

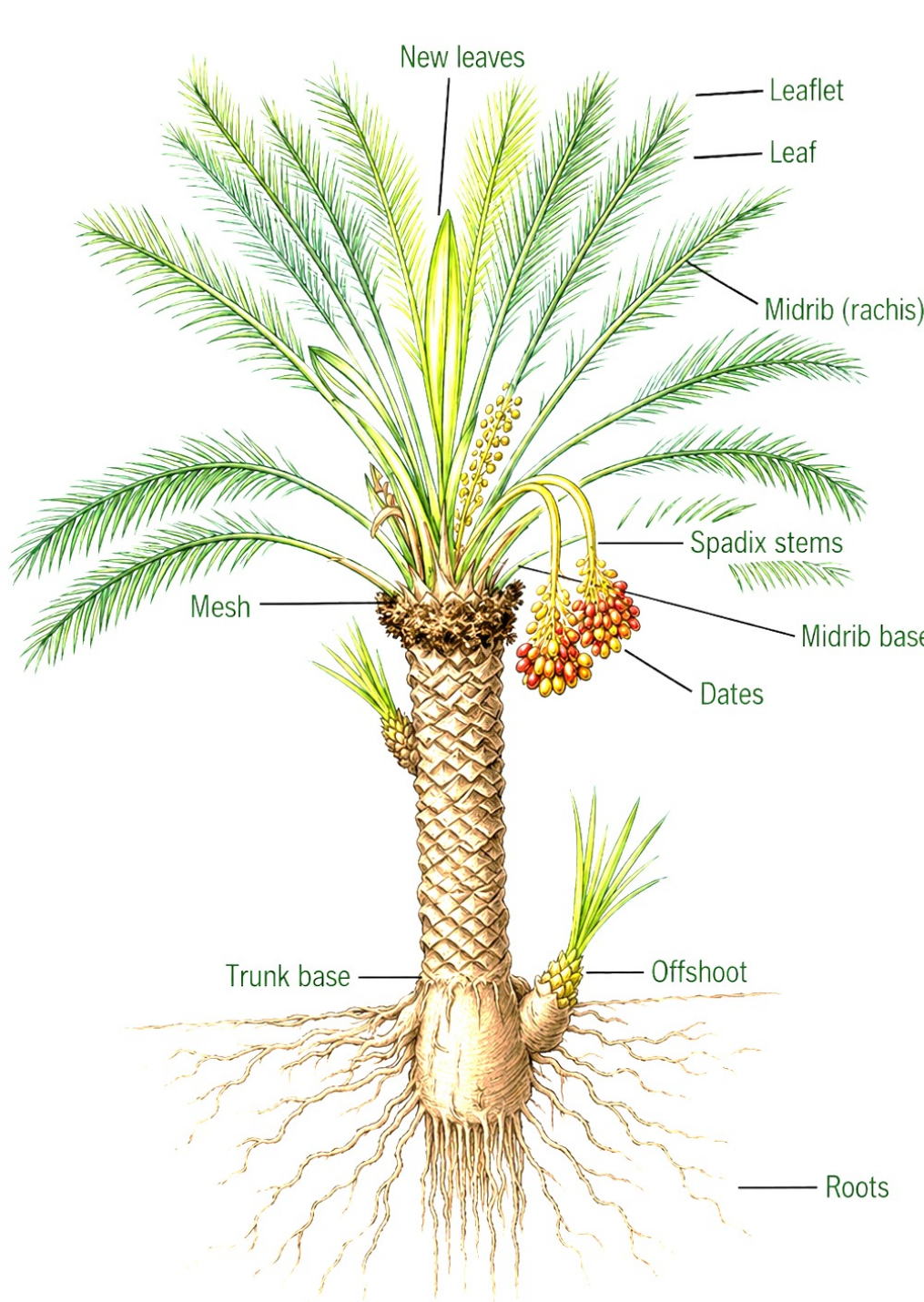
Design of date palm waste valorization unit for syngas and green hydrogen production using renewable energy: smart circular economy approach

