Carbon Intensity Estimation and its Impact on Process Design: A Case Study in Hydrogen Production



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Introduction and Objective

- The drive to achieve long-term decarbonization in the Energy sector is motivating the industry to investigate ***alternative means of hydrogen production***.
- Non-conventional biomass-to-hydrogen pathways allow for the ***potential production of a net carbon negative Hydrogen product***.
- Carbon intensity, therefore, plays a major role in the integration of process systems and the deployment of biomass conversion technologies.

Through this case study of two hydrogen generation pathways, Hatch investigated as how process design decisions and facility integration can impact carbon intensity

✓ *Conventional Autothermal Reforming of Natural Gas paired with CO_2 capture*

✓ *Gasification of a waste woody biomass feedstock with CO_2 capture*

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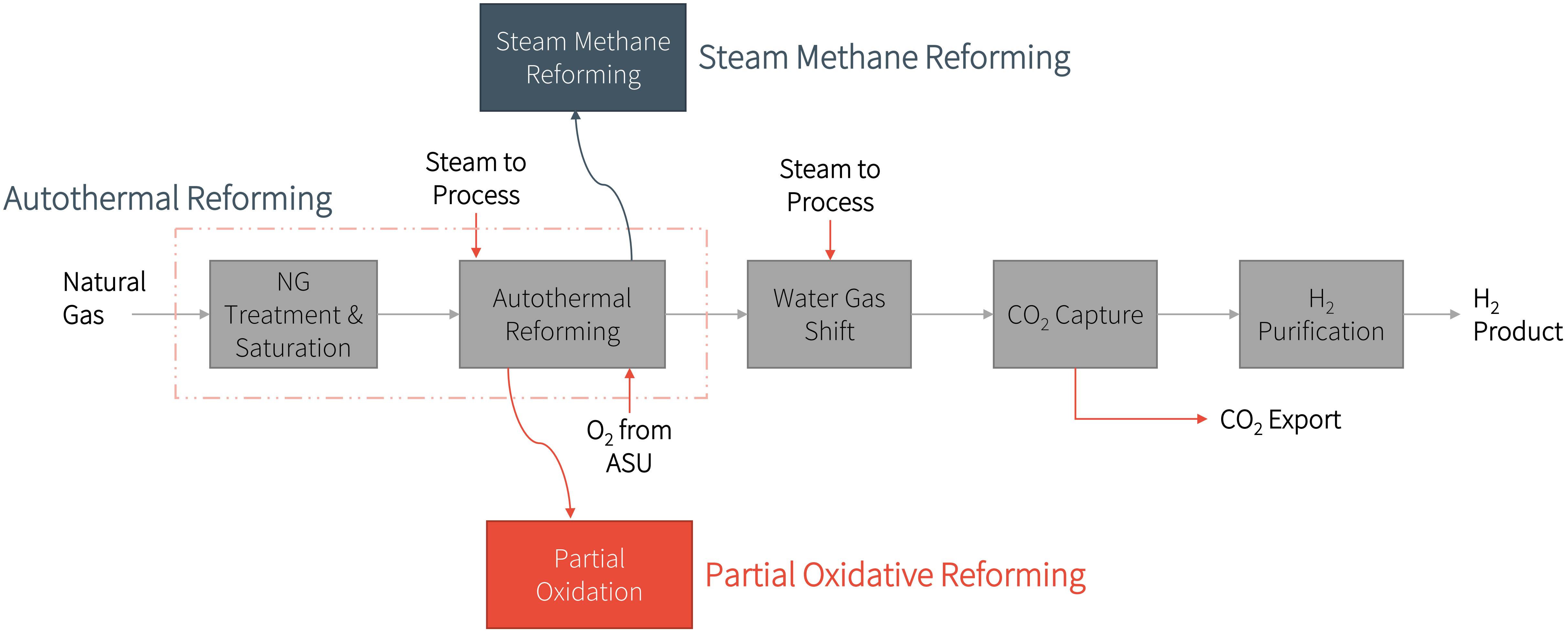
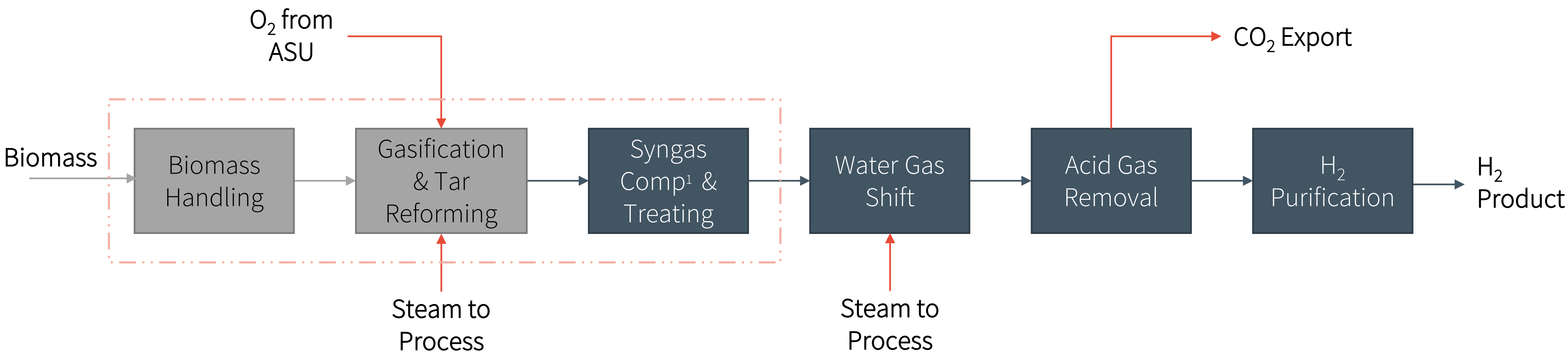
Conventional Blue Hydrogen Production Pathways



