Clean and efficient microCHCP by micro turbine based hybrid systems.

EUBCE
31st European Biomass Conference & Exhibition

Dr Michel Delanaye, MITIS SA

Fit4Micro

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Fit4Micro

Project overview

- Context
- Solution
- Project structure
- Key Technical Work
- Impact

- RIA 9 partners
- Budget: 4 993 387.50 EUR
- Duration: 48 months
- 1/10/2022

Hybrid heating & cooling to meet 2050 targets

- Reduce energy consumption :
  - Lower heat demand
  - More efficient heating supply
  - Better distribution networks
- Replace fossil fuels
  - mix of green electricity
  - low-carbon gases
  - biofuels from biomass/biogas

→

- Massive deployment of heat pumps (HP)
  - Well insulated buildings
  - High burden of elec grid
- Hybrid heating (HP + boiler)
  - High temperature heat
  - High burden of elec grid
- Hybrid Micro-CHP (HP + micro-CHP)
  - High efficiency power & heat
  - Supply electricity to HP

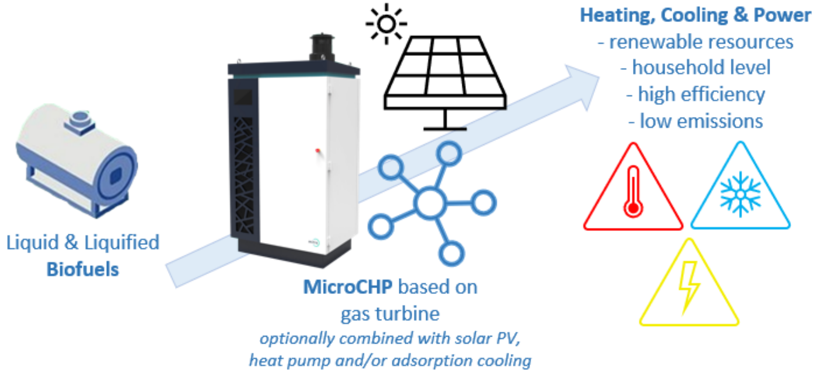
Objectives

- Design and demonstrate at TRL5 a highly efficient **micro combined heat/cool and power system** working on renewable energy.

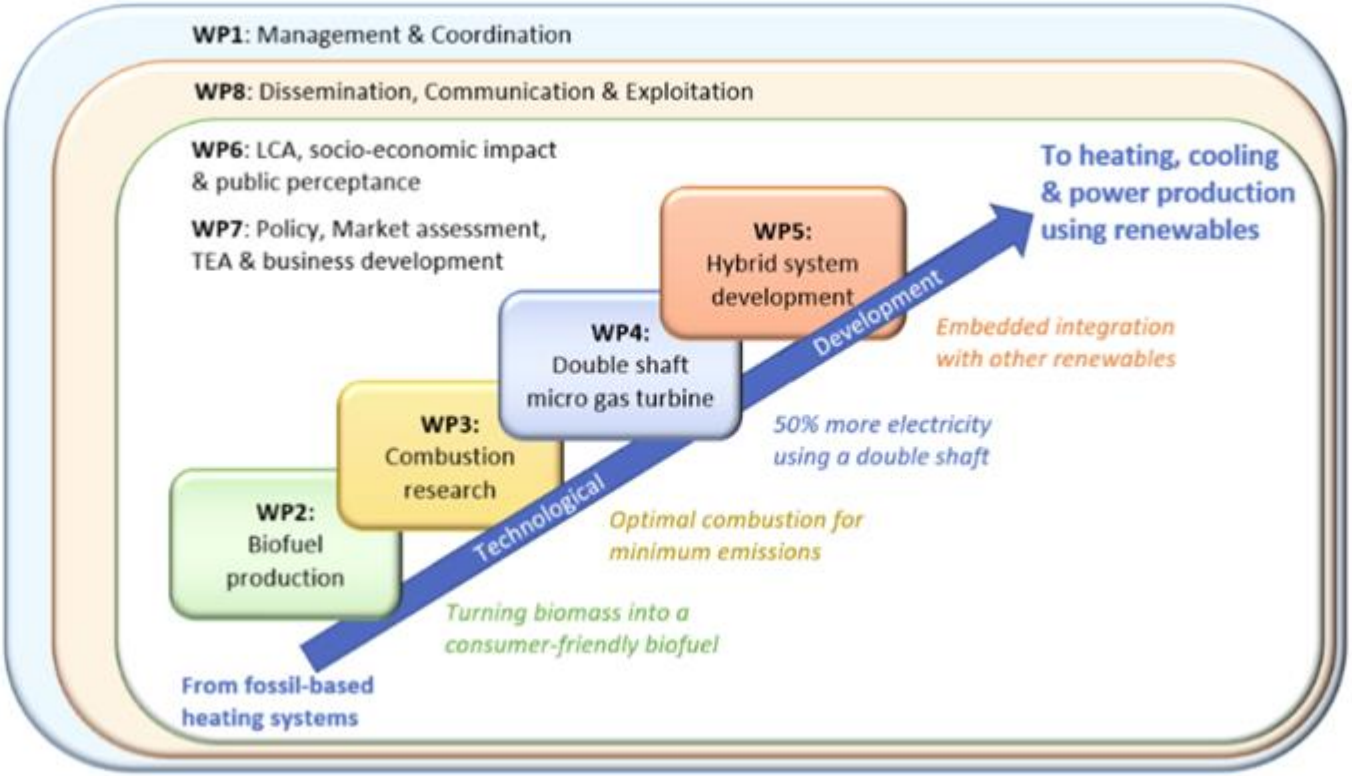
- User-friendly, generating the highest comfort levels, while keeping total cost of ownership to a minimum to ensure significant penetration of renewables at household level.

