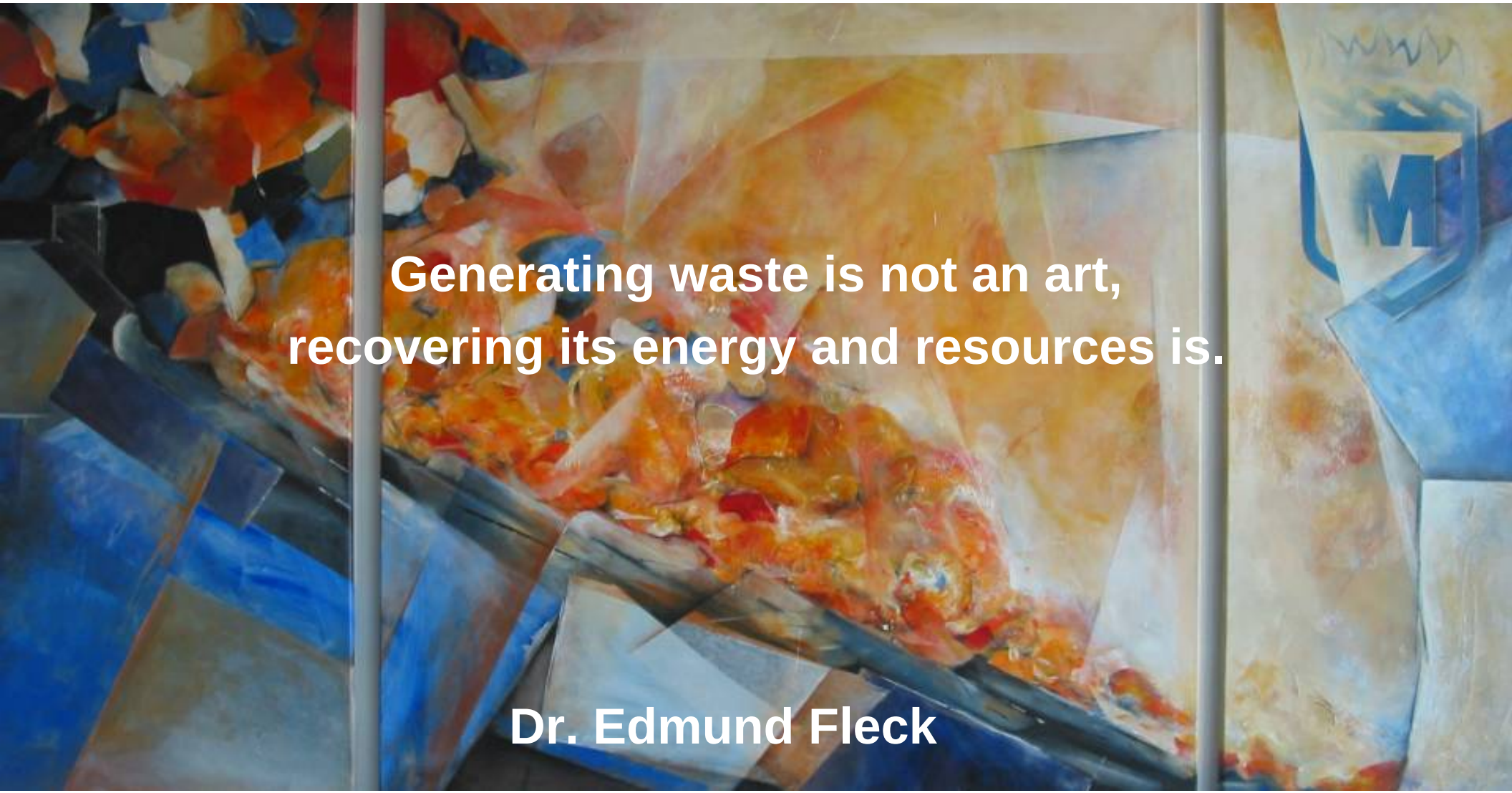
MARTIN GmbH
für Umwelt- und Energietechnik



Recent Developments in WTE Grate Combustion: Technology and Implementation

Recent Developments in WTE Grate Combustion: Technology and Implementation

Contents

1. Introduction

PAST

Waste Incineration Plant

Thermal Waste Treatment Plant

Waste Heating Power Plant

TODAY

Waste-to-Energy Plant

Energy from Waste Plant

2. Historic Overview

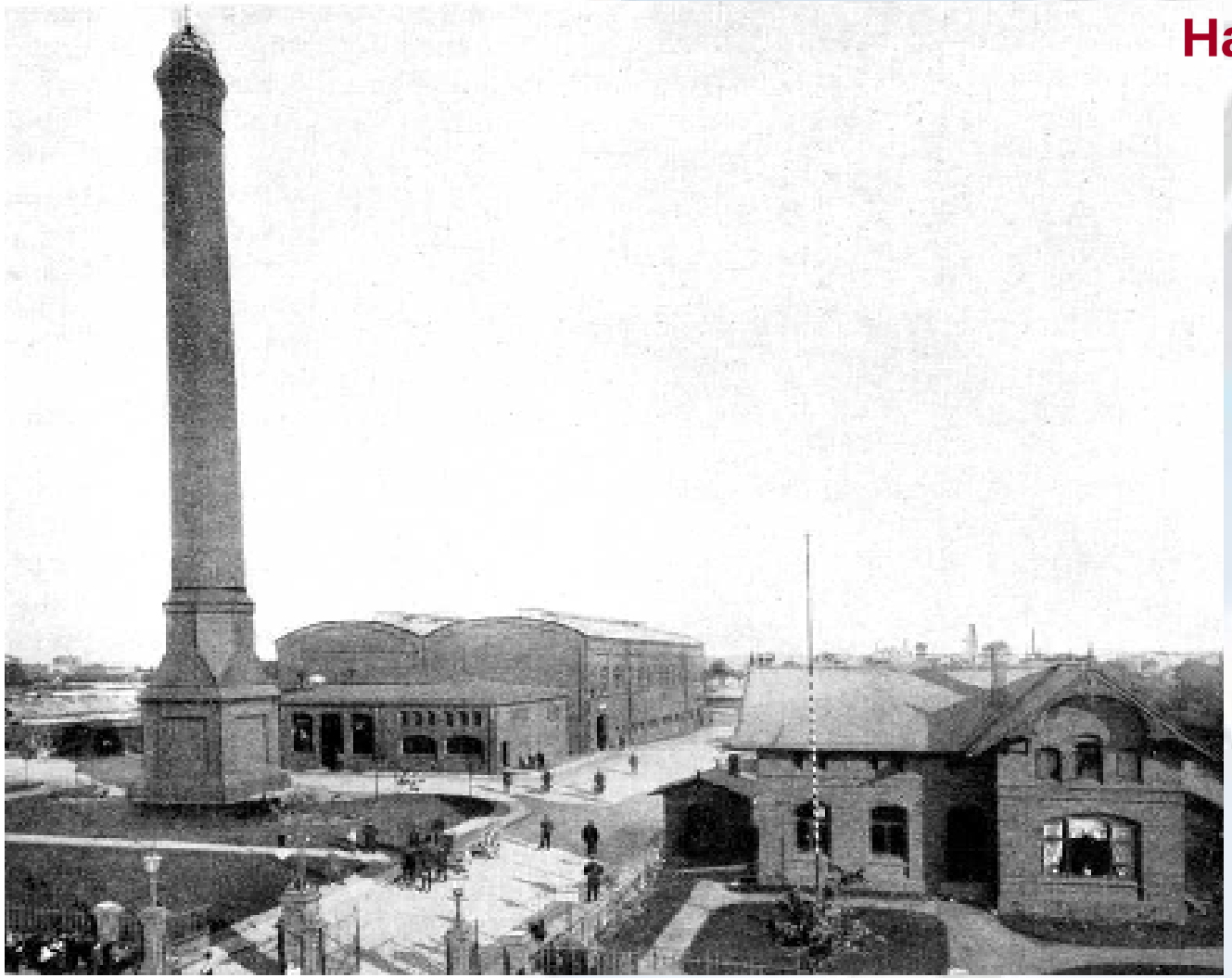
- **First waste incineration plants were built in Europe in the middle of the 19th century**
- **Simple, batch type technology - no heat recovery, no flue gas treatment**
- **Large-scale application of waste incineration only after end of WW II**
  - **Landfill space became more scarce**
  - **Environmental consciousness increased**
  - **Financial resources available**

2. Historic Overview, cont`d

- **Technology substantially improved**
- **Continuous waste feeding and residue removal**
- **Heat recovery introduced**
- **Flue gas treatment in several steps**
  - ➢ **Particulate removal - ESP, FF**
  - ➢ **Removal of acid components (HCl, SOx etc) - wet, dry, semi-dry**
  - ➢ **Removal of organic substances and heavy metals - active carbon/coke (fixed bed, 'filsorption')**
  - ➢ **Removal of NOx - SNCR, SCR**

