INNOVATION AND COMPETENCE

IN WtE DESIGN and CONSTRUCTION

INDEX

TERMOMECCANICA GROUP

KEY NUMBERS

Turnover 2017: **215 M€**

EBIT 2017: **7 M€**

STAFF 2017: **Head Office 357 units**
O&M 316 units

Certifications:

LLOYD'S REGISTER QUALITY ASSURANCE
ISO9001 • ISO14001
OHSAS 18001

TM.E. – THE COMPANY

THE ACTIVITIES

TM.E. S.p.A. is the Company, certified by UNI EN ISO/9001/2000, ISO/14001/2004, OHSAS 18001 and SA 8000 standards, of the Termomeccanica Group, specialized in the design, construction and management of environmental and industrial engineering works, developing its activities as follows:

Energy & Waste

- Waste to energy plants
- Biogas energy recovery plants
- Waste sorting plants
- RDF and compost production plants
- Energy from biomass

Renewable Energies

- Wind farms

Water Treatment

- Drinking water production plants
- Desalination plants
- Remineralization plants
- ION Exchange Water Treatment Plants (Demineralization and condensate treatment processes)
- Industrial waste water treatment plants
- Municipal waste water treatment plants

Sludge treatment

- Dewatering
- Drying
- Combustion
- Inertization
- Solidification

TM.E. – ENERGY & WASTE DIVISION

TM.E. S.p.A. has proprietary technologies for grate stoker, rotary kiln and fluidized bed for waste incineration and can use dry, semi dry and wet flue gas cleaning systems, all resulting in a highly efficient treatment process. TME is also a licensee of Kawasaki Heavy Industries for the construction of large capacity Waste to Energy grate plants.

Combustion
Moving stoker Grate (Air and/or water cooled)
Rotary kiln
Fluidised bed

Flue gas cleaning systems
Dry systems (lime, sodium bicarbonate)
Semi dry/wet systems (lime)
Wet systems (sodium hydroxide)

TM.E. – ENERGY & WASTE DIVISION - Main References

WASTE TO ENERGY PLANT
Gdansk (Poland)

- Customer: ZUT
- Throughput: 160.000 tonnes/year
- Plant Type: 1 line, moving grate
- Energy Recovery: 15 Mwe
  40 MWth
- Flue Gas Treatment: Semi Dry and Wet
  + SNCR

Note: CONTRACT IN PROGRESS

TM.E. – ENERGY & WASTE DIVISION - Main References

WASTE TO ENERGY PLANT
Beringen (Belgium)

- Customer: Bionerga
- Throughput: 200.000 tonnes/year
- Plant Type: 1 line, moving grate
- Energy Recovery:
  - 24 Mwe
- Flue Gas Treatment: Dry + SCR

Note: CONTRACT IN PROGRESS

TM.E. – ENERGY & WASTE DIVISION - Main References

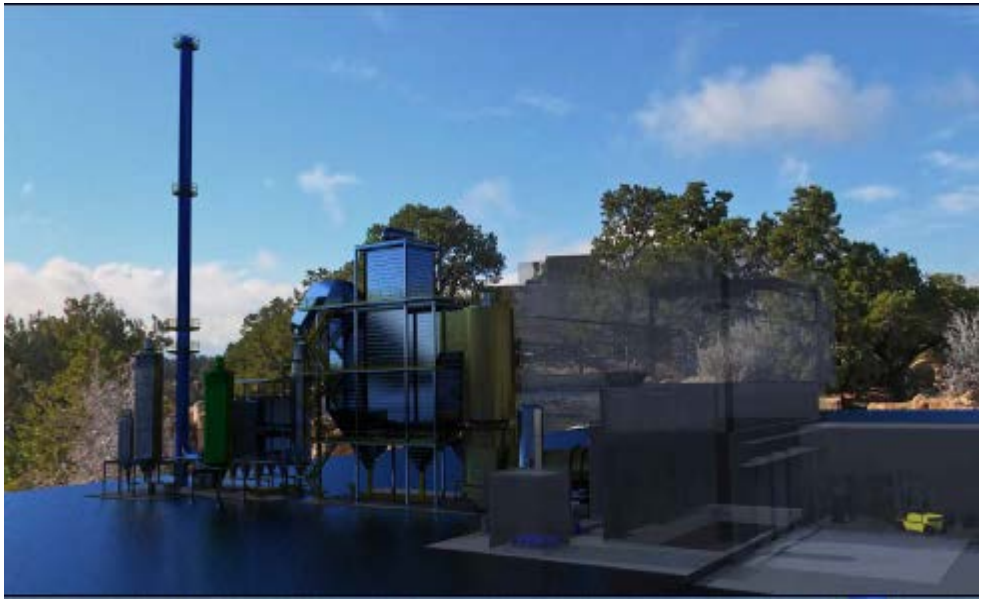
COMPLETION OF THE WASTE TO ENERGY PLANT Szczecin (POLAND)

- Customer: ZUO - Szczecin
- Throughput: 150.000 tonnes/year
- Plant Type: 2 lines, moving grate
- Energy Recovery:
  - 13 Mwe
- Flue Gas Treatment: semi Dry

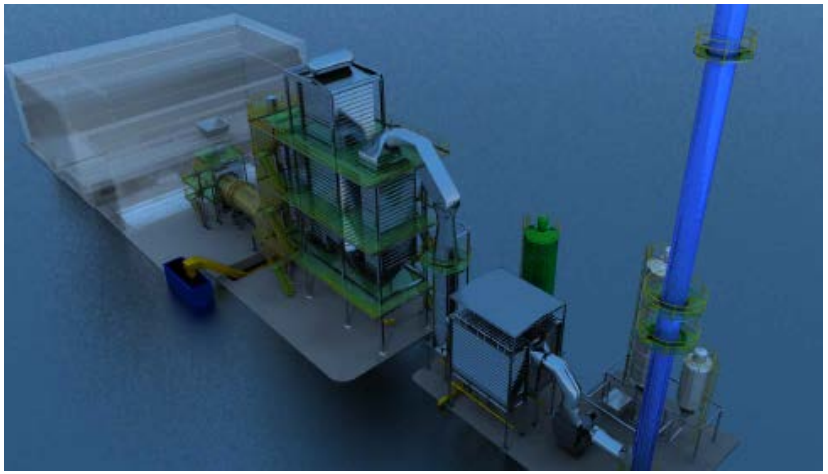
Note: CONTRACT IN PROGRESS

TM.E. – ENERGY & WASTE DIVISION - Main References

Rotary Kiln Incinerator for Takreer Refinery (Abu Dhabi)



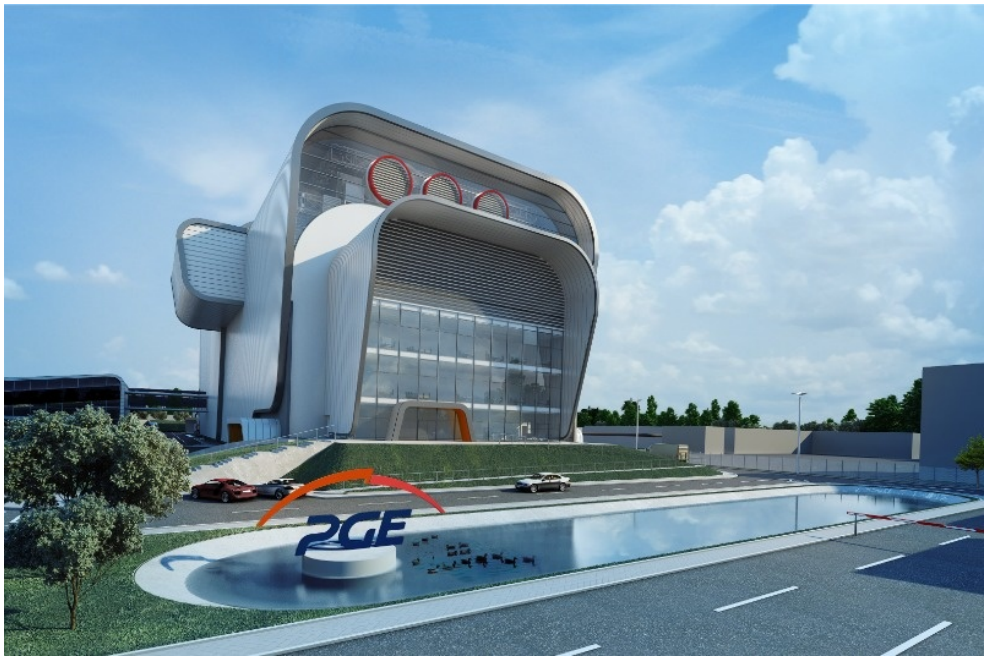
- Customer: Intecsa Industrial (Spain) for Takreer Refinery (Abu Dhabi)
- Throughput: 24.000 tonnes/year
- Plant Type: 1 line, rotary kiln
- Energy Recovery: 37 MWth
- Flue Gas Treatment: Dry



Note: CONTRACT IN PROGRESS

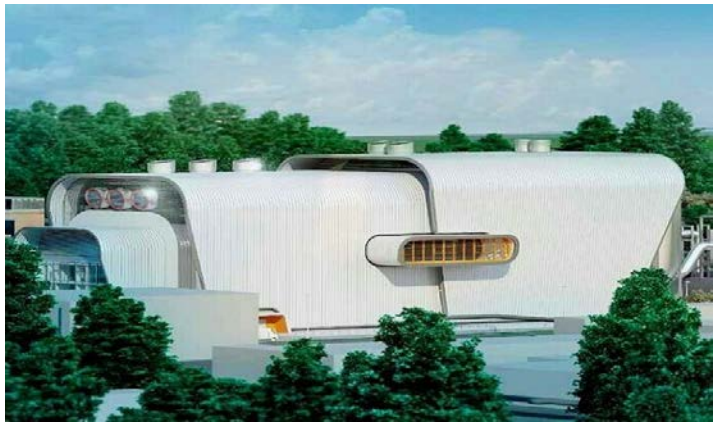
TM.E. – ENERGY & WASTE DIVISION - Main References

WASTE TO ENERGY PLANT RZESZÒW (POLAND)



- Customer: PGE
- Throughput: 100.000 tonnes/year
- Plant Type: 1 lines, moving grate
- Energy Recovery:
  - 8 Mwe
  - 17 MWth
- Flue Gas Treatment: semi Dry

