Fit4Micro

Newsletter
Issue 3 | February 2025

A clean way to power homes off the electricity grid

This newsletter reports the latest news and developments of the project that have occurred up to February 2025 including communication and dissemination actions.

Fit4Micro - Clean and Efficient microCHCP by microturbine based hybrid systems, is a Horizon Europe project aiming at developing a highly efficient microCHCP hybrid system running on sustainable liquid biofuels and able to provide renewable heating, cooling and power production for demand-driven applications such as multi-family houses specially at remote and/or off-grid locations, non-residential buildings and industrial facilities requiring cooling or water as refrigerant in their processes.
Fit4Micro system is based on a double shaft micro gas turbine combined with a humidification unit. A high GHG emission reduction is obtained by our flameless combustor using RED-III compliant biofuels. Its fast response time and fuel-flexible operation make it ideal for a highly efficient hybrid CHP system, resilient to changes in fuel and power markets and empowering the consumers through digital solutions. Fit4Micro can be integrated with a compression heat pump, an adsorption chiller and a solar PV system.

CONTENTS

1. Fit4Micro is operating within the context of the European building sector 1
2. Final mass, energy and elemental balance input for value chain assessments 1 2
3. Analysis of Humidification techniques for the IRRGT cycle 4
4. Report on 4 use case definitions for system development and evaluations 5

1. Fit4Micro is operating within the context of the European building sector

The workshop on "Technologies for biofuel hybrid biomass turbines" was organised as a hybrid event by the Fit4Micro consortium in Aachen, Germany, last September 2024 and opened by Michel Delanaye (MITIS, Belgium, and Fit4Micro coordinator).

He presented Fit4Micro "Presentation of Fit4Micro Project" and confirmed that the context where the project is working is basically related to the European building sector. In particular, he highlighted that the way we are heating that sector and providing power to it is consuming 40% of final energy totally consumed in Europe and emitting about 36% of the total greenhouse gases, which is a huge amount representing a heavy contributor to the climate change.
A significant portion (79%) of energy consumption is dedicated to heating, cooling, and domestic hot water.
Currently, this energy production relies heavily (75%) on fossil fuels, primarily natural gas and some heating oil. Achieving net-zero emissions by 2050 necessitates a shift away from fossil fuels.

Presentation "Clean and efficient microCHCP by micro turbine based hybrid systems" of Michel Delanaye. Source: Fit4Micro.

Potential replacements can include biofuels (both existing and novel), green electricity, low-carbon gases, and biogas derived from biomass. Widespread adoption of heat pumps is also crucial where feasible.

The Fit4Micro project aims to integrate these elements. It focuses on producing second or third-generation biofuels from organic waste and residues, prioritizing environmental sustainability. The specific biofuel produced in the project is a liquid one called hydrotreated pyrolysis oil, which can effectively replace conventional fuels (for further information see the following section in this newsletter).

The project's goal is to utilize this liquid biofuel for both heating and power generation. Converting the fuel into electricity is considered the most efficient approach. This conversion will be achieved using a new generation micro gas turbine, forming a microCHCP system for heating, cooling and power generation.

Decentralized cooling will also be provided by connecting additional elements and integrating either vapor compression heat pumps or adsorption chillers with the micro gas turbine.

In essence, the project offers a pathway from renewable organic waste to highly efficient, decentralized power generation.

For further information, video of the event is available in the project Youtube channel: youtube.com
and to this link of the project website, Results webpage.

2. Final mass, energy and elemental balance input for value chain assessments 1

Ideally, a renewable fuel should have a high energy density to limit storage volumes and optimize distribution. For flexible operation, either a gaseous or liquid form is preferred to rapidly control the combustion process. In terms of sustainability and availability, it is important that a wide and diverse feedstock base, preferably consisting of residues, can be utilized. In Fit4Micro, the ambition is to produce a liquid biofuel with high energy density from Renewable Energy Directive III (RED-III) compliant resources.

