WHERE WASTE BECOMES HEAT AND ELECTRICITY

Sävenäs Waste-to-Energy plant, Gothenburg

Renova

! Annual energy production at Sävenäs is equivalent to cover the need for heating and hot water production for about 124,000 apartments and to drive an electric car 32,000 times around the entire world.

Benefitting society in several ways

Renova's waste-to-energy plant in Sävenäs, Gothenburg, is one of the most efficient in the world. Each year, we handle as much as 550,000 tonnes of waste while producing electricity and heat.

The combustible waste handled here is consists of roughly fifty-fifty between household waste and non-household waste. The residual waste in your rubbish bag is incinerated here, as is non-household waste that is unsuitable for recycling. Certain types of hazardous waste that need to be removed from circulation are also incinerated at Sävenäs. The plant has an important role in society. We recover the energy from waste that cannot be recycled in any other way.

The waste is mainly sourced from the ten municipalities in the Gothenburg region that own Renova. A smaller share comes from other parts of Sweden and Europe.

Reliable energy provider

The waste-to-energy plant is a major energy provider in the local community. We produce district heating and hot water for homes and offices as well as electricity for the common electrical grid – also when it is cloudy and there is no wind.

The Sävenäs plant produces one third of the heat in the Gothenburg area's district heating network and electricity equivalent to five percent of the needs of Gothenburg's residents.

How the plant works

Each day, some 200 trucks with waste arrive at Sävenäs. The waste is emptied into the bunker. Large cranes are used to lift the waste over to the four furnaces.

Each furnace has a boiler that uses the heat from the incinerator to convert water the incinerator. The steam drives a turbine, which in turn drives a generator that produces electricity. The steam is also used to heat the water fed into the district heating network. Heat pumps ensure that any remaining energy is utilised as district heating.

Non-combustible material in waste forms slag, which is removed from the furnaces and delivered to our plant in Tagene. There we sort out the metals. The remnants – slag gravel – are used as a construction material.

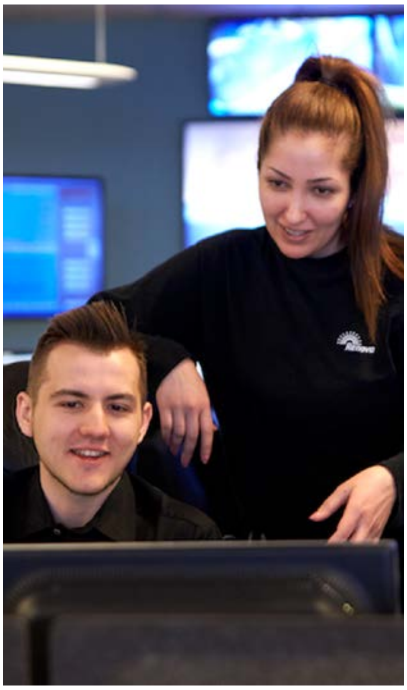
The flue gases from incineration go through several treatment stages. Zinc is recovered from the fly ash. The small amount of residue resulting from treatment ends up as landfill.

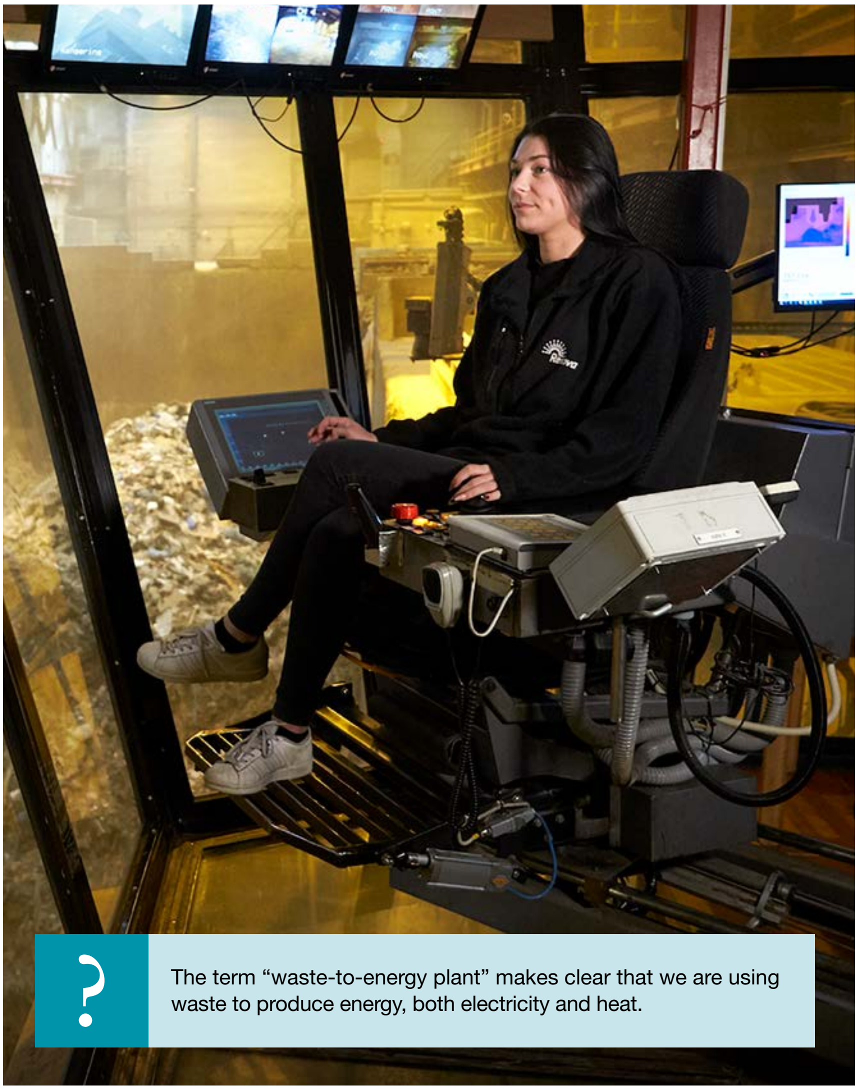
The waste-to-energy plant operates around the clock, all year round. You can follow the entire process on the centre spread of this brochure.

Annual summer maintenance

As there is less need for district heating during the summer, the boilers at the waste-to-energy plant are shut down one at a time for inspection and maintenance. Sometimes, more than 100 people work with plant maintenance at the same time.

During the summer, we mostly incinerate waste from households. Combustible waste from construction and industry is stored in bales at Renova's landfill in Tagene. These are incinerated during the winter months, when there is greater need for heat and electricity and all four boilers are fully operational.





?

The term "waste-to-energy plant" makes clear that we are using waste to produce energy, both electricity and heat.

All-important flue gas treatment

When waste is incinerated, various substances are released that should not enter the environment. Examples of such substances include dioxins, heavy metals and sulphur dioxide.