2. Historic Overview, cont`d

Hamburg 1896



Source: A. Nabasik and A. Nottrodt

2. Historic Overview, cont`d

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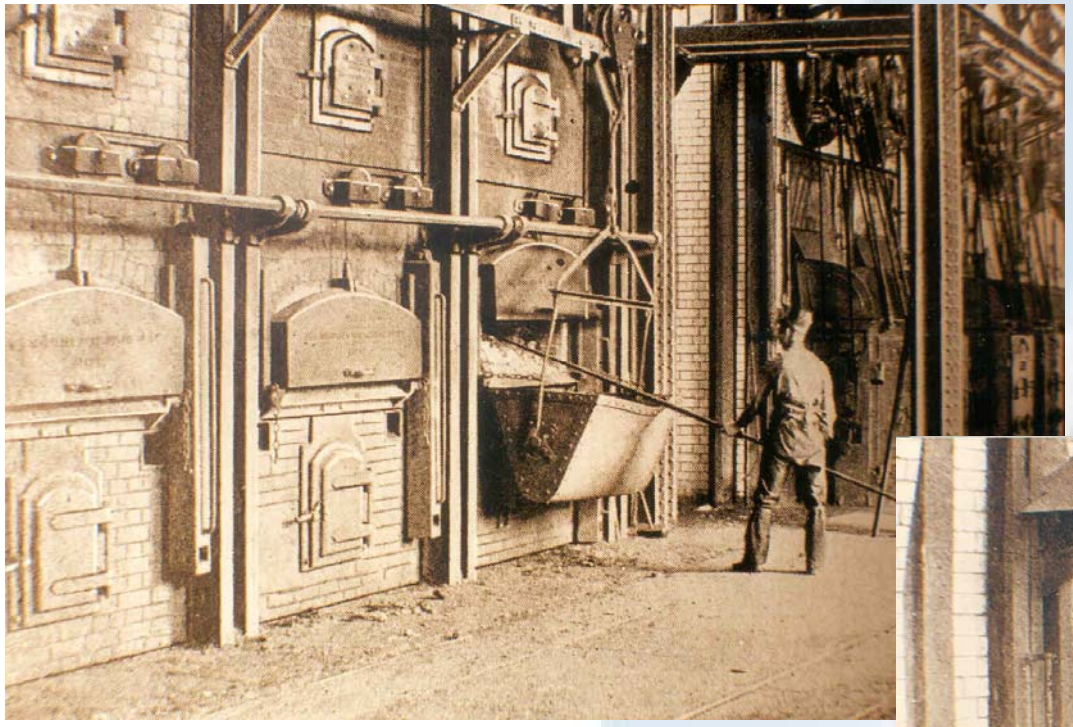

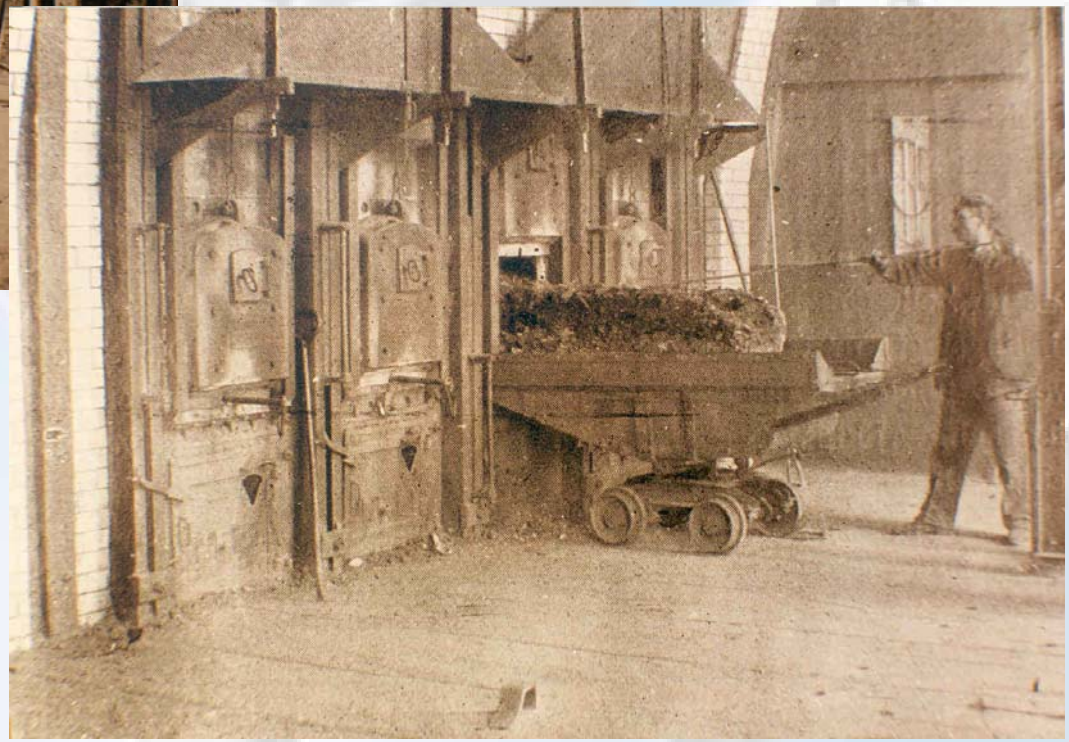

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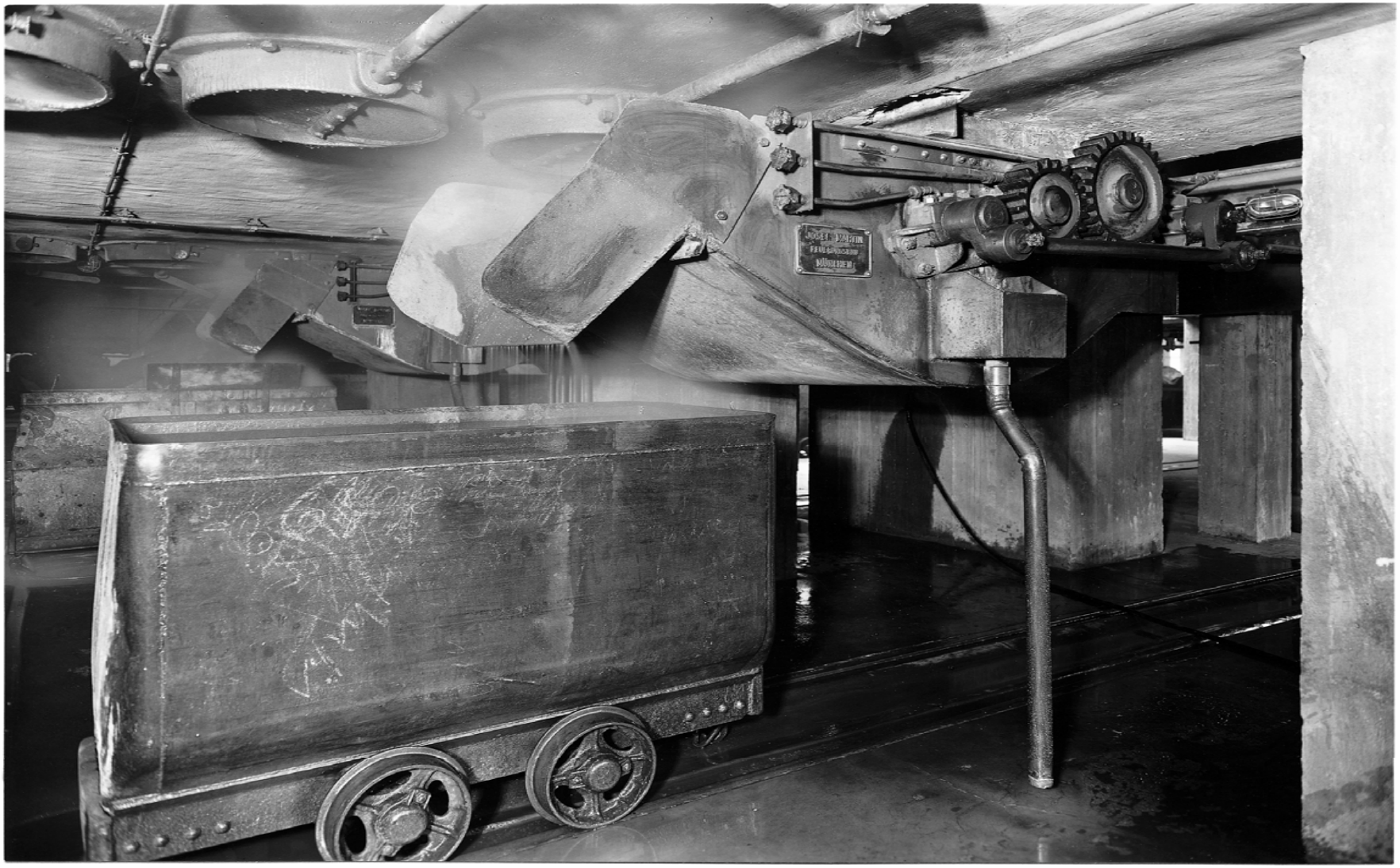
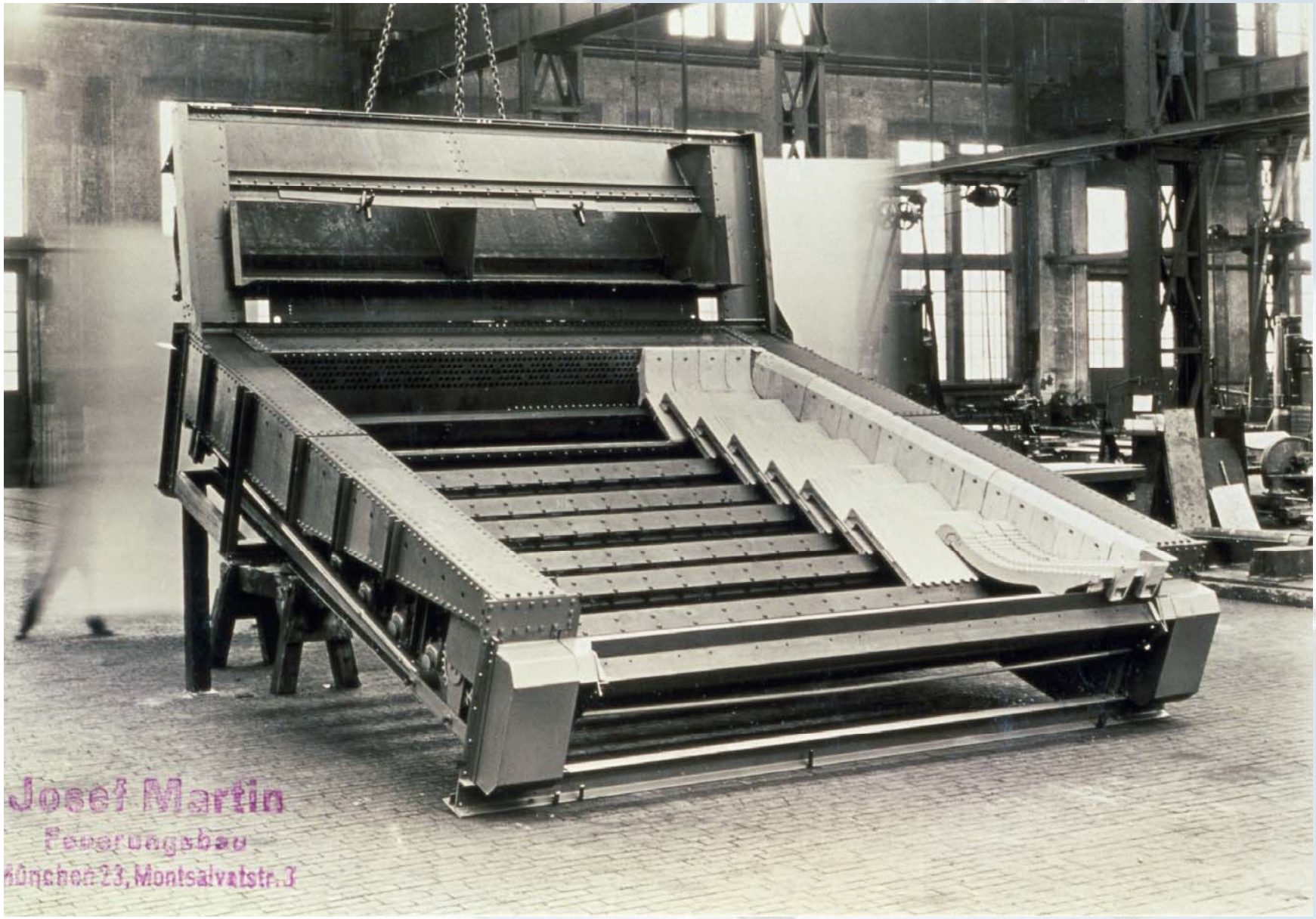
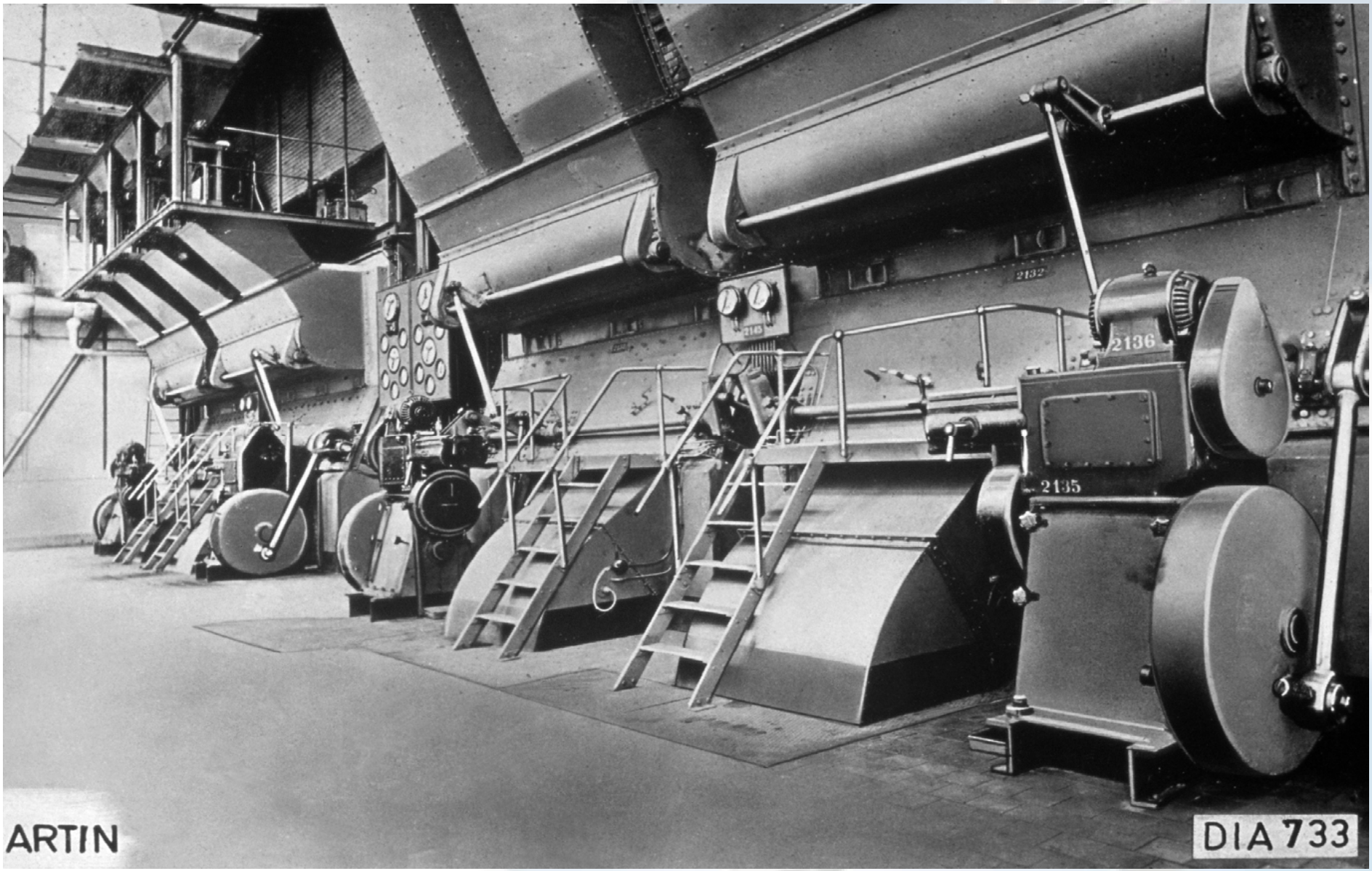


