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Towards a Carbon Clean micro Gas Turbine: Carbone Capture Penalty Reduction Using Exhaust Gas Recirculation

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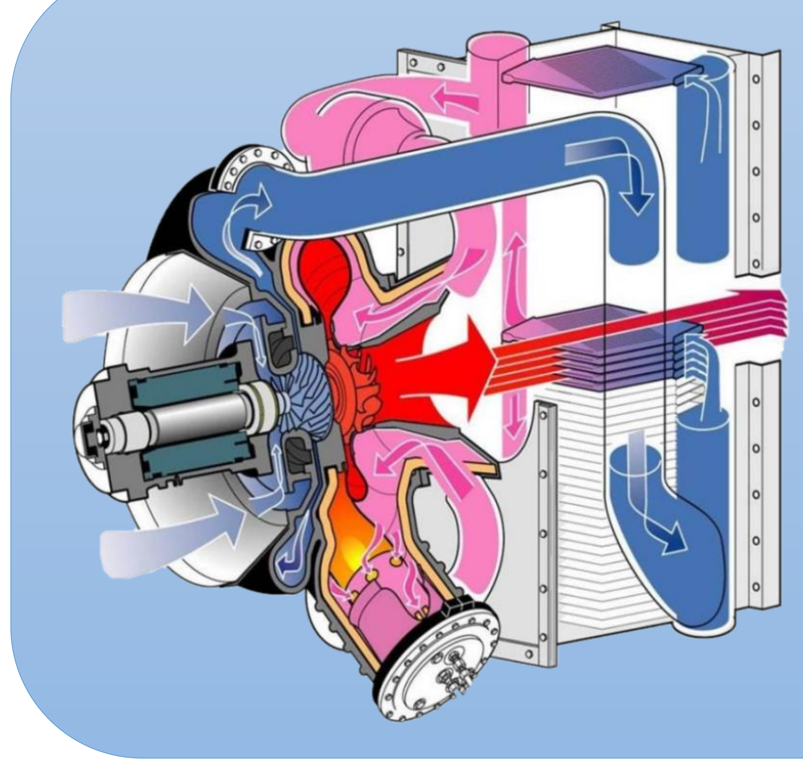
Motivations



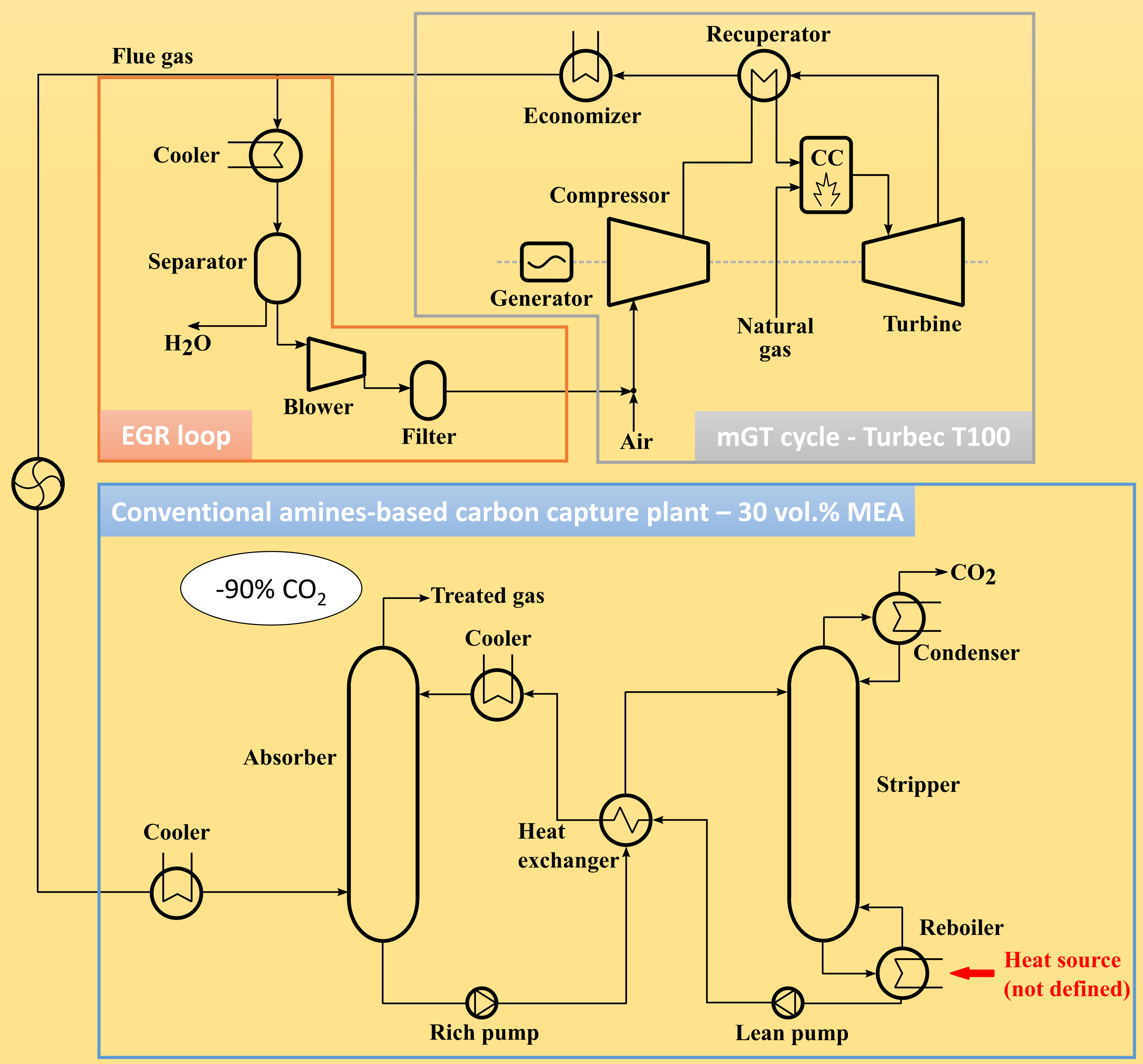
Micro gas turbine (mGT) offers high potential to provide the required flexibility for electricity generation given the growing share of renewables energies in the total energy mix. Nevertheless, reducing the carbon footprint of mGTs is essential to move towards a carbon clean energy production. In this perspective, applying post-combustion Carbon Capture (CC) offers a solution. However, the very lean mGT operating conditions result in a low CO_2 concentration in the flue gases, which is disadvantageous from a CC point of view.

