Water injection in a micro Gas Turbine

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Objective

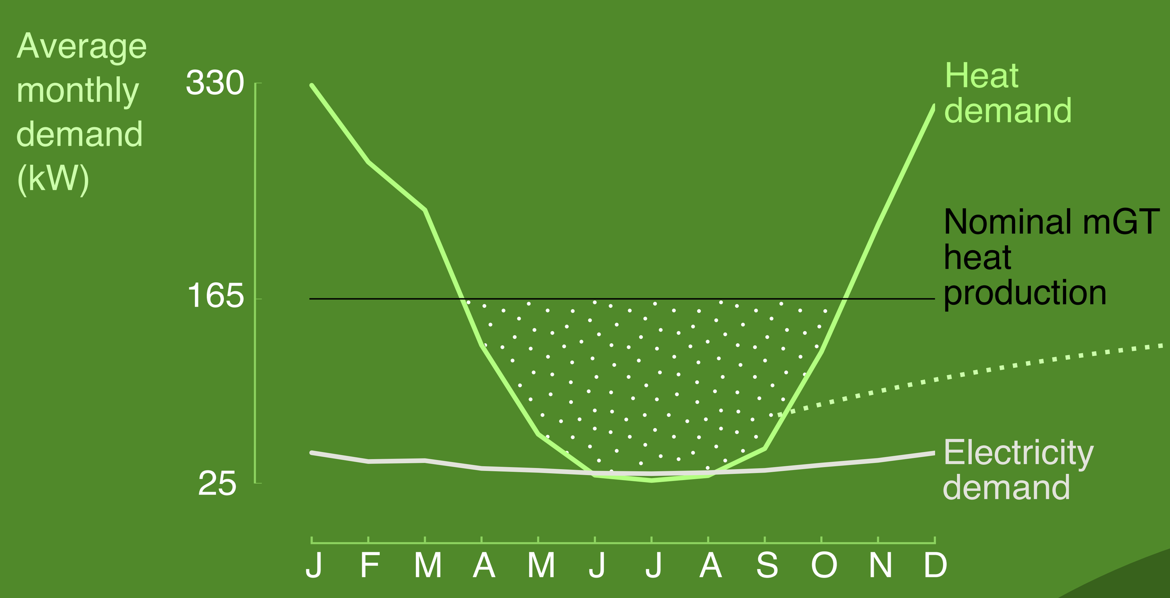
Experimentally characterise the operation of the mGT Turbec T100 working as a micro Humid Air Turbine (mHAT)

Limitations of micro Gas Turbines for Combined Heat and Power

Micro Gas Turbines (mGTs) offer various advantages for Combined Heat and Power (CHP) generation compared to internal combustion engines: cleaner exhaust, lower maintenance cost, concentration of the residual heat in a single source, etc.

The main disadvantage of mGTs is their low electric efficiency (~30%). When the heat demand decreases (e.g. during summer) the overall efficiency of the cycle substantially drops down along with the economic feasibility of the plant.