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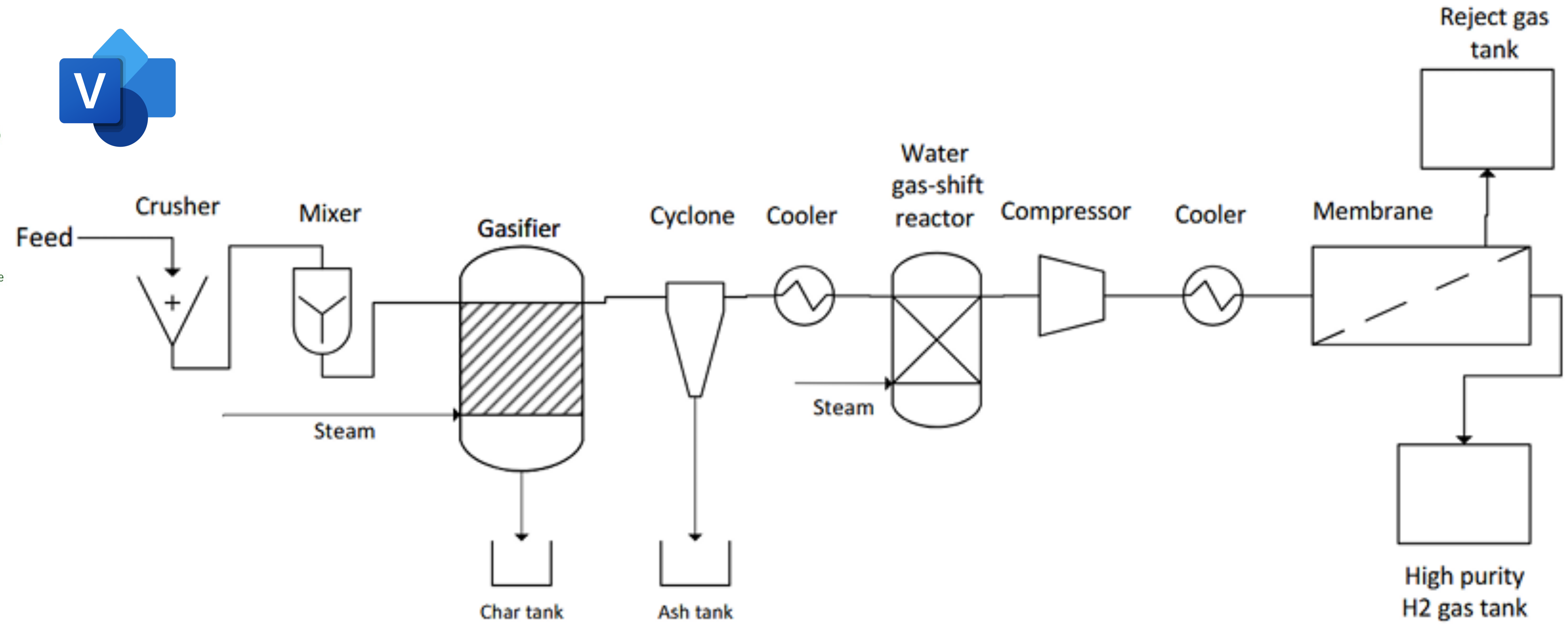
Chemical Engineering Department
June-2026

