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Power-to-Gas/Liquid - biomass gasification and SOEC combined system

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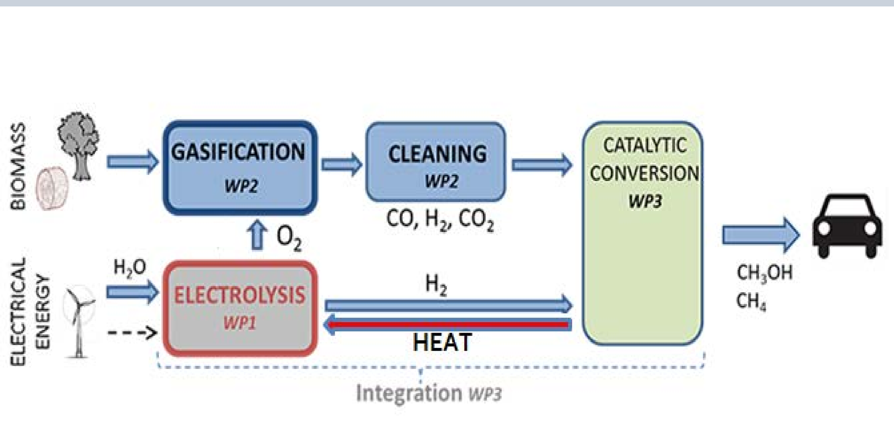
Motivation

- Electricity Surplus and storage
  Gigantic surplus of electricity in future (i.e. between 7 and 11 TWh!)
- Lower efficiency i.e. Alkaline electrolysis (low temperature electrolysis)
- Limited biomass source (lower efficiency e.g. Gasifier + Methanol ~ 59%)[1,2]
- CO_2 emissions, Fossil free (EU Environment, Denmark Energy policy)

- Power-to-Gas, Power-to-Liquid, Power-to-Chemicals etc.
- High temperature electrolysis
- Combine system (E+G) (Higher efficiency e.g. Gaisfier+SOEC+Methanol ~71%)[1]
- Renewable fuels e.g. SNG, DME Methanol etc.



Methdology

❑Electrolysis

- The ability to produce hydrogen at elevated pressure to reduce energy demand and investment costs for compressors
- Higher efficiency to avoid energy loses
- Dynamic behaviors to avoid fluctuating power input

❑Gasification