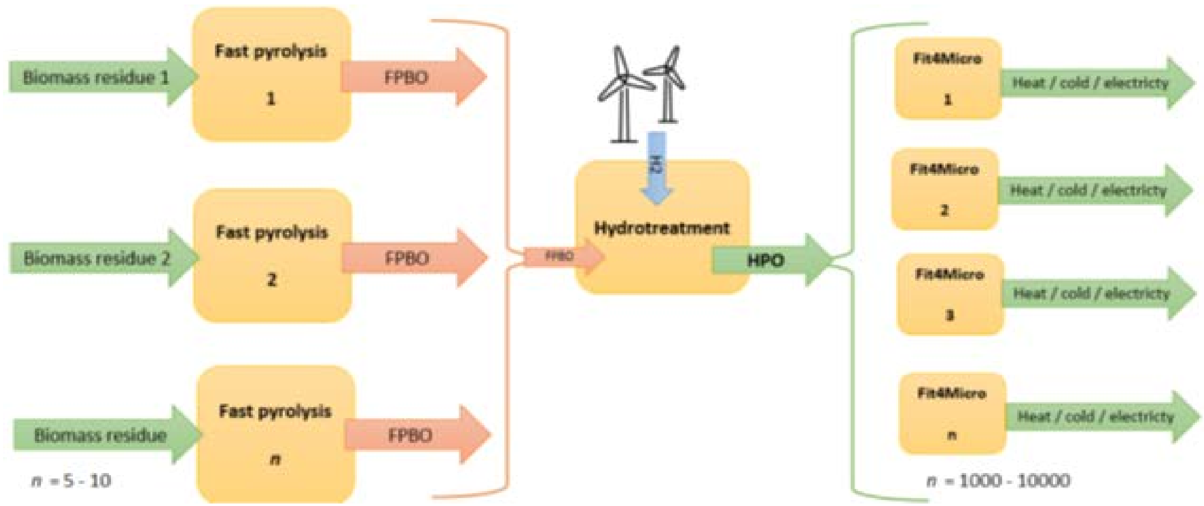
These resources will be converted into a liquid biofuel suitable for domestic heating, cooling and power system through processing in two stages: i) fast pyrolysis and ii) hydrotreatment.

The final product obtained from processing is referred to as 'Hydrotreated Pyrolysis Oil', abbreviated to HPO.

In the first stage, the fast pyrolysis process, the solid residue is converted into a liquid bioenergy carrier referred to as 'Fast Pyrolysis Bio-Oil' or FPBO in short. Fast pyrolysis is a relatively simple process, involving the rapid heating of a feedstock in absence of oxygen. The product is a mixture of shorter fragments of the original feedstock. The fast pyrolysis process is self-sustaining and requires no external energy input, some surplus renewable energy is even available for local usage. Furthermore, no chemicals or other resources are required for processing. This results in relatively low operational costs, combined with the limited investment costs for the installation make

that the fast pyrolysis process can be applied at a medium scale (~25 MW input). Additionally, construction of the pyrolysis plant near the feedstock avoids long distant transport of the biomass saving additional costs and making the process even more affordable. FPBO is a liquid bioenergy carrier with properties that differ from conventional, fossil derived, fuels.
The hydrotreatment process converts the FPBO into a hydrocarbon fuel. The process is currently under development and not yet commercially available. During the process development, the best results (in terms of carbon efficiency) are obtained when a two-stage process is applied. First the FPBO is stabilized to form Stabilized Pyrolysis Oil (SPO), in a second stage the SPO is converted to the HPO product. If desired, the HPO can be further purified for example by distillation.

Contrary to FPBO, HPO is fully miscible with conventional fuels and can be distilled to obtain various fractions which fall for example in the diesel or gasoline boiling point range. Partner in the consortium BTG developed an upgrading process involving two stages; first the FPBO is stabilized by reacting it with hydrogen gas over a proprietary catalyst to form the SPOto further hydrogenate it over a conventional hydrotreatment catalyst to form HPO.
The overall concept for the biofuel supply considered in the Fit4Micro project is presented in the figure. One of the goals in the Fit4Micro project is to obtain a HPO product with suitable quality for micro gas turbine usage, at the lowest possible operational costs. This is targeted by i) reducing the biomass feedstock costs by targeting residual streams and ii) limiting the hydrogen consumption in the hydrotreatment process.
Experimental activities are employed within the project on both approaches.
For the Fit4Micro project, three different resources have been selected already in the proposal stage, i.e. forest/woody residues(bark), contaminated wood and wheat straw.
Experimental research is scheduled to be performed for each of these materials within the project to provide the data required for the value chain assessments performed in WP6 “LCA, socio-economic impact and public perceptance”.
It must be noted here that the HPO can also be considered for other applications, and possible by-products could be used as well in the micro gas turbine.



Concept of decentralized fast pyrolysis, centralized hydrotreatment and HPO utilization. Source: Fit4Micro.

