Fit4Micro solution for a microCHCP hybrid heating system running on biofuels

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EUBCE 33rd European Biomass Conference & Exhibition

33° European Biomass Conference, 9—12 June 2025, Valencia Spain

Fit4Micro

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Switching fossil fuel off means ….
Multiple combined solutions

Fit4Micro

- Reduce energy consumption :
  - Lower heat demand
  - More efficient heating supply
  - Better distribution networks
- Use organic carbon fuels:
  - mix of green electricity
  - low-carbon gases
  - biofuels from biomass/biogas
- Increase use of electric or hybrid heat pumps

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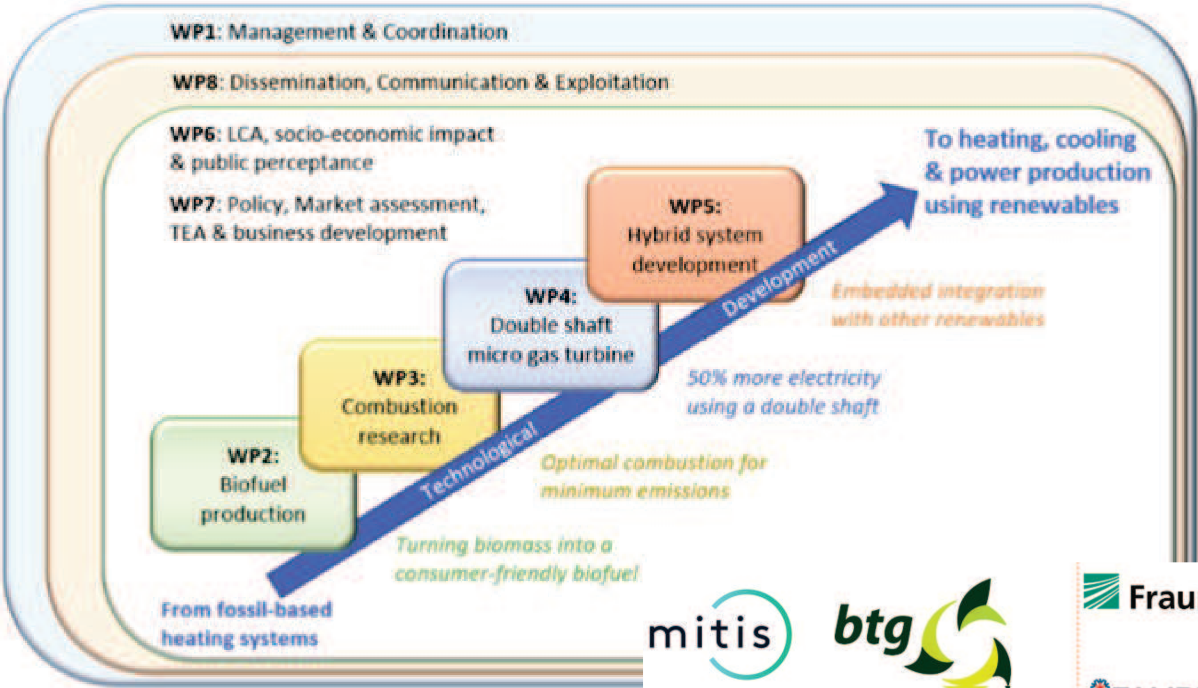

Fit4Micro

- RIA 9 partners
- Budget: 5 MEUR
- Duration: 48 Mths
- 1/10/2022

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WP2: Biofuel production

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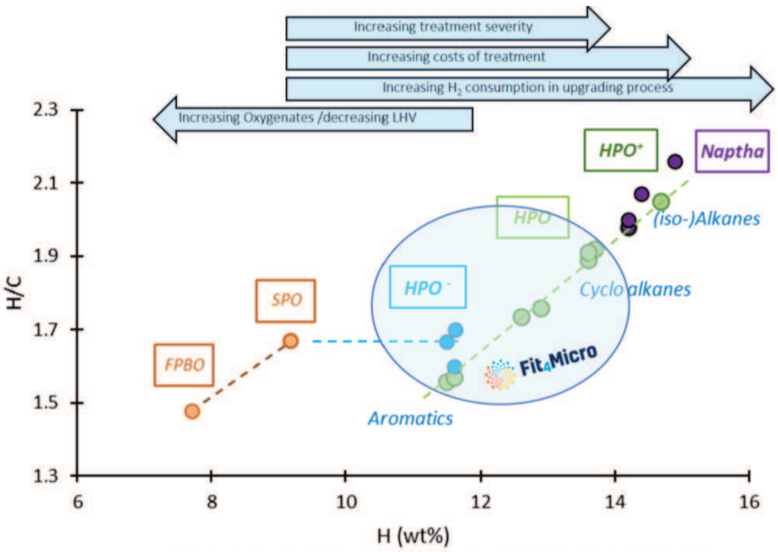
SO-4: Production of truly sustainable 2nd generation liquid biofuels suitable to fuel the microCHCP system