To remove them, the flue gases pass through a number of treatment stages, such as an electrostatic precipitator, a wet scrubber and a catalytic converter, before being discharged via the 126-metre-high stack.

The concentrations of different substances in the flue gases are measured in compliance with a control program, meeting the limit values of current legislation by very healthy margins. EU directives also require that waste-to-energy plants use the best available technologies, including those to prevent emissions to air and water.

Here at Renova, we constantly strive to further improve our emission treatment.

Recovering zinc from flue gases

Some substances can actually be recovered from the flue gases to form useful raw material! Renova began recovering zinc in 2022. This is the first plant of its kind in the world. We extract the zinc from the fly ash formed in the electric percipitator.

!

Two-thirds of the Sävenäs plant comprise flue gas and water treatment.

The incineration of 1 kg of waste releases 1 kg of carbon dioxide (CO_2).

Plastic in waste releases greenhouse gases

All incineration produces carbon dioxide (CO_2). This is a gas that contributes to global warming. At present, we are unable to capture carbon dioxide from the waste-to-energy plant's flue gases.

The Sävenäs plant emits some 540,000 tonnes of carbon dioxide annually. About 60 percent is of non-fossil origin and is formed when, for example, wood or paper is combusted. This carbon dioxide is part of the natural cycle. About 40 percent is carbon dioxide of fossil origin, such as from incinerated plastic products. Emissions of this type of carbon dioxide accelerate global warming.

We all need to help

To reduce emissions of fossil carbon dioxide from the waste-to-energy plant, society needs to reduce its plastic use and we all need to help source separate more plastic for recycling. This is very important for the environment! We also need to see increased demand for recycled plastic, so that more plastic processing plants are built.

Here at Renova, we have long worked to reduce the climate impact of our operations and the waste we process. The best thing we can do for the climate is to offer our customers climate-smart alternatives for source separation, sorting and recycling.

Carbon capture – a necessary complement

Carbon capture at the waste-to-energy plant will be a necessary complement to other measures taken by society to reduce carbon dioxide emissions. Carbon capture and storage (CCS) technology entails capturing carbon dioxide from flue gases and transporting it to places where it can be stored in the bedrock. You can read more about Renova's plans for this on the next page.

Important also in the future

What does the future hold for waste-to-energy plants? Will plants such as Sävenäs be needed?

Even though we reduce waste in our community and become increasingly proficient at recycling, the waste-to-energy plant will still be needed. The Gothenburg region is growing, which means more waste in total. There will still be some types of waste unsuited to recycling, such as pharmaceuticals and toxic plastics.

Moreover, Renova's waste-to-energy plant in Sävenäs is also a reliable base for the region's energy supply.

Continuous development

To maintain sufficient capacity to treat the region's combustible waste even in the future while also meeting increasingly stricter environmental and climate requirements, the Sävenäs plant needs to be continuously developed.

Both short- and long-term planning is being conducted. A project to modernise the flue gas treatment of one of the boilers will soon begin.

Parallel to this, we constantly strive to prepare for the future, with a timespan of at least 30 years.

Upcoming CCS technology

Renova's Board of Directors has a long-term ambition for the waste-to-energy plant to invest in carbon capture and storage (CCS) technology for flue gas treatment. Renova, Göteborg Energi and the municipal owners are working together to develop a technical solution to separate the carbon dioxide from one of Renova's incinerators. If the project is implemented, come 2030 we will be able to separate about 100,000 tonnes of carbon dioxide.

Networks and research

Renova participates in partnerships and networks both nationally and internationally, within the industry authorities and academia. We participate in projects encompassing everything from waste treatment through plastic recycling and carbon capture to energy efficiency and the recycling of residual products. All with the aim of enabling Renova and the Sävenäs plant to benefit society for many years to come.

Goal: As little waste as possible

Renova complies with the EU Waste Hierarchy.

Waste is to be managed as high up in the hierarchy as possible. Moreover, the waste management at each level of the hierarchy must be as efficient as possible with the least possible impact on the environment and the climate.

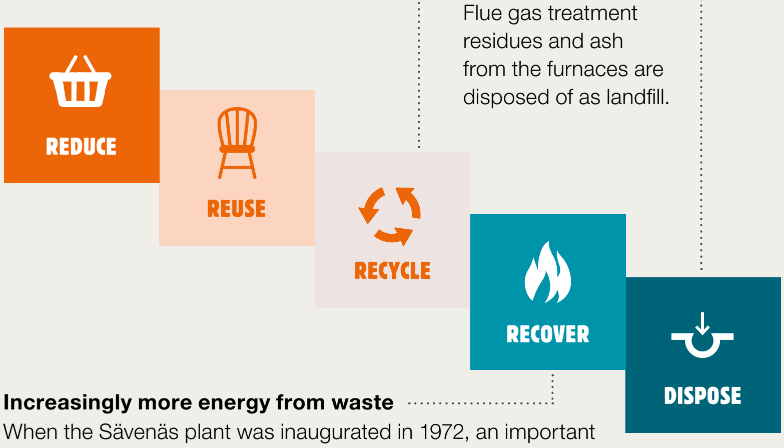
At the top, on the "prevention" level, we are to avoid generating waste. This is our goal!

At the bottom is the disposal level. As little waste as possible is to end up here. Many countries in the world have not reached even this level, with waste dumped outside any regulations.

The EU Waste Hierarchy and the Sävenäs plant

Sorting and recycling
Today, several residual products from the waste-to-energy plant can be recycled: Slag from the furnaces is sorted. Metals are recovered and the rest – the so-called slag gravel – is used as a construction material. Zinc from the fly ash is recovered to provide new raw material.

Residue to landfill
Flue gas treatment residues and ash from the furnaces are disposed of as landfill.



Increasingly more energy from waste
When the Sävenäs plant was inaugurated in 1972, an important step up the hierarchy was taken. Previously, combustible waste was sent to landfills – now energy could be recovered instead. Initially, only district heating was produced, with electricity being added in 1989. Over the years, the plant's energy efficiency has been steadily improved, with increasingly more energy recovered from each tonne of waste.

Today, households, businesses and Renova sort out at source or later increasingly more material. Energy recovery is the alternative for combustible waste that cannot or should not be recycled into new materials.

ALSO FOUND AT SÄVENÄS

Hazardous and classified waste facility

The plant has a special facility for hazardous and classified waste. A separate conveyor system transports the packaged waste directly into the furnaces. The entire process is monitored by CCTV.

You can read more about Renova's services for transporting and handling hazardous and classified waste at **renova.se**

Separate animal cremation

The waste-to-energy plant has a special furnace for separate pet cremation. Owners, who so wish, can also get an urn with the ashes of their cremated pet to bury.

