

Operational Flexibility in Distributed Power Generation: micro Gas Turbines

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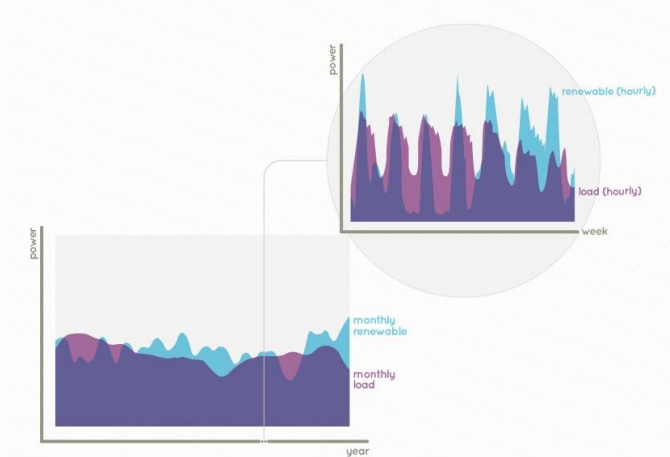
**OPERATIONAL FLEXIBILITY IN DISTRIBUTED
POWER GENERATION:
MICRO GAS TURBINES**

Ward De Paepe

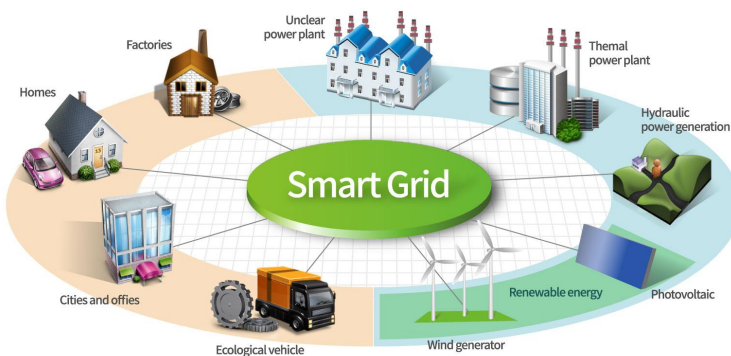
In the past, energy production was fairly simple.

<p>Electricity</p>  	<p>Heat</p> 
<p>Centralized</p>	<p>Decentralized</p>

The large deployment of Renewable Energy increases the demand for flexibility.



Micro Gas Turbines or mGTs have their place in future energy production.



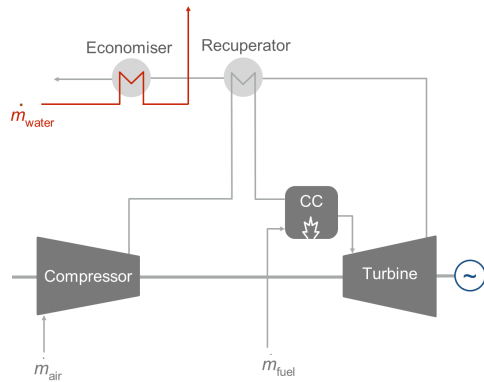
To get this place in the future energy production, the mGT needs to evolve.

The mGT has to become more efficient
both at full and part load operation

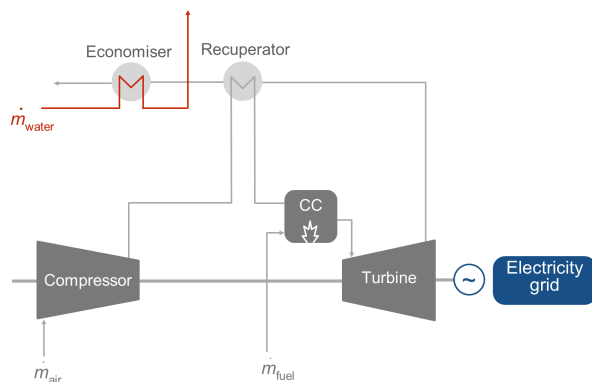
The mGT has to become fully CO₂ neutral/negative
by using biofuel/bio-energy
by possible integrating capture

The mGT has to become MORE flexible
flexible in terms of fuel
flexible in terms of cycle layout
flexible in terms of operation

