Fit4Micro Newsletter
Issue 2 | November 2024

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 October 2024 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.

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1. Project workshop on "Technologies for biofuel hybrid biomass turbines"

The workshop on "Technologies for biofuel hybrid biomass turbines" was organised as a hybrid event by the Fit4Micro consortium on Wednesday 25th of September 2024, afternoon, INNSiDE Hotel, Aachen, Germany, in conjunction with the second-year project meeting and the visit to the OWI facilities.
The online part was implemented to involve as many interested stakeholders and participants as possible.
This event, chaired by Sangeetha Ramaswamy of OWI, introduced and explained the main current activities performed by several partners of Fit4Micro project, as for example biofuels from residues via fast pyrolysis and hydrotreatment, research on biofuels for combustion applications, gas foil bearings for small scale turbomachinery and heat pumps and chillers with natural refrigerants.
In addition, in the first part of the event, Prof. Alessandro Parente presented particular aspects of industry decarbonisation related to combustion technologies.
At the end of each presentation, time was

properly allocated for Q&A from the audience.

This workshop was chaired by Sangeetha Ramaswamy (OWI, Germany). Wilfried Plum (OWI) introduced and presented the event, then Michel Delanaye (MITIS, Belgium, and Fit4Micro coordinator) presented Fit4Micro Project, confirming that the context where we are working is basically related to the European building sector. In particular, the way we are heating that sector and also providing power to it, because the European building sector is consuming 40% of final energy totally consumed in Europe, which is huge, still emitting about 36% of the total greenhouse gases.

Alessandro Parente (Université libre de Bruxelles, Belgium) provided a detailed overview of the role of diluted combustion technologies concerning hydrogen and ammonia for industry decarbonisation.

Presentations of Evert Leijenhorst (BTG, The Netherlands) and Dirk Möntmann (OWI) addressed, respectively, the production of biofuels from residues via fast pyrolysis and hydrotreatment, and biofuels for combustion applications as analysed at OWI.

The presentation of Danish Rehman (MITIS) concerned the use of gas foil bearings for small scale turbomachinery, and Gerrit Füldner (Fraunhofer ISE, Germany) focused on heat pumps and chillers with natural refrigerants.

This event was promoted through the project website, project social media and personal invitations to potential participants some weeks prior to the workshop, totalising as follows:

- 23 participants on site;
- 67 participants connected online:

These 90 participants in total represented many countries, mainly from Belgium, Germany, Italy, The Netherlands, France, Poland and Portugal, but also from Brazil, India, Thailand, South Africa and Argentina.

Presentation of Michel Delanaye.
Source: Fit4Micro.

Presentation of Alessandro Parente.
Source: Fit4Micro.

Some pictures of workshop presentations as follows:
All presentations are available to this link of the project website:
fit4micro.eu/news/workshop-on-technologies-for-biofuel-hybrid-biomass-turbines

Video of the event is available in the Youtube channel:
youtube.com

and to this link of the project website:
fit4micro.eu/results

2. Dissemination and Communication activities

Since the very beginning of the project, Communication and Dissemination activities have been ongoing, focusing on events and participation in national and international conferences.

In order to increase the number of potential adopters of the Fit4Micro solution, the project has been presented and disseminated in several scientific and policy events in partners' countries.

These occasions gave partners the opportunity of presenting the results of the project to an audience of academic and industry representatives as well as policy makers.
As a consequence, together with the schedule of activities planned in the project, the Fit4Micro consortium participated in relevant events concerning cogeneration and clean energy production, where partners illustrated the project's main results and achievements.

In June 2024, the Fit4Micro project attended the European Biomass Conference and Exhibition (EUBCE), the largest conference and exhibition in the world about biomass, held in Marseille, France.