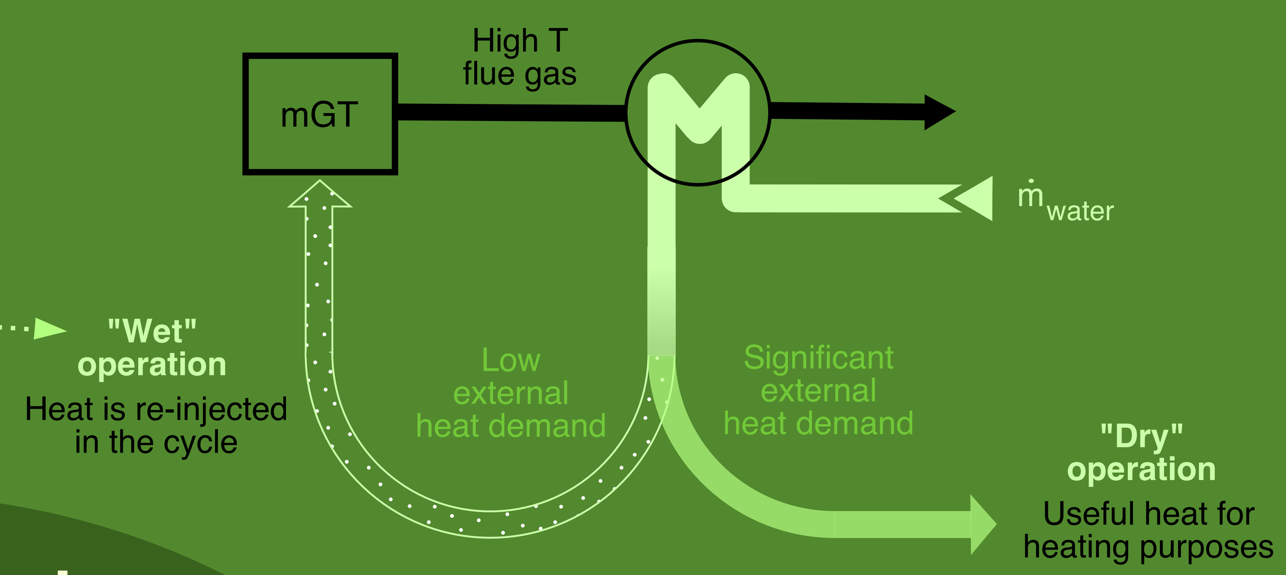
Typical electricity and heat demand profiles of a group of 120 average European dwellings



Flexible heat production is possible with micro Humid Air Turbines (mHATs)

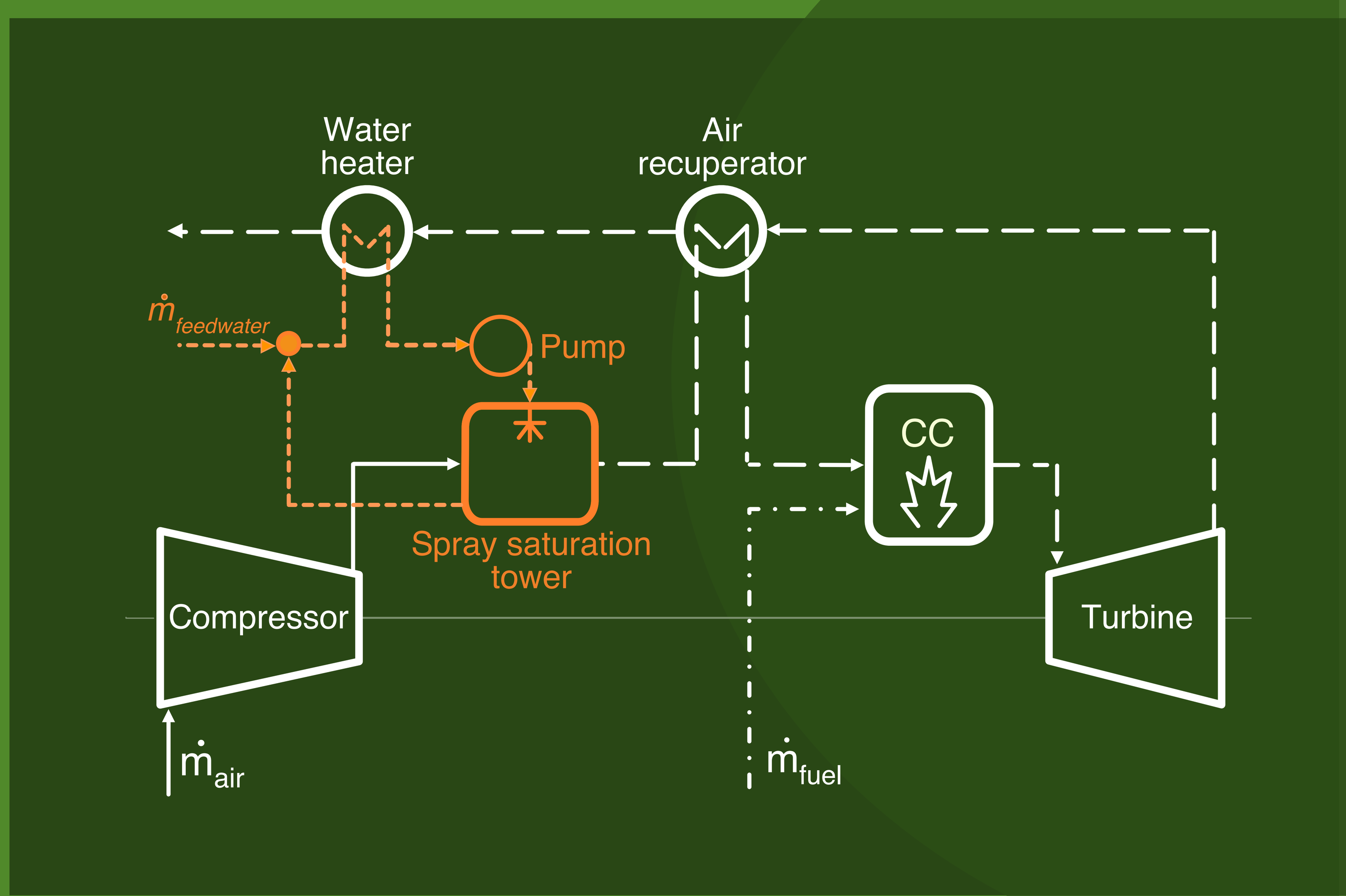
Water injection in mGTs allows increasing the electric efficiency in moments of low heat demand by re-introducing the residual heat in the flue gas back into the cycle.