Note: CONTRACT IN PROGRESS



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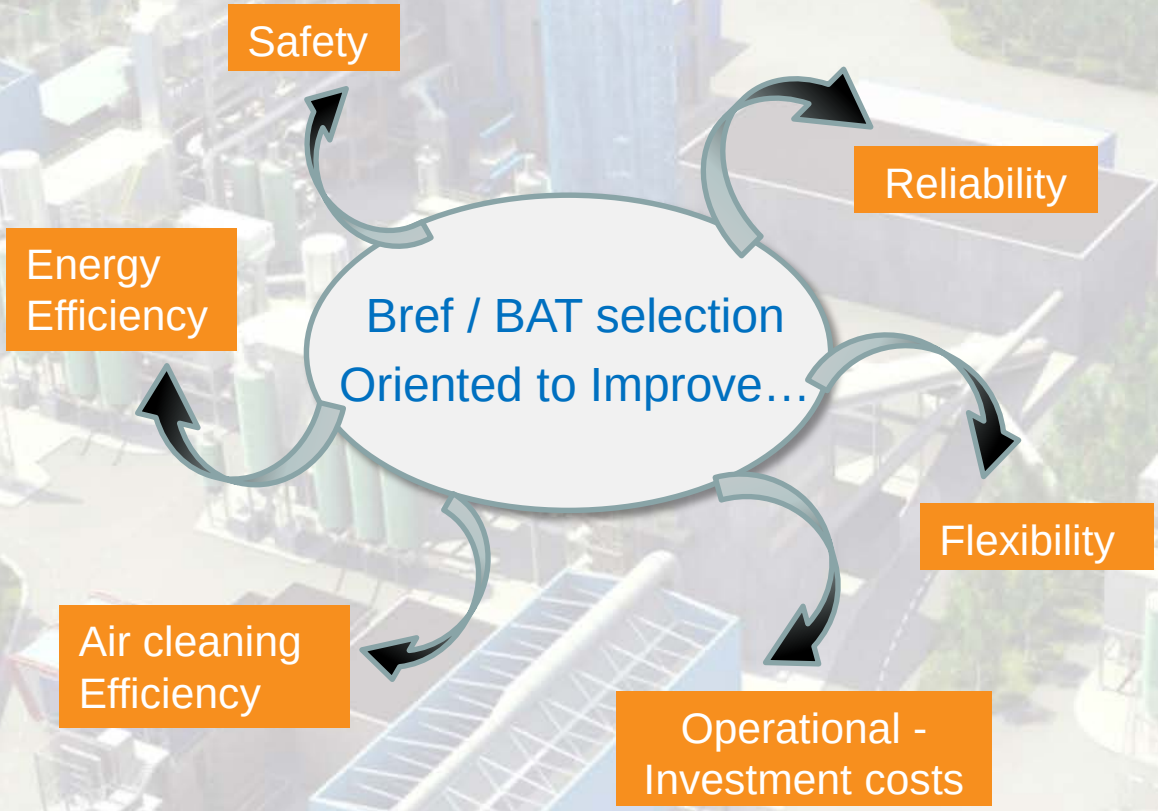
TM.E. philosophy

Key success factors for BAT selection



TM.E member of:

ESWET

European Suppliers of Waste to Energy Technology Association

TM.E philosophy

TM.E innovative approach for WtE design

- **CFD technique for improvement of**
  - **Combustion technology**
  - **Flue gas treatment technology**
  - **Energy Recovery technology**
- **Thermoflow technique for improvement of**

In order to define the maximum efficiency operating condition

- **Advanced Automatic System Controls for**
  - **Combustion (ACC) (patent)**
  - **FGT (patent)**
  - **Energy Recovery**

In order to operate in the maximum efficiency point

TM.E philosophy

TM.E. bases the design upon the parameters requested by the Client and own experiences:

1. Furnace technology:

   Air / Water cooled grate, cooperation by

TM.E. S.p.A. - Termomeccanica Ecologia
Gruppo Termomeccanica

REVI TEC
FEUERUNGSBAU AG

2. Boiler technology:

   Vertical / Horizontal tail, cooperation by

TM.E. S.p.A. - Termomeccanica Ecologia
Gruppo Termomeccanica

WEHRLE WERK AG
1860

3. Flue gas treatment technology:

   SCR / SNCR + Semi-Dry / Dry / Wet combination system

TM.E. S.p.A. - Termomeccanica Ecologia
Gruppo Termomeccanica

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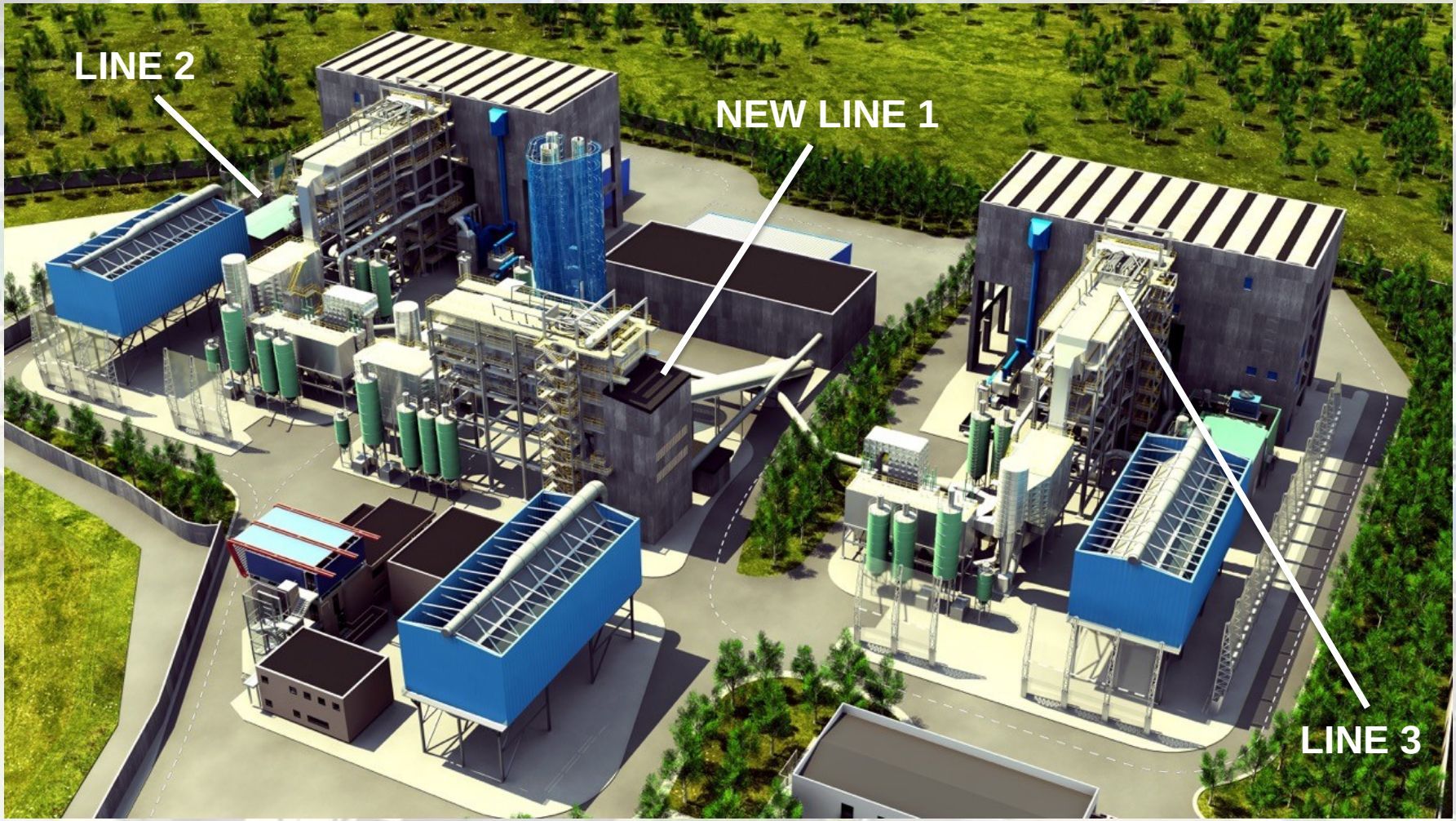
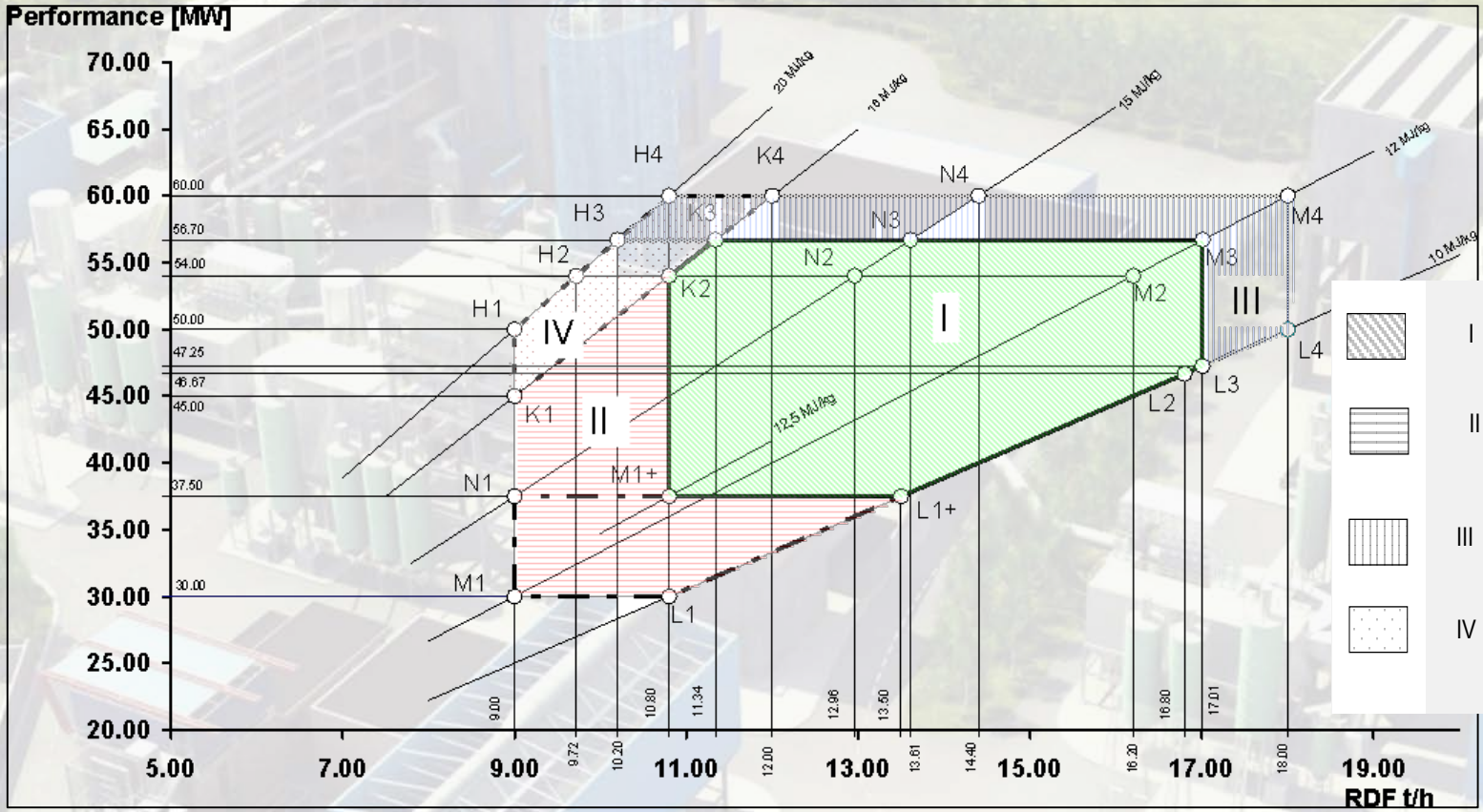
- Furnace
- Boiler
- Flue Gas Treatment
- Thermal Cycle
- 3D video of San Vittore Plant