Fit4Micro at EUBCE 2024 in Marseille, France: visibility point on the project in the Exhibition area.
Source: ETA Florence

Here, Fit4Micro had a visibility point in the Exhibition area for the whole duration of the event, where project partners had the occasion of disseminating the most important information about Fit4Micro to visitors and attendees.

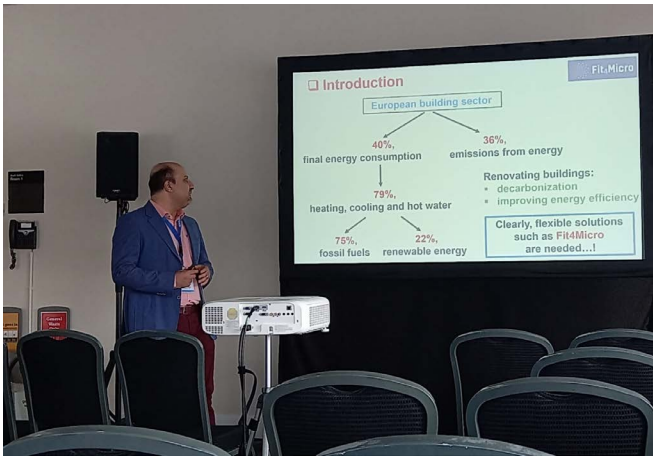
In addition to that, two posters were presented by project partners.

Fit4Micro at EUBCE 2024 in Marseille, France: project presentation in the Poster area.
Souce:EUBCE 2024

Siri Harboe-Minwegen, Research Coordinator at OWI Science for Fuels gGmbH, an institute of RWTH Aachen, Germany, presented "Development of a Micro Gas Turbine Converting Biofuel Into Renewable Heating, Cooling and Power Generation" in the session *New approaches in biomass combustion.*
This poster can be summarised as follows: the objective of the presented work is to investigate the combustion properties of Hydrotreated Pyrolysis Oil (HPO) within the MITIS combustion chamber.
The minimum fuel quality required for operating the MGT, while achieving reliable combustion performance and low emissions will be determined.
The physical and chemical properties of the HPO fuel are used as a basis of future predictive analyses and further development of the fuel and combustion behaviour.
This is achieved by performing quantitative tests of the fuel properties and benchmark tests with domestic heating oil (DHO).

Also the presentation "Combustion Study of High Steam Content Syngas in a Conventional Micro Gas Turbine: Analysis of Combustion Performance and Impact on Pollutant Emissions" of Jeremy Bompas, UMONS, Belgium, was related to renewable resources produced from organic waste; in this case, the syngas was investigated in the context of decentralized production, such as the use of micro gas turbines in low-power cogeneration applications.

The project activities were orally presented in another important international context in June 2024: the ASME Turbo Expo Conference in London, UK, a Conference where global experts and turbomachinery engineering leaders from industry, academia, and government gathered to actively address the 2050 goals for a sustainable future.



Fit4Micro at ASME 2024, in London, UK.
Source: Fit4Micro

For further information, D8.2 is on "Dissemination, Exploitation and Communication Plan 2", available here fit4micro.eu/results

3. Production report of 200 L reference-quality HPO (D2.1)

In Fit4Micro the ambition is to significantly widen the feedstock basis, and use RED-III compliant resources, for biofuel production. To achieve this ambition, feedstocks will be first converted into Fast Pyrolysis Bio-Oil (FPBO), a liquid bioenergy carrier.

The production of FPBO can be done from a wide variety of lignocellulosic biomass resources at relatively small scale, which prevents transport of large quantities of biomass residues.
In addition, the conversion by fast pyrolysis is self-sustaining and no external energy input is required. Fast pyrolysis of biomass is a thermochemical conversion technology, where the biomass is rapidly heated in the absence of oxygen to form an organic vapour, non-condensable gas and a solid by-product (char). The organic vapour is rapidly quenched to form the FPBO, the non-condensable gas and char are both combusted in the process to generate the heat for the pyrolysis process as well as a surplus for external usage. Excess heat can be used to dry the biomass before the process and/or be sold as renewable heat or power. FPBO is already produced on a commercial scale in Europe.