2. Historic Overview, cont`d



2. Historic Overview, cont`d

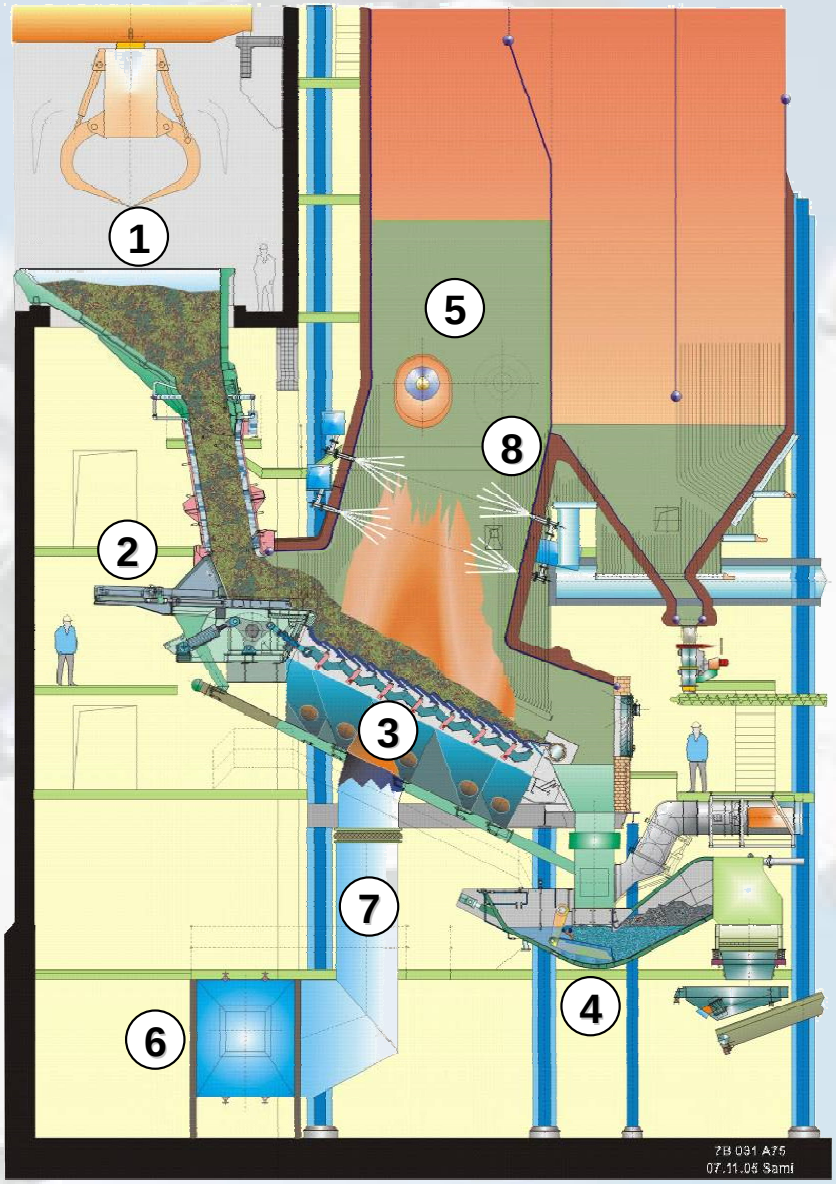


3. Martin Technologies

- **Reverse-acting grate 26°**
- **Reverse-acting grate 24° / SITY2000**
- **Horizontal grate**
- **Boiler design for vertical and horizontal boilers**
- **SYNCOM / SYNCOM-Plus**
- **Combustion control**
- **SNCR - DeNOx - system**
- **Sewage sludge co-combustion systems**
- **Ash handling systems**

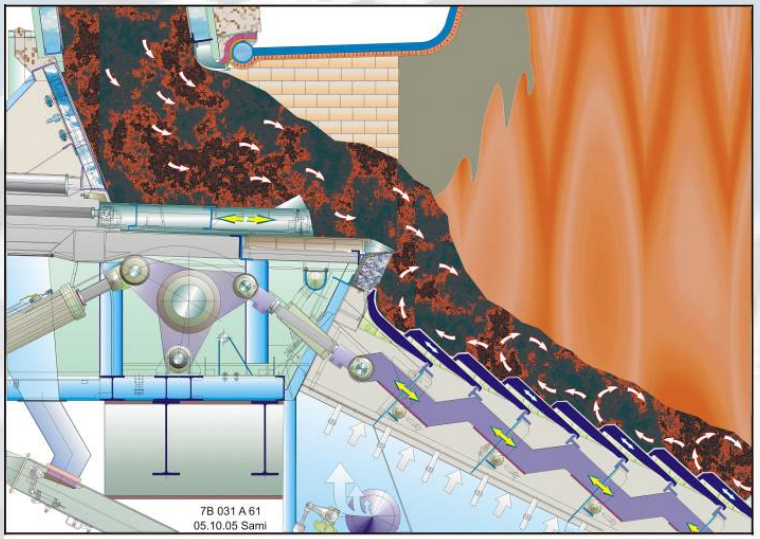
MARTIN reverse-acting grate System

1. **Feed hopper**
2. **Feeder**
3. **MARTIN reverse-acting grate**
4. **MARTIN discharger**
5. **Furnace**
6. **Steam heated air preheater**
7. **Primary combustion air (underfire)**
8. **Secondary combustion air (overfire)**



