



**POLITECNICO  
DI MILANO**



**October 10, 2014**

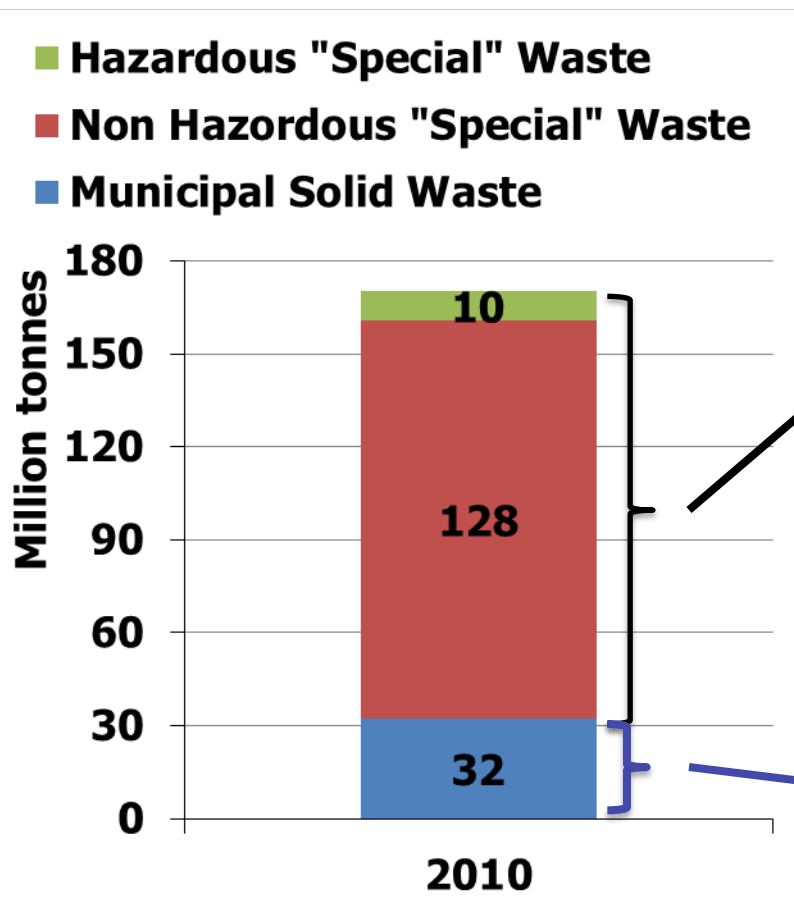
**The 2014 Bi-annual Meeting of WTERT  
Columbia University**

# **Recent developments of WTE in Italy and the MatER model**

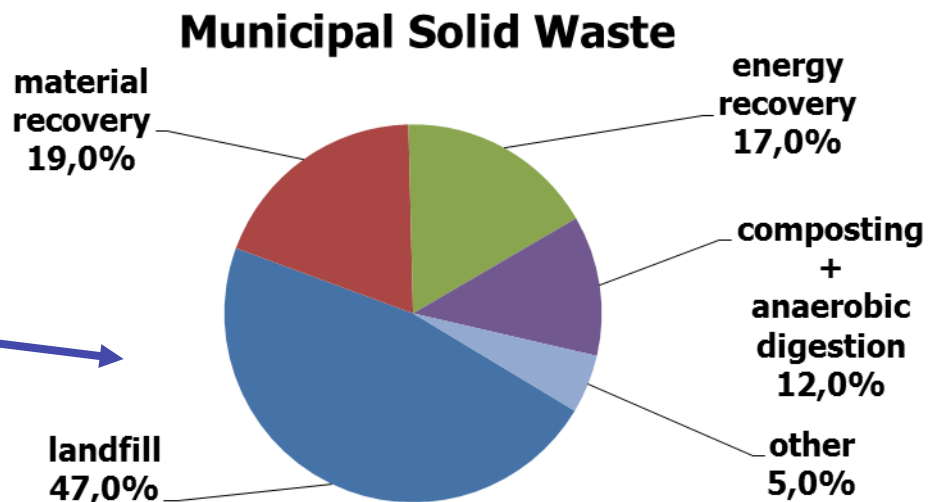
**Prof. Stefano Consonni**  
**Dept of Energy - Politecnico di Milano / MatER**  
**with contributions from ingg. G. Bortoluzzi and M. Zatti**  
**MatER**

