Steinmüller Babcock Environment
The Company &
Concept of a modern EfW-Plant Project

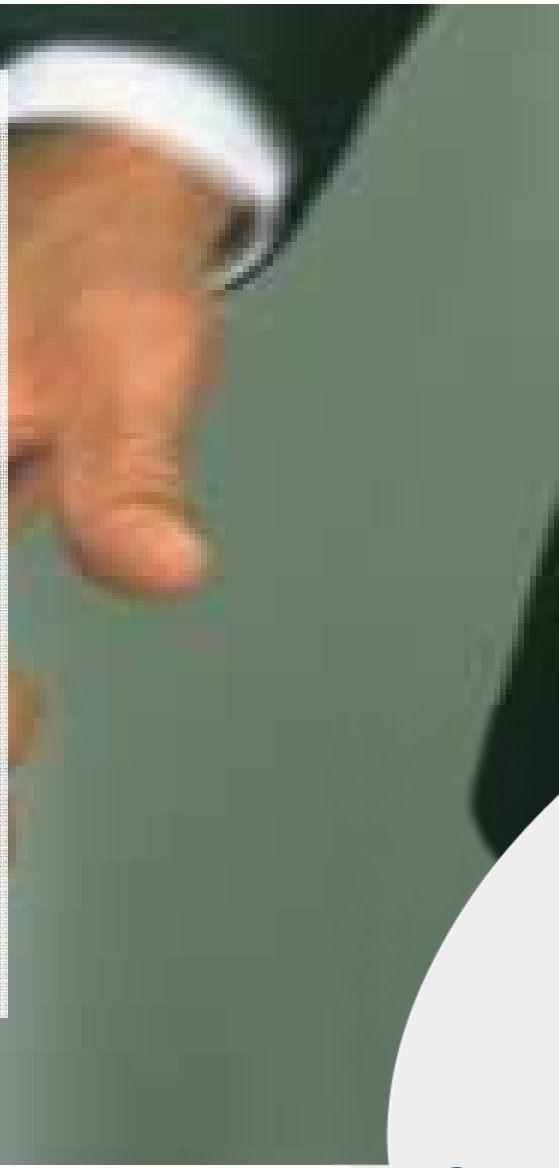
Wilfried Frehmann, AVG Cologne, 22 November 2017

Steinmüller Babcock Environment
SBENG
NIPPON STEEL & SUMIKIN ENGINEERING GROUP

Agenda

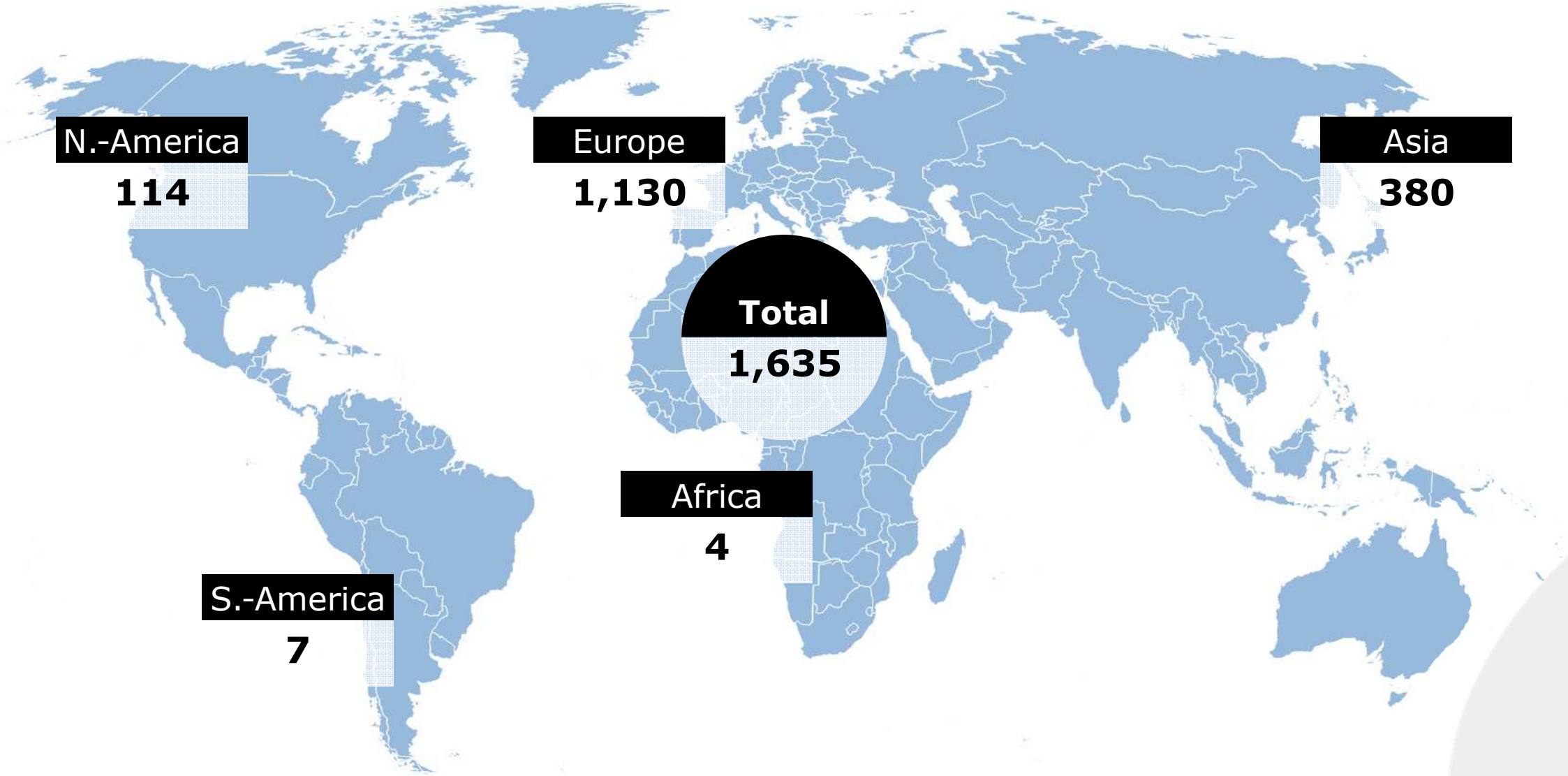
- **Who is Steinmüller Babcock Environment**
  - **Ownership Structure**
  - **Company Information**
  - **Product Divisions/References**
- **WTE- Process Technology**
- **Concept of a modern WtE- Plant**
- **WtE- Reference Plant Examples**

SBENG in brief



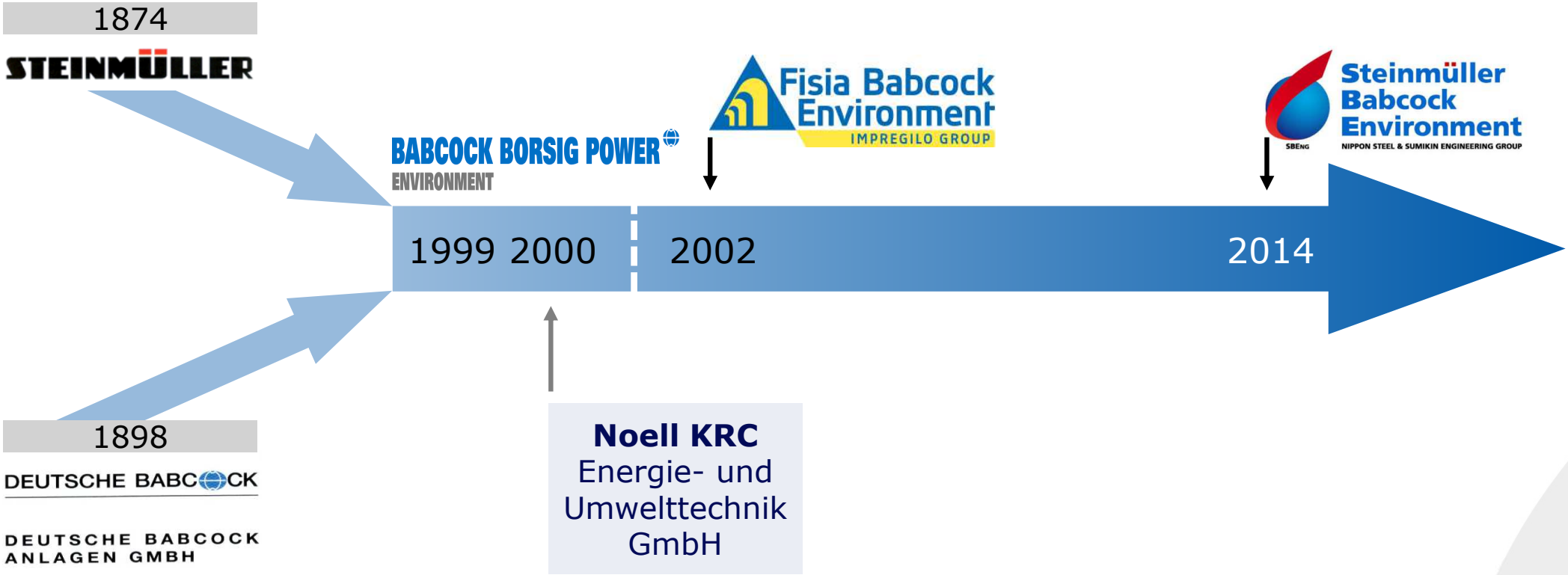
- International company for plant construction in the field of environmental and energy technology
- More than 150 years of tradition and know-how
- Worldwide more than 1,600 reference plants
- EPC-Contractor for turnkey plants
- Member of the Nippon Steel & Sumitomo Metal Corporation

References worldwide – EfW and FGC



(as at December 2015)

History


1874
STEINMÜLLER
BABCOCK BORSIG POWER
ENVIRONMENT
Fisia Babcock Environment
IMPREGILO GROUP
Steinmüller Babcock Environment
NIPPON STEEL & SUMIKIN ENGINEERING GROUP
1999 2000
2002
2014
1898
DEUTSCHE BABCOCK
DEUTSCHE BABCOCK ANLAGEN GMBH
Noell KRC
Energie- und Umwelttechnik GmbH

Milestones

1974: First EfW turnkey-plant in Germany
(Göppingen/Germany)

1985: First industrial large-scale SCR-plant in Europe
(Altbach/Germany)

1993: First application of Inconel cladding at waste incineration plant in Europe
(Burgkirchen/Germany)