TME – Incineration plant of San Vittore del Lazio



Design Furnace Data

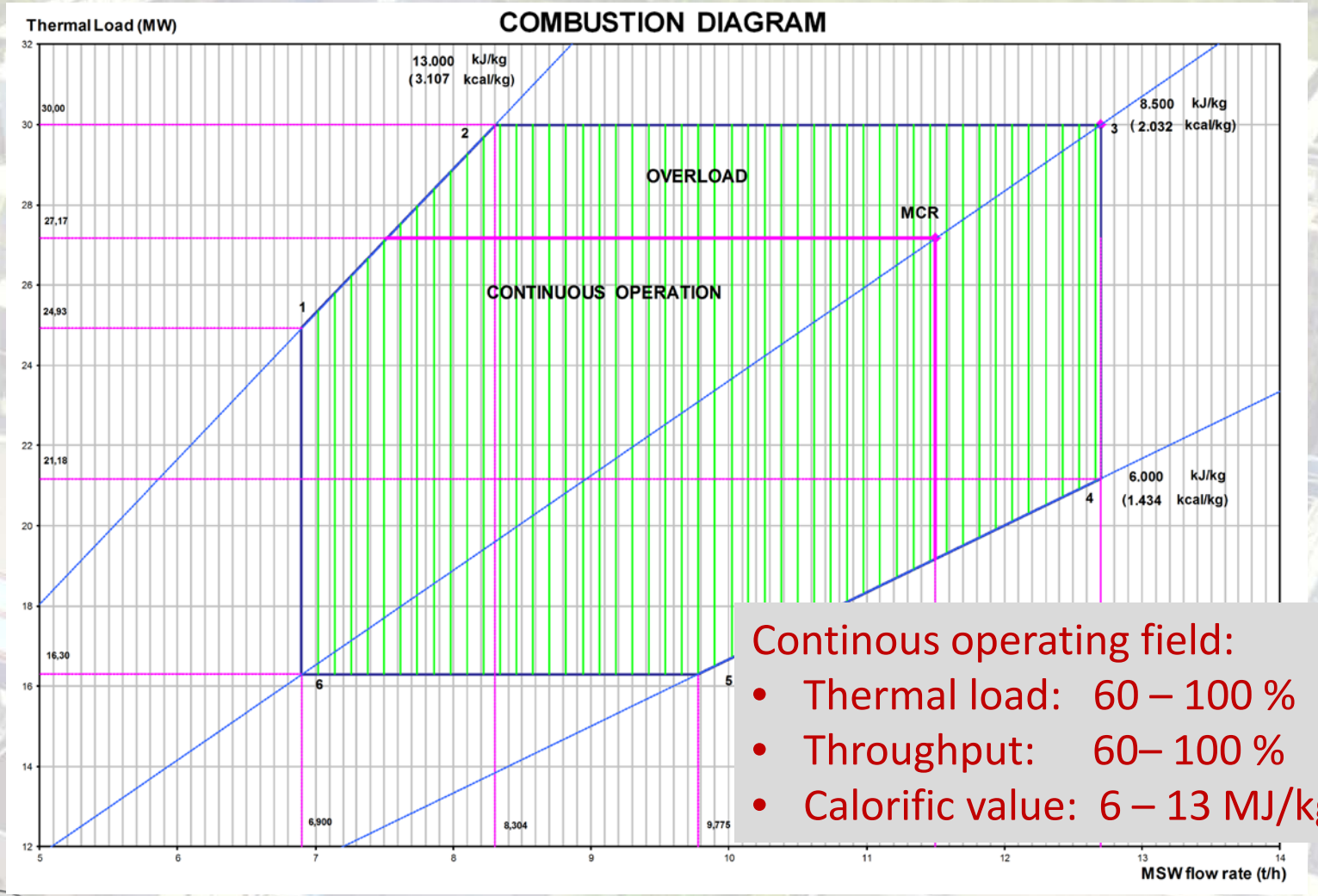
Typical CD RDF waste: San Vittore Project



Continous operating field:

- Thermal load: 52 – 100 %
- Throughput: 53 – 100 %
- Calorific value: 10 – 20 MJ/kg

Bydgoszcz Project: MSW waste



Continous operating field:

- Thermal load: 60 – 100 %
- Throughput: 60– 100 %
- Calorific value: 6 – 13 MJ/kg

Design Furnace Data

Grate technology: Air-cooled / Water-cooled moving grate

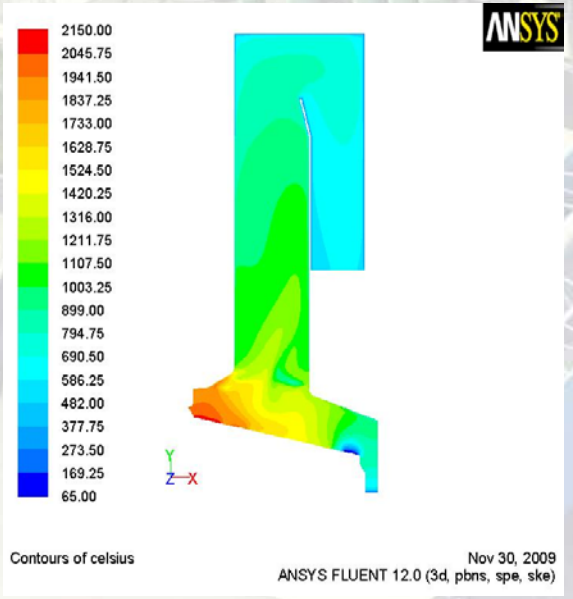
Field design of the furnace system:

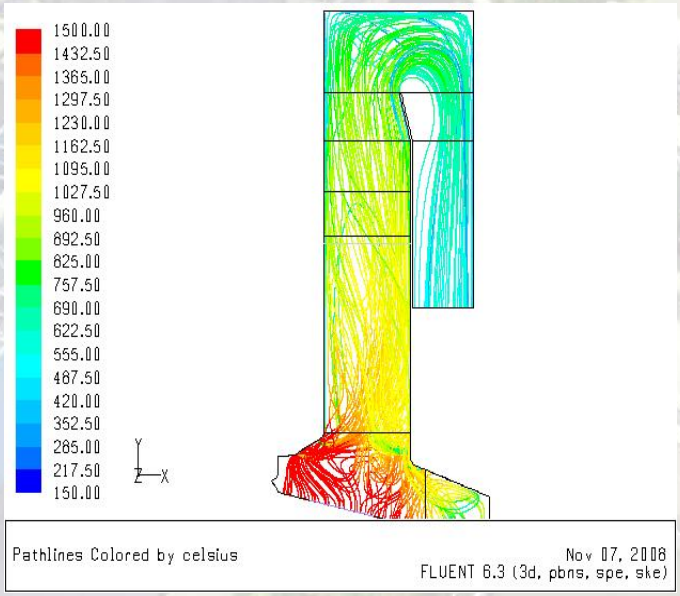
- Throughput : 2 – 35 t/h
- Thermal load: 10 – 110 MWth
- Calorific value: 6 – 20 MJ/kg
- Waste type: RDF, MSW, industrial waste, sludge, biomass, etc..
- Availability: 8.000 – 8.400 operating hours / year

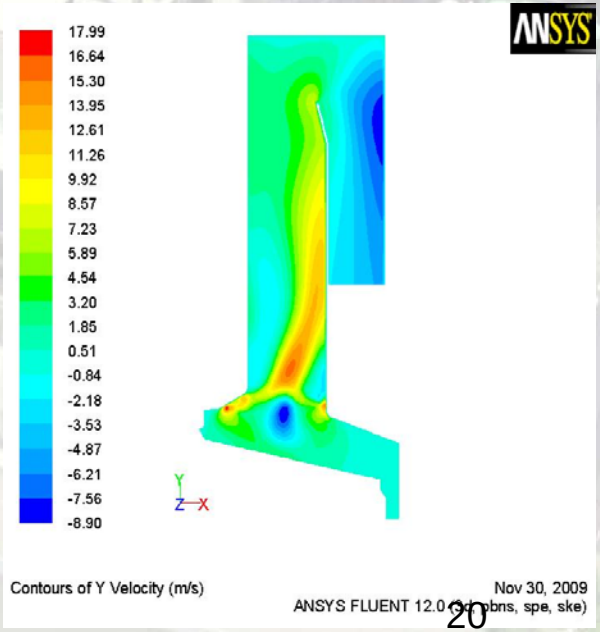
Combustion chamber advanced design

TM.E uses a CFD modeller to improve the combustion technology:

- Optimization of secondary air and flue gas recirculation injection in order to:
  - create a good turbolence in the combustion chamber
  - control the combustion temperature
  - control the oxigen distribution in the injection area





