


Microgasturbine fed with liquid biofuels: conversion and testing


David Chiaramonti, Andrea Maria Rizzo
CREAR and RE-CORD, University of Florence (ITALY)
david.chiaramonti@unifi.it


Objective

To investigate the behaviour of biofuels as
fossil fuels-substitute in microturbines through the
selection, adaptation and testing of a small size MGT



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Summary


- ✓ Bioliquids
- ✓ Migro gasturbine selection and adaptation
 1. Combustor re-design
- ✓ Test of bioliquids
 1. Biodiesel
 2. Pure vegetable oil
 3. Blends of di biodiesel/vegetable oil
 4. Alcohol and Pyrolysis Oil
- ✓ Conclusion

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Bioliquids/Biofuels

Characteristic	Diesel (EN 590)	Biodiesel (various VOs)	Vegetable oil (sunflower)	Pyrolysis oil (pine, fast pyrolysis)
Density @15°C [kg/m³]	820-845	865	916	1207
LHV [MJ/kg]	42 (typ.)	36.3	37.2	17.7
v @20°C [cSt]	-	6.9	80.7	65.1
v @40°C [cSt]	2-4.5	4.2	40.6	20
Acidity [mgKOH/g] pH [-]	- -	0.38 -	4.44 -	2.85
Water [ppm]	<200	200	738	21.7 %wt
Flash Point [°C]	>55	>101	238.5	-
%O [%wt]	0	12.4	10.6	49.6

- ✓ Pure vegetable oil (high-oleic sunflower)
- ✓ Biodiesel from mixed oils (*Novaol*, EN 14214 compliant)
- ✓ Pyrolysis oil (*BTG*, fast pyrolysis of pine)
- ✓ Ethanol (99%)


Chemical and physical aggressiveness (erosion-corrosion), deposits (due to Ca, Mg, K), poor lubricity, high solid content, reduced compatibility with plastics and metals...

Higher flowrate


Preheating


Corrosion-erosion resistant materials

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Activities

Selection of appropriate materials (literature)

MGT selection

Original injector immersion test in PO

Design and construction of a new fuel line and components selection (pump, heaters, valves, pumping...)

MGT characterization with diesel

Instruments installation and set-up of the data acquisition system (DAQ)

Design and construction of control panels and auxiliary


Construction of the test bench (skid)

Test with biofuels


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MGT selection

The selection of the unit was driven by :

Minimal CC

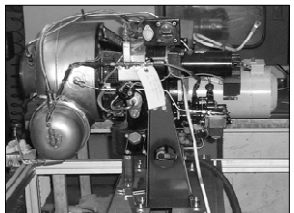
- ...minimum number of components to be modified

Silo combustor

- ...feasibility of mechanical modification (e.g. lengthening, redesign of the air access)

Engine lay-out

- ...servicing and access at hot parts (inspection/substitution)
- ...wide operating range



**Garrett-AiResearch
GTP 30-67**


Characteristics:

- Single injector, pressure swirl, reverse flow silo CC
- Fixed rotation speed, approx. 53000 rpm
- Follows the load by varying the air/fuel ratio in CC
- Direct coupling of turbine-AC generator
- AC Output : 25 kVA, 0.8 pF, 400 Hz, 120/208 V


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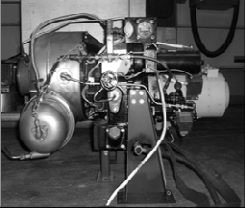
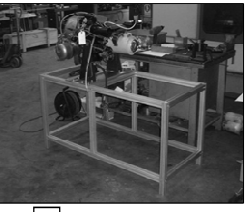
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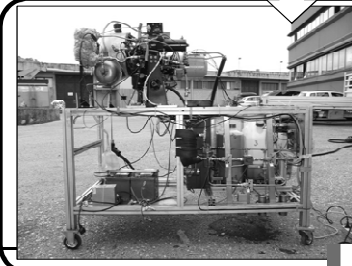




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Test bench set-up I












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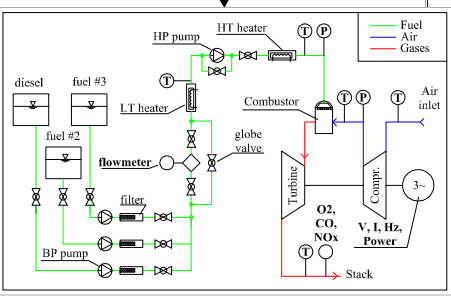


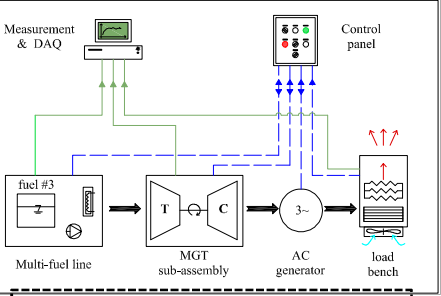
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Test bench set-up II