FPBO is a liquid bioenergy carrier with properties that differ from conventional fossil fuels. The FPBO is a mixture of hundreds of different organic molecules.
The FPBO also contains a significant amount of water (typically 20-30 wt.%) and the oxygen content is high (~50 wt.% on as received basis). As a result, the heating value of FPBO is quite low (LHV ~ 16 MJ/kg) compared to fossil fuels.
FPBO may be used for (domestic) heat generation, however the relatively poor combustion properties (such as the low energy density and difficulty to ignite) and incompatibility to conventional boiler materials complicate the technology.
In particular, for small scale heat and power generation, improving the FPBO fuel properties before usage is desirable. Various options to improve the fuel properties have been investigated, both by BTG and other companies and institutes. One of the most promising ways to improve the fuel property is through hydrotreatment. By hydrotreating the FPBO, oxygen is removed from the fuel, increasing the heating value and ultimately a hydrocarbon fuel chemically similar to conventional fossil fuels can be obtained.

The hydrotreatment of FPBO involves reacting the FPBO with hydrogen gas at high pressure, elevated temperature and in the presence of a catalyst.
The hydrotreatment technology is already applied in fossil fuel refineries, where hydrotreatment primarily aims to remove heteroatoms such as nitrogen and sulfur from the oil. Hydrotreatment of FPBO requires some adjustments as the FPBO is very reactive due to the large number of chemical components. Over the last twenty years BTG established an efficient upgrading process which involves two stages, an initial stabilization of the FPBO, followed by hydrotreatment.
During the stabilization process the most reactive components in the FPBO are converted first while suppressing polymerization and cracking reactions.
The liquid product is referred to as Stabilized Pyrolysis Oil (SPO). For the production of SPO, BTG developed a proprietary catalyst "Picula™".
In the second stage, the SPO is reacted over a conventional hydrotreatment catalyst such as CoMo or NiMo, the product from this stage is referred to as Hydrotreated Pyrolysis oil (HPO). HPO is a mixture of hydrocarbons, HPO can be used 'as such' as a fuel, or it can be separated by distillation to obtain various fuel qualities.

If desired a low boiling fraction referred to as 'HPO-Naphtha' or 'lights' can be separated from the HPO.
This can be done for example to increase the flashpoint of the other fraction 'HPO-Diesel' in order to comply with existing fuel (safety) standards.

The product properties of HPO can be controlled by adjusting the process conditions (severity) in the hydrogenation stage:

- HPO- denotes a 'less severely' treated product;
- HPO is the 'conventional, or reference, quality';
- HPO+ involves more severe hydrotreatment.

During a trilateral meeting between MITIS, OWI and BTG it was decided to start with two samples, standard HPO and the 'HPO-Naphtha' fraction as preliminary test by MITIS were very positive with this sample. In total BTG produced 2x 0.9 L of HPO. In addition, 2x 0.7 L of 'HPO-Naphtha' were produced. These samples were sent to OWI in February 2023.
Larger volumes (2x 4.5L) of reference HPO and HPO+ (a more severely treated product) were produced in the bench scale hydrotreatment facility by BTG and supplied to OWI for initial combustion tests.
These samples were sent in March 2023.

Photograph of the HPO samples sent to OWI, reference HPO on the left, HPO+ on the right side.
Source: Fit4Micro.

A large batch of 'reference quality' HPO was produced in BTG's pilot scale hydrotreater for combustions tests at OWI.

After discussing the planned activities, it was decided that 100 L would be sufficient for the combustion test program, the remaining HPO will be used at BTG for further upgrading and characterization work.

For further information, D2.1 "Production report of 200 L reference-quality HPO" is available here: fit4micro.eu/results

Drums containing the HPO products.
Source: Fit4Micro.

