Sustainable Waste to Energy Technology

How waste becomes an environmentally friendly key resource for a sustainable society

Peter Karlsson, Tecknical Director, Modernization Project Unit 6, for Mälarenergi

Mälarenergi AB, Unit 6 waste plant.

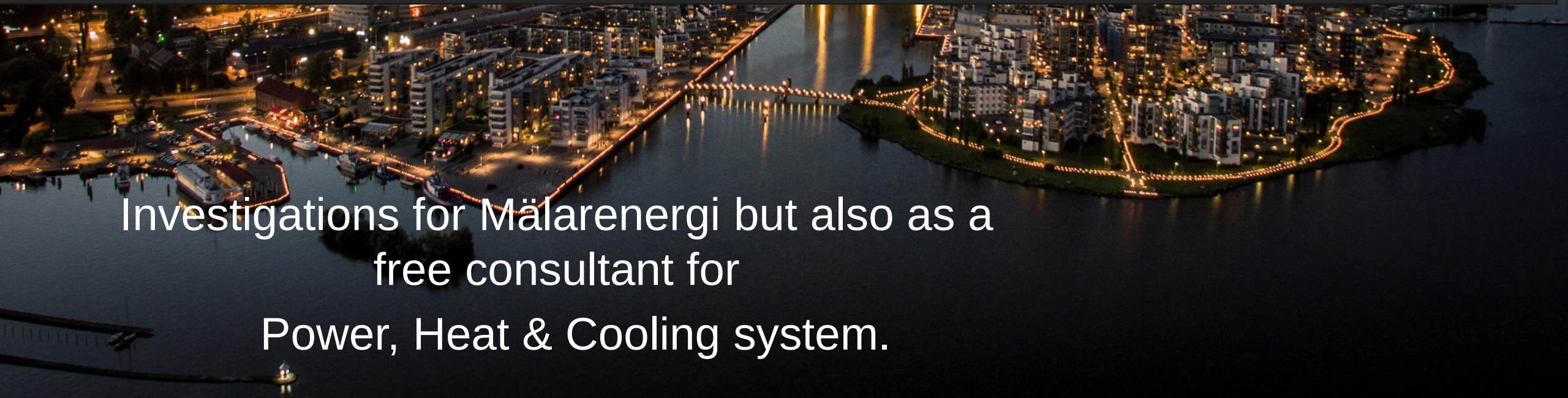
Operation spring 2014, 2.850 MSEK (276 MEUR)

Technical Manager, responsible for the commissioning
and in the steering and controlling group for the Project

Unit 7 recyckled wood.

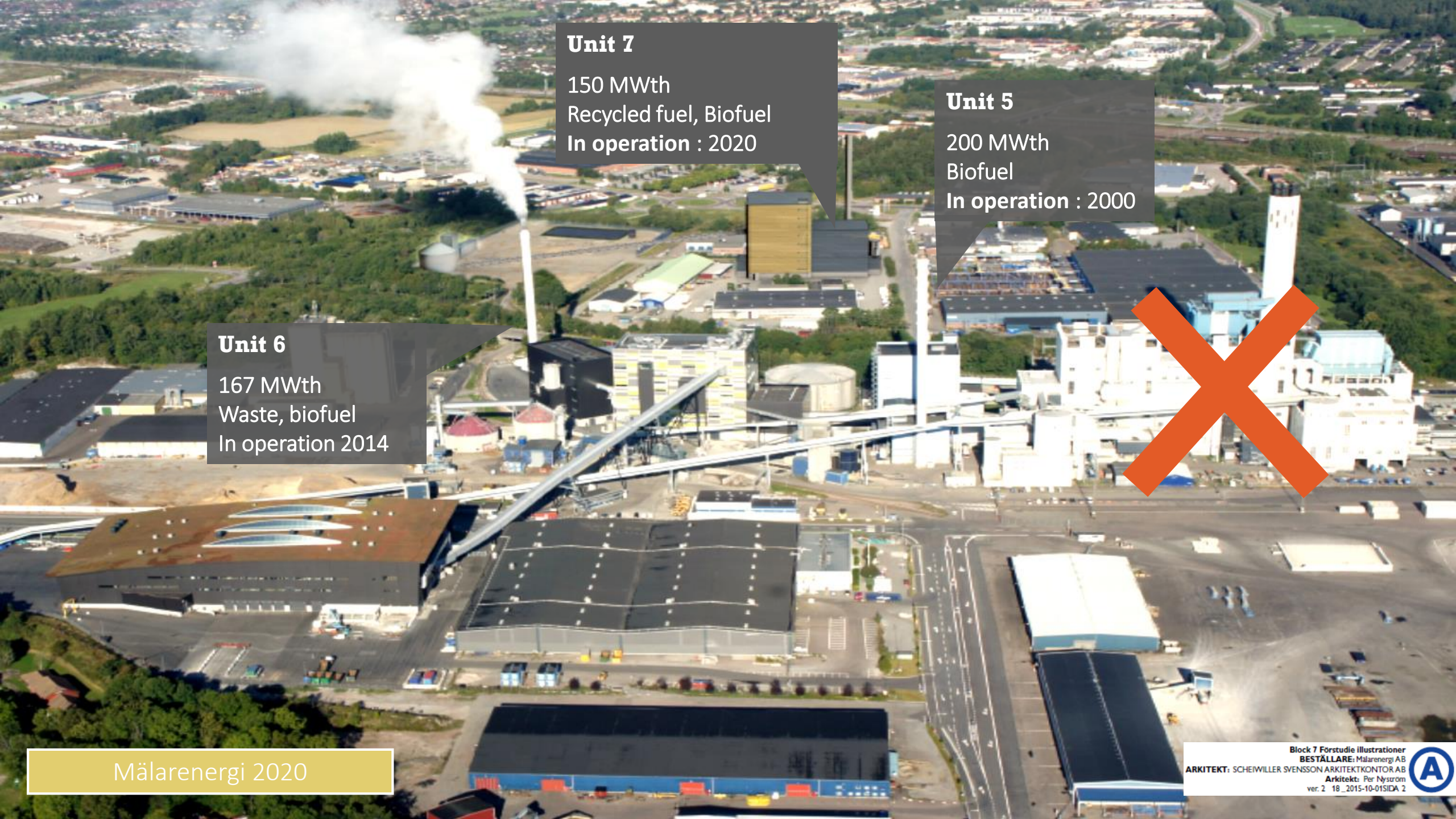
Operation 2020, Investment 1.800 MSEK(174 MEUR)

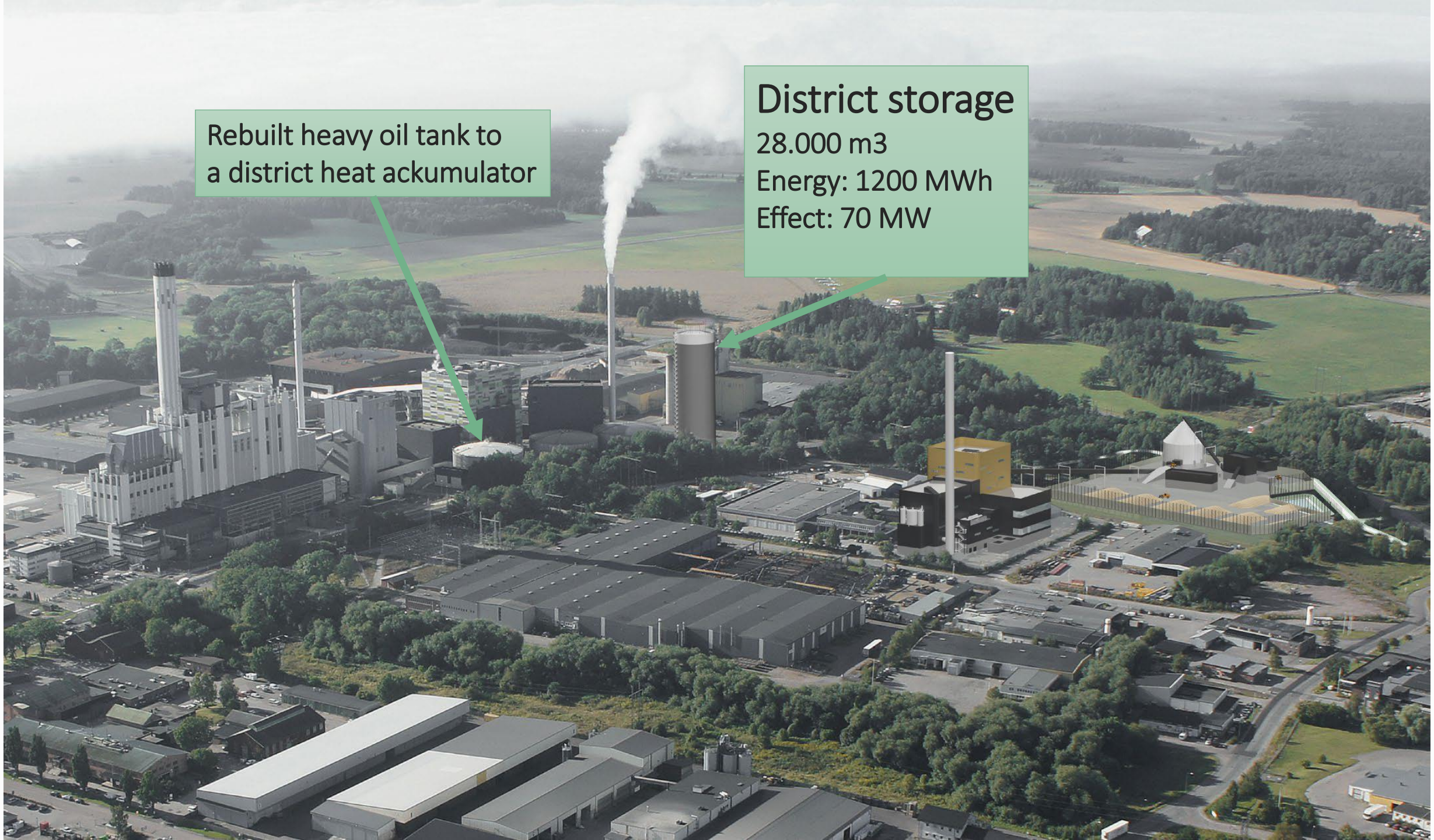
Technical Manager and in the governing group for the Project, 2015- March 2016



Investigations for Mälarenergi but also as a free consultant for

Power, Heat & Cooling system.

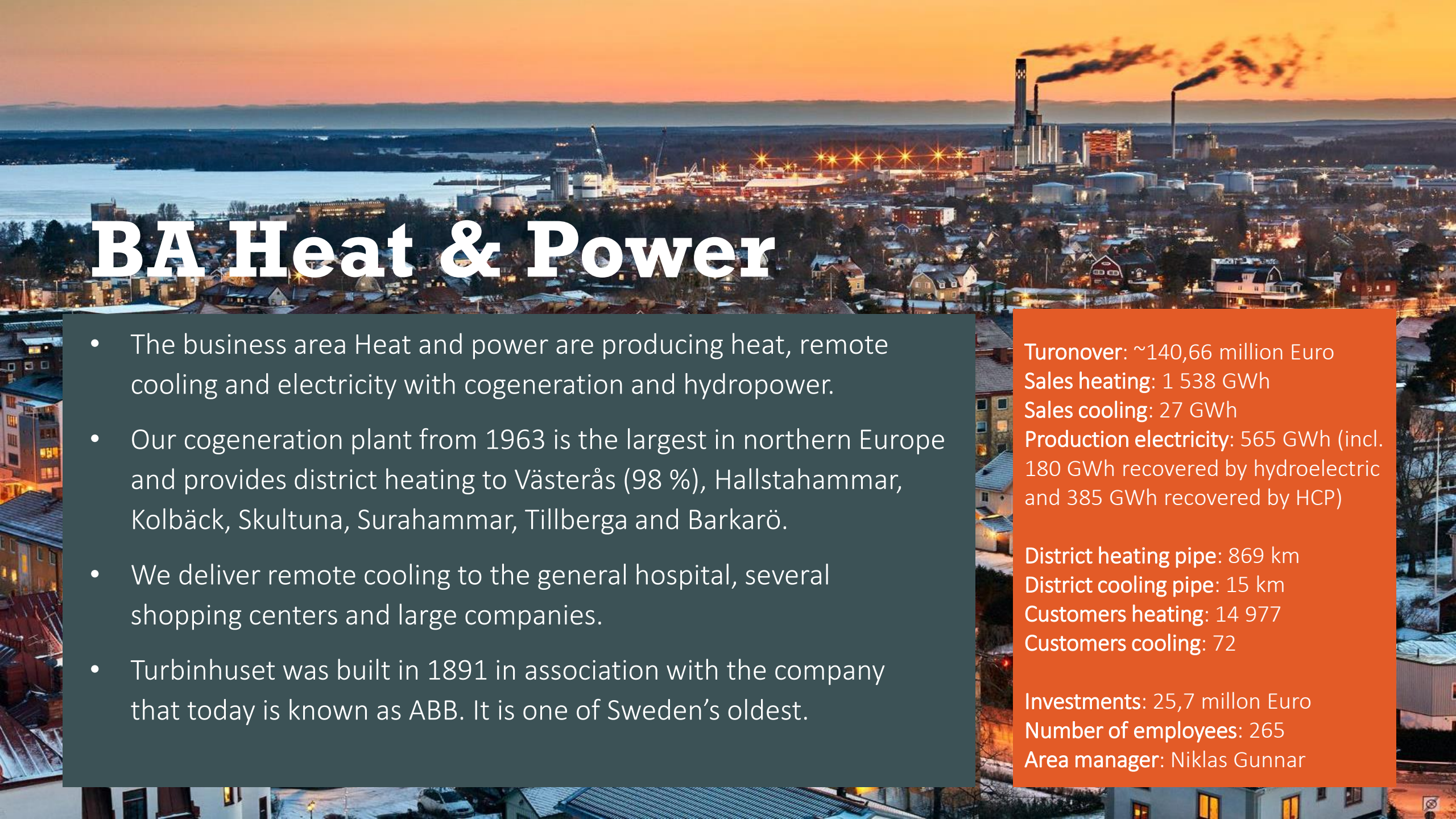

Unit 7
150 MWth
Recycled fuel, Biofuel
In operation : 2020
Unit 5
200 MWth
Biofuel
In operation : 2000
Unit 6
167 MWth
Waste, biofuel
In operation 2014
Mälarenergi 2020
Block 7 Förstudie illustrationer
BESTÄLLARE: Malarenergi AB
ARKITEKT: SCHEIWILLER SVENSSON ARKITEKTKONTOR AB
Arkitekt: Per Nyström
ver. 2 18_2015-10-01SIDA 2


Rebuilt heavy oil tank to
a district heat ackumulator
District storage
28.000 m3
Energy: 1200 MWh
Effect: 70 MW

This is Mälarenergi

Mälarenergi's products and services are the core of several fundamental functions in the society, such as energy-, water- and broadband solutions. We have a wide range of services that provide both individuals, organizations, companies and the general public benefits.

Owner: Västerås City
Turnover: ~3 million Euro
Number of employees: 700
Head office: Västerås



BA Heat & Power

- The business area Heat and power are producing heat, remote cooling and electricity with cogeneration and hydropower.
- Our cogeneration plant from 1963 is the largest in northern Europe and provides district heating to Västerås (98 %), Hallstahammar, Kolbäck, Skultuna, Surahammar, Tillberga and Barkarö.
- We deliver remote cooling to the general hospital, several shopping centers and large companies.
- Turbinhuset was built in 1891 in association with the company that today is known as ABB. It is one of Sweden's oldest.

Turonover: ~140,66 million Euro
Sales heating: 1 538 GWh
Sales cooling: 27 GWh
Production electricity: 565 GWh (incl. 180 GWh recovered by hydroelectric and 385 GWh recovered by HCP)

District heating pipe: 869 km
District cooling pipe: 15 km
Customers heating: 14 977
Customers cooling: 72

Investments: 25,7 millon Euro
Number of employees: 265
Area manager: Niklas Gunnar

Comparison of Fuels Regarding Energy Content

- SRF/ RDF is Fully Comparable to Other Commercial Fuels on the Market Such as Biomass and Coal.