Biomass to Hydrogen Production Pathways

Conventional Gasification Reforming Pathway



NOTES:

1. Requirement for syngas compression dependent on design pressure profile, matched for comparison.
2. Process integrated Steam and Fuel Gas systems not depicted in this simplified BFD.

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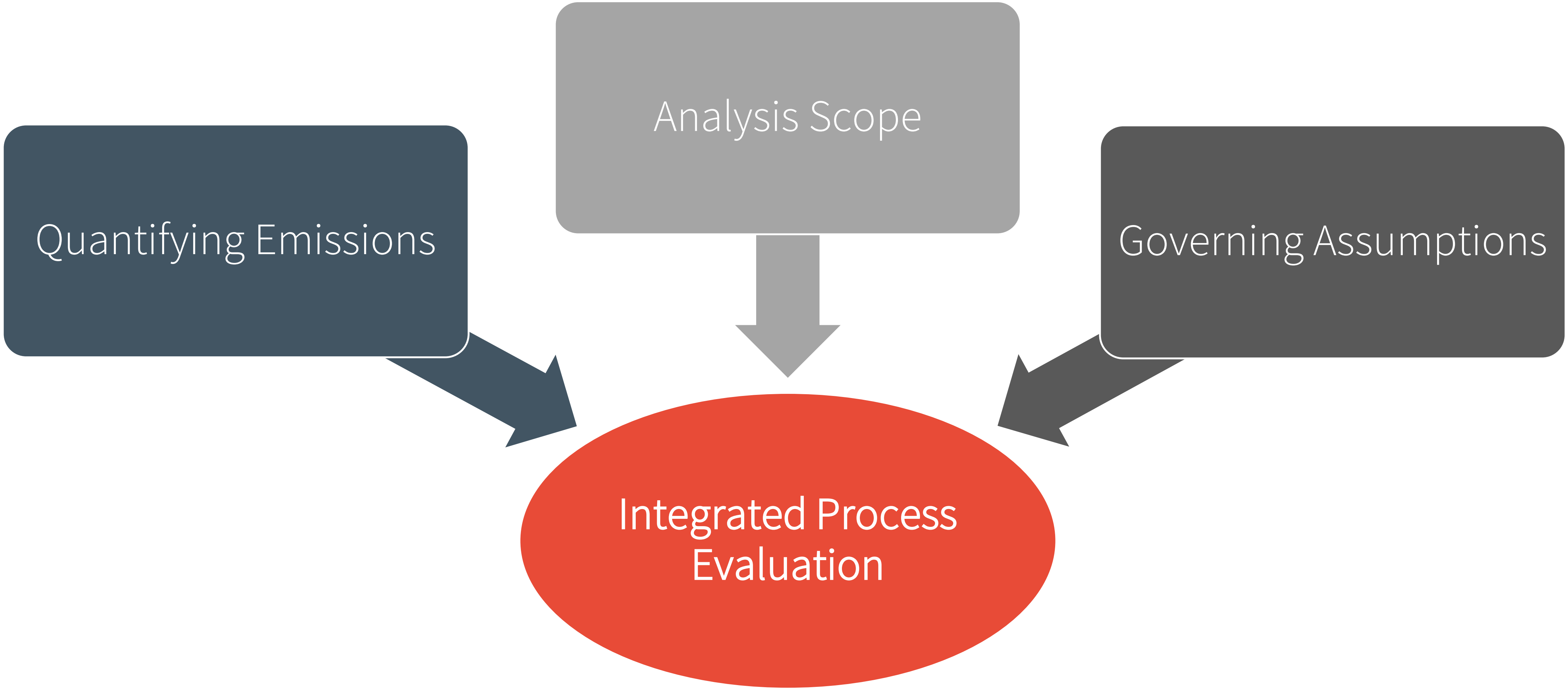
Investigative Approach