For further information, Deliverable 2.7 “Final mass, energy and elemental balance input for value chain assessments 1”.

3. Analysis of Humidification techniques for the IRRGT cycle

Beneficiary Université de Mons a Fit4Micro project partner is responsible for the Humidification cycle, Mr Ward De Paepe, Fit4Micro project manager in the university presented "Alternative Micro Gas Turbine cycles – Cycle Humidification for Improved Efficiency and Flexibility" at Carnot 2024 "Belgian Symposium of Thermodynamics", the 16th of December 2024 in Liège, Belgium.

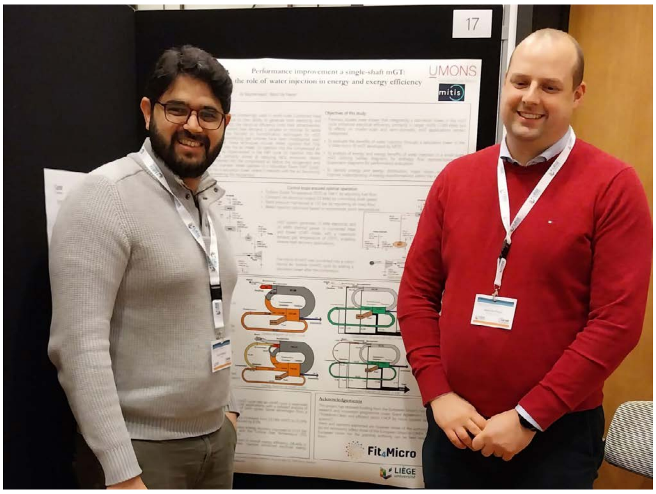
Fit4Micro aims to develop a flexible hybrid energy system, able to provide renewable heating, cooling and power production for demand-driven domestic (multifamily) usage. The core of the micro-CHCP (Combined Heating, Cooling and Power) unit is a novel, high-efficiency micro gas turbine (mGT). By implementing an Intercooled Regenerative Reheat Gas Turbine Cycle (IRRGT) with a double shaft turbogenerator system and cycle humidification option, waste heat is recovered leading to increased electric efficiency while providing a flexible heat and power output. Flameless combustion further ensures minimum pollutant emissions and high fuel flexibility to allow the use of various liquid biofuels.

The Fit4Micro MITIS system is based on the recuperated Brayton cycle and consists of an assembly of a compressor, combustion chamber, turbine, recuperator and generator. The IRRGT cycle is characterized by two stages of compression separated by intercooling and two stages of turbines with a reheat (second combustor) between the LP (low pressure) and HP (high pressure) stages. Combustors, designed to operate using renewable fuels and for two pressure levels, 3 bar (LP) and 5 – 6 bar (HP), will be developed. Simulations to assess the impact of the different selected pathways for humidification on the mGT have been performed on a 10 kWe mGT, the µ10 of MITIS (single shaft engine, exploiting the classical recuperated Brayton cycle layout) and on a 20 kWe version of the mGT, µ20 (exploiting the IRRGT cycle). Dry simulations models of MITIS of both machines, including compressor and turbine, characteristics, as well as recuperator and intercooler performance, were used as basis for the wet simulation. The wet simulations, done to assess the impact of cycle humidification on the mGT cycle, were performed assuming constant mass flow rate in the mGT cycle and constant Turbine Inlet Temperature (TIT) (approach typically exploited in literature). Constant mass flow rate is ensured by altering the engine shaft speed, while constant TIT is obtained by modifying the mass flow rate of fuel injected in both combustion chambers.

This means that the power available on the shafts for electricity production will increase.

Simulation results confirm indeed previously observed trends, highlighting that the use of a saturation tower with water loop has the highest potential for cycle humidification. Especially for the IRRGT cycle, a significant increased performance can be obtained, mainly due to the increased waste heat recovery due to the largest amount of water introduced in the cycle.

For further information, Deliverable D4.3 "Analysis of Humidification techniques for the IRRGT cycle".



Fit4Micro project partners at Carnot 2024 "Belgian Symposium of Thermodynamics". Source: UMONS.

4. Report on 4 use case definitions for system development and evaluations

The objective of the analysis is the identification of promising heating and cooling applications for the micro gas turbine (mGT) systems under development in the project Fit4Micro. The mGT is possibly in combination with an electric heat pump, a thermally driven chiller (TDC, in this case an adsorption chiller) and/or photovoltaics – seems generally promising in terms of system layout, economics and ecological aspects.