Interconnection of functional units

Localization of measurement points





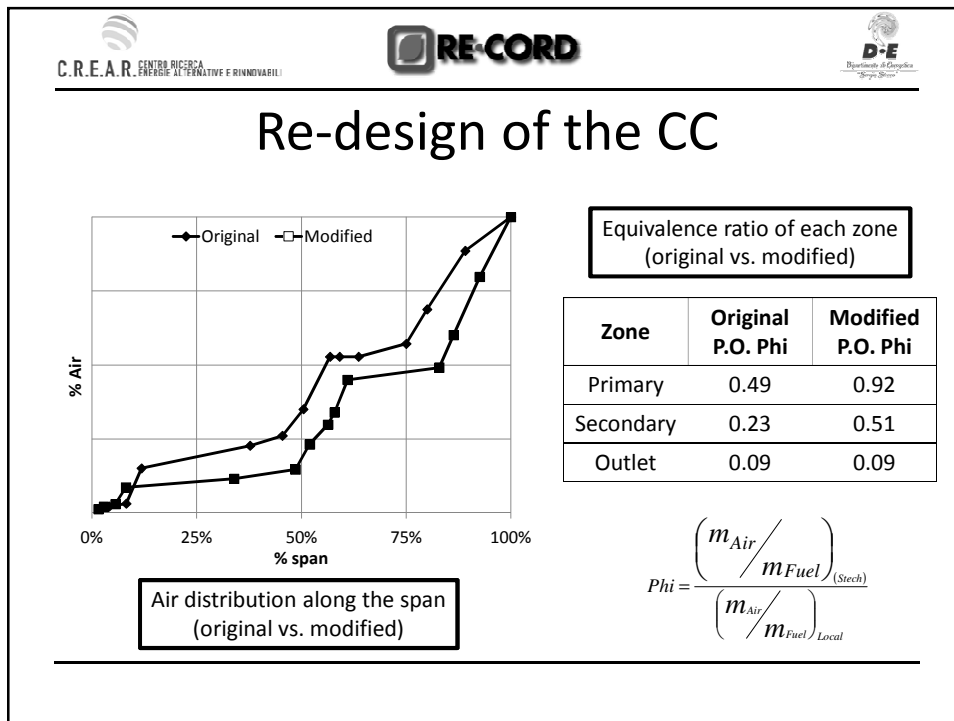
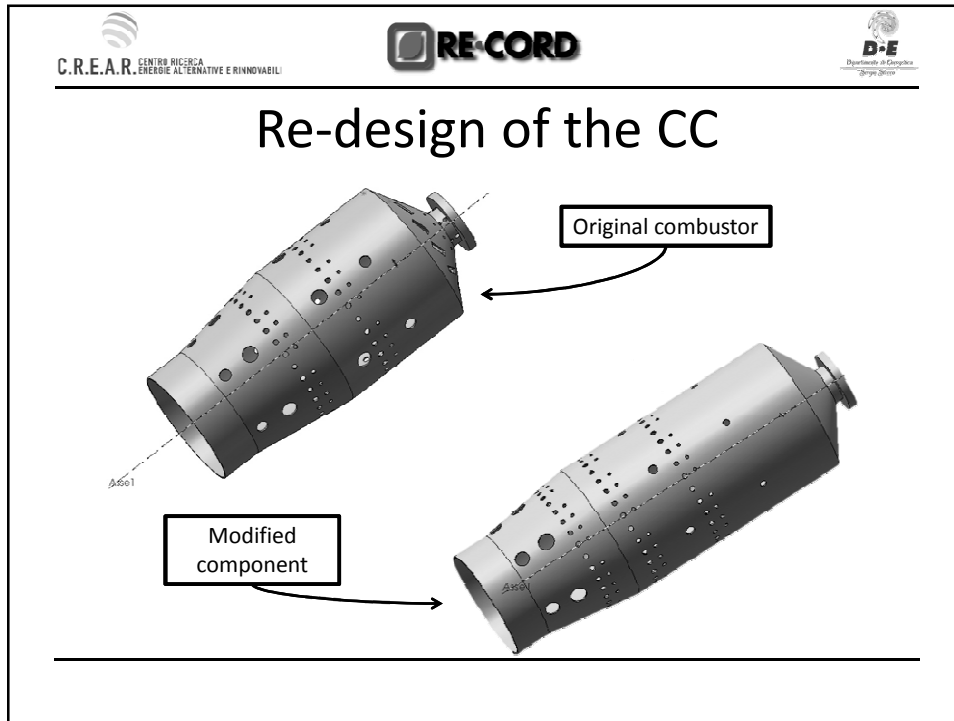
Mechanical modifications