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Carbon Intensity (CI)

Inclusions

- Emissions from power generation
  - Biomass boiler
  - Gas turbine generators (H_2 / NG GTG)
- Flare and thermal oxidizer systems
- Minor process scope point source emissions
- Carbon content within the resultant hydrogen product

Exclusions

- A complete accounting of life cycle emissions in accordance with ISO 14040
- Upstream lifecycle emissions i.e NG extraction & transportation, land-use changes, or waste material collection
- Process scope fugitive emissions
- H_2 transportation and distribution

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Results

Key Performance Indicators

Yields	• Hydrogen Yield ~50 MMSCFD • 21.1 MMSCFD of NG import (NG-to-H_2) • 3,950 tpd of wet (45 wt%) biomass import (Biomass-to-H_2)
Carbon Intensity	• Elevated power demands (Biomass-to-H_2) • 2.2-time higher rate of CO_2 sequestration rate (Biomass-to-H_2) • Biomass-to-H_2 Carbon Intensity -132 gCO_2 /MJ H_2 • NG-to-H_2 Carbon Intensity 10.9 gCO_2/MJ H_2
CLASS V Capital Cost	• Biomass-to-H_2 4.7-times higher capital cost than conventional NG-to-H_2 • Potential to off-set elevated CAPEX with reductions in CO_2 emissions

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Expansion

Alternate Biomass to Hydrogen Process Configurations

Basic Considerations

- Biomass Drying
  - Steam
  - Gas Fired
  - Hot Water
- Gasification Feeding Systems
  - Pelletization
  - Lock Hoppers
- Acid Gas Recovery
  - Rectisol®
  - Conventional Amine
  - Selexol
- Water Gas Shift
  - Multi-Stage Configuration
  - Isothermal Technology
  - Sour Shift
  - Sweet Shift
- Hydrogen Purification
  - PSA Separation
  - No Further Processing
  - Methanation
- Power Generation
  - Biomass Boiler
  - Biomass Boiler + CCUS
  - Natural Gas Combined Cycle
  - Natural Gas Combined Cycle + CCUS