✓ *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$_h$)***



Product qualities as function of hydrogen content

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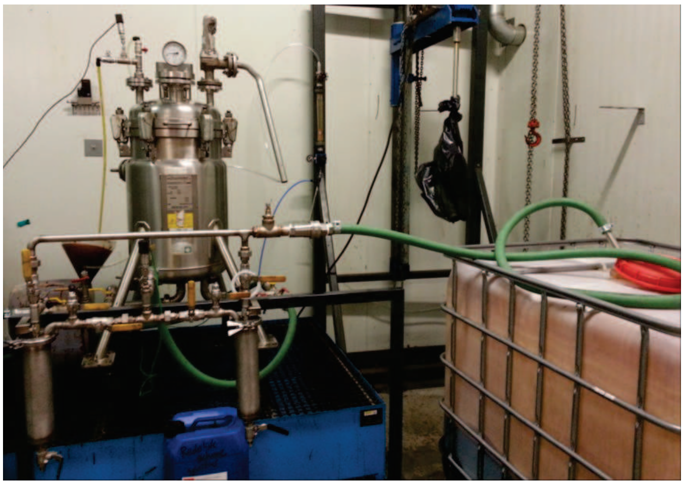
WP2 (contd.): Production HPO (Hydrotreated Pyrolysis Oil)

- Production of hydrotreated pyrolysis oil (HPO)
  - Reference quality (task 2.1) *current SOTA*
  - Low severity (task 2.2) *lowering fuel costs*
  - From residues (task 2.3) *lowering fuel costs*
  - Nitrogen removal (task 2.4) *limiting emissions*



WP3: Biofuel combustion research

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***

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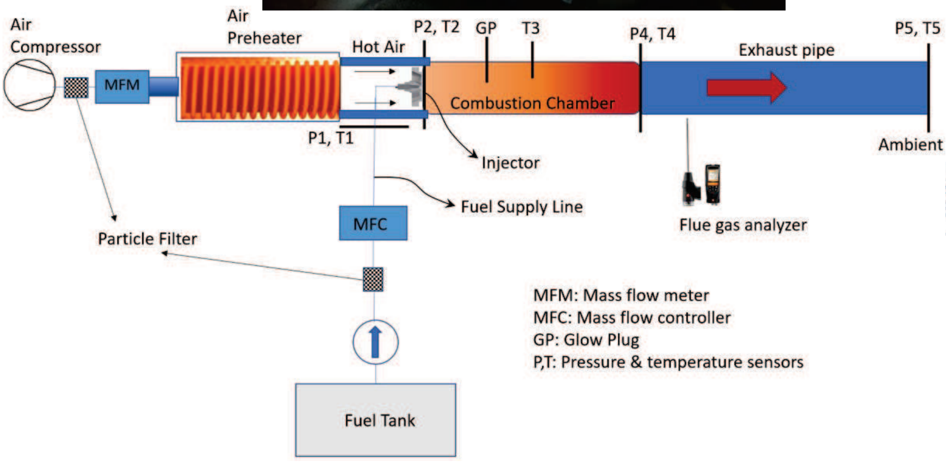