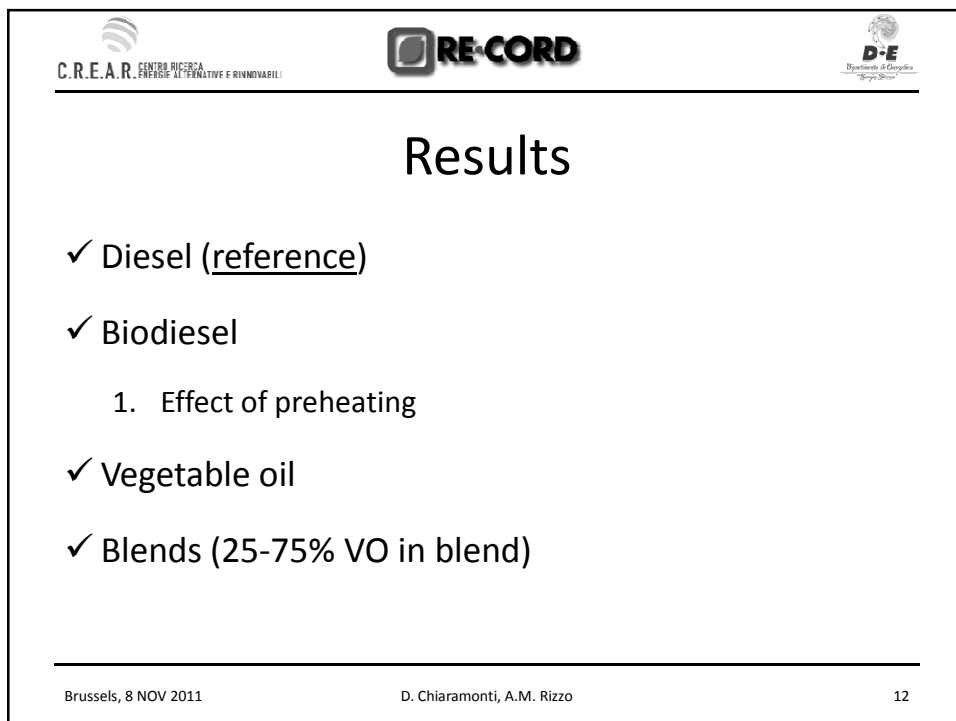
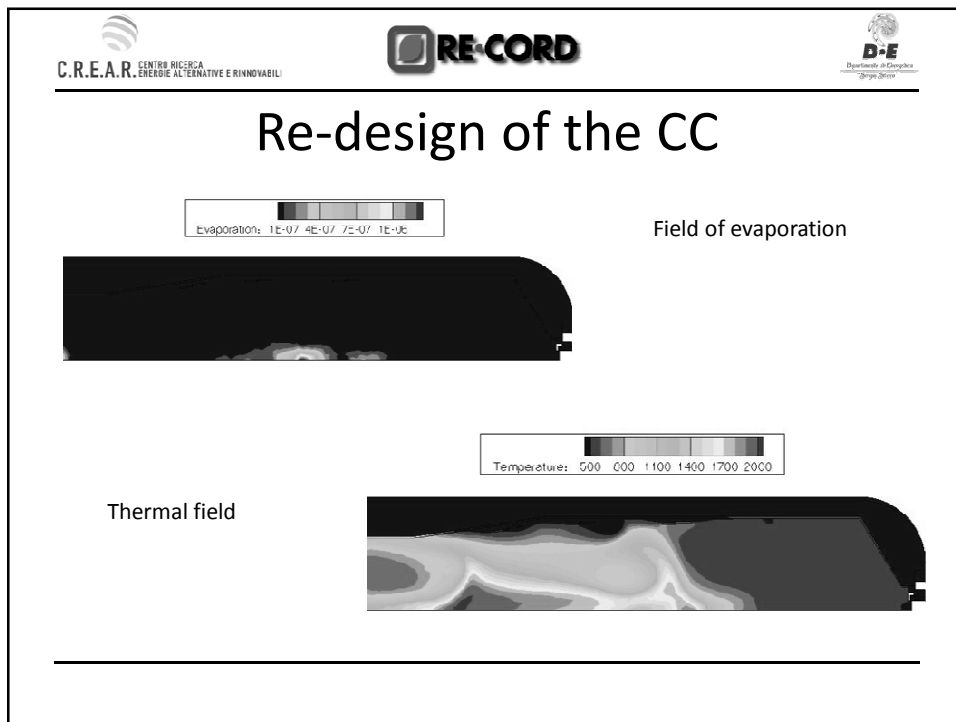
1. Instruments
 - Pressure transducers, thermocouples, fuel flowrate, gas concentration (exhaust)
2. Data acquisition system
 - National Instruments hardware and software
3. Auxiliary heaters
 - 2x Watlow Cast-X
4. Fuel line (pump, materials, storage tanks...)
5. Control/auxiliary panel and resistive load