Fuel Comparison: *)

- Bio Fuel 10 – 12 MJ/kg
- SRF/RDF Fuel 9 -18 MJ/kg
- Coal Fuel 11- 28 MJ/kg

*) typical values of variation

Reduced Consumption

Reuse

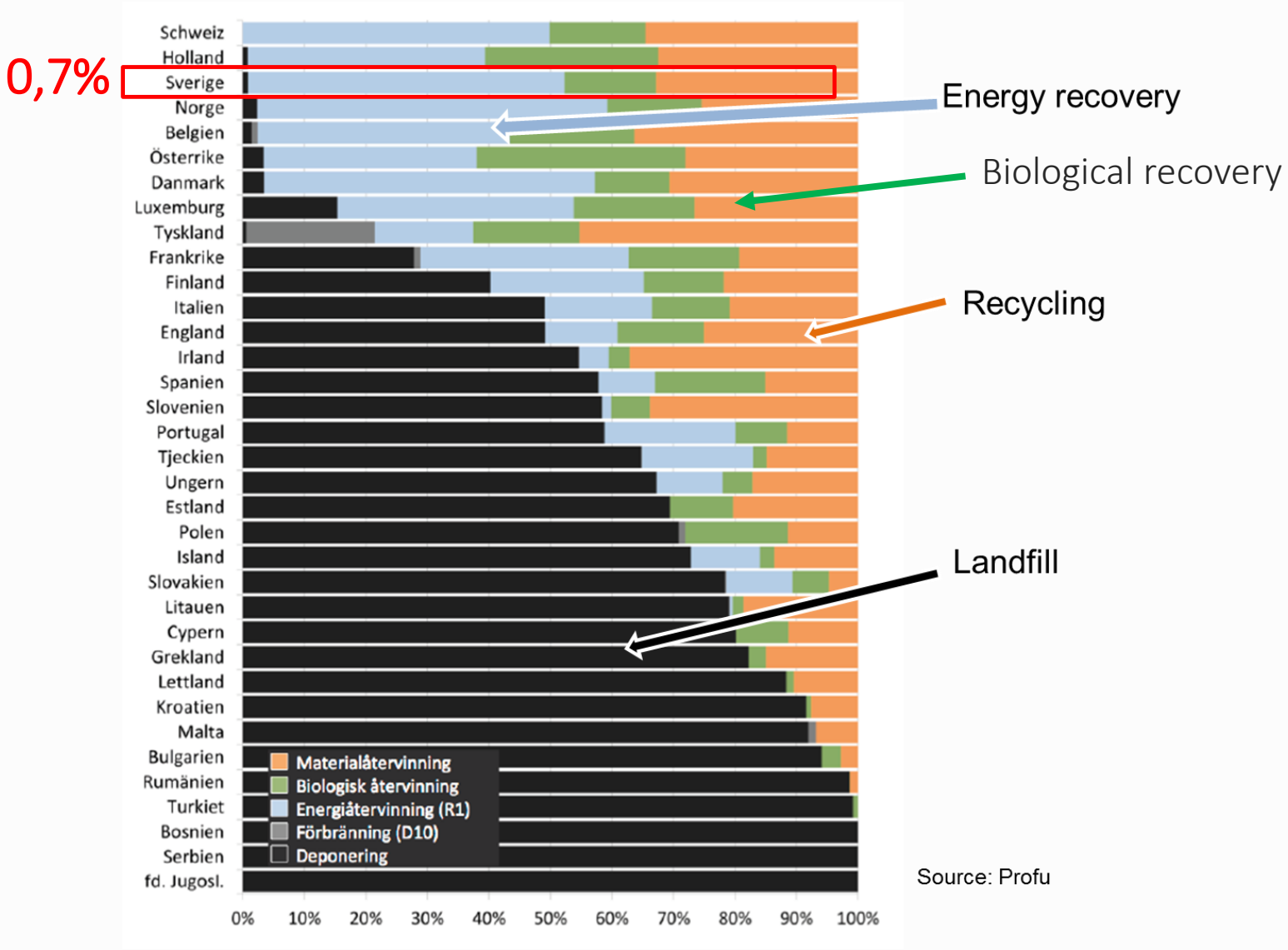
Recycling

Energy Recovery (RDF-fuel)

Disposal

Sweden have less than 1% landfill disposal

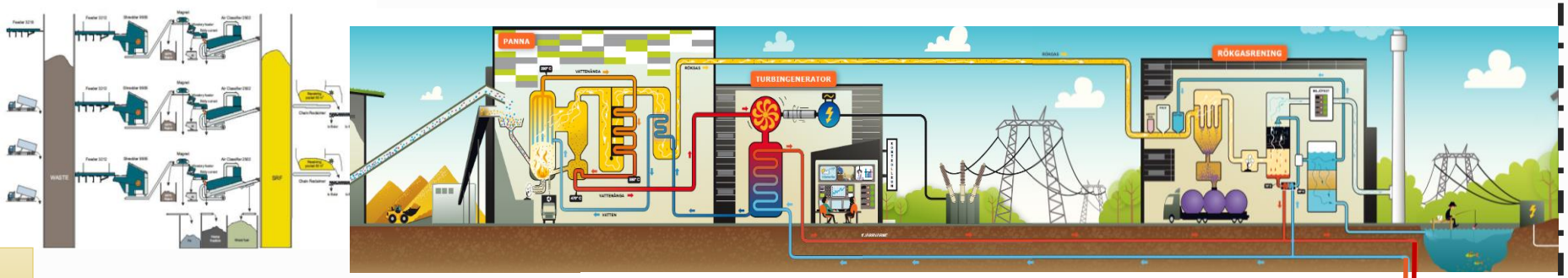
- More countries needs to reduce the landfill disposal



Source: Profu

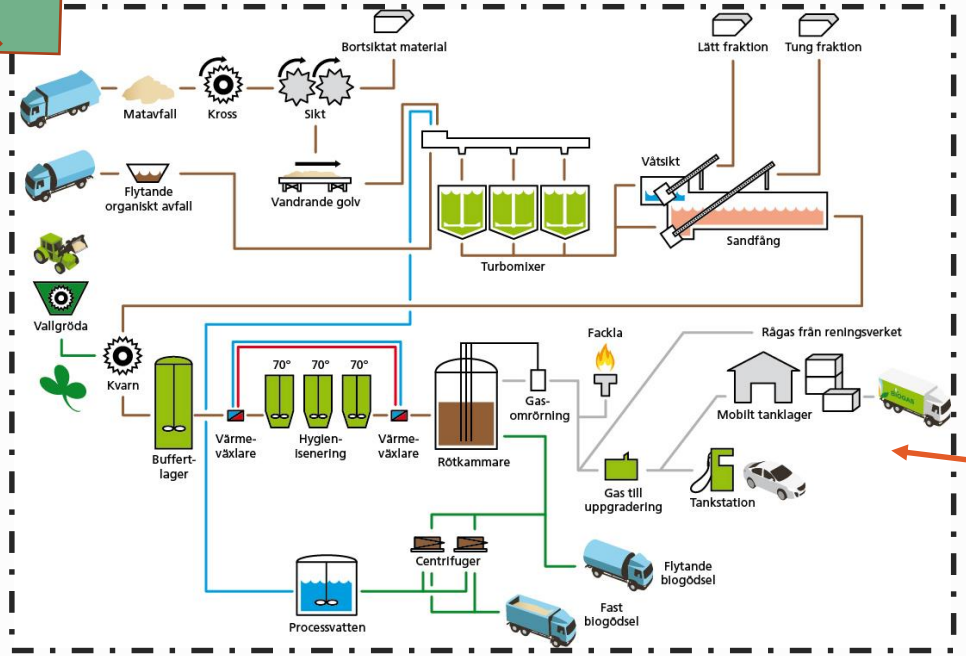
Waste to Energy Combined Heat & Power Plant

Waste



Organic Waste

Organic Waste Processing



Thermal Energy from Power Generation to be used for District Heating and/or by Absorption Chillers in District Cooling system

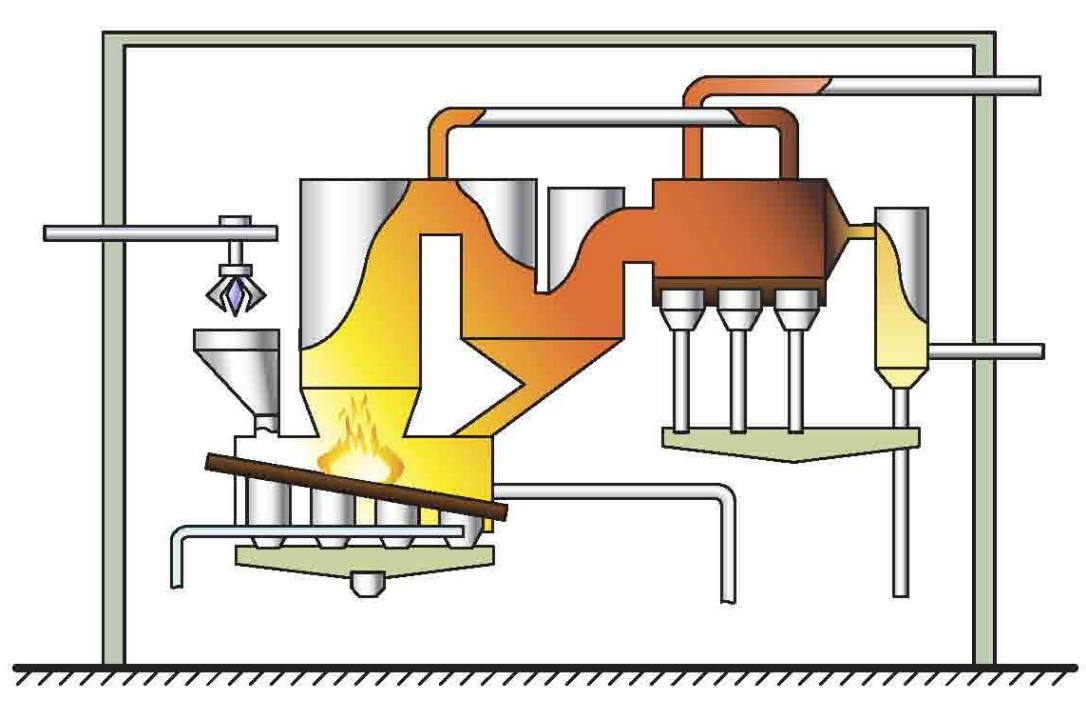
Bio-fuel from digester process upgraded o transportation fuel and used by City buses and Taxis

The technology of the Waste to Energy Plant Mälarenergi

Why this solution?

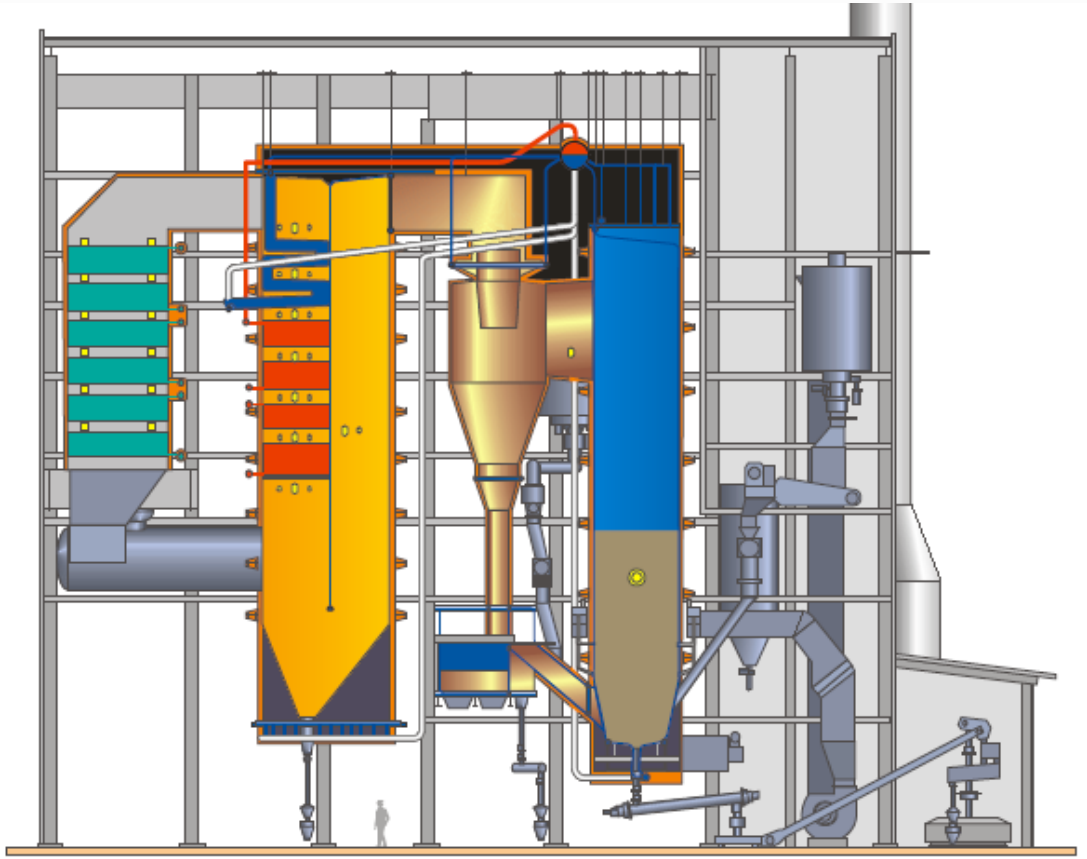
Comparison Techniques

Grate Technology

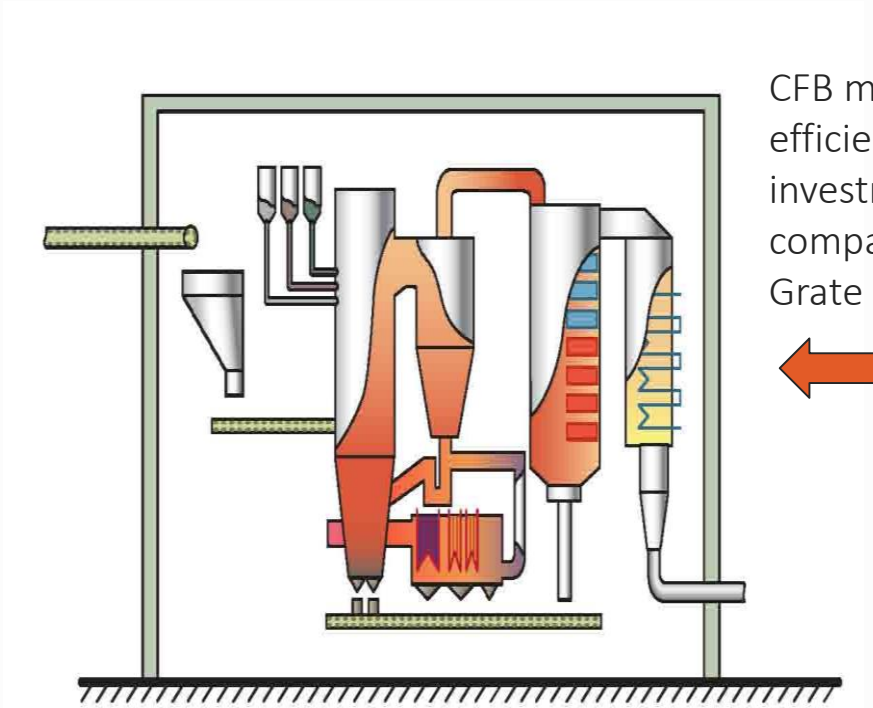


- Most common technology

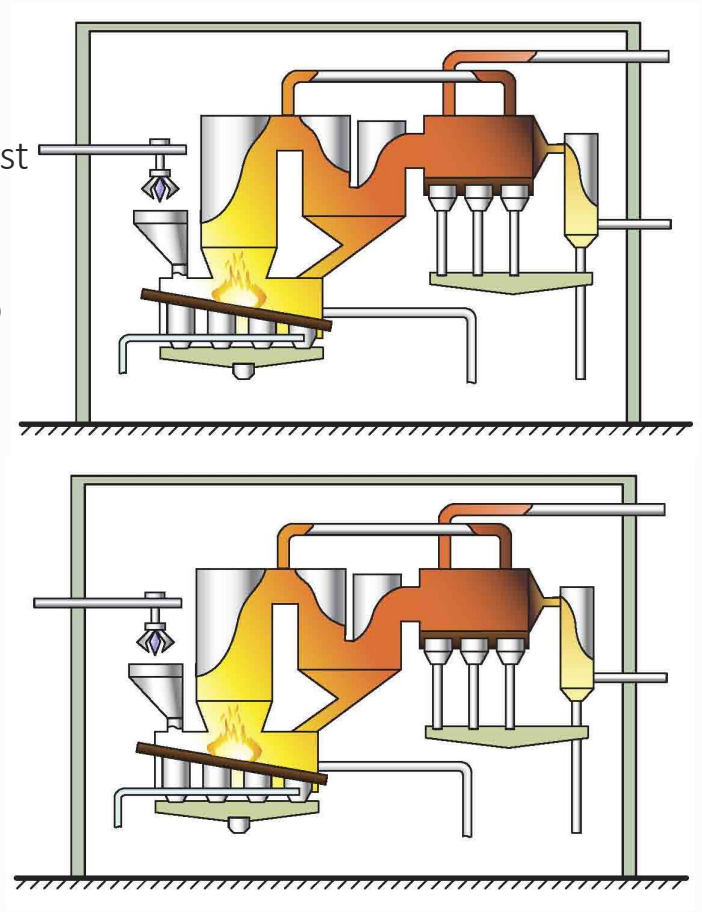
Circulating fluidized bed boiler(CFB)



400 000 ton/year Consumtion



CFB more cost efficient investment compared to Grate



Comparison Techniques

Grade Boiler

Advantages

Well proven technique

Minimal fuel preparation

Disadvantages

Limited capacity per line about 100 MW of fuel

Low steam data

Limited fuel flexibility without rebuilding

Limited opportunities for SNCR, environmental requirements can lead to SCR

CFB-Boiler

Advantages

Can scale up to big effects 220 MW of fuel.