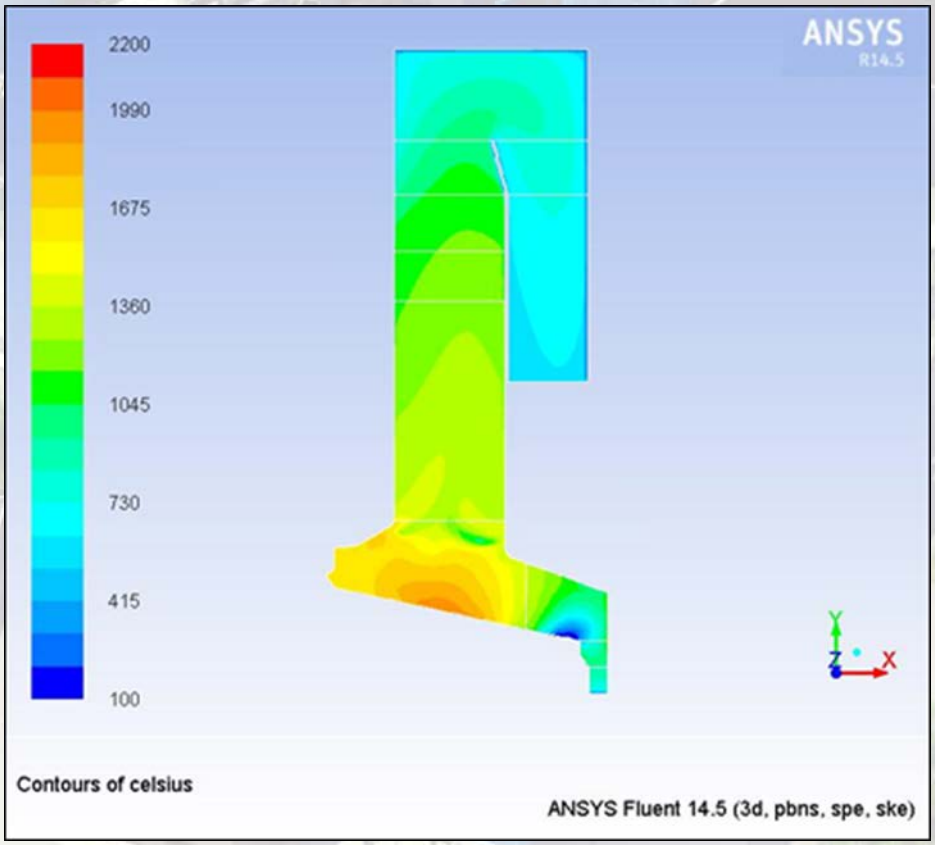


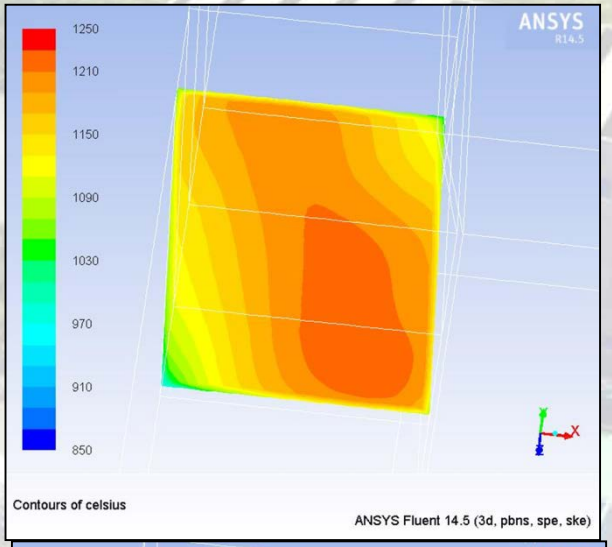
FLUENT

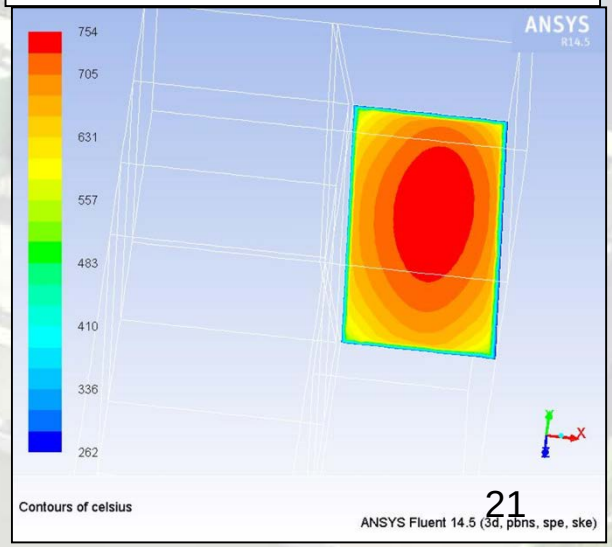
Combustion chamber advanced design

Temperature Profile:

2 Second height Level







Temperature Profile:

Second Pass

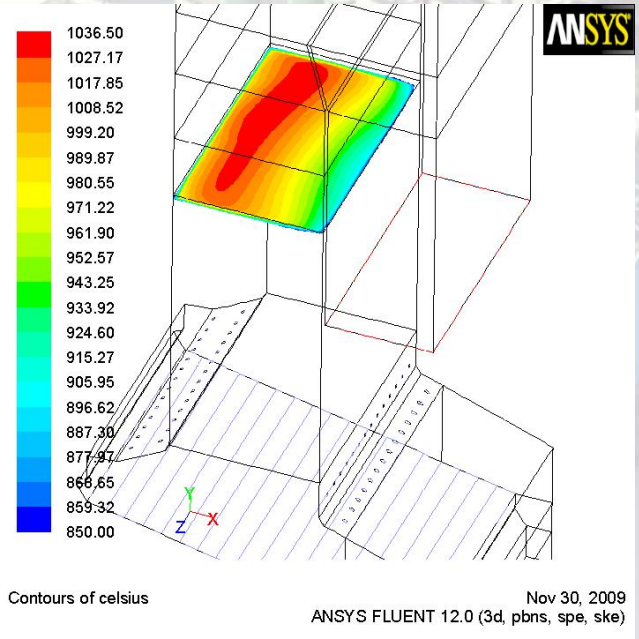
CFD Technic

Combustion chamber advanced design

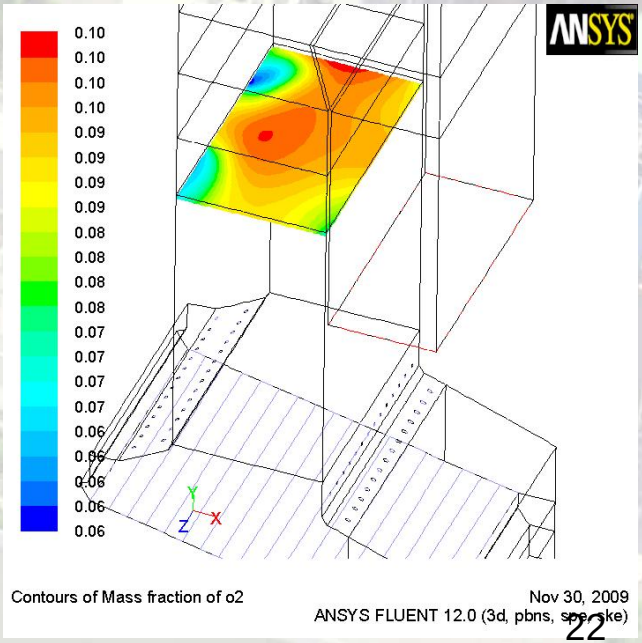
TM.E uses a CFD modeller to improve the combustion technology:

- Verification of the respect of the law in force as regards the post combustion temperature

Temperature profile and oxigen concentration in the section that correspond to minimun residence time of 2 sec after the last injection of air



FLUENT



Furnace

Water cooled grate?

Problems observed in several installation: waste with C.V. > 12 MJ/kg:

- Grate bar shorter lifetime;
- Uncontrolled gaps between grate bars and middle beams;
- Un-uniform burning over the cross section of grate;
- Sifting problems;
- Metallic deposits on grate bars;
- Combustion control/air distribution poor;
- High wearing/sintering for refractory;
- Un-uniform gas streams in boiler;
- High dust formation;
- CO-peaks, NO-peaks;