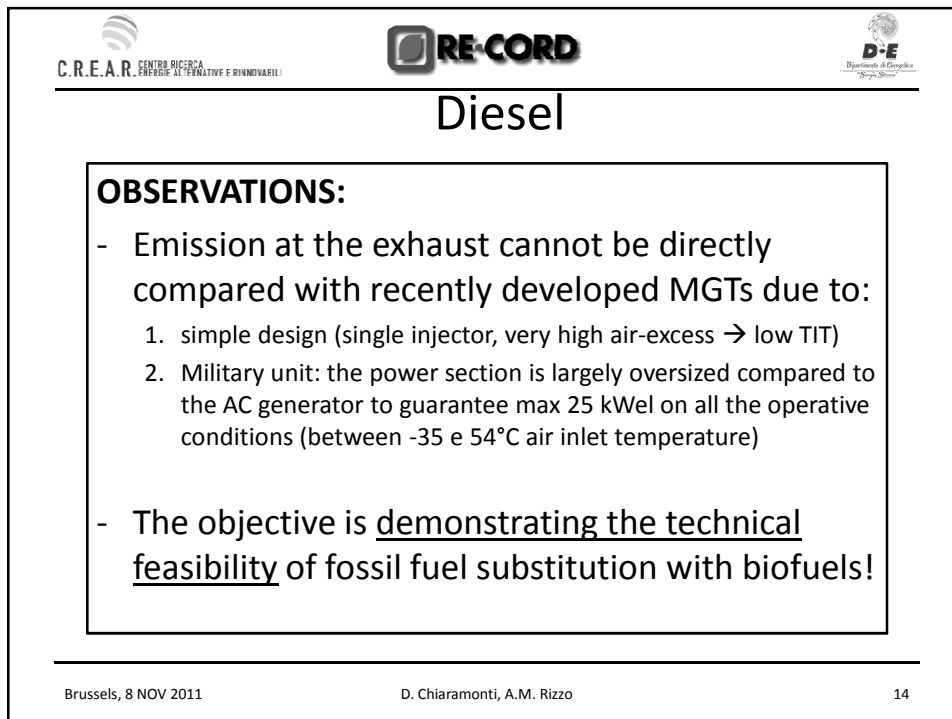
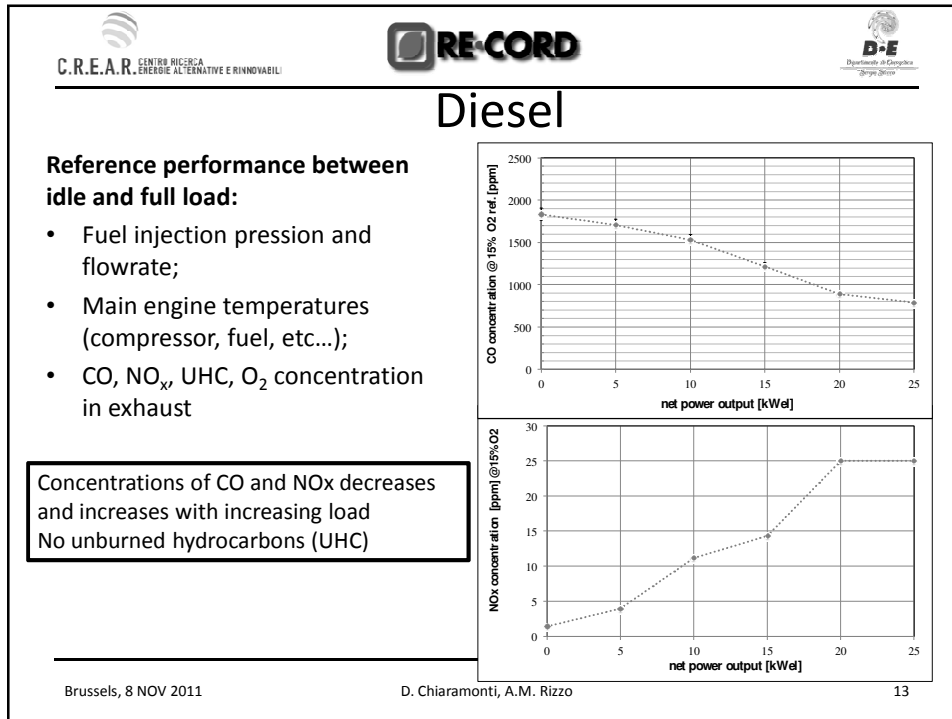
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