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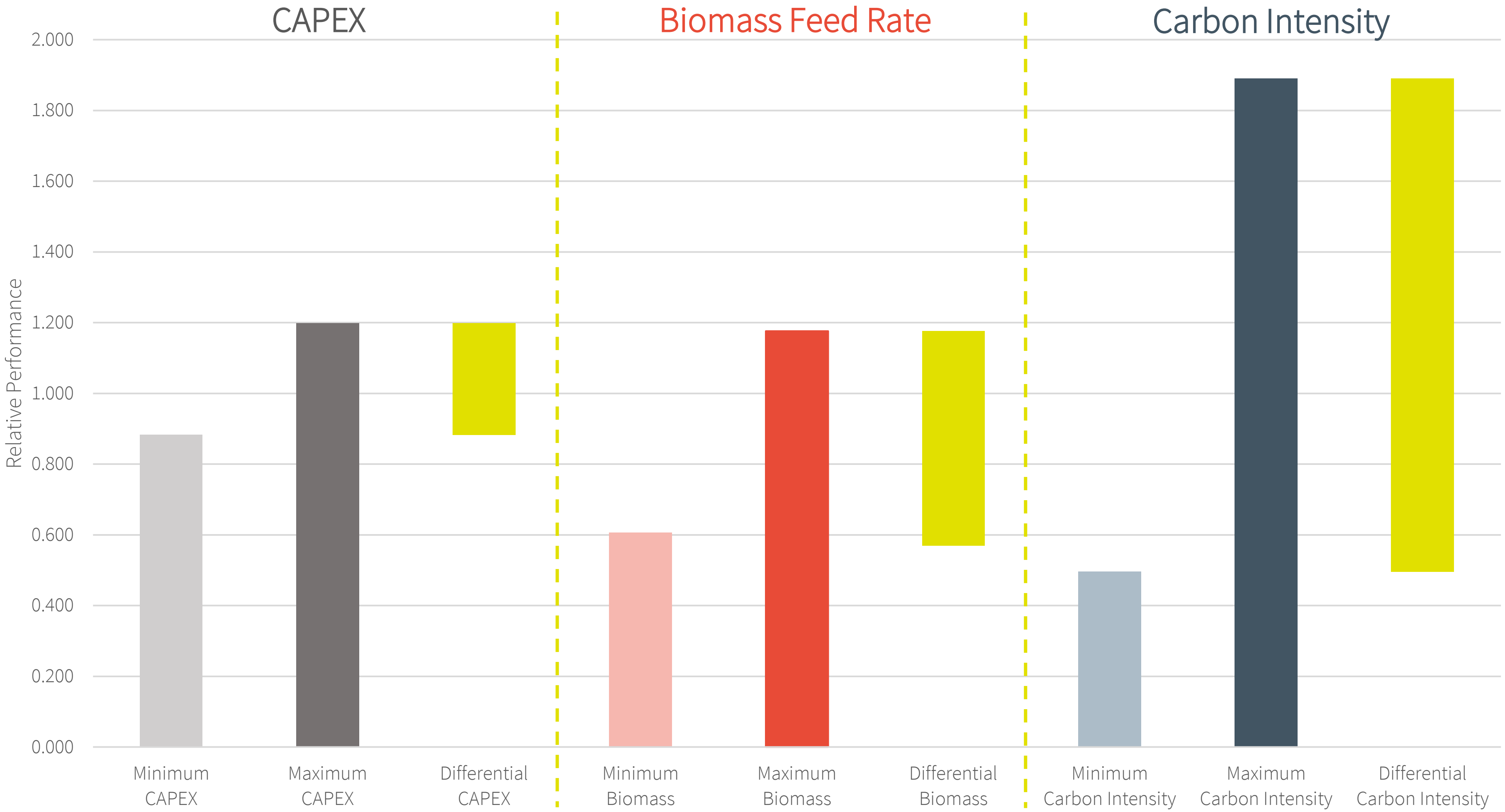
Relative Process Performance Variation



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Conclusions and Takeaways

1. *There does not exist a single "cure-all" solution, approaches must be tailored to project specific drivers*

2. *Considered technology selection may only partially impact project CAPEX; however, can significantly alter carbon intensity*

3. *Flowsheet integration is key to project success*

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