4. Scientific paper on the ASME Turbo Expo 2024 presentation

A. Baghernejad and W. De Paepe from University of Mons, and D. Rehman and M. Delanaye from Mitis are the authors of the scientific paper titled "Humidification impact on the performance improvement of a novel two-shaft micro gas turbine: thermodynamic cycle performance assessment", published in the Proceedings of ASME Turbo Expo 2024 (Turbomachinery Technical Conference and Exposition) at the end of September 2024, DOI reference: 10.1115/GT2024-128549.

As a distributed energy technology, micro Gas Turbines (mGTs) are becoming increasingly important as an integral part of the heating, cooling, and electrical power industry.
These small gas turbines can be used for small-scale power generation alone or operated as combined heating and power (CHP) systems with cogeneration efficiency of up to 80% (30% electrical plus 50% heat efficiency) for a 100 kWe size engine.

However, these efficiencies are only reached when the heat in the exhaust gases is entirely used for external heating purposes. When there is no or low heat demand, the heat produced by the cogeneration unit has to be rejected. This means that the overall efficiency of the CHP system is reduced to the electrical efficiency of the unit. This negatively affects the economic performance of the units, even forcing the unit to shut down.

Micro Gas Turbines (mGT) humidification is a promising technique that can enhance electrical efficiency during periods of low or no external heat demand. By introducing hot water or steam, which is auto-raised using the heat from the flue gases, additional mass can be added to the gas turbine cycle, increasing the produced electrical power and thus specific power output. Moreover, when humidification occurs in such a manner that waste heat is recovered from the flue gases and reintroduced in the cycle (via the humidification), the electrical efficiency of the cycle can be improved, offering a solution for the operation when there is no demand for heat.

Despite appearing as a promising technology for small-scale decentralized Combined Heat and Power (CHP), the relatively low electrical efficiency of micro Gas Turbines (mGTs) prevents them from being attractive to users with variable heat demand. Transforming the cycle into a micro Humid Air Turbine (mHAT) by

adding a saturation tower in the cycle allows for an increase in the electrical efficiency of these units in moments of low heat demand.
Although humidification is well studied and proven effective on the simple recuperated Brayton cycle mGTs, its potential for cycle performance improvement when applied on more advanced mGT cycles is currently unknown.
Therefore, the numerical study presented in this paper aims to assess the impact of humidification on the performance of a novel two-shaft mGT from MITIS, exploiting the intercooled regenerative reheat gas turbine cycle concept.
The benefits of water injection mostly rely on the increased heat capacity of the air-vapor mixture, and the more significant amount of heat recovered in the recuperator, both resulting at the lower fuel consumption.
Simulation results show indeed that by introducing a saturation tower in this two-shaft turbogenerator system, waste heat is recovered, leading to increased electrical efficiency from 35.12% for the mGT cycle to 36.31% for the mHAT cycle while providing a flexible heat and power output. This rise in the efficiency is maybe might be small, but could be increased further by going towards more advanced cycle configuration (aftercooling) as well as by optimizing the Turbines Inlet Temperature (TIT).
In the present study, a novel two-shaft mGT cycle, working as a CHP unit, is transformed into an mHAT cycle and thoroughly evaluated from the view of thermodynamics. For both cycles, the Sankey diagrams are drawn to show the enthalpy flows between the different components of the system. Results show the positive effect of water injection on increasing electrical efficiency.

For further information, check the content of this paper that is available here:
orbi.umons.ac.be/handle/20.500.12907/49696

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 9 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);
- two industry partners: FAHRENHEIT GmbH (Germany) and 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).

Fit4Micro

PARTNERS

mitis · COGEN · OWI Science4Fuels an der RWTH Aachen · etaflorence renewable energies · UMONS University of Mons · Fraunhofer ISE · FAHRENHEIT · btg biomass technology group · AALBORG UNIVERSITY

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