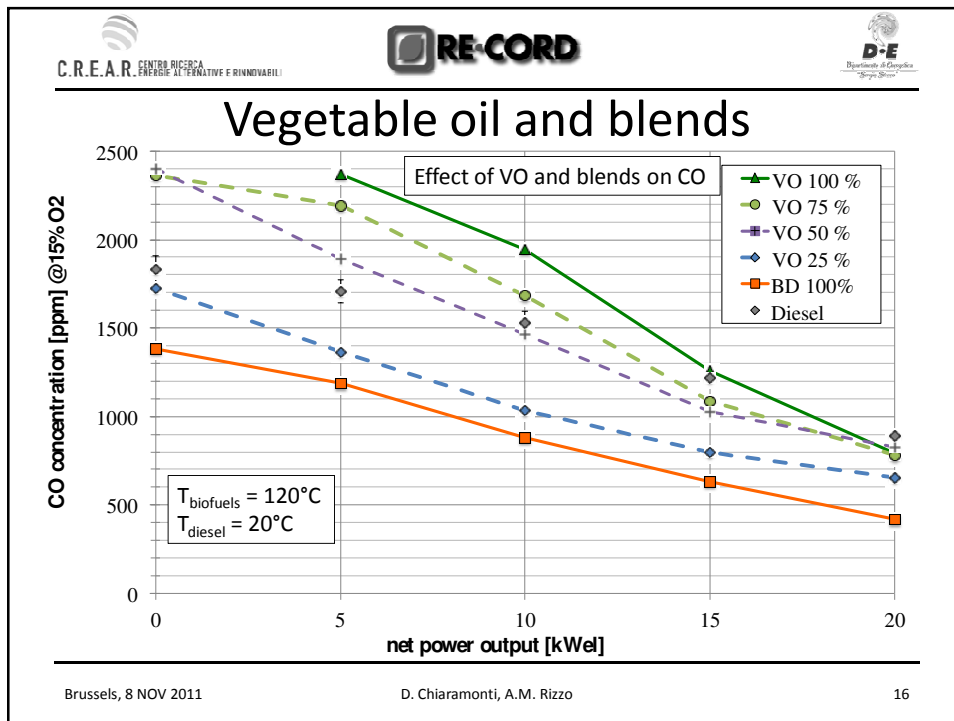
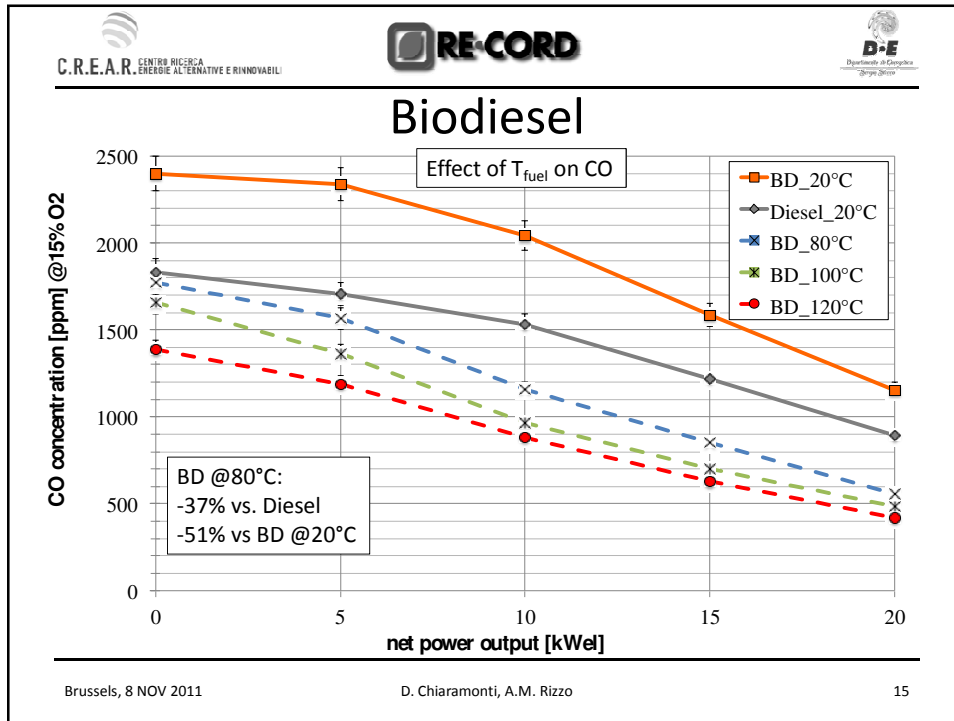
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