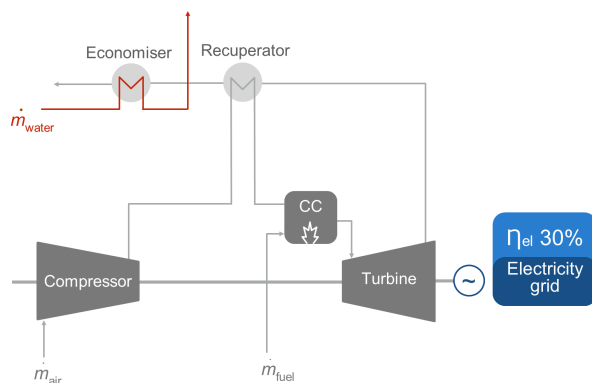
micro Gas Turbines (mGTs) have very high Combined Heat and Power (CHP) efficiencies



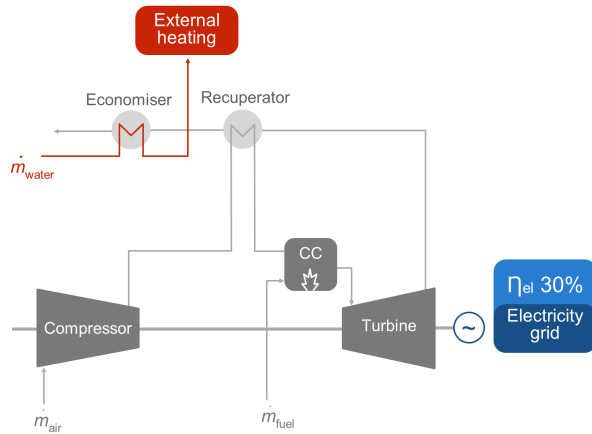
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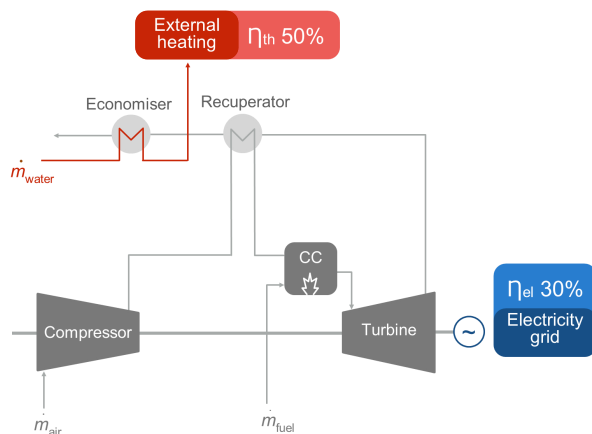
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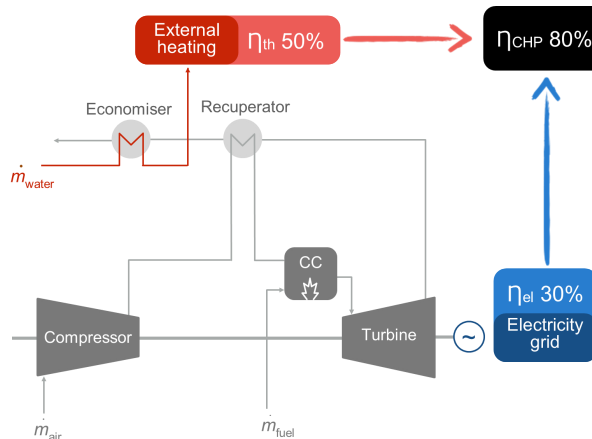
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The flexible mGT needs to become more operational flexible

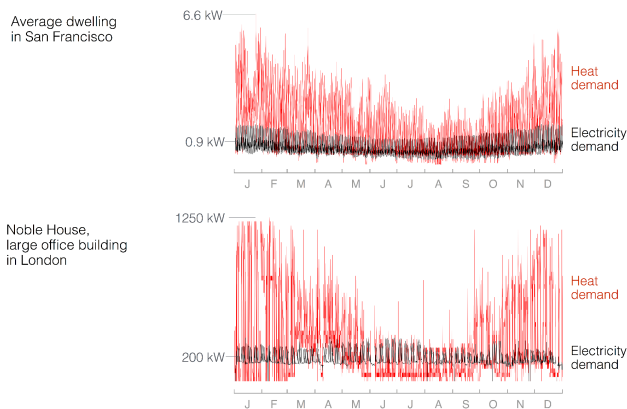
mGTs are already highly flexible

production of electricity and heat can be changed very fast, but both productions are coupled.

mGTs are linked to real users with real demand curves.

