Washkewicz College of Engineering

Blue Hydrogen Production

(AICHE 2025 Design Competition)

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Objectives

Design a process to produce 250 MMSCFD of blue hydrogen from natural gas through an Auto-Thermal Reforming (ATR) reaction process coupled with CO_2 capture and sequestration.

Reactions	Stoichiometry	ΔH
Pre-Reforming	$C_nH_m + nH_2O \rightarrow nCO + (n + \frac{1}{2}m)H_2$	Endothermic
Partial Oxidation	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$	Exothermic
Autothermal Reforming	$CH_4 + H_2O \rightarrow 3H_2 + CO$	Endothermic
	$CH_4 + 2H_2O \rightarrow 4H_2 + CO_2$	Endothermic
WGS (Water-Gas Shift)	$CO + H_2O \leftrightarrow CO_2 + H_2$	Exothermic

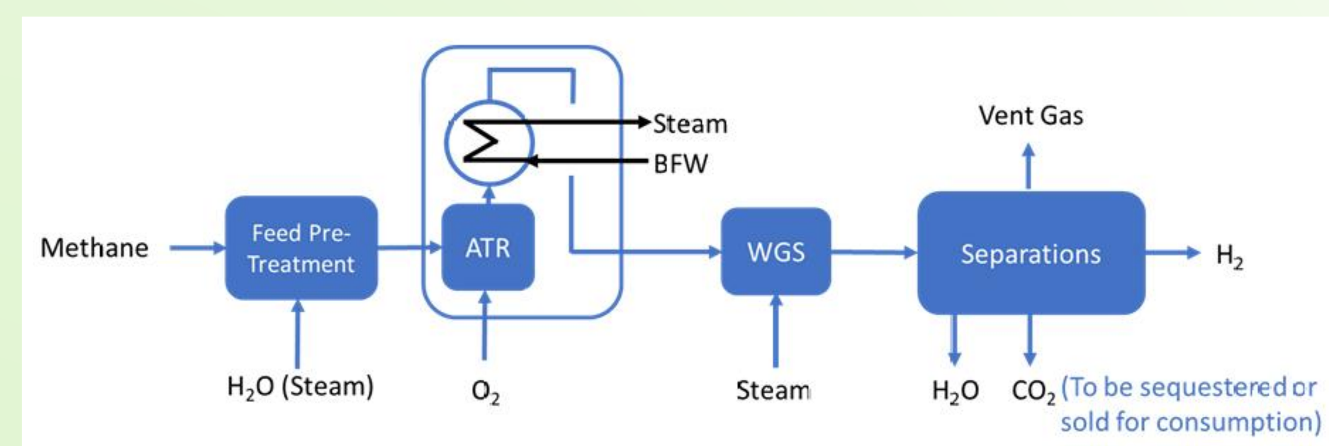

Figure 1: High level overview of the Blue Hydrogen Process.

Main Process Units

1. Pre-Reformer: Break down larger hydrocarbons
2. ATR Reactor: Combustion and Hydrogen production
3. Water-gas shift Reactor: Maximize hydrogen and reduce emissions by reacting CO
4. Absorber & Stripper: CO_2 capture utilizing MEA
5. Pressure Swing Absorber: Hydrogen purification

Background

- Hydrogen is a key component in the transition from fossil fuels to cleaner energy.
- Although green hydrogen (via electrolysis using renewable energy) is the long-term goal, most hydrogen today is produced from fossil fuels, know as gray hydrogen.
- Blue hydrogen offers a transitional solution: it is produced from fossil fuels but with carbon capture and sequestration to reduce greenhouse gas emissions.
- Blue hydrogen supports near-term decarbonization while building infrastructure and demand for a future green hydrogen economy.

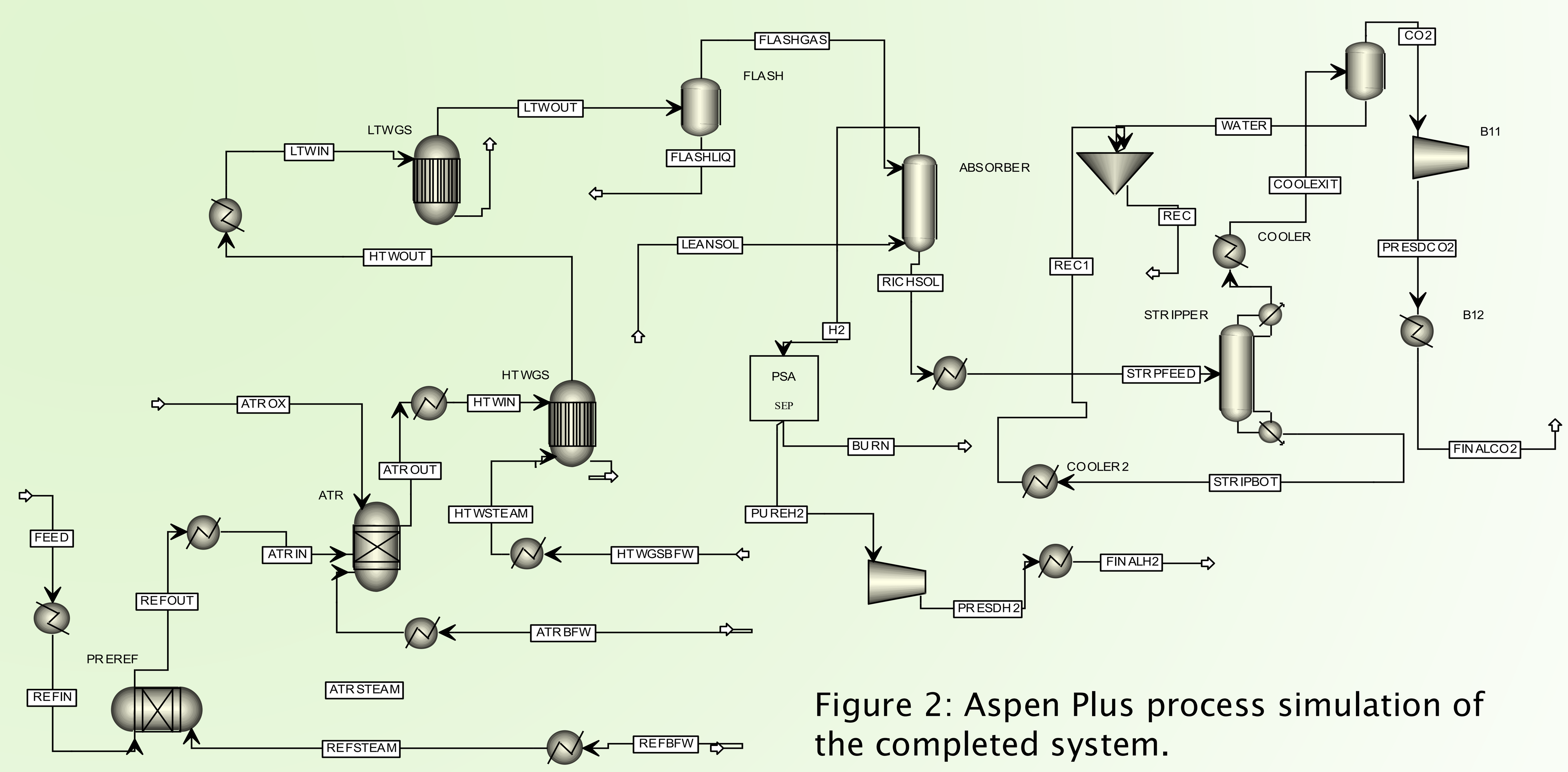

Figure 2: Aspen Plus process simulation of the completed system.

Table 1: List of process unit and stream parameters.

Process Parameter	Value	Units	Comment
Pre-Reformer Inlet Temperature	650	F	
Pre-Reformer Inlet Pressure	700	PSI	
Pre-Reformer Steam/Hydrocarbon Ratio	0.8		Molar
ATR Reactor- Inlet Temperature	1200	F	
ATR Reactor- Outlet Temperature	2000	F	
ATR- Inlet Pressure	600	PSI	
HT WGS Steam/Dry Gas Ratio	0.5		Molar
High Temperature (HTS) WGS Reactor Inlet Temperature	750	F	
Low Temperature (LTS) WGS Reactor Inlet Temperature	360	F	
Natural Gas Supply Pressure	700	PSI	at 60 F
O2 Pipeline Supply Pressure (100% O2)	700	PSI	at 60 F
Hydrogen Pipeline Injection Pressure	900	PSI	at 120 F
CO2 Pipeline Injection Pressure	900	PSI	at 120 F
Boiler Feed Water Supply Conditions	900	PSI	at 200 F
Cooling Water Supply Conditions	70	PSI	at 70 F
Cooling Water Return Conditions	110	F	
Heat Exchanger Approach Temperature	15	F	

Conclusion and Future Work

- With this process, roughly 293 MMSCFD of hydrogen was generated.
- 86% of the produced CO_2 was recovered via deployment of commercially available MEA solvent.
- Heat integration enabled the recovery of 168 MMBtu/hr, improving overall thermal efficiency of the plant.
- A gross annual revenue of $535 million per year resulted from the sale of blue hydrogen.
- Future efforts will include a comprehensive quantitative risk assessment in addition to a Hazard and Operability Study.
- A detailed techno-economic analysis, incorporating capital expenditure (CAPEX), equipment depreciation, and lifecycle cost modeling, is required to rigorously assess the economic viability and long-term profitability of the proposed process.