Project Overview

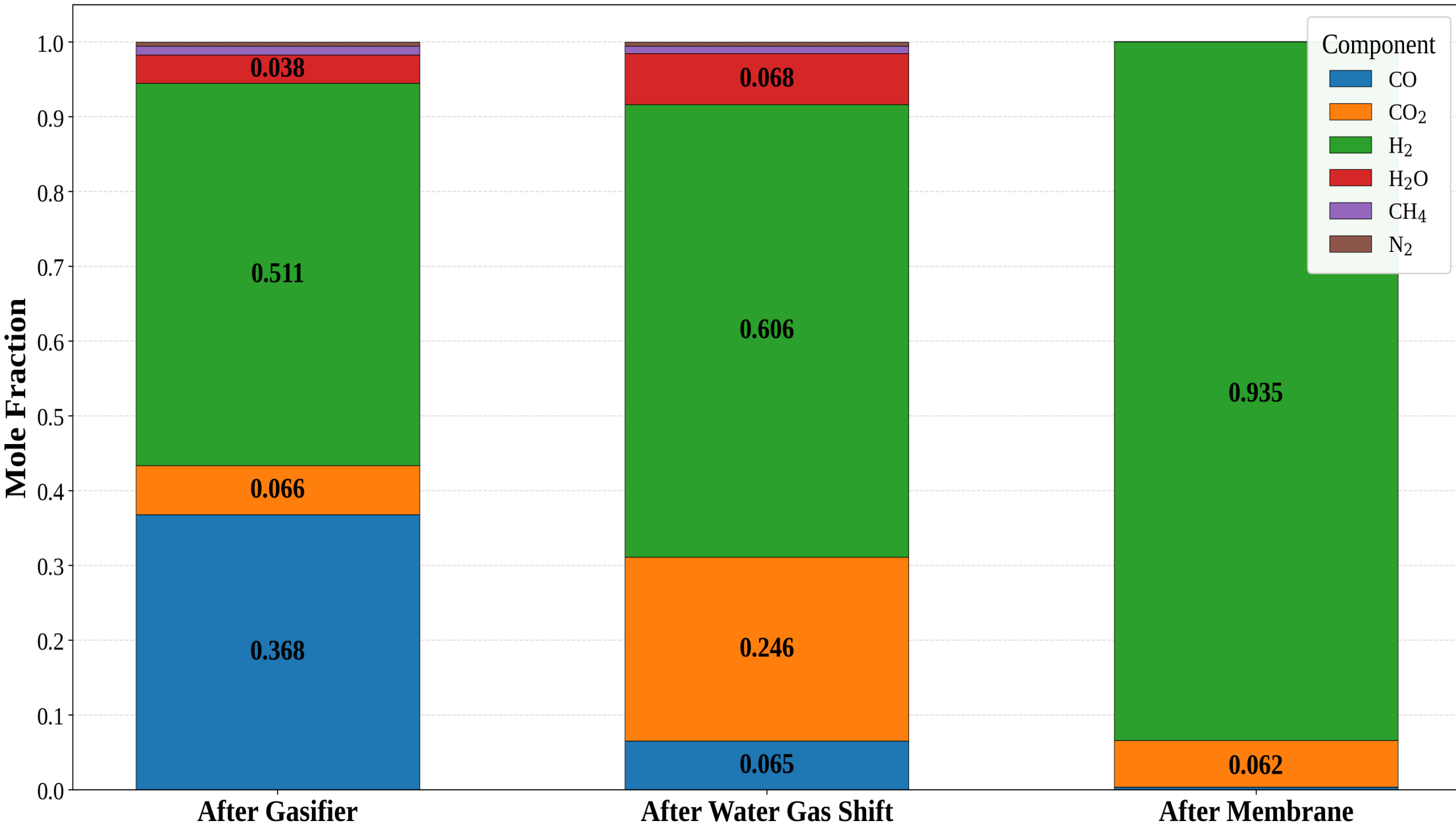
Saudi Arabia produces over 1.295 billion kg of date palm waste annually, much of which is burned or landfilled, causing pollution and loss of valuable biomass. This project designs an integrated process to convert date palm waste into syngas and green hydrogen using steam gasification, water-gas shift reaction, gas compression, and membrane-based hydrogen separation. The process was modeled using Aspen HYSYS with the SRK equation of state. The final design produced 2,304 kg/h of hydrogen at 93.5 mol% purity, equivalent to 18.43 million kg/year. Economic analysis showed a capital investment of 73.46 M\$, annual profit of 35.26 M\$/year, ROI of 48%, and a payback period of 3.08 years. The project demonstrates strong technical and economic feasibility while supporting waste reduction, clean energy production, and Saudi Vision 2030.