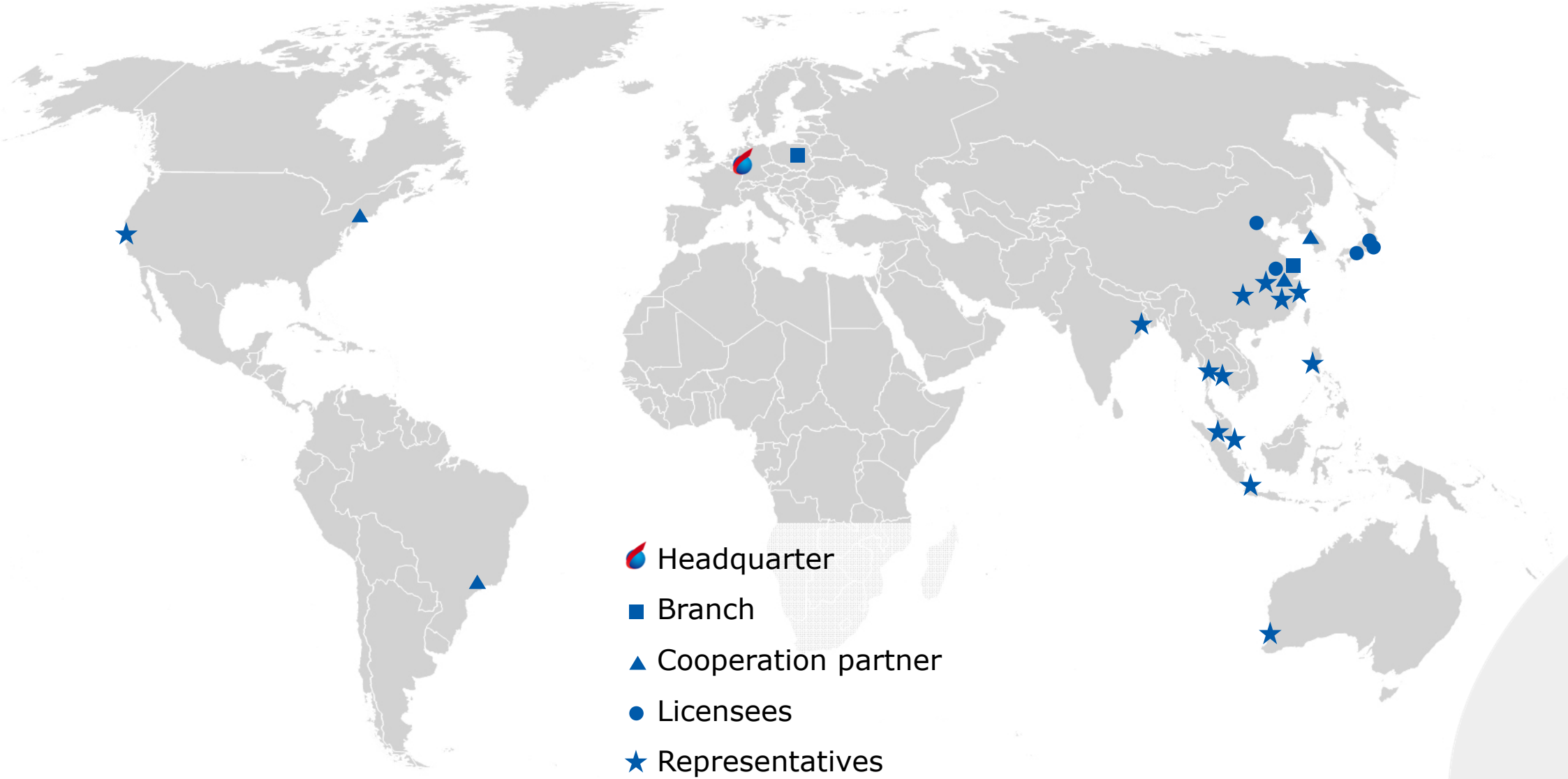
1994: World's first water-cooled grate surface for municipal waste
(Horgen/Switzerland)

2004: First entire cladded combustion chamber at EfW plant in Europe
(Aarhus/Denmark)

2009: First turbine in EfW plant with an electrical output > 120 MW
(Naples/Italy)

2012: Largest EfW unit in Germany with 1,000 t/d waste output in one line
(Berlin-Ruhleben/Germany)

Global network



Group structure NSSMC and NSENGI

NSSMC

- Chemicals
- Steelmaking
- Engineering (NSENGI)
- New Materials
- System Solutions

Steel Plant and Machinery

Marine Engineering/ Construction

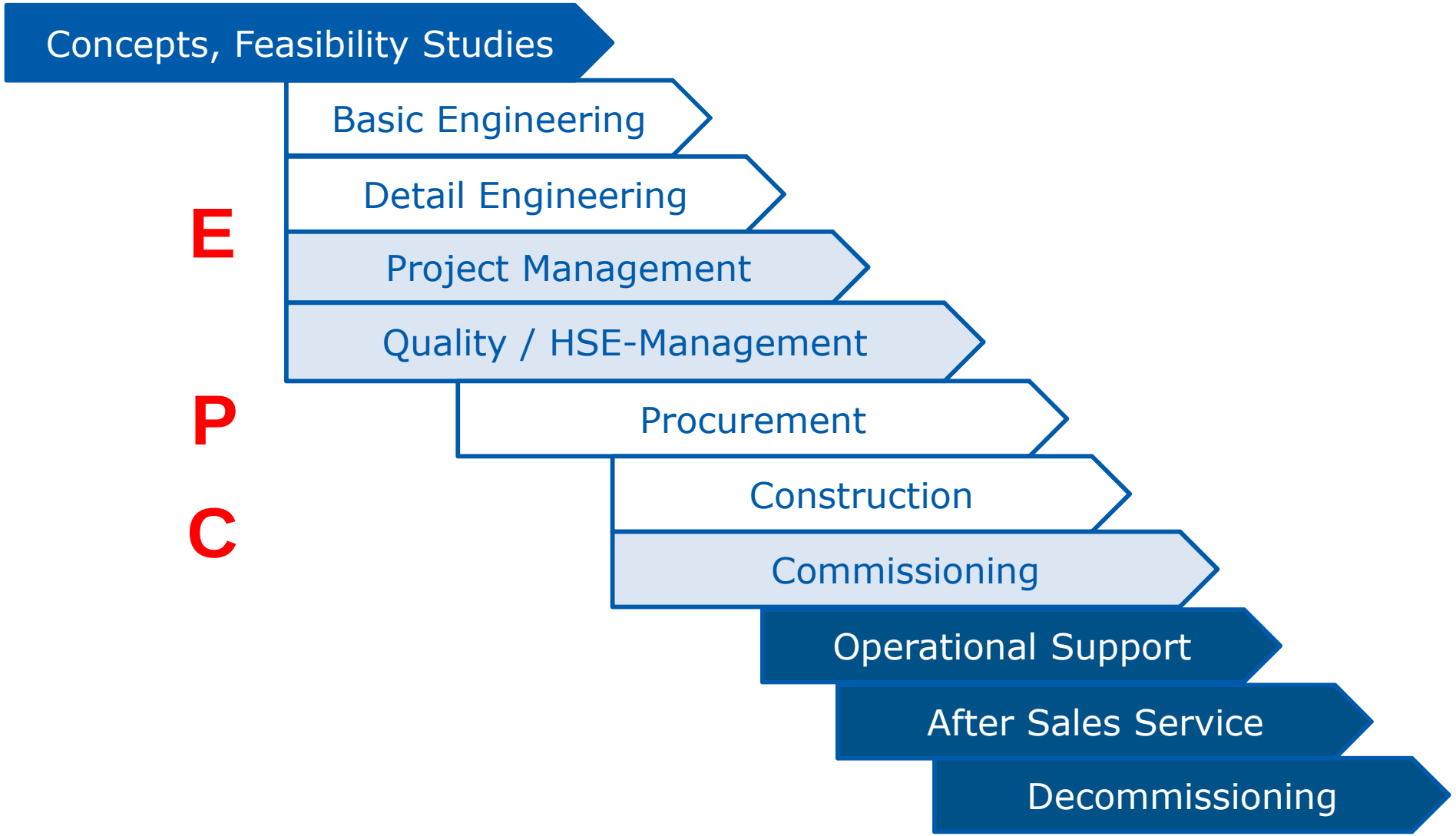
Environmental Solutions

Energy/ Pipeline

Building Construction/ Steel Struct.

Technical/ Business Develop.

Your partner along the plant life-cycle



Your partner for turnkey solutions

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Project Management

Overall Planning, Quality Assurance, Expediting, HSE, Procurement, Logistics, Planning & Supervision of Site Activities

Incineration Technology	**Water-Steam Cycle**	**Infrastructure**
Boiler Technology	**Electrical Systems**	**Civil Works**
Flue Gas Treatment	**I & C System**	
	Balance of Plant	

Own basic & detail engineering

► **Chute-to-stack**

Own basic engineering

► **Full technology package**

Procured

► **Complete turnkey solutions**

Our integrated management system for quality, environment and safety

Steinmüller Babcock Environment
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NIPPON STEEL & SUMIKIN ENGINEERING GROUP


CERTIFICATE

Management system as per
DIN EN ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that

Steinmüller Babcock Environment GmbH
Fabrikstraße 1
51643 Gummersbach
Germany

applies a management system in line with the above standard for the following scope

Plants, Components and Systems for Power- and Environmental-Tech
Design, Engineering, Erection, Commissioning and Service

Certificate Registration No. 44 100 066261 — Valid from 2013-08-15
Audit Report No. 3513 5236 — Valid until 2016-08-14

Certification Body at TÜV NORD CERT GmbH — Essen, 2014-08-29

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedure regular surveillance audits.

TÜV NORD CERT GmbH — Langemarckstraße 20 — 45141 Essen

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

DIN EN ISO 9001:2008


CERTIFICATE

Management system as per
DIN EN ISO 14001 : 2009

In accordance with TÜV NORD CERT procedures, it is hereby certified that

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Certificate Registration No. 44 104 066261 — Valid from 2014-05-17
Audit Report No. 3513 2662 — Valid until 2017-05-16
Initial certification 2011

Certification Body at TÜV NORD CERT GmbH — Essen, 2014-08-29

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TÜV NORD CERT GmbH — Langemarckstraße 20 — 45141 Essen — www.tu

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

DIN EN ISO 14001:2009


CERTIFICATE

for the HSE management system
SCC** - unrestricted certification
Standardised "Safety Certificate Contractors" (SCC) rules & regulations, Version 2011

TÜV NORD CERT GmbH hereby certifies that the company in question has introduced a HSE manage accordance with standard SCC** unrestricted certification and that this system complies with the stand "Safety Certificate Contractors" (SCC) rules & regulations, Version 2011. Certification for standard SC also includes certification for standard SCC*.

Steinmüller Babcock Environment GmbH
Fabrikstraße 1
51643 Gummersbach
Germany

This certificate is valid for:

Plants, Components and Systems for Power- and Environmental-
Design, Engineering, Erection, Commissioning and Service

Certificate Registration No. 44 106 066261 — Valid from 2015-05-12
Audit Report No. 3515 4382 — Valid until 2018-05-11
Initial certification 2006

Certification Body and SCC Coordinator at TÜV NORD CERT GmbH — Essen, 2015-05-12

TÜV NORD CERT GmbH — Langemarckstraße 20 — 45141 Essen

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

SCC** Contractors/ Producing Establishments

ZERTIFIKAT ◆ CERTIFICATE ◆ CERTIFICADO ◆ CERTIFICAT


ZERTIFIKAT

Die Benannte Stelle nach Druckger
- Zertifizierungsstelle für Qualitätssiche
der TÜV SÜD Industrie Service

bescheinigt, dass das Unternel

Steinmüll
Babcock
Environm

Steinmüller Babcock Enviror
Fabrikstraße 1
51643 Gummersbach

für den Geltungsbereich

Herstellung und Montage von Roh
nach EU-Baumusterprüfungen (Entw

ein Qualitätssicherungssystem nach der Dn
2014/68/EU (vormals 97/23/EG) Anhan

eingeführt hat und anwend

Durch ein Audit, Bericht -Nr.: P-IS-DD1-LEI-C
Nachweis erbracht, dass die betreffenden Anfo

Der Hersteller ist berechtigt, die im Rahmen de
dieses Qualitätssicherungssystems hergestellte
Kennzeichnung mit unserer Kenn-Nummer wie d

CE 0036

Zertifikat - Nr. DGR-0036-QS-1121-14
gültig bis 12. Juni 2016
Mannheim, 16. September 2014

TÜV SÜD Industrie Service GmbH — Tel. +49 621 39 51 15 — Fax +49 621 39 55 94 — e-mail: martina.john@tuev-sued.de
Westendstraße 199, 80686 München, Germany

TÜV SÜD Industrie Service GmbH · DGR-QS-Zertifizierun

2014/68/EU, Annex III Modul B1


TÜV NORD

CERTIFICATE

Management system as per
BS OHSAS 18001 : 2007

Steinmüller Babcock Environment GmbH
Fabrikstraße 1
51643 Gummersbach
Germany

applies a management system in line with the above standard for the following scope