# Waste production in Italy (2010)

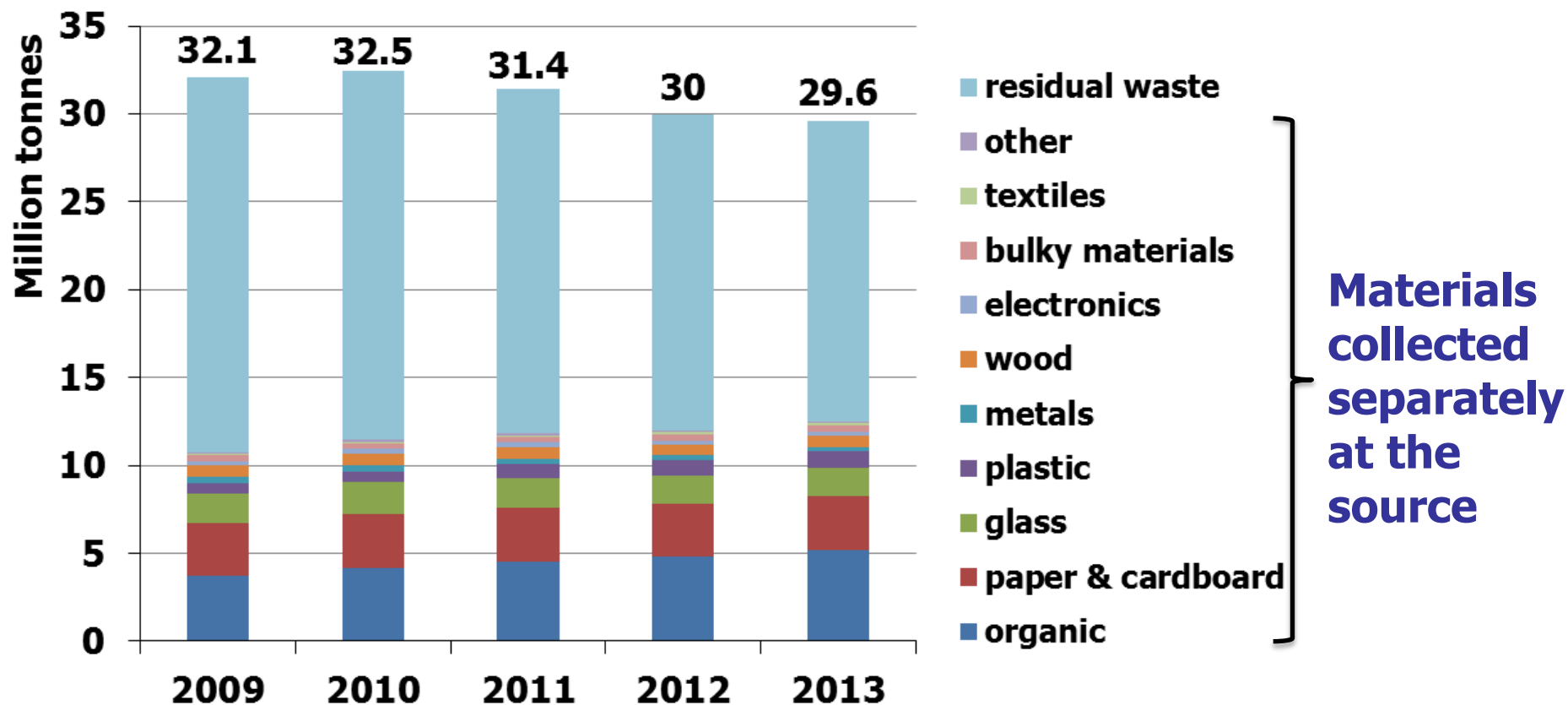
## Total production 170 Mt



**Includes demolition and commercial waste  
nearly 60% recycled  
about 10% to landfill**

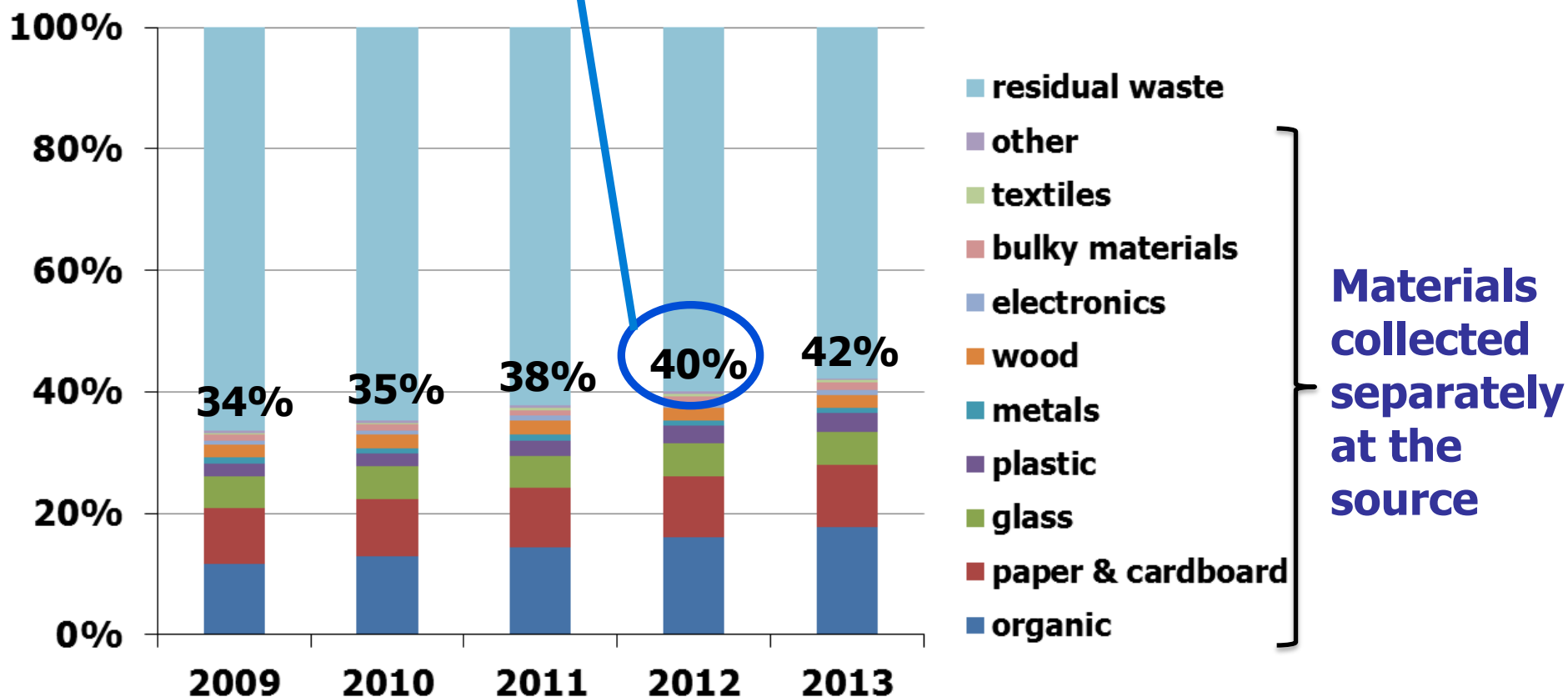


## Evolution of total MSW production and Separate Collection



# Evolution of Separate Collection

**mass % of Separate Collection refers to materials collected at the source --> different from recycling**



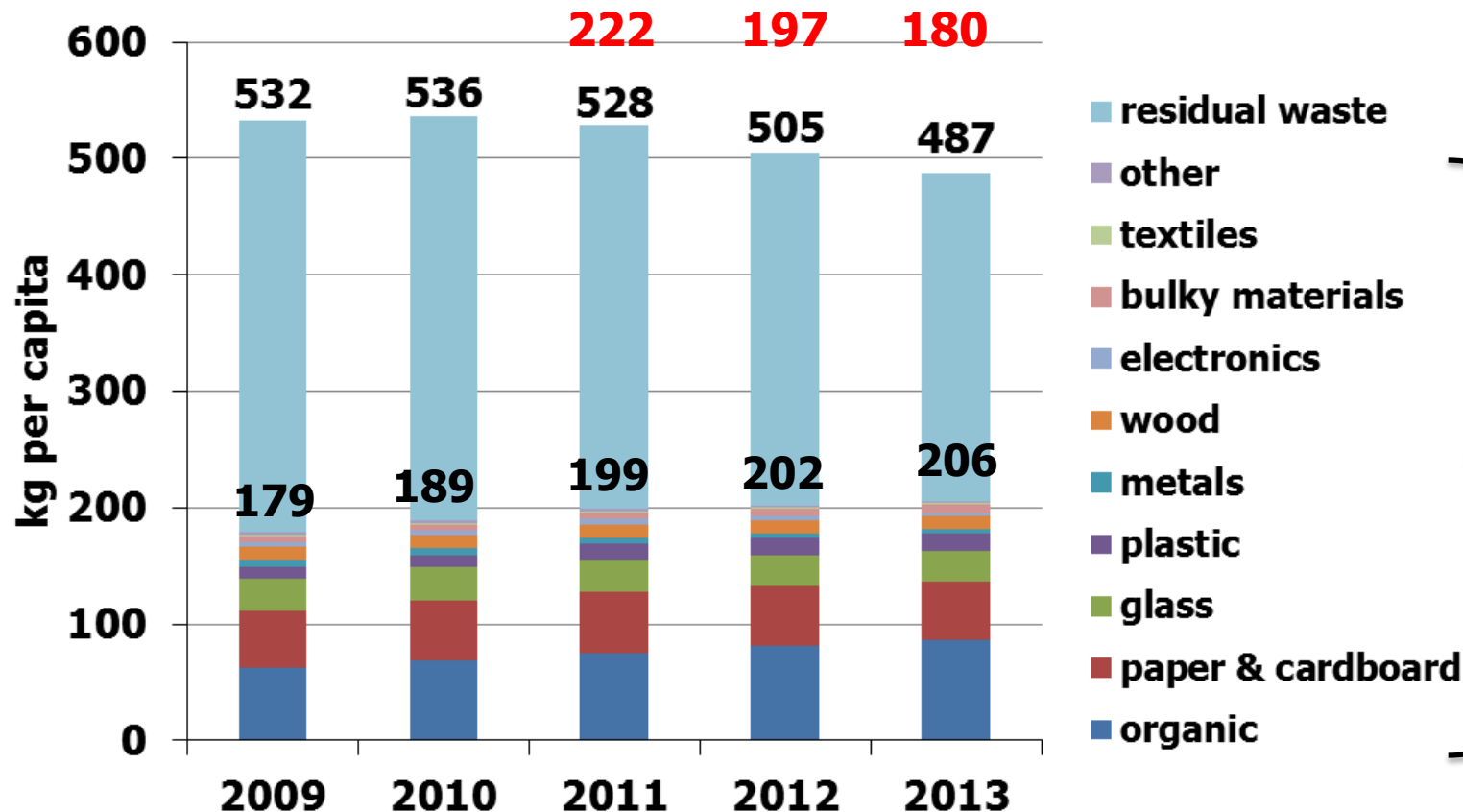
# Per capita production and SC

**kg per capita of "fresh" MSW  
disposed in landfill**

**In 2012, "fresh" MSW to  
landfill (per capita):**

**- UE-28 160 kg**

**- US 388 kg**



Piacenza

| Energy recovery                            | 2012  | 2013  |
|--------------------------------------------|-------|-------|
| Number of plants [#]                       | 49    | 48    |
| Amount of treated waste [Mton]             | 5,17  | 5,40  |
| Electrical production [GWh <sub>e</sub> ]  | 3.828 | 4.234 |
| Electrical production [kWh <sub>e</sub> ]  | 741   | 785   |
| Thermal production [GWh <sub>ton</sub> ]   | 1.718 | 2.473 |
| Thermal production [kWh <sub>t/ton</sub> ] | 332   | 458   |