MARTIN reverse-acting grate

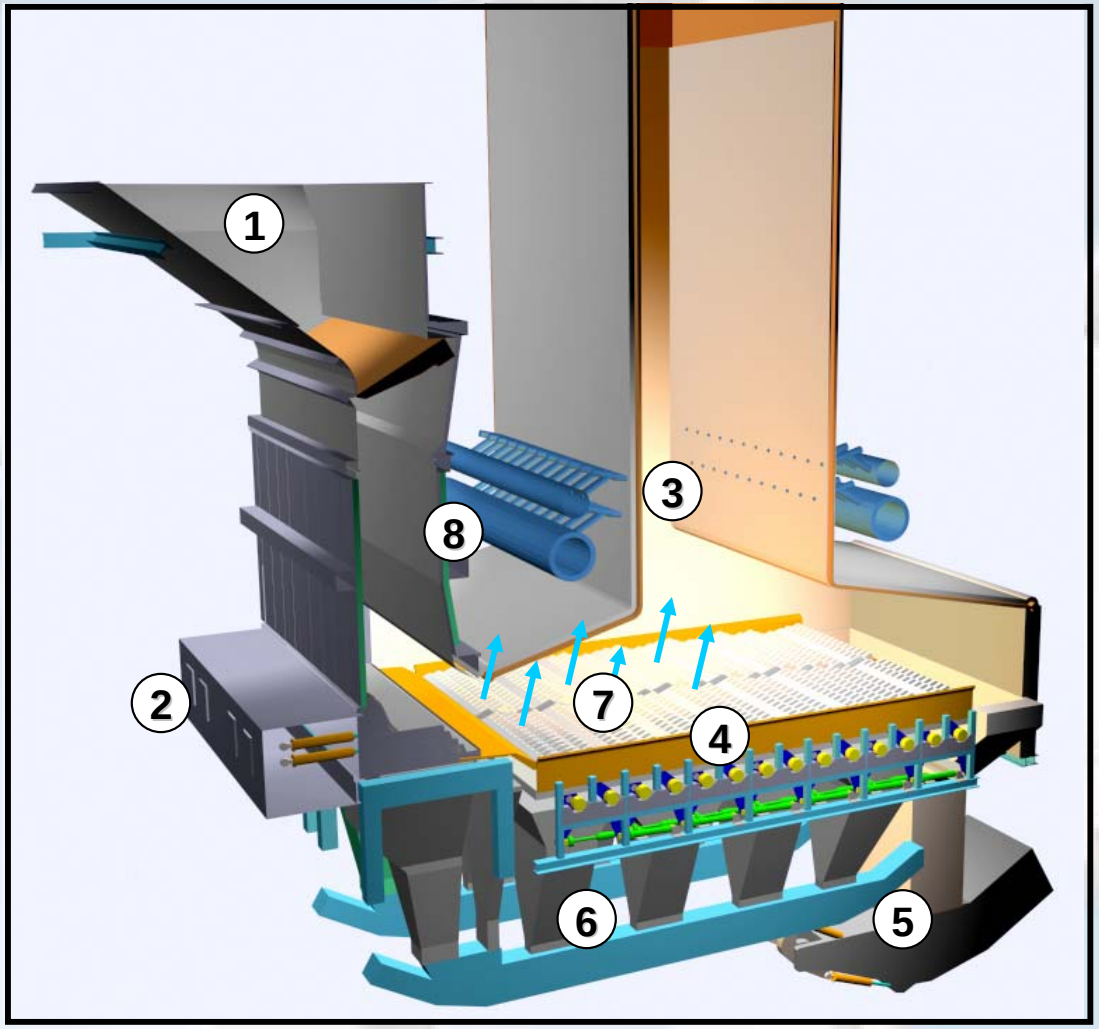
- **Movement against the direction of waste flow**
- **Uniform covering of grate**
- **Protection against intensive heat from radiation**
- **Protection against thermal wear**
- **Long service life**
- **Excellent stoking and mixing of waste**



Furnace with 5 runs

MARTIN horizontal grate system

1 Feed hopper
2 Feeder
3 Furnace
4 Horizontal grate
5 Discharger
6 Grate siftings conveyor
7 Primary combustion air (underfire)
8 Secondary combustion air (overfire)



4. Market Requirements

Background

- **Waste 'hierarchy' (avoid, re-use, recycle, recover, disposal)**
- **Landfilling is considered the worst alternative (pollution, greenhouse gases, long-term liability) for residual waste; banned in many countries**
- **WtE is more and more accepted by legislators as one component in sustainable waste management (recover the energy)**
- **Still substantial public opposition against WtE plants though**

- **Waste is a Resource!**
- **Waste-to-Energy can be considered 'recovery'**

4. Market Requirements, cont'd

Challenges

- **Use the energy contained in the waste 'efficiently'**
  - ➢ **Combine with steam users/heating networks**
  - ➢ **Increase electrical conversion efficiency**

- **Recyclable residues**
  - ➢ **Dry slag discharge**
  - ➢ **Glass-like ('inert') residues**

- **Other types of waste**

5. Martin Development Activities

- **Electrical conversion efficiency => higher steam parameters, new concepts**
- **Residue quality => SYNCOM, SYNCOM-Plus**
- **Dry slag discharge**
- **Pre-treated waste (RDF, SF, CDR etc)**

Increasing energy efficiency

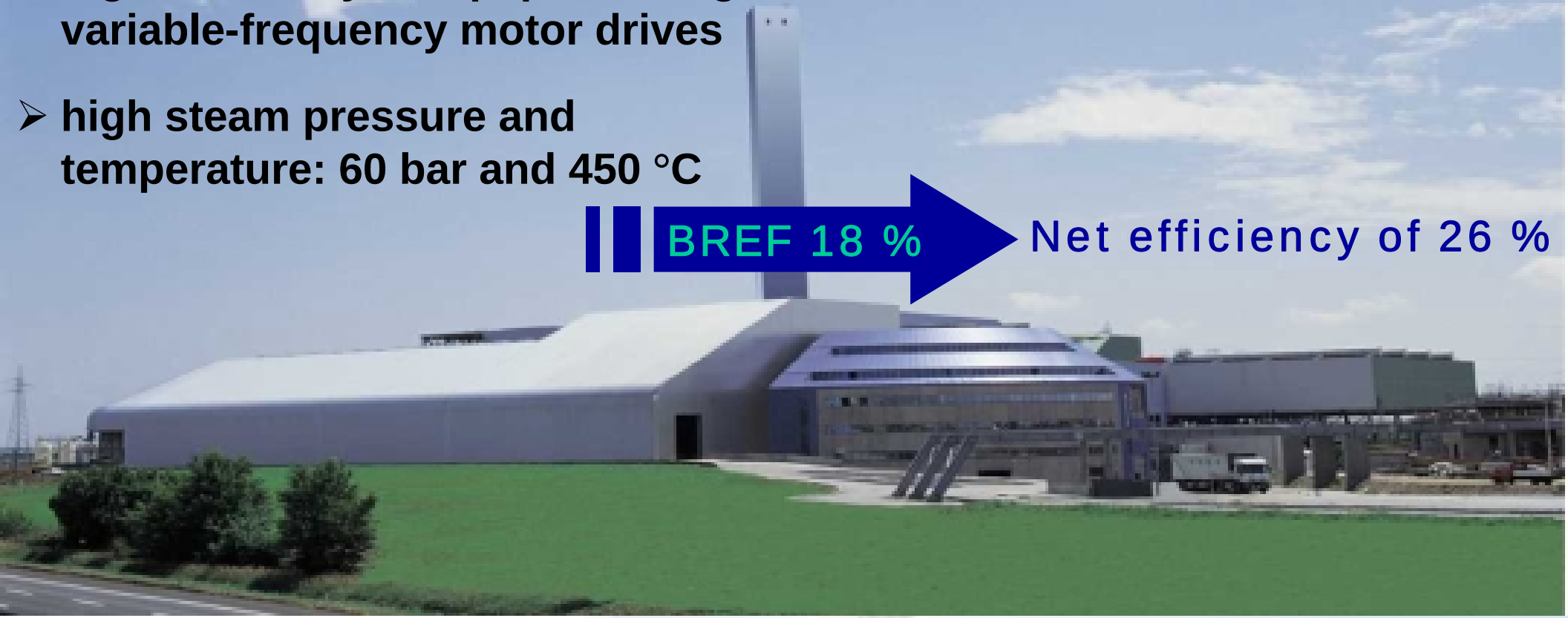
Premium for electricity from renewable waste fractions

- 14.5 €/MWh for 10 years if efficiency > 26 % in the Netherlands (2003)
- 170 €/MWh with the CIP6 program in Italy (replaced by 'Green Certificate')
- 23.4 €/MWh in Spain (Directive 1998)
  Bilbao example: 30 % premium on the electricity price