Plants, Components and Systems for Power- and Environmental-
Technology, Design, Engineering, Erection, Commissioning and Service

Certificate Registration No. 44 116 066261 — Valid from 2015-06-01
Audit Report No. 3515 4383 — Valid until 2018-05-31
Initial certification 2012

Certification Body at TÜV NORD CERT GmbH — Essen, 2015-05-12

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH — Langemarckstraße 20 — 45141 Essen — www.tuev-nord-cert.com

DAkkS Deutsche Akkreditierungsstelle D-ZM-12007-01-01

BS OHSAS 18001: 2007

Our product quality

2014/68/EU,
Annex III
Modul H1

ASME „S“ stamp

ASME „R“ stamp

ASME „NB“ stamp

Energy from Waste

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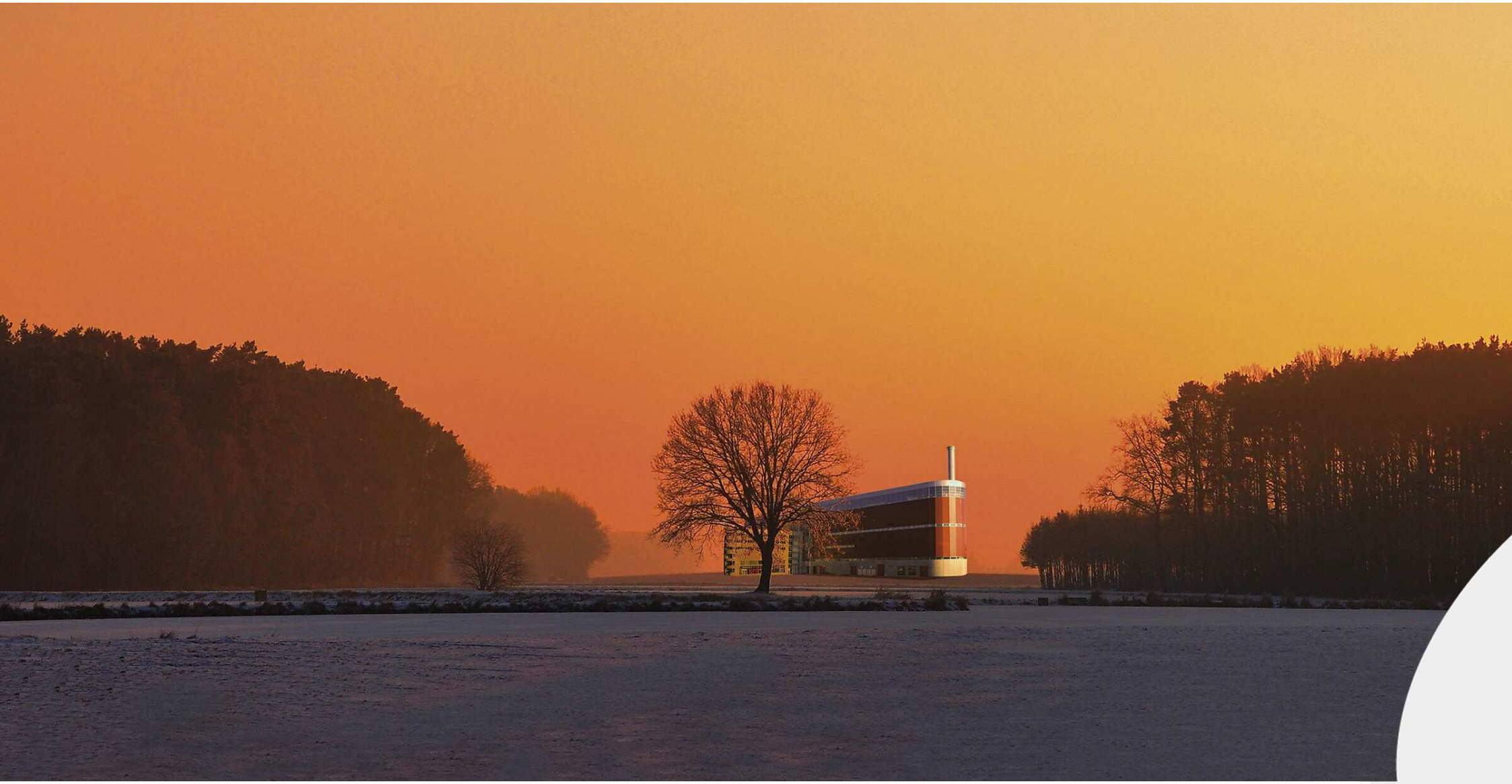

A solution for every kind of waste

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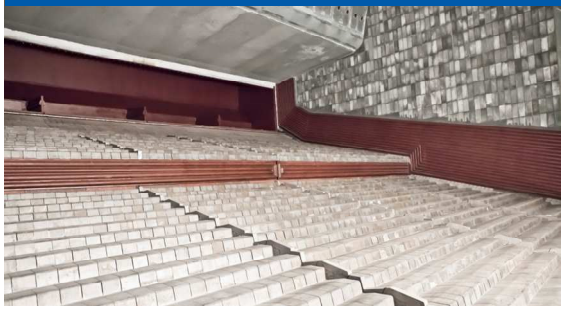
Grate incineration



Gasification (DMS)

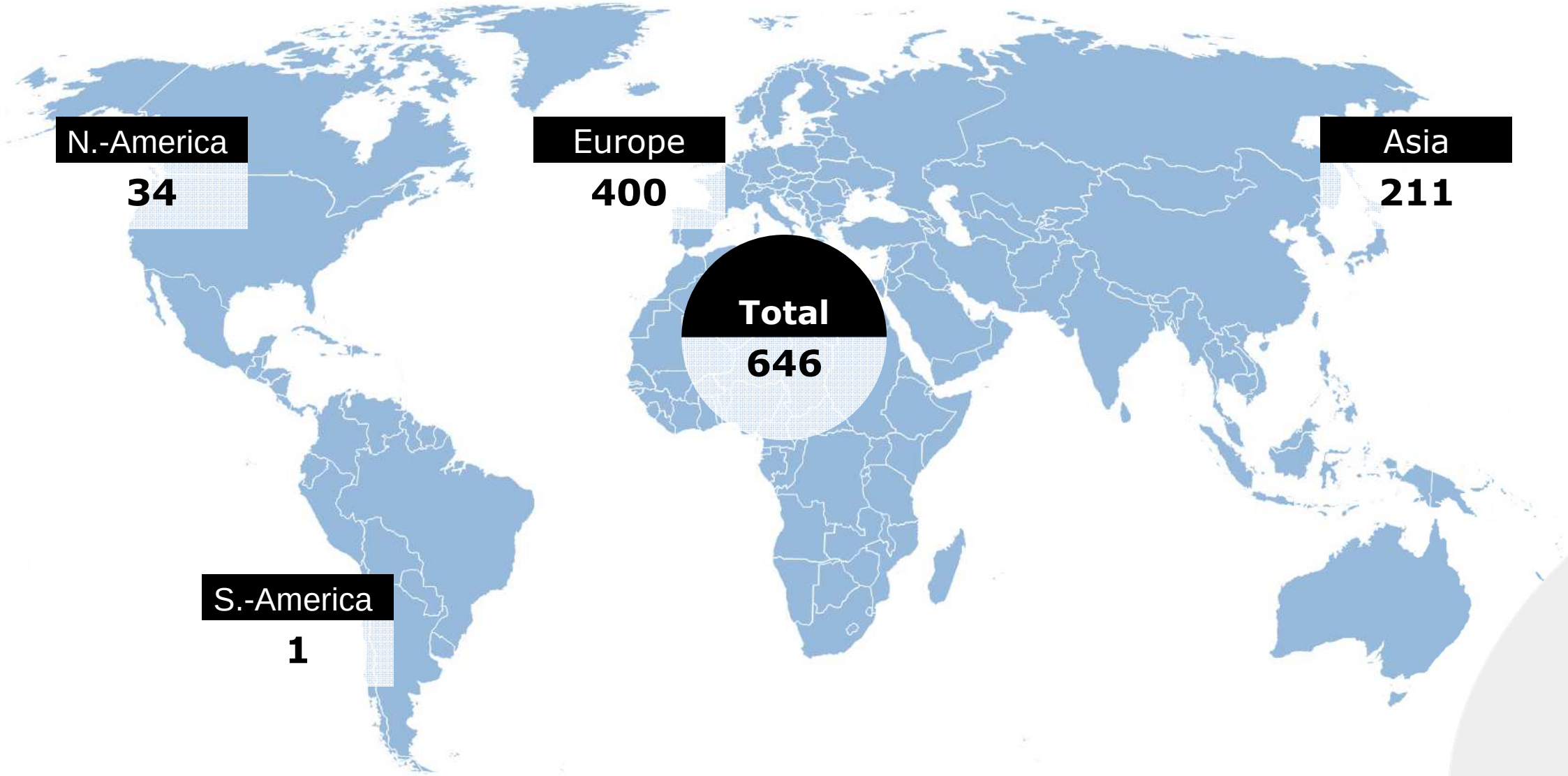
Rotary kiln incineration

www.steinmueller-babcock.com

Incineration and co-incineration of:

- Municipal solid waste
- Refuse derived fuels
- Industrial waste
- Bulky waste
- Biomass
- Sewage sludge
- Shredder light fraction
- Tyres
- Animal waste
- Hospital waste
- Hazardous waste – solid
- Hazardous waste – pasty
- Hazardous waste – liquid

Reference projects - Energy from Waste



(as at December 2015)

