Reduction of the CO_2 emission by fueling small scale cogeneration blocks with bio-butanol blends

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Abstract

- The paper presents an experimental study and original interpretation concerning the environmental impact of a small cogeneration plant driven by a diesel engine loaded in various steps, when the primary fuel is partially replaced with bio-butanol blends;
- Using bio-fuels in addition to the fossil fuels, in special designed technologies, assures the reduction of the fossil originated CO_2 exhaust, supplementary other advantages are driven such as regional energy independence, lower cost, local utilisation of waste energy resources, new opening of business possibilities and working places, etc;
- The paper closes with conclusions regarding the optimum usage of bio-butanol blends for achieving the highest efficiency and lower emissions.

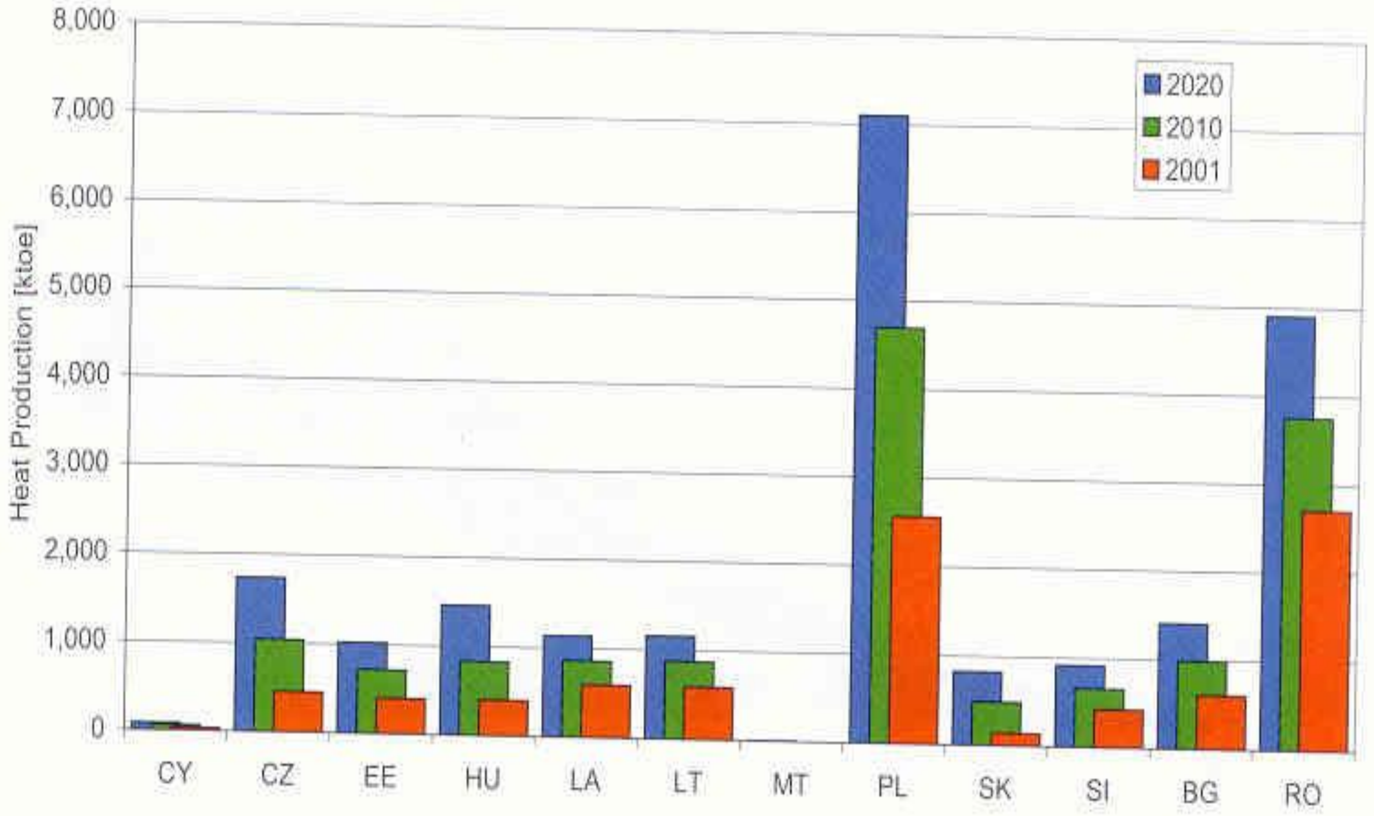
Necessity

- Among the available alternative energy sources to mitigate greenhouse emissions, bio-energy is the only carbon-based sustainable option.
- One possibility to reduce greenhouse-gas emissions is to substitute for ex. biomass for coal or butanol for fossil diesel in (small) co-gen units.

Main arguments for the research

- When fossil fuels burn they emit pollutants, including green house gases that are causing irreversible modification on the Earth climate;
- Countries without adequate reserves of fossil fuels are facing increasing risks to the security of their energy supplies;
- Their amount on earth is declining, as utilization is accomplished in an incomparable amount as their natural refresh.