WP3 (contd.): Biofuel combustion research

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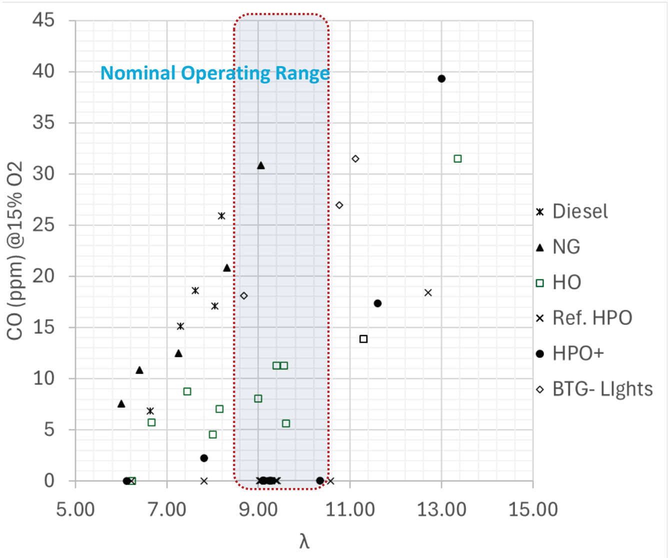

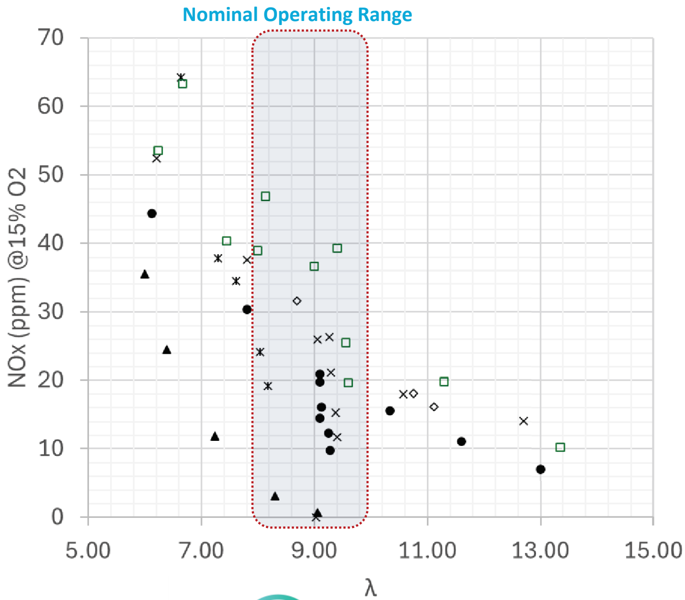

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WP3 (contd.): Biofuel combustion research

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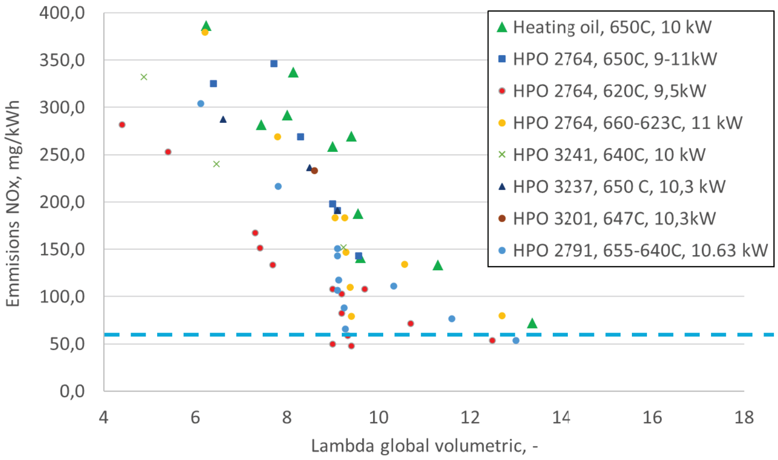
Heating oil, HPO



$$X = \frac{x_m \cdot F^x}{CO_{2\,m}}$$

X = emission in unit (e.g. mg/kWh)
x_m = measured emission in ppm
F^x = calculation factor
(e.g. 29.36 for DHO, mg/kWh)
$CO_{2\,m}$ = measured CO_2 value in Vol%

Source: Dittmann, 2008

- HPO has similar or lower NOx than DHO for similar conditions
- **KPI Fit4Micro: NOx<60mg/kWh**

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WP3 (contd.): High-temperature materials‘ assessment