Process Modeling and Simulation



Composition Change Across Units



Optimization of HX Network

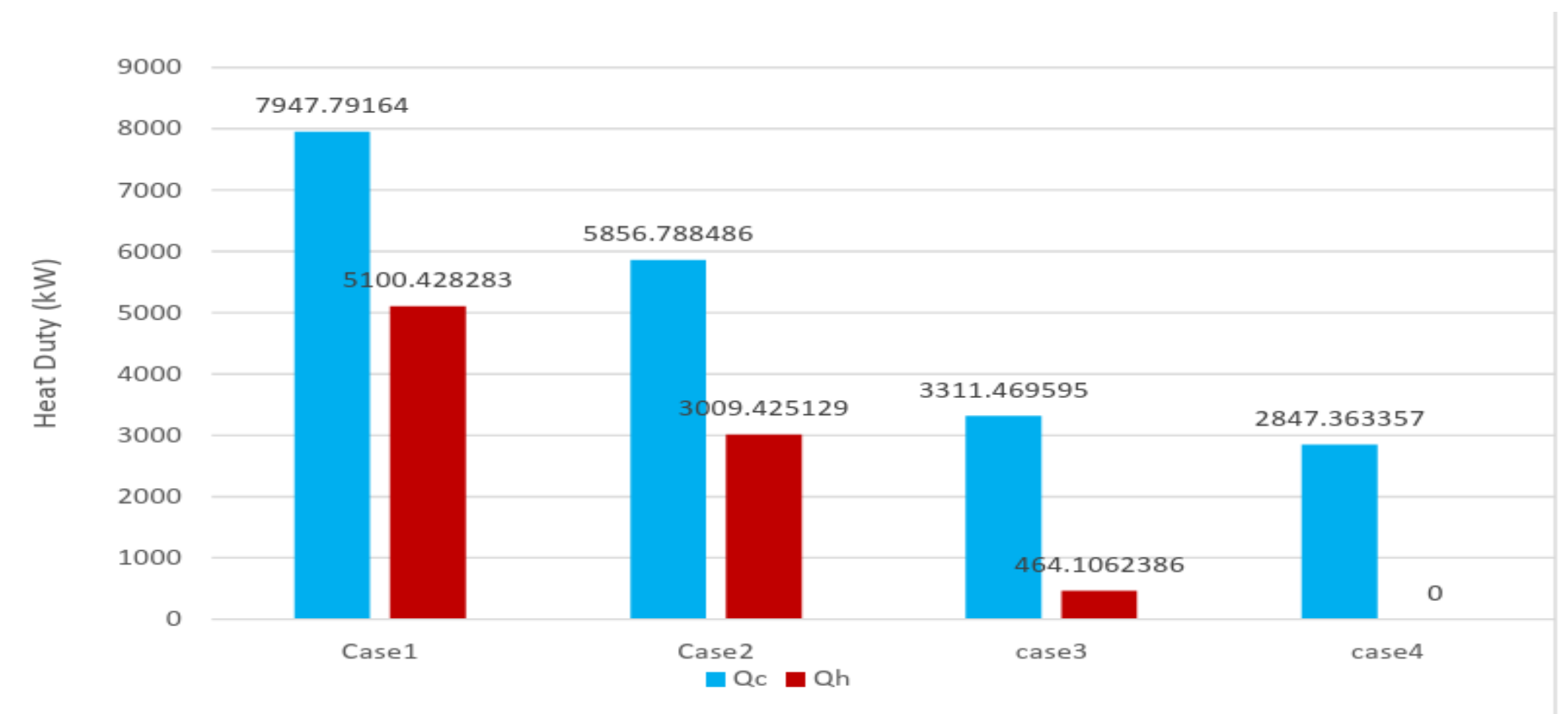
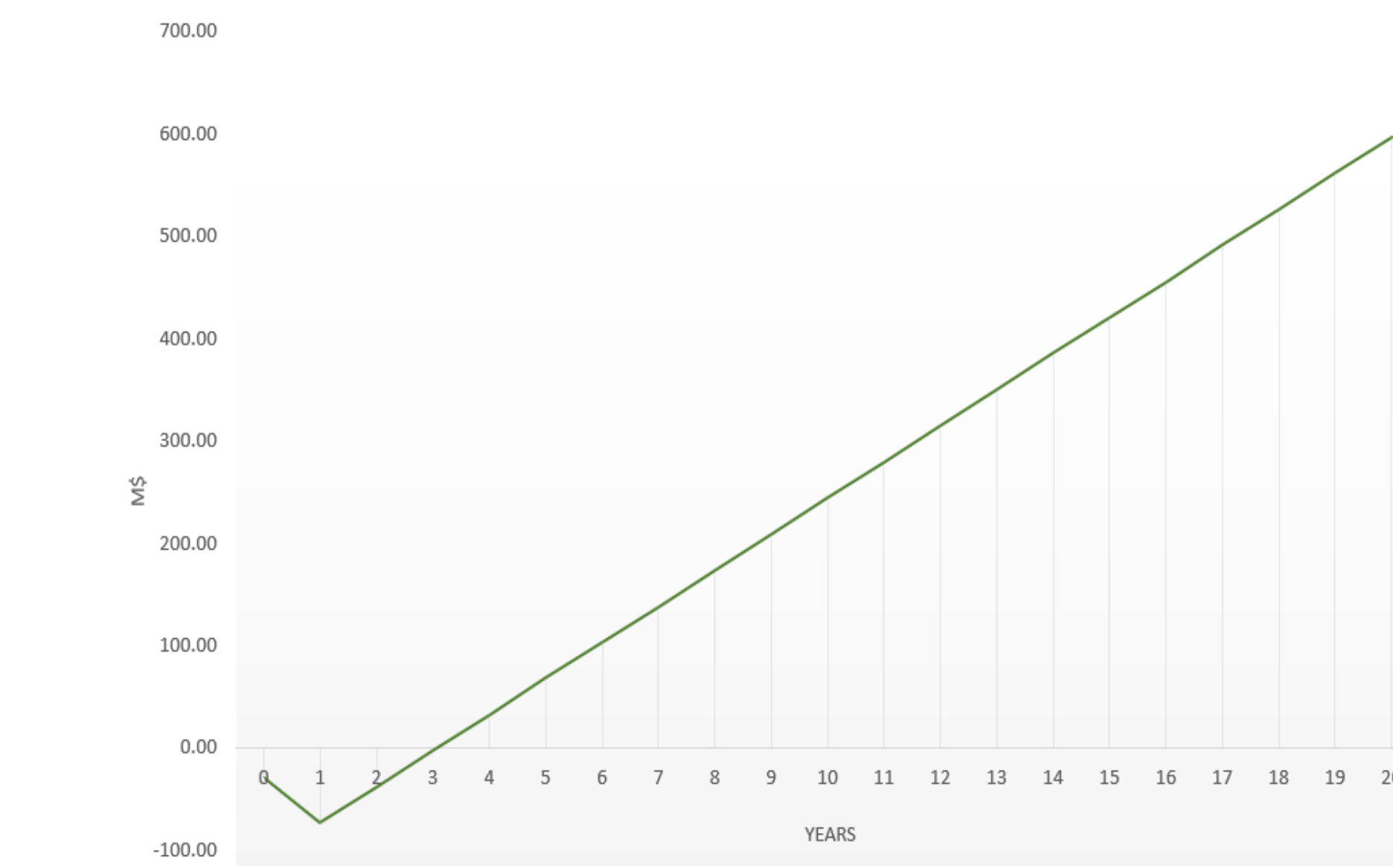