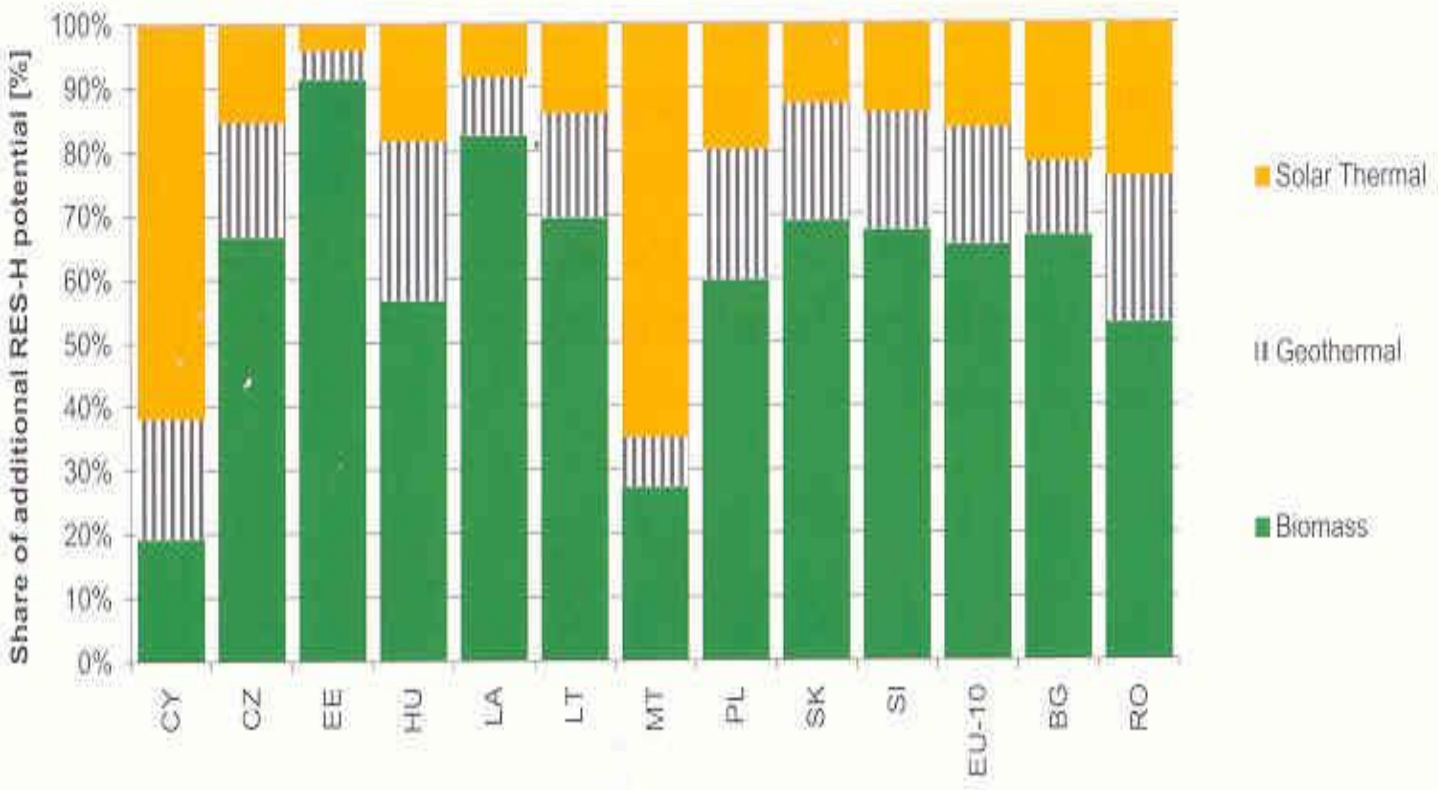
Country specific RES heat generation in EU -10 and Romania & Bulgaria



Country-specific RES heat generation in the EU-10 and Bulgaria and Romania under the policy scenario until 2020

•EU internet information, 2006

Share of the total realizable potential of RES



Share of the total additional realisable potential of RES-H in 2020 for EU-10 Member States & Bulgaria, Romania

•**EU internet information, 2006**

Possible solutions for CO_2 reduction

Energy Mix for Stationary Use
Future Options

- Nuclear power
- Non C - renewables
  - --hydropower
  - --wind power
  - --solarpower
  - --others