Very good combustion

Higher steam data possible

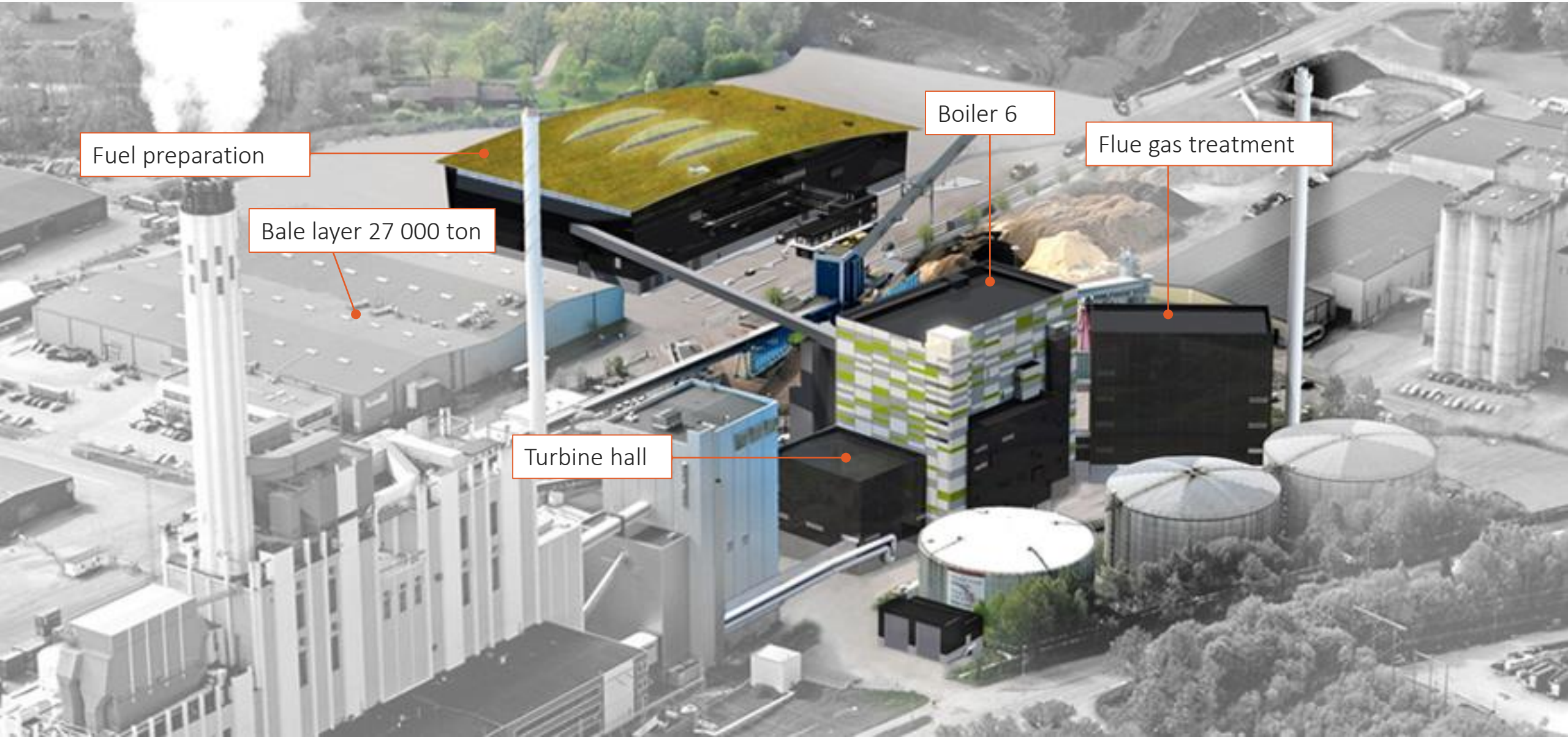
Low air surplus provides high boiling efficiency and high yield from flue gas condensation

Fuel-flexible with the possibility of burning biofuels to 100

Disadvantages

Requires comprehensive fuel preparation

Unit 6 - A world-unique cogeneration plant



Process Unit 6.

World’s biggest waste CFB-line

Produce 50 MW of electricity,100 MW heat and 30 MW heat in the condensing plant.

Operation time 8000 hour/year.

Outage two times a year from 9-13 days each.

2016 we has consumed 400 000 ton of waste.

Efficiency 97% (Low Heating Value)

Waste as fuel.

- Around 50 % from the region and Sweden.
- Around 50 % imported. Supplied in bales of around 1 ton each

Fuel to Boiler 6:

- Household waste, paper, plastic
- Industrial waste, wood, paper, plastic, metal
- Wood waste, for example, impregnated timber.

Focus efficient logistics.

MälarEnergi

From the boat to the prepreation plant or the fuel layer

Fuel storage
Indoor storage for baled fuel 27.000 ton.

Fuel preparation.

A smart fuel preparation plant with both Crushing and sorting

Reception, preparation, handling

480,000 tonnes of industrial and household waste annually.

Weighing-in, inspection and crushing

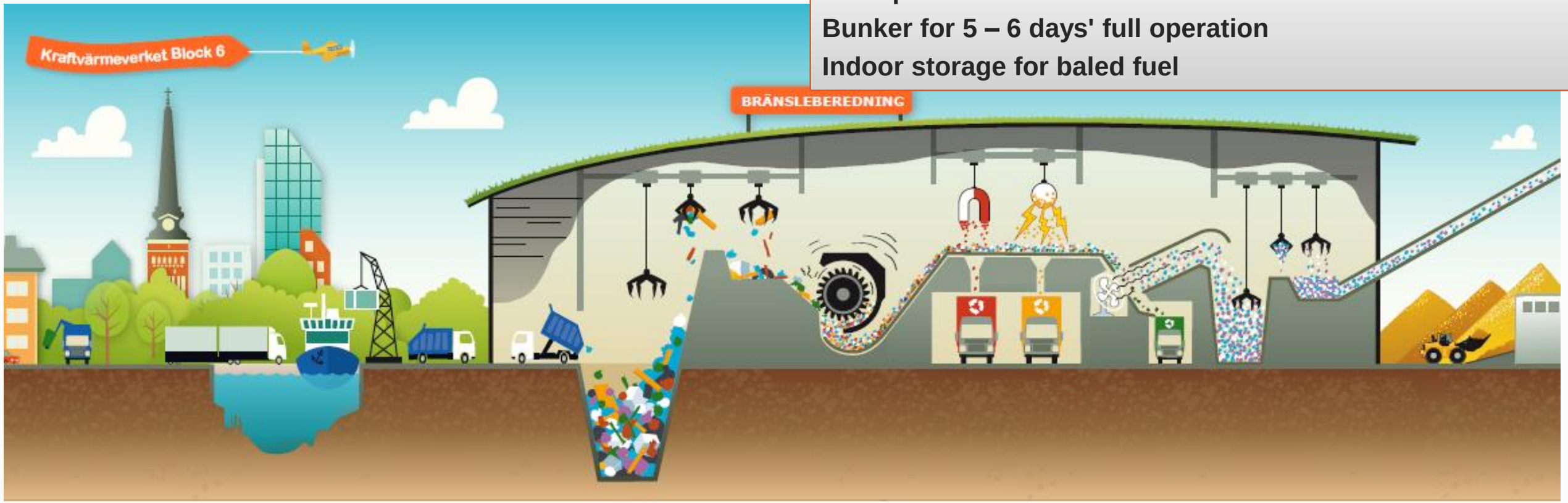
Separation of unwanted material

Bunkering

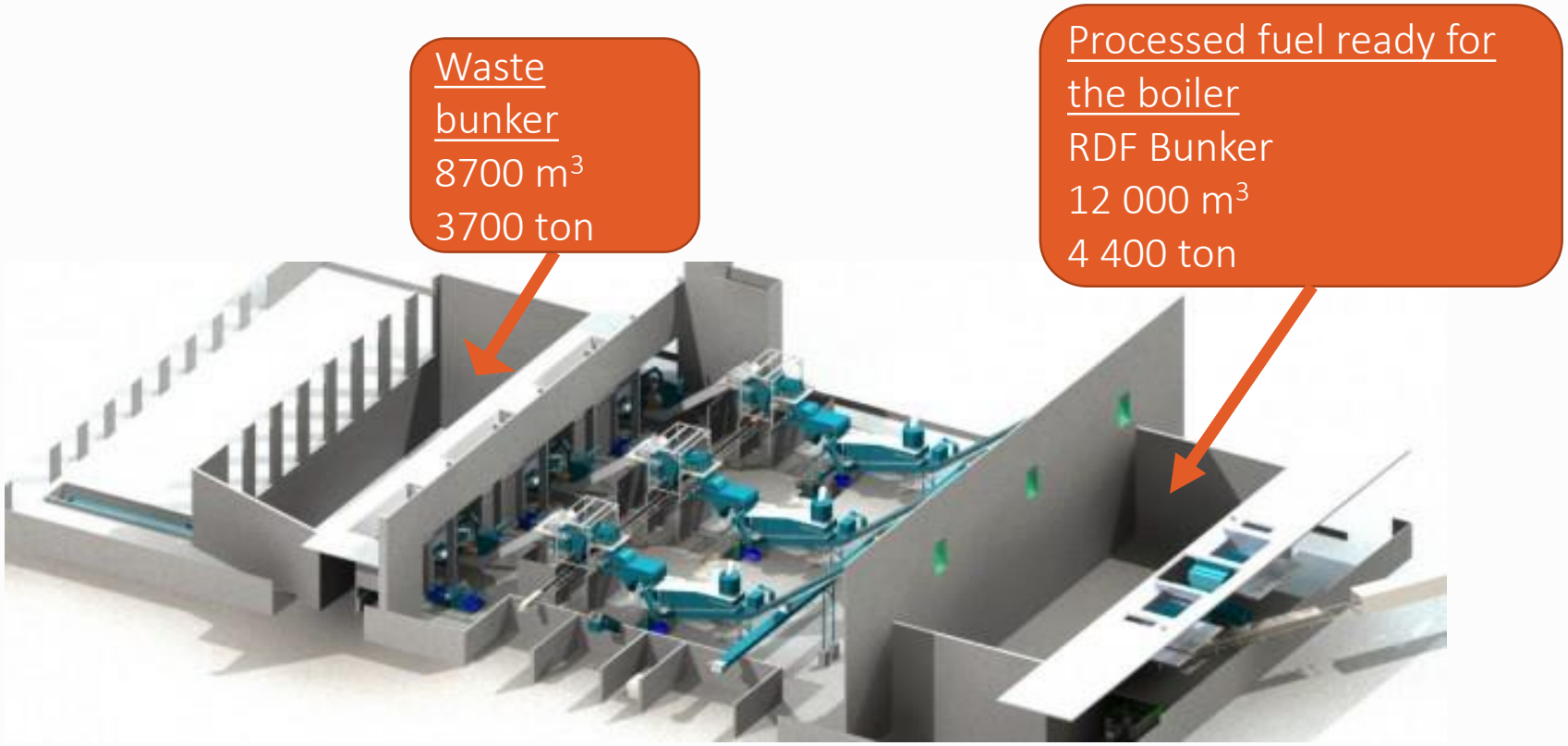
Transportation to the incinerator

Bunker for 5 – 6 days' full operation

Indoor storage for baled fuel

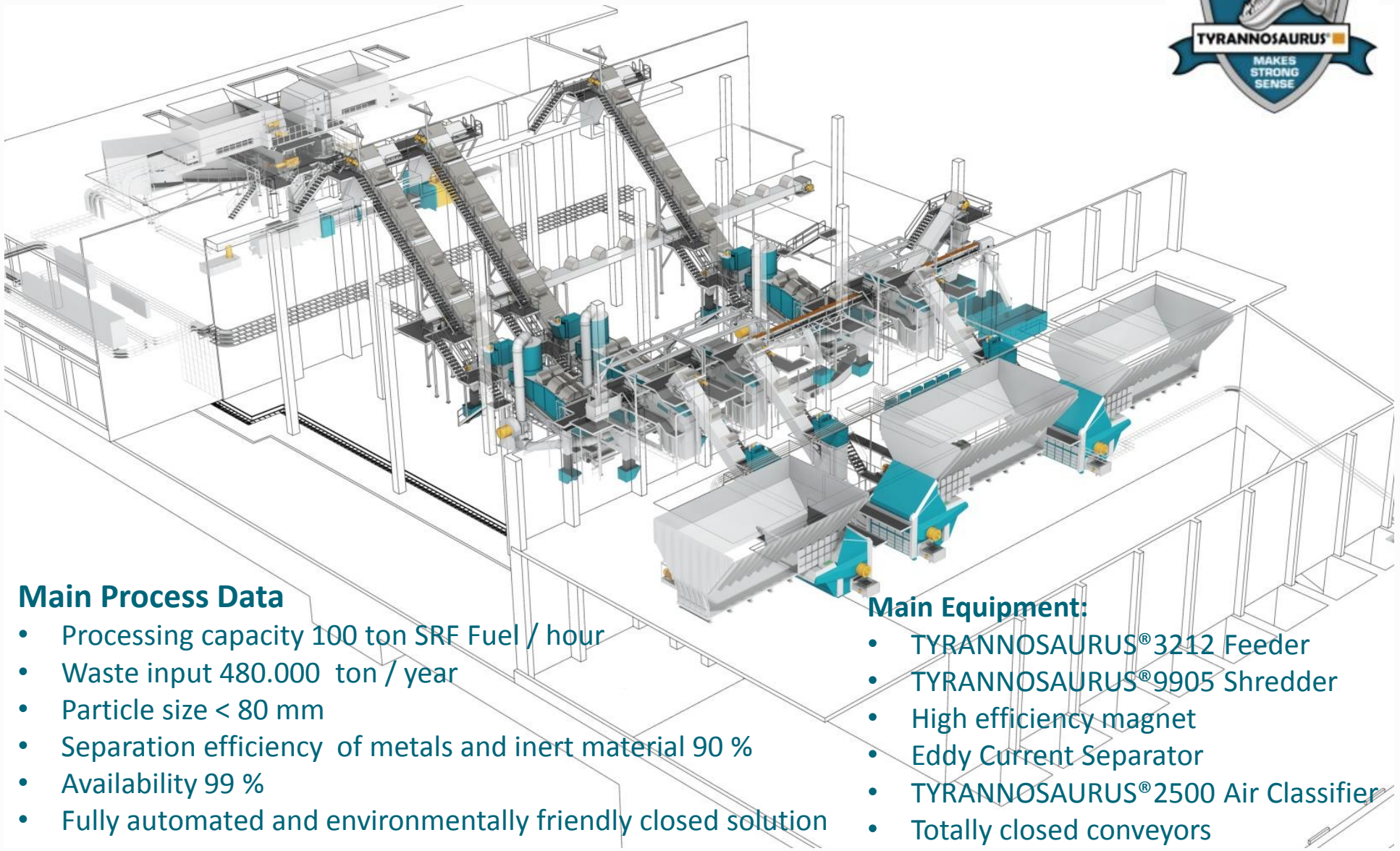


Fuel flow to the boiler 1500 ton/dygn



One process line 40 ton/h, totally 3 lines, manufacture of RDF fuel and Recykled wood