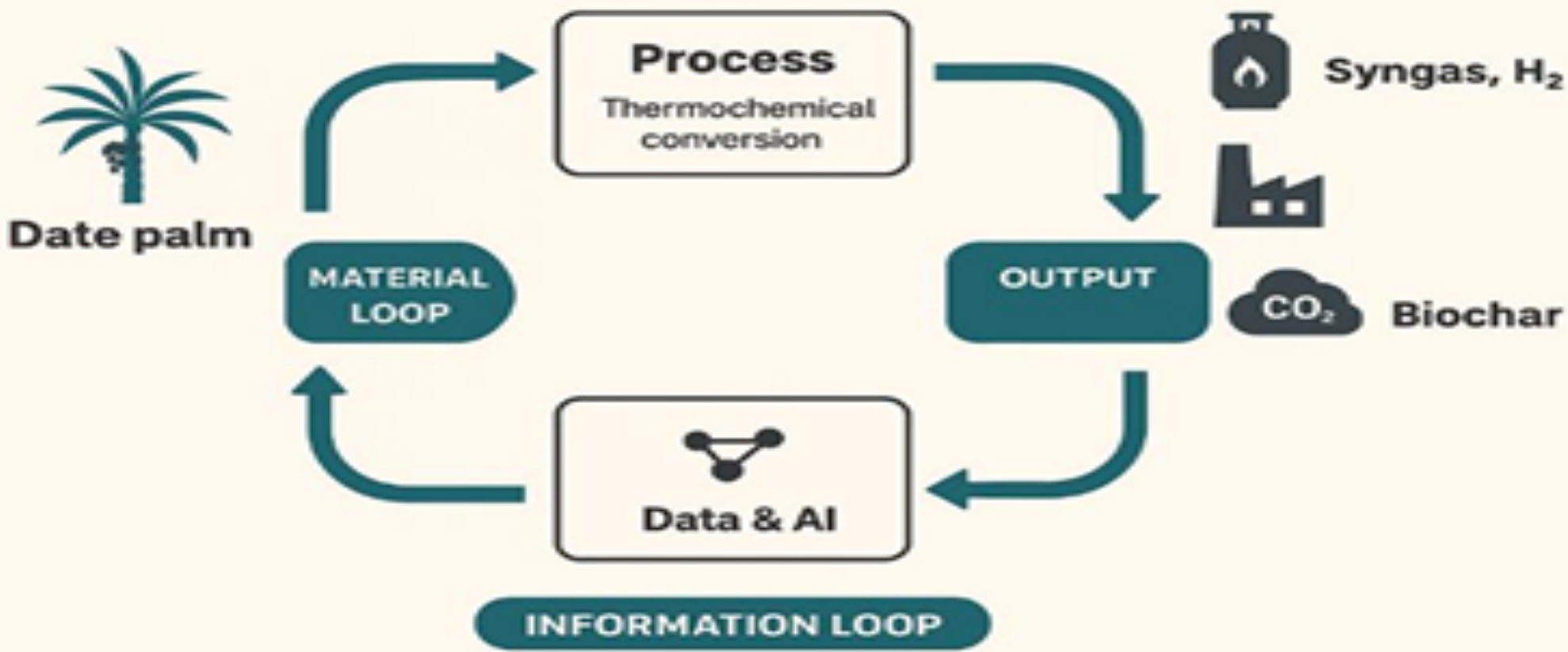
Fig. 4.1 Hot and Cold Utility Requirements for Heat-Integration Cases.