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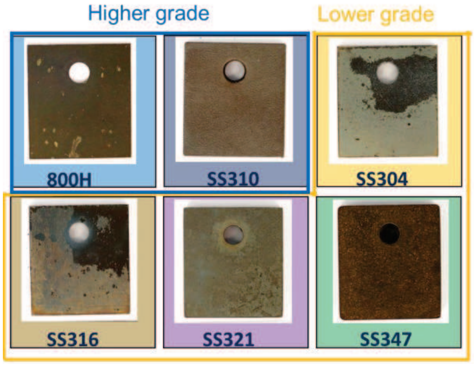
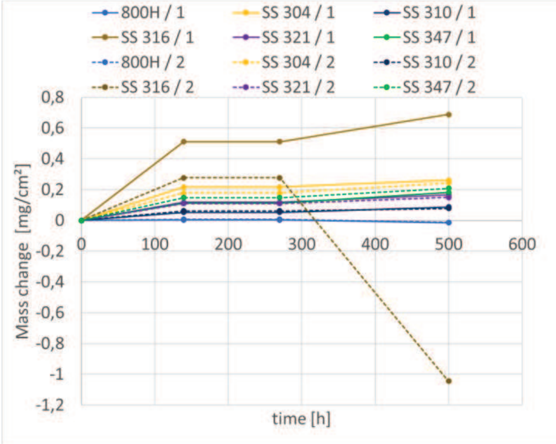
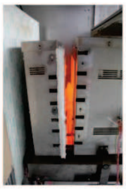
- Determination of long-term stable, high-temperature, oxidation-resistant materials for the combustion chamber and turbine wheels that meet the requirements



Photographs of 18x20 mm² alloy samples after 270 h

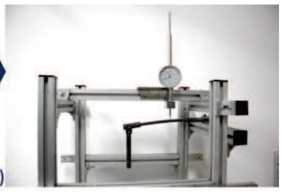


Furnace



100h

Bending measurement at RT (discontinuous)



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WP4: Humidifed Intercooled Regenerative Reheat Gas Turbine Cycle

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

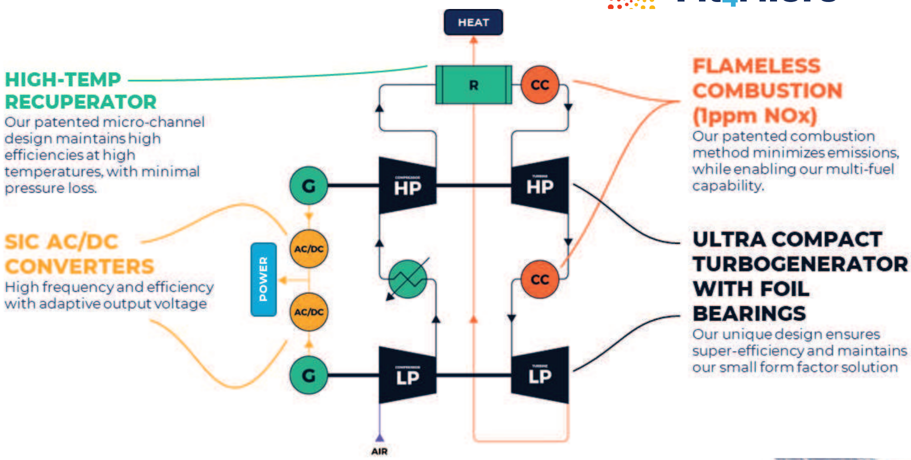
✓ *Ex: KPI-2a: Achieving at least **40%** electrical efficiency.*

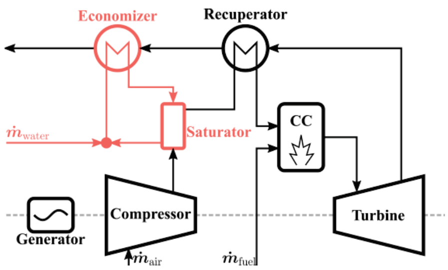
SO-3: Flameless combustion of liquid biofuels with same or higher efficiency than natural gas in the gas turbine cycle.

✓ *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. (*)*





	Steam injection	Water injection	saturator
	Δη/η$_{ref}$	Δη/η$_{ref}$	Δη/η$_{ref}$
µ10	+10.9%	+9.4%	+12.9%
µ20	+13.2%	+15.0%	+22.9%

mHat cycle

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WP4 (contd.): LP stage – micro-10

Fit4Micro

HIGH-TEMP RECUPERATOR
Our patented micro-channel design maintains high efficiencies at high temperatures, with minimal pressure loss.