In an mHAT hot water is injected at the back of the compressor. This first increases the mass flow through the turbine for a given compressor input; second, it enables the re-utilisation of the residual heat in the exhaust gases.



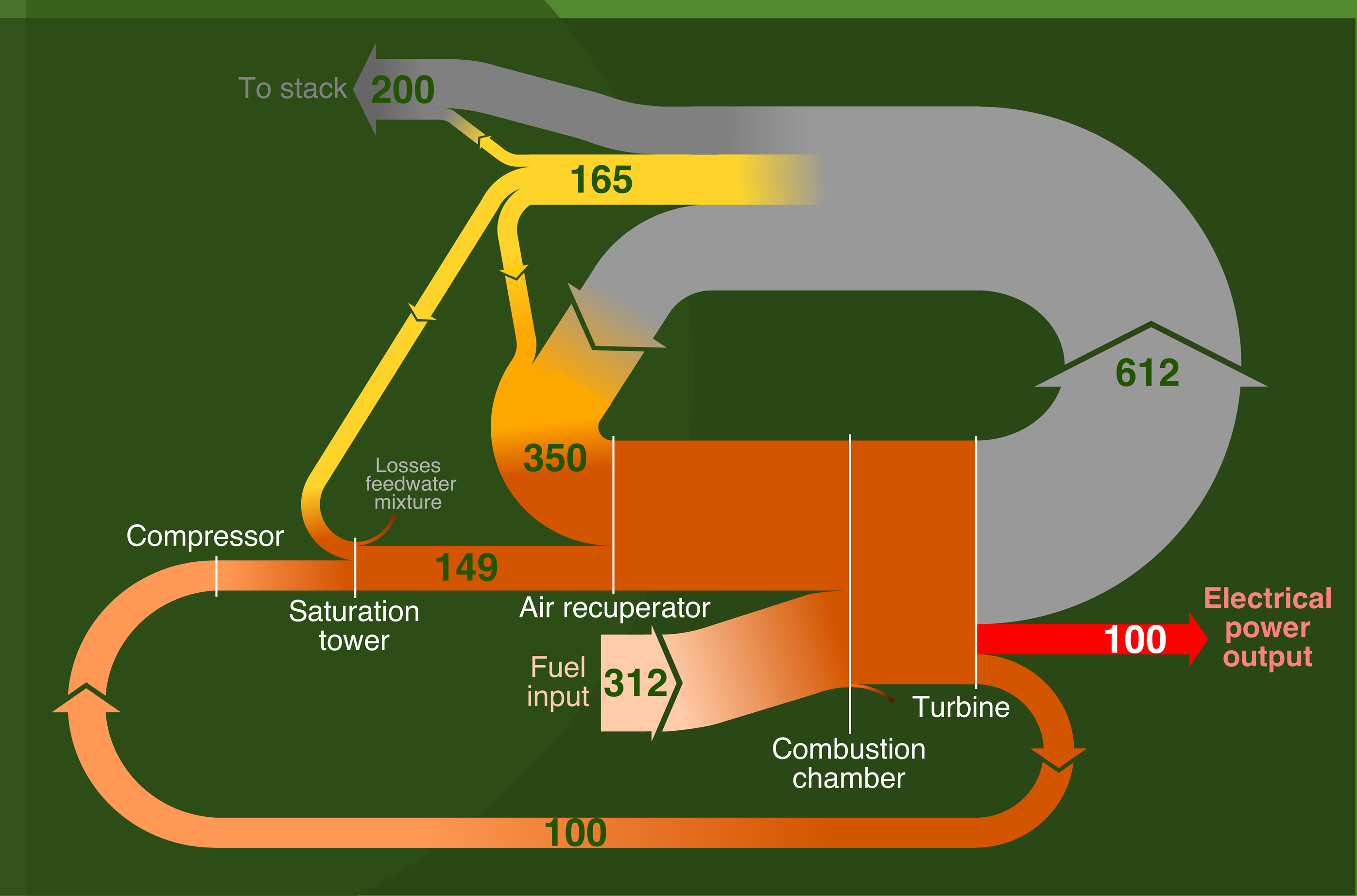
mHAT layout

Layout of the micro humid air turbine based on the mGT Turbec T100 installed at the VUB. In white, the typical components of a recuperated mGT. In orange, the water system required for an mHAT (saturation tower, feedwater, pump)



Sankey diagram

Sankey diagram based on simulations of the Turbec T100 working as an mHAT. The diagram displays the enthalpy flows (in kW) through the different cycle components