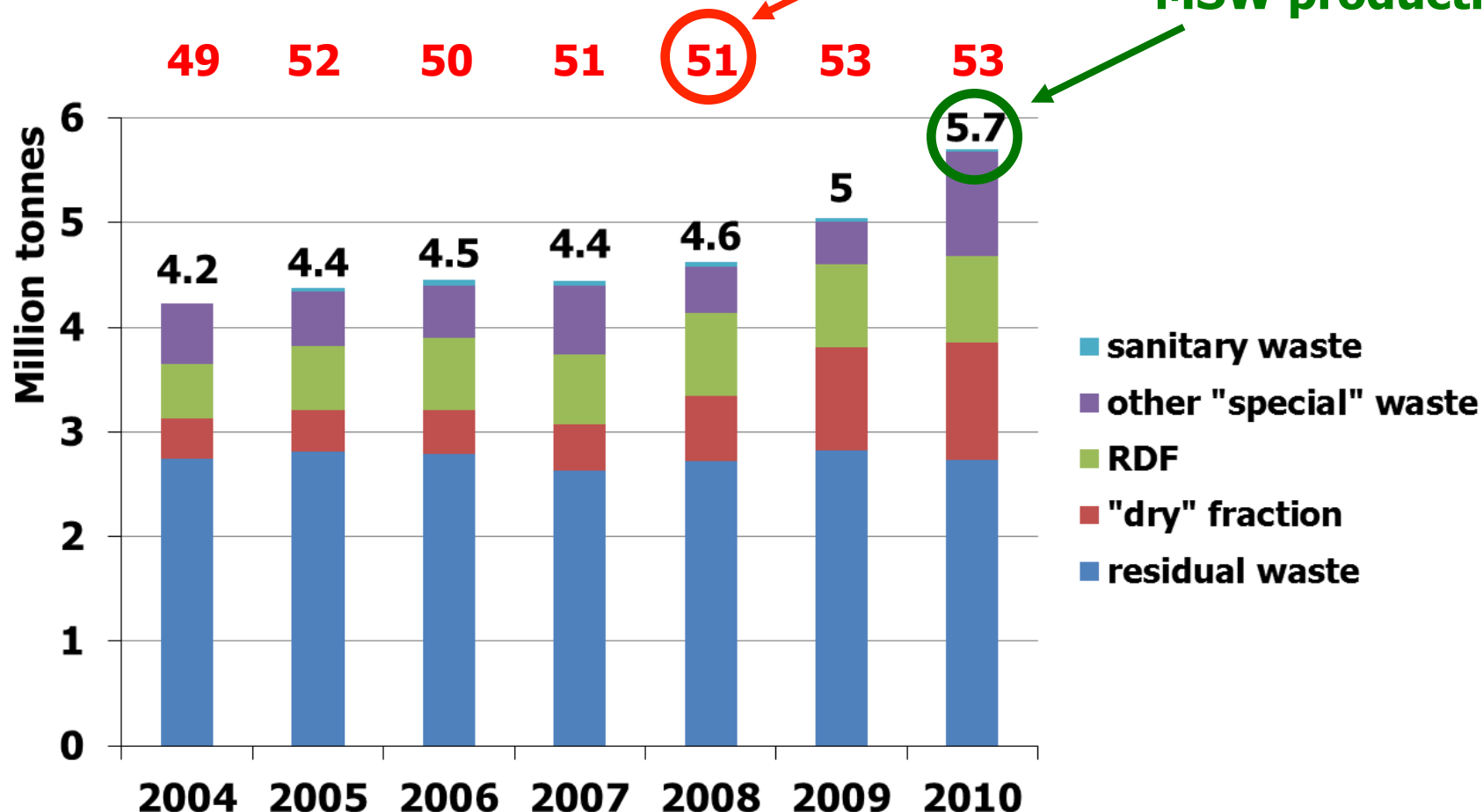


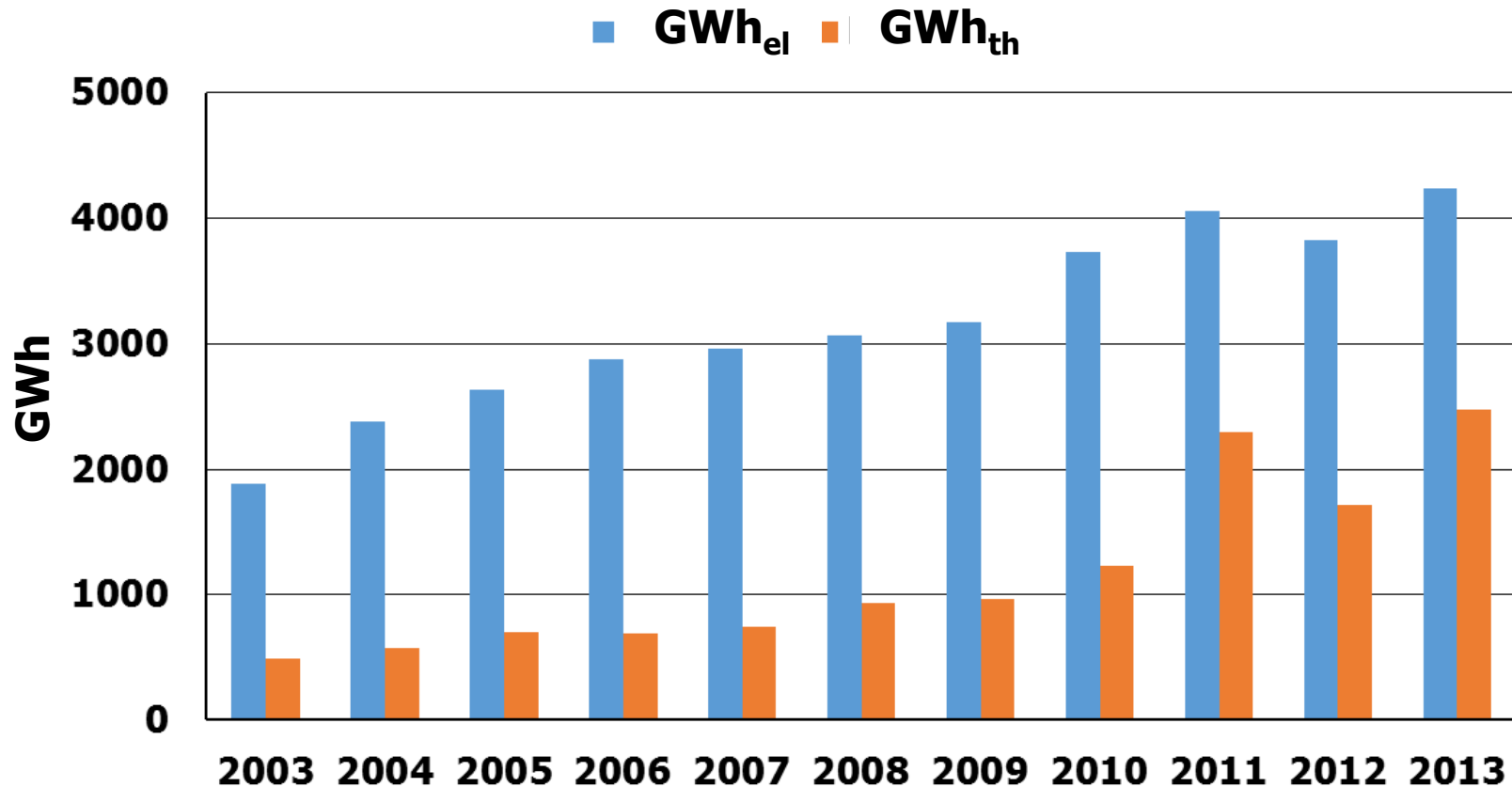
# Breakdown of WTE plants feedstock

**Amount of total  
waste treated**

**Number of plants  
in operation**

**about 20% of  
MSW production**





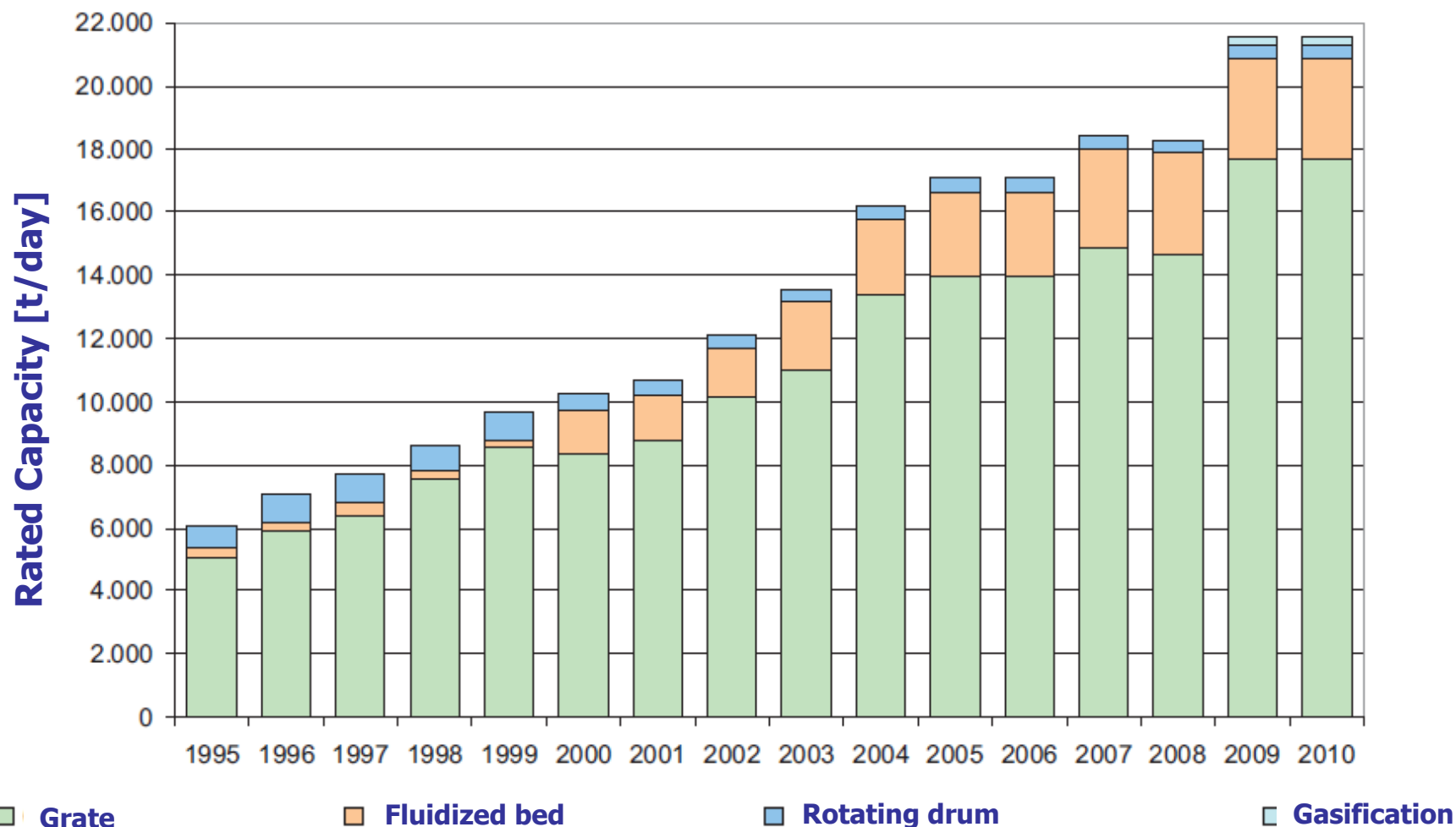
**4000  $\text{GWh}_{\text{el}}$  is about 1.2% of total electricity demand in Italy**

**Under reasonable, "non-aggressive" assumptions, could go up to 4-5%**



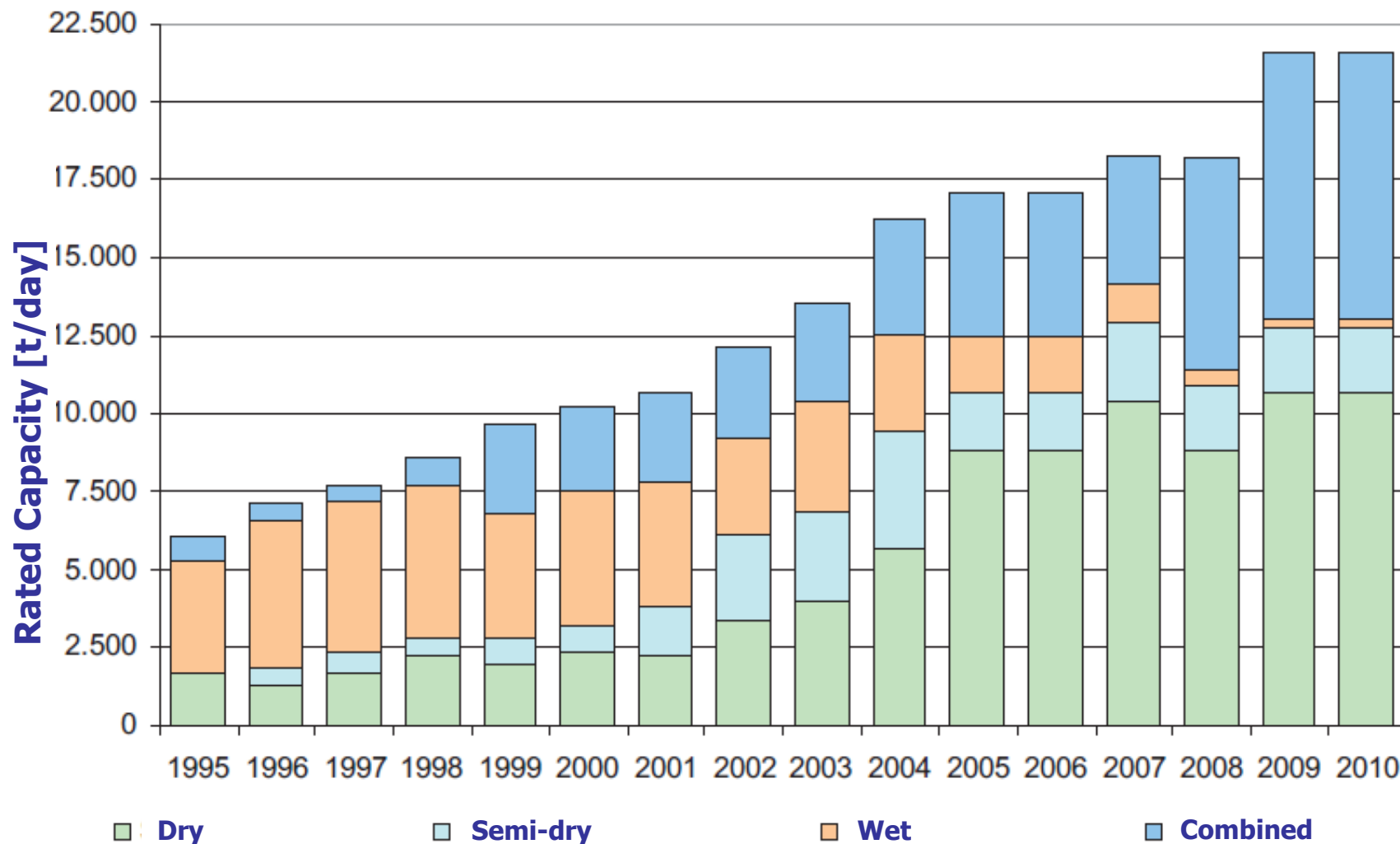
## Evolution of thermal treatment technologies