SiC AC/DC CONVERTERS
High frequency and efficiency with adaptive output voltage.

FLAMELESS COMBUSTION (1ppm NOx)
Our patented combustion method minimizes emissions, while enabling our multi-fuel capability.

OIL-FREE ULTRA COMPACT TURBOGENERATOR WITH AIR FOIL BEARINGS
Our unique design ensures super-efficiency and maintains our small form fac

Protected through 12 patents and patent applications in EU, US, CN.

WP5: Integrated hybrid trigeneration system development & evaluation

Fit4Micro

- 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.*

- 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

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WP5 (contd.): Definition of use cases and system design

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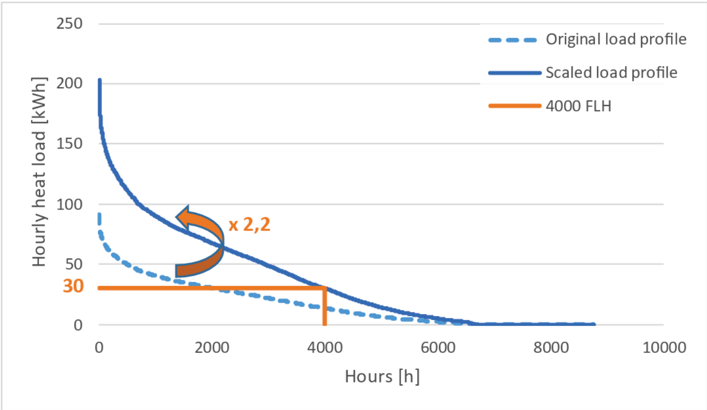
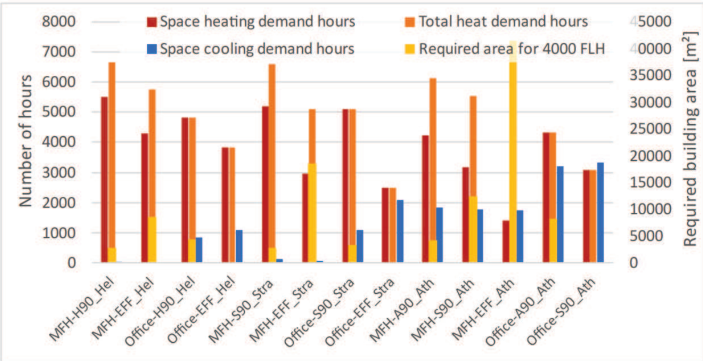
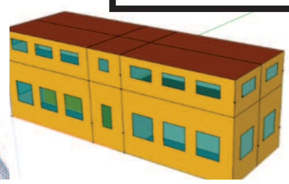
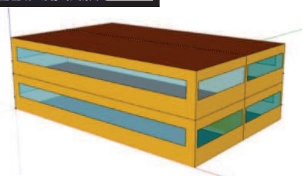






Multi-family home (MFH)



Office Building

WP5 (contd.): Definition of use cases and system design

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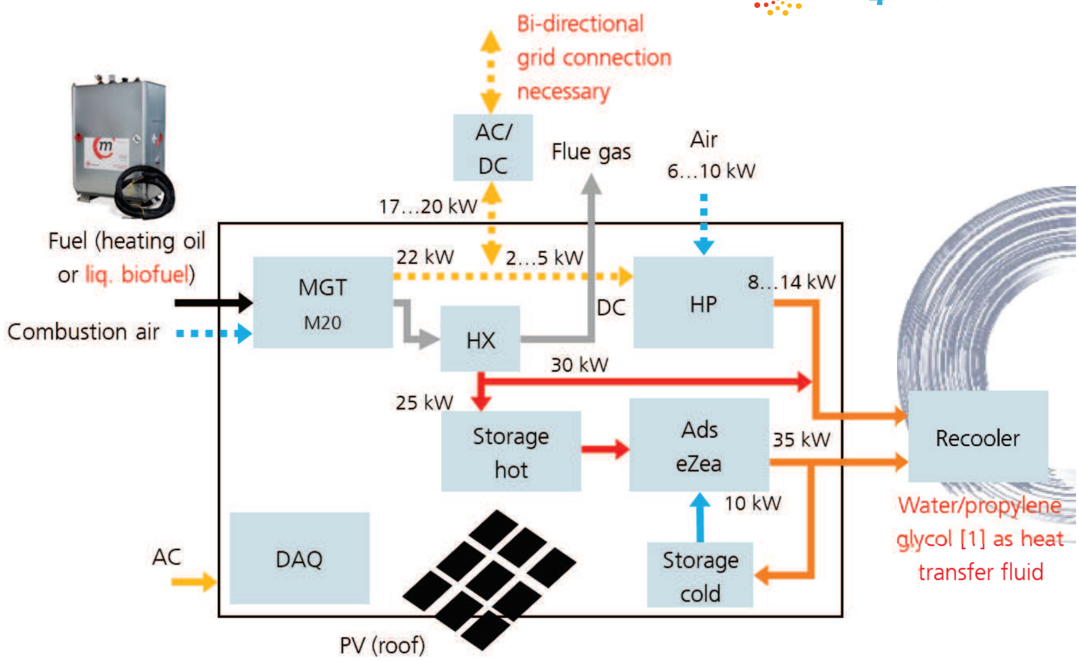
- Main components:
  - MGT – micro gas turbine
  - HP – Heat pump
  - Ads – Adsorption chiller
  - DAQ – Data Acquisition