New, innovative experimental mHAT facility at Vrije Universiteit Brussel

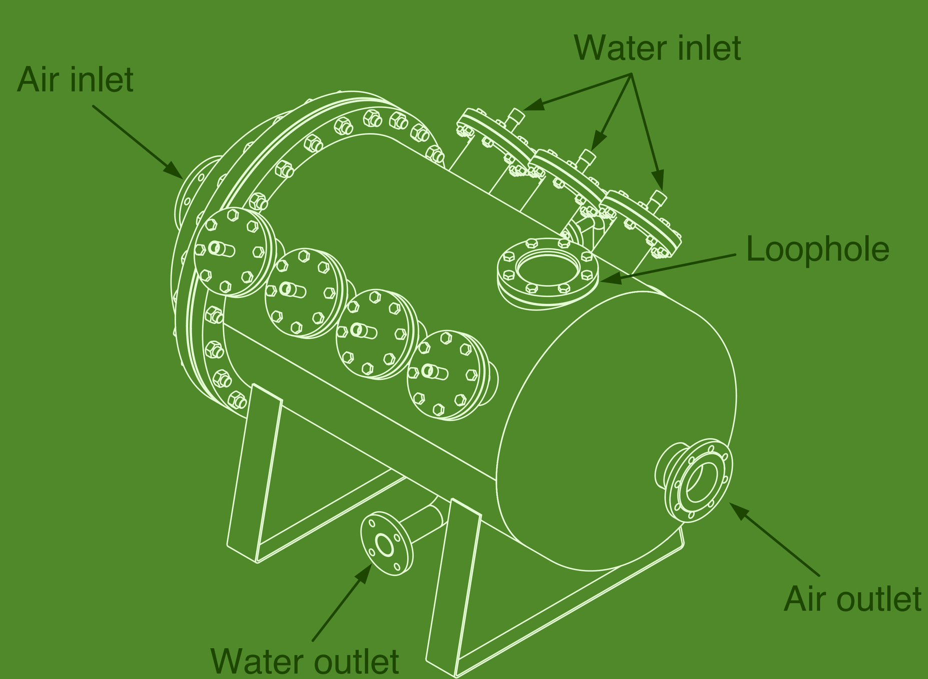
Turbec T100 technical details:

Power output:
100 kWe
165 kWth

Efficiency:
30% electric
80% total CHP

At the VUB, the mGT Turbec T100 has been transformed into an mHAT by adding a spray saturation tower to humidify the compressed air. Unlike traditional saturation towers —which make use of packing material— in a spray saturator the contact area between water and air is boosted by atomising the inlet water flow through nozzles.