Objective

Evaluate the impact of applying Exhaust Gas Recirculation (EGR), which is a way to enhance the CO_2 fraction in flue gases, on the mGT, on the CC plant and on the mGT-CC coupled system.

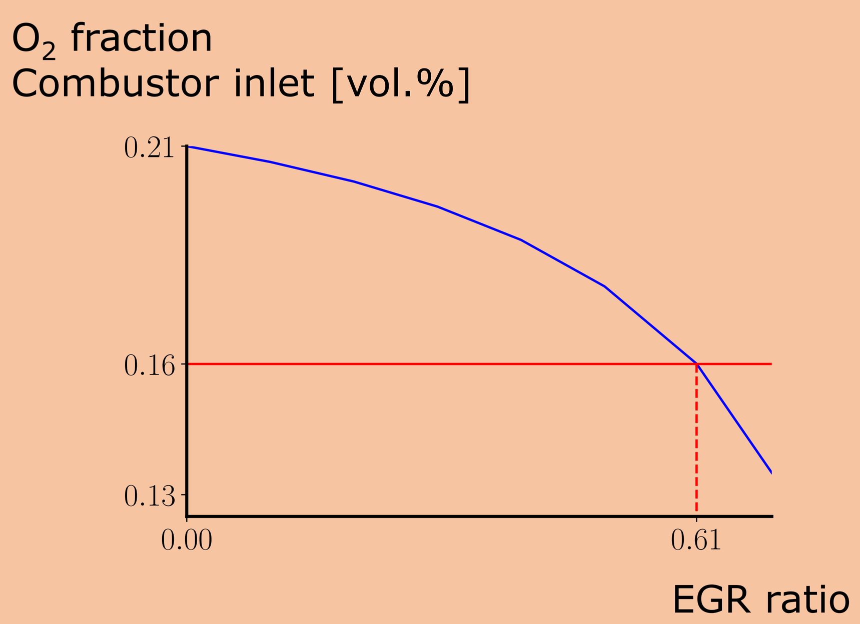
Methodology

Thermodynamic cycle simulations, including mGT, EGR loop and CC plant, were performed using Aspen Plus.



Previous work : Determination of the maximal achievable EGR ratio

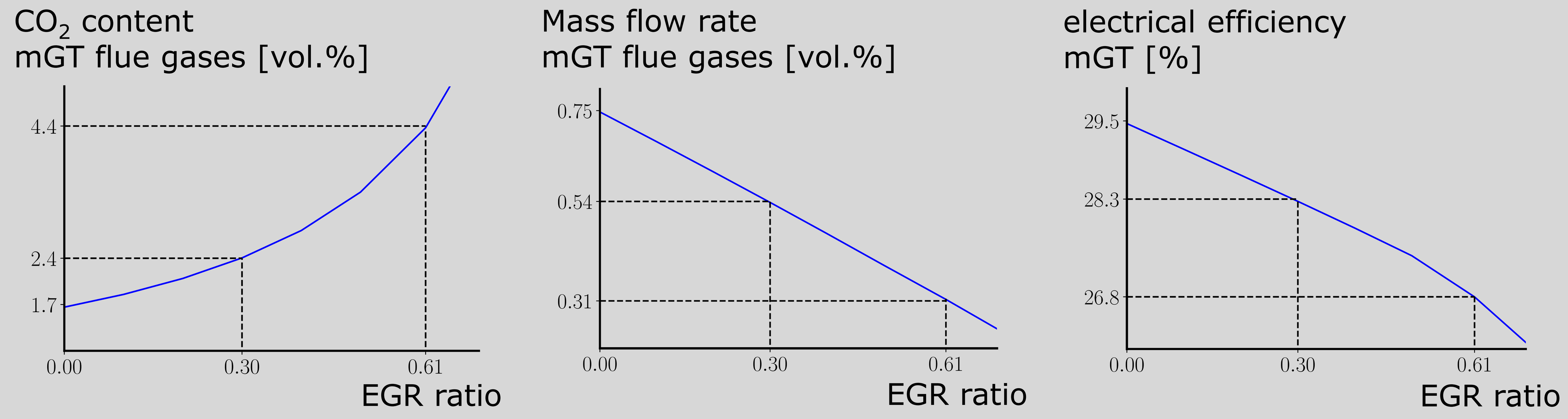
To ensure a stable combustion, the O_2 concentration in the air flow entering the combustion chamber must be higher than 16 vol.%



(Giorgetti et al. 2018, Applied Energy 207, 243-253)

Results

Impact of EGR on the mGT

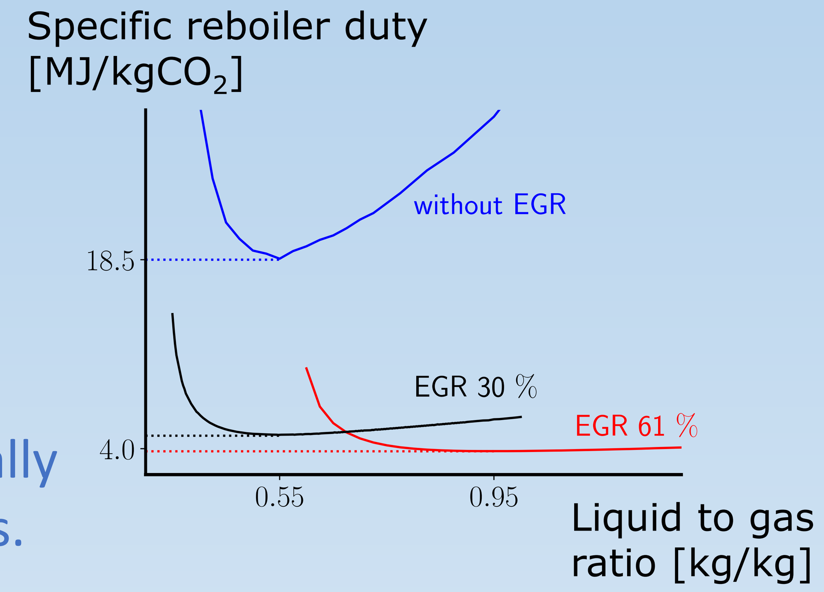


Impact of EGR on the CC plant

For each EGR ratio, the solvent flow rate has been optimized to minimize the Specific Reboiler Duty (SRD) defined as:

$$SRD = \frac{Reboiler\ duty\ [MJ/s]}{Mass\ flow\ of\ captured\ CO_2\ [kg/s]}$$

The **energy consumption** of the CC plant is drastically **reduced** by increasing the CO_2 fraction in flue gases.

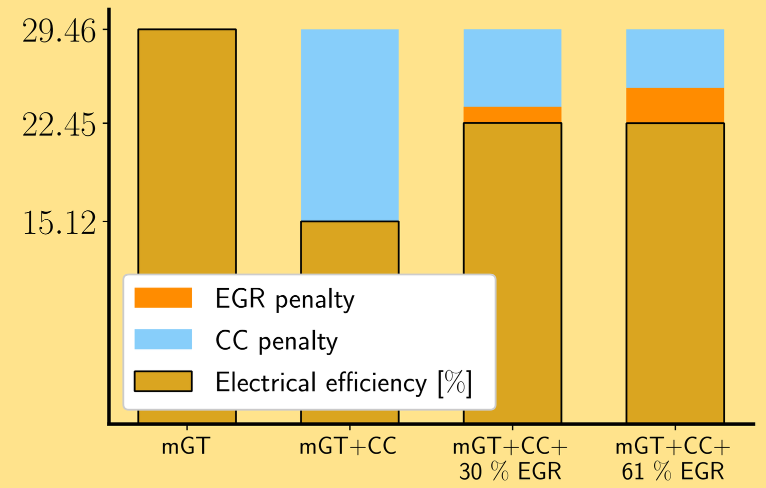


Impact of EGR on the mGT-CC coupled system

The electrical efficiency of the global mGT+CC system has been evaluated as follows:

$$\eta_{el} = \frac{P_{el} - P_{pumps}}{\dot{m}_{gas} LHV_{gas} + Reboiler\ duty}$$

Although EGR induces a small contribution to the global **energy penalty**, applying EGR allows to significantly reduce this **energy penalty**.



Conclusions

Adding CC to an mGT strongly reduces the electrical efficiency from **29.5%** to **15.1%** due to the low CO_2 content in flue gases (1.7 vol.%). The increase of this CO_2 concentration up to 4.4 vol.%, by performing EGR, showed an efficiency increase up to **22.5%**. Moreover, a high EGR ratio induces smaller gas flow rate, that reduce the size, and thus the cost of the CC equipment's.