Heat flow HT (70…95 °C)

Heat flow MT (30…50 °C)

Heat flow LT (5…50 °C)



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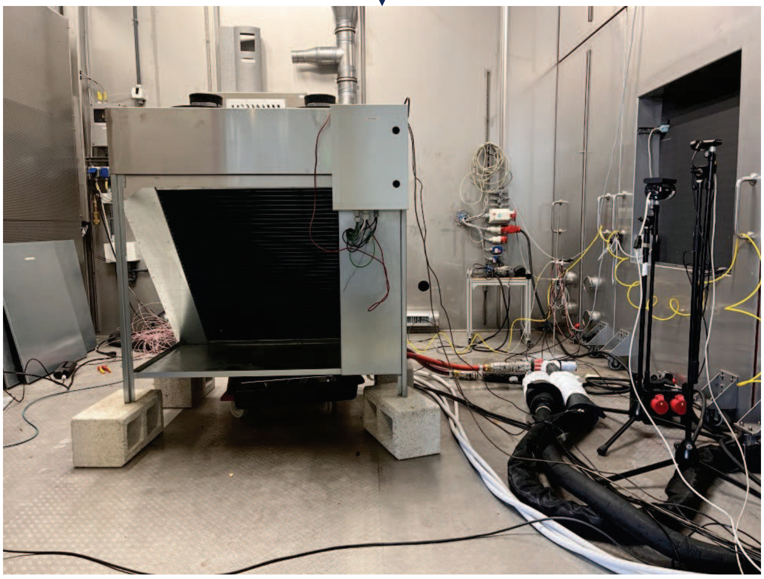
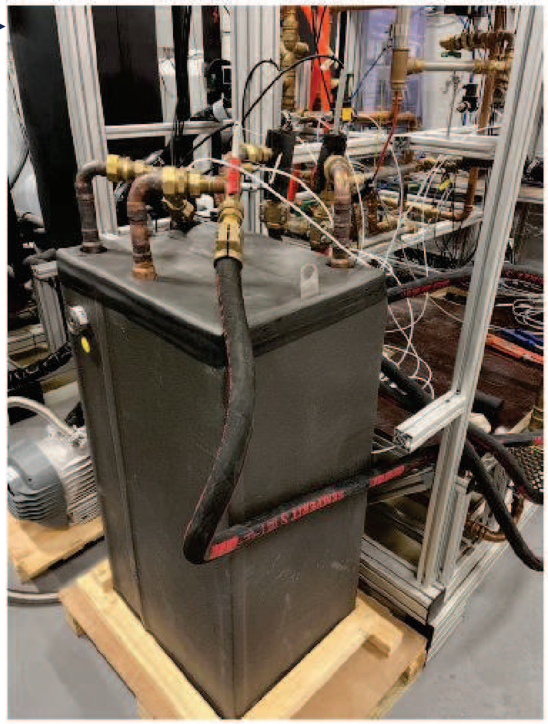
[1] https://www.glysofor.de/glysofor-l/#:~:text=Glysofor%20L%20ist%20weder%20Gefahrstoff,%C2%A735%20AwSV%20keine%20R%C3%BCckhaltung.