The Waste to Fuel Preparation Plant, BMH



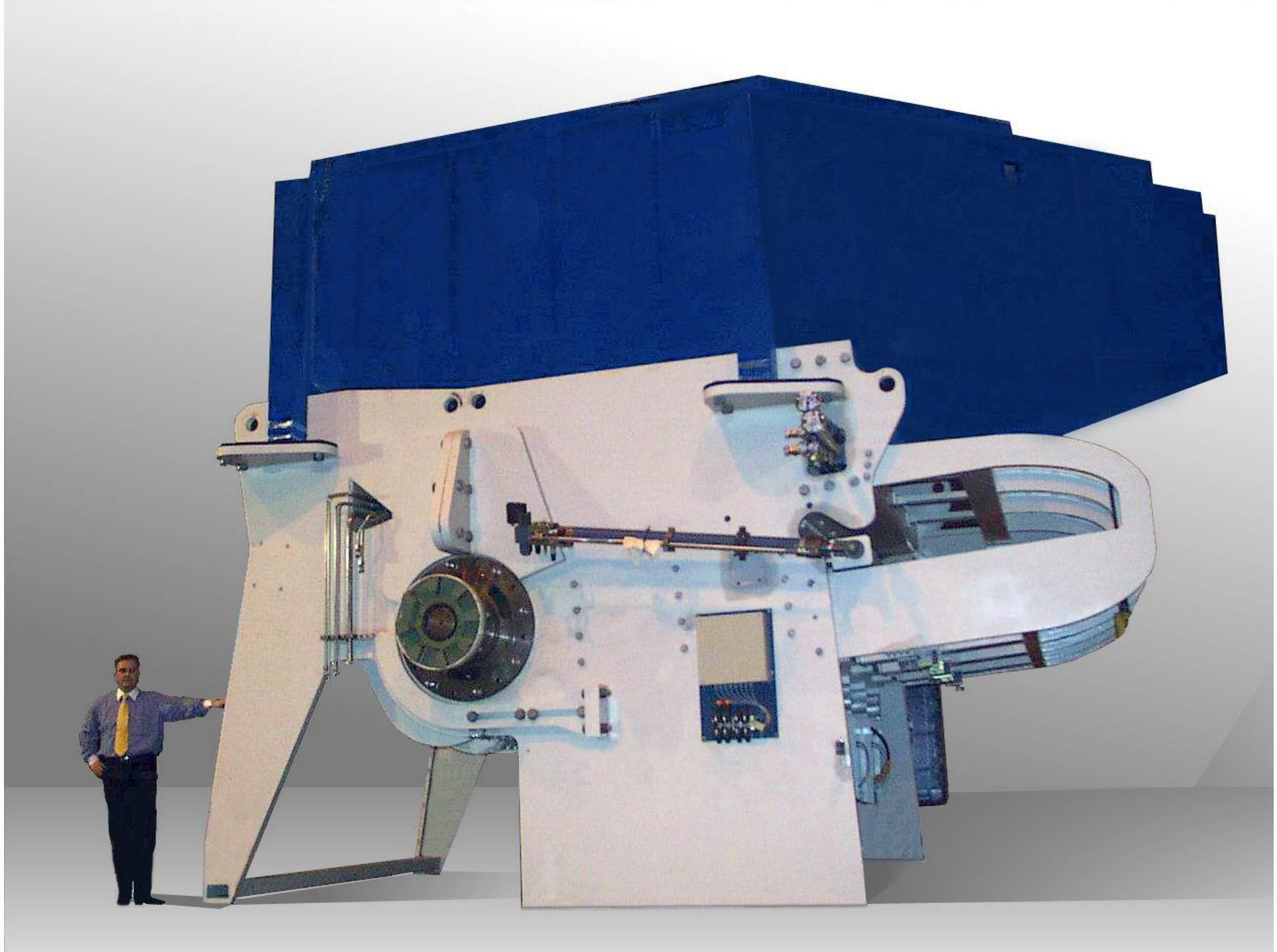
Main Process Data

- Processing capacity 100 ton SRF Fuel / hour
- Waste input 480.000 ton / year
- Particle size < 80 mm
- Separation efficiency of metals and inert material 90 %
- Availability 99 %
- Fully automated and environmentally friendly closed solution

Main Equipment:

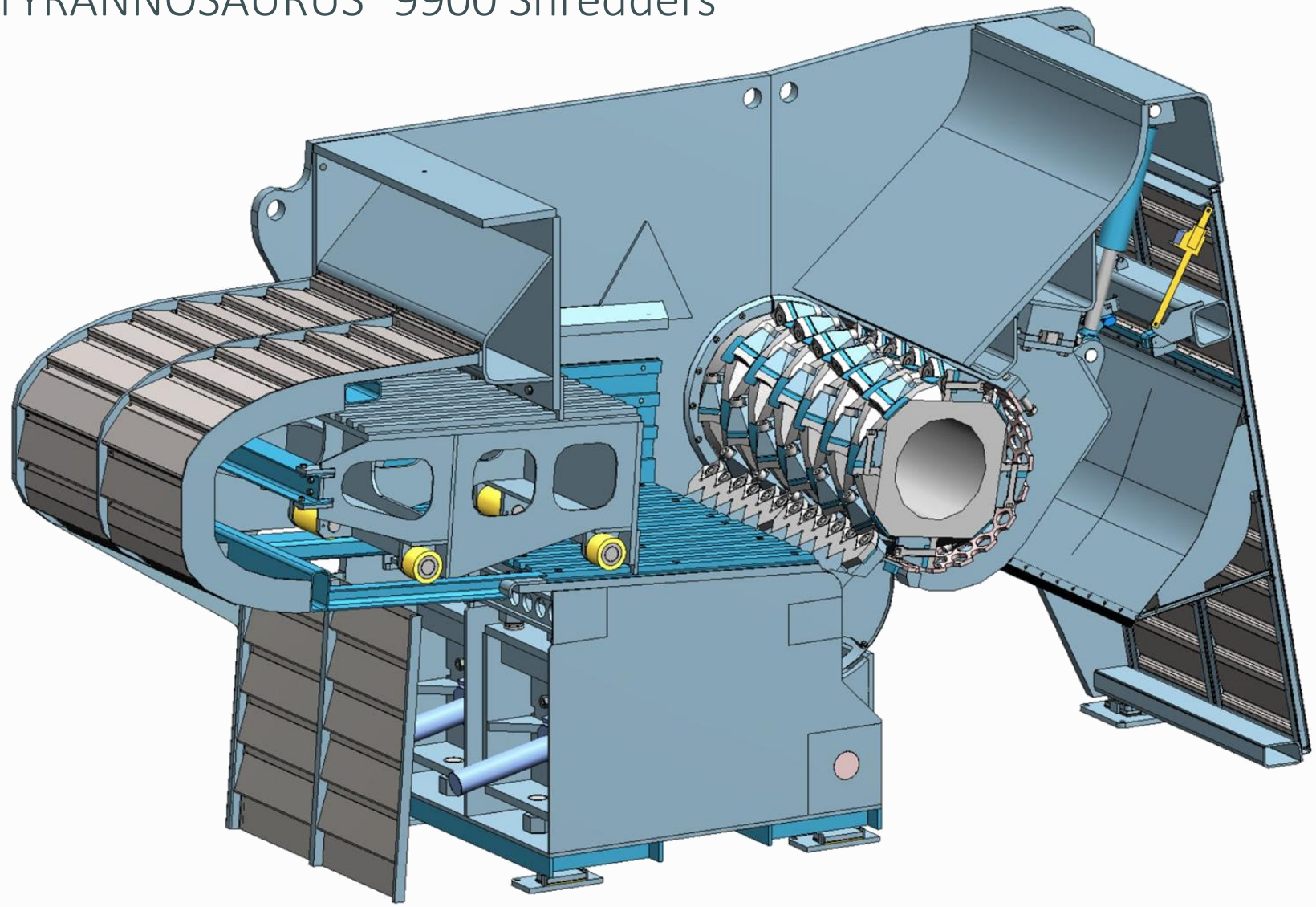
- TYRANNOSAURUS®3212 Feeder
- TYRANNOSAURUS®9905 Shredder
- High efficiency magnet
- Eddy Current Separator
- TYRANNOSAURUS®2500 Air Classifier
- Totally closed conveyors

The Waste to Fuel Preparation Plant



The shredder has a key function.

TYRANNOSAURUS® 9900 Shredders

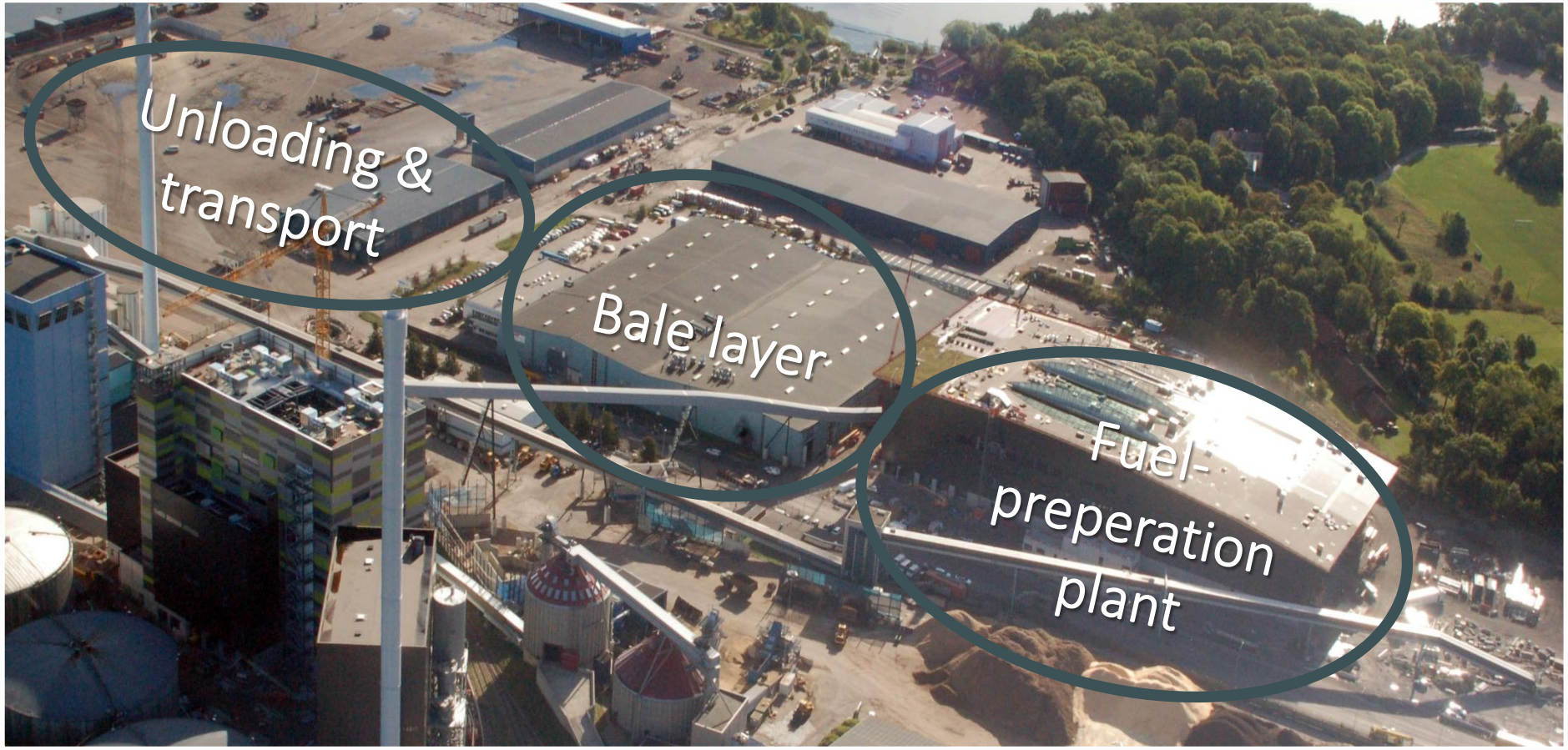


Jaws on Tyrannusaurus

A challenge of managing waste in a production plant in the outskirts of the city of Västerås with respect to smell.

Per Karlsson, mail12@gmail.com

Actions to minimize smell



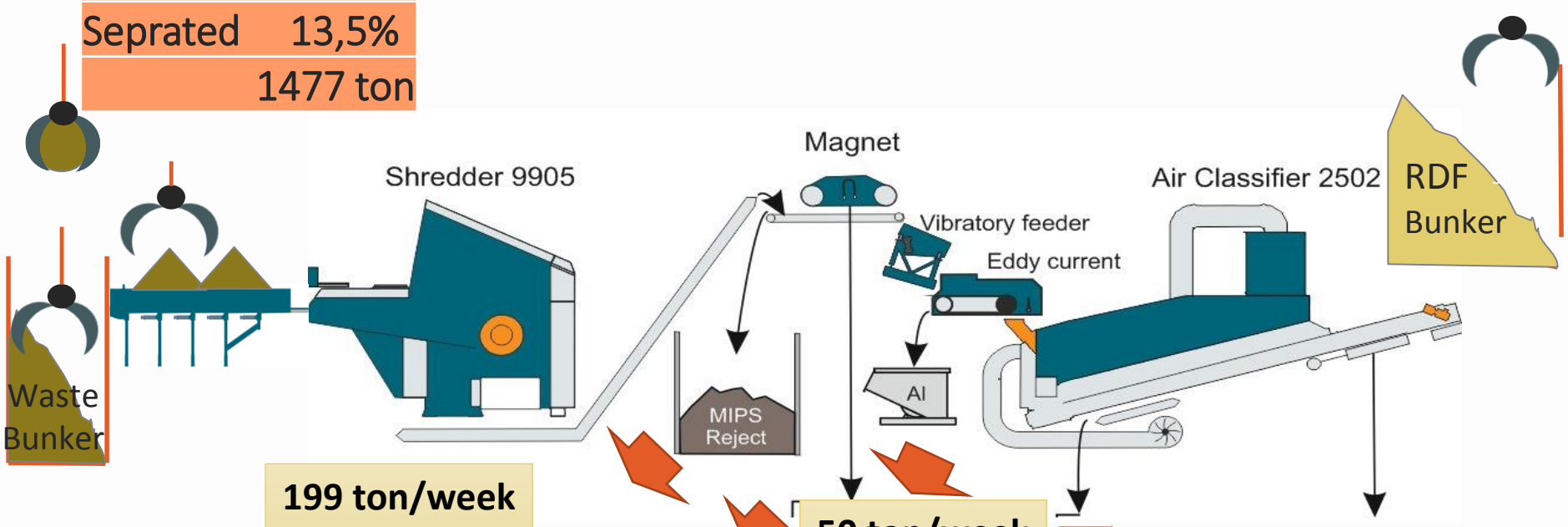
- Air duct to boiler

Radioactivity Quality Control

The waste to fuel processing plant, production experience

Fuel ton/week	
10940	
Seprated	13,5%
1477 ton	

9463 ton/week RDF to the boiler



199 ton/week (1,8%)

141ton/week 1,2%

50 ton/week 0,5%

1134 ton / week 10,4%

Boiler Fuel

Recycled wood or biofuel mix as secondary fuel 0 - 70% of energy input

Peat briquettes as secondary fuel 0 - 30% of energy input

Sewage sludge 0 - 4% of energy input

Municipal waste 0 - 70% of energy input

Mixed industrial and municipal waste 0-100% of energy input. Waste EWCcodes

Quality of the fuel from the preperation plant BMH.

MälarEnergi

The fuel seems to be close to the design specifications in the contract when it comes to the chemical content as well as general fuel properties (moisture, ash content, melting temperature).