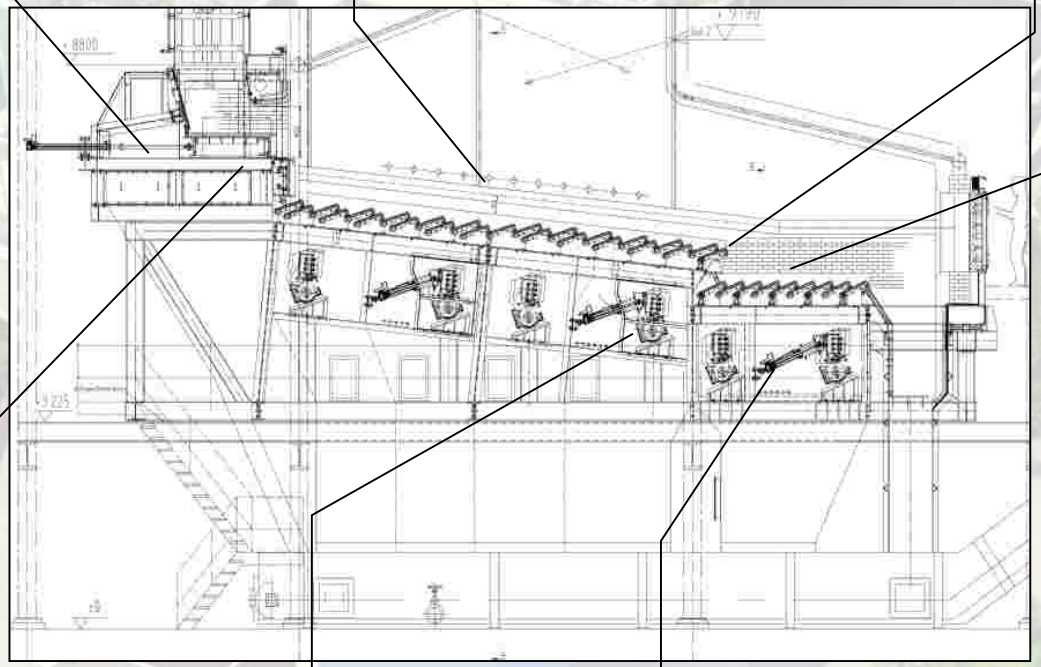
Furnace

feeding system with external drives and bearings

watercooled grate bars for main grate

watercooled chute between main & bournout grate

air cooled burnout grate



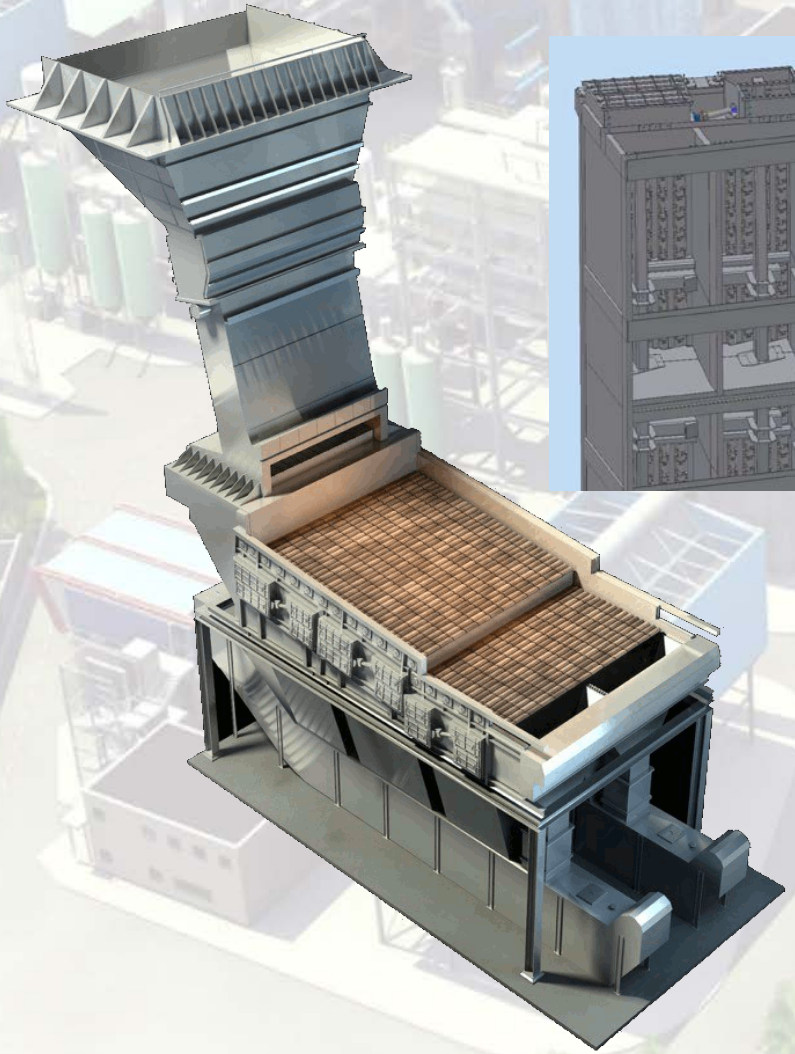
feeding system with watercooled chute

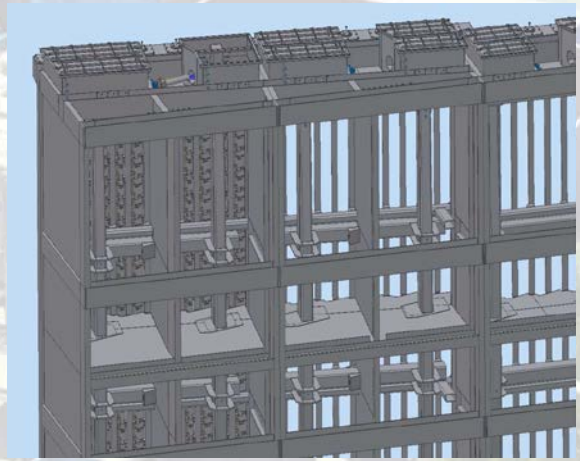
grate carriage with external bearings

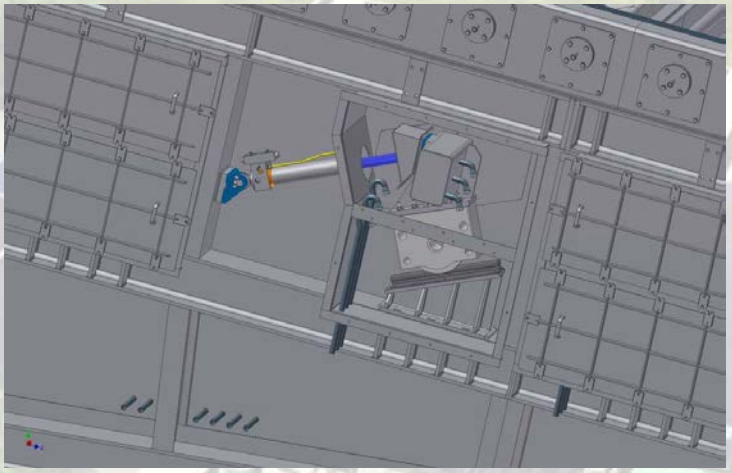
External drives with synchronous travel

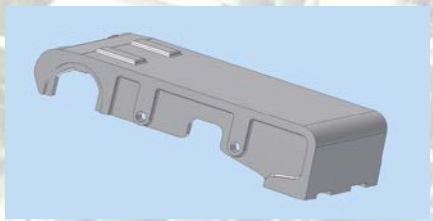
The Revi Tec grate main characteristics (based upon Noell technology)

Furnace









- **One-track design**
- **Slope zone: 6° (1 & 2) – 0° (3)**

Furnace

Main assets of Revi-Tec water cooled grate

- Low inclination of the grate: better control of waste distribution
- Low thickness of the waste: better quality of the combustion
- Shape of grate bar: better wear resistance and self cleaning
- No middle beams internal in the grate: no wear internal zones
- No gaps: better control of waste distribution, minimization of “low-melting metals”, better wear resistance of the grate bars
- Water cooling circuit: uniform cooling of the grate bars surface, no steam formation and no water leakage
- No water fittings positioned underneath: no problems for “low-melting metals” deposits, maintenance during operation

Furnace

Key success factors of the Revi-Tec technology

Major advantages for Revi Tec technology using a water cooled grate system can be seen in the following parts:

- grate bar elements
- water cooling system
- 1-track design of grate
- drive system outside of grate
- grate side expansion system

As a result, the following economic advantages can be mentioned:

- high availability and reliability of the grate system
- low maintenance/repair/service costs
- excellent combustion control and energy distribution
- low emission values, high bottom ash quality

OPERATION AND PERFORMANCE - MAINTENANCE

Thermal load: 58 MWth
Grate dimension: 6,9 m x 9,6 m
Calorific value: about 15 MJ/kg

San Vittore WtE Plant L2&L3

no replacements in 4 years

no failure tax of the furnace vs operational hours of plant

tickness wear 15%

Grate bars life time: over 6 years

acea ambiente

Furnace

Automatic Combustion Control (ACC)

An automatic combustion control (ACC) have been developed and patented since 2004. Design merged from several plant installed.

Patented Closed-loop - ACC

Commissioning, Set up and optimization of the ACC
by
SAR – TM.E team

Furnace design - Performance of ACC

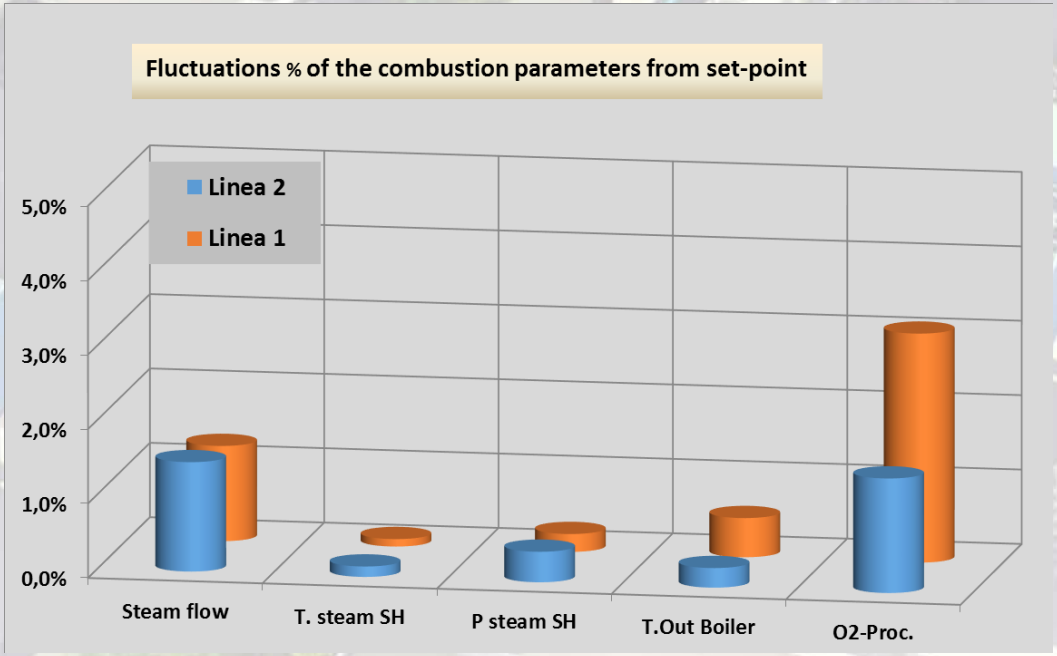
ACC system results in Europe WtE plant (average daily values):

- Average CO level Emission : < 10 (mg/Nm3, 11%O2 drygas)
- Fluctuations of Steam flow from set-point required: < 2%
- Unburned in the slag (%C): 1 %

TM.E Patent

Tested with different mix of waste:

- MSW
- RDF
- Biomass
- Sludge
- Sanitary



Improvement of the Environmental performance

Environmental performance achieved:

Performance test	San Vittore del Lazio	Bydgoszcz
Thermal Capacity (MWth)	58 MWth	27,2 MWth
Fluctuation from Steam Set-point	< 1%	< 1,5%
Daily average value CO - Stack (mg/Nm3, dry gas 11%O2)	< 5	< 15
Unburned (TOC) in the slag (%)	< 1%	0,2%

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- Flue Gas Treatment
- Heat Recovery System
- 3D video of San Vittore Plant

Boiler

Key success factors

Several experiences in WtE plant for TM.E and Wehrle Werk in order to minimize pollution, erosion and corrosion problems .

Best Technologies / Techniques used:

- **Geometry / configuration of the steam boiler:**
  - Boiler completely integrated in the combustion chamber;
  - CFD analysis in the first / second pass;
  - Boiler type: n° 2/ 3 vertical radiation empty passes and vertical / horizontal pass for installation of convective bundles

Basic Design with WEHRLE WERK AG

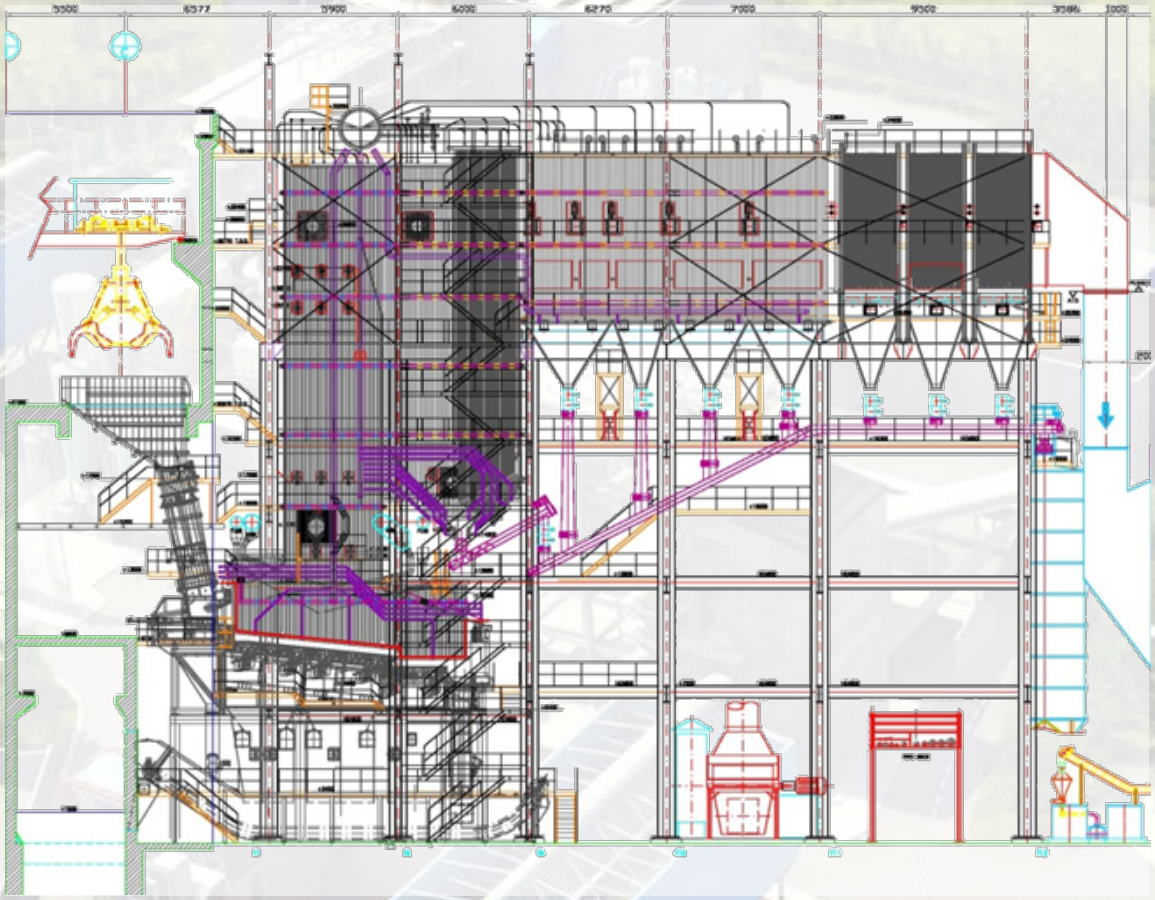
Boiler

Key success factors

- **Criteria design of the boiler:**
- Superheated Steam pressure: 40 – 48 bar
- Superheated Steam temperature: 380 - 440°C
- Gas velocity in the convective part: < 5 m/s
- Flue gas temperature at the exit of first channel: about 900°C
- Flue gas temperature at the inlet of first superheater: about 650 °C
- Flue gas temperature at the exit of the boiler: 180–200 °C

