Hydrogen Fired Combined Cycle Gas Turbine

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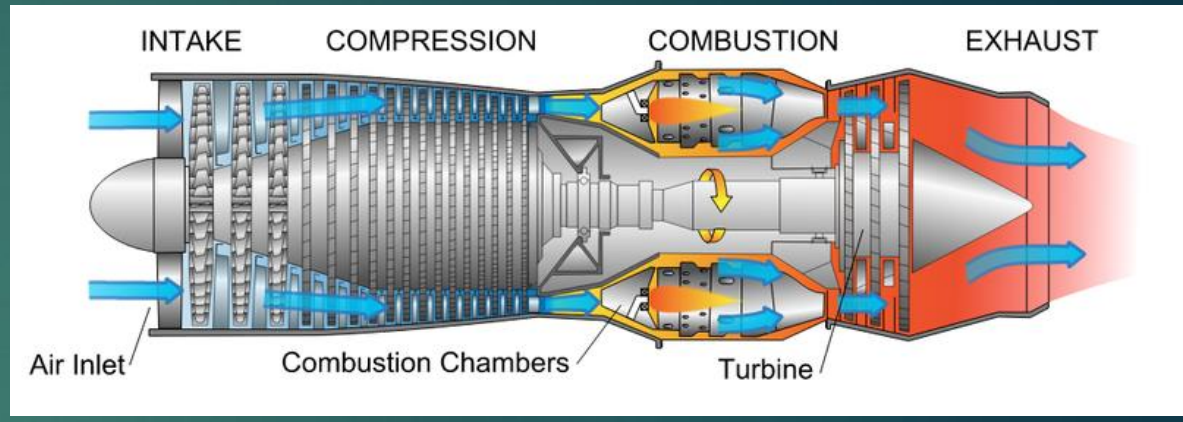
Introduction

WHY HYDROGEN?

Natural gas turbines

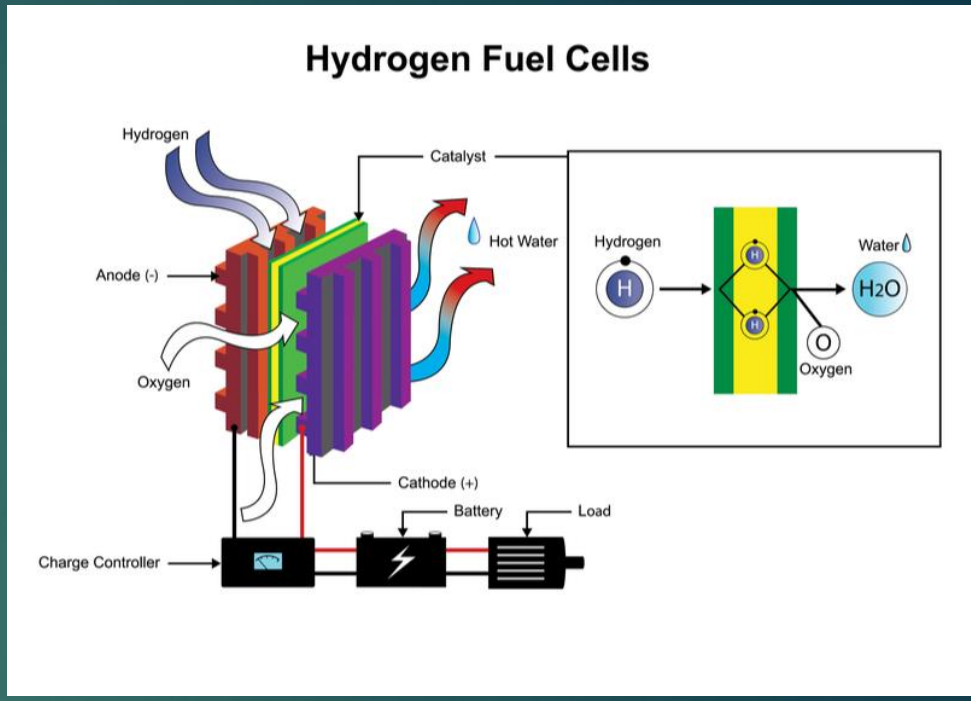
- A typical natural gas turbine:
  - Air is drawn in
  - Natural gas is injected
  - Mixture is combusted
  - Resulting gas spins blades
  - Blades drive compressor and generate electricity
- Natural gas turbines can provide energy during times of low wind and solar energy generation
- Does not capture excess energy generated by wind and solar
- Uses non-renewable energy source
- Efficiency of 50-60%



https://energyeducation.ca/encyclopedia/Gas_turbine

Hydrogen-based energy

- Fuel cell approach
  - Excess electricity stored as hydrogen through water electrolysis
  - Transformed back to water to regenerate electricity as needed
  - Efficiency of up to 60%
- Turbine approach
  - Hydrogen can be combusted in a gas turbine
- Does not rely on non-renewable energy like natural gas or produce CO2
- Due to the issue of Nitrous Oxides (NOx) produced in turbines, the team decided to work with Hydrogen and Oxygen
  - Similar research in Hydrogen and Oxygen is ongoing in Japan



https://www.power-technology.com/comment/standing-at-the-precipice-of-the-hydrogen-economy/

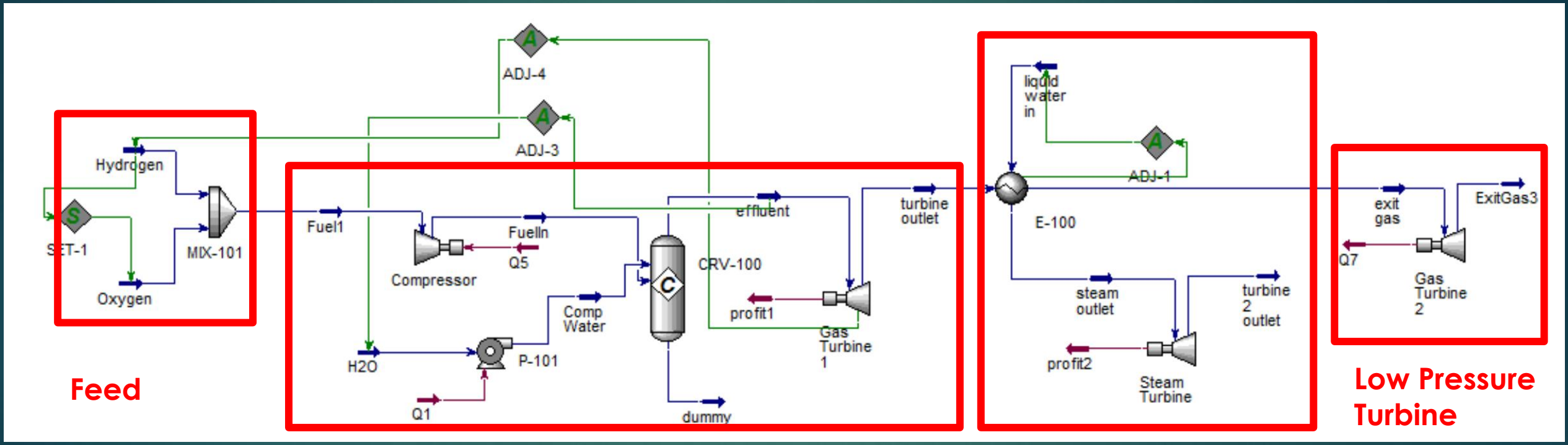
Methodology

Simulation Software

- ASPEN HYSYS for modeling
- HYSYS is a process simulator that is used to mathematically model chemical processes.
  - Can be used for individual operations or an entire plant.
- Two different Simulations
  - Electrolysis
  - Combined cycle power plant

https://seeklogo.com/vector-logo/348083/aspentech-hysys

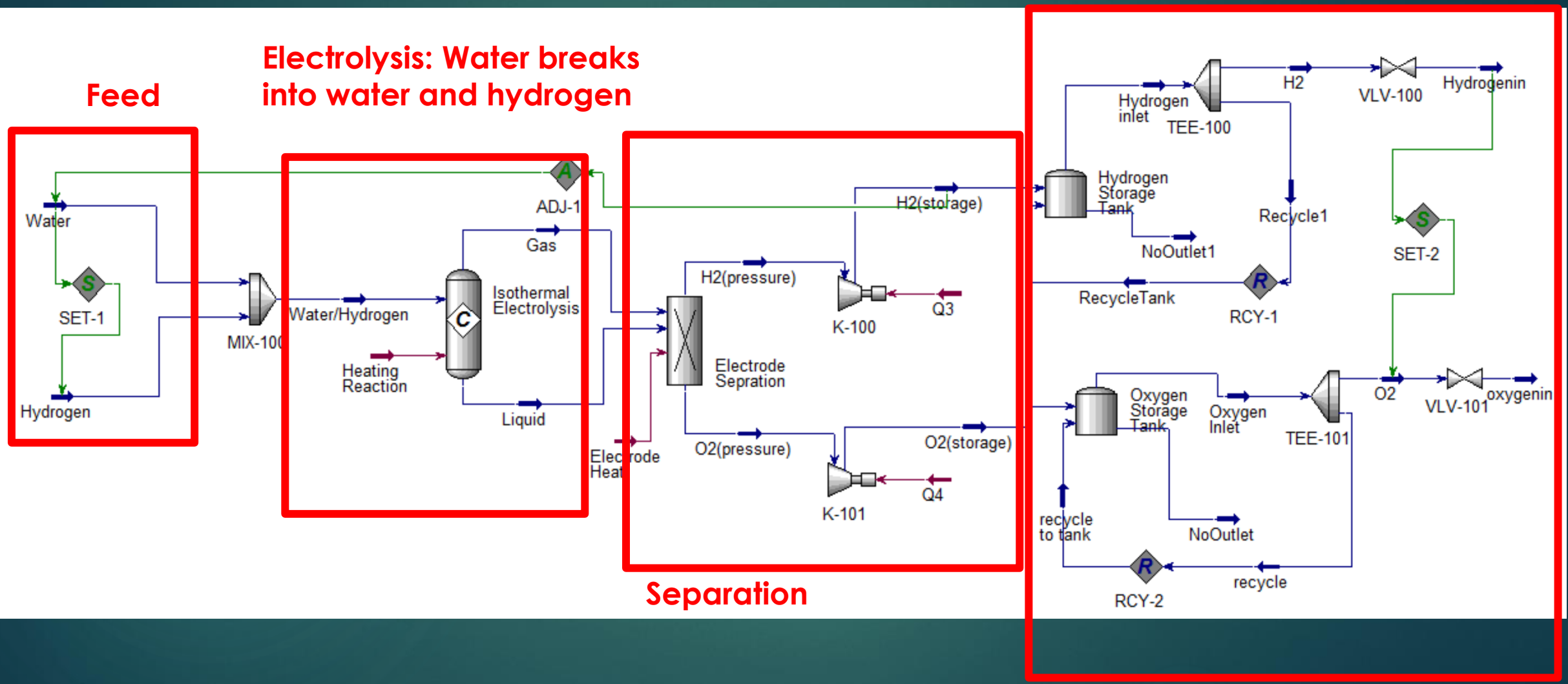
ASPEN-HYSYS


ADJ-4
ADJ-3
Hydrogen
SET-1
MIX-101
Oxygen
Fuel1
Compressor
FuelIn
Q5
effluent
CRV-100
Comp
Water
profit1
Gas
Turbine
1
turbine
outlet
H2O
P-101
Q1
dummy
liquid
water
in
ADJ-1
E-100
steam
outlet
turbine
2
outlet
profit2
Steam
Turbine
exit
gas
ExitGas3
Q7
Gas
Turbine
2
Feed
High Pressure Turbine
Heat Recovery Steam
Generator
Low Pressure
Turbine

Storage and routing to turbine

Feed

Electrolysis: Water breaks into water and hydrogen



Separation

Our Recommendations and Conclusions

Efficiency

- Our current HYSYS has a LHV efficiency of 42.3%. When producing 500 MW.

To improve the efficiency:

- Increasing the pressure of the inlet gases.
- Increase the temperature of the inlet gases.

Outcomes

- Efficiency is below desired, making it difficult to compete with both natural gas turbines and fuel cells.
- The use of water in place of air allows high temperature combustion to take place without the concern of generating NOx gases
- Major cost drivers:
  - Electrolysis is one of the most expensive means of generating hydrogen, but the most carbon neutral
- Future analysis:
  - Fine tuning thermodynamic properties
  - Cooling systems for the electrolysis