Optimized conventional type

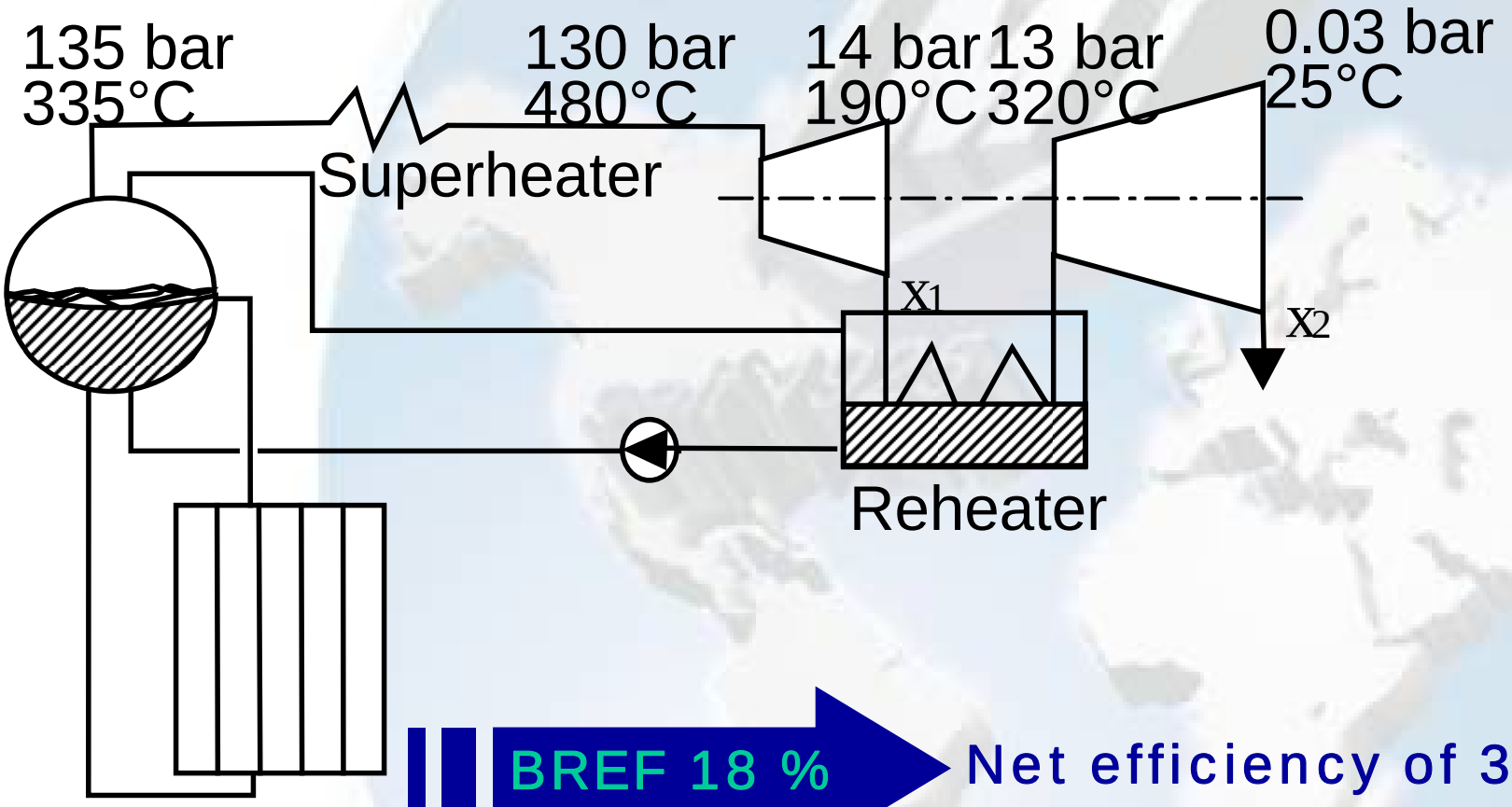
- Brescia concept -

- **low excess air rate**
- **cooling of flue gases to 130 °C**
- **high efficiency of equipment, e.g. variable-frequency motor drives**
- **high steam pressure and temperature: 60 bar and 450 °C**