To this end simulated load profiles of five different building applications are evaluated in terms of achievable full load hours. It turns out that a substantial number of full load hours, required for economic feasibility of such a technology (4.000 hours were selected, as for other types of CHP), occurs only in large existing buildings in central northern European climates. A high demand of domestic hot water (e.g. in hospitals, hotels, retirement homes) supports the feasibility of an mGT system. The average consumption indicates that the electricity production of the mGT can be used onsite to a large extent.

With regard to cooling by combining the mGT with a thermally driven chiller (e.g. adsorption chiller), it turns out that it is unlikely to reach sufficient operating hours for a profitable system merely for the air conditioning of buildings.
The following four use cases have been defined for system development and evaluation in the project:

- Existing (1990s) multi-family house in Helsinki, Finland
- Existing (1990s) office building in Strasburg, France
- Old existing health building in Potsdam, Germany
- Old existing lodging building in Potsdam, Germany

To meet the objective described above, the applications were split into two major groups which were studied separately in the following:

- buildings and their respective heating and/or cooling demand, to be studied for all variants of mGT-system configurations;
- industrial/commercial (manufacturing) processes which require cooling as potential applications for the combination of a mGT with a TDC.

The assessment of these applications with regard to their suitability for the mGT-systems requires the definition of evaluation criteria.
For what concerns office and residential buildings, this evaluation has pointed out that only sufficiently large existing buildings can have a number of full load hours able to support a CHP technology, similar to the one developed by Fit4Micro.
More specifically, the mGT seems promising as a base load supplier of heat, with a dimensioning of the heat power up to 15% of maximum load.

Fit4Micro project partners at Carnot 2024 "Belgian Symposium of Thermodynamics". Source: Fit4Micro.

Moreover, in office buildings with an extended cooling demand, the combination of the mGT with a thermally driven chiller could be attractive. Together with residential buildings, also non-residential ones (hence hospitals and retirement homes) are feasible for the mGT technology: in this case, the high demand of domestic hot water results in a more constant load – and consequently the mGT can cover a higher share of the required load.
The analysis has proven that a dimensioning up to 30% of the peak demand can be feasible, and hence a high share of the electricity produced by the mGT can be consumed in the building itself. This evaluation has been made by calculating a substantial number of full load hours required for the economic feasibility of CHP technologies (4.000 FLH in this case).

The main result is that the Fit4Micro technology can be adapted in all the analysed use cases, but with some differences for what concerns its application:

- For residential buildings, only large ones can be considered suitable for the heat supply;
- For non-residential buildings, the feasibility of an mGT system can be suitable if there is a high demand of hot domestic water (or heat for other processes).

Further activities of this analysis are focusing on the development of robust and efficient control strategies, together with the testing of a system demonstrator for the two most promising use cases.

For further information, Deliverable 5.1 "Report on 4 use case definitions for system development and evaluations".

ABOUT THE PROJECT

The core activity of FIT4MICRO is to design a technology that will guarantee an improvement in energy efficiency rates of existing buildings, through the reduction of energy consumption and the replacement of fossil fuels with biofuels.
The project has a total duration of 48 months from October 2022 to September 2026 and is funded by the European Union under the Horizon Europe programme.

The project Consortium during the visit at OWI in Aachen, Germany. Source: Fit4Micro project.

FIT4MICRO is coordinated by MITIS, a clean-tech startup developing flameless combustion microturbine working with air foil bearings, with the main aim of providing immediate and drastic emission reductions during primary energy conversion.
The project consortium has put together 8 partners from 5 countries with long-term expertise in renewable energy applications, from technology developments to the market implementation, including:

- two research institutions: Fraunhofer ISE and OWI Aachen (Germany);
- one industry partner: MITIS (Belgium);
- two SMEs: ETA Florence Renewable Energies (Italy) and BTG Biomass Technology Group (The Netherlands);
- two universities: University of Mons (Belgium) and Aalborg University (Denmark);
- one European association: COGEN Europe (Belgium).

PARTNERS

CONTACTS

Michel Delanaye - Project Coordinator:
michel.delanaye@mitis.be

info@fit4micro.eu

FOLLOW US

fit4micro.eu
LinkedIn
X
Youtube

Funded by the European Union

Funded by the European Union (Grant n. 101083536).
Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.