(from ENEA, waste-to-energy report 2012)



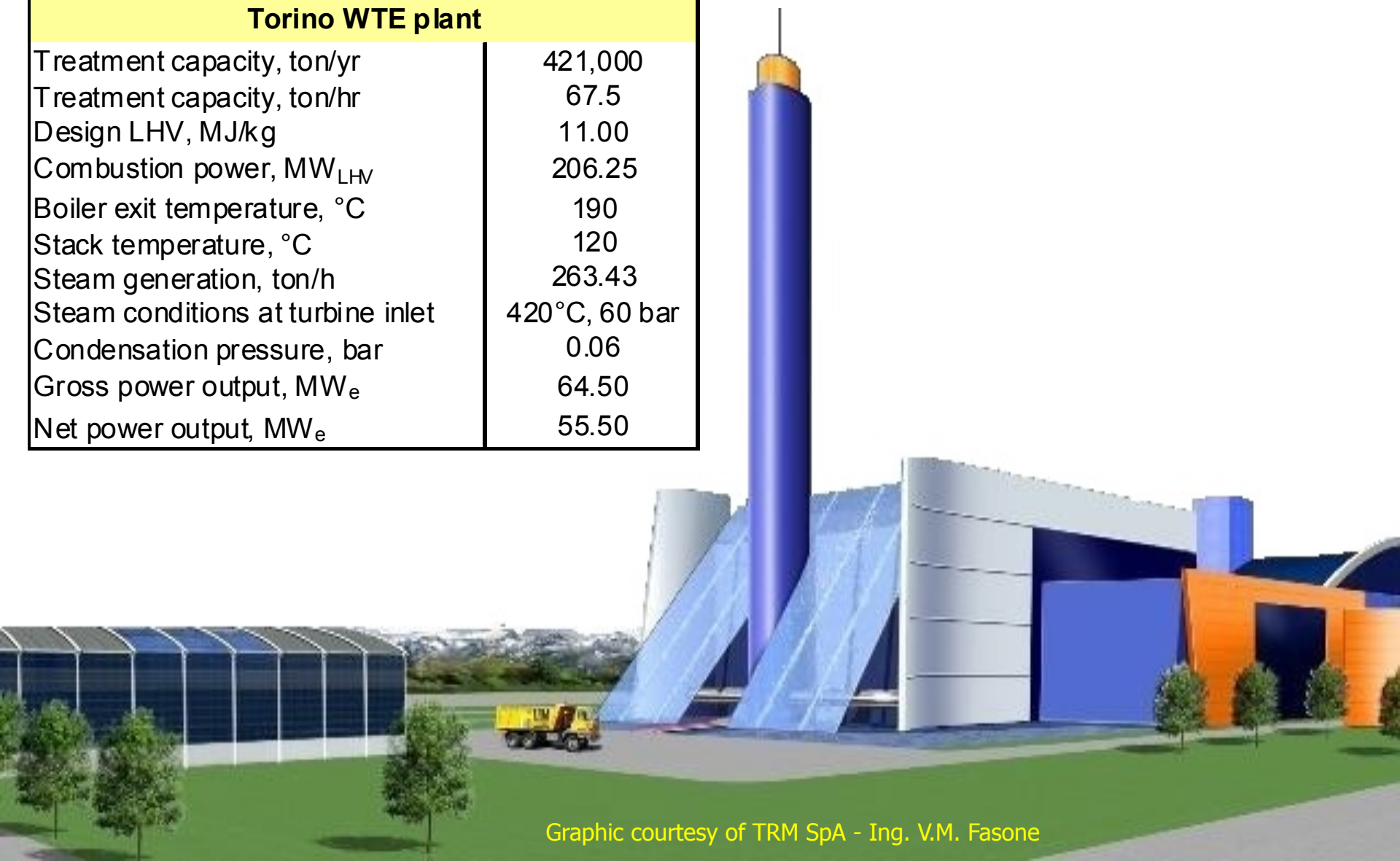
## Evolution of flue gas treatment technologies

(from ENEA, waste-to-energy report 2012)

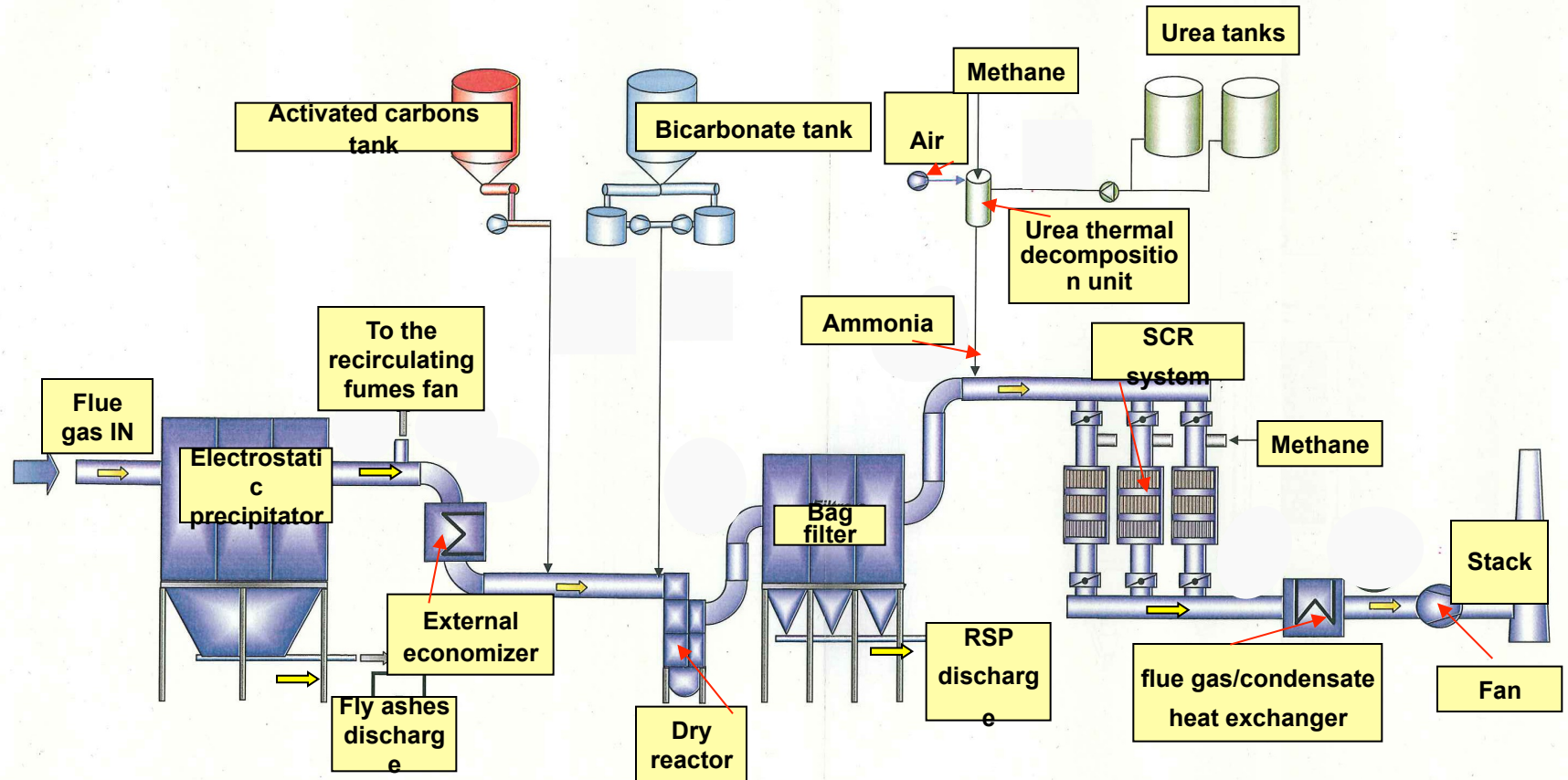


## Torino WTE plant

|                                     |               |
|-------------------------------------|---------------|
| Treatment capacity, ton/yr          | 421,000       |
| Treatment capacity, ton/hr          | 67.5          |
| Design LHV, MJ/kg                   | 11.00         |
| Combustion power, MW <sub>LHV</sub> | 206.25        |
| Boiler exit temperature, °C         | 190           |
| Stack temperature, °C               | 120           |
| Steam generation, ton/h             | 263.43        |
| Steam conditions at turbine inlet   | 420°C, 60 bar |
| Condensation pressure, bar          | 0.06          |
| Gross power output, MW <sub>e</sub> | 64.50         |
| Net power output, MW <sub>e</sub>   | 55.50         |