Intermediate superheating

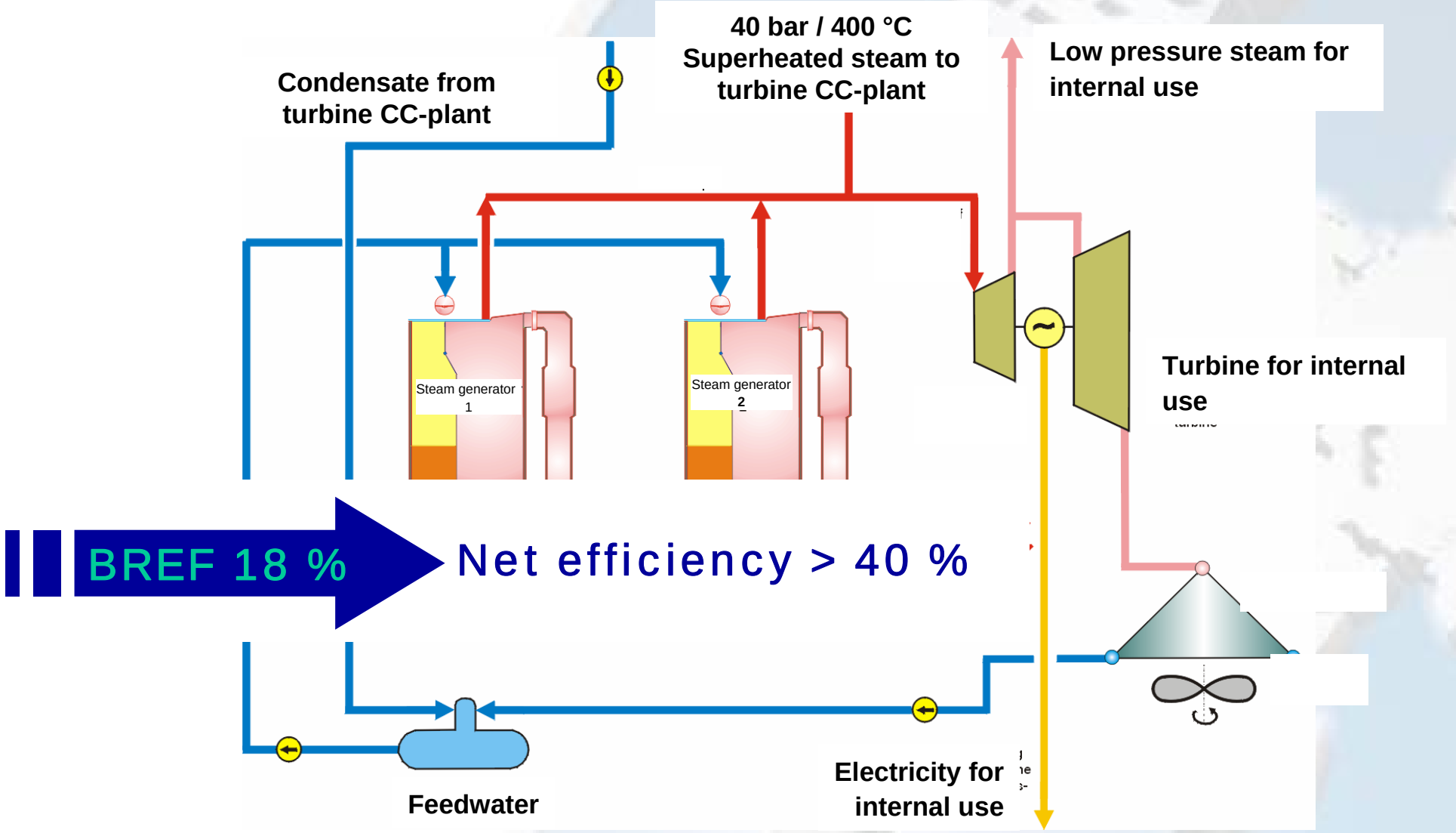
- Amsterdam concept -



BREF 18 % → Net efficiency of 30 %

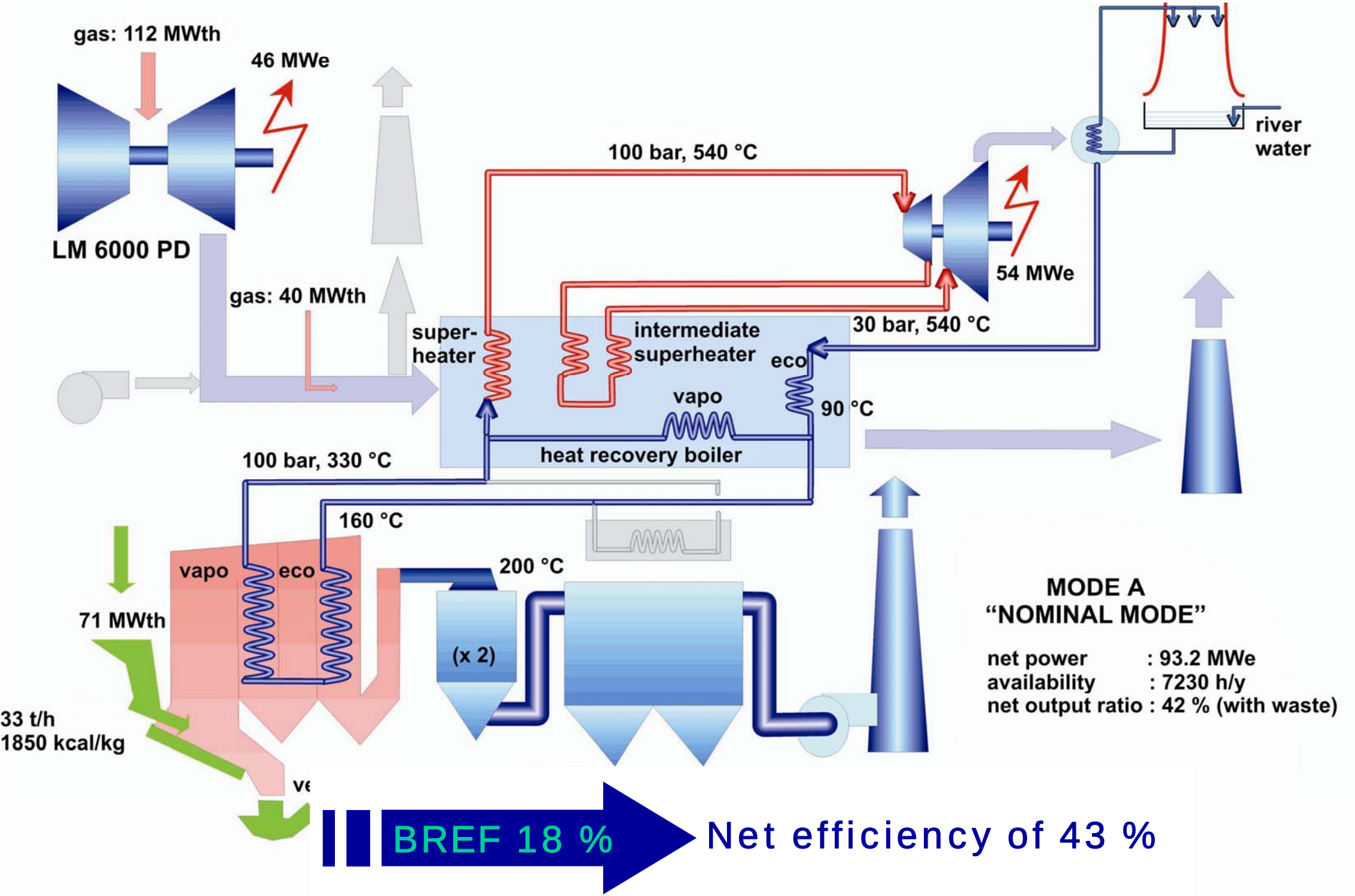
Combination with gas turbine

- Mainz concept -



Combined waste-to-energy / natural gas

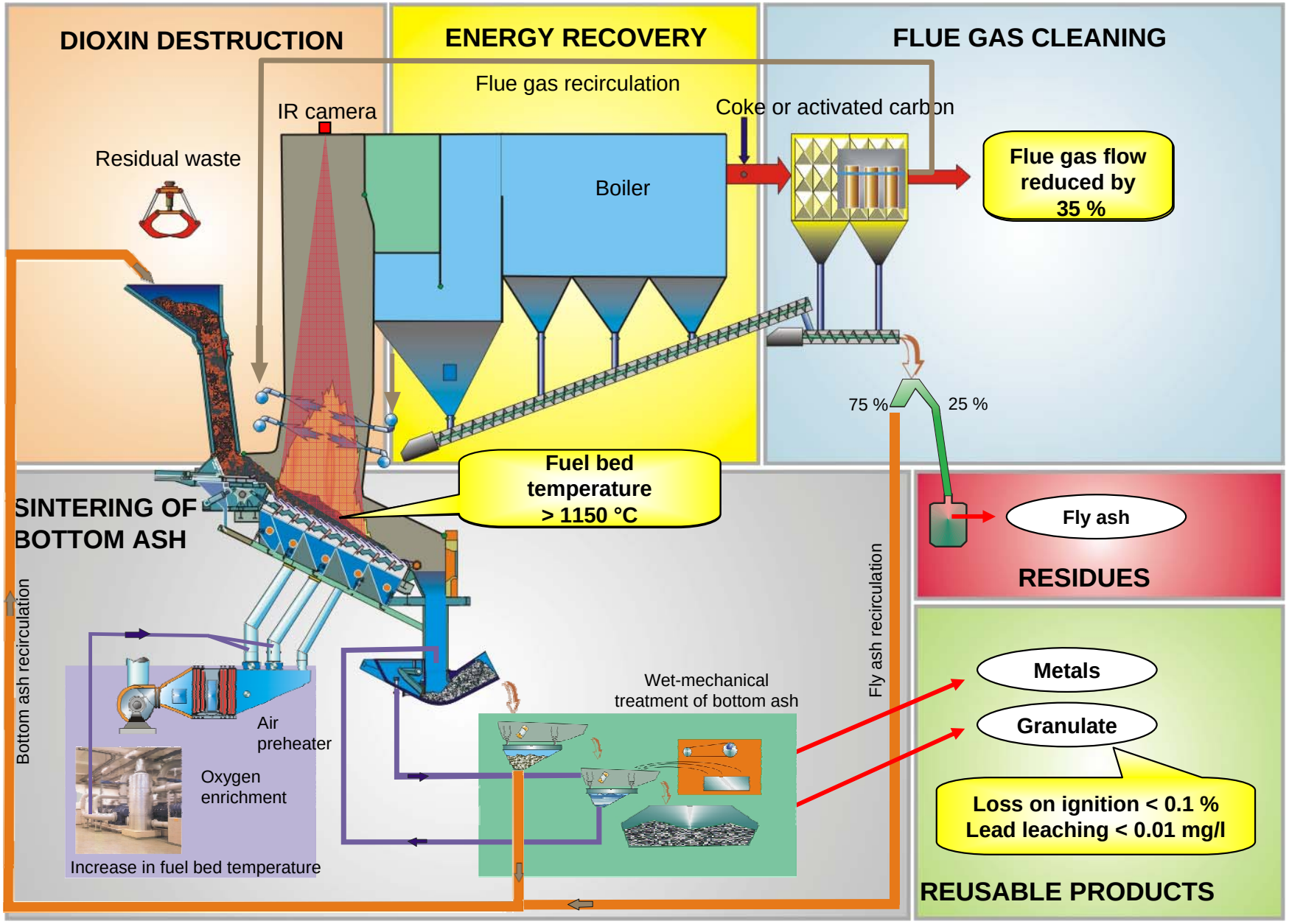
- Bilbao plant realized by CNIM -



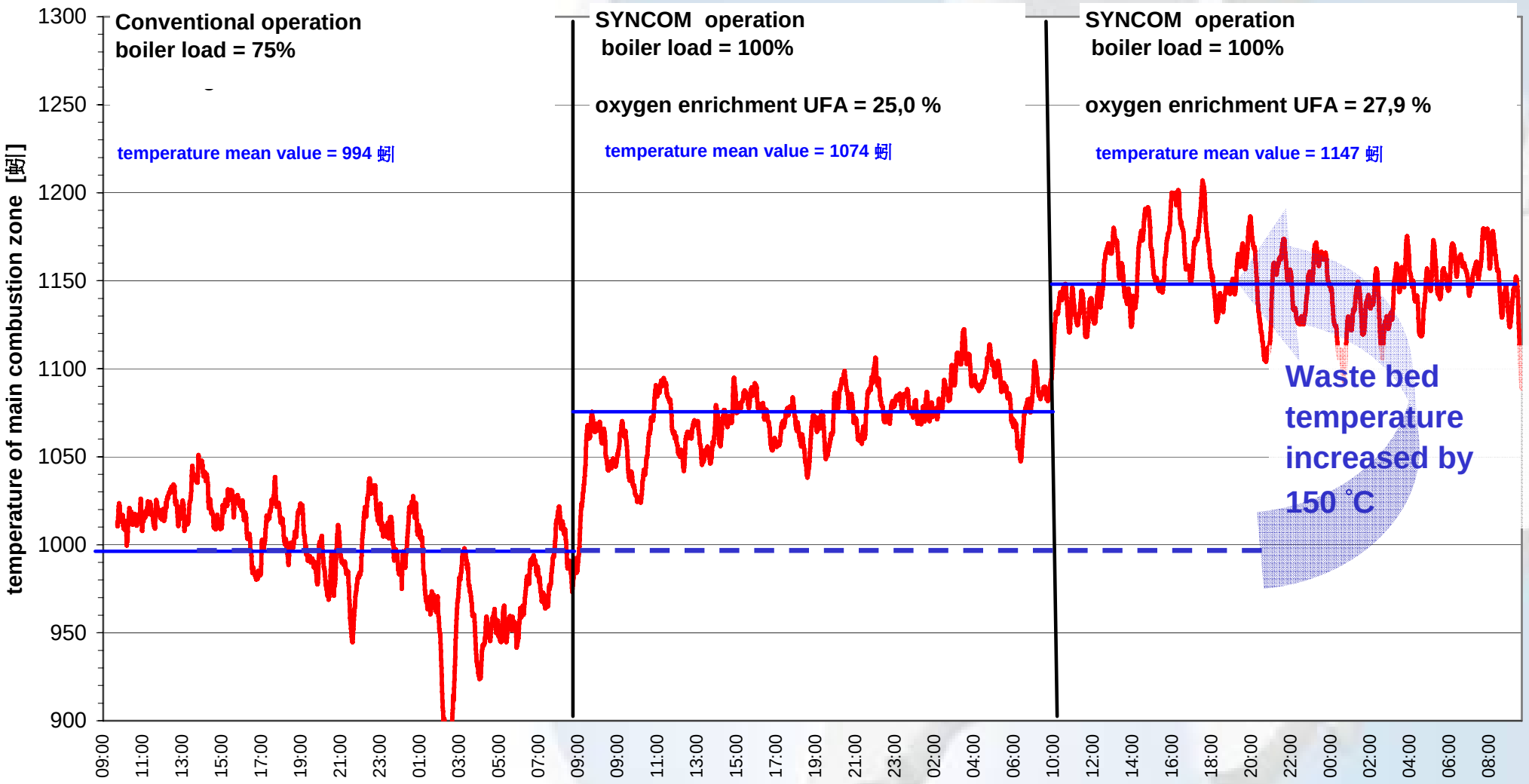
New WTE plants with increased efficiency

Plant	Brescia # 1+2 (Italy)	Brescia # 3 (Italy)	Amsterdam # 5+6 (Netherlands)	Mainz (Germany)	Bilbao (Spain)
Start-up	1998	2004	2006	2003	2004
Combustion system	MARTIN reverse-acting grate	MARTIN reverse-acting grate	MARTIN horizontal grate	MARTIN reverse-acting grate	MARTIN reverse-acting grate
NOx reduction	SNCR	SNCR	SNCR	SNCR	SNCR
Special feature	Optimized for high efficiency	Optimized for high efficiency	Intermediate steam superheating and water condenser	Coupled with combined cycle process (natural gas turbine)	Integration with combined cycle process (natural gas turbine)
Fuel	MSW, sewage sludge, biomass	Biomass, sewage sludge	MSW	MSW, natural gas	MSW, natural gas
Steam pressure [bar]	61	73	130	40	100
Superheated steam temperature [°C]	450	480	440	400 / 555	540
Gas temperature at boiler outlet [°C]	135	135	180 (135 °C with additional heat recovery after ESP and fabric filter)	200	200
Electricity produced [%; gross]	27	28	> 30	> 40 (referred to total gross heat of waste + natural gas) 25,8 (referred to gross heat of waste)	46 (referred to total gross heat of waste + natural gas)
Electricity exported [%; net]	24	25	30	> 40 (referred to total gross heat of waste + natural gas) 23,3 (referred to gross heat of waste)	42 (referred to total gross heat of waste + natural gas)