You can read more about separate cremation at **renova.se**

Education centre

The Sävenäs plant also houses Renova's Education Centre, where we conduct all our educational activities.

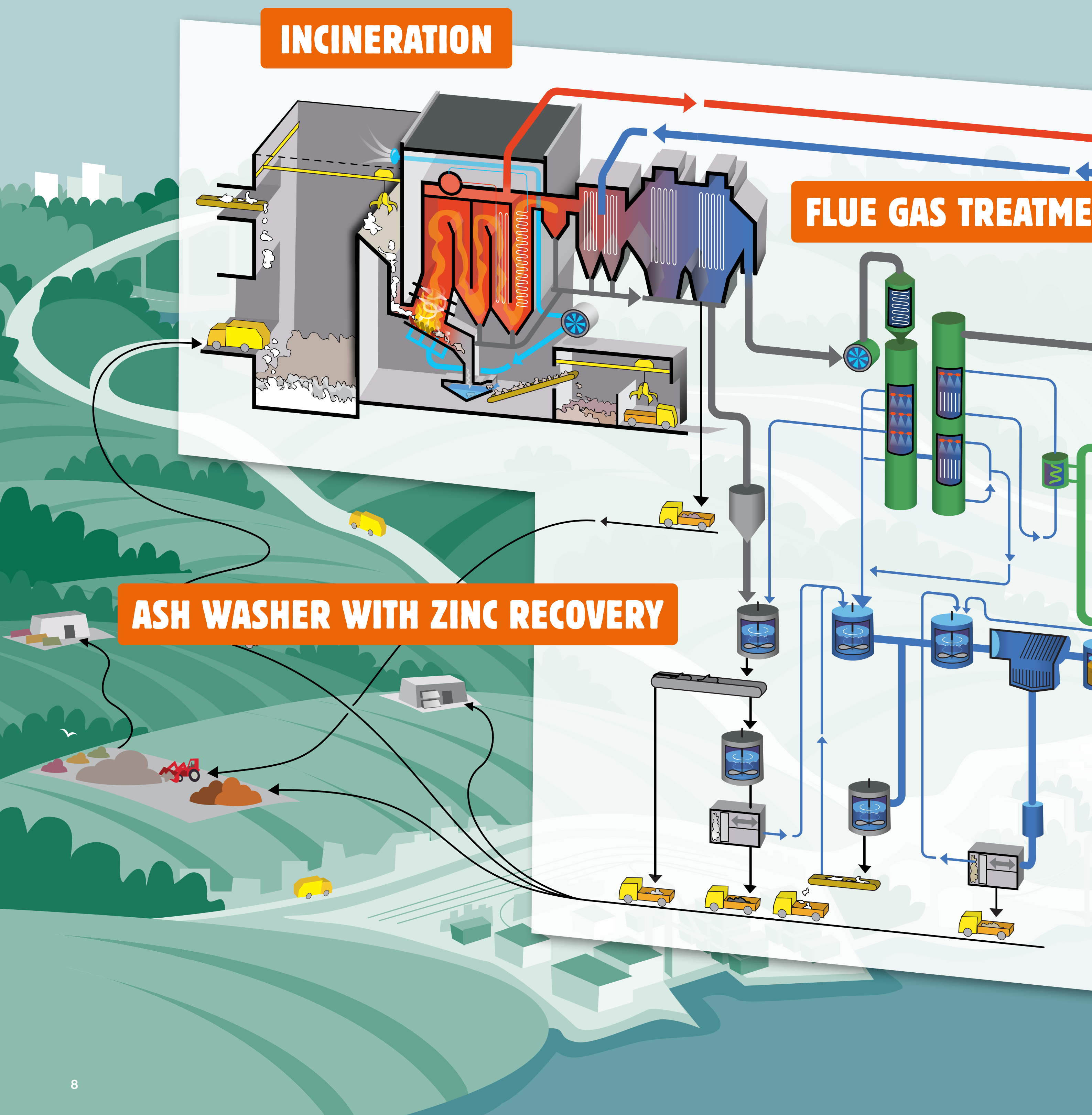
Here, on behalf of our municipal owners, we welcome pupils from school year 4 to our waste- and environmental school as well as companies for whom we hold environmental courses. We also welcome study visits.

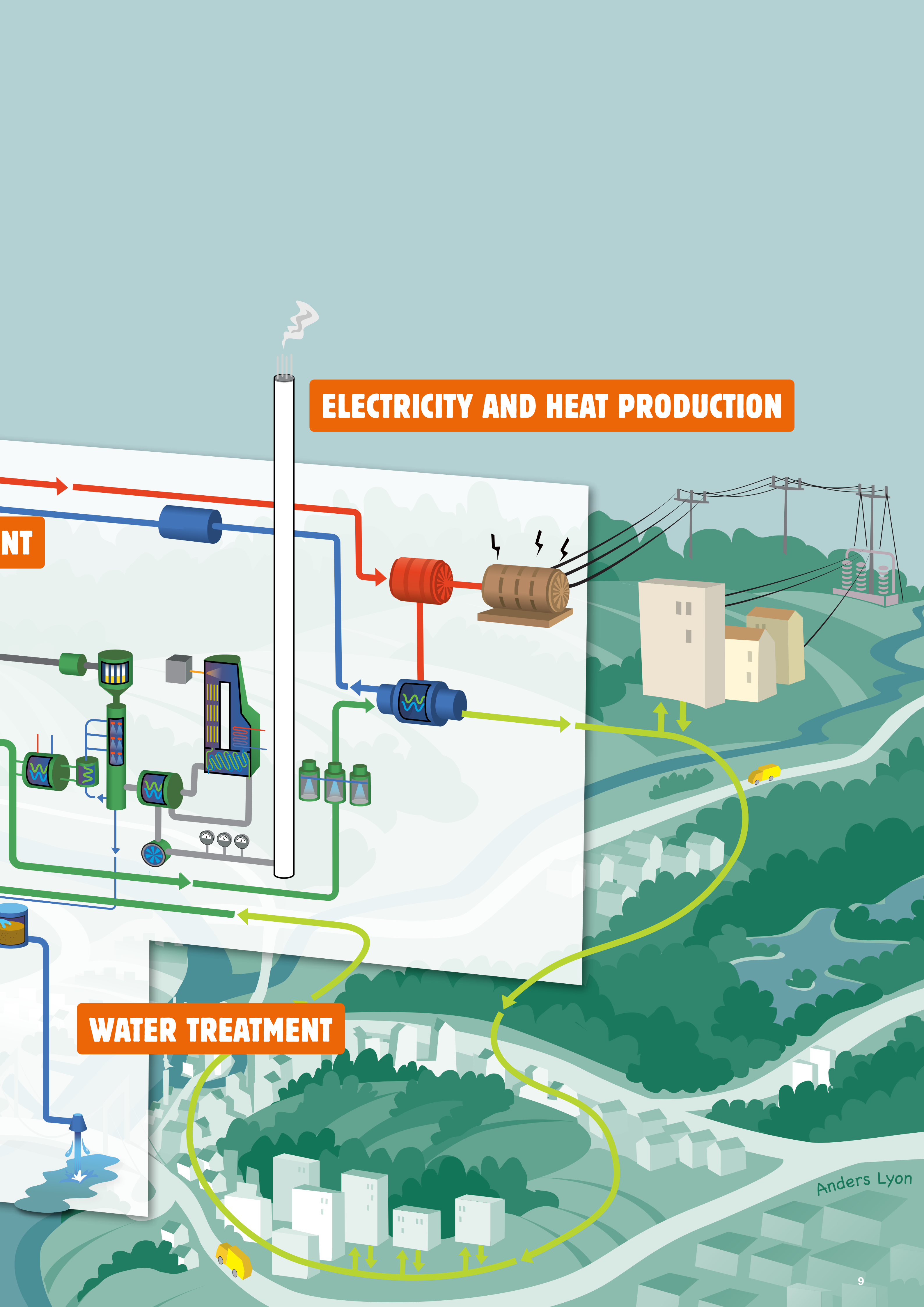
You can read more about our waste- and environmental school as well as the courses we give for companies at **renova.se**

