PROCESSES AND TECHNOLOGIES FOR THE VALORIZATION OF WASTES AND BIOMASSES

Istituto di Ricerche sulla Combustione

Consiglio Nazionale delle Ricerche

THE FRAMEWORK

- Design out waste
- Build resilience through diversity
- Rely on energy from renewable sources
- Think in ‘systems’
- Waste is food

i. Raw materials have **NO** or negative **commercial value**
ii. The achievement of a zero economical/ecological balance is a **win**
iii. Social **perception** is generally **positive**
iv. There is an increasing **interest to invest** from good producers

MISSION

Define, Enhance and Field-Test Processes and Technologies with the aim of realizing a sustainable nutrients cycle exploiting waste and residual biomasses resources with a focus on energetic issues

STRATEGIES OF INTERVENTION

Exploit the power of a combined approach in designing innovative multistep and multifaceted processes:

- pretreatment - processing - reforming
- combined renewable/waste/residues treatments
- targeting of secondary raw material production to high added value application
  - metal recovery
  - catalytic materials
  - soils improvement

EXPERTISE, METHODOLOGIES AND INSTRUMENTS

Expertise

Design and realization of experimental systems from laboratory up to pilot scale.

Processes diagnostics and control.

Physical and chemical materials characterization.

Catalytic processes and technologies.

Computational reactive fluid dynamics.

Advanced optical diagnostics

Sizing, reactivity and surface properties of condensed matter from nano to macro size.

Diagnostics

Spectroscopy *(IR, VIS, UV)*

Chromatography

Microscopy

Mass spectrometry

Thermogravimetric analysis

Laser diagnostics *(PIV, PLIF)*

Mobility analysis

Infrared Thermometry

High speed imaging

Processes

Combustion

Pyrolysis

Gasification

Bio-technologies

Facilities

Fermenters

Pyrolyzers

Gasifiers

Burners

Fixed and fluidized bed reactors

(fully instrumented and up to the pilot scale).

Computational resources.

Chemical analysis laboratories.

In-line ed off-line diagnostics and monitoring systems.

Researchers

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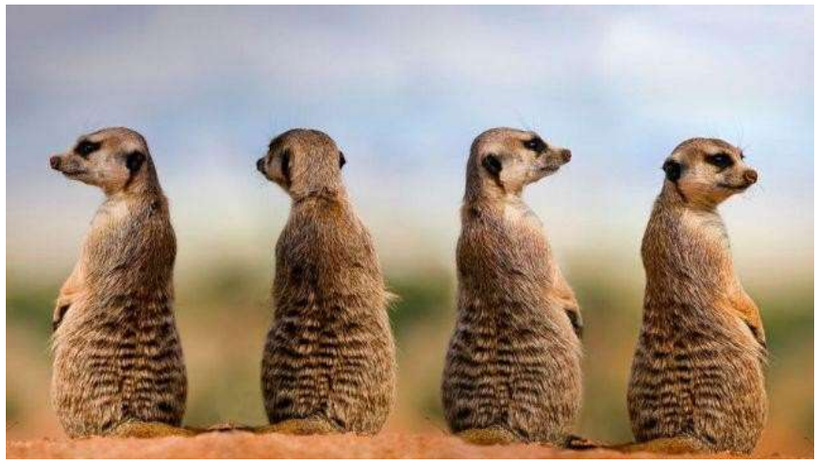
CHALLENGES



- Societal challenges
- Secure, clean and efficient energy
- Climate action, resource efficiency and raw materials

LINE OF ACTIVITIES

1. Processes and Technologies for **material recovery** from wastes and biomasses

2. Processes and technologies for the **energetic valorization** of wastes and biomasses

COMMON ACTIVITIES

MATERIALS AND PROCESSES CHARACTERIZATION

- **Standard**
  - Proximate analysis
  - Ultimate analysis
  - Inorganic content
  - Morphology
  - TAR (UNI CEN/TS 15439)
  - Electron microscopy
- **Non Standard**
  - Reactivity
  - Detailed chemical analysis using in house developed analytical methodologies and protocols for: GC-MS, HPLC, TG-MS, FTIR
  - In situ analysis in laboratory scale reactors

NUMERICAL SIMULATION

Experimental, theoretical and numerical studies aimed at better definition of:

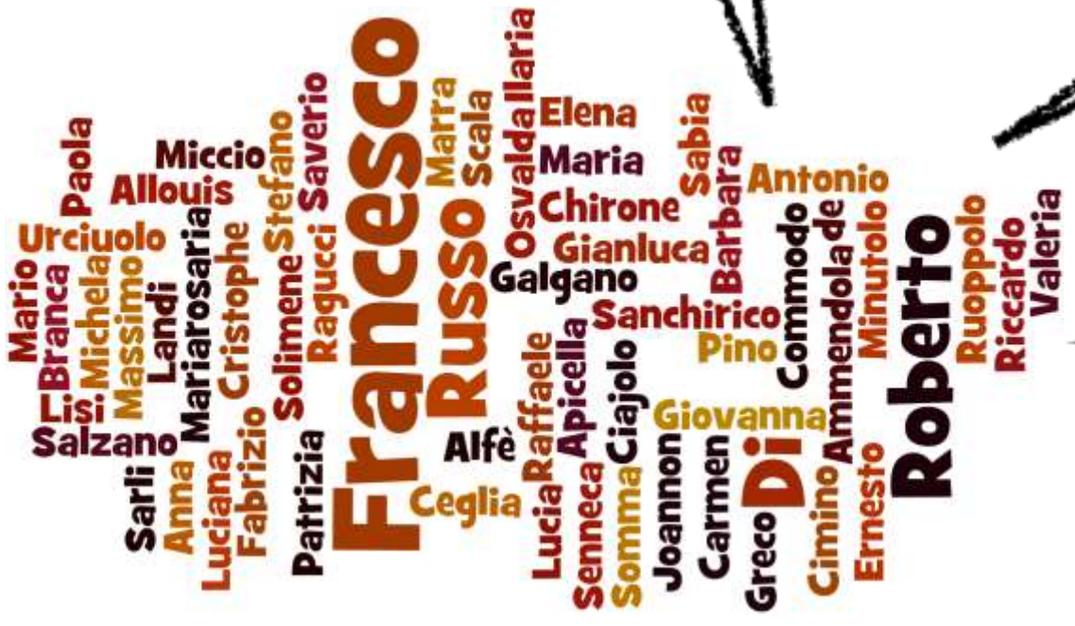
Chemical kinetics data

Transport phenomena

Fluid-dynamics

Critical task for unconventional fuels and feedstocks.

Process targeted approach



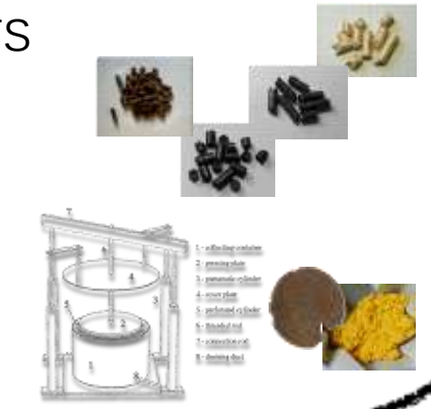
PRE-TREATMENTS

Grind

Dry

Make pellets

Torrefy



Process and Technologies for material recovery from wastes and biomasses

Pyrolysis

- Slow, fast and flash pyrolysis for:
  - material disposal (waste, contaminated biomasses, biofuel and agroindustrial byproducts ...)
  - chemicals and secondary raw materials production
- "Process to Plant Modeling" approach
  - chemical kinetics definition
  - transport phenomena effects
  - feedstock and process evolution interactions

Gasification

- Syngas ready for chemicals production
- Wide range of materials (Wastes, End-of-life, Biomasses....)
- Advanced monitoring and analysis tools

Bio-technologies

- Waste and sludge suitable for biological fermentation
- Lab scale process development and optimization

Combustion

- Oxygen carriers produced by sewage sludge fluidized bed combustion
- Detailed fuel and products characterization
- Fluid-dynamics and chemical kinetics optimization
- Ash remediation

Processes and technologies for the energetic valorization of wastes and biomasses

Pyrolysis

- "Process to Plant Modeling" approach
  - chemical kinetics definition
  - transport phenomena effects
  - feedstock and process evolution interactions
  - TAR reforming
  - Energy recovery from pyrolysis products

Gasification

- Feedstock preparation (pellettization, drying, torrefaction)
- Wide range of materials (Wastes, End-of-life, Biomasses…)
- Wide temperature range and carrier composition
- Advanced monitoring and analysis tools
- Gas cleaning
  - TAR reforming
  - particulates removal

Bio-technologies

- Solar energy and biotech combination
- Lab scale process development and optimization

Combustion

- Advanced combustion processes for unconventional fuels
- Fluidized bed
- MILD burner
- From elementary reactors to pre-pilot scale
- Combustion and Co-combustion concepts
- Very different fuels.
  Sludges, TAR, syngas, lignocellulosic matters
- Detailed fuel and products characterization
- Fluid-dynamics and chemical kinetics optimization

PARTNERSHIP/PROJECTS

- **Collaborations**:
  - Università di Napoli Federico II
  - Centro Sviluppo Materiali S.p.A
  - Broadcrown
  - Western University Canada
  - Gaia Energy
  - Solidea
  - Politecnico di Torino
  - Politecnico di Milano
  - Università di Salerno
  - Università della Calabria
  - Università di Messina
  - Technische Universität München
  - Fraunhofer UMSICHT
  - ENI

- **Projects**
  - Joint Paes Valle Caudina
  - Biopolis Distretti alta tecnologia
  - LIFE Ecoremed
  - PRIN RE-CYCLE Italy
  - "Processi innovativi per la produzione di energia da mix di biomasse e rifiuti speciali"
  - "Produzione di energia rinnovabile con il minimo impatto da un mix di biomasse e rifiuti speciali non pericolosi attraverso processi innovativi"