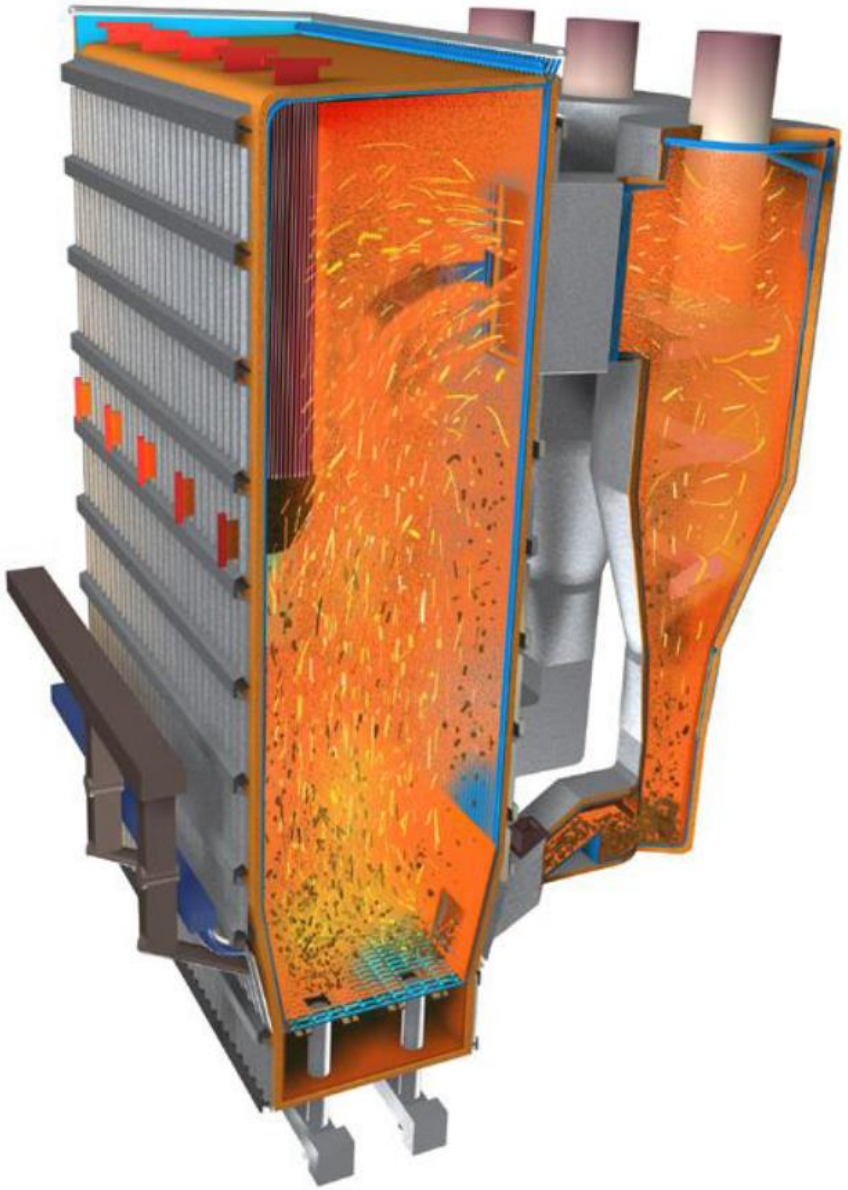
The ash content is in the higher range of the design specifications but still below the maximum value indicated(max 25%Ts).

The glass content in the fuel are clearly higher 4%(2%)

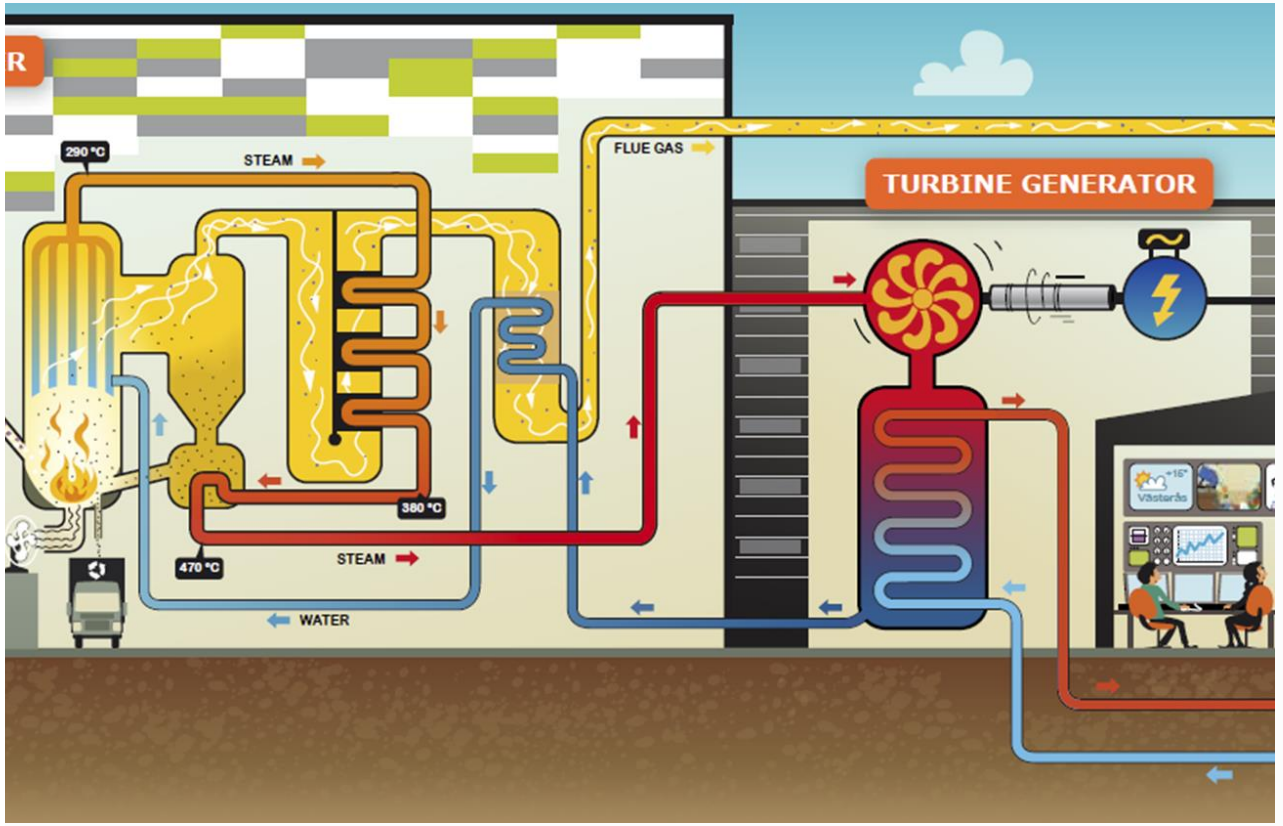
In some cases the ferrous and other metals were higher than the limits given in the contract.

Metallic aluminium are in some cases also too high.

	Guarantee quality supplied to CFB		Typical Mälarenergi fuel analyses (weekly averages, 2015)	
Element, dry basis	**Average**	**Maximum**	**Week 17**	**Week 18**
Chlorine, % db	0.9	1.6	1.1	1.2
Fluorine, % db	0.03	0.05	0.01	0.05
Ash % db		25	22	23
Glass % db		2	4.3	0.1
Sodium + Potassium, % db	1.2	2	1.2	0.92
Metallic Aluminium % db	0.5	1	1.2	1.2
Calcium % db			3.6	3.6
Magnesium % db			0.3	0.3
Antinomy mg/kg db	30	45	42	26
Arsenic mg/kg db	4	37	3.3	4.7
Lead mg/kg db	90	500	148	118
Chromium mg/kg db		300	109	305



d efficient



ur of fuel

articulated truck loads per day

zed Bed incinerator – CFB.

Steam production

Converts to around 50 MW electricity and around 100 MW district heating

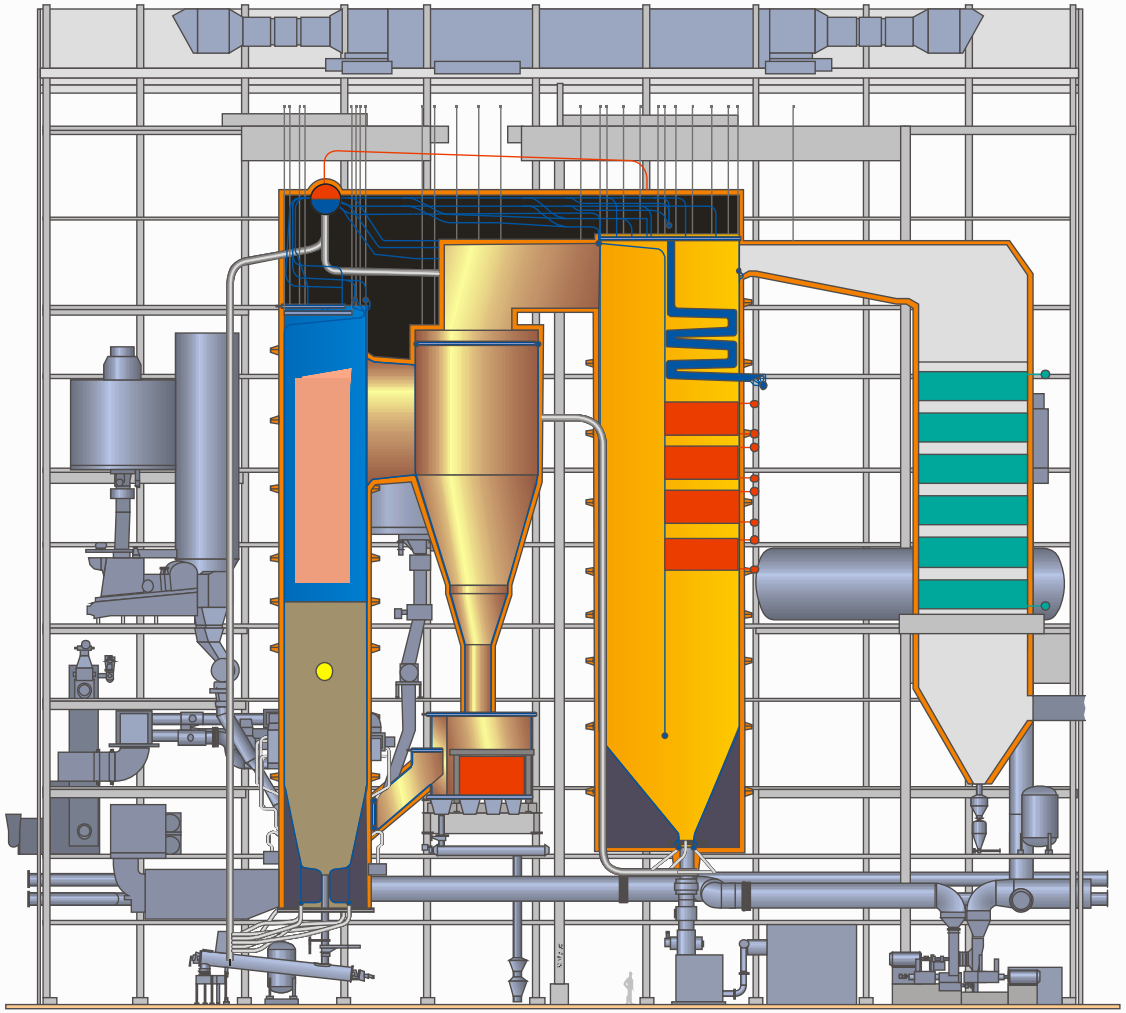
CYMIC boiler - Valmet

Circulating Fluidized Bed (CFB) technology

Steam	155 MW_{th} 56 kg/s 74 bar 470°C
Fuels	MSW, industrial waste, recycled wood, wood, peat
Start-up	2014

Plant energy output:

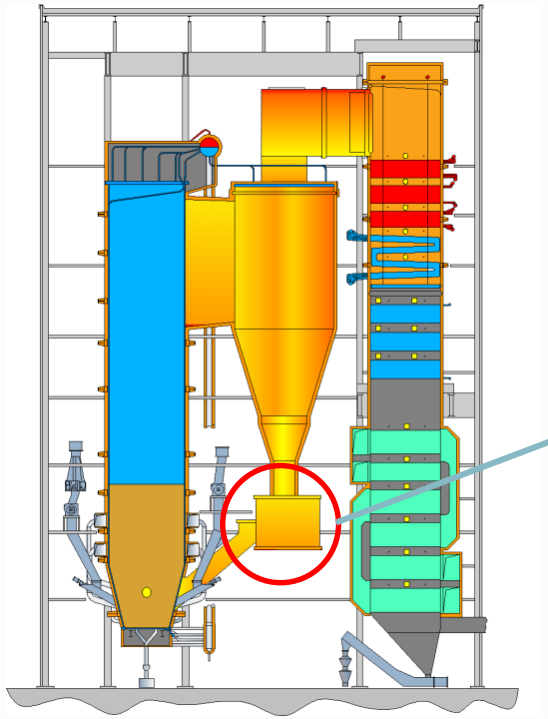
- 50 MW Electricity
- 100 MW District heat from turbine condenser
- 30 MW District heat from flue gas condenser