SÄVENÄS WASTE-TO-ENERGY PLANT

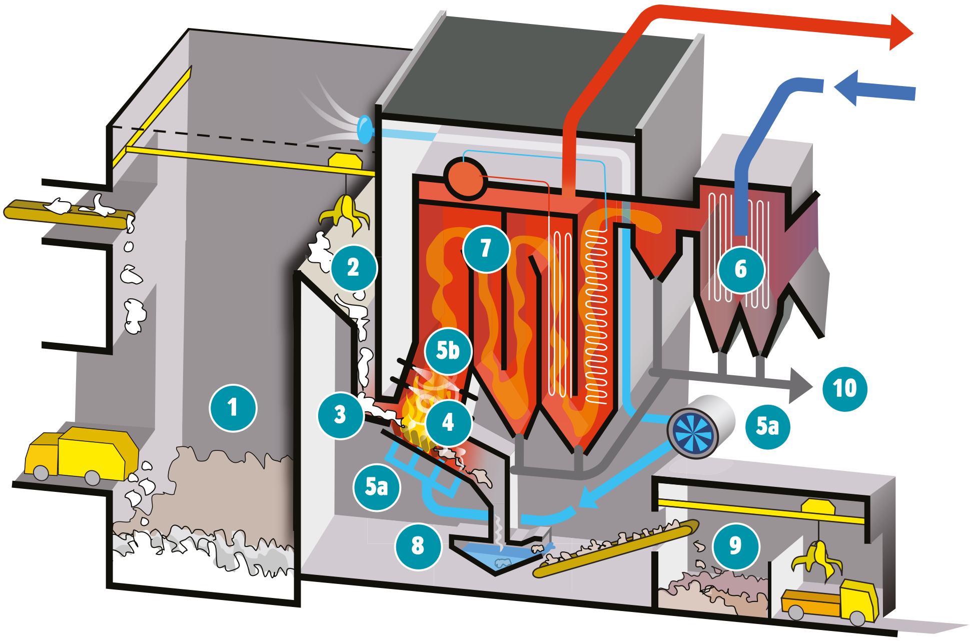
Renova's waste-to-energy plant plays an important role in society. In the illustration, you can follow how the waste delivered to the plant is incinerated and converted into electricity and district heating via the water heated in the steam boilers. You can see the many flue gas and water treatment stages. You can follow the zinc recovery process and the journey other residual products take to either recycling or landfills.

The different sections of the plant are presented in greater detail on the following pages.




ELECTRICITY AND HEAT PRODUCTION
NT
WATER TREATMENT
Anders Lyon

INCINERATION



1 Waste bunker
The waste is emptied into a waste bunker. The bunker holds 22,000 m³, enough to fuel all four furnaces at the plant for almost a week.

2 Feed hopper
Two large cranes lift the waste to the furnace's waste chute. Waste of varying energy content are mixed to optimise the incineration.

3 Ram feeder
A ram feeds the waste into the furnace.

4 Hearth/furnace
The grate temperature is at least 1,000°C. The waste moves downwards on a bed towards the bottom of the furnace to ensure it is fully combusted.

5 Air supply
To ensure sufficient combustion, extra air is blown into the furnace at different stages.

a. Primary air is drawn in from the underside to the fuel bed on the grate. The air comes from the waste bunker and is preheated with low-pressure steam from 20°C to 120°C. This is done to dry the waste for improved combustion. During incineration, some 4,000 m³ of primary air is consumed per tonne of waste.

b. Higher up in the furnace secondary air is supplied from the slag bunker and recirculated flue gases are added. This lowers the nitrogen oxide content of the exhaust flue gases.

6 Economiser
The feed water passes through an economiser where it is preheated.

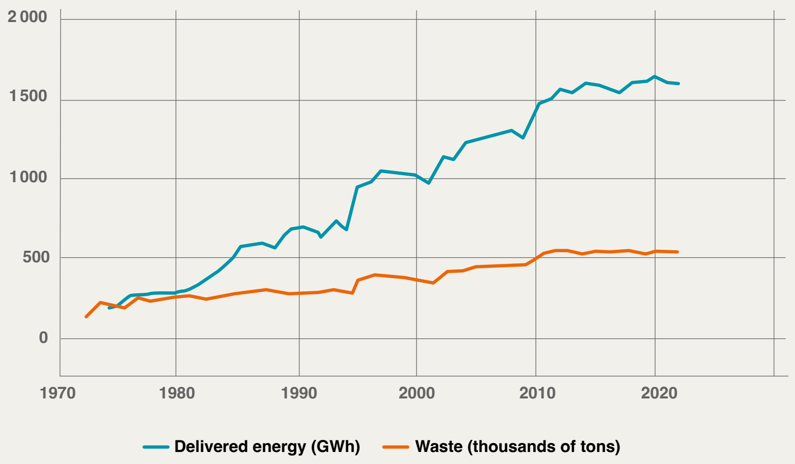
7 Boiler
The water is then routed to the boiler walls, which are lined with pipes. The heat from incineration heats the water in the pipes, turning it into steam. At the top of each boiler there is a steam dome to regulate the water level. When leaving the boilers to generate electricity and district heating, the steam has a temperature of 400°C and a pressure of 40 bar.

8 Slag cooler
Once the waste in the furnace is fully combusted, only non-combustible slag remains. This falls into a water filled trough where the slag gets cooled.