Location of Major Reference Plants in Europe since 2003

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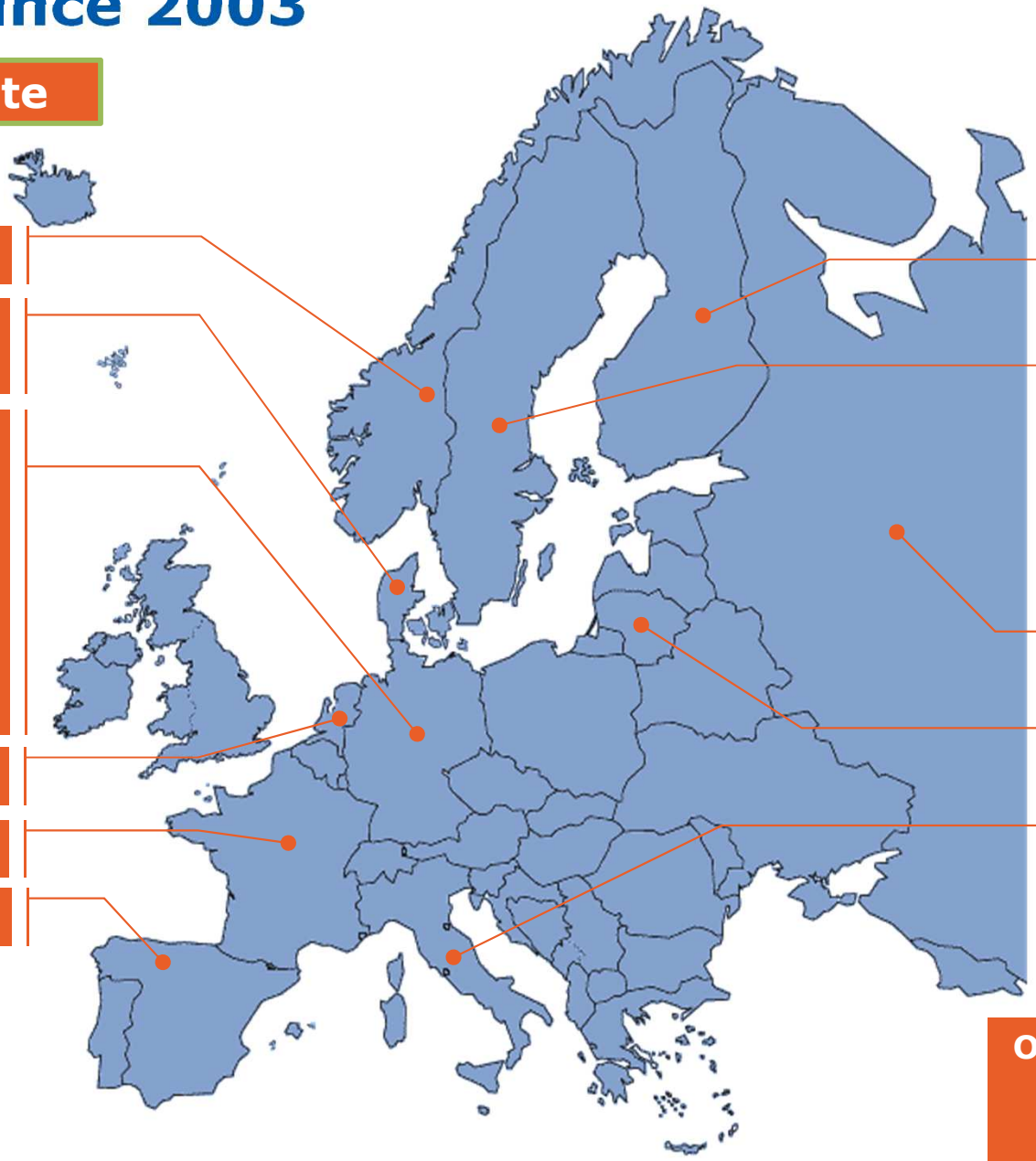
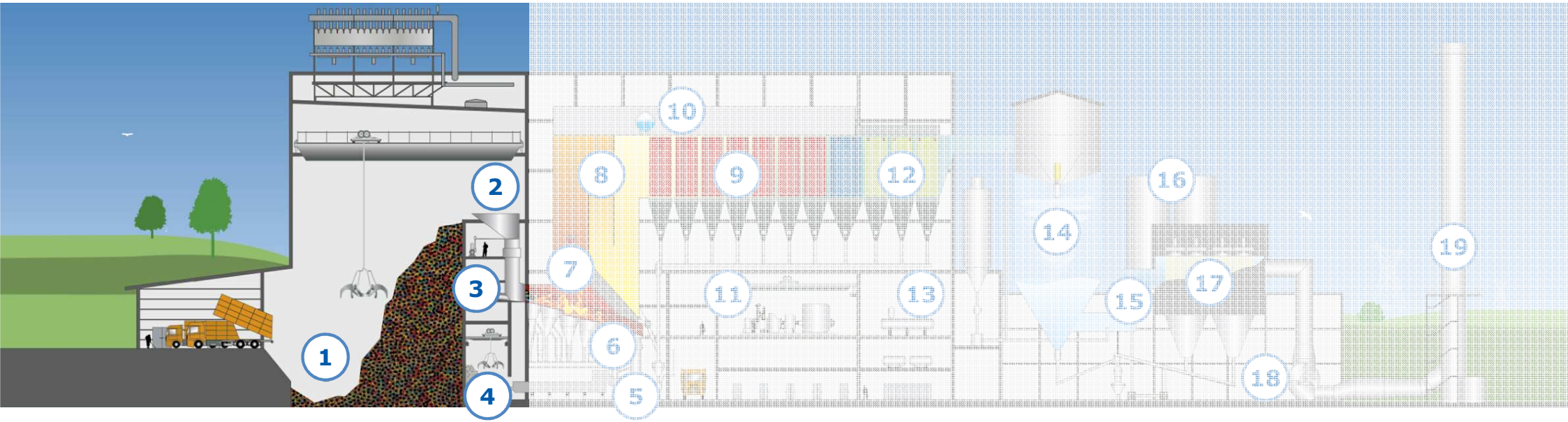
Energy from Waste



- Kristiansand
- Århus
  Glostrup
- Ruhleben
  Hameln
  Oberhausen
  Rüdersdorf
  Herten
  Heringen
  Krefeld
  Wuppertal
- Delfzijl
- Carriere-Sur-Seine
- San Sebastian
- Riihimäki
  Tampere
- Halmstad
  Joenkoeping
  Uddevalla
  Borlänge
  Linköping
  Högbytorp
- Moscow
- Klaipeda
  Vilnius
- Naples

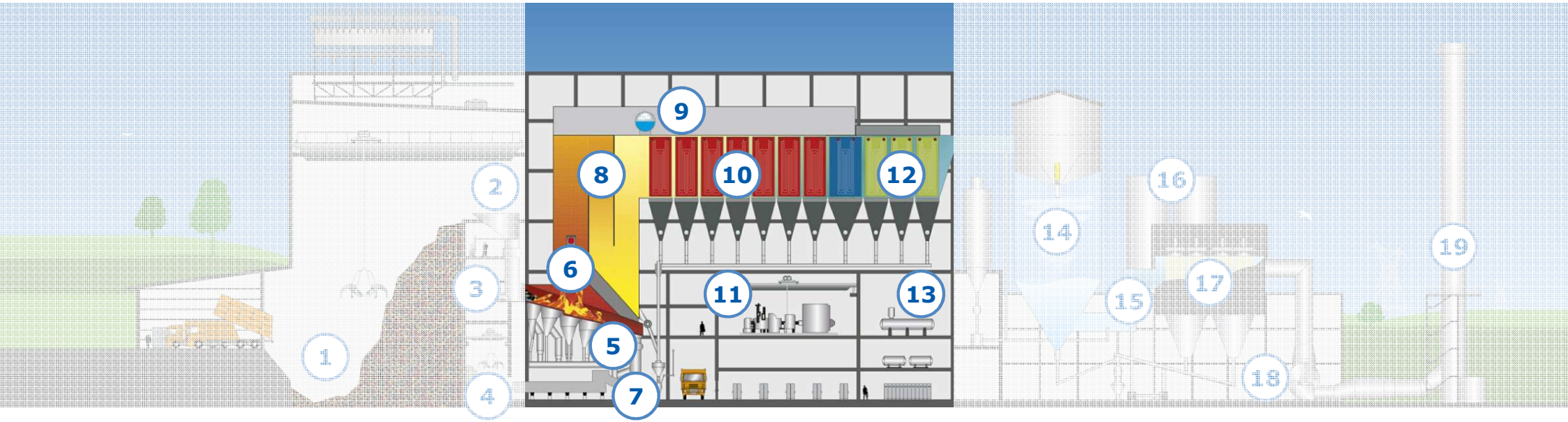
Outside Europe:
Icheon
Gyeongju
Anyang
Hefei

Process of waste incineration



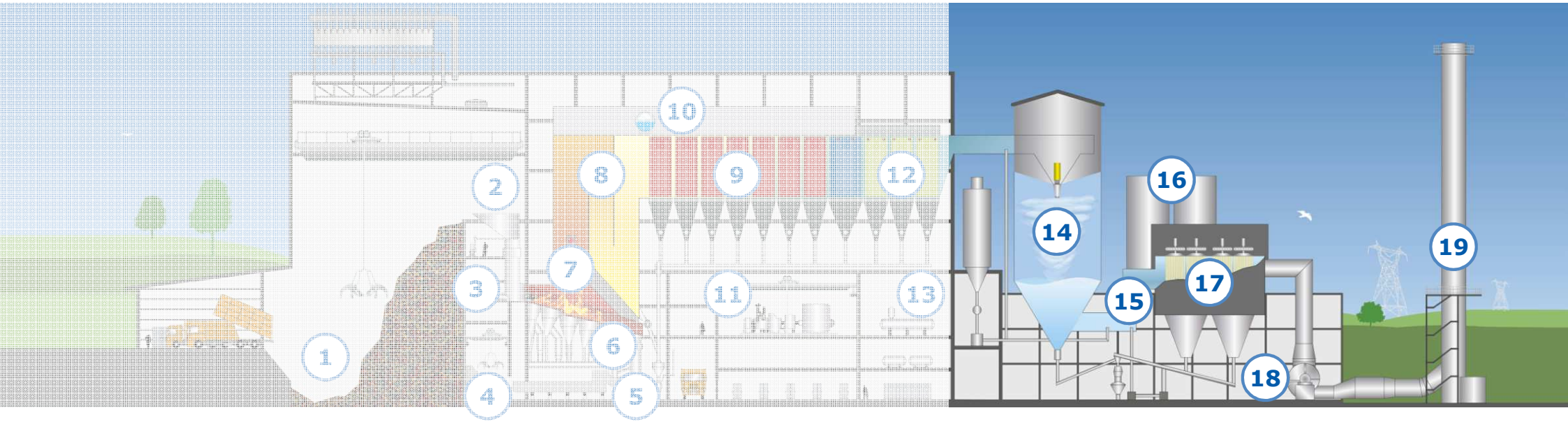
1) Waste bunker
2) Waste feed hopper
3) Feeder
4) Slag bunker

Process of waste incineration



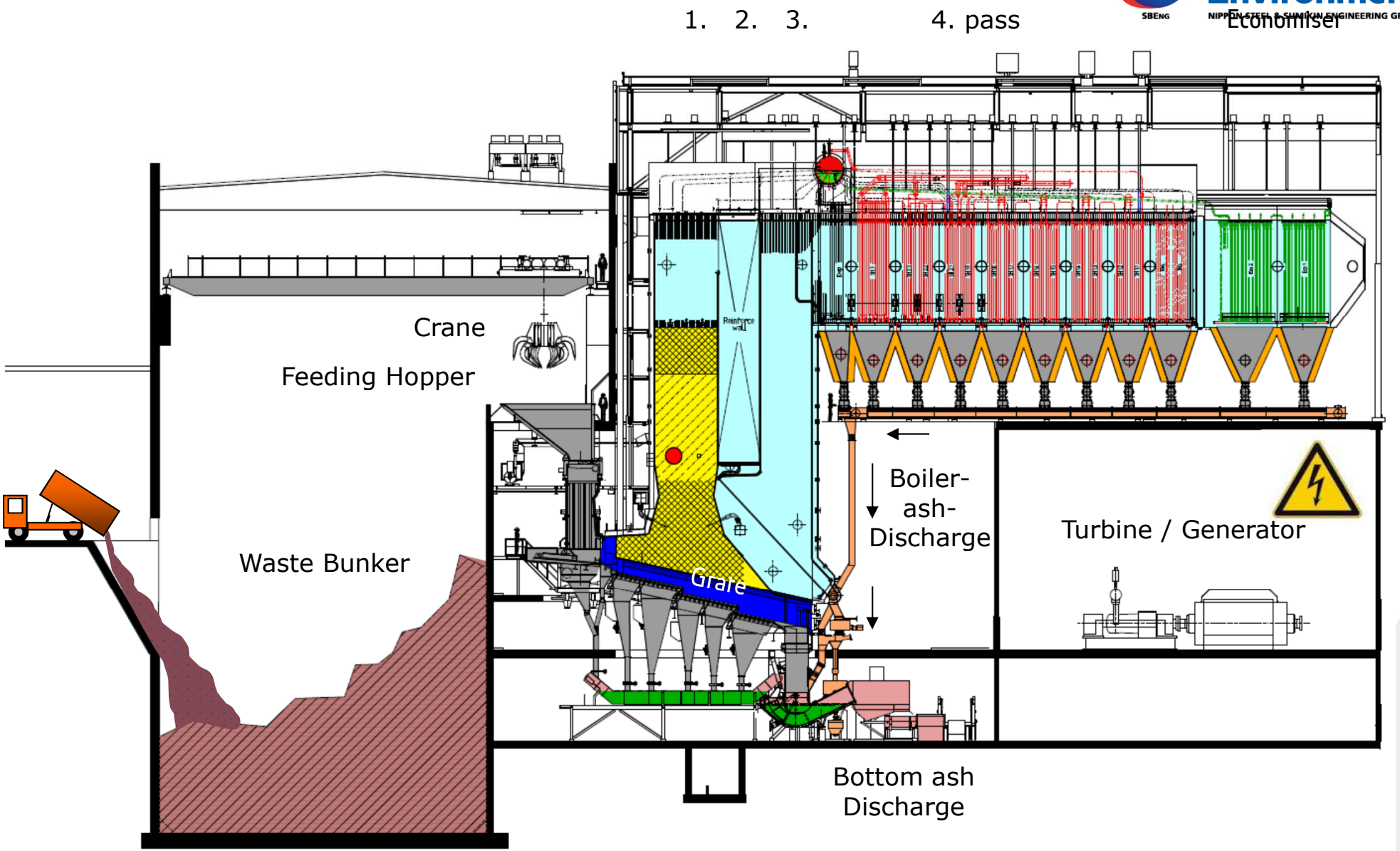
5) Grate
6) Furnace/waste fire
7) Slag extractor
8) Evaporator
9) Boiler drum
10) Superheater
11) Turbine
12) Economiser
13) Feedwater tank