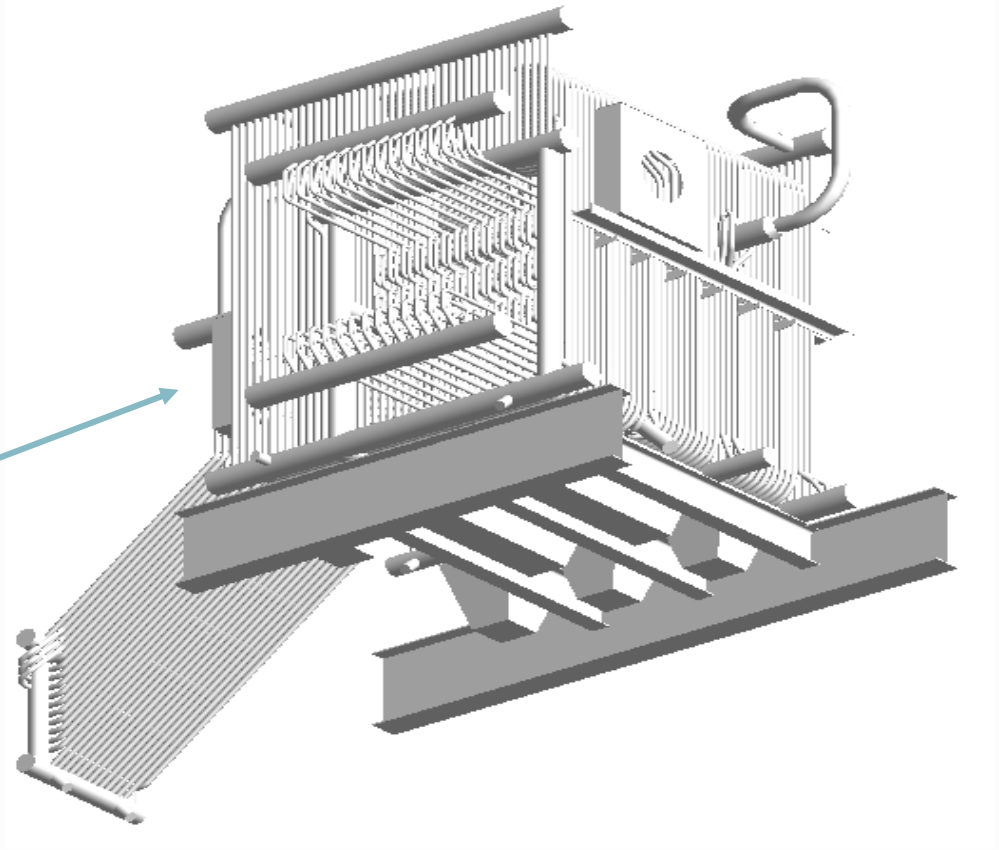


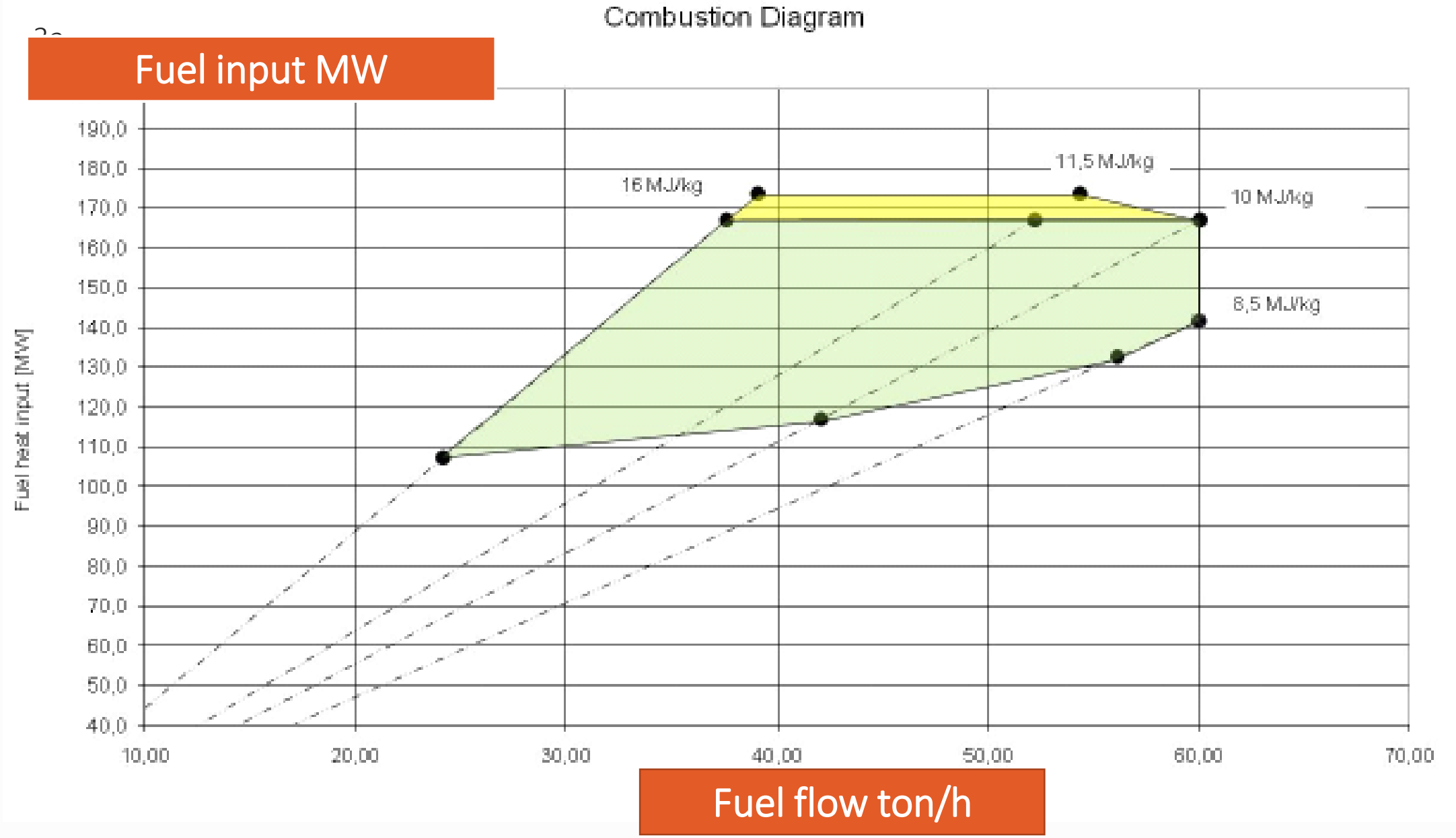
Final superheater

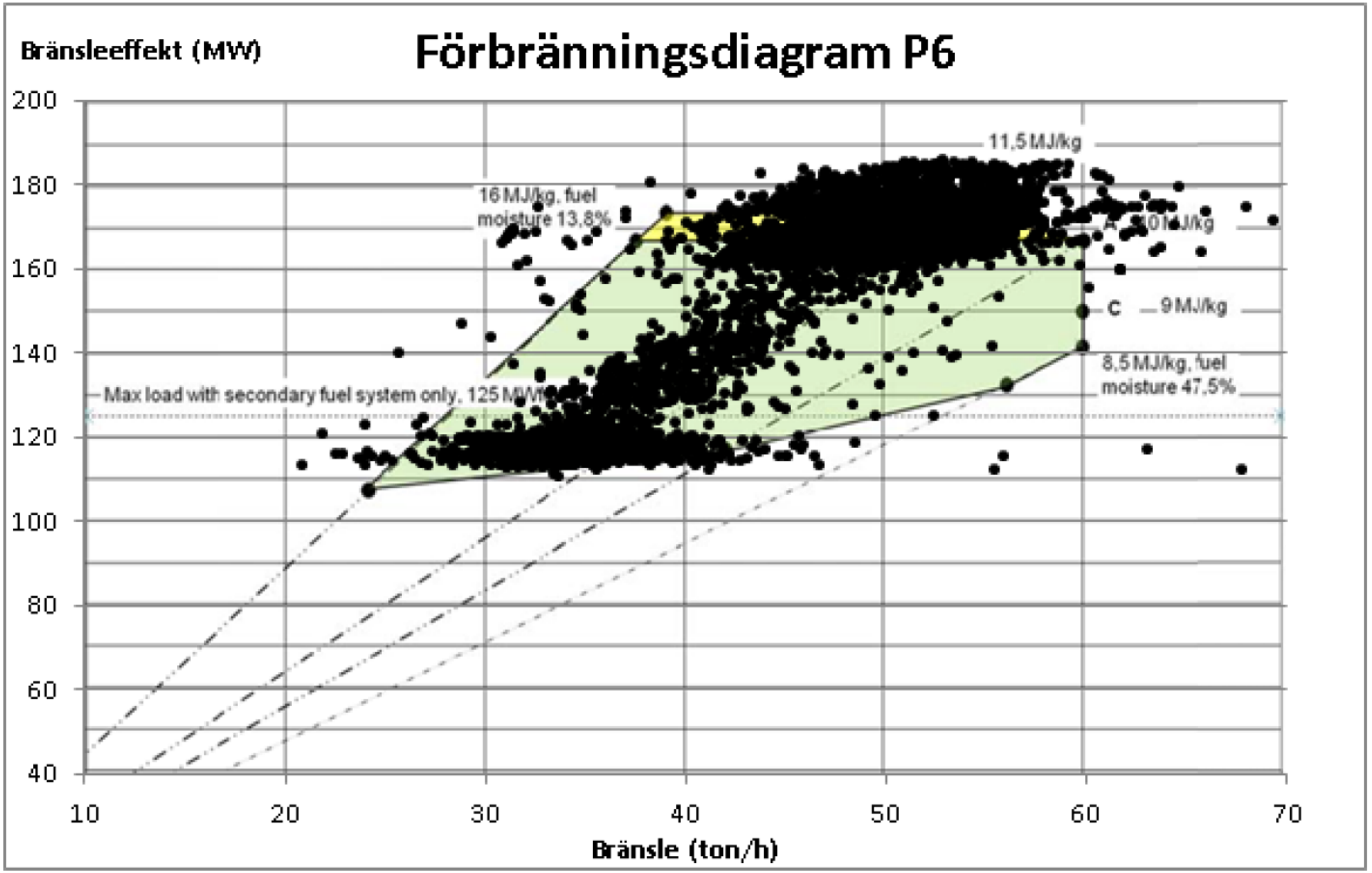
New design with external heat exchanger

CYMIC boiler - Circulating Fluidized Bed (CFB) technology






Combustion Diagram
Fuel input MW
Fuel heat input [MW]
190,0
180,0
170,0
160,0
150,0
140,0
130,0
120,0
110,0
100,0
90,0
80,0
70,0
60,0
50,0
40,0
16 MJ/kg
11,5 MJ/kg
10 MJ/kg
8,5 MJ/kg
10,00
20,00
30,00
40,00
50,00
60,00
70,00
Fuel flow ton/h

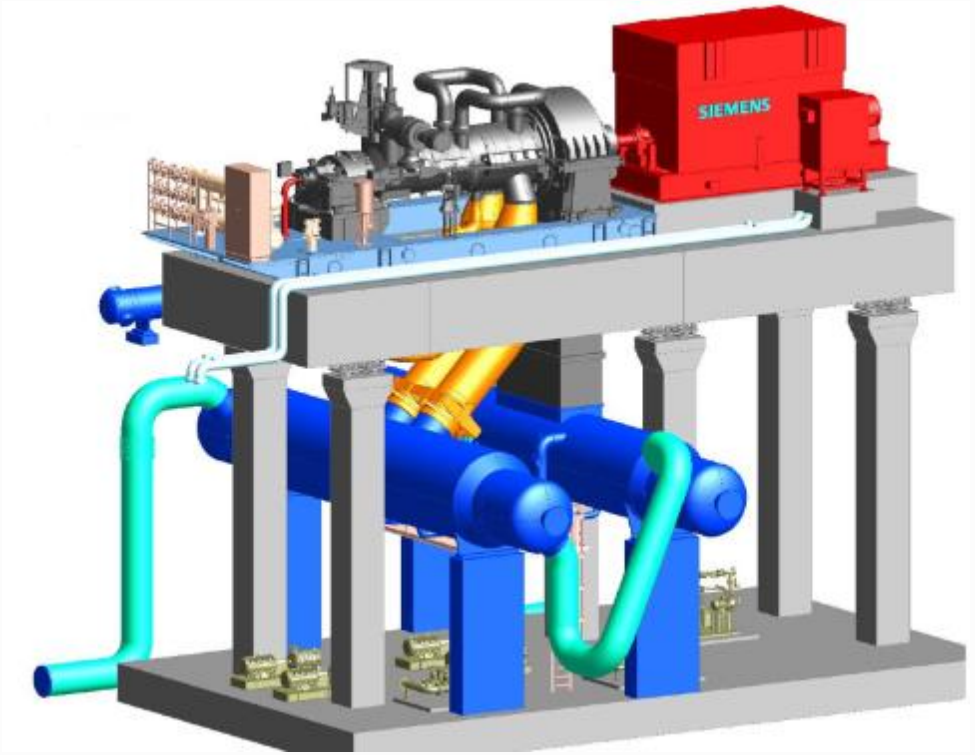


Figur 2. Förbränningsdiagram för föregående månads drift med P6.

Turbine/Generator Siemens

General technology

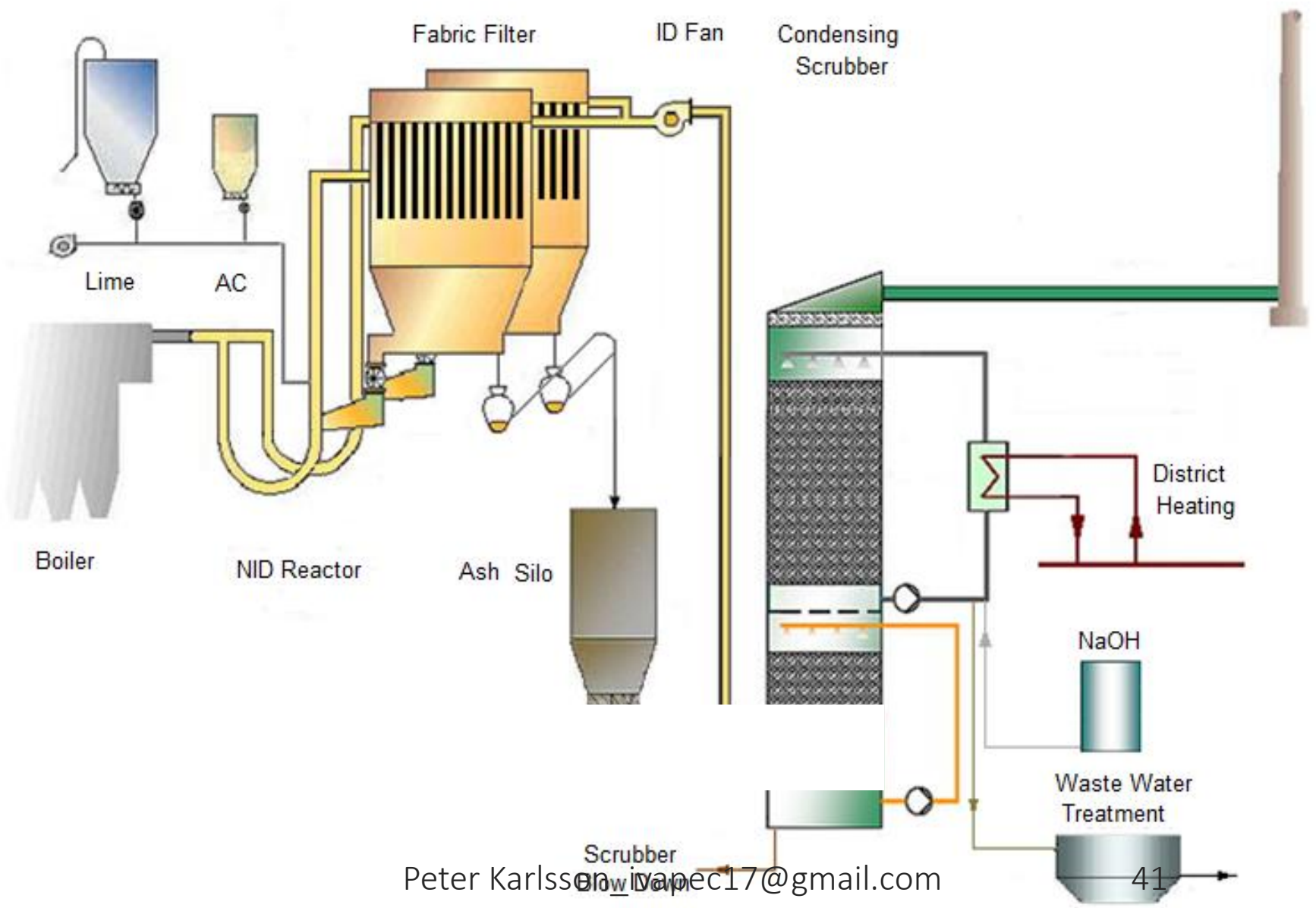
- Turbine Siemens SST-600
- 47-51 MW electricity depending on flow temperature
- Low pressure pre-heater
- Direct-drive generator
- Oil tank integrated in the framework
- Two-stage single-pass district heating condensers
- Built in Görlitz, Germany

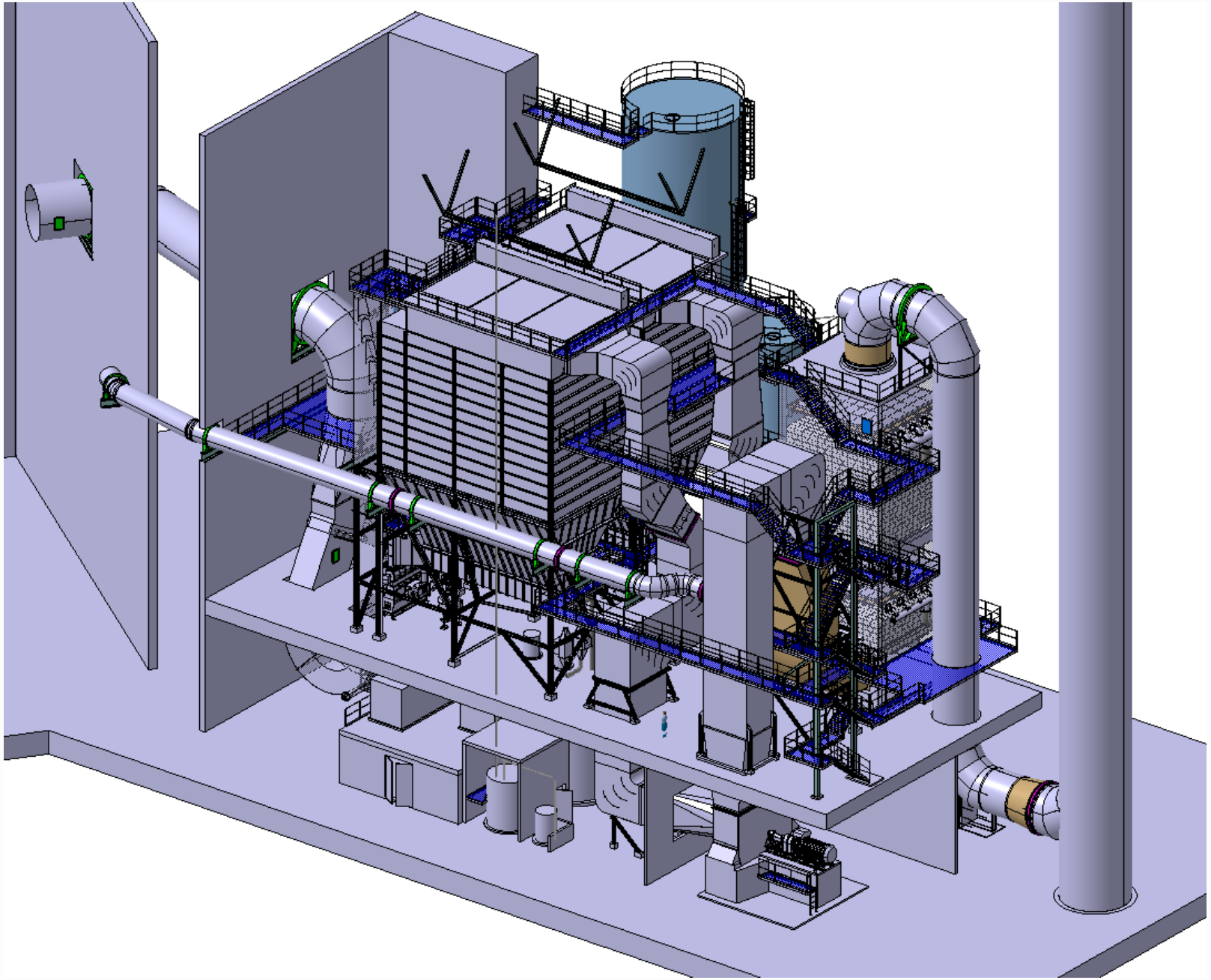


Flue gas treatment
- Technology overview

- Semi-dry filtration technique with preceding addition of lime and activated carbon, followed by wet cleaning with flue gas condensation and heat recovery.
- Only one residual product remains from the process – the dry residue from the semi-dry filtration stage.
- Great flexibility and buffer effect in the system.
- High environmental goals with good margins against limit values.
- Recovery of up to 30 MW heat for the district heating network.
- Purified condensed water for re-use in the plant or to recipient (lake)