The FIT4Micro system: Hybrid micro-CCHP system

- A micro gas turbine with Intercooled Regenerative Reheat cycle and humidification for high efficiency and flexible heat/power ratio
- Flameless combustion to minimize emissions (NOx, soot)
- Use liquid biofuels produced by fast pyrolis of wood or other waste
- Combined with vapor compression heat pump and adsorption for efficient chiller
- Combined with photovoltaic for power integration



Project structure



New generation of HPO biofuels

btg biomass technology group

Science4Fuels OWI an der RWTH Aachen

- To produce hydrotreated HPO from woody biomass as reference case for the combustion tests
- To lower the severity of the hydrotreatment process, limiting the overall hydrogen consumption
- To remove inorganic contaminants from FPBO, allowing the use of residual biomass materials and protect hydro-processing catalysts
- The removal of nitrogen by HydroDeNitrofication (HDN) to avoid fuel-NOx formation upon combustion

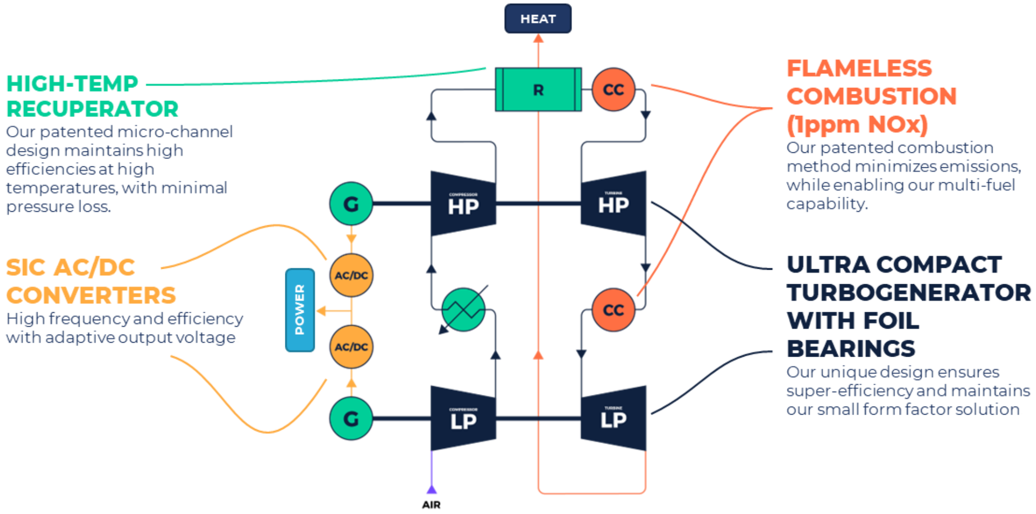
SO-4: Production of truly sustainable 2nd generation liquid biofuels suitable to fuel the microCHCP system

✓ *Ex: KPI-4a: Production of **HPO with LVH > 40 MJ/kg** from residual biomass materials.*

SO-5: Achieving economically competitive operation for the microCHCP system.