Basic Design with

Horizontal Steam Boiler: Arrangement

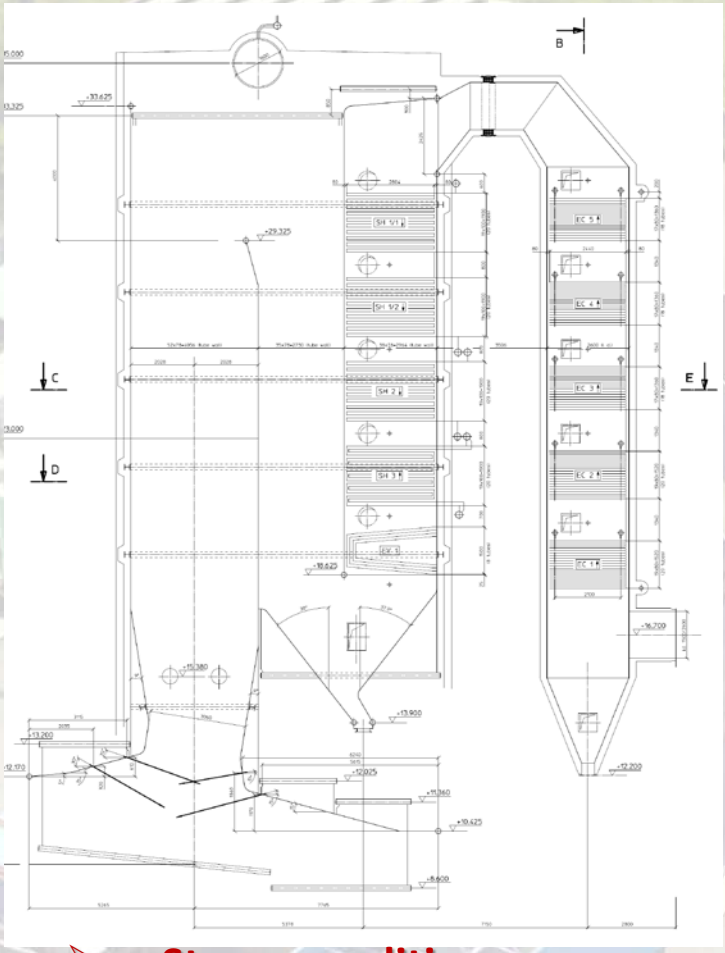


San Vittore WtE Plant

- **No. 3 vertical radiant evaporative flue gas passes**
- **No 1 horizontal convective section:**
  - **No. 1 evaporative bundles**
  - **No. 4 superheater bundles**
  - **No. 3 Economizer bundles**
- **Cleaning system:**
  - **Hammer technology**

- **Steam conditions :** **T = 420 °C P = 44 bar abs**
- **Membrane walls / SH material:** **ASTM A210 A1 / ASTM A335 T11**
- **Cladding: top of 1st empty pass, 2nd empty pass and 1st SH are cladded with Inconel 625 – 2 mm**

Vertical Steam Boiler: Arrangement



Bydgoszcz WtE Plant

- **No. 2 vertical radiant evaporative flue gas passes**
- **No 1 vertical convective section in 3° pass:**
  - **No. 1 evaporative bundles**
  - **No. 3 superheater bundles**
  - **No. 5 Economizer bundles**
- **Cleaning system:**
  - **Soot-blowing technology**

- **Steam conditions :** **T = 420 °C P = 45 bar abs**
- **Membrane walls / SH material:** **ASTM A210 A1 / ASTM A335 T11**
- **Cladding: top of 1st empty pass, 2nd empty pass and 1st SH are cladded with Inconel 625 – 2 mm**

Boiler

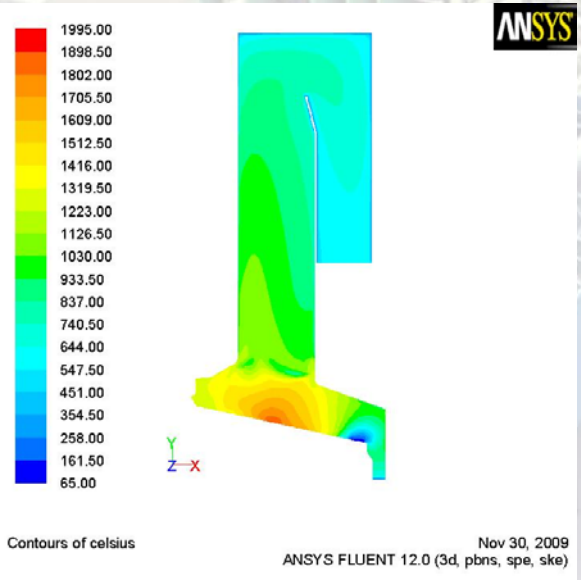
Refractory advanced design

TM.E uses a CFD modeller to improve the combustion technology:

- Choise of the best technology as regards the refractory lining of the furnace in order to assure the right heat exchange

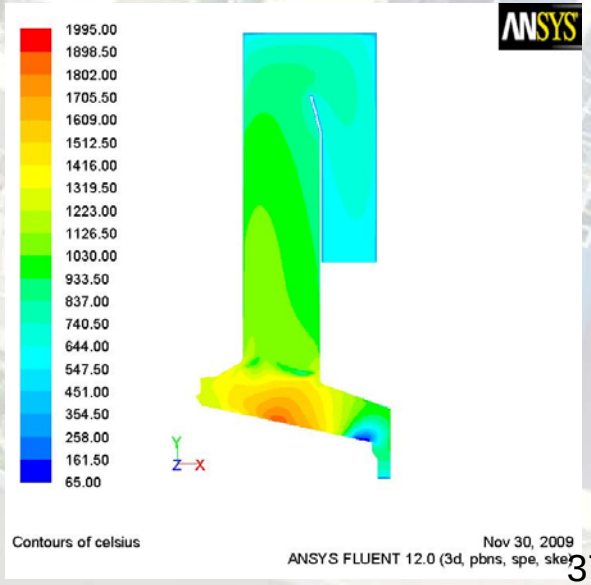
Combustion chamber lined with SiC tiles

Post-combustion chamber lined with SiC tiles (considering the fouling of combustion chamber)



Combustion chamber lined with SiC tiles

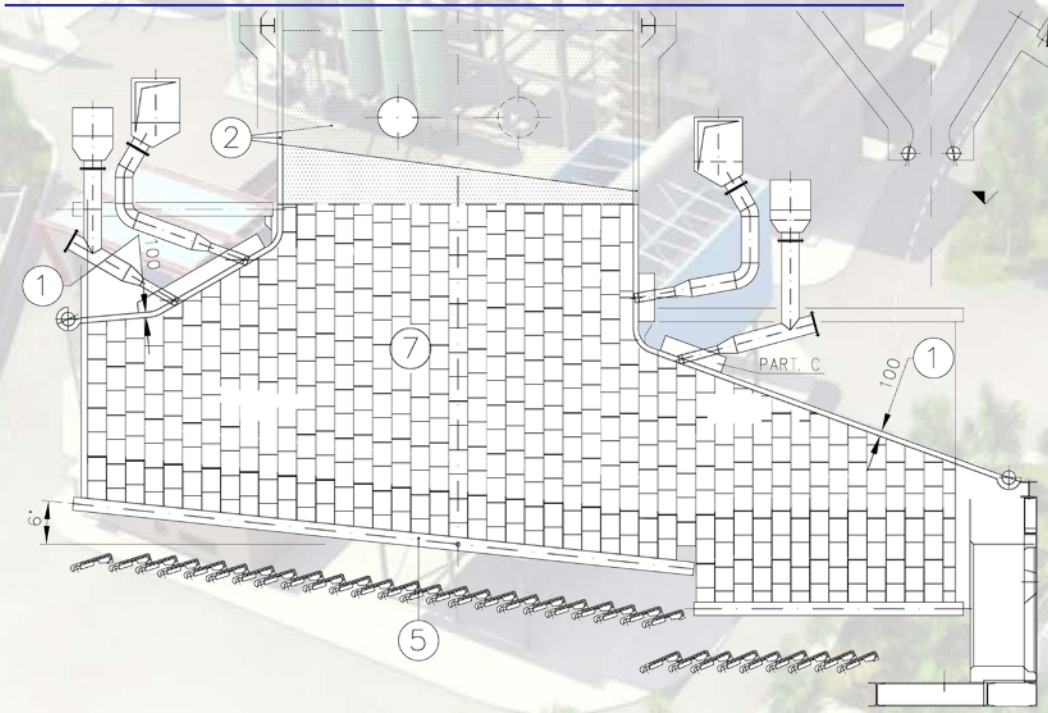
Post-combustion chamber lined with SiC castable (considering the fouling of combustion chamber)

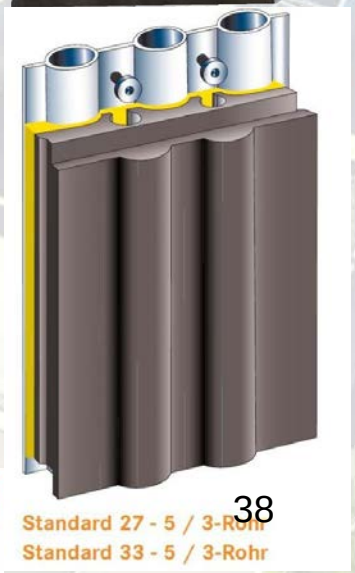


Boiler

Refractory System

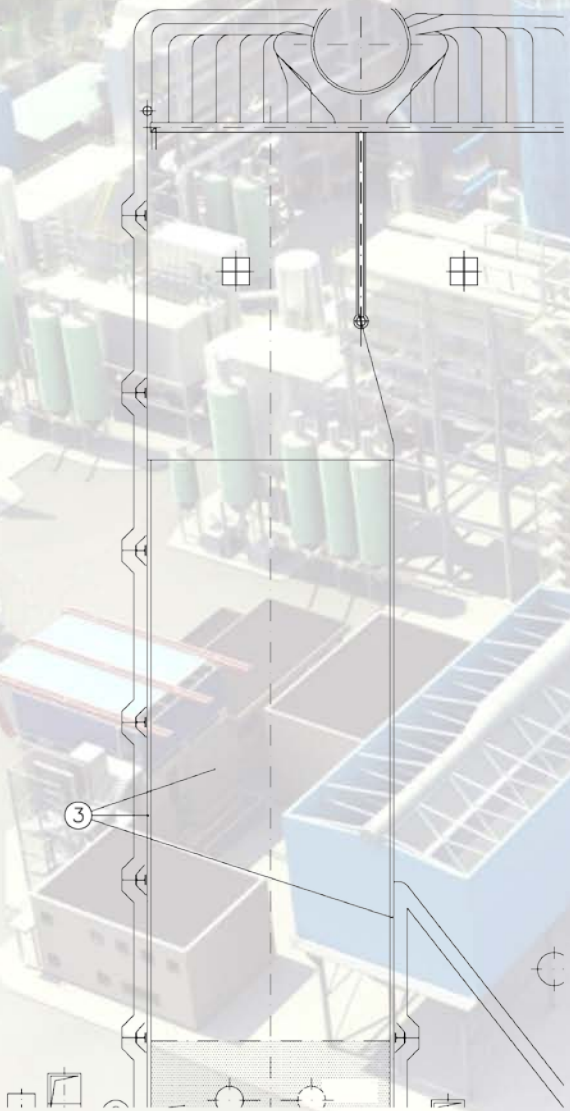
SIC	Position	Thickness
SIC Castable	1	100 mm
SIC Castable	2	65 mm
SIC Monolitic	5	50 mm
SIC Tiles	7	