NID system with condensing scrubber Alstoem





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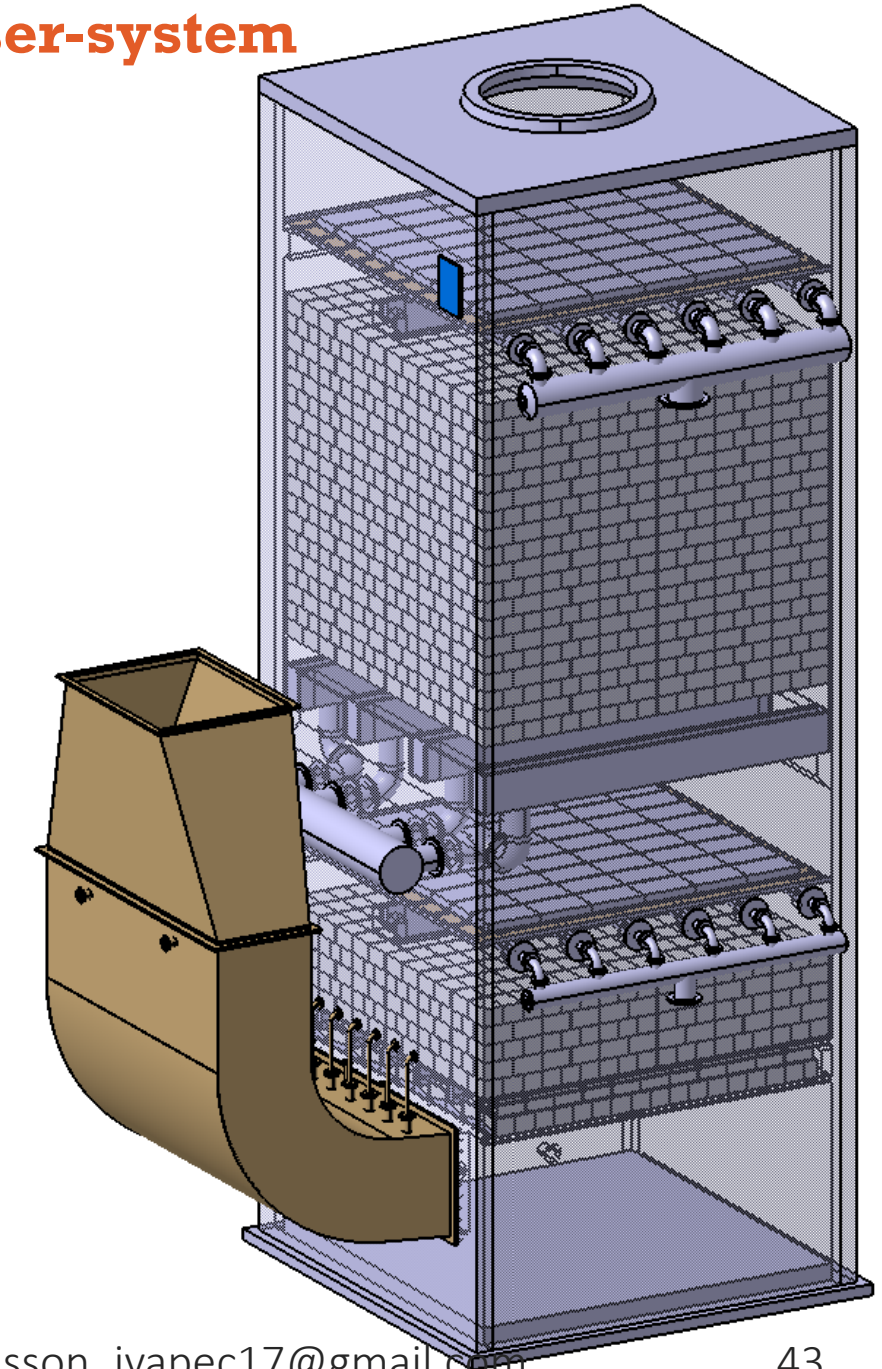
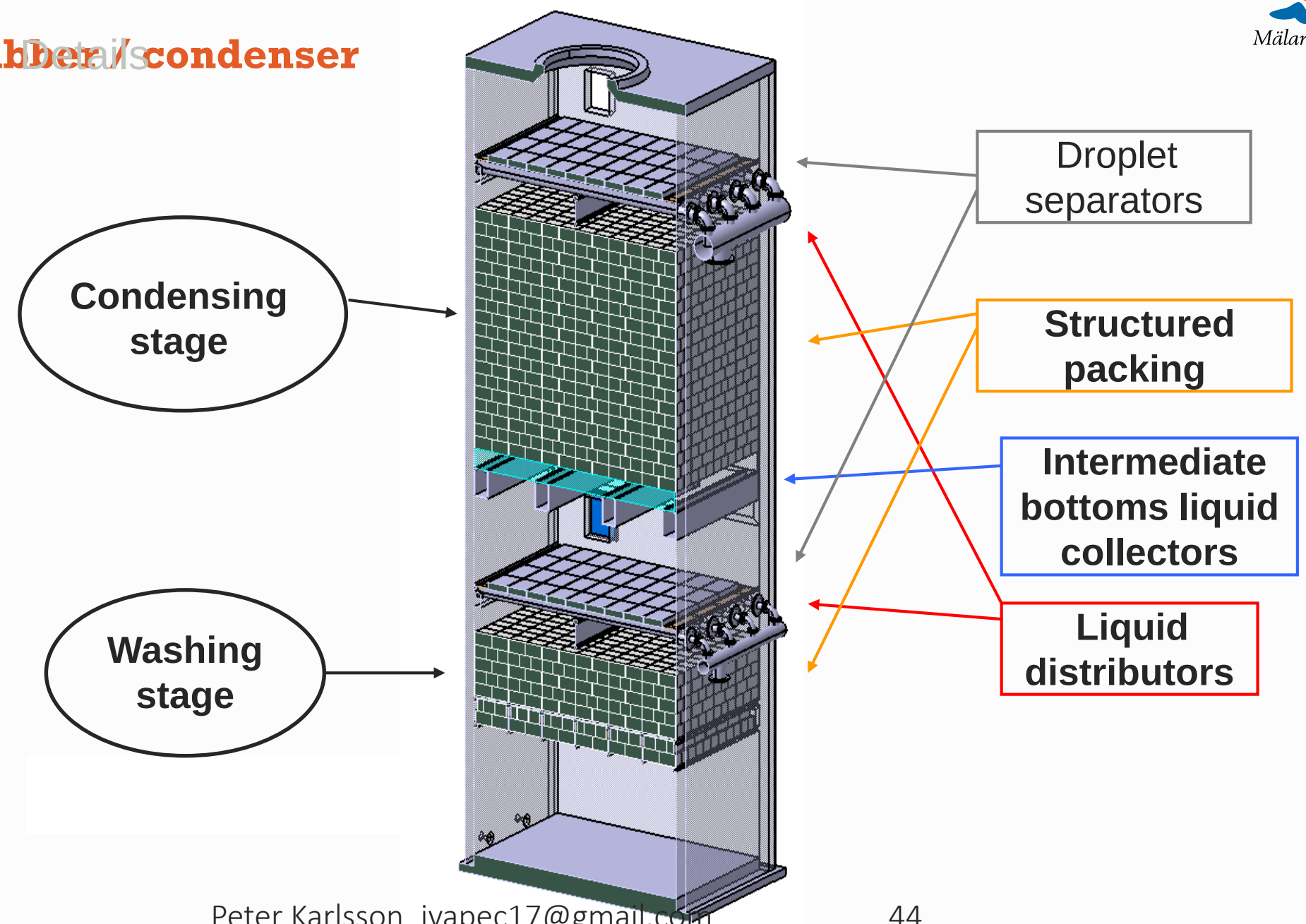
ALSTOM scrubber / condenser-system

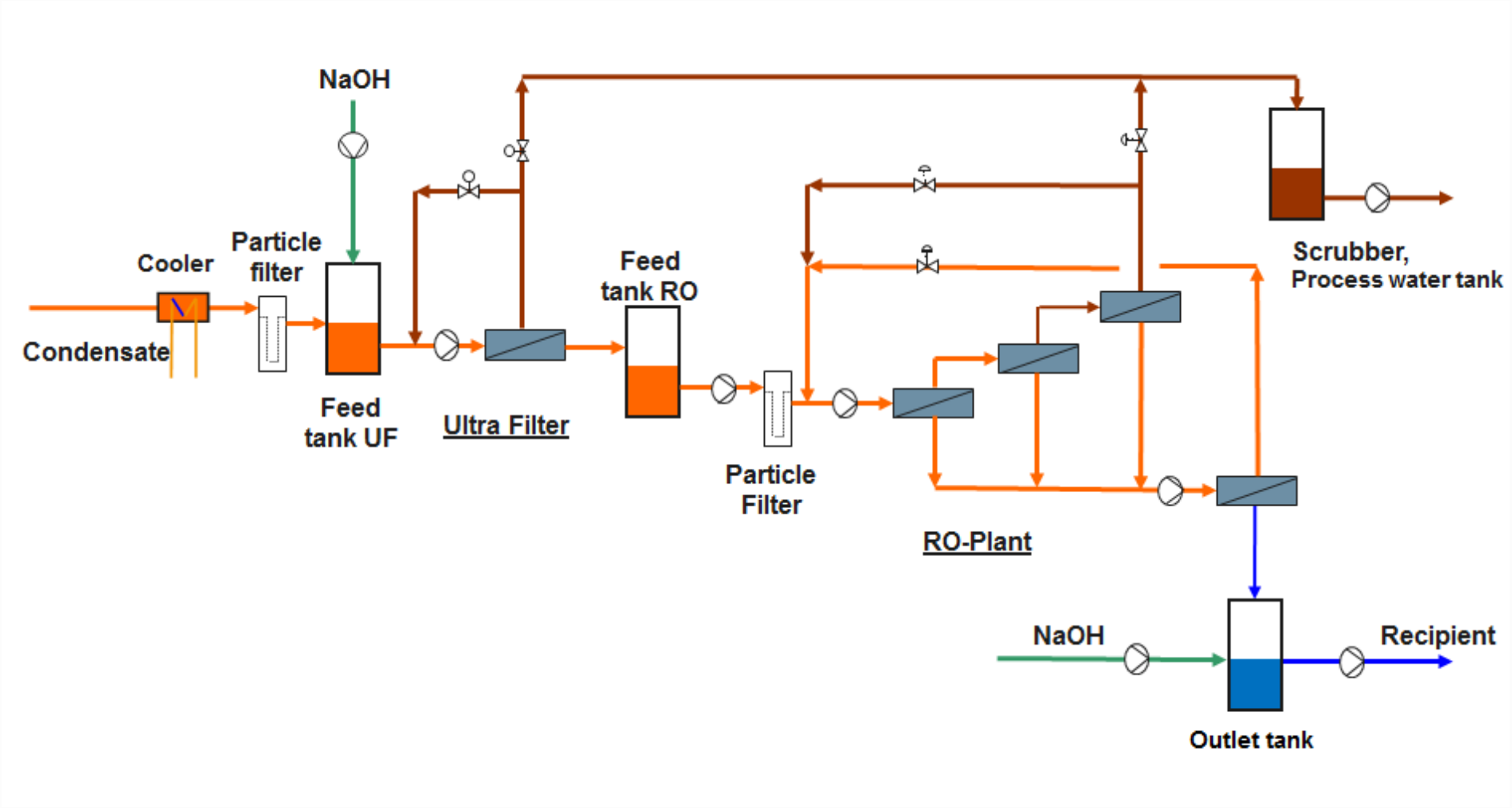


ALSTOM scrubber / condenser

Details



Mälarenergi
WWTP with UF- and RO-filter system



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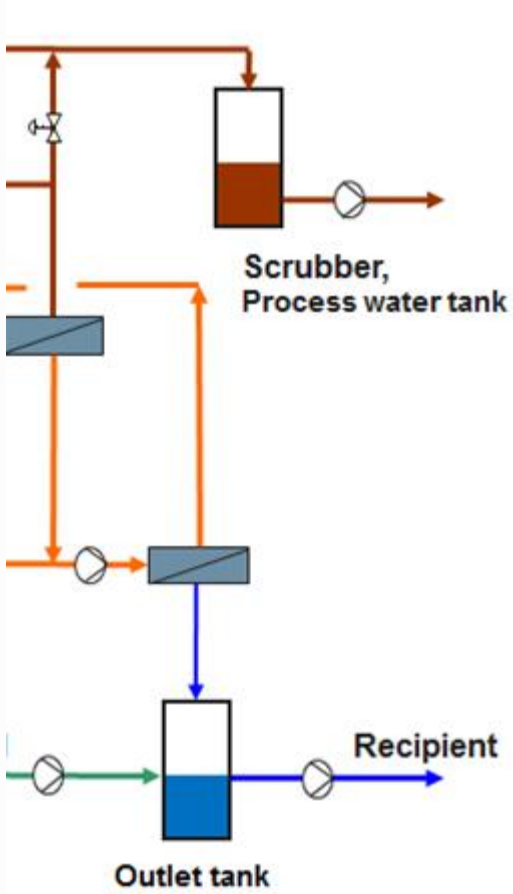


Water Emissions	Unit	100% MCR	Årsmedel Värde
Flow	kg/h	24 700	
pH	-	6-10	7,11
Total suspended solids	mg/l	8	0,88
Ammonium NH3-H	mg/l	15	0,44
Hg	mg/l	0,003	0,00010
Cd	mg/l	0,003	0,00002
Tl	mg/l	0,003	0,00100
As	mg/l	0,01	0,00020
Pb	mg/l	0,006	0,00021
Cr	mg/l	0,03	0,00055
Cu	mg/l	0,03	0,00076
Ni	mg/l	0,03	0,00050
Zn	mg/l	0,2	0,00586
Dioxins and Furans	ng/l	0,05	0,00450

Design and Typical Emissions average for 2015 & 2016					
		Boiler outlet		Stack	
		Design	Actual	Design	Actual
Flue gas flow	Nm^3/h wet	320,000		254,000	
Temperature	°C	165		47	
Pressure	Pa	-4,000		100	
Dust, Particle PM10+PM 2,5	mg/Nm^3	10,000		3	0.49
HCl	mg/Nm^3	1,000	365-640	3	0.28
SO_2	mg/Nm^3	400	0-50	7.5	1.6
NH_3	mg/Nm^3	10	5.8	10	0.55
HF	mg/Nm^3	5		1	0.017
Hg	mg/Nm^3	0	0.0114	0.02	0.0001
Cd+Ti	mg/Nm^3	1	0.0586	0.02	0.0002
Sb+As+Pb+Cr+Co + Cu+Mn+Ni+V	mg/Nm^3	300	7.48	0.3	0.037
Dioxins	ng/Nm^3	5		0.08	0.00661(2016)
All emissions at 6% $O_{2,\ dry\ basis}$					

- CO: 4.3 mg/Nm^3 at 6% O_2 dry;
- NOx: 32 mg/Nm^3 at 6% O_2 dry;
- N_2O: 4.3 mg/Nm^3 at 6% O_2 dry.

Mälarenergis environmental demands for dioxin

Periodic measurements 2 times/year

0,1 ng TEQ/m^3 at 11 % O_2 ndg

Measurements of all emissions

The total annual emissions from boiler 6 may not exceed 0,1 ng TEQ/m^3 at 6 % O_2 dg.