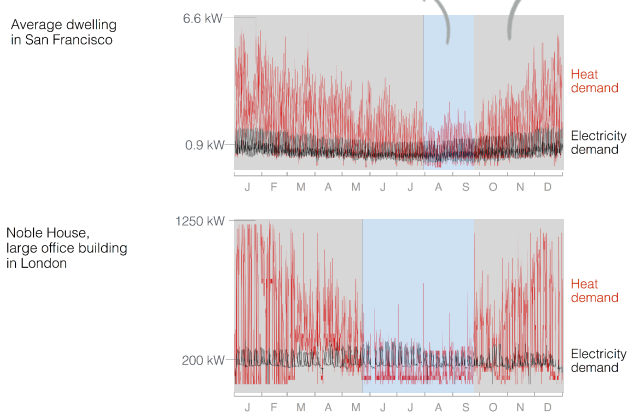
users have specific demands
electricity and heat demands are not linked
electricity is easier to handle than heat

mGTs in decentralized CHP applications are linked to real users with real demand curves.

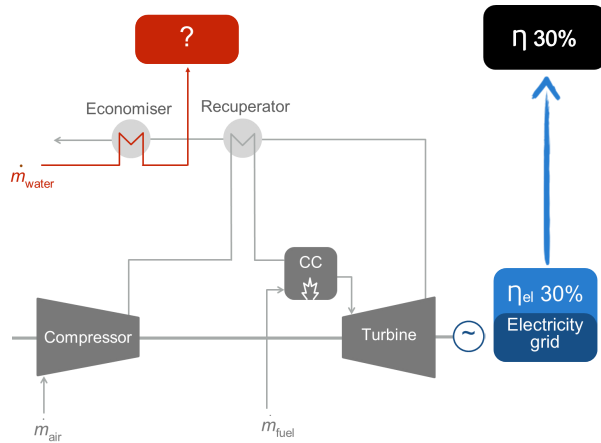


mGTs in decentralized CHP applications are linked to real users with real demand curves

CHP operation



If there is no use for the heat output,
the total efficiency is too low



Several options are available for waste heat recovery
to increase the operational flexibility.

**Introduce mGT into a system
with **heat storage****

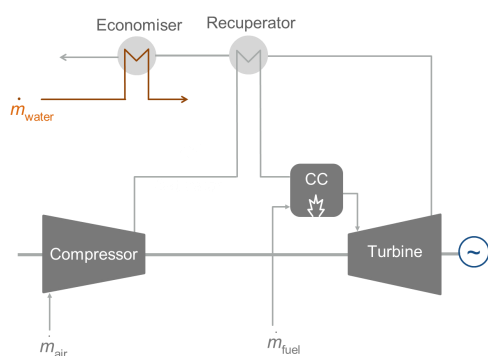
short term storage is possible with
current technology
long term storage is still an issue

**Link the mGT
with a **bottoming cycle****

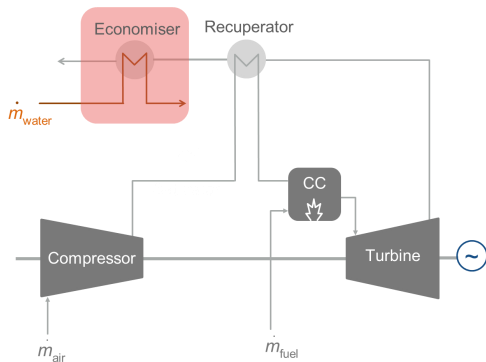
large investment cost and even less
operational flexibility

**Re-introduce waste heat
into the cycle **through humidification****

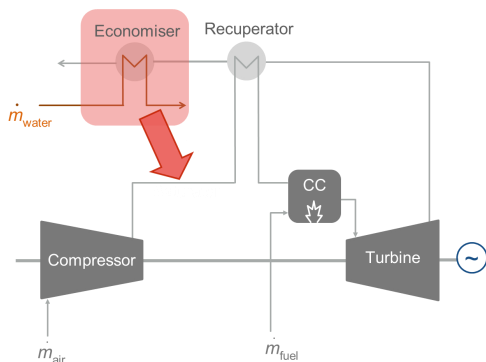
When heat demand is low...
the hot water is re-used in the mGT