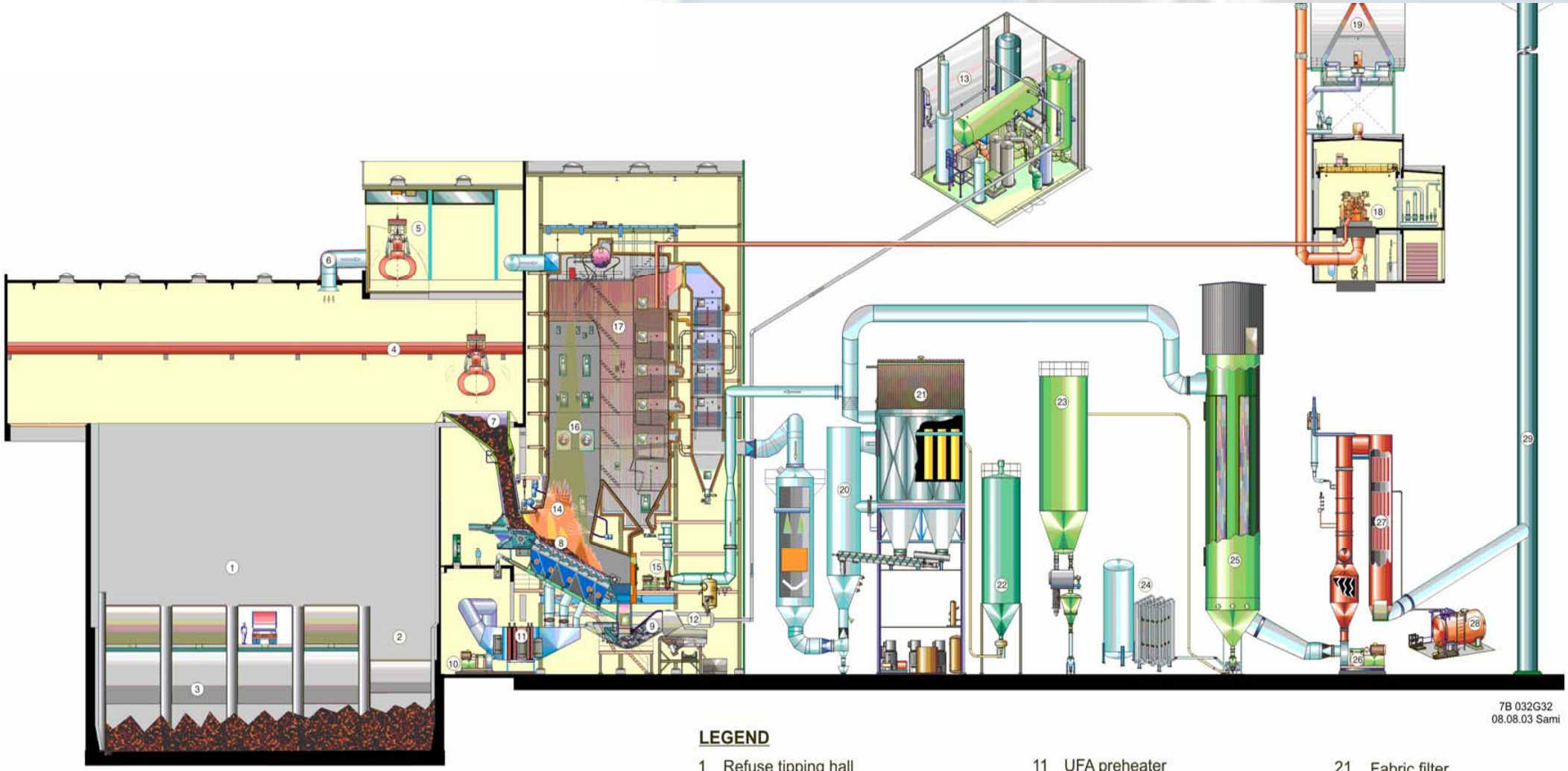
Inert ash with grate based technology: SYNCOM-Plus



Temperature of main combustion zone



SYNCOM reference plant in Arnoldstein



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TECHNICAL DATA

Waste throughput	=	1x10,7	Mg/h
At refuse heating value	=	10,000	k J/kg
Gross heat release	=	1x29,6	MW
Superheated steam pressure	=	41	bar
Superheated steam temperature	=	400	°C
Flue gas temperature	=	200-240	°C

REVERSE-ACTING GRATE

Grate runs	=	2
Number of steps	=	13
Run width	=	2000 mm
Grate width	=	4160 mm

LEGEND

1 Refuse tipping hall
2 Bulky waste crusher
3 Waste pit
4 Waste crane
5 Crane housing unit
6 Suction facility in the refuse pit
7 Feed hopper
8 Reverse-acting grate and furnace
9 Discharger
10 Underfire air fan
11 UFA preheater
12 Oxygen distributor
13 Air separation plant
14 Overfire air nozzles
15 Recirculated flue gas ventilator
16 Ignition and auxiliary burners
17 Steam generator
18 Steam turbo-generator set
19 Air- cooled condenser
20 Turbo reactor
21 Fabric filter
22 CaOH silo
23 Used coke silo
24 Oxygen tank
25 Coke filter
26 ID fan
27 Catalytic converter
28 Aqueous ammonia
29 Stack

CDR, RDF and similar fuels

- **CDR: (from Italian: “Combustibile Derivato dai rifiuti”)**

  Synonym for all kinds of waste processed to achieve a high calorific value

- **RDF: Refuse derived fuel - “secondary fuel“ etc. from municipal solid waste**
- **Industrial waste (such as DIB - “Dechets industriels banal”)**
- **Car shredder residues and shredded tires**
- **Biomass**

CDR, RDF and similar fuels

Typical compositions

Waste type	CDR (I)	RDF (GB)**	DIB (F)***
Calorific range	> 15 MJ/kg *	15 - 17 MJ/kg	13 - 18 MJ/kg
Moisture	< 25 % *	10 - 18 %	9 - 18 %
Ash (dry)	11 - 25 % expected	15 - 22 %	8 - 16 %
Chlorine	< 0.9 % *	0.6 - 1.2 %	0.8 - 2.2 %
Sulphur	< 0.6 % *	0.1 - 0.4 %	0.02 - 0.1 %