# Recent WTE plants: Torino



| Feedstock                   | ton/yr         | LHV<br>MJ/kg  |
|-----------------------------|----------------|---------------|
| "Dry" fraction              | 70,000         | 15.50         |
| Commercial waste            | 18,000         | 17.00         |
| Waste from recycling plants | 15,000         | 20.00         |
| Sanitary waste              | 7,000          | 22.00         |
| Dried sludge                | 20,000         | 10.50         |
| <b>Total</b>                | <b>130,000</b> | <b>15.803</b> |

## Boiler and power cycle

|                                     |               |
|-------------------------------------|---------------|
| Combustion power, MW <sub>LHV</sub> | 71.33         |
| Boiler exit temperature, °C         | 190           |
| Stack temperature, °C               | 130           |
| Steam generation, ton/h             | 79.35         |
| Steam conditions at turbine inlet   | 400°C, 45 bar |
| Condensation pressure, bar          | 0.10          |

| Power output                              | summer | winter |
|-------------------------------------------|--------|--------|
| Electricity (gross), MW <sub>e</sub>      | 17.80  | 12.50  |
| Heat to district heating, MW <sub>t</sub> | 0.00   | 40.00  |

- 2 lines with grate combustors + integrated boiler
- single turbo-generator and air-cooled condenser
- SNCR with 25% NH<sub>3</sub> solution
- "double" flue gas treatment:
  - injection of lime+active carbon
  - 1st bag filter
  - NaHCO<sub>3</sub>+carbon
  - 2nd bag filter
  - injection of NH<sub>3</sub> solution
  - SCR
  - low temp heat recovery

**Commercial operation started  
April 2014**

# Recent WTE plants: Parma





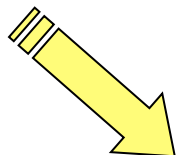
## Emissions at the stack

| species            | mg per m <sup>3</sup> <sub>n</sub> dry, 11% O <sub>2</sub> |                                |        |
|--------------------|------------------------------------------------------------|--------------------------------|--------|
|                    | emission<br>limit                                          | daily averages<br>Jan-Aug 2014 |        |
|                    |                                                            | Line 1                         | Line 2 |
| HCl                | 8.0                                                        | 0.74                           | 1.31   |
| HF                 | 1.0                                                        | 0.04                           | 0.04   |
| SO <sub>2</sub>    | 40.0                                                       | 1.25                           | 2.12   |
| NO <sub>x</sub>    | 70.0                                                       | 25.48                          | 26.97  |
| NH <sub>3</sub>    | -                                                          | 0.04                           | 0.03   |
| CO                 | 30.0                                                       | 4.15                           | 5.43   |
| TOC                | 10.0                                                       | 0.04                           | 0.02   |
| Particulate matter | 5.0                                                        | 0.39                           | 0.22   |

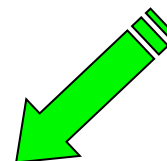
**MatER Research Center (Material and Energy from Refuse) is a project carried out by LEAP (Piacenza Energy and Environment Laboratory) with the scientific support of the Energy Department and Civil and Environmental Engineering Department of Politecnico di Milano**



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**LEAP**  
Laboratorio Energia e Ambiente Piacenza



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**Fluxes of mass and energy IN  
and OUT (waste ?) are an  
ESSENTIAL ingredient of life**

**HEAT  
OUT**

**MATTER +  
ENERGY IN**

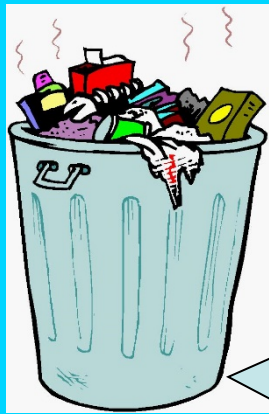
**MATTER  
OUT**

**HEAT  
OUT**

**Fluxes IN / OUT are not  
an option: setting them to  
zero brings to death**

**WORK  
OUT**

# Position in waste hierarchy



**Reduction**

## BENEFITS:

- resource savings
- raw materials consumption reduction
- energy consumption reduction

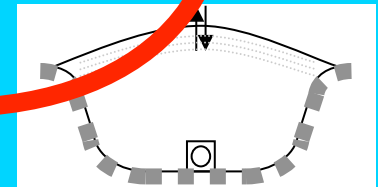
**Re-use**

**Recycling**

**Energy Recovery**



**Landfill  
(INERT  
residues)**

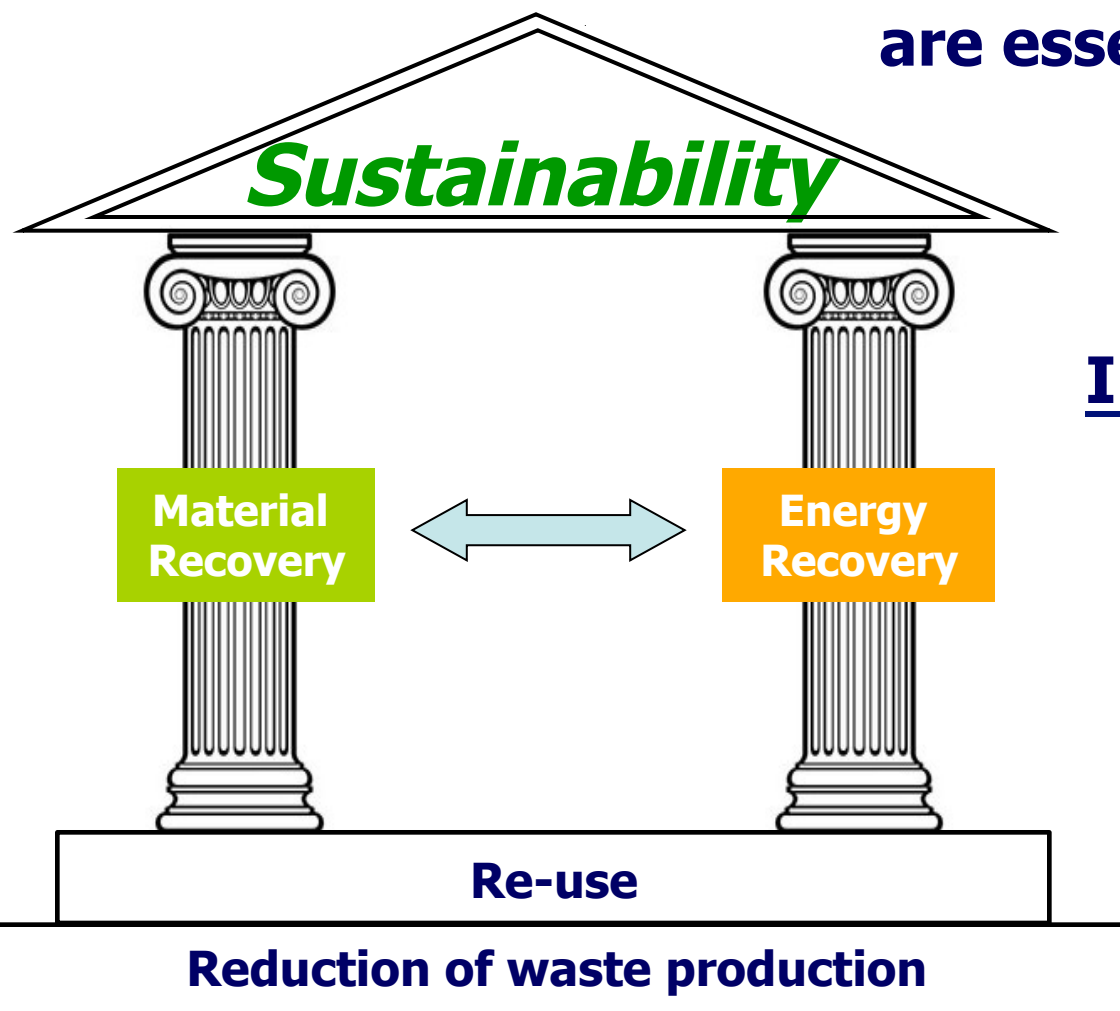


## PROBLEMS/HURDLES:

- coordination of different subjects
- complex management
- costs

# MatER point of view

**BOTH material recovery  
AND energy recovery  
are essential for Sustainability**



## Integrated system:

- 1) Reduction
- 2) Re-use
- 3) Recovery
- 4) Inerts disposal

## DIRECTOR



**Prof. Stefano  
Consonni**

## SCIENTIFIC BOARD



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Giugliano**



**Prof. Stefano  
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**Eng. Mario  
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**Eng. Lucia  
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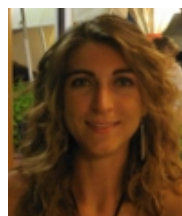