The total emissions shall be determined after semi-continuous covering the total annual emissions of dioxins and furans

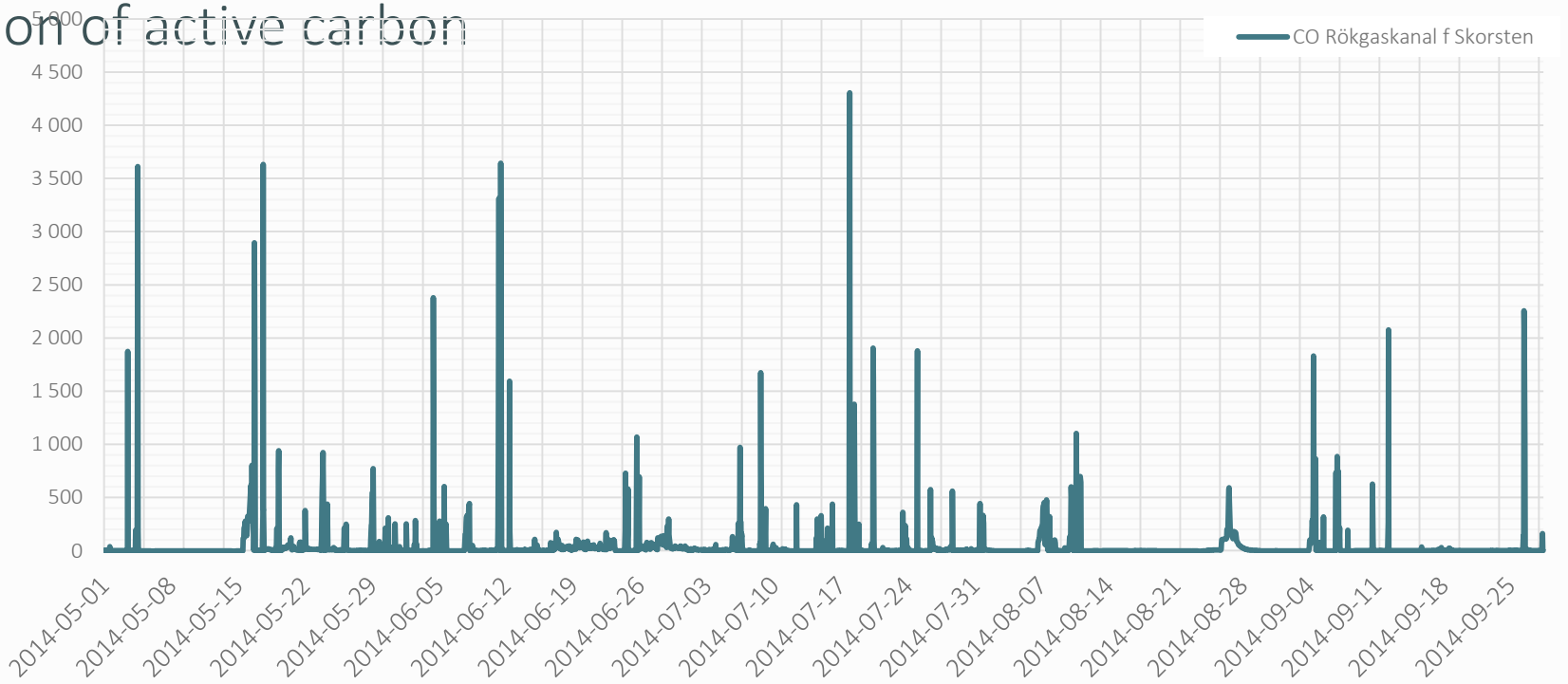
From start up, operation to out of operation should be measurements.

Analysis of causes
In case of disturbance boiler or fuel trip a dioxin peak may occur

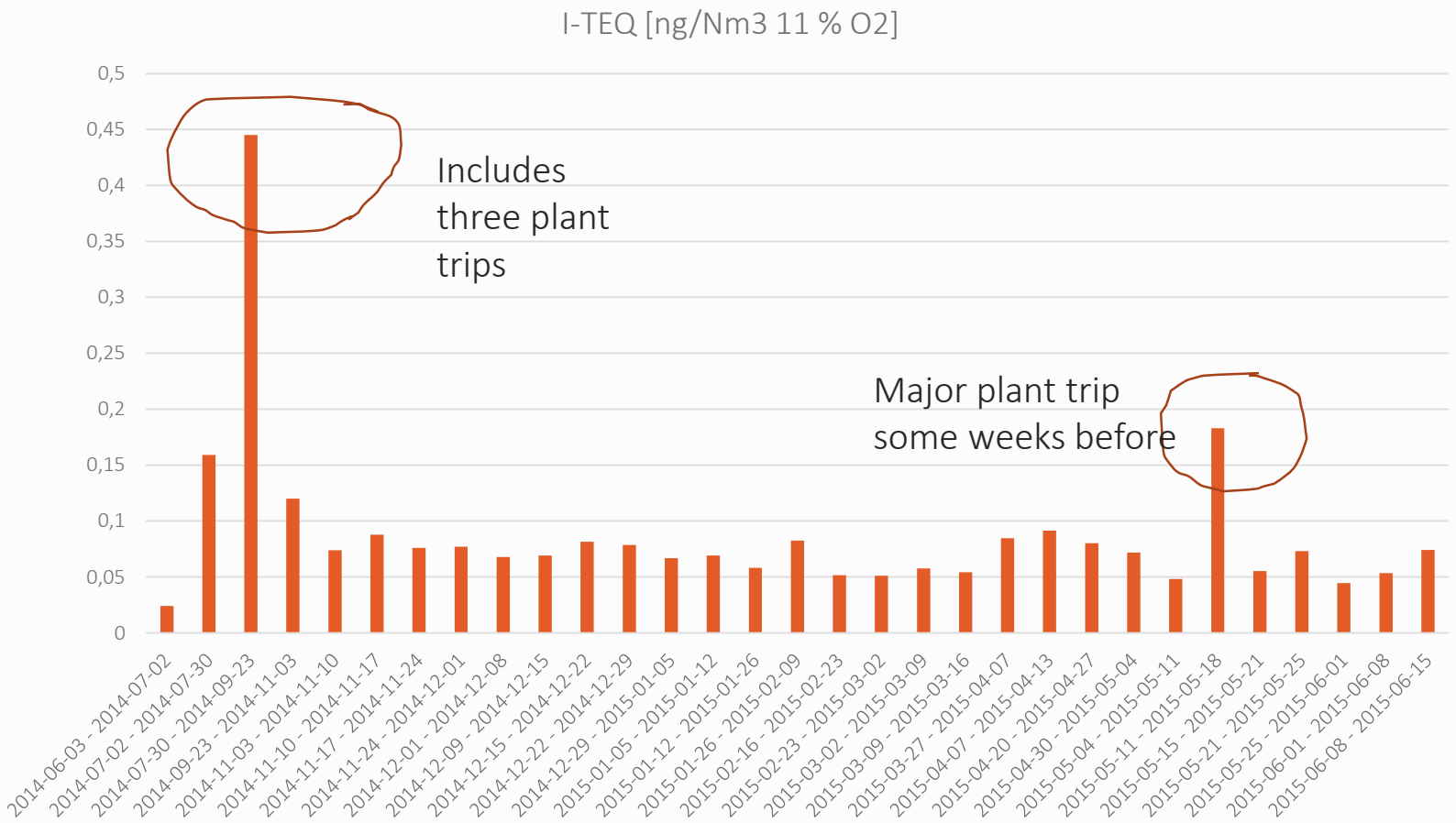
CO-peaks

Operation stops

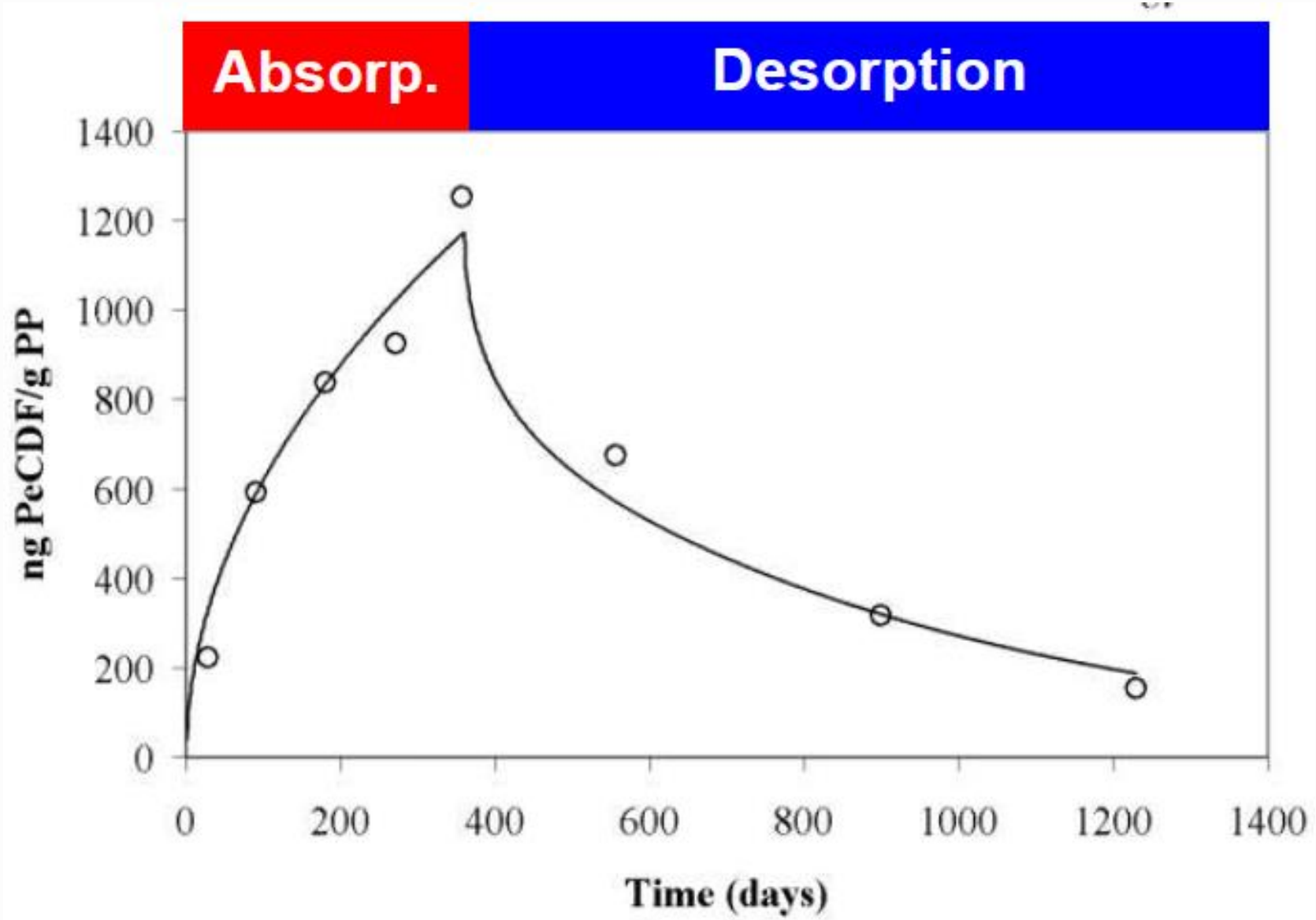
Low injection of active carbon



Test results



High values of dioxin emissions can cause memory effects for a long time in bag filters, flue gas ducts if there is dust and in the plastic for the scrubber.



Measures to reduce dioxins

Optimization of combustion.

Optimization of combustion in case of disturbance.

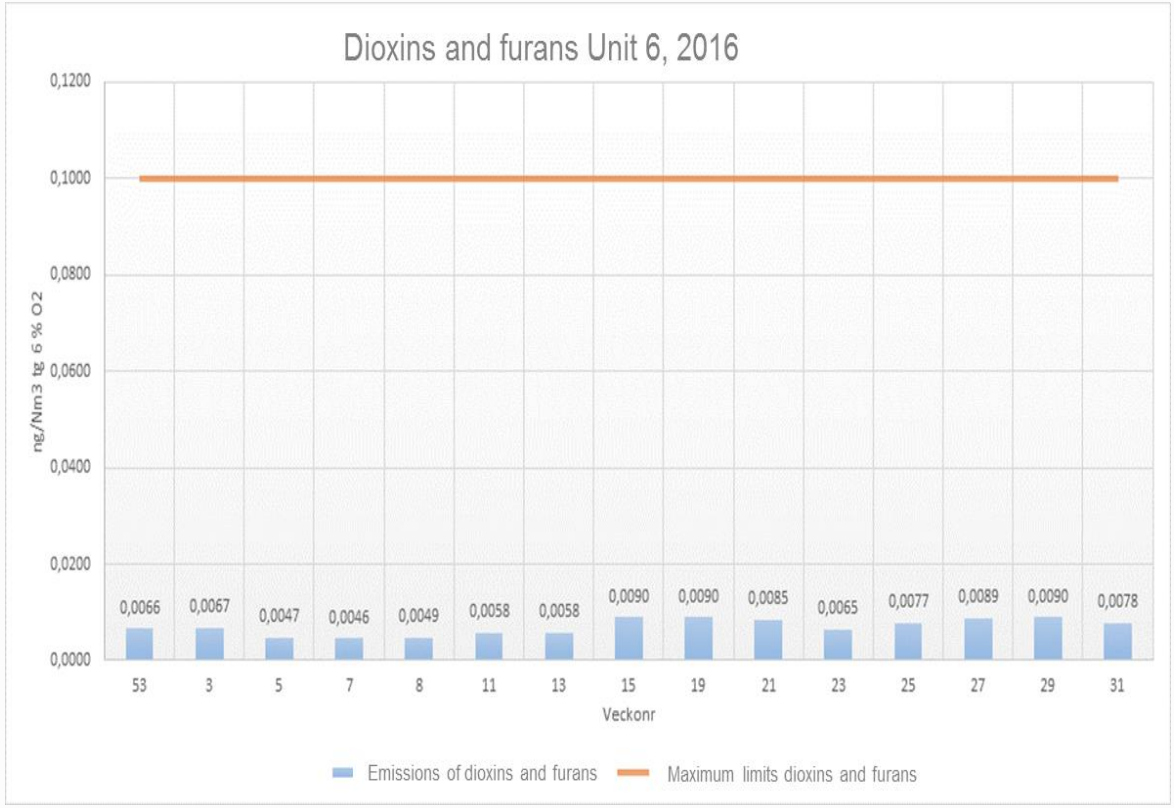
Optimization of active carbon dosing to bag filter

Installation of acustic sooting for economizer

Installation of ADIOx Cleaning

Acustic sooting from Infraphone has been installed for the economizer.

Västerås Unit 6 has very low emissions of dioxins and furans



- High demands from authorities resulted in continuous measurement
- Mälarenergi:s Waste Plant had an **average emission level year 2016 of 0.0070 ng/Nm^3 at 6% O_2** equals 0.0066 ng/Nm^3 at 11% O_2 (continues monitoring)

Challenges

The plant availability

Smell from the plant when it´s not so long from central city.

Could the BMH fuel preparation plant produce a suitable fuel for the boiler.

Corrosion boiler with high steam data.

Emissions from the plant

Municipal Waste Management is a Major Challenge for a Sustainable Society

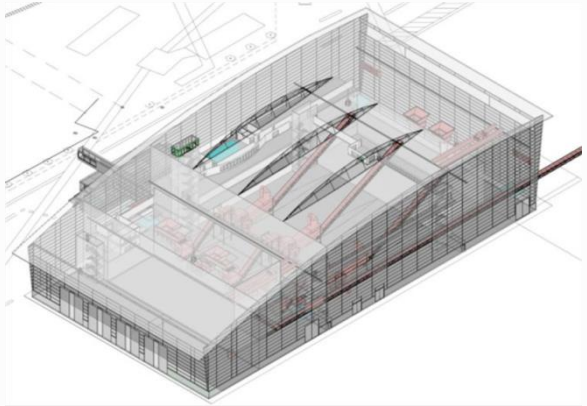
- Municipal waste management is one of the most urgent environmental challenges in modern Society.
- It is a major environmental problem caused by inefficient and outdated waste management that makes landfill continues to grow.
- Growing landfills creates problems due to shortages of landfill capacity, as well as methane emissions and water and soil pollution. The landfills also collect large amounts toxins in a limited area. With time the substances leaking into the surrounding environment.
- If government optimizes its waste management policy and implement modern technologies, it can shift towards environmentally friendly waste management systems for recycling and energy recovery that will reduce the need for landfill disposal.

Advantages with own Fuel factory for RDF

- Possibility to receive more (heavy) waste fuel fractions and this provides greater opportunities to economically optimize fuel purchases.

- Sorting out the fuel preparation reduces unwanted fractions / substances into the boiler.

- Metals can be extracted from the fuel and be sold for recycling.



Unit 7 - A fossil-free production by 2020

Mälarenergi AB, Västerås Unit 7, Sweden

Recycled Wood Fired Multifuel CFB

65 MWe, 150 MWth, 58.1 kg/s, 91 bar(a), 520°C

Block 7 produktion

Årlig drifttid	5500 timmar
Fullast tid	4500 timmar
Värmeproduktion	600 GWh
Elproduktion	250 GWh
Återvunna trädbränslen	250 000 ton
Övrigt bränsle	Avverkningsrester och biprodukter.

Thank you!

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