* Values for “combustibile derivato da rifiuti“ pursuant to Italian ordinance

** Refuse derived fuel

*** Déchets industriels banals (shredded)

RDF combustion tests
WTE plant St. Gallen

Start up: 1988

Number of lines: 2

Waste throughput:
5.2 t/h - 9,600 kJ/kg

Design heating value:
5,200 kJ/kg - 14,650 kJ/kg

Gross heat release: 50.24 GJ/h

Grate run width: 2,250 mm

Grate steps: 13

Grate area: 18.1 m^2

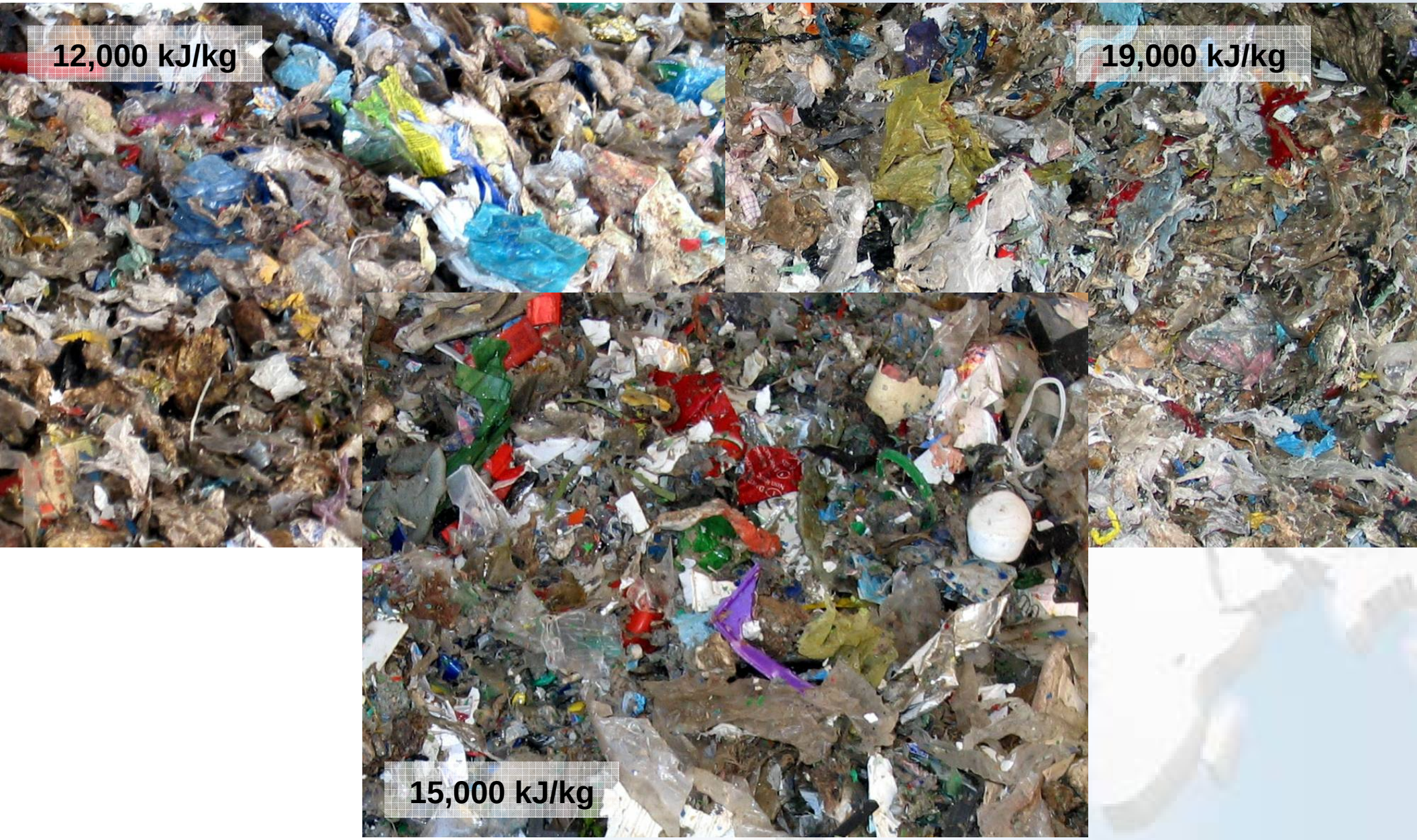
Steam parameters: 40 bar / 400 °C

Steam production: 15.1 t/h

Fuel properties

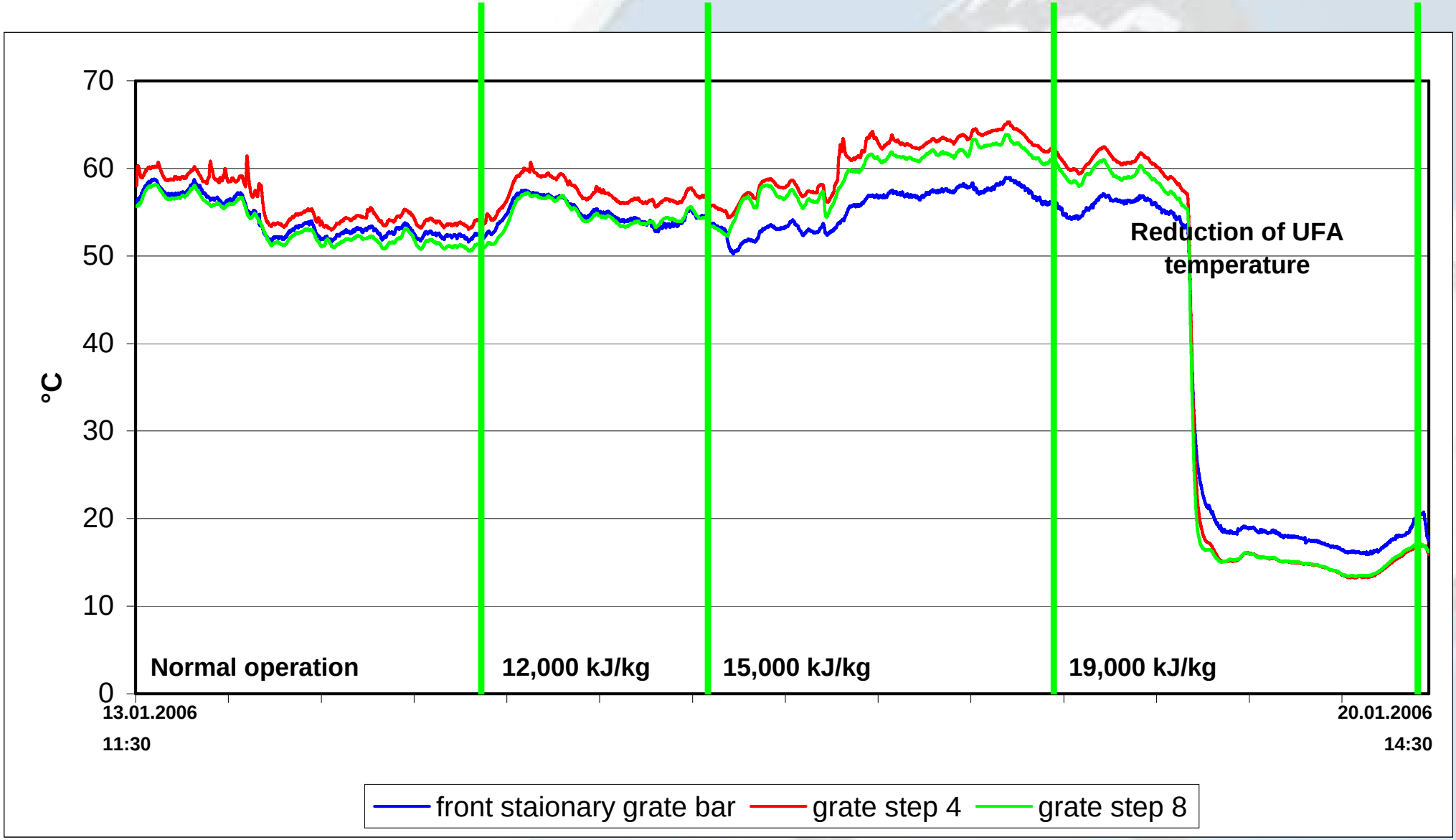
Heating value	**12,000 kJ/kg**	**15,000 kJ/kg**	**19,000 kJ/kg**
Heating value range	**12 - 14 MJ/kg**	**15 - 17 MJ/kg**	**18 - 20 MJ/kg**
Moisture	**12 - 16 %**	**10 - 18 %**	**7 - 13 %**
Ash (dry)	**28 - 34 %**	**15 - 22 %**	**14 - 20 %**
Chlorine	**0.4 - 1.0 %**	**0.6 - 1.2 %**	**0.8 - 1.3 %**
Sulphur	**0.1 - 0.3 %**	**0.1 - 0.4 %**	**0.2 - 0.4 %**
Waste throughput	**158 t**	**200 t**	**138 t**

Fuel properties



Test results

Test results (grate bar temperature)



Conclusions from St. Gallen tests - for existing MARTIN WtE plants -

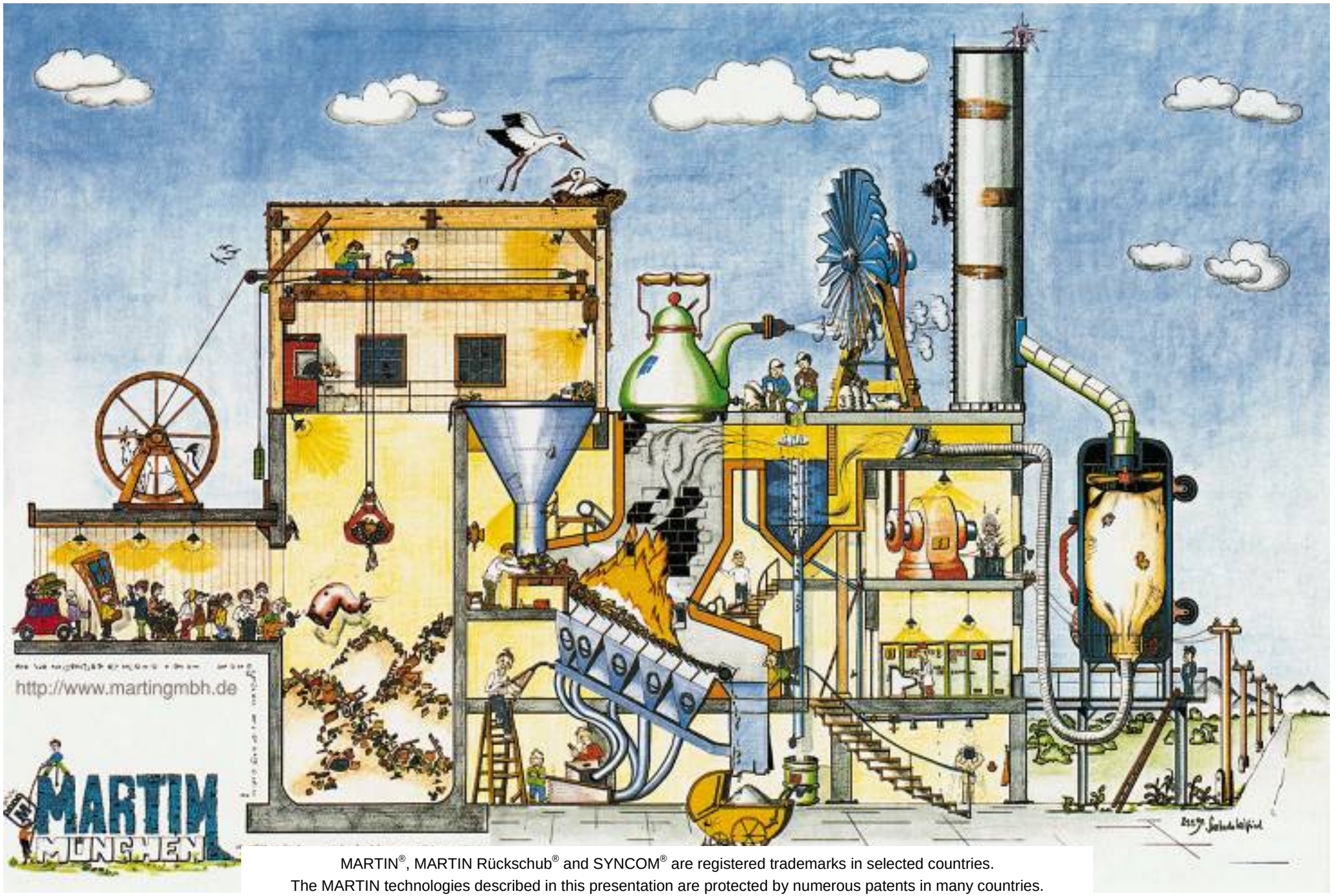
- **Co-combustion of high-calorific fractions is already reality in several WtE plants**
- **Combustion of high calorific monofractions on existing MARTIN reverse-acting grates is possible, some characteristics have to be checked and possibly adjusted:**
  - **Secondary air system**
  - **Construction of feeding area**

Additional components/assemblies for the handling of this fuel are NOT necessary !!!

6. Summary

- **Waste-to-Energy has a long history**
- **Continuous development has taken place**
- **Modern Waste-to-Energy plants are safe and reliable to operate, have high availability and pose no harm to the environment**
- **Waste-to-Energy is ‘the’ choice in Europe to treat residual MSW**
- **Focus is on high efficiency of the energy recovered and on recyclable residues**

- **Martin is the leading supplier of the core technology**
- **Martin has strong development activities in order to meet future challenges**



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The MARTIN technologies described in this presentation are protected by numerous patents in many countries.

Mainz, Germany

ASM Brescia, Italy

Amsterdam, Netherlands

Technical features of the of the new grate type „VARIO“

Grate

- **Design with inclination of 24°-26°**
- **Clinker weir for all grate sizes**
- **Pre-assembled design**

VARIO Grate

Technical features of the of the new grate type „VARIO“

Feeder:

- **Smaller feeder access opening between front wall header and feeder**
- **Increased height of the feed ram**
- **Adaptation of the stroke frequency to the higher calorific value**
- **Slightly inclined feed table with low feed edge**

Grate:

- **Three individual drives for grate movement**

Air supply:

- **Possibility of "staging" the UFA temperature**
  i.e. zone 1, 4 and 5 without preheating
  zone 2 and 3 individually preheated