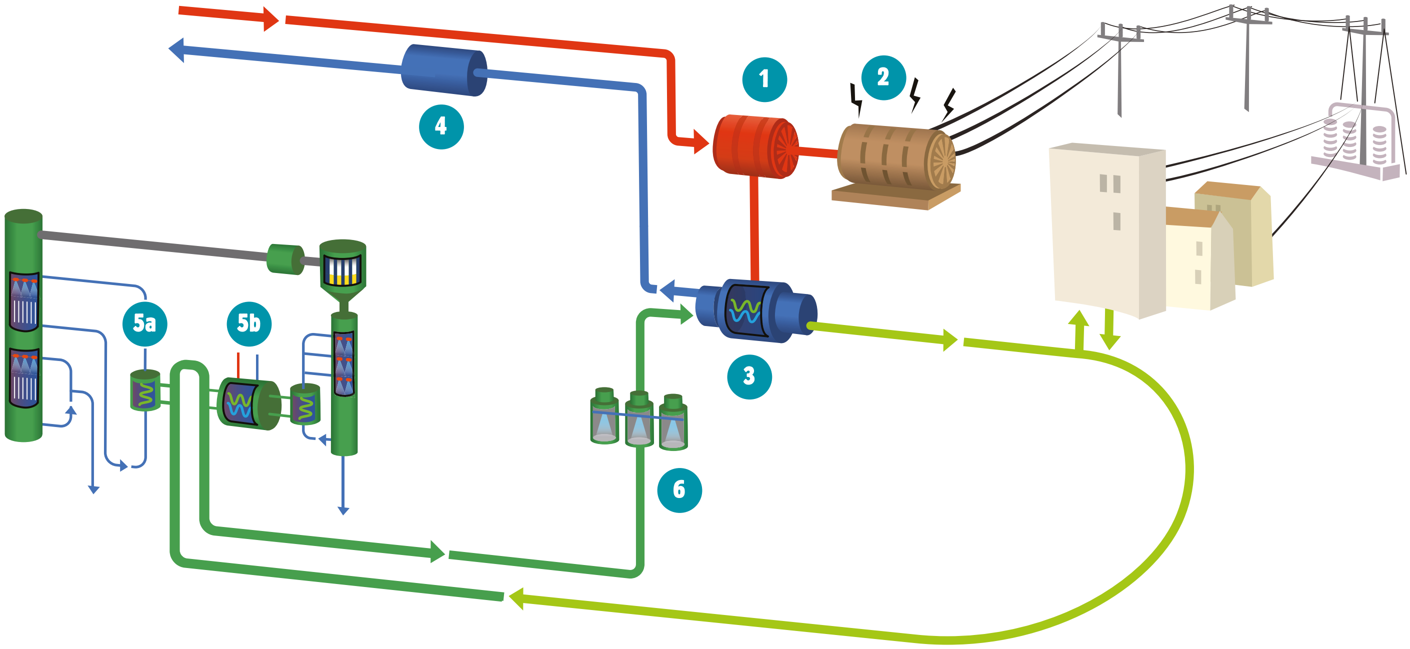
9 Slag bunker
The slag is fed into a slag bunker. From here it is transported to Renova's landfill where it is sorted and recycled.

10 Ash from boilers
The ash from the boilers is collected and wetted. It is then transported to the landfill.

MORE EFFICIENT WASTE-TO-ENERGY PRODUCTION



ELECTRICITY AND HEAT PRODUCTION



1 Turbine
The steam from the waste-to-energy plant boilers is routed to a turbine. The turbine drives the electric generator (2). The steam is thereafter condensed in the turbine condensor (3). A small amount of the steam supply is diverted from the turbine to the low pressure steam system. This low-pressure steam is used to power, for example heat pumps, flue gas reheaters and primary air preheaters.

2 Generator
Here, the kinetic energy from the turbine is converted into electrical energy via mechanical rotational movement which is then fed into the common electrical grid. The generator can produce up to 42.7 MW of electricity.

3 Turbine condenser
In the condenser, heat from the steam is transferred to the district heating water in a heat exchanger. District heating water is heated to 90–115°C and is thereafter fed into the district heating network to heat homes and businesses.

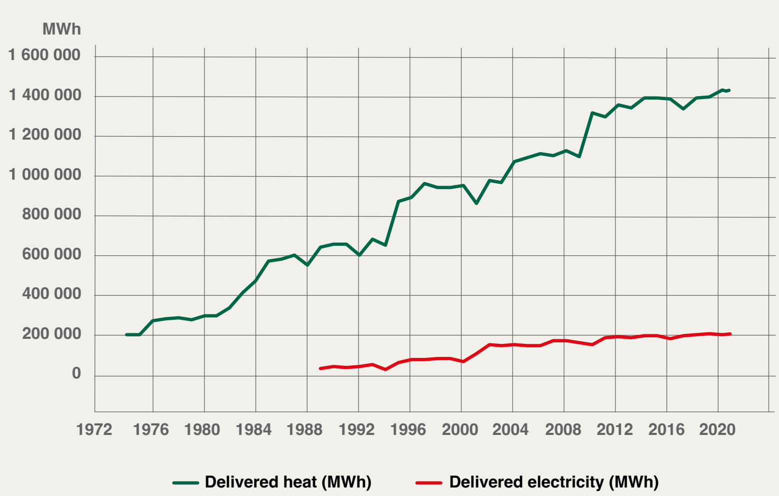
4 Feed water tank
The steam that has transferred its heat to the district heating water condenses into water. This water is pumped to the feed water tank and then, via the economiser, back to the boiler to be heated again.

5 Incoming district heating water
The incoming water from the district heating network has a temperature of 40–50°C . It is preheated by heat recovered from the flue gases in the various treatment stages.
The district heating water is preheated by means of:
a. direct condensation
b. heat pumps

Heat is also absorbed from the hot water economisers. The preheated water is then routed to the feed water tank.

6 Cooling towers
If more district heating than the network can handle is produced, it can be cooled internally by means of cooling towers.

DISTRICT HEATING AND ELECTRICITY PRODUCTION



FLUE GAS TREATMENT

1 **Electrostatic precipitator**
The flue gases from the incinerator first pass through an electrostatic precipitator. Here, more than 99.5 percent of the fly ash is separated from the flue gases. This ash is then transported to an ash washer with zinc recovery.

2 **Booster fan**
The first flue gas fan ensures a stable negative pressure/partial vacuum in the furnace.

3 **Hot water economiser**
The flue gases are cooled to about 140°C while heating the district heating network.