Process of waste incineration

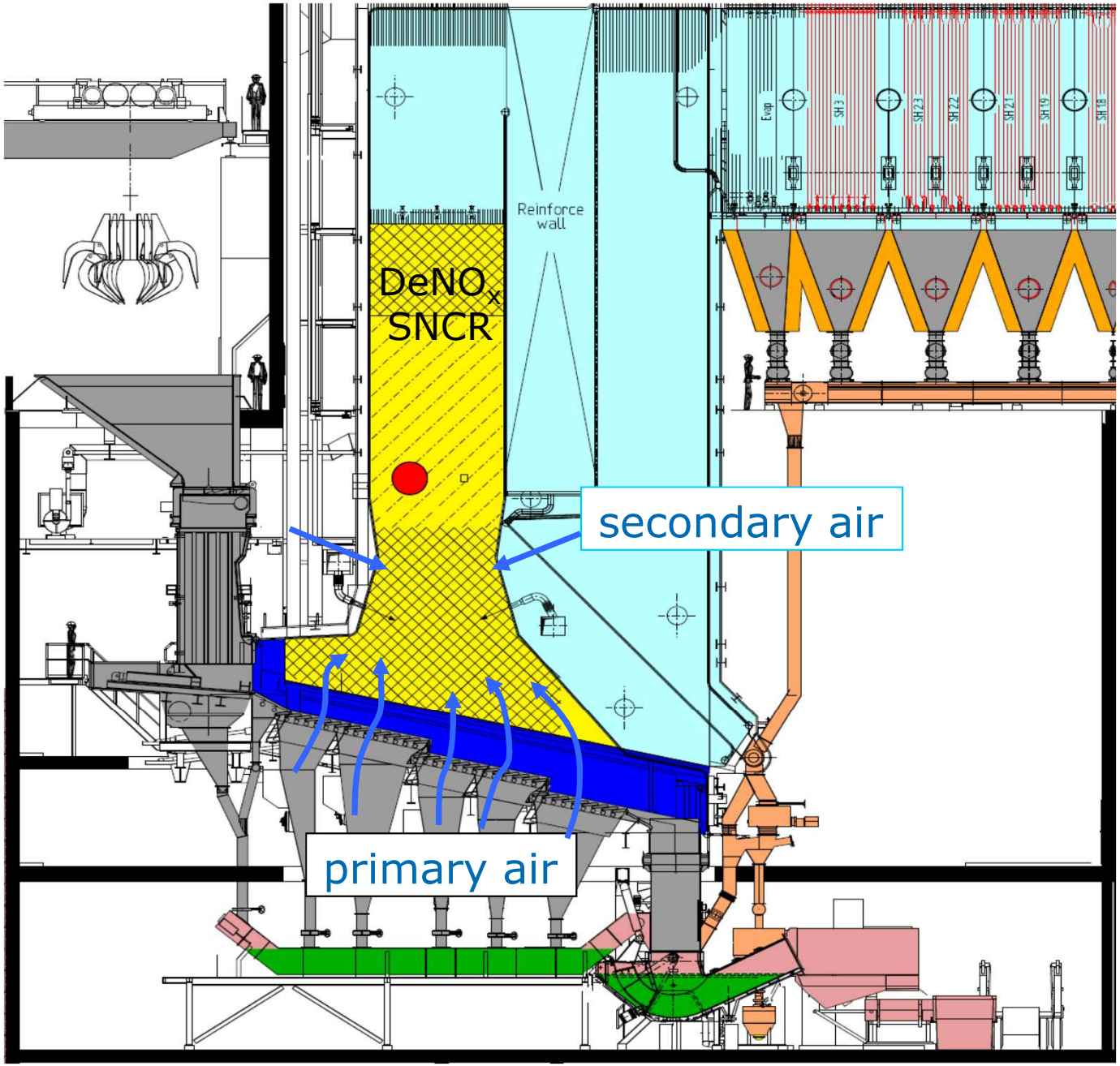


14) Spray absorber
15) Flow reactor
16) Silos
17) Fabric filter
18) ID-Fan
19) Stack

Longitudinal Section, Grate & Boiler with a horizontal 4th pass



Section, Grate & Boiler



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Air Passage

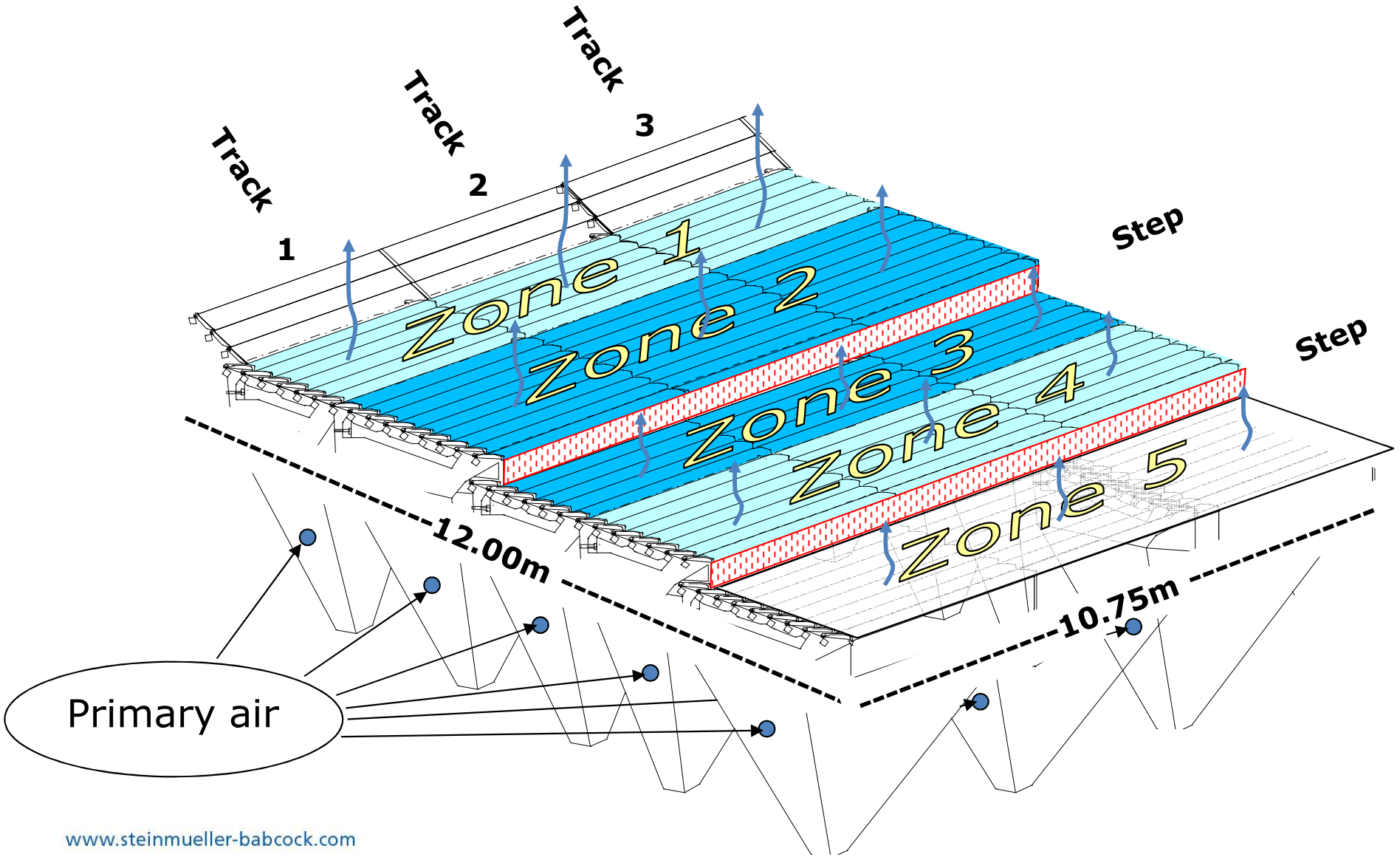
&

Denitrification

Forward moving grate, example with 3 tracks

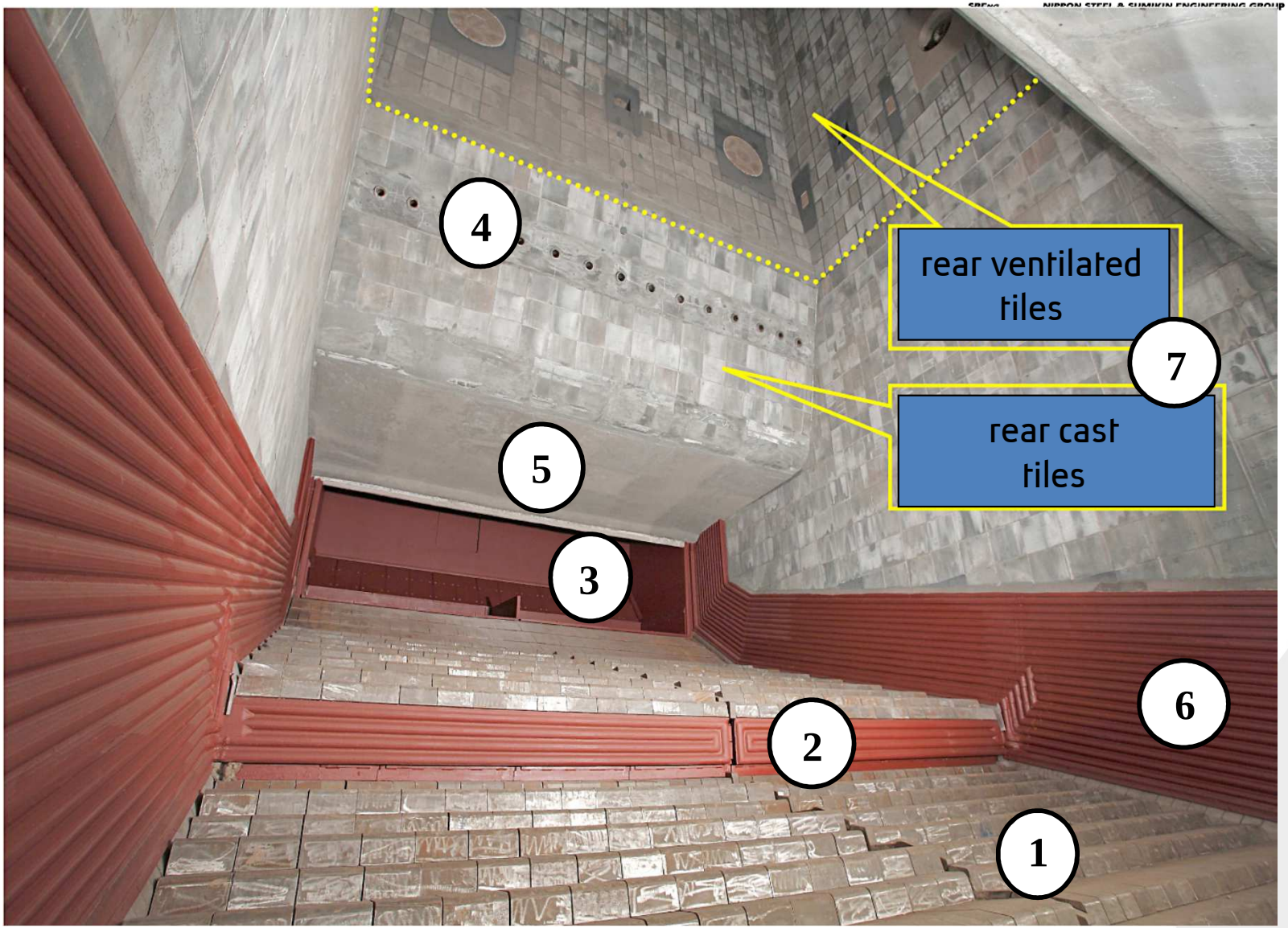
> Air cooled for Municipal Solid Waste

> Water cooled i.e. for RDF (high calorific values) as an option



Forward moving grate, example with 2 tracks

1 Grate surface
2 Grate step
3 Feed shaft
4 Secondary air nozzles
5 Ignition roof
6 Grate side tubes
7 Refractory with tiles