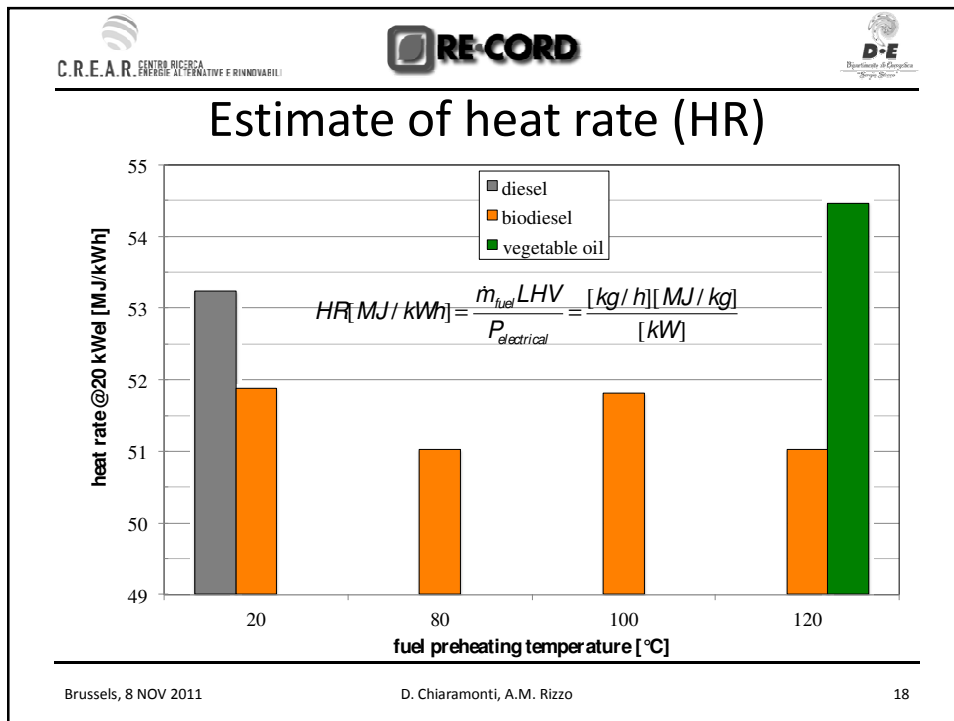
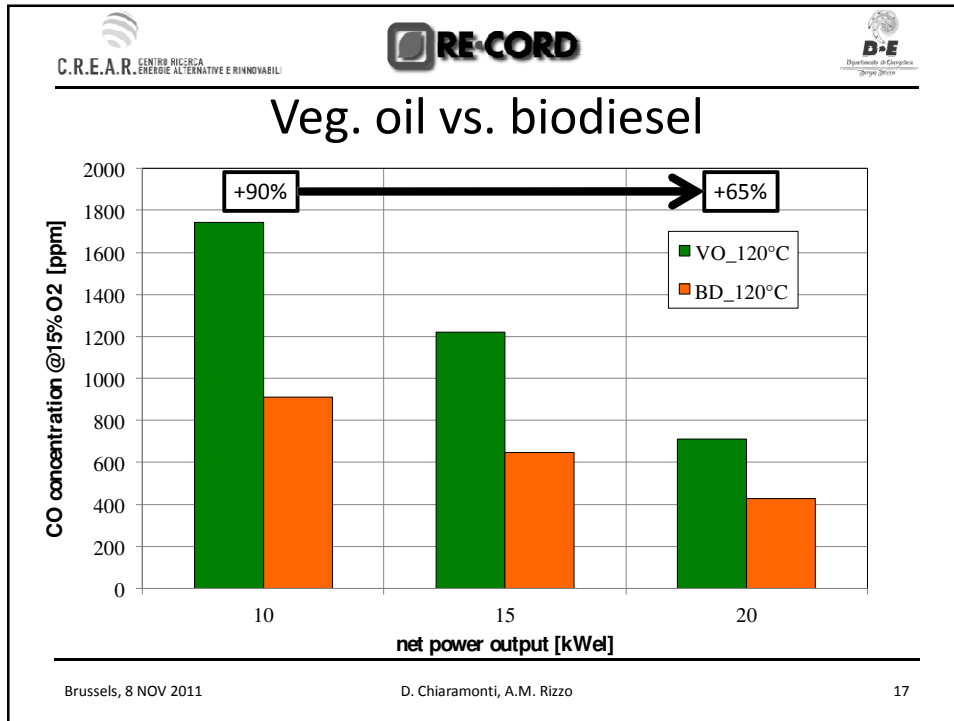