4 **Wet flue gas treatment**

a. Flue gas scrubber
The flue gas from the economiser is cooled to about 60°C . The first washer comprises of an open spray scrubber. The flue gas passes through several water curtains where dust, hydrochloric acid, hydrofluoric acid, mercury and other heavy metals dissolve into the water.

b. Sulphur scrubber & direct condesation column
Sulphur is separated in two steps: First, lye is added to the washer water to raise the pH to about 6. The sulphate-rich water is routed to the gypsum water treatment stage.

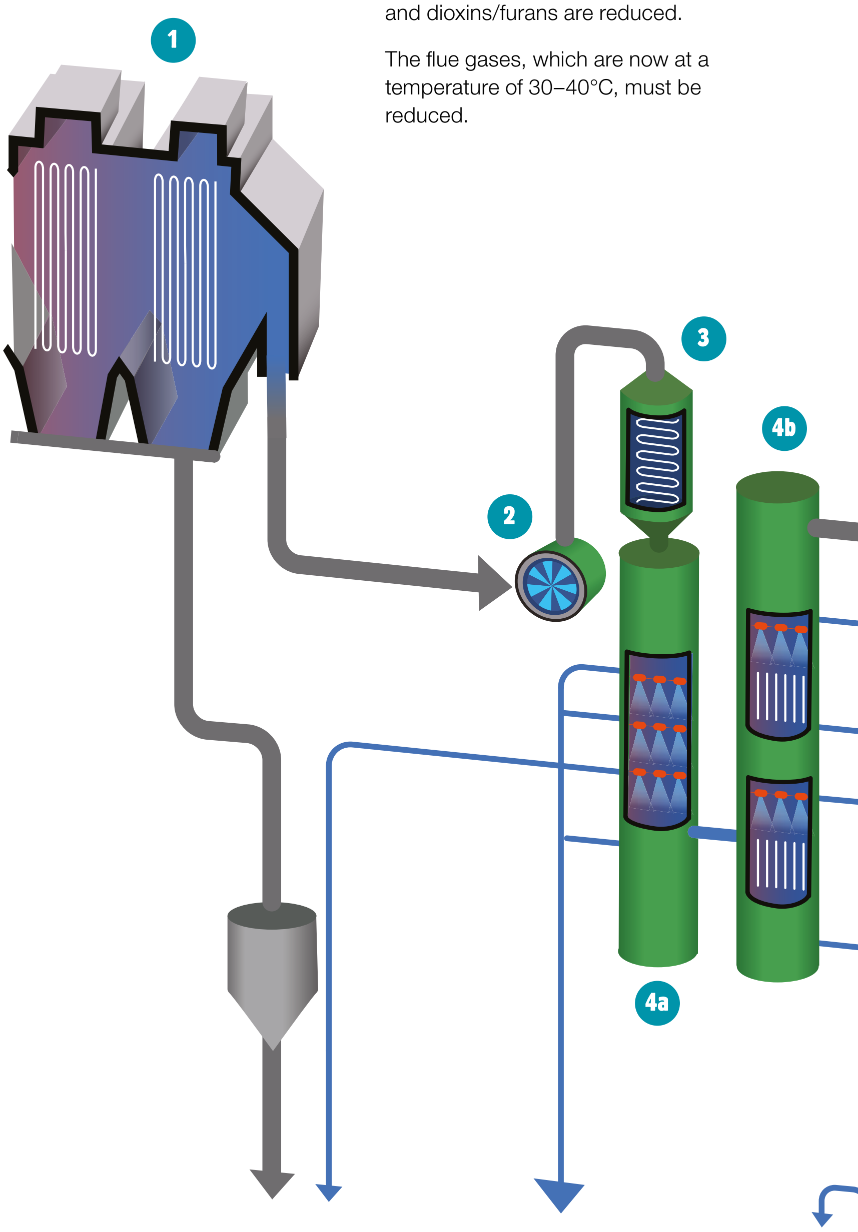
Next, some of the flue gas energy is recovered by means of direct condensation. The circulating water cools the flue gases and the heat is transferred to the district heating system by direct condensation.

c. Electric filter modules
This is the final dust removal stage. The flue gases pass through twelve parallel electric filter venturi tubes, each fitted with a high-voltage electrode and a spray nozzle outlet. The dust particles gain a negative charge and are attracted to the positively charged water droplets. The water droplets are transported together with the flue gases into the underlying condensing column.

d. Condensing column
An open spray column is used to recover more heat by means of flue gas condensation. Water is circulated and sprayed at different levels and high speed so that the flue gases pass through several water curtains. The flue gases are cooled by the water and more flue gas moisture is condensed. The circulating water circuit is fitted with a heat exchanger that transfers the heat to a cooling system. The heated water is routed to absorption heat pumps that raise the water temperature to a level that enables the transfer of the energy to heat the water in the district heating system.

5 **Catalytic converter**
The flue gases from the newest boiler* pass through a catalytic converter. Here, any nitrogen oxides and dioxins/furans are reduced.

The flue gases, which are now at a temperature of 30–40°C, must be reduced.



a. First, the gases pass through two different types of heat exchangers.

b. Next, 400°C high-pressure steam is used to heat the gases in a tube heat exchanger. The gases now have a temperature of about 240°C.

c. Ammonia is injected into the heated flue gases, and when they pass through the catalytic converter, a chemical reaction takes place in which the nitrogen oxides are converted into water and nitrogen gas.

6 Flue gas fan and muffler

The flue gas fan draws the gas through the entire system and to the chimney. To prevent disturbing noises from the stack top, the flue gases pass through a muffler.

