RE-CORD
Renewable Energy Consortium for R&D

CREAR/RE-CORD Activities:
Thermo-Chemical Processes for the Energy of Tomorrow

Eng. Matteo Prussi, Ph.D.
WHAT IS RE-CORD?
CREAR
(Public Research Center)

Pianvallico SpA
(Developer of the industrial area of Mugello - FI)

Az.Agr. Montepaldi
(Agricultural farm located in the Chianti Region)

Spike Renewables SrL
/Private research subject/
National and Internazional Network

- **International Energy Agency - Bioenergy**
  - (IEA-Bioenergy, T34-Pyrolysis → T39, 1st & 2nd gen biofuels – M&G group)
- **EU Biofuel Technology Platform**
  - (WG4-Sustainability)
- **THERMALNET**
  - Intelligent Energy for Europe
- **Italian Biofuel Technology Platform**
  - (WG2 – Conversion)
- **ISES-Italia**
  - (Ital.sect. of Int.Solar Energy Society-Board of Dir.)
- **Coordination of EC-R&D&D and IT-MATT projects**
- **International Master Course IMES on Bioenergy**
  - (Bioenergy and Environment)
- **SIBA**
  - (Italian Society for Agroindustries and Bioenergy)
Industrial partnerships

- Mossi & Ghisolfi / Chemtex (IT)
  - Second generation bioethanol from woody feedstock
- SILO (IT)
  - Esterified vegetable oil plant
- Galigani Filtri (IT)
  - Design and construction of cold extraction vegetable oil plant
- VWP (DE)
  - Vegetable oil engines
- Riello (IT)
  - Test on vegetable oil burners
- Assocostieri (IT, Novaol coord.)
  - Innovative microalgae cultivation
- IBT/Capstone (IT/US)
  - Microturbine adaptation for biofuel feeding
- TURBEC (Sweden)
  - Microturbine minor modifications for external combustion feeding
- BTG *Biomass technology group (Netherland)*
  - Pyrolysis oil test in an adapted microturbine
- SEA Marconi (IT)
  - Design and construction of biomass torrefaction and pyrolysis reactors
- Mawera - Viessman (A-DE)
  - Solid biomass furnace development
Institutional partnership

- **ENEA (IT)**
  - Biomass gasification systems, bioethanol production, steam explosion treatments
- **CNR – Istituto Motori (IT)**
  - Tests and advanced measurements on biofuels spraying and combustion behavior
- **Indian Institute of Science and Technology (Bangalore - INDIA)**
  - Biomass gasification systems
- **Aston University (Birmingham - UK)**
  - International Master on renewable energies
- **CSGI Consortium for large interphase systems (Florence - IT) [CREAR member]**
  - Emulsion of diesel and biofuels for use in prime movers
- **TUG Technical University of Graz (Graz - UK)**
  - Clean and efficient biomass combustion systems
  - CFD simulation of biomass combustion
- **Imperial College of London (UK)**
  - Assessment on biofuels market, potential and perspectives
- **IFEU (Heidelberg - DE)**
  - LCA on power production from renewable resources
- **Agronomic department (Florence - UK) [CREAR member]**
  - Energy-crop activities
- **FCT, Universidad Nova de Lisboa, (Portugal)**
  - Vegetable oil related activities
- **Boreskov Institute of Catalysis (Novosibirsk, RU)**
  - Catalytic treatment of biofuels and emission reduction from power plant
Resources

- RE-CORD has an experimental area of 1 ha located in Montepaldi
- Analytical lab located in Mugello, focus on solid and liquid biomass
- RE-CORD, controls several plants fed by RES
Pianvallico (FI)

- Chemical LAB
- Gasification plant (Prog.Min.Ambiente-MNRE India)
- Pyrolysis pilot plant (Prog.7PQ)
Montepaldi (FI)

- Experimental Area (1 Ha)
- MGTs (20 and 30 kWel) for PVO, BCO, etc, biofuels
- Engines for PVO feeding
Projects in Florence Region

- EC FP7 BIOLIQUIDS CHP
- IEE – EUBIONET3
- EC LIFE VOICE – Veg.Oil (PVO)
- RT MPS Siena Biodiesel
- RT MPS Siena Veg.Oil
- MICROALGAE – Assocost MAMBO
- EC FP7 BIOFAT
- Ind 2015 PRIT (M&G) Bioeth
- RE-CORD - Lab
- RE-CORD - Office
- EC FP6 BIO_MGT
- Progetti PSR in negoziazione
- MATT – IT/India Gasific.
- RT - Esterified VO
- MSE - GIS Census ENEA
- Jatropha (nursery & oth)
- EC FP6 REACT (Sol.cool.)
- EC FP7 ALONE (Sol.cool.)
- RT - SALTO (Sol.cool.)
RE-CORD
FIELDS OF INTEREST

• Biofuels and Bioliquids
• Thermochemical processes
Research areas in bioenergy & biofuels

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<th>BASIC &amp; APPLIED R&amp;D</th>
<th>DEMONSTRATION</th>
<th>EARLY COMMERCIAL</th>
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<td>Bioethanol</td>
<td>Lignocellulosic ethanol</td>
<td>Ethanol from sugar &amp; starch crops</td>
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<td>Diesel - type Biofuels</td>
<td>Biodiesel from microalgae</td>
<td>Syndiesel (from gasification + FT(^1))</td>
<td>Renewable diesel (by hydrogenation)</td>
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<tr>
<td>Biomethane</td>
<td>Gasification + methanation</td>
<td>Biogas upgrading</td>
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<td>Other Fuels &amp; Additives</td>
<td>Novel fuels (e.g. furanics)</td>
<td>Biobutanol, Pyrolysis-based fuels</td>
<td>DME(^2) Methanol</td>
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<td>Hydrogen</td>
<td>All other novel routes</td>
<td>Gasification with reforming</td>
<td>Biogas reforming</td>
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1. Fischer-Tropsch
2. Dimethylether