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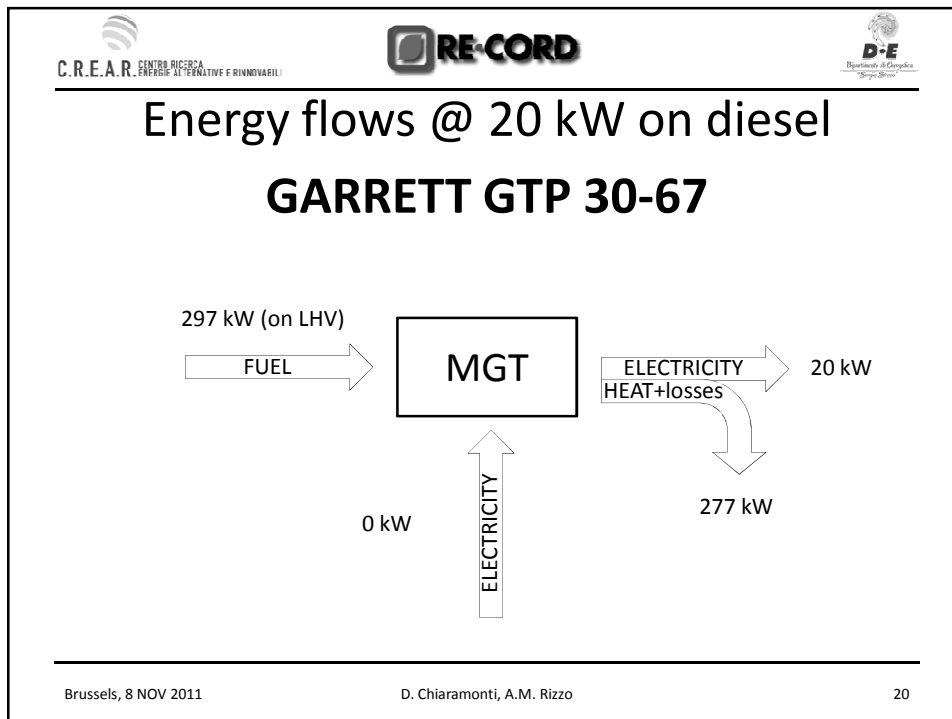
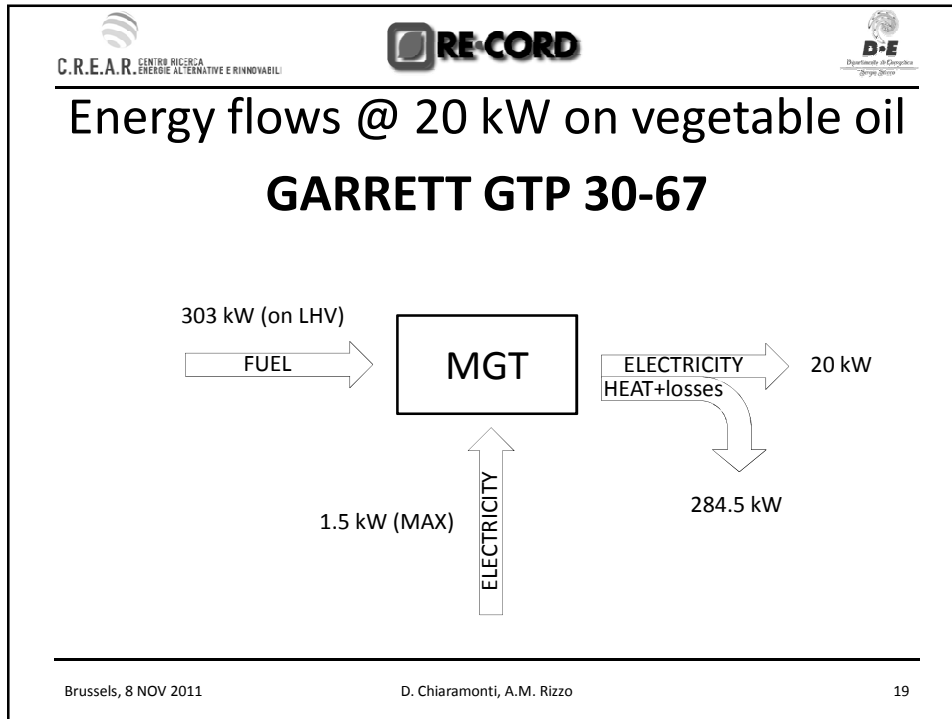