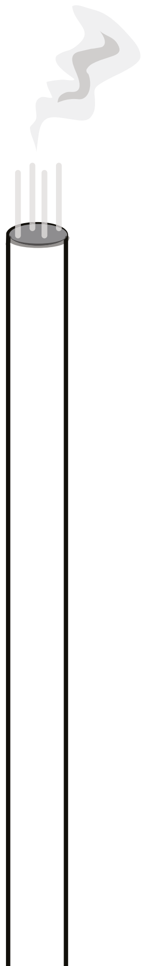
7 Emission measurements

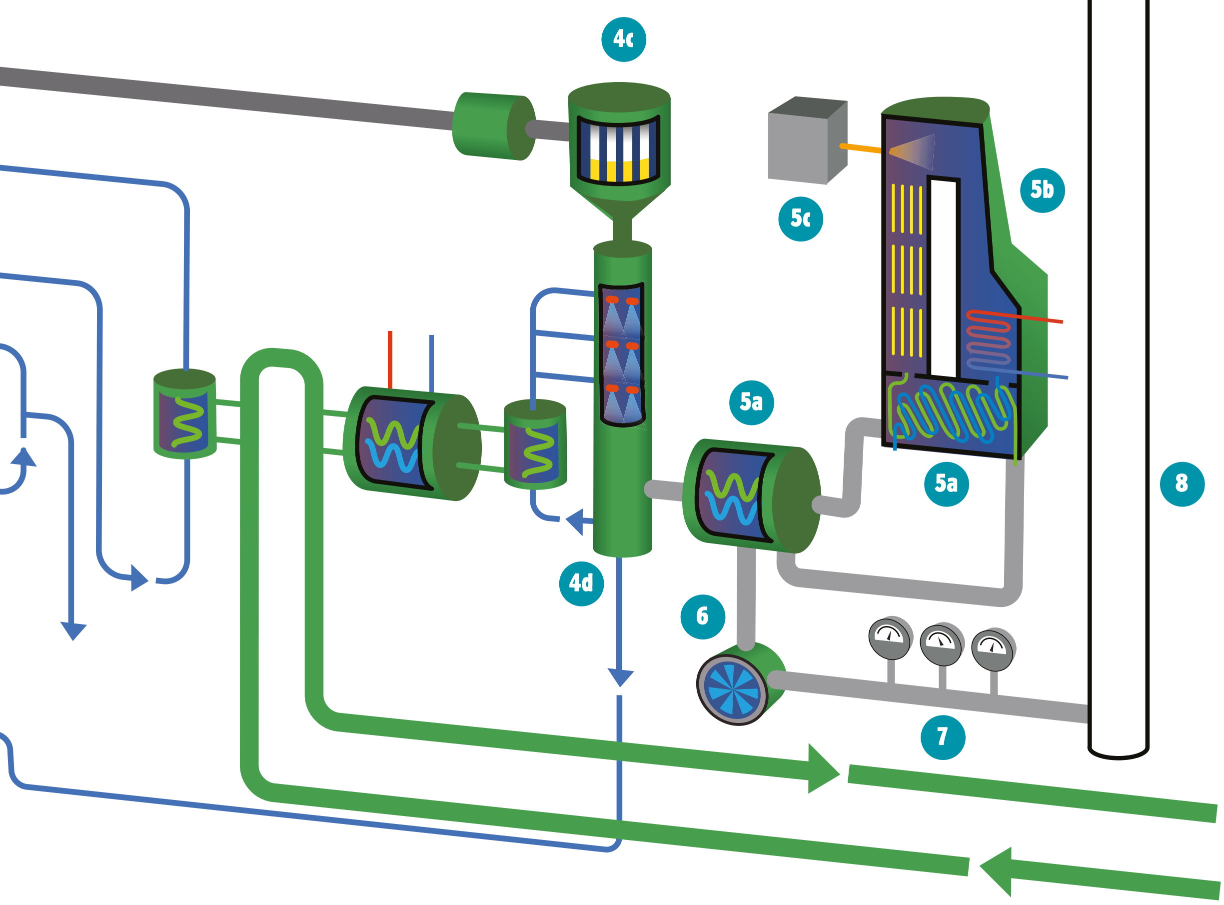
The flue gas duct passes through a measuring room where, among other things, the dust, hydrogen chloride, sulphur and nitrogen oxide content is measured and analysed continuously.

8 Stack

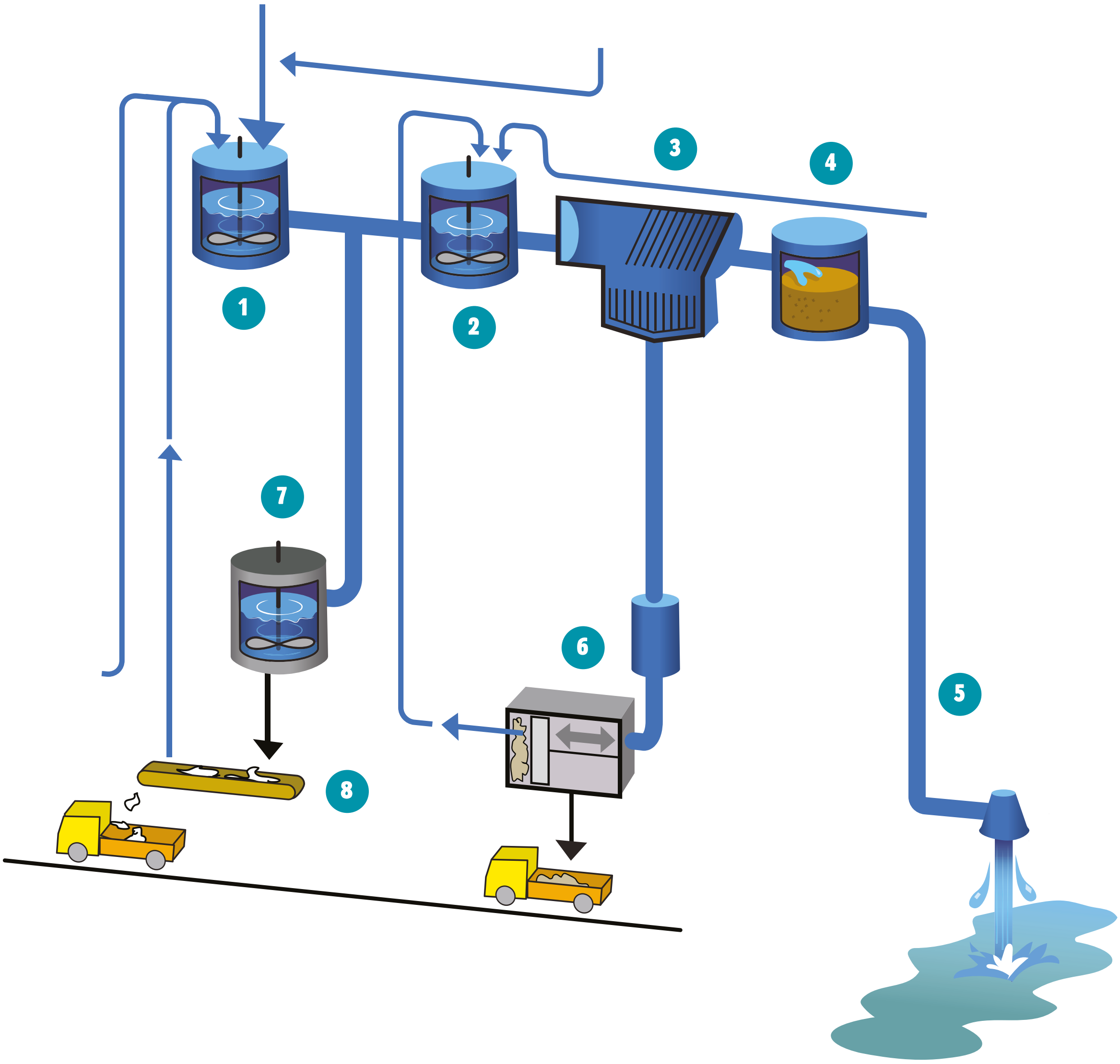
Finally, the flue gases are discharged via the 126-metre-high chimney stack.