Boiler

Refractory System

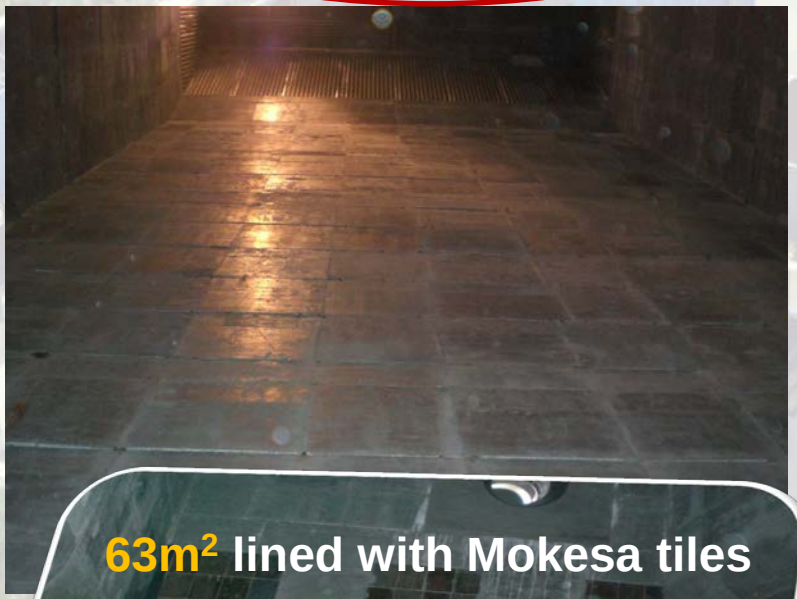


SIC	Position	Thickness
SIC Castable	3	65 mm

Self-flowing low cement materials
Pannel 500 x 500 mm

Refractory Performance

San Vittore WtE Plant

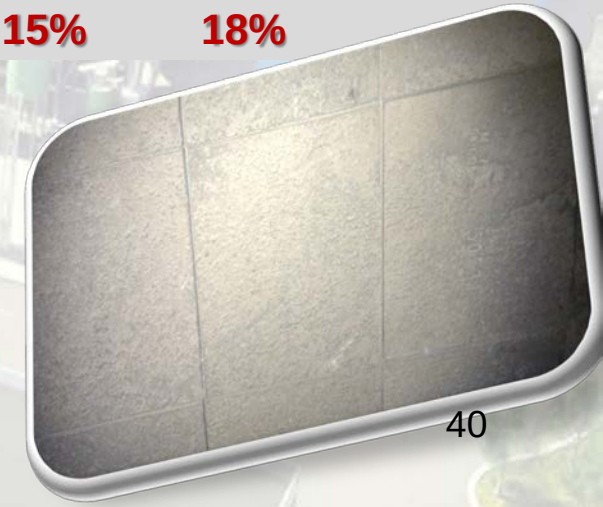


63m² lined with Mokesa tiles

NO INTERVENTIONS in first 4 years

TOTAL SURFACE LINED: 480 m²
COMBUSTION CHAMBER: 184 m²
AFTER BURNING CHAMBER: 290 m²

YEAR	LINE 2	LINE 3
2011	/	/
2012	26 m²	8 m²
2013	8 m²	30 m²
2014	17 m²	30 m²
2015	22 m²	18 m²
TOTAL m²	73 m²	86 m²
% REPAIR / 5 YEARS	15%	18%



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- 3D video of San Vittore Plant

Flue gas treatment

References in WtE Plant with Grate Technology

WtE Plant	Air Pollution Cleaning (APC) Technology	Reagents
Casic Cagliari N°1 line	DeNOx SNCR Semi-Dry + Wet method	Urea Solution Hydrated Lime Activated Carbon Soda Solution
Granarolo Bologna N°2 lines	DeNOx SCR Semi-Dry + Wet method	Ammonia Solution Hydrated Lime Activated Carbon Soda Solution
Valmadrera Lecco N°2 lines	DeNOx SNCR + SCR Dry + Wet method	Ammonia Solution Sodium Bicarbonate Activated Carbon Soda Solution Adiox packing
San Vittore del Lazio N°3 lines	DeNOx SCR Dry method	Ammonia Solution Sodium Bicarbonate Activated Carbon
Bydgoszcz N°2 lines	DeNOx SNCR Semi-Dry + Wet method	Ammonia Solution High reactivity hydtrated lime Activated Carbon Soda Solution
Terceira Azores Island N°1 line	DeNOx SNCR Dry method	Urea Solution Sodium Bicarbonate Activated Carbon

Air emission FGT performance

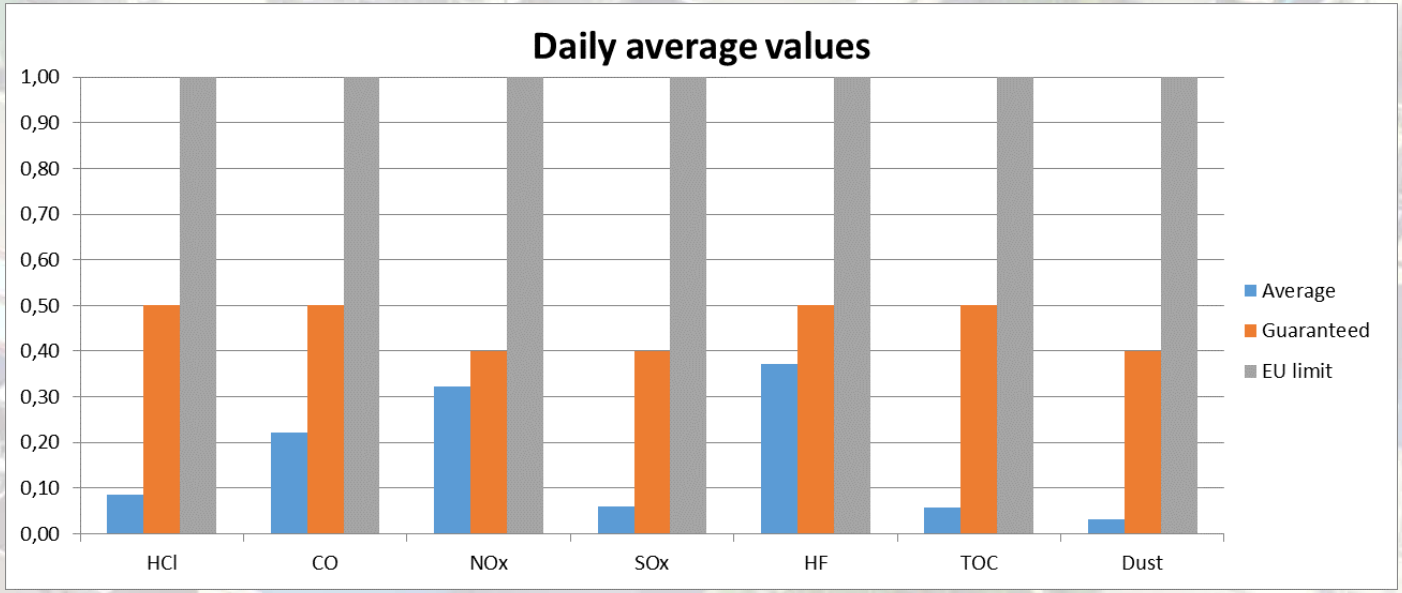
Pollutant (Concentration referred to dry gas, O_2 11% vol.)	**Law values - daily average**	**Lecco** Measured values (daily average)	**Bologna** Measured values (daily average)	**San Vittore** Measured values (daily average)
		Bicar Dry + wet FGT	**Lime Semi-dry + wet FGT**	**Bicar Dry FGT**
HCl	10 mg/Nm3	< 1 mg/Nm3	2 mg/Nm3	< 1 mg/Nm3
CO	50 mg/ Nm3	3,5 mg/ Nm3	10 mg/ Nm3	3 mg/ Nm3
$NO+NO_2$ as NO_2	200 mg/ Nm3	95 mg/ Nm3	90 mg/ Nm3	33,5 mg/ Nm3
SO_2+SO_3 as SO_2	50 mg/ Nm3	2 mg/ Nm3	5 mg/ Nm3	0,5 mg/ Nm3
HF	1 mg/ Nm3	0,1 mg/ Nm3	0,1 mg/ Nm3	0,1 mg/ Nm3
TOC	10 mg/ Nm3	0,3 mg/ Nm3	0,4 mg/ Nm3	0,3 mg/ Nm3
Dust	10 mg/ Nm3	0,2 mg/ Nm3	0,9 mg/ Nm3	0,2 mg/ Nm3
Cd + Tl	0,05 mg/ Nm3	0,001 mg/ Nm3	0,002 mg/ Nm3	0,001 mg/ Nm3
Metals	0,5 mg/ Nm3	0,03 mg/ Nm3	0,05 mg/ Nm3	0,003 mg/ Nm3
Hg	0,05 mg/ Nm3	0,005 mg/ Nm3	0,005 mg/ Nm3	0,0015 mg/ Nm3
PAH	0,01 mg/ Nm3	0,0001 mg/ Nm3	0,0003 mg/ Nm3	0,0001 mg/ Nm3
PCDD+PCDF	0,1 ng/ Nm3	0,012 ng/ Nm3	0,008 ng/ Nm3	0,023 ng/ Nm3