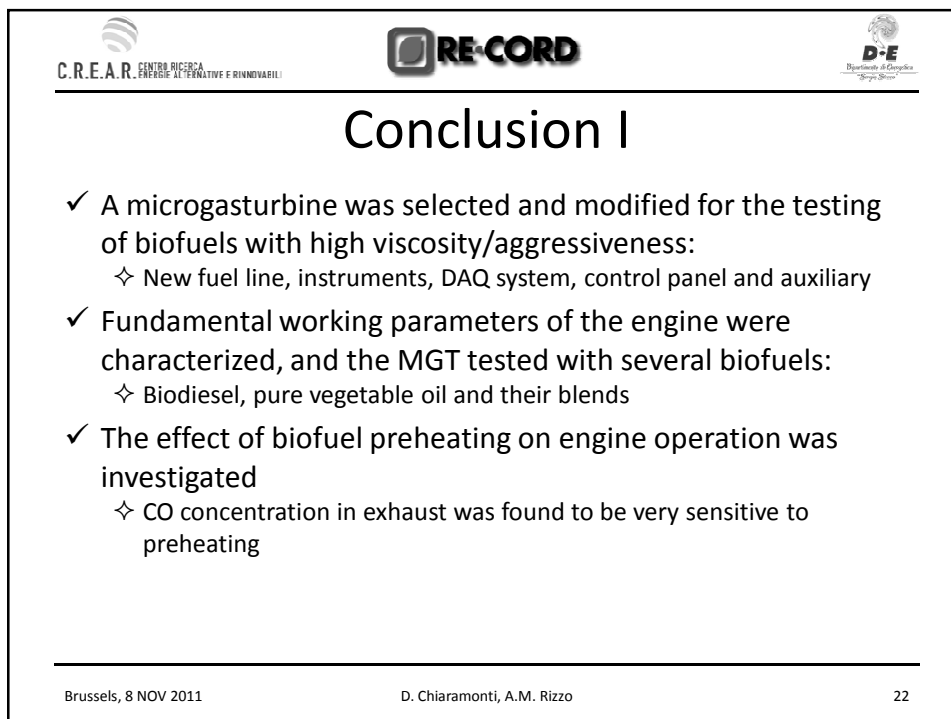
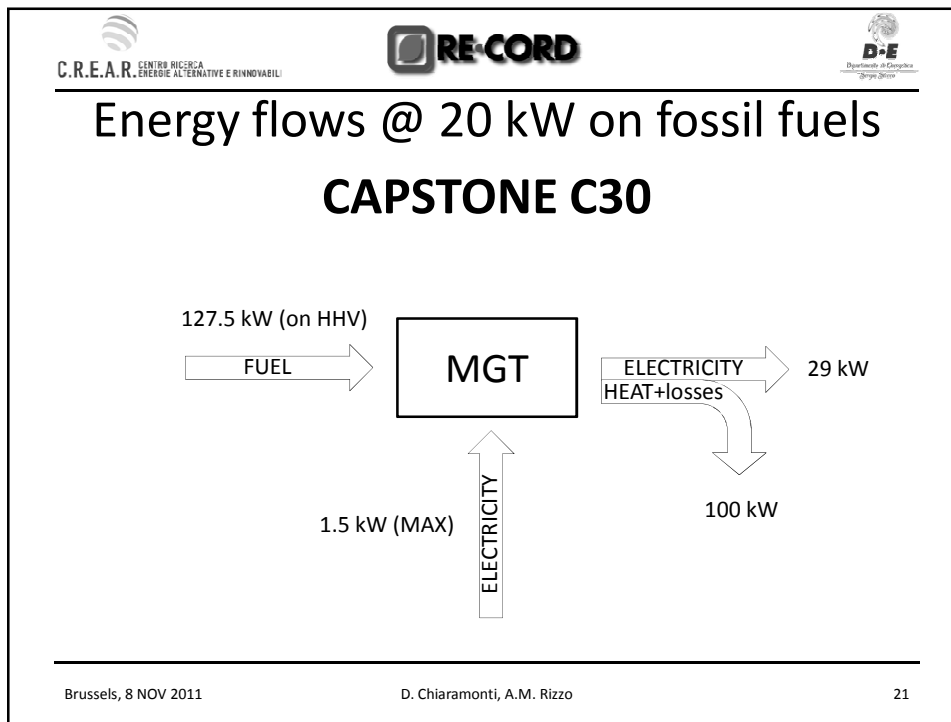

















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Conclusion II


- ✓ Biodiesel: effect of preheating at 20 kW:
 - ✧ CO concentration drops between -51% (80°C) e -64% (120°C) versus no-preheating;
- ✓ Biodiesel: comparison with diesel at 20 kW:
 - ✧ For the same fuel temperature (20°C) → CO concentration +30%;
 - ✧ With preheating → CO concentration between -37 % (80°C) and -53% (120°C);
 - ✧ Slight decrease of heat rate (approx. -1.5%)
- ✓ Vegetable oil and blends:
 - ✧ vs. diesel, CO conc. increases at part load, decreases at full load (-11%)
 - It is confirmed the possibility of using vegetable oil in MGT, further longer duration campaign are needed to back-up this result
 - ✧ vs. biodiesel at 20°C, measured CO concentrations are almost equal
 - Emission are comparable to those of a small reciprocating engine on VO (es. Kubota GL-7000)

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Thank You!

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