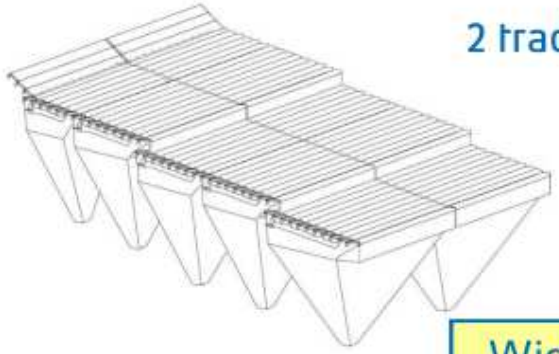


Maximum Widths of Grates

1 track

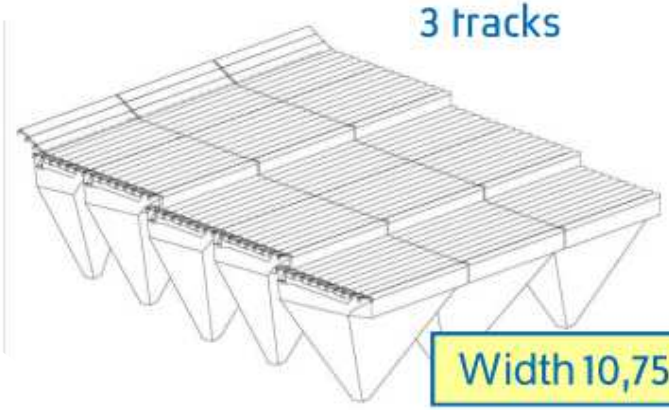
Width 3,55 m

2 tracks



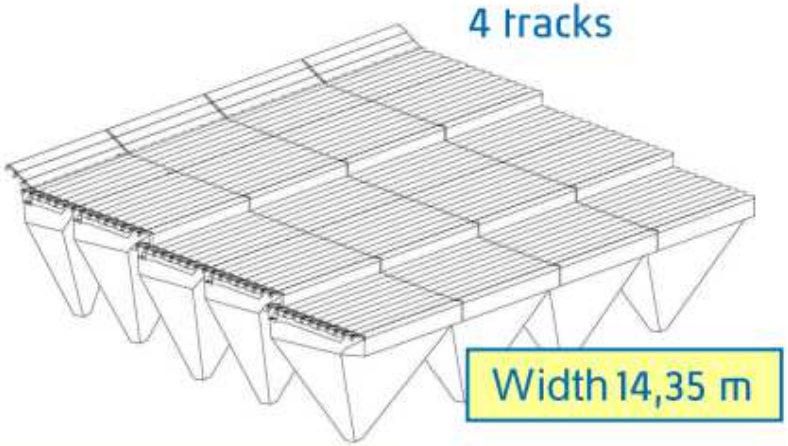
Width 7,15 m

3 tracks



Width 10,75 m

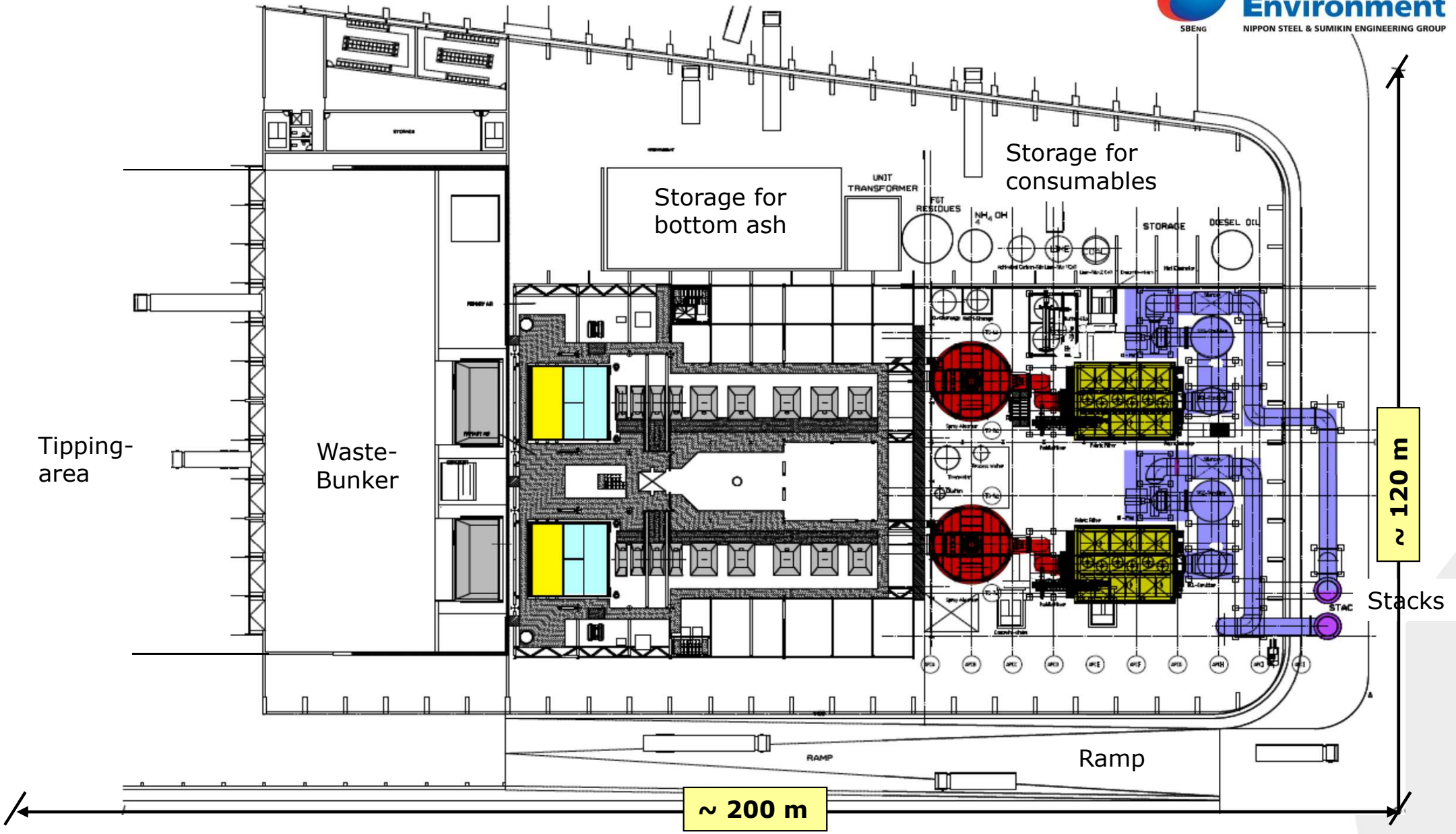
4 tracks



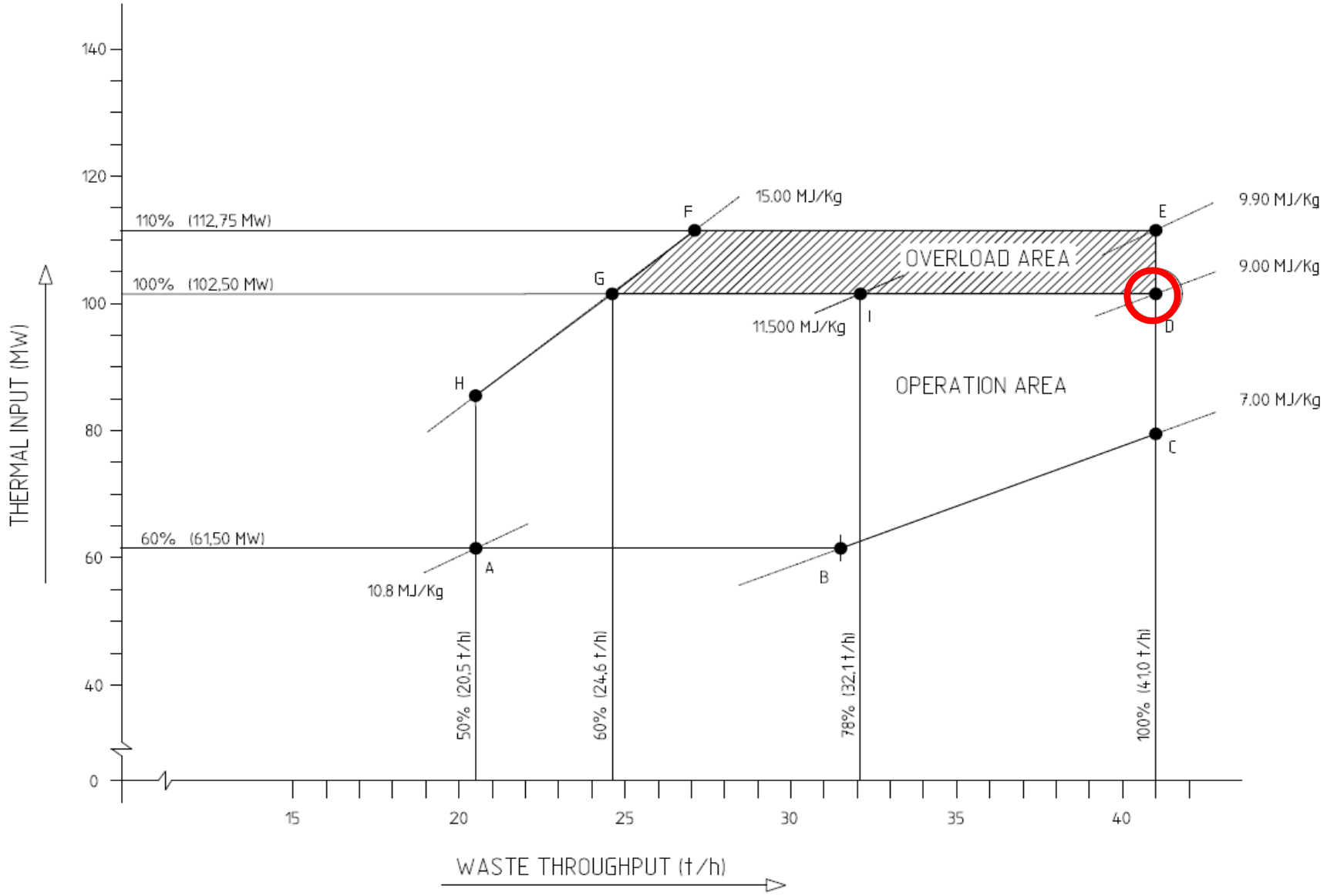
Width 14,35 m

Intermediate grate sizes are not shown
Minimum width 2,25 m

Top View on a EfW – Example Plant -



Firing Capacity Diagram
- Example Concept -



Main Data - Example Concept -

No. of Lines		**2**
No. of Grate Tracks		**3**
Waste Capacity (LP 1)	**Mg/h**	**2 x 41**
	Mg/d	**2 x 1 000**
Annual Waste Capacity (LP1)	**Mg/a**	**650 000**
Calorific Value (LP 1)	**MJ/kg**	**9.0**
Calorific Band With	**MJ/kg**	**7.0 – 15.0**
Heat Capacity (LP 1)	**MW**	**2 x 102.5**
Steam Parameter	**°C / bar(ü)**	**444 / 61**
Steam Flow at 100% (LP 1)	**Mg/h**	**2 x 123.2**
Flue Gas Temp. downstream Eco	**°C**	**180**
Flue Gas Temp. downstream Cooler	**°C**	**125**
Flue Gas Quantity	**Nm^3/h_{wet}**	**2 x 181 000**
Flue Gas Emissions	**according to EU-Directive 2000/76/EC**	
Energy Production, gross	**MW_{el}**	**60.0**
Energy Production, net	**MW_{el}**	**54.5**
Boiler Availability	**% annual h**	**> 90**

