Dal biogas alla bioraffineria

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The picture...

- ...seems clear...

- **Biogas**
  - Mainly $\text{CH}_4$, $\text{CO}_2$

- **First generation biorefineries**
  - Land, water, energy, food

- **Second generation biorefineries**
  - Waste/residue

- **Third generation biorefineries**
  - Algae

- ...but the opposite is true
The picture

- Biogas
  - Mainly CH$_4$, CO$_2$
- First generation biorefineries
  - Land, water, energy, food
- Second generation biorefineries
  - Waste/residue
- Third generation biorefineries
  - Algae
A complex picture

- **Biogas**
  - Mainly CH$_4$, CO$_2$
- **First generation biorefineries**
  - Land, water, energy, food
- **Second generation biorefineries**
  - Waste/residue
- **Third generation biorefineries**
  - Algae
- **Need for energy and H$_2$**
- **Net outcome of CO$_2$**
- **‘Integration’ is the key**
  - Energy, process, biotechnology
Ongoing projects

- **CAB2**
  - Innovative downstream processing for the conversion of algal biomass to jet fuels and green diesel
  - MIUR

- **BIOREFILL**
  - BIOREFinery Integrated Lombardy Laboratories
  - Fondazione CARI PLO, Regione Lombardia

- **LIDIA**
  - LIgnocellulosic DIcarbossilic Acids
  - MiSE, National Cluster Green Chemistry

- **BioMAN**
  - Bio-revaluation of the Chemical District of Mantova by Planning Non-Food Biomass Supply and its Upgrading to Bio-Products
  - Fondazione CARI PLO
The CAB2 strategy

The BIOREFILL strategy

- BIOREFinery Integrated Lombardy Laboratories

**Arundo Donax and Lignocellulosic Residues**

2nd Gen Biomass

Sugar

- Pre-treatment (chemical-physical or biological)
- Hydrolysis

Liquid Residue

- Chemical-physical treatment (inverse osmosis)

Solid Residue

- Gasification/Comb

Lignocellulosic Residue

- Polymers

Biochemicals

Algae

3rd Gen Biomass

- Fertilizers

Biosyngas

Bio-MeOH/DME

Heat Energy

Biomethane

CO₂

Integration:
- Biogas 2nd Gen
- 3rd Gen

Target:
- Energy
  - H₂
  - CO₂

11 partners

2013-2015

Fond. CARIPOLO and Reg. Lombardia

Manenti, F., Adani, F., Integrating the Concept of Bio-Refinery onto the Biogas Field: The BIOREFILL Strategy, Computer Aided Chemical Engineering, 33, 1513-1518, 2014
Lignocellulosic residue

• Collaboration
  ▪ Canada
  ▪ USA
  ▪ Belgium
  ▪ Italy

• Units
  ▪ Updraft
  ▪ Fluidized-bed

• Feedstock
  ▪ Biomass
  ▪ Hybrid
    • Waste/coal

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Experiments
Multi-complex study

**Solid**
- Characterization
- Pyrolysis
- Heterogeneous reactions

**Gas**
- Characterization
- Secondary gas phase reactions

**Particle**
- intra-particle resistances
- sector discretization

**Reactor**
- inter-phase phenomena
- fluid dynamics
- contact time

**Component characterization**
- composition (functional groups)
- thermodynamic properties
Model prevision

• Devolatilization
  • Cellulose

Cell. thermal degradation

Low and medium heating rates

Data: Antal et al., 1995-1998

- Exp.
- Modello

1°C/min
80°C/min

High heating rates

Data: Milosavljievic and Suuberg, 1995

100°C/min
1000°C/min

Pyrolysis

5°C/min

Data: Williams et al., 1997

Pino
C 45 E 28 L 27
B (78-11-11)

5°C/min
10°C/min

Data: Muller-Hagedorn et al., 2003

10°C/min

Carpino bianco
C 48.9 E 23.3 L 27.8
A (15-18-67)
Conclusions

**BioMAN** – Bio-revaluation of the Chemical District of Mantova by Planning Non-Food Biomass Supply and its Upgrading to Bio-Products

Biomass Components
Fermentation
Thermal treat.
Residue
Supply chain
Revamping
LCA

Full integration & exploitation
Thanks for kind attention

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