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2. Dimethylether
Pure Vegetable Oils

• Traction
• Energy production
LIFE-VOICE
Farm-scale implementation of the Extraction plant (DIN V 51605)
Re-esterified oils – OVEST project

- Alternative feedstock for oil production:
  - “Acid oils”, obtained by the edible oils processing
  - Waste cooking oils
  - Sludge oils

- “New - not edible - oils”
  - Good characteristic for the use in engines
  - Lower costs respect to PVO
  - Environmental sustainability
Vegetable and Re-esterified oils

- Adaptation of technologies
  - Standard reciprocating engines
  - Micro Gas Turbine = IBT-CAPSTONE 30 kWel
Use of Pyrolysis oil

• Traction
• Energy production
Thermo-chemical conversion of solid biomass => Pyrolysis Oil (PO)

- **Slow, Intermediate, Fast**

  - **Bioliquid for energy generation**

  - **Feedstock for bio-refinery**

- **Use in conversion technologies not demonstrated yet**
- **FP7 EU-Russian** cooperative project
- **Biomass Pyrolysis Oil (PO)**
  - LHV: 13-18 MJ/kg, 40-60 wt% O₂, 20-30 wt% H₂O, high viscosity, Ph 2-3
- **MGT fed by PO (RE-CORD)**
  - Modified 20 kWel GARRETT MGT
- **Oil Upgrading**
Next generation BioFuels

• BioDiesel
• BioEthanol
VO and Biodiesel from microalgae – MAMBO project

- High potential productivity (15-20 t_{oil}/ha VS 4-5 t_{oil}/ha palm oil)
- “MAMBO” project (supported by the Italian biodiesel producers).

GOALS of MAMBO project:

- Reduction of the energy consumption per kg of algae
- Definition of the chemical-physical oil characteristics for biodiesel production
- Design of a pilot plant
BioEthanol from Lignocellulosic feedstocks

Source: IEA-Bioenergy

PRIT project
XIX ISAF
International Symposium on Alcohol Fuels

Verona, 10-14 October 2011

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Organised by: European Commission & Brazil

Facilitated by: Mossi & Ghisolfi/Chemtex

Chairs: Dario Giordano & Kyriakos Maniatis

Organising Committee:
Mrs Soares Pinto, Hart Energy
Mr David Chiaramonti, University of Florence
Mr Marco Aurelio Lima, LNCTB
Mr Kyriakos Maniatis, DG ENER

Logistics: Verona Fiere & Media Consulta

Co-located with: International Symposium on Alcohol Fuels
RE-CORD
FIELDS OF INTEREST

• Biofuels and Bioliquids
• Thermochemical processes
Research areas in bioenergy

- Biomass Densification
  - Torrefaction
  - Pyrolysis
- Biomass to Heat
  - ORC
  - Stirling engine
- Combustion
  - Gasification
  - Steam cycle
- Gasification
  - IGFC
  - IGCC
  - IGGT
  - Gasification + Steam Cycle
- Co-firing
  - Indirect co-firing
  - Parallel co-firing
  - Direct co-firing
- Anaerobic Digestion (AD)
  - Microbial fuel cells
  - Biogas upgrading
  - 2-stage AD
  - 1-stage AD

Source: E4tech, 2009

1 Hydrothermal upgrading; 2 Organic Rankine Cycle; 3 Integrated gasification fuel cell; 4 & 5 Integrated gasification combined cycle (CC) / gas turbine (GT)

BIOENERGY – A SUSTAINABLE AND RELIABLE ENERGY SOURCE - A review of status and prospects - IEA BIOENERGY: ExCo: 2009:05
Adaptation of an interesting Indian gasification tech. to EU standards

Demonstration of reliability and availability with EU feedstock

Emissions control

Implementation of automatic devices (loading, control, etc)
Main Advantages

- Larger heating area respect to traditional downdraft gasifiers

=>

- Higher residence time
- Improved Tar cracking
- Better gas quality
**Gasifier details for 70kWe**

- **Capacity**: 100kg/hour
- **Power generation**: 70 kWe gas engine
- **Fuel consumption**: 1.2 to 1.3kg/kWh of BM
- **Gasifier turn down ratio**: 1:0.35
- **Gas average calorific value**: 1100 kcals/Nm³
- **Cold gas Tar**: <15 mg/Nm³
- **Cold gas particulate**: <15 mg/Nm³

Gas composition:
- CO: ~20%
- CH₄: ~3%
- H₂: ~20%
- CO₂: ~12%
Thermo-chemical conversion to improve solid biomass characteristics:

- Higher density
- Hydrophobic material after treatment
- Lower energy consumption for grinding

**Pyrolysis and torrefaction**

SEM analysis of torrefied BioMass
Design of a small lab-scale reactor for pyrolysis and torrefaction

- Batch reactor (1kg of dry BM)
  - $D_{in} = 250\text{mm}$, $L = 400\text{mm}$
  - $T_{max} = 600^\circ\text{C}$
- Automatic loading system (4 ltr)
- Electrical heaters
- Nr. 3 Thermocouple for monitoring
- PID Controller
✓ Innovativity of Pyrie plant
  ✓ Use of spheres for heat-transfer
  ✓ Improved design of the mixing system
Potential collaborations

• Development of **process controls** for our plants
• Development of **measurements systems** inside the machines and plants
• Development of **innovative processes** and **pilot plants** based on Renewable Energy Sources
RECORD

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