Reference plant
EfW plant Herten/Germany

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Client:	RZR Herten II GmbH
Fuel:	Municipal and commercial waste
Capacity:	2 x 52 MWth; 2 x 17 t/h; 10,800 kJ/kg
Grate system:	Forward moving grate
Commissioning:	2008
Scope:	General contractor → Enlargement of the existing plant by two incineration lines for municipal waste on a turnkey basis (incl. grate, boiler, flue gas cleaning, turbine, erection, commissioning)
Special features:	Facility consists of 6 lines (2 x hazardous waste and 4 x municipal waste) Municipal waste: line 3 & 4 → general contractor; line 1 → grate, boiler, flue gas cleaning Hazardous waste: line 1 & 2 → rotary kiln, boiler, flue gas cleaning

Reference plant
EfW plant Berlin-Ruhleben/Germany

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Client:	Berliner Stadtreinigungsbetriebe
Fuel:	Municipal waste
Capacity:	90 MWth; 1 x 41 t/h; 9,000 kJ/kg
Grate system:	Forward moving grate
Commissioning:	2012
Scope:	General contractor → turnkey construction of line A incl. grate, boiler, flue gas cleaning, civil works, control and monitoring system, electrical systems
Special features:	One of the largest MSW grates worldwide, replacement of 4 old lines by 1 new line

Reference plant
EfW plant Acerra/Italy

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Client:	Fibe S. p. A.
Fuel:	Refuse derived fuel
Capacity:	3 x 113 MWth; 3 x 27 t/h; 15,070 kJ/kg
Grate system:	Forward moving grate (water-cooled)
Commissioning:	2009
Scope:	Member of general contractor consortium for the construction of turnkey plant → incl. grate, boiler, flue gas cleaning, turbine, erection, commissioning
Special features:	660,000 tons throughput capacity per year, optimised energy efficiency, turbine/generator with 120 MWel

Turnkey competence EfW
Reference plant Cologne/Germany

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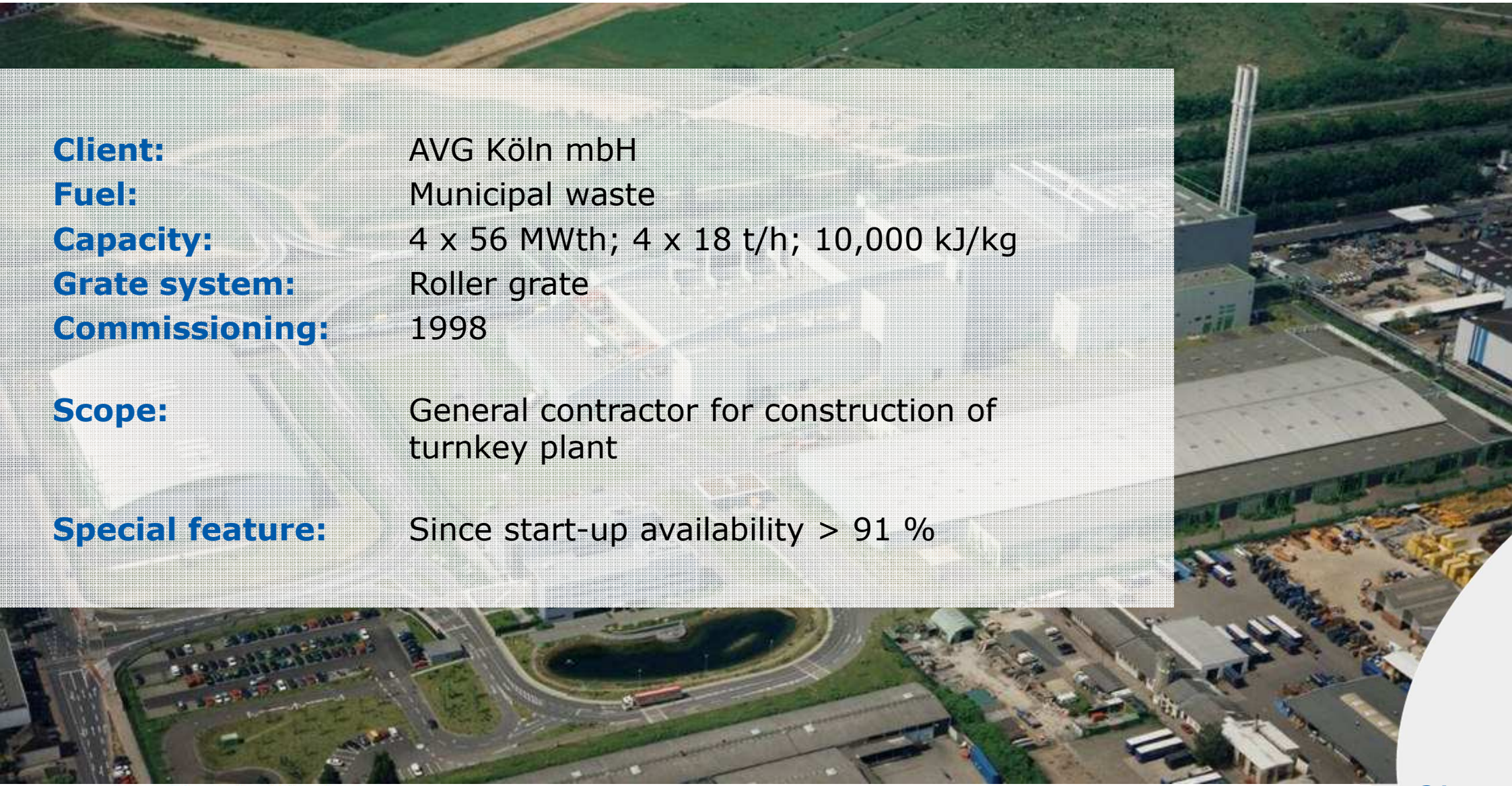

Client:	AVG Köln mbH
Fuel:	Municipal waste
Capacity:	4 x 56 MWth; 4 x 18 t/h; 10,000 kJ/kg
Grate system:	Roller grate
Commissioning:	1998
Scope:	General contractor for construction of turnkey plant
Special feature:	Since start-up availability > 91 %

Reference plant
EfW plant Cologne/Germany

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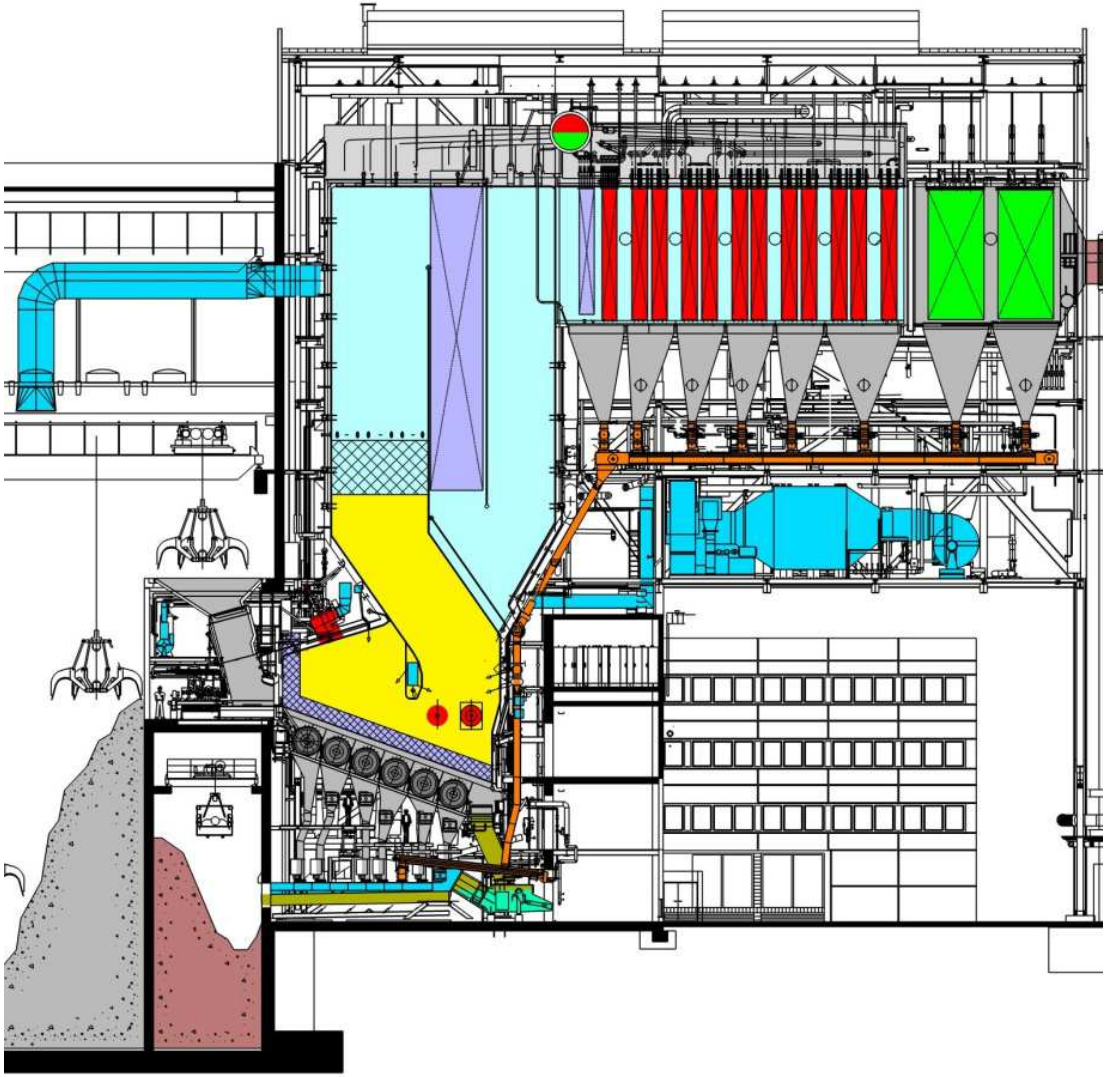
KONTINUIERLICH ERMITTELTE EMISSIONSWERTE				
Emission	Gesetzlicher Grenzwert	Genehmigungs-wert	RMVA-Wert	Anteil am Grenzwert in %
Kohlenmonoxid	50 mg/Nm³	50 mg/Nm³	1,8 mg/Nm³	3,6
Gesamtkohlenstoff	10 mg/Nm³	5 mg/Nm³	0,1 mg/Nm³	1,0
Chlorwasserstoff	10 mg/Nm³	5 mg/Nm³	0,2 mg/Nm³	2,0
Schwefeldioxid	50 mg/Nm³	10 mg/Nm³	0,1 mg/Nm³	0,2
Stickstoffdioxid	150 mg/Nm³	70 mg/Nm³	39,6 mg/Nm³	26,5
Ammoniak	10 mg/Nm³	3 mg/Nm³	0,2 mg/Nm³	2,0
Staub	5 mg/Nm³	5 mg/Nm³	0,1 mg/Nm³	2,0

Roller Grate Example



View to end of grate

Flue Gas Cleaning System
Waste to Energy Plant Cologne

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The Cologne waste combustion plant counts among the best of its kind in the world. In the first instance, that has to do with the highly effective flue gas cleaning. Under the 17th Federal Emissions Act, all waste combustion plants in

Germany must comply with very stringent limits. Not only does the Cologne plant achieve those limits effortlessly, it also comes in substantially below them. This is the result of intensive cleaning of the flue gas.