** The other boilers use a method in which the flue gases pass through a baghouse filter instead of a catalytic converter to remove dioxins. The nitrogen oxide content has already been reduced by injecting ammonia in the hearth/furnace.*





WATER TREATMENT



1 Gypsum reactor
Limestone and slaked lime are used to adjust the pH of the contaminated process water from the wet flue gas treatment, which is piped to the gypsum reactor. Residual water from the ash washer and the gypsum system is also piped here.

2 Condensate tank
This is where condensate from flue gas treatment and water extracted by the sludge press are collected. Added to this is a precipitating agent, an organic sulphide to separate the contaminants from the water. The contaminants are collected and non-soluble sulphide bonds are formed.

3 Flocculation and sedimentation tank
A polymer, a flocculant that binds the precipitated contaminants into larger flocs that sink to the bottom, is added to the flocculation and sedimentation tank. The flocs are pumped to a sludge tank while the water is piped to a filtration stage.

4 Filtration
The separated water is further treated by being filtered through sand or textile filters.

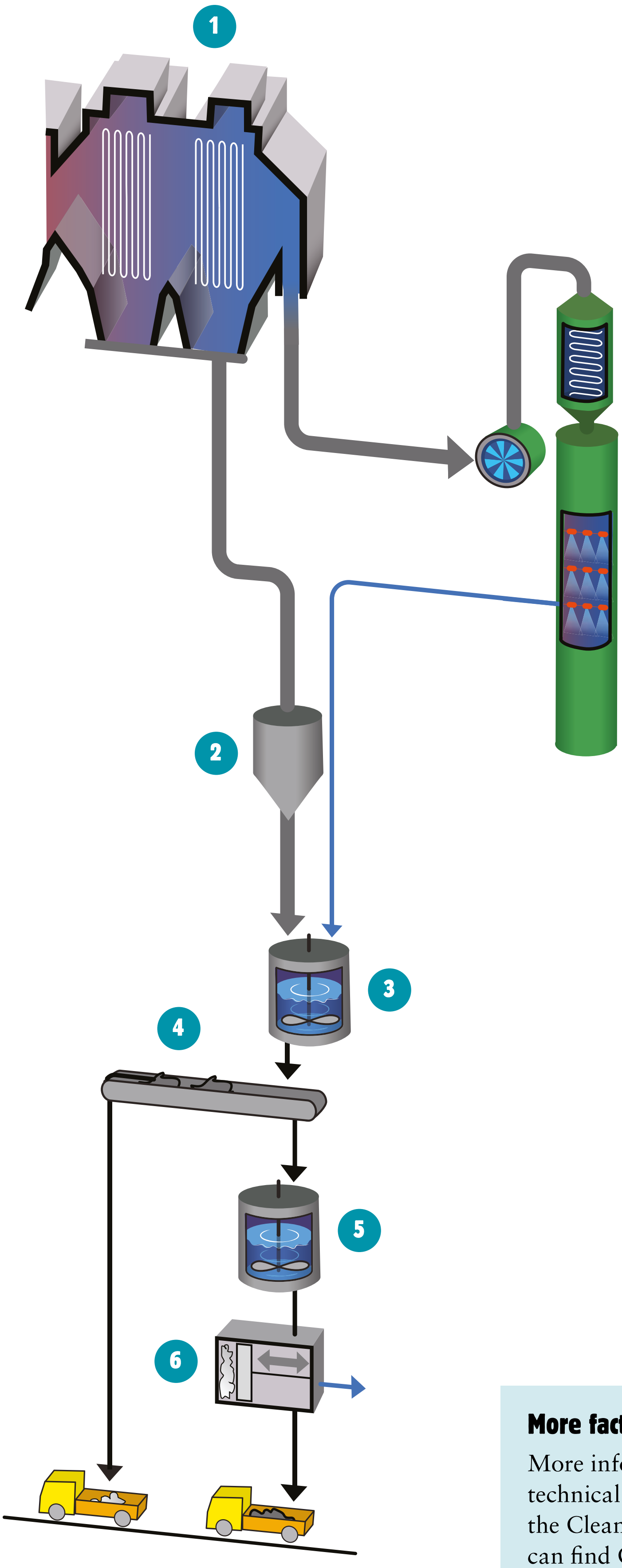
5 Water pipe to Göta älv
The treated water is slightly saline. It is pumped via a five-kilometre pipeline in the tributary Säveån to the parent river, Göta älv. Water quality is monitored by taking regular samples.

6 Sludge press
The contaminated sludge is routed from the sludge tank to a press. There, it is pressed into a sludge cake that is transported to the landfill. The extracted water is piped back to the water treatment system to be treated again.

7 Gypsum system
Wet desulphurisation produces sulphate water. This sulphate water is mixed with neutralised water from the water treatment system containing calcium. A slurry of calcium sulphate (gypsum) is formed.

8 Vacuum belt filter
The gypsum slurry is then transported to a vacuum belt filter where most of the water is removed. This water is pumped back. The gypsum is transported to the landfill.

ASH WASHER WITH ZINC RECOVERY



1 Electrostatic precipitator
The fly ash is collected by the flue gas treatment system's electrostatic precipitator.

2 Ash storage silo
Compressed air is used to transport the collected ash to the ash storage silo.

3 Ash slurry tank
It is then transported from the ash silo to a tank where the ash is washed using the hydrochloric acid (HCl) produced during the wet stage of flue gas treatment. The chemical reaction in the ash slurry tank results in, among other things, zinc being transferred from the fly ash to the acidic liquid.

4 Vacuum belt filter
A vacuum belt filter is used to separate the ash from the liquid. Most of the washed ash is returned to the waste bunker and incinerated once again to degrade dioxins.

5 Precipitation tank
The zinc-rich liquid is routed to a precipitation tank. There, sodium hydroxide (lye) is added, causing the zinc to react and precipitate as flocs.

6 Filter press
To obtain a solid zinc product the flocs are passed through a filter press. The liquid that is extracted is piped to the plant's water treatment system. The zinc product can be refined and reused by society.

More facts about the Waste-to-Energy plant

More information about the waste-to-energy plant – technical data, emissions and more – can be found in the Clean Facts flyer, which is updated annually. You can find Clean Facts under Printed matter at **renova.se.**

Photography: Lars Ardarve, Will Rose and Renova. Illustrator: Anders Lyon. Text: Renova. Graphic production: Nowa Empower, June 2023.

Renova AB, Box 156, 401 22 Gothenburg.
Street address: Gullbergs Strandgata 20-22, 411 04 Gothenburg.
Tel: 031-618 000, e-mail: info@renova.se.
www.renova.se

Waste-to-energy plant street address: von Utfallsgatan 29, 415 05 Gothenburg.