  } CO_2 - free

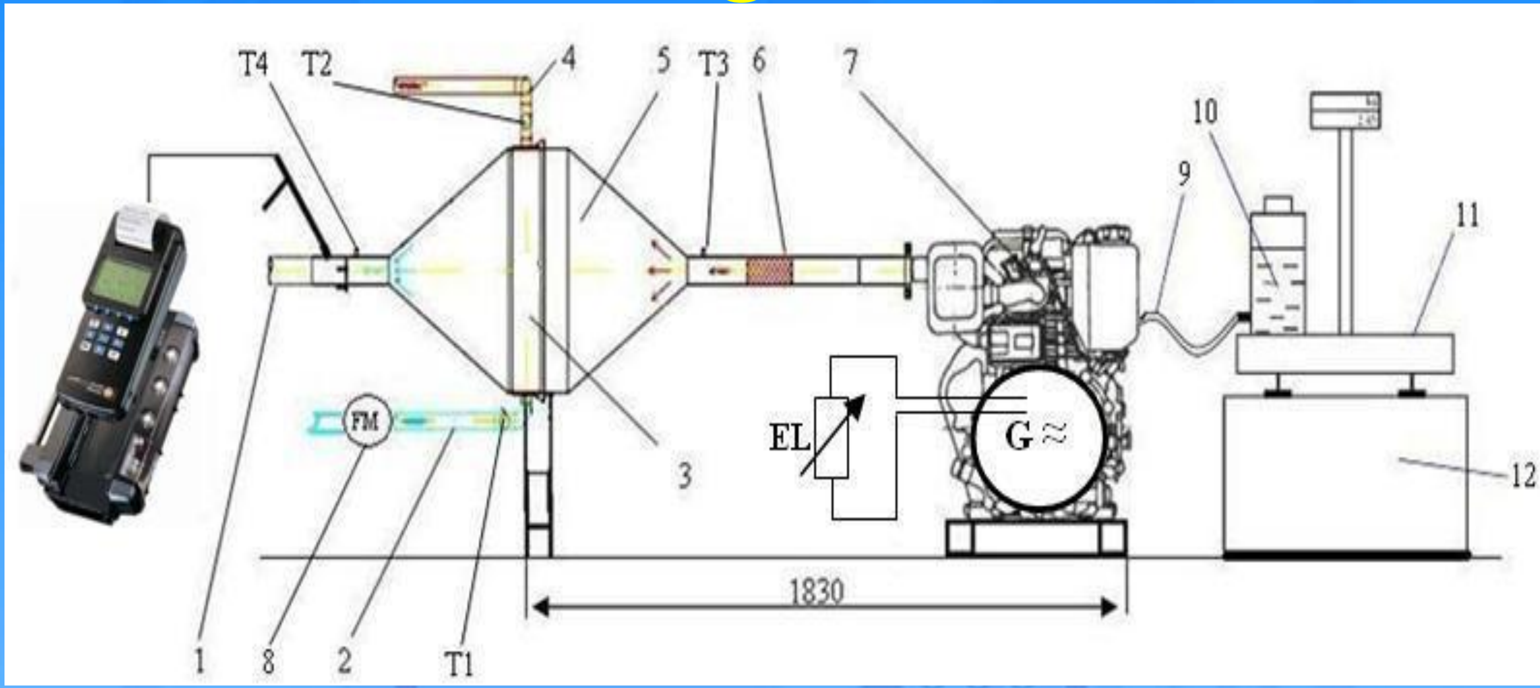
- C - renewables
  - --biomass
  - --garbage wastes

  } „CO_2 - neutral"

- Fossil resources
  - --natural gas
  - --solids

  } „CO_2-rich" → CO_2 lean → „CO_2 - free"
  (< 2010) (> 2020)

Co-generation plant with diesel internal combustion engine



1- Exhaust gas outlet, 2- Water inlet (cold), 3- Heat exchanger, 4- Water outlet (warm), 5- Nozzle, 6- Engine vibration absorber, 7- Diesel engine, 8- Water flow meter, 9- Fuel pipe, 10- Additional fuel tank, 11- Electronic weightier, 12- Weightier frame, G- electric generator, 13- Electric load, T1,T2- Thermocouples for water, T3,T4- Thermocouples for exhaust gases.

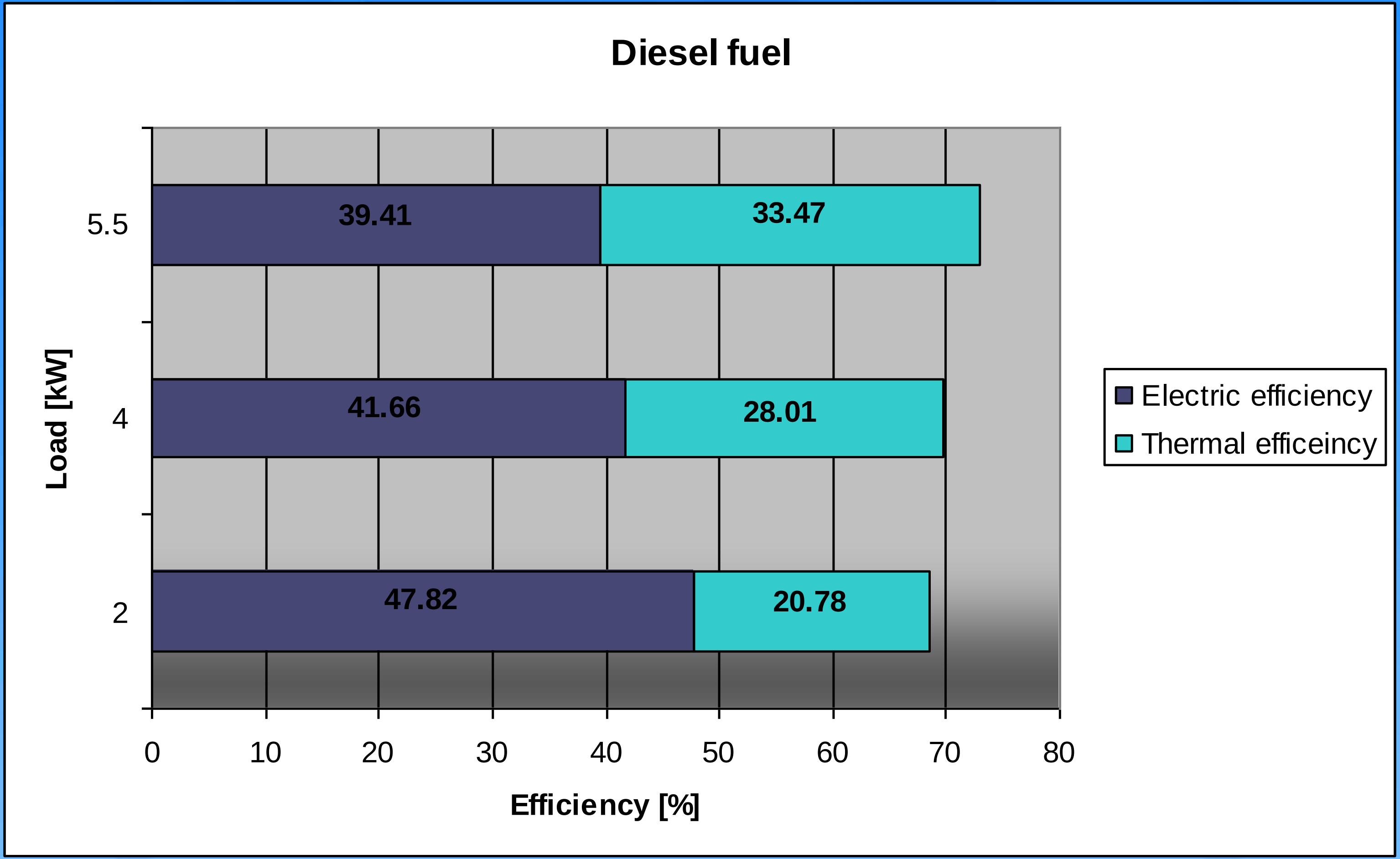
Butanol

- It is a primary alcohol with a 4 carbon structure and the molecular formula of **C_4H_9OH.**
- It belongs to the higher alcohols and branched-chain alcohols.
- It can be produced by fermentation of biomass by a process that uses the bacterium Clostridium acetobutylicum, also known as the Weizmann organism.
- Butanol is appropriate to be used as a fuel in an internal combustion engine.
- Because it’s longer hydrocarbon chain causes to be fairly non-polar, it is more similar to gasoline than it is to ethanol.
- The challenge of the experiments consisted in the bio-etanol utilization in diesel engines, replacing a part of the fossil diesel.

Measurement plan

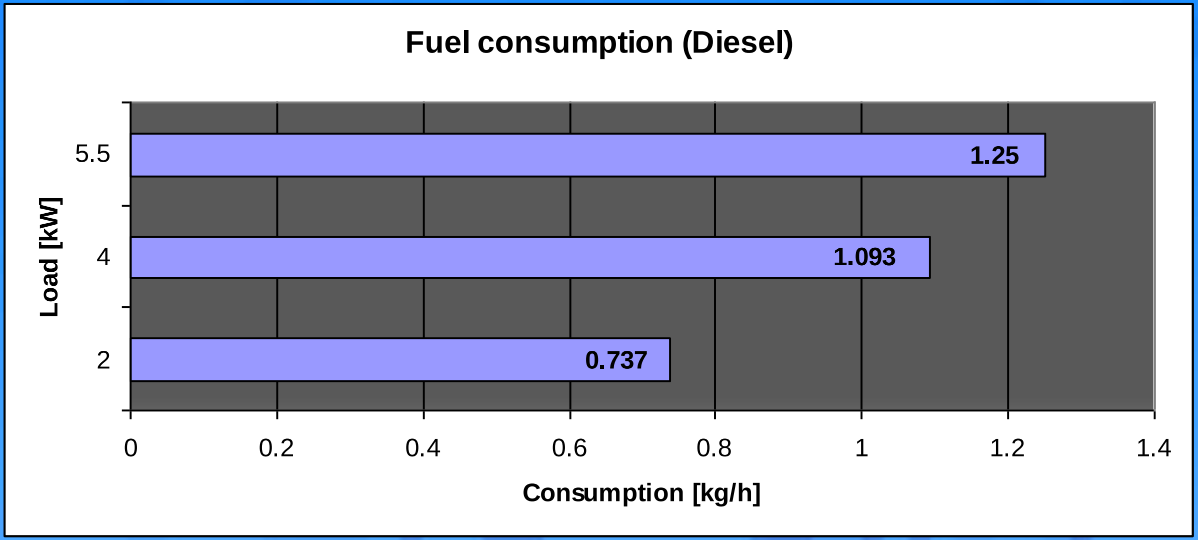
- The concentration of butanol by volume parts in diesel was increased in two steps: 5 %, 10 % by volume parts butanol in diesel.
- In order to achieve comparative results, for each regime (load 2; 4; 5.5 kW) one established comparable operating conditions for all tests.
- The comparison is achieved in reference to a standard fossil fuel (100 % diesel) test, in similar load conditions.
- The load was adjusted for three levels, thus totally in the cogeneration plant one tested and compared 3 x 3 (3 reference) = 9 study cases.

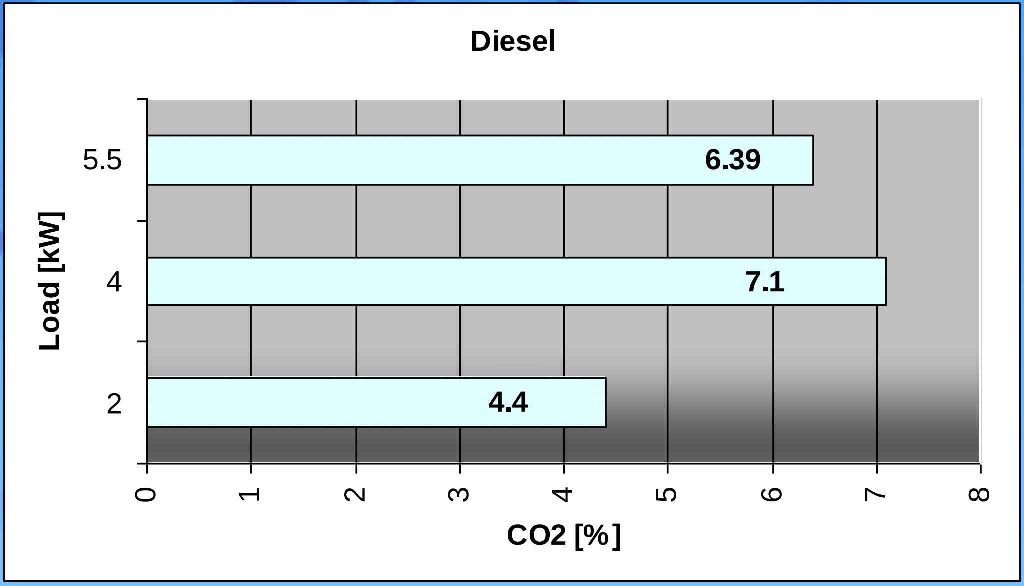
Efficiency of the cogeneration plant for the reference fuel



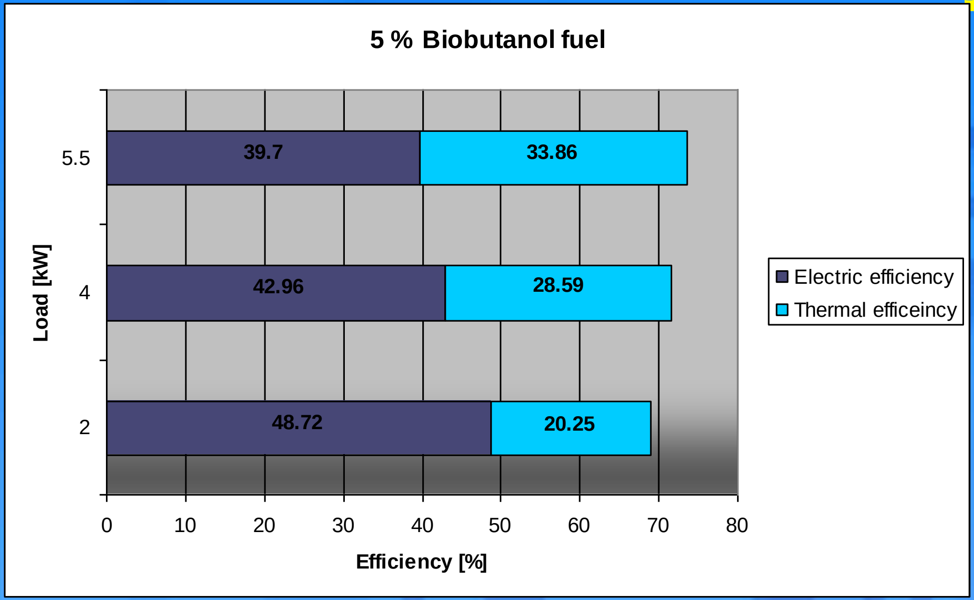
Efficiency of cogeneration is improved for the 5.5 kW (nominal) load.

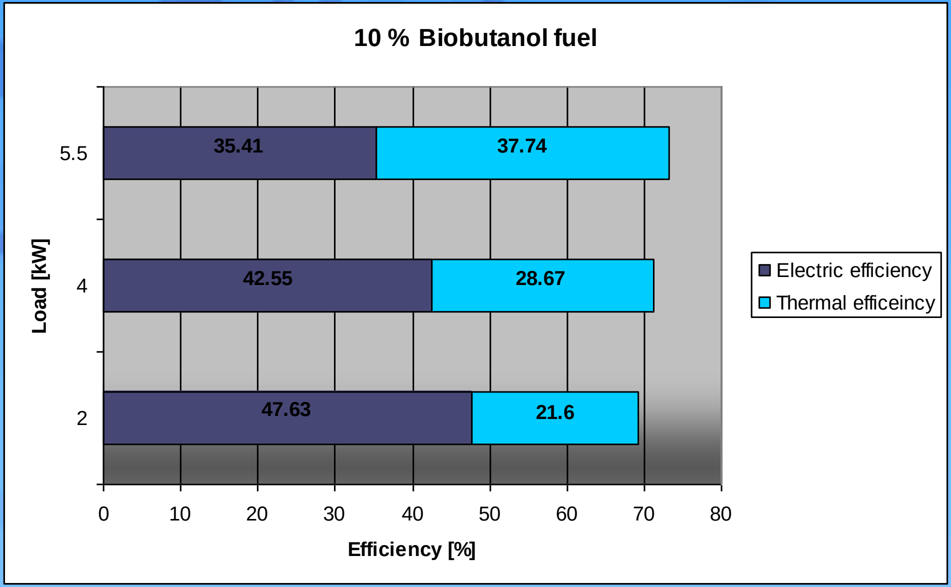
Fuel and CO_2 consumption for the reference fuel



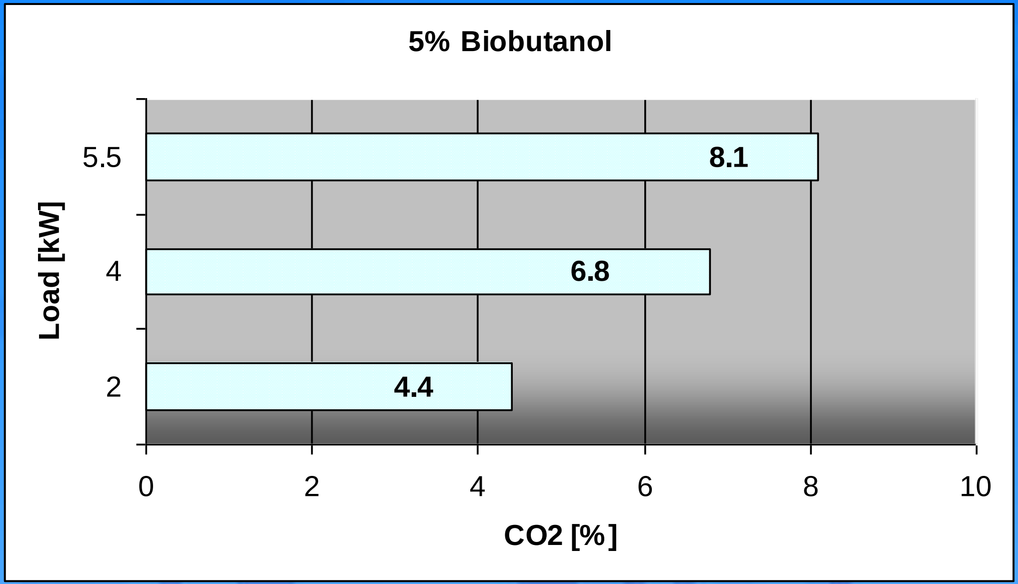


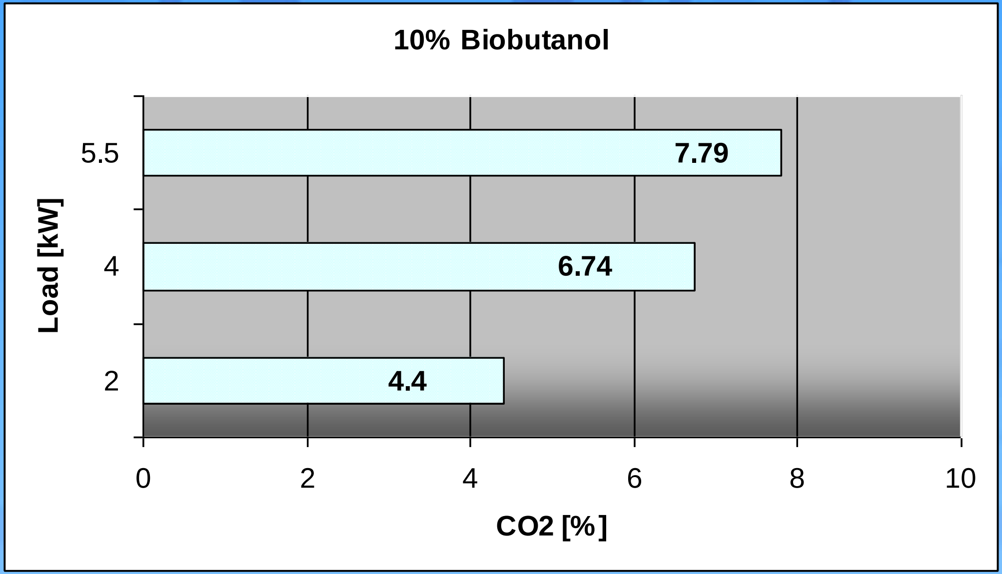
Comparative results for efficiency



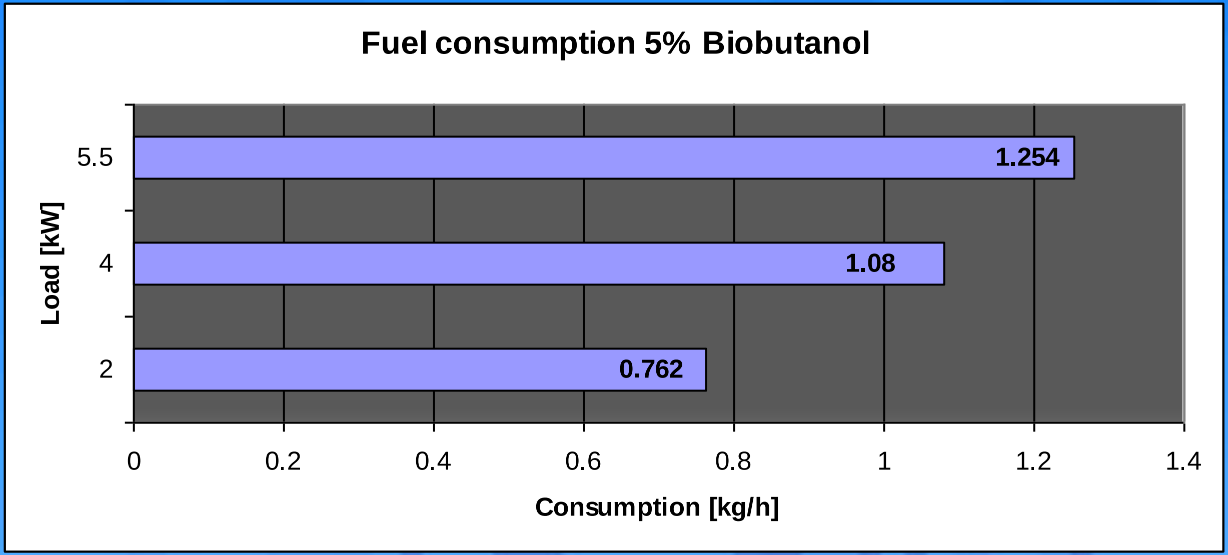


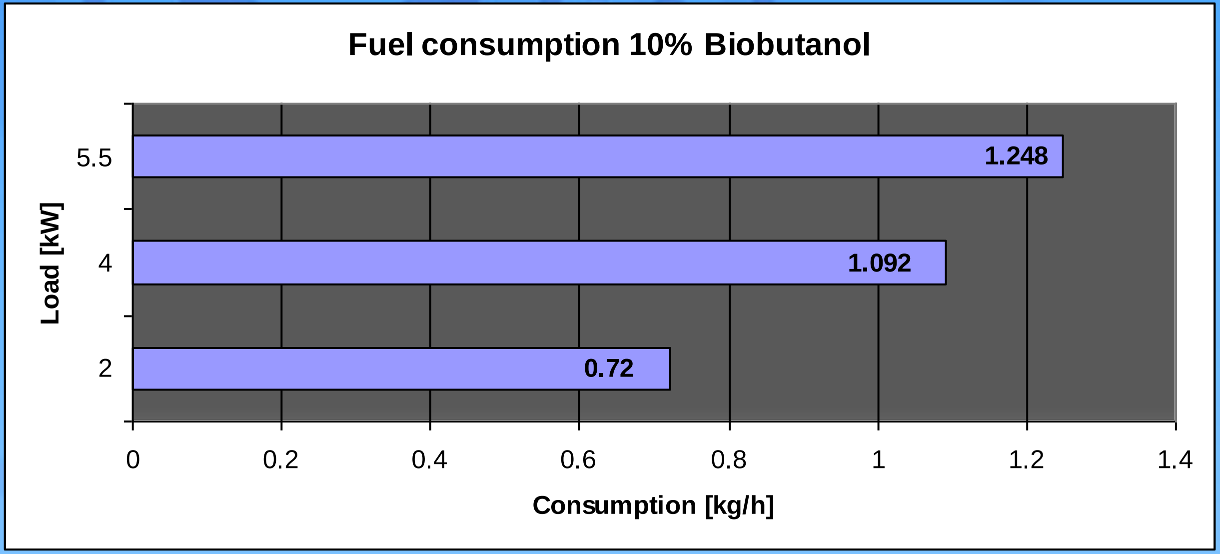
Comparative results for CO_2



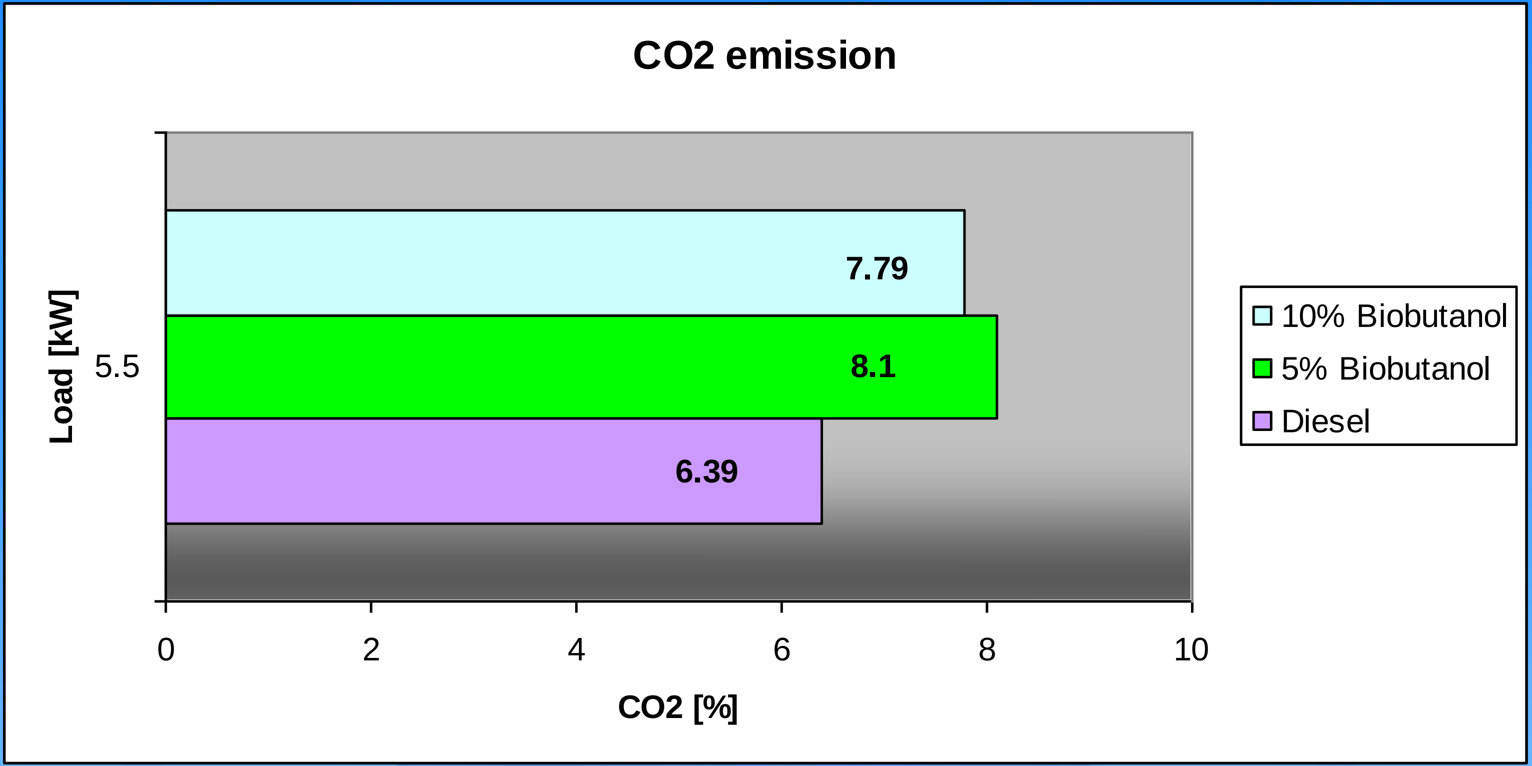


Comparative results for fuel consumption



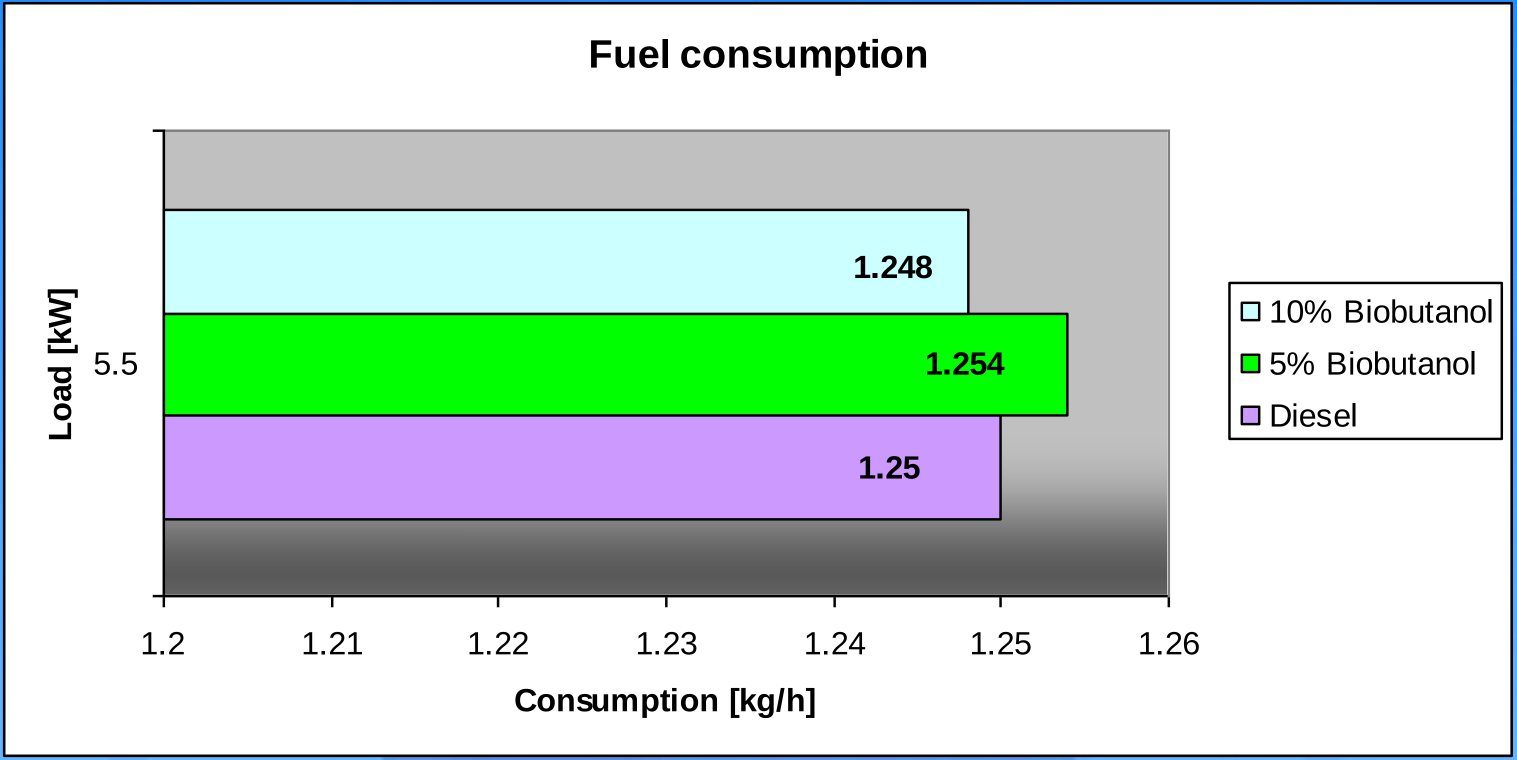


Conclusions regarding CO_2 emission



Lower CO_2 emission at 10 % percent bio-butanol in diesel in comparison with the 5 % situation

Conclusions regarding fuel consumption



One accomplished a fossil fuel reduction by 10 %, without affecting the total efficiency of the cogeneration plant, and in the same way a reduction of CO2 emission.

General conclusions

- The advantages regarding the CO_2 emission are in accordance with the demands imposed by Directive 2003/30/EC;
- The fuel consumption remained slightly the same as the percentage of bio-fuel in diesel is increased;
- Blending solid or liquid fossil fuels with corresponding bio originated fuels in different applications (from small to large scale) is possible.
- Combined combustion of bio-originated fuels with fossil fuels is a quick and relatively reliable way to reduce greenhouse gas emissions and preserve natural resources.

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