**Eng. Federico  
Viganò**

## MatER TEAM



**Eng.  
Giulio Bortoluzzi**

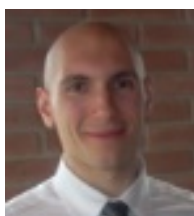


**Eng.  
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**Eng.  
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**Eng.  
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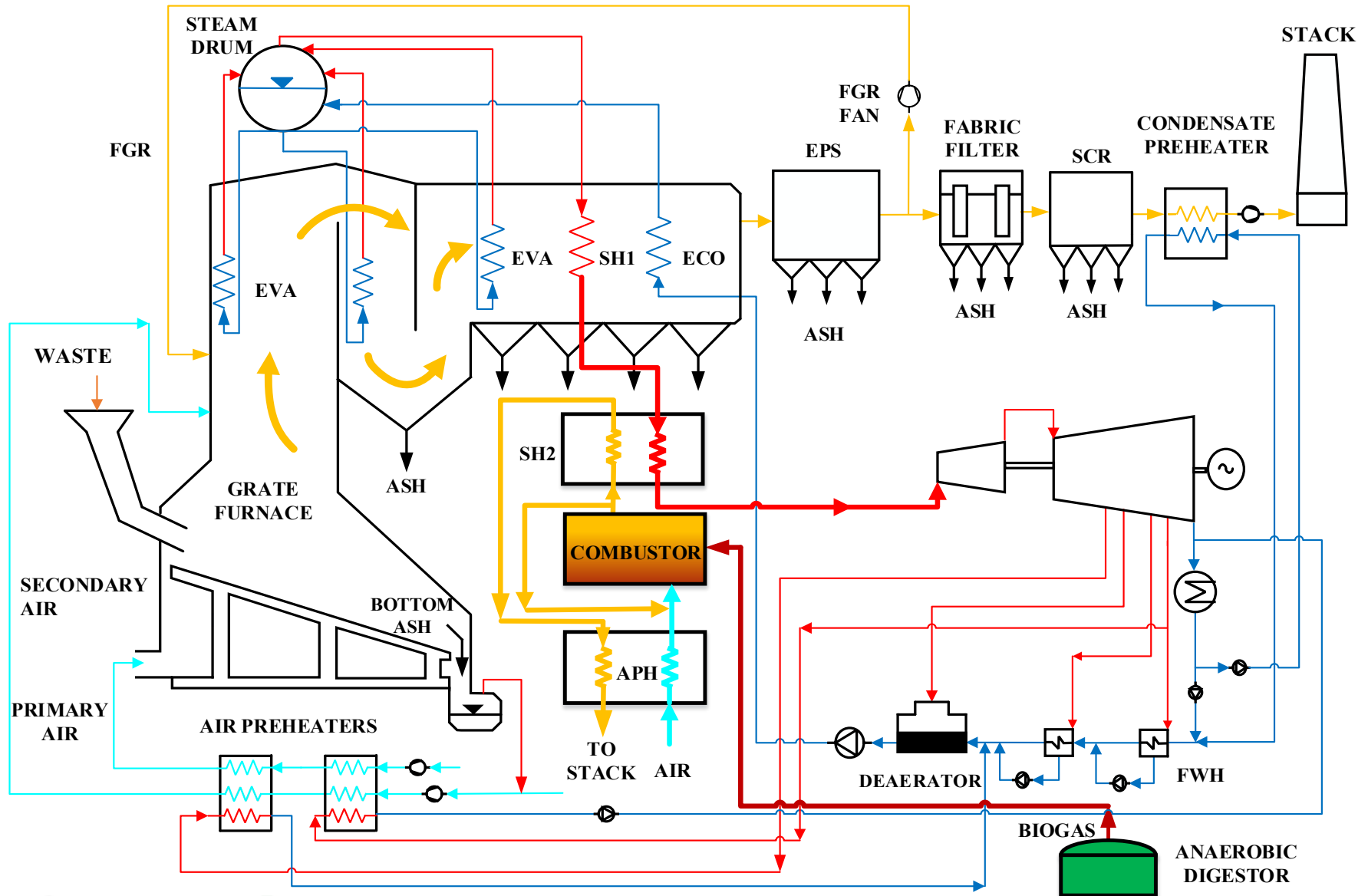


**Prof. Andrzej Bialowiec**  
from Univ. of Wroclaw, Poland to MatER

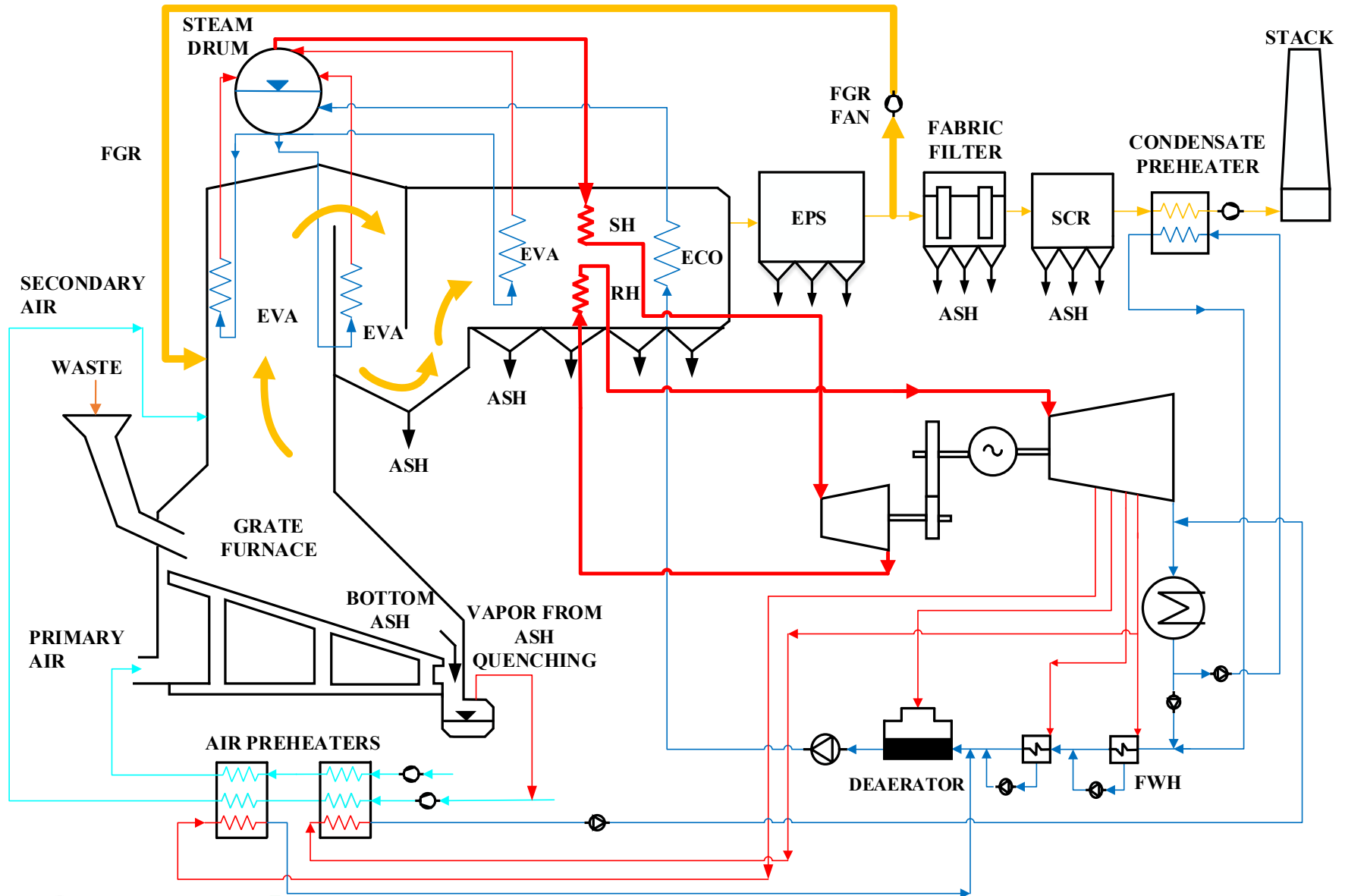


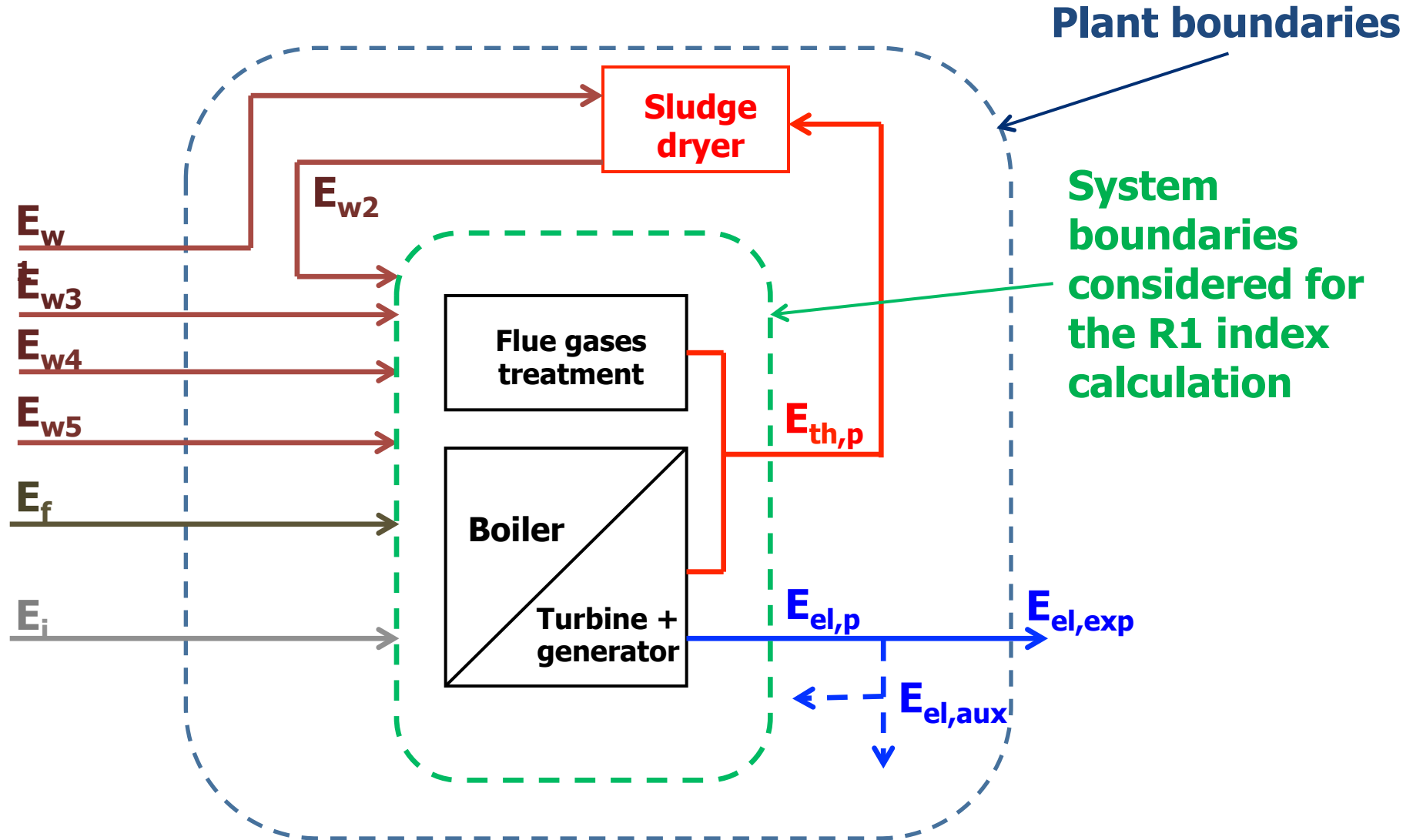
- 1) WTE integrated with biogas production**
- 2) Steam reheat as means to improve efficiency (and reduce environmental footprint)**
- 3) Evaluate energy recovery coefficient R1 (as defined by EU directive)**
- 4) Biogas upgrade**
- 5) Emissions of ultrafine particles**
- 6) Modeling Mechanical Biological Treatment (MBT)**
- 7) Evaluate performances of Integrated Waste Management Systems (IWMSs)**