When heat demand is low...
the hot water is re-used in the mGT



When heat demand is low...
the hot water is re-used in the mGT



Several options exist for waste heat recovery
through water injection

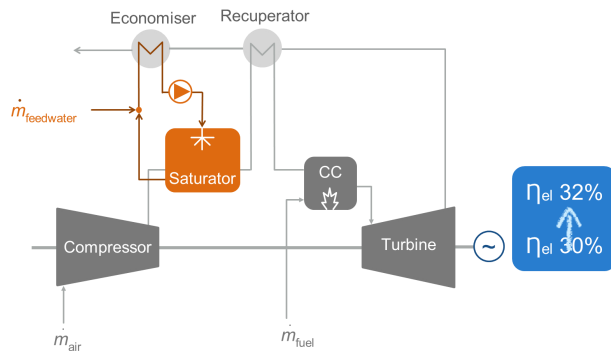
3 main categories

- steam injected cycles
- water injected cycles
- cycles with a saturation tower

**The micro Humid Air Turbine (mHAT)
is the most promising cycle**

- combines high efficiency with cycle simplicity
- possible to operate both dry and wet mode.

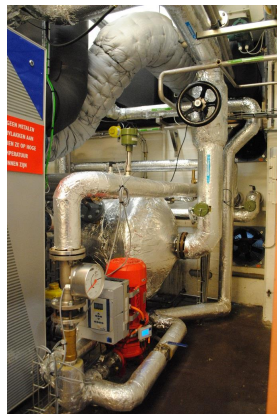
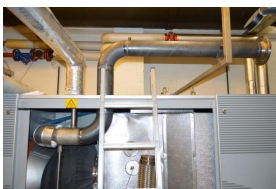
By humidifying the compressed air we increase the electrical efficiency

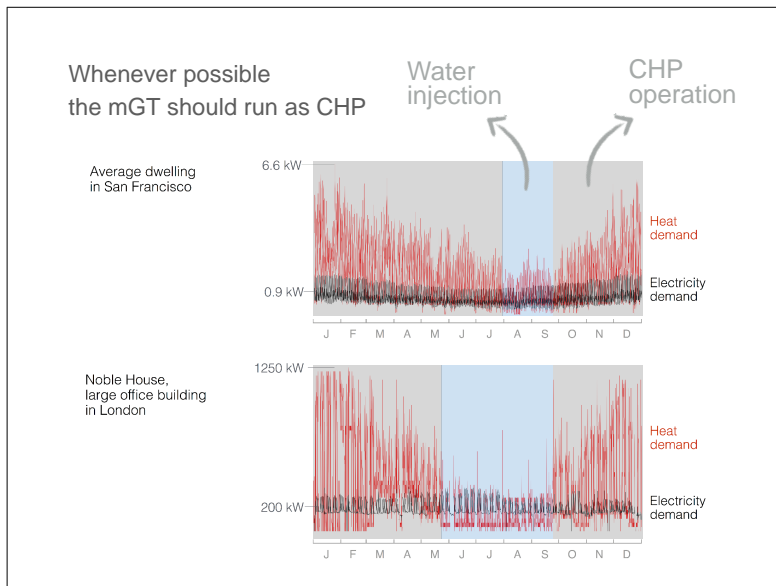


The mHAT concept was experimentally tested and validated in our test rig



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Recommendations for improved operational flexibility of mGTs using humidified cycles.

Despite the **proven economical potential**, no cycle is commercially available.

There are still **technical challenges** or opportunities that need to be tackled:

- Turbo-machinery: off-design behavior
- Cycle layout: must be kept simple
- Combustion: stability of the combustion
- Recuperator: fast-destruction

We are still focusing on these challenges.

To get this place in the future energy production, the mGT needs to evolve.