When the exhaust gas leaves the furnace area at a temperature of about 220 °C, it is first cooled down to about 170 °C by a **spray drier.** Dust particles are caught by the subsequent **fabric filter.** That completes the first cleaning stage.

Two washing stages, but no wastewater

Then follows the first washing stage in an **HCl scrubber**. Here, the flue gas still has a temperature of around 65 °C. Hydrogen fluorides and chlorides are dissolved in this "acid stage". Heavy metals - in particular mercury - are caught by a resin filter. The washing liquid is neutralised using lime injected into the spray drier, and thus evaporated. So the system works without wastewater.

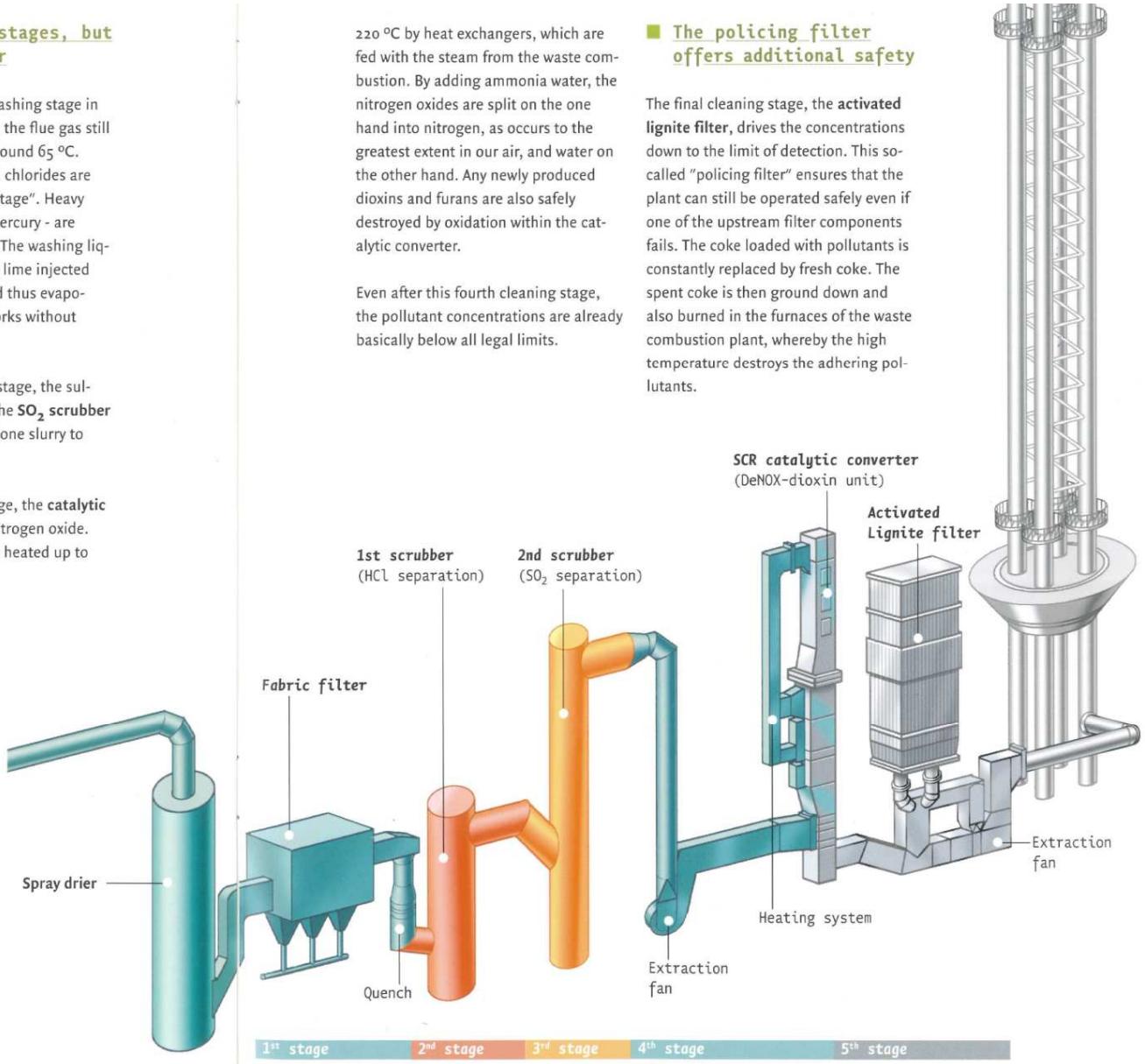
In the second washing stage, the sulphur dioxide reacts in the **SO_2 scrubber** with the injected limestone slurry to form gypsum.

The fourth cleaning stage, the **catalytic reactor**, destroys the nitrogen oxide. To do so, the flue gas is heated up to 220 °C by heat exchangers, which are fed with the steam from the waste combustion. By adding ammonia water, the nitrogen oxides are split on the one hand into nitrogen, as occurs to the greatest extent in our air, and water on the other hand. Any newly produced dioxins and furans are also safely destroyed by oxidation within the catalytic converter.

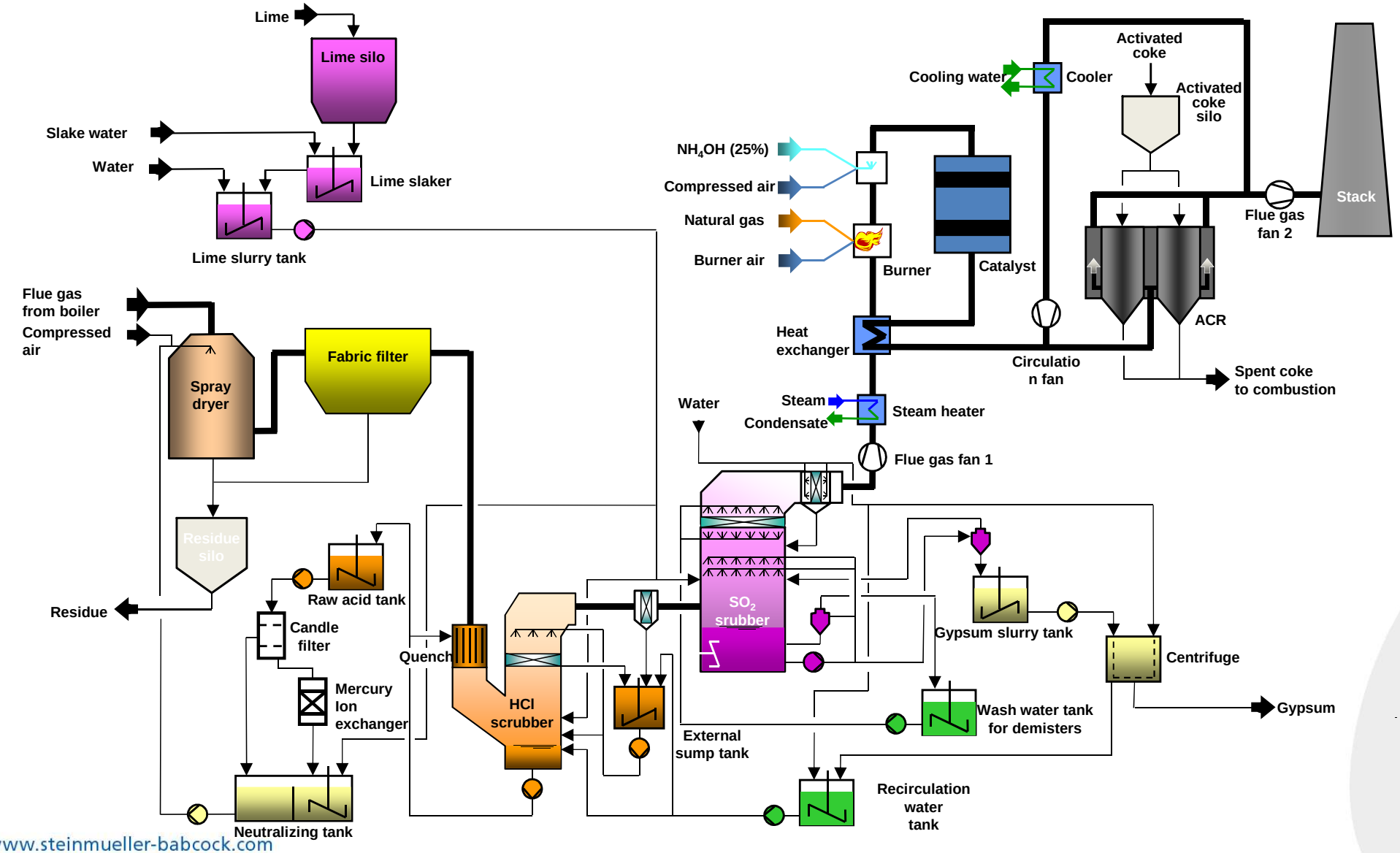
Even after this fourth cleaning stage, the pollutant concentrations are already basically below all legal limits.

The policing filter offers additional safety

The final cleaning stage, the **activated lignite filter**, drives the concentrations down to the limit of detection. This so-called "policing filter" ensures that the plant can still be operated safely even if one of the upstream filter components fails. The coke loaded with pollutants is constantly replaced by fresh coke. The spent coke is then ground down and also burned in the furnaces of the waste combustion plant, whereby the high temperature destroys the adhering pollutants.



Schematic of the Flue Gas Cleaning Plant
Waste to Energy Plant Cologne



MV Rugenberger Damm, Hamburg/ Germany

Steinmüller Babcock Environment
SBEng
NIPPON STEEL & SUMIKIN ENGINEERING GROUP

Location
Hamburg, Germany

Owner
City of Hamburg (45%)
Vattenfall (55%)

Fuel
Municipal solid waste

Capacity
57.63 MWth
2 x 21.5 t/h
9 650 kJ/kg

Grate System
Forward moving grate

Year of Start Up
1999

SBEng Scope of supply
Firing system
Steam generator
Flue gas cleaning
Recovery plant and gypsum production

www.steinmueller-babcock.com

MV Borsigstrasse, Hamburg/ Germany

Steinmüller Babcock Environment
SBEng NIPPON STEEL & SUMIKIN ENGINEERING GROUP

Location
Hamburg, Germany

Owner
City of
Hamburg

Fuel
Municipal solid waste

Capacity
57.78 MWth
2 x 21.5 t/h
9 675 kJ/kg

Grate System
Forward moving grate

Year of Start Up
1994

SBEng Scope of supply
Firing system
Steam generator
Flue gas cleaning
Recovery plant and gypsum production

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SBENG
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Revision/ maintenance

Inspection and repairs

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Service contracts for wear parts

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Optimisation and management of technical mode

Operators training

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