# External superheating with Biogas









8th i-CIPEC

October 15-18, 2014 HangZhou, China

## Techno-economic assessment of biomethane production from agricultural residues in Italy

Giulio Bortoluzzi<sup>a,b,\*</sup>, Giorgia De Guido<sup>c</sup>, Manuele Gatti<sup>a,b</sup>, Simone Gamba<sup>c</sup>,  
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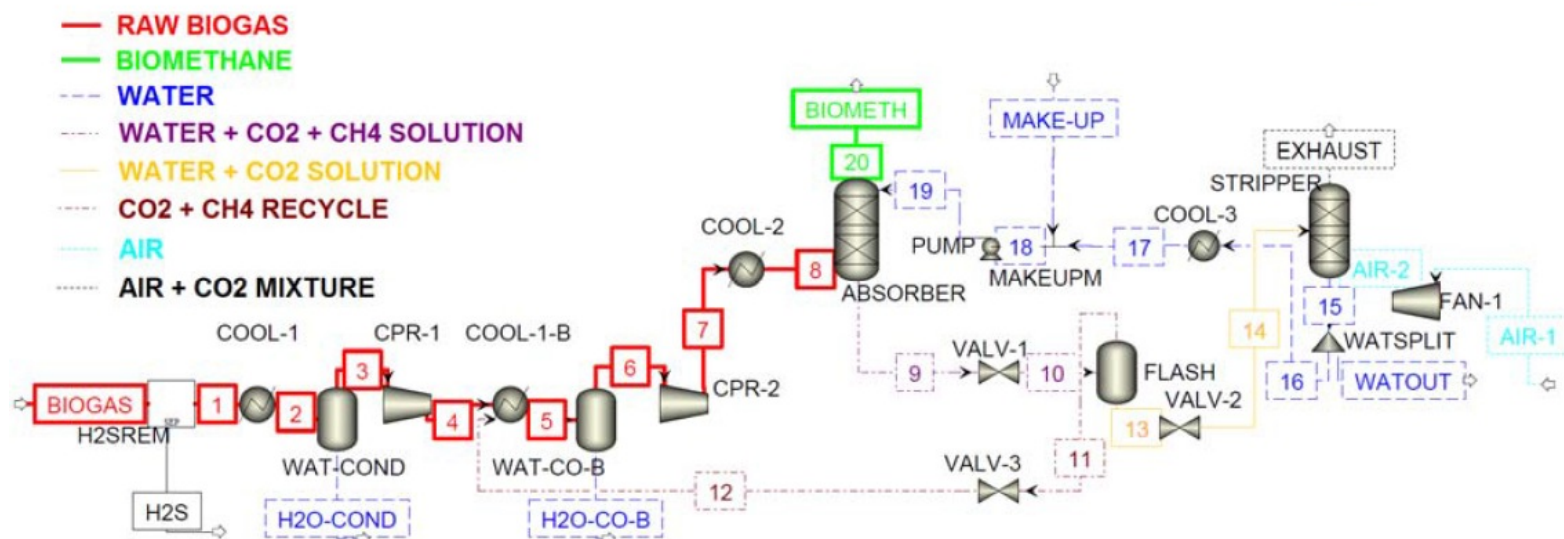
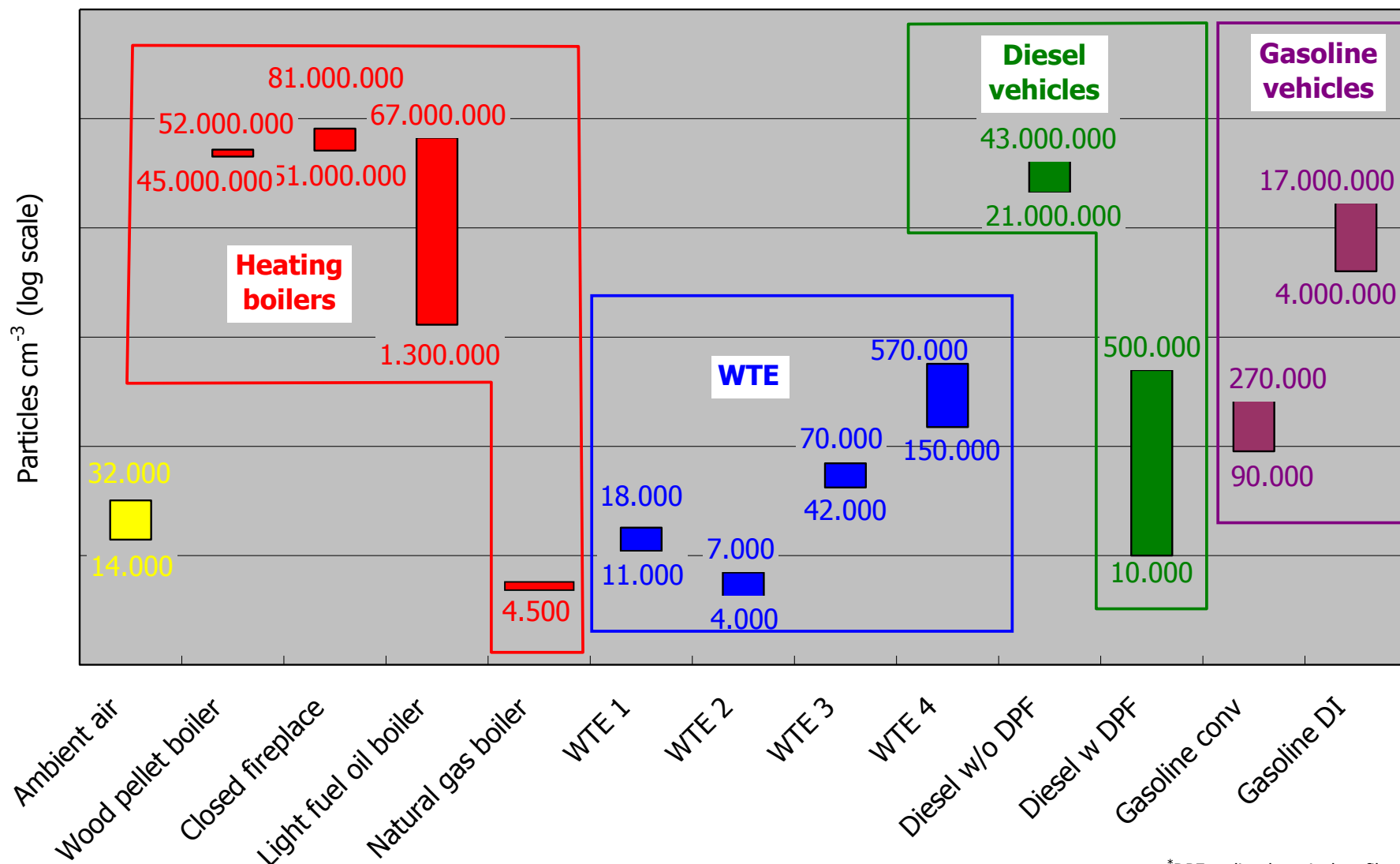
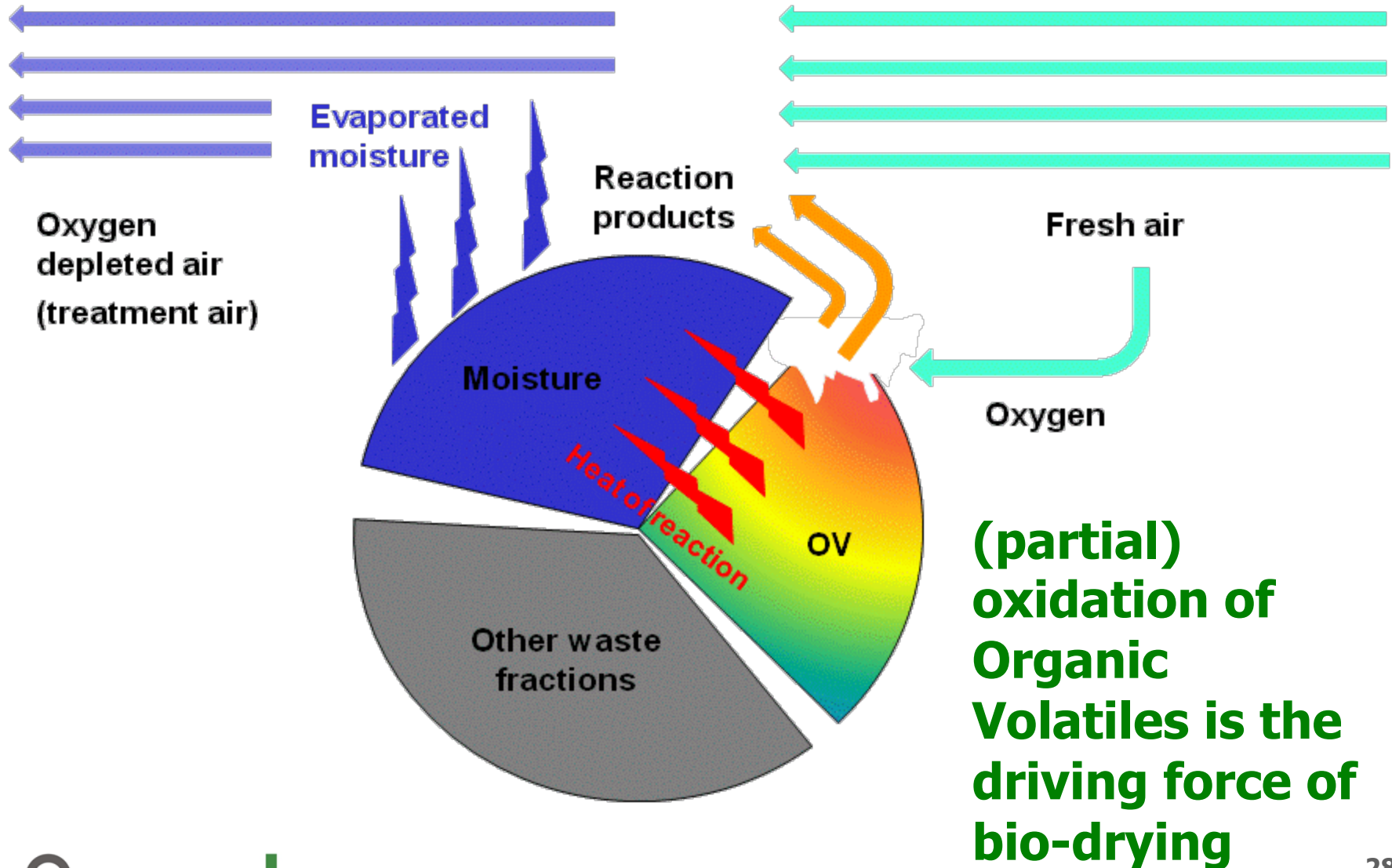