The mGT has to become more efficient
both at full and part load operation

The mGT has to become fully CO₂ neutral/negative

- by using biofuel/bio-energy
- by possible integrating capture

The mGT has to become MORE flexible

- flexible in terms of fuel
- flexible in terms of cycle layout
- flexible in terms of operation

In our research, we focus on the design of small, sustainable, carbon-clean, flexible mGT cycles.

Focus on possible synergies between different energy vectors

traditional + renewable + storage

Focus on all scales of the cycle

system level up to components

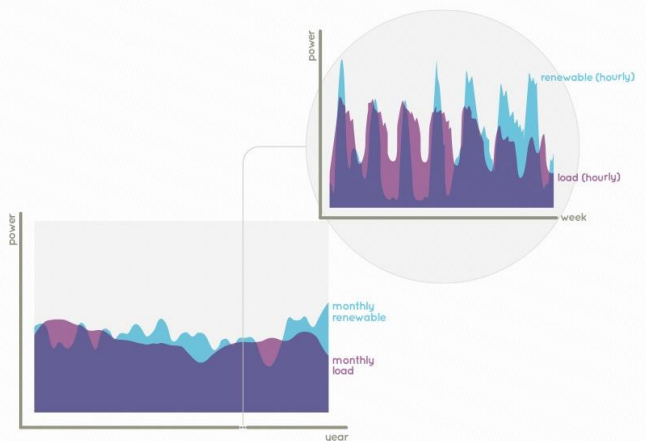
Combine two approaches:

numerical + experimental validation

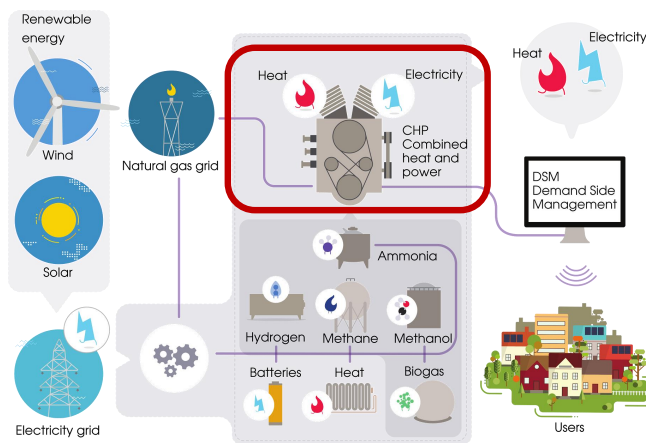
Focus on several possible applications

power production, CHP, range extender

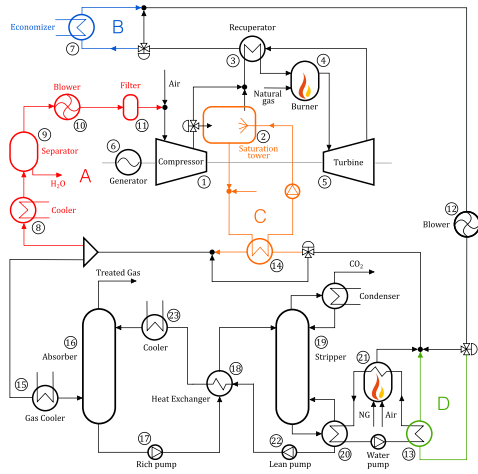
Example: Small, flexible, carbon clean power production in combination with power-to-gas offer possibilities.



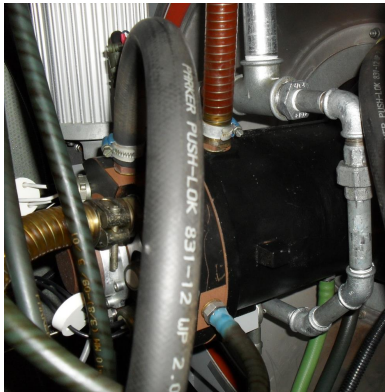
Example: Small, flexible, carbon clean power production in combination with power-to-gas offer possibilities.



Current Status: Integration of Carbon Capture in mGT cycle.



Ongoing work: Experimental validation of EGR on the mGT test rig



Still potential to be unlocked.

**BETTER PERFORMANCE EXPECTED WITH
ADAPTED MGT FOR MHAT OPERATION
AND INTEGRATED CARBON CAPTURE
LEADING TO MORE OPERATIONAL
FLEXIBILITY**



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