WP5 (contd.): Heating and cooling case testing

Heat pumps to be integrated with the micro gas turbine are tested..

- Silicagel adsorption module from Fahrenheit
- R290 Heat Pump from MITIS





WP5 (contd.): Definition of use cases and system design

WP7: Policy, market assessment

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1. Monitored and assessed key policy files that have the potential to impact the uptake of micro-CHP and hybrid heating solutions.
2. Market assessment
3. Techno-economical analysis
4. Business development

Opportunities

- Increased focus on energy efficiency, especially for renewable gases
- Need to accelerate the decarbonisation of buildings
- Moving away from the combustion of fossil fuels in buildings (incl. natural gas)
- RES gases/bioenergy of strategic importance to displace Russian gas
- Electrification requires scaling up the deployment of flexible generation
- Micro-CHP & hybrids recognised as green investments

Threats

- Prioritising electrification and district heating for buildings
- Prioritising gas, even renewable gases, for hard-to-decarbonise industrial customers (vs. space heating/electricity)
- Promoting "non-fossil"/non-gas flexibility options, namely demand-side response and storage

WP7 (contd.): High-level findings

Fit4Micro

- Overall, the micro-CHP sector is stagnant, given competition and support coming from heat pumps
- Renewable CHP is expected to grow. Yet uncertainty remains around the availability, affordability and support for renewable fuels
- Low awareness across EU markets about off-grid applications/bioliquids
- Countries with potential for growth (Off-grid/bioliquids): Czech Republic, France, Germany, Netherlands, Poland, Turkey

Segment	Current trend*	Outlook*	Key markets
RES	50%	70%	AT, CZ, DK, DE, NL, PL, ES, TR
Off grid micro-CHP, Domestic, Small commercial	78%	80%	CZ, FR, TR
Bioliquids	45%	55%	DE, PL, NL, TR

COGEN EUROPE

WP8: Where to find us ?

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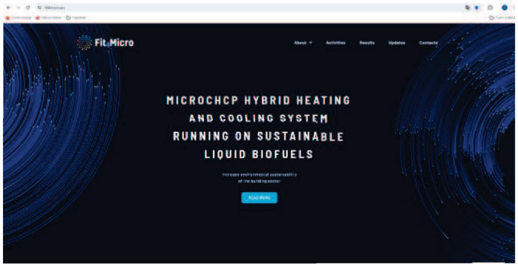
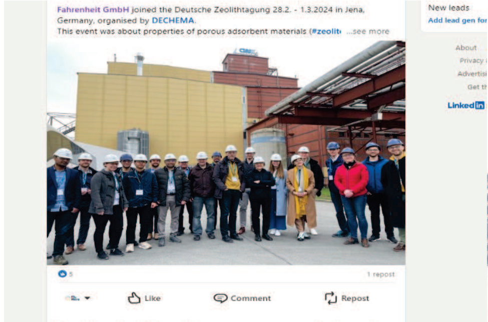
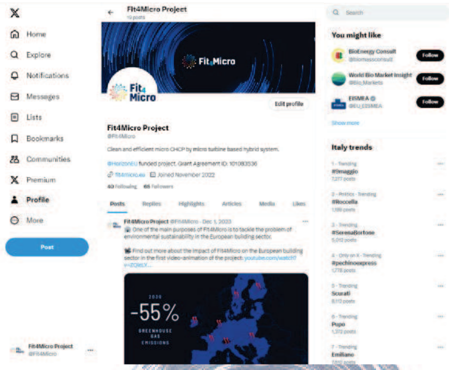
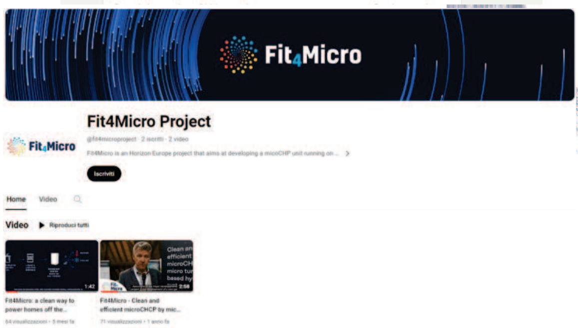
- fit4micro.eu
- @Fit4Micro
- Fit4Micro Project
- info@fit4micro.eu









Thank you!

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