Figure 1: Plant scheme of the water washing upgrading process.

# Emissions of ultrafine particles



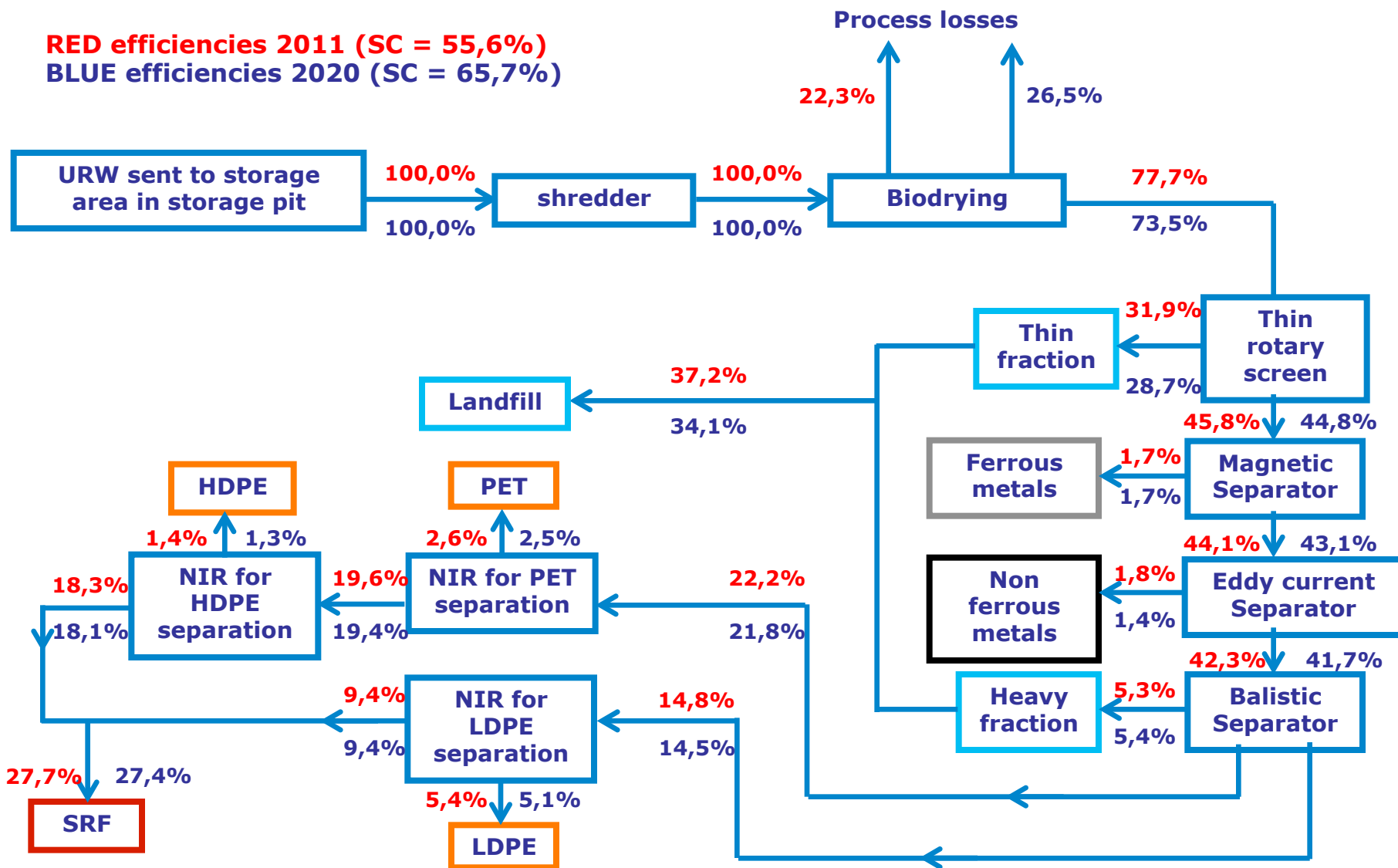
# Basic mechanism of bio-drying



# An Italian case study - MBT 1

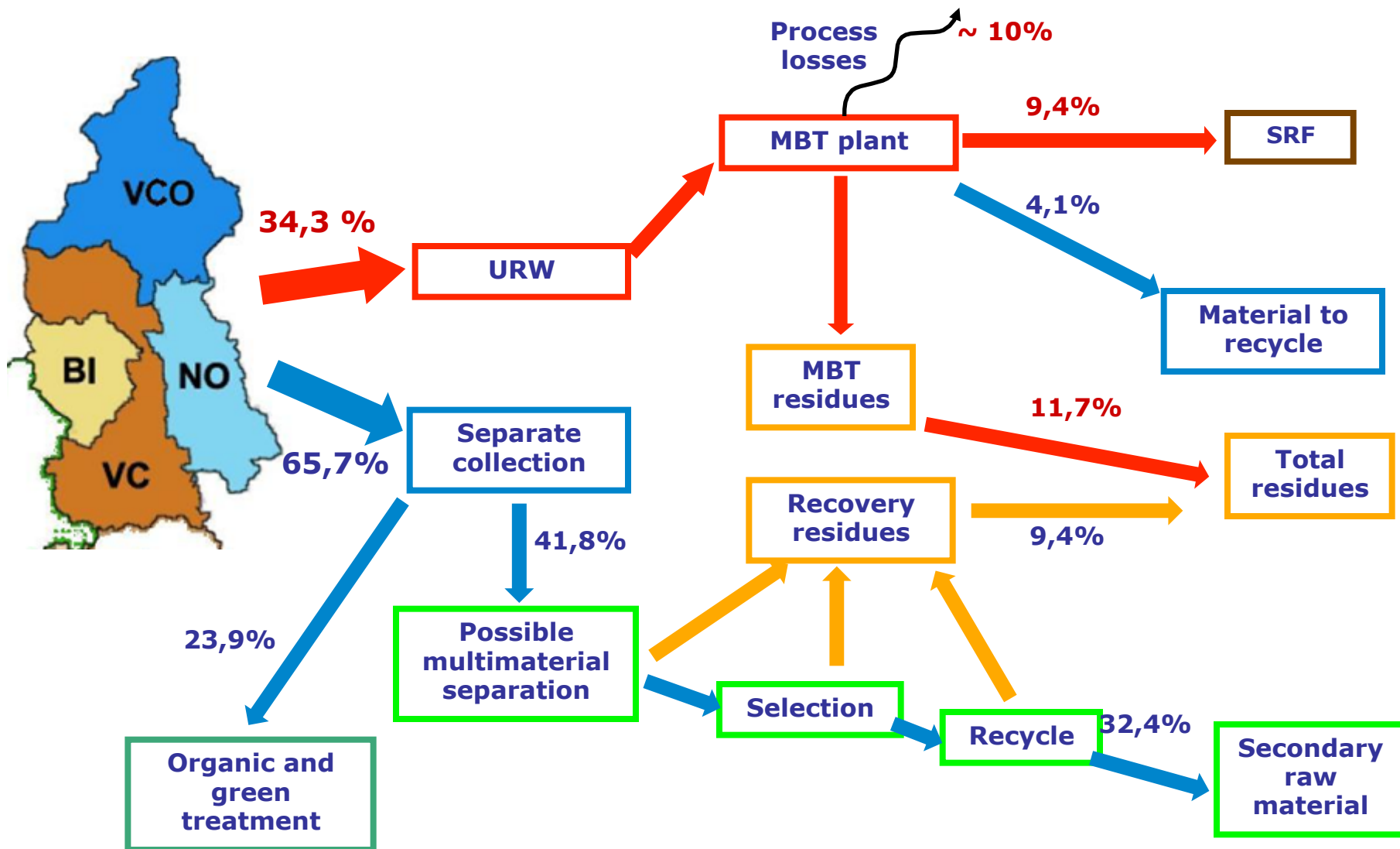
**RED efficiencies 2011 (SC = 55,6%)**

**BLUE efficiencies 2020 (SC = 65,7%)**





# An Italian case study - MBT 1



- 1) Combination of a variety of competences: recycling, energy systems, evaluation of environmental impact, technical-economic evaluation, etc.**
- 2) Involvement of major waste management companies**
- 3) Support of national federation**
- 4) Combination of routine activities (website, events, participation to meetings/debates) with research and educational activities**
- 5) Address also actual operational and design issues**
- 6) Communicate with administrators, politicians, administrators, environmentalists, etc.**
- 7) Involve sponsors in all major decisions**
- 8) Team of motivated, enthusiastic, (young) people**

# Thank you for your attention !



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