FGT performance: Bydgoszcz

ProNatura Polonia - 8 hours Capacity test

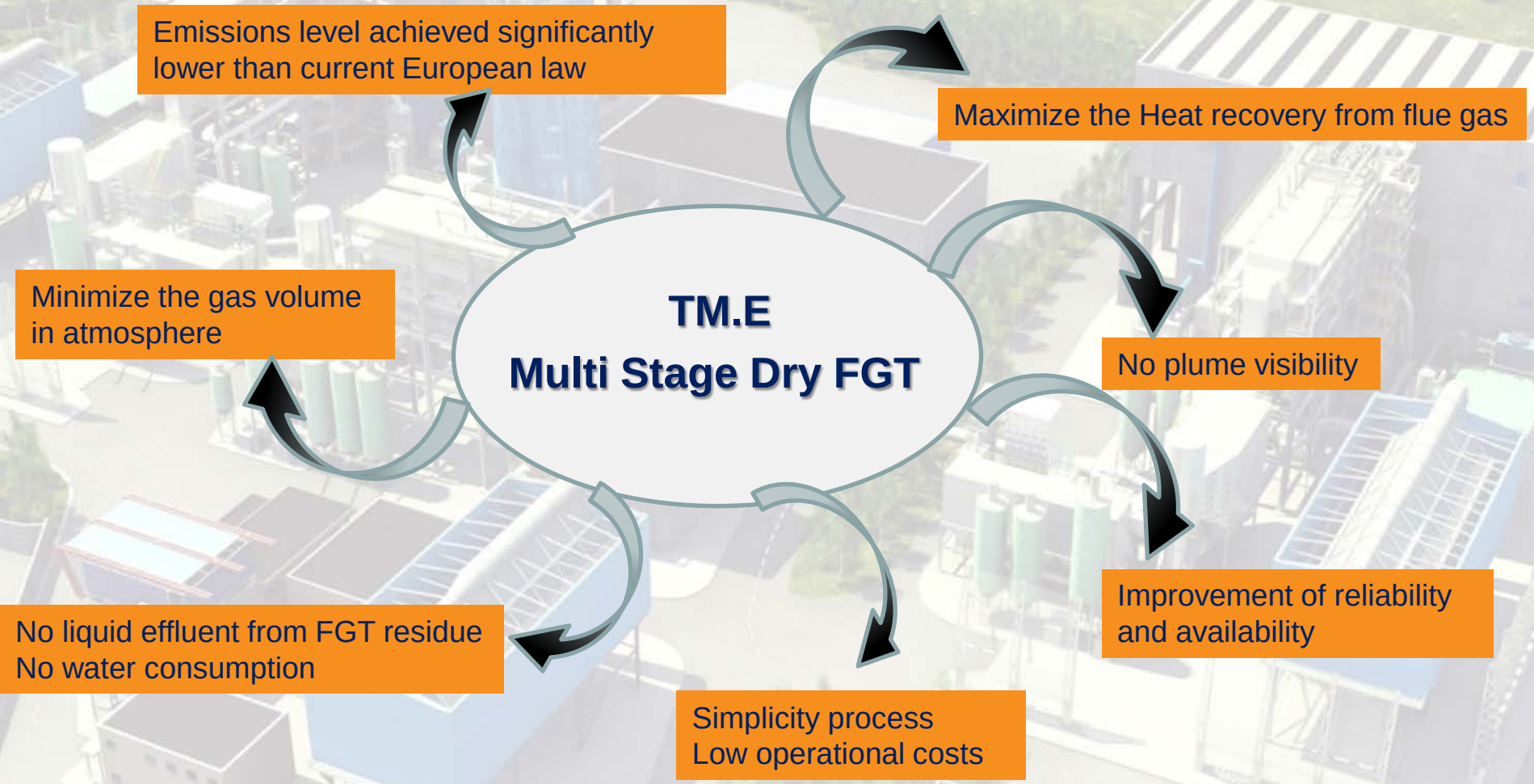
Half Hour Report - STACK

		Hydr Chloride	Carbon Monox	Nitrogen Oxides	Sulphur Dioxide	Hydr Fluoride	Total Org Carb	Dust
Date	Time	mg/Nm3	mg/Nm3	mg/Nm3	mg/Nm3	mg/Nm3	mg/Nm3	mg/Nm3
Daily average	IED 2010/75 EU	10,0	50,0	200,0	50,0	1,0	10,0	10,0
Daily average	Guaranteed values	5,0	25,0	80,0	20,0	0,5	5,0	4,0
average		0,87	11,08	64,48	2,98	0,37	0,57	0,33



Flue gas treatment

TM.E PHILOSOPHY



Advanced Automation & Control (TM.E patent)

Gas Acid Neutralization: Philosophy of Multi Reagents Control

Depurcal Mg

Sodium Bicarbonate

Soda

1st reagent

2nd reagent

3rd reagent

Furnace/Boiler DeNOx SNCR

Dry FGT Reactor Bag filter

DeNOx SCR Low Temp Shell Catalyst

Wet FGT Scrubber Adiox packing

Fiow rate
HCl
SOx
HF (optional)

Fiow rate
HCl
SOx
HF (optional)

Fiow rate
HCl
SOx
HF (optional)

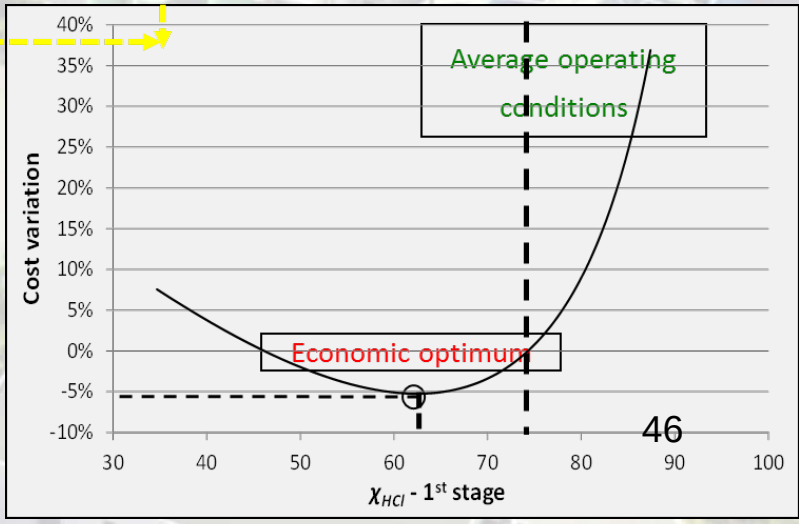
MASTER CONTROLLER

TM.E Patent

REAGENTS:

- **EFFICIENCY (%)**
- **COST (€/t)**
- **RESIDUES IMPACT (€/t)**

Goal



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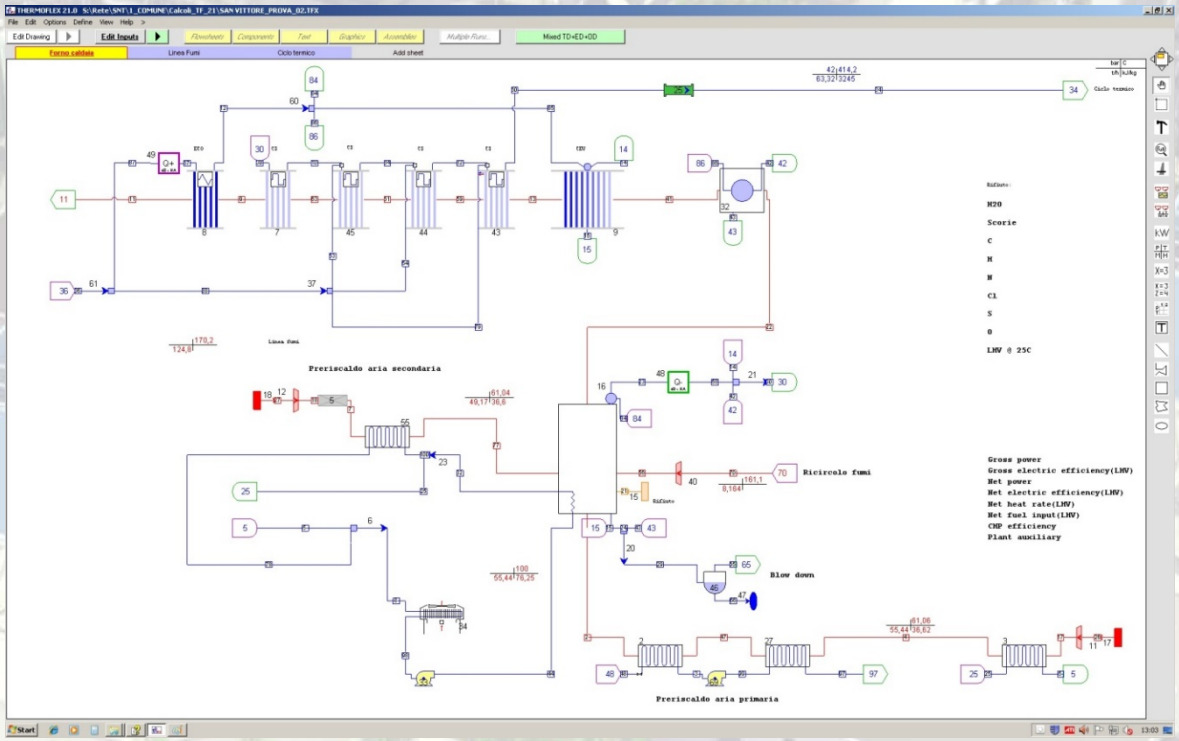
- Heat Recovery System
- Residues
- 3D video of San Vittore Plant

Heat Recovery system

TM.E uses a calculation and simulator software, Thermoflow, in order to:

- **Elaborate materials and thermals balance**
- **Verify the correct design of the equipments**
- **Define the best configuration of the steam/water cycle**
- **Optimize the overall efficiency of the plant**



Energy Performance

San Vittore del Lazio (FR) Plant	Guaranteed values	Checked values	Increase	% increase
Total efficiency of the plant	24.00 %	27.13 %	+ 3.13 %	+ 11.54 %
Electric energy production	14.50 MWh	15.24 MWh	+ 0.74 MWh	+ 5.4 %

Bydgoszcz Plant	Guaranteed values	Checked values	Increase
Gross electric power generated (full condensation mode)	13 MWe	13,4 MWe	+ 3%
Gross electric power generated (district heating mode): 27,7 MWth produced	9,2 MWe	9,6 MWe	+ 4,3%

Availability of San Vittore Plant

Year	Line 2 + Line 3
2012	15755 h
2013	16087 h
2014	16180 h
2015	16680 h
2016	16405 h

Average operational hour per line during 5 years: ~ 8111 h per year

WtE DIVISION: MAIN PATENTS

1. **Multi Stage Dry Flue Gas Treatment (MSD)**
   IT patent since 2016
   EU pending 2017
2. **ACC (Automatic Combustion Control)**
   IT patent since 2015
   EU patent since 2017
3. **Municipal Sludge Treatment System (Drying and Incineration)**
   IT patent since 2014
   EU pending 2016
4. **Furnaces**
   patent since 2011
5. **Flue Gas Treatment ZEP (Zero Emission Process)**
   patent since 2002

"Creativity is the skill to move from abstract to a concrete solution idea… …the skill to solve problems and create new ways to drive the market …"

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Thank you for your attention