Impact of H_2 and H_2-based fuels on the thermodynamic performances of different sizes of gas turbines

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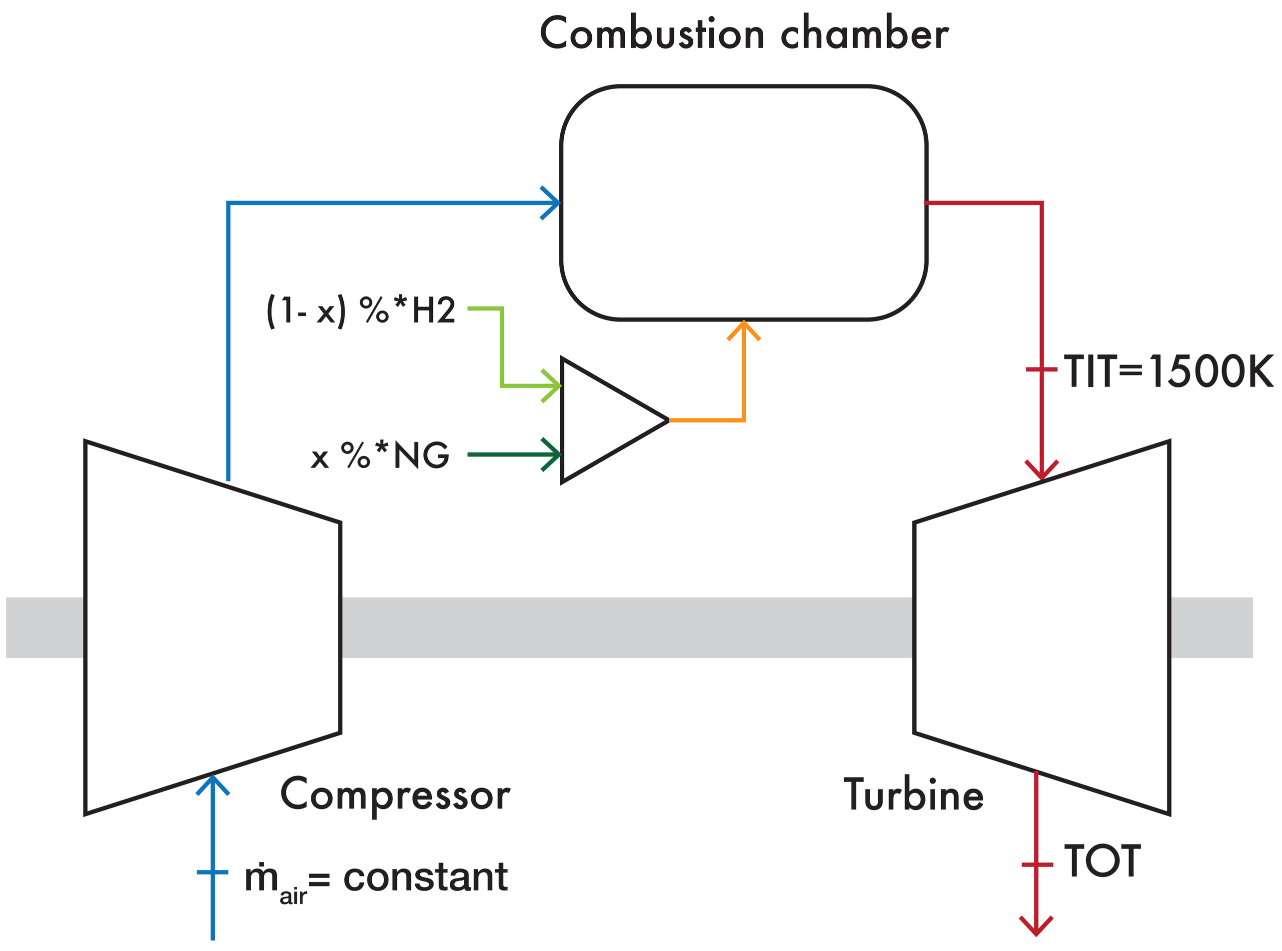
CONTEXT

Gas turbines are **dispatchable** and **flexible** power production means. They can reinforce system stability by balancing demand and supply. Therefore, they can be particularly valuable for an energy system with a high share of Variable Renewable Energies (VRE).

Currently, Natural Gas (NG) fired turbines satisfy this requirement. Nevertheless, low-carbon alternatives fuels will be essential to attain a **Net Zero Carbon Scenario in 2050**.

The analysis of the thermodynamic cycle can give us an outlook on the potential of **H_2 to replace NG** and its impact on gas turbine performances.



CHALLENGES

- Competition with other power production means.
- Hydrogen combustion: flashback and instability.
- Hydrogen supply, storage, and safety.
- NO_x emissions.

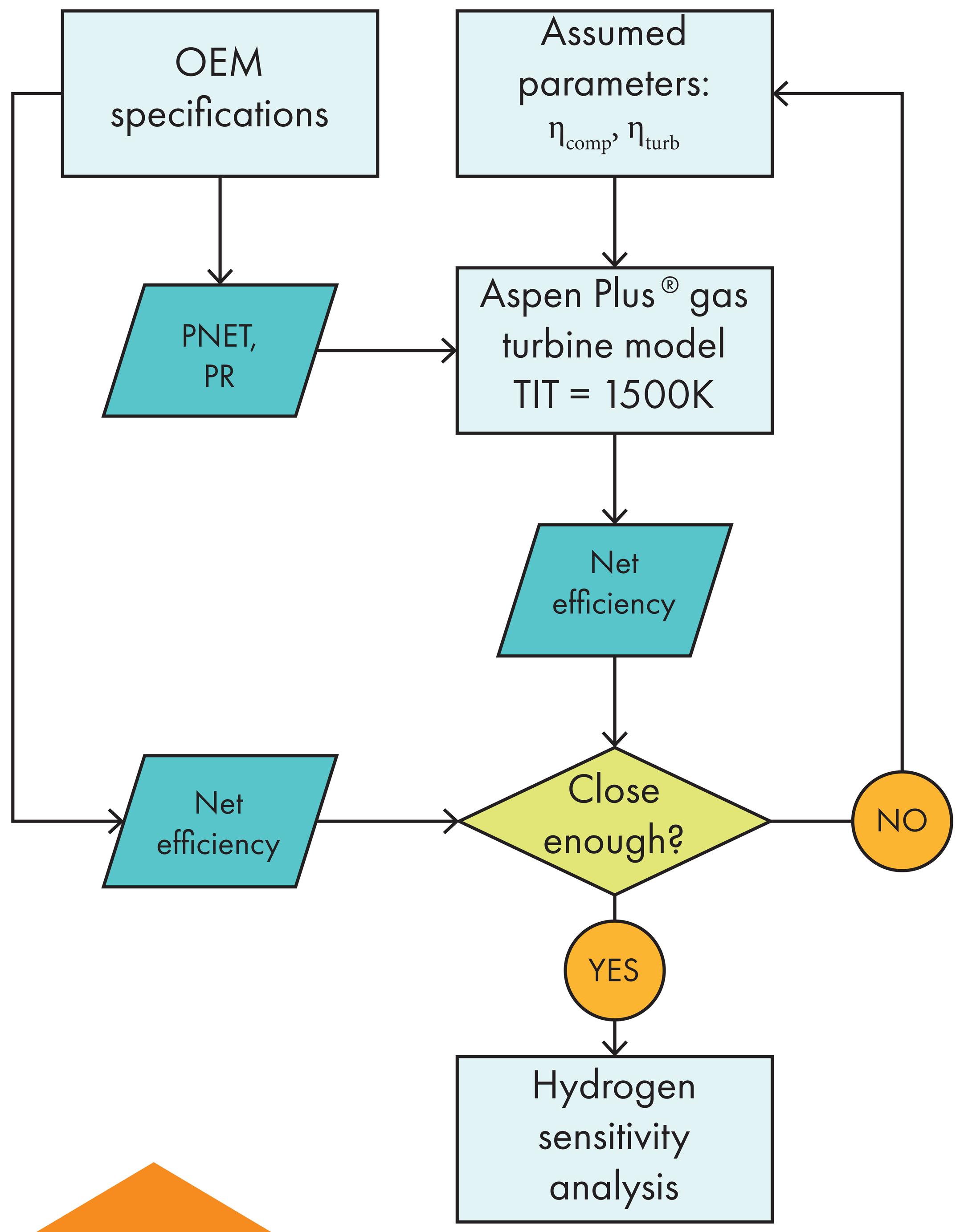
METHODS

SOFTWARE: Aspen Plus®, a process simulation software based on heat and energy balance calculations.

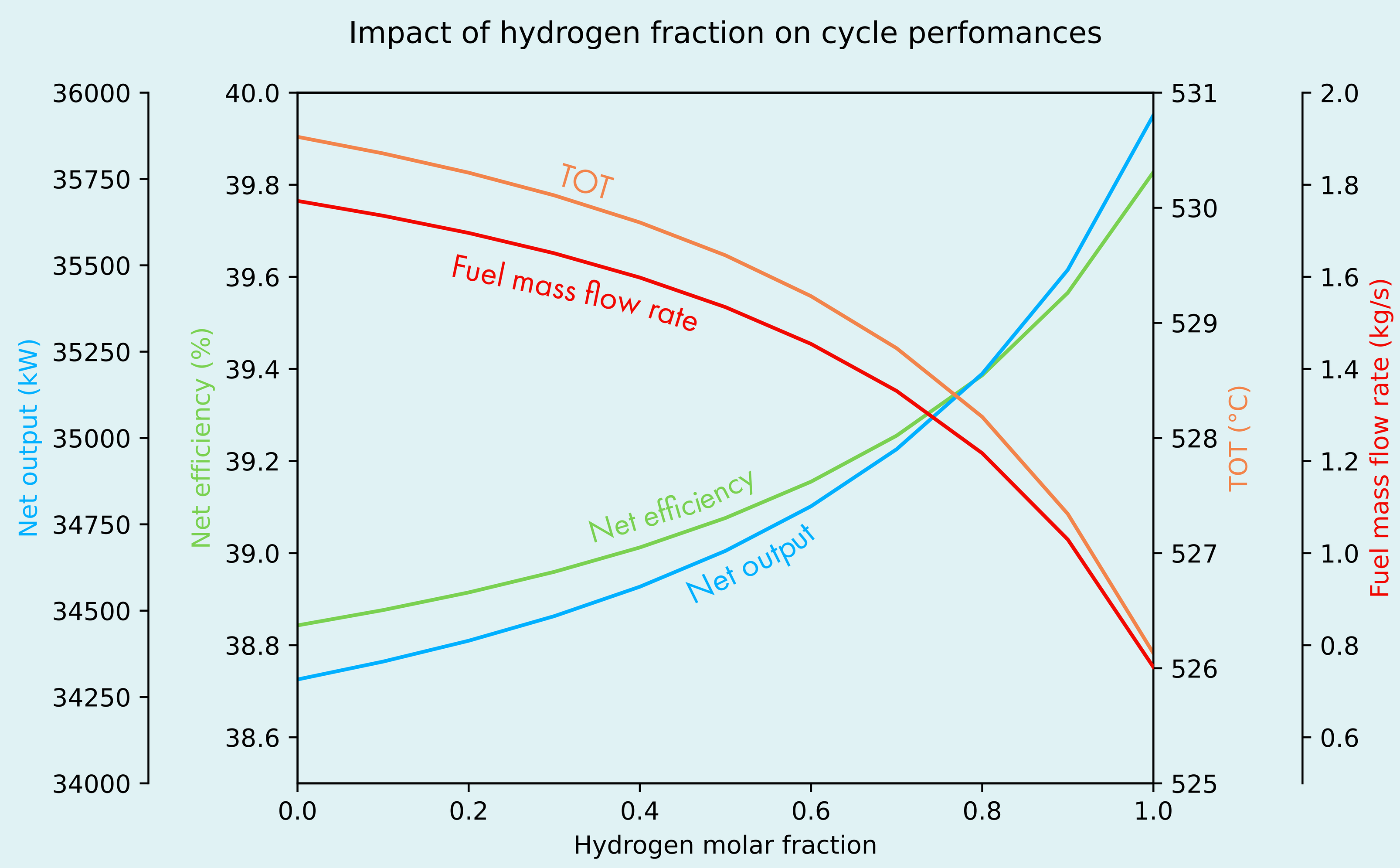
TEST CASE: 34MW aero-derivative gas turbine. Simulation in **steady-state**.

SENSITIVITY ANALYSIS: increase of H_2 molar fraction, while respecting a **Turbine Inlet Temperature** (TIT) of 1500K and keeping a constant air mass flow rate.

Model validation procedure



RESULTS



Replacing NG with H_2 has **a minor or lightly positive impact on the thermodynamic cycle**.

The **improvement of the net efficiency and the net power output** of the gas turbine is due to an augmentation of water content in exhaust gases.

The heat capacity ratio is higher for water than for CO_2 for a wide range of temperatures; as a result, the **Turbine outlet temperature (TOT) decreases** following the isentropic relations for ideal gases.

We can also notice a **diminution of the fuel mass flow rate**. It is due to the **high LHV of H_2** in terms of mass.

CONCLUSION AND PERSPECTIVES

For this preliminary assessment, **hydrogen caused no or slightly positive effect on thermodynamic cycle performances**. We will continue to assess the **impact of H_2 and H_2-based fuel blends** on the thermodynamic cycle for more other settings under **steady** and **transient-state**.

NEXT STEPS:

- Add **details** to components (e.g. fuel system).
- Analyse **multiple configurations** (e.g. Combined Cycle Gas Turbine (CCGT)).
- Assess systems under **part-load and off-design conditions.**
- Perform **techno-economic analysis** for the most illustrative cases.

ACKNOWLEDGMENTS

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