Simulations in Aspen Plus predict a **4.8% absolute** potential electrical efficiency increase with water injection in this facility.

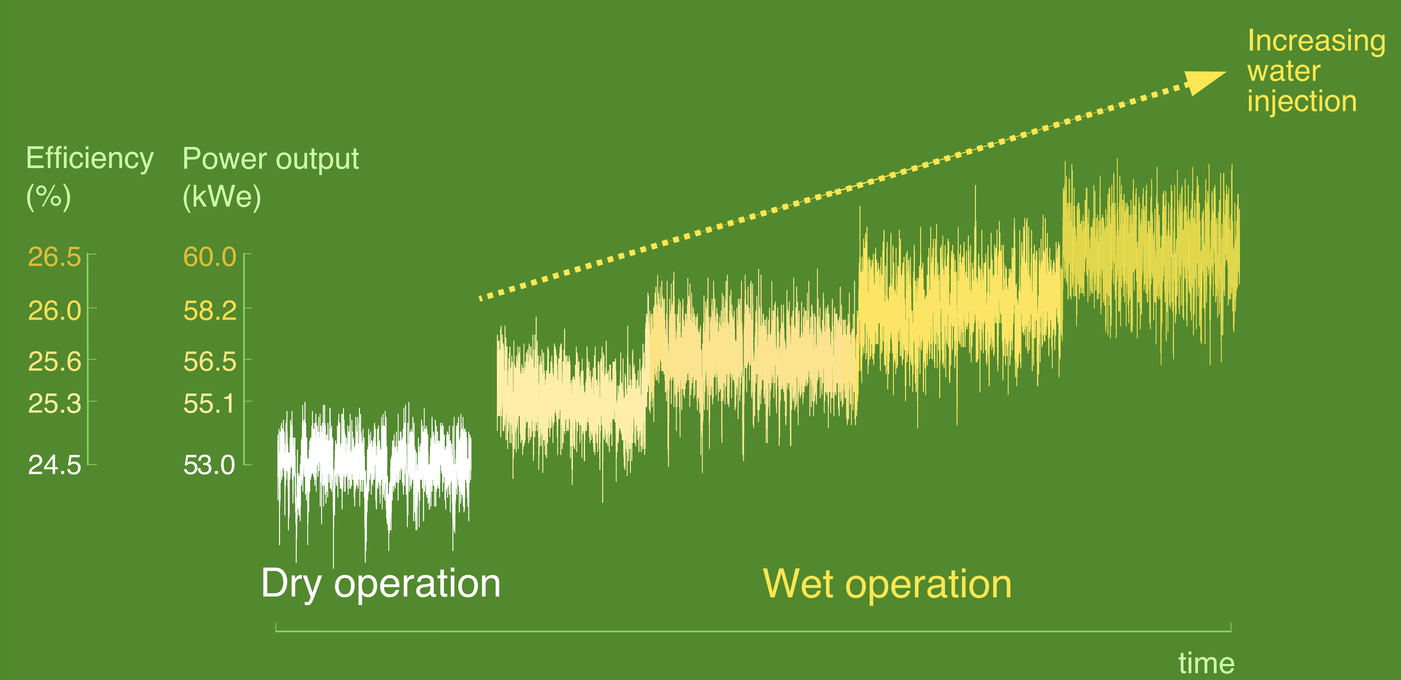


Spray saturation tower placed at the VUB lab

Preliminary tests at part load confirm mHAT's efficiency increase

Results from several test campaigns confirm the stable operation of VUB's mHAT. In order to avoid compressor surge, air was bled from the compressor.

As expected, rising water injection levels lead to an increase of both power output and electrical efficiency.



Conclusions

The mGT Turbec T100 installed at the VUB has been turned into an mHAT and equipped with an innovative spray saturation tower. Preliminary tests show a **2% total and 8% relative electrical efficiency increase with water injection at part load operation.**

LABORELEC GDF SUEZ

Electrabel GDF SUEZ

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