✓ *KPI-5b: Producing biofuels with cost price < 22 €/GJ **(~0.08 €/KW$_h$)***

Humidifed Intercooled Regenerative Reheat Gas Turbine Cycle



- Develop and demonstrate the efficiency of the IRRGT cycle
- Add humidification for efficiency and flexibility in heat/power ratio

SO-1: Validation of the hybrid microCHCP (relevant environment)

- ✓ *Ex: KPI-2a: Achieving at least **40%** electrical efficiency.*

SO-3: Flameless combustion of liquid biofuels with same or higher efficiency than natural gas in the gas turbine cycle.

- ✓ *Ex: KPI-3b: Pollutant emissions to be 50% of the actual norms or lower, with **NO_x < 60 mg/kW$_h$ fuel***

SO-5: Achieving economically competitive operation for the microCHCP system.

- ✓ *KPI-5a: Investment costs for the microCHCP < 2500/**500 €/KW$_e$** for a 20 KW$_e$ system, achieving pay-back times < 10 years.* (*)

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Integration and technico-economic assessment

- Design at least 2 hybrid systems and variants for different use cases
- Develop robust and efficient control strategies
- Test a system demonstrator for two most promising use cases in a laboratory environment
- Optimize and evaluate systems based on system simulations

- SO-6: Demonstrate and validate the sustainability of the HPO-fuelled microCHCP system by detailed LCA assessment.

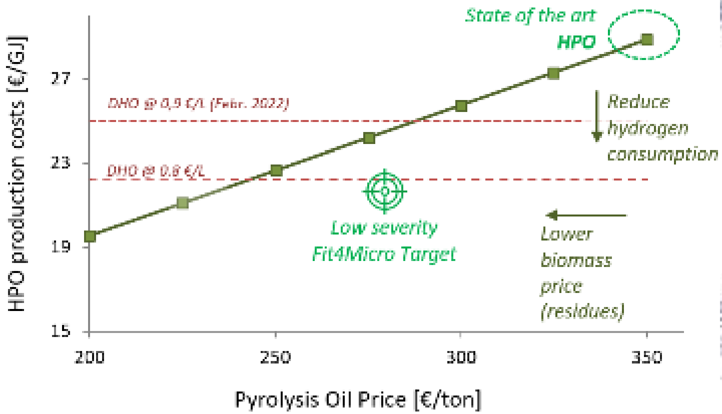
✓ *KPI-6a: Primary energy savings > **100%** through improved fuel utilization efficiency.*

✓ *KPI-6b: GHG emission savings > **80%** compared to using domestic heating oil fuelled CHP system with similar H:P ratio (55% heat, 35% electric).*

✓ *KPI-6c: Reduction of GHG emissions for cooling by **100%** compared to compression cooling by using water as refrigerant.*

Impact

- Increased technical performance, robustness, feasibility and penetration of renewables at household level
  - Replacing conventional oil-fired boilers by modern high efficiency hybrid microCCHP systems using liquid biofuels
- Increase technology leadership and competitiveness of European industry
  - MITIS (micro-CHP), BTG (HPBO fuels), Fahrenheit.cool (adsorption chillers)
- Increased production share of renewables at consumer level
  - Decrease HPO price, widening residual waste cost & green H2
- Increased socioeconomic and environmental sustainability of renewables-based energy systems at household level
  - Replacing DHO by HPO
  - Using low emissions flameless combustion
  - Use forest residues and bark for HPBO & green hydrogen to reach 15gCO2eq/MJ biofuel (ok for 80% GHG cut wrt oil based)



Thank you!

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info@fit4micro.eu

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