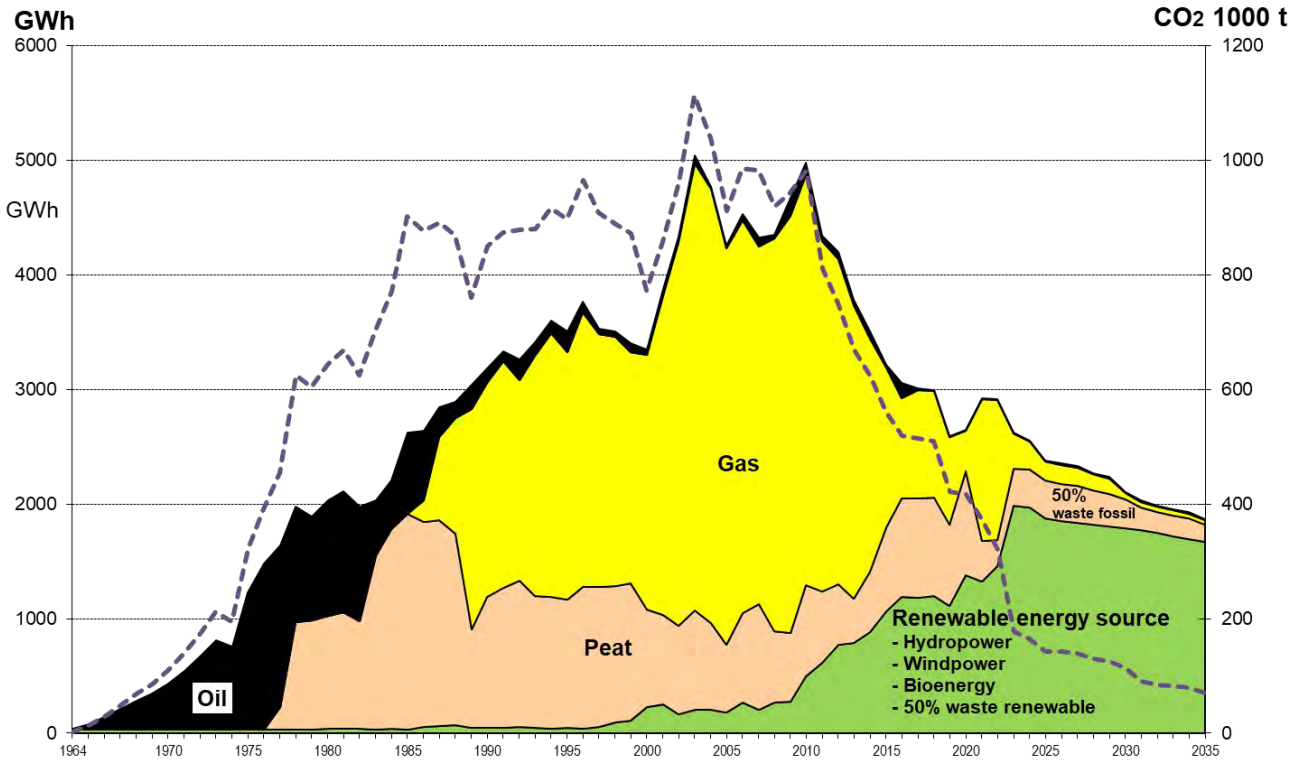
As the waste management company is responsible for the acquisition of waste-derived fuel and for its quality, it is in the best interest of the company to improve the heating value of waste and to decrease the number of objects unfit for incineration. In Tampere, separate collection of bio-waste has been implemented more than 20 years ago in all buildings with more than five apartments. To increase recycling rates, more than 5000 containers for recyclable glass and metal have been distributed free of charge to housing cooperatives since 2016 in the Tampere region. Separate collection of plastic in residential buildings started in 2018.

Quality control for waste reception has been enhanced also at the weighing station by directing 30 % of the arriving waste loads to the new pretreatment plant where metals and non-combustible is separated and the remaining waste is crushed. By developing its collection system, the local waste management company has increased its recycling rate by nearly 5 % in the past few years. At the same time, the amount of incineration bottom ash has decreased by 10 % and its TOC has stabilized at a level of 0.5 % thanks to the improved quality of waste and efficient incineration process.



2.3 WASTE INCINERATION BENEFITS FOR POWER UTILITY

Tampere has been one of the biggest users of natural gas in Finland since the 1990s. Waste incineration is replacing the use of fossil fuels in Tampere region, especially gas. In the same time the greenhouse gas emissions in energy production has decreased by 10 %. The production of renewable energy in Tampere has also increased by 20 % due to waste incineration. The flexible and fast production control possibilities in a modern waste incineration plant has brought new opportunities for energy production optimization for power utilities. Waste incineration plant has no longer to be of a production unit running fixed base loads. The production plan of the Tampere WtE plant is optimized daily in the energy management system as part of a larger production complex while taking into account the market conditions for fuel and electricity. Profitability at the Tampere WtE plant effectiveness has significantly been increased by the use of a heat accumulator, when the cost of electricity has been low or increased heat production has been required in peak load situations.



3. SUMMARY

The local waste management company and the energy company in Tampere region have managed to construct, in a Public-Private Partnership, an efficient energy recovery concept for municipal solid waste. This concept provides an annual added value of 30 million euros and the waste fees are the lowest in Finland. The waste management company has provided residents with thorough waste sorting counselling. 450,000 residents are now source separating waste in homes. Only 1 % of the municipal solid waste is disposed to landfills in the Tampere region.

In the Tammervoima plant, 100 % of the waste energy is recovered with the operational efficiency of 95 %. Waste incineration has decreased local CO2 emissions by 60,000 tons annually and it has compensated for 600 GWh of natural gas export. Today, waste-to-energy covers 15 % of the district heating and electricity production in Tampere.

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