Conclusion



This project confirms the feasibility of converting date palm waste into syngas and green hydrogen. The system produced 2,304 kg/h of H₂ at 93.5 mol% purity, with a 48% ROI and a 3.08-year payback period, supporting waste valorization and Saudi Vision 2030 sustainability goals.

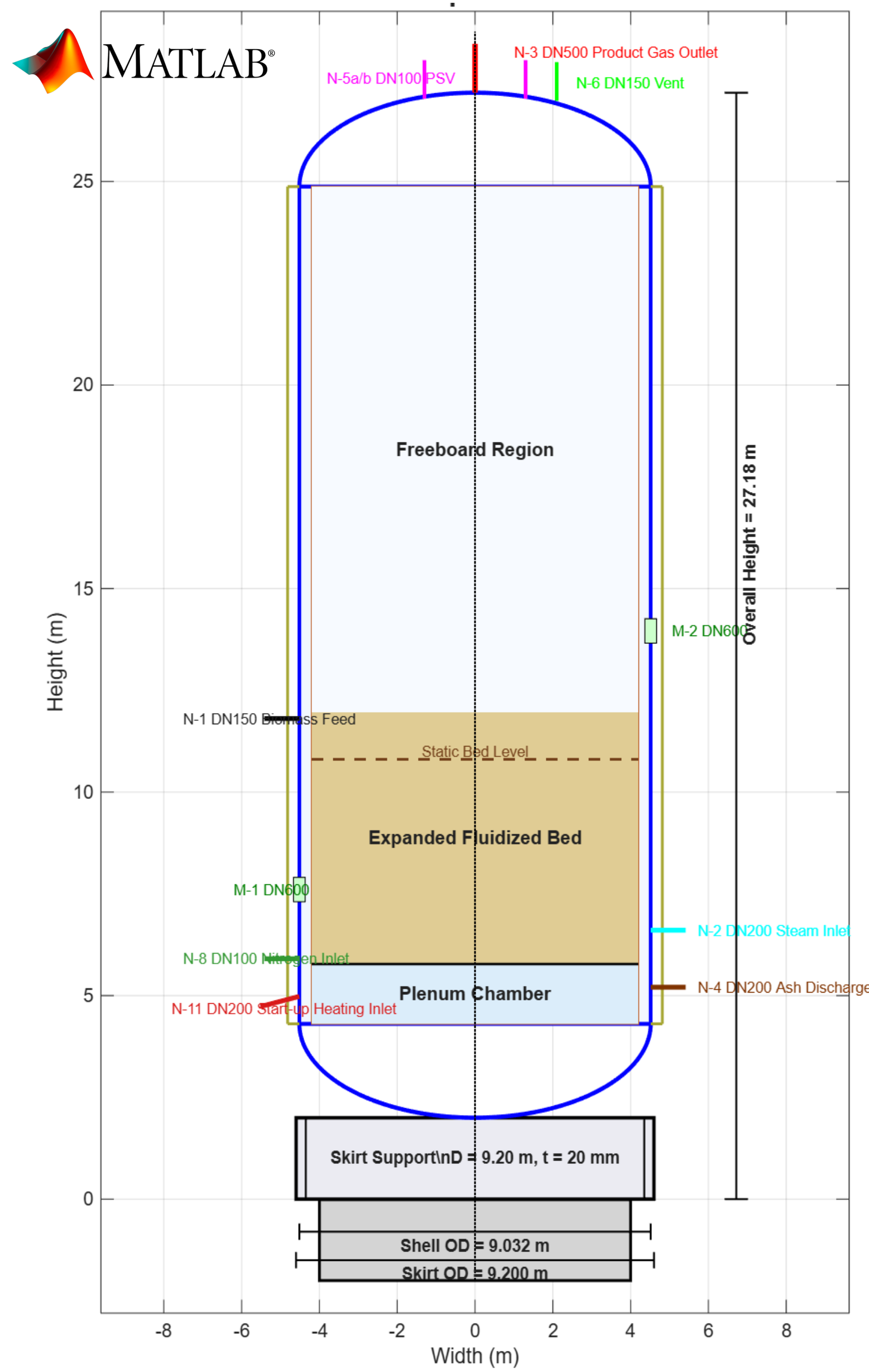
SMART CIRCULAR ECONOMY



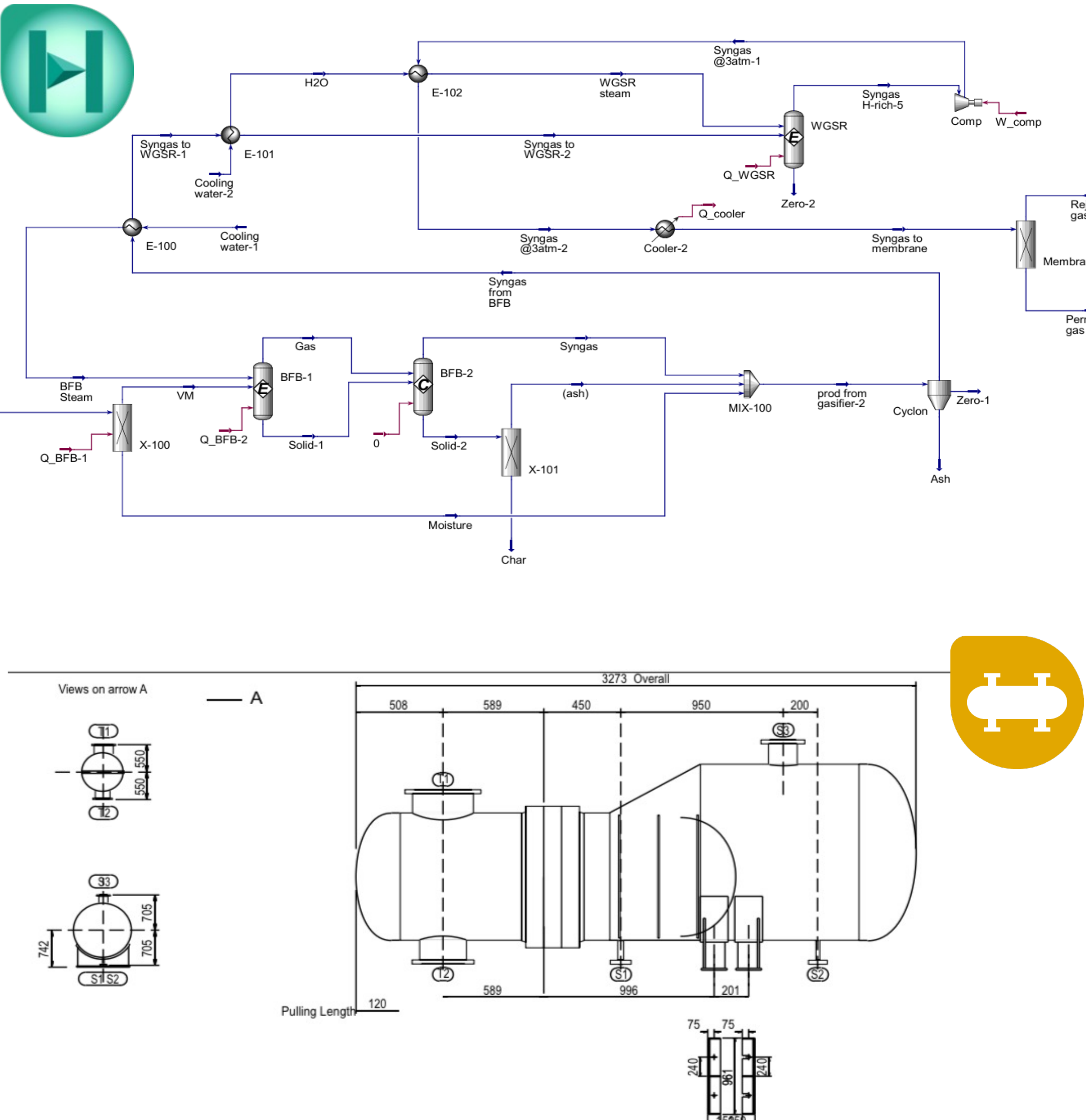
Mass and energy Balance

Stream number	1	2	3	4	5	6	7	8	9	10	11	12	13
Mole flow $\frac{kmol}{s}$	-	0.03	0.02	-	-	0.21	0.07	0.27	0.14	0.14			
Mass flow $\frac{kg}{s}$	3	0.62	0.19	3.43	0.36	3.07	1.18	4.24	3.6	0.64			
Component	Mass Composition												
Carbon	0.42	-	-	-	-	-	-	-	-	-	-	-	-
Hydrogen	0.05	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Oxygen	0.35	-	-	-	-	-	-	-	-	-	-	-	-
C(Char)	-	-	1	-	-	-	-	-	-	-	-	-	-
Ash	0.12	-	-	0.11	1	-	-	-	-	-	-	-	-
CO	-	-	-	0.6	-	0.67	-	0.12	0.14	0.02			
CO ₂	-	-	-	0.17	-	0.20	-	0.71	0.73	0.58			
H ₂	-	-	-	0.06	-	0.07	-	0.08	0.02	0.4			
H ₂ O	0.05	1	-	0.04	-	0.05	1	0.08	0.09	Trace			
CH ₄	-	-	-	0.01	-	0.01	-	0.01	0.01	Trace			
N ₂	-	-	-	0.01	-	0.01	-	0.01	0.01	Trace			
SUM	1	1	1	1	1	1	1	1	1	1			

Equipment Design



BFB Gasifier Design Layout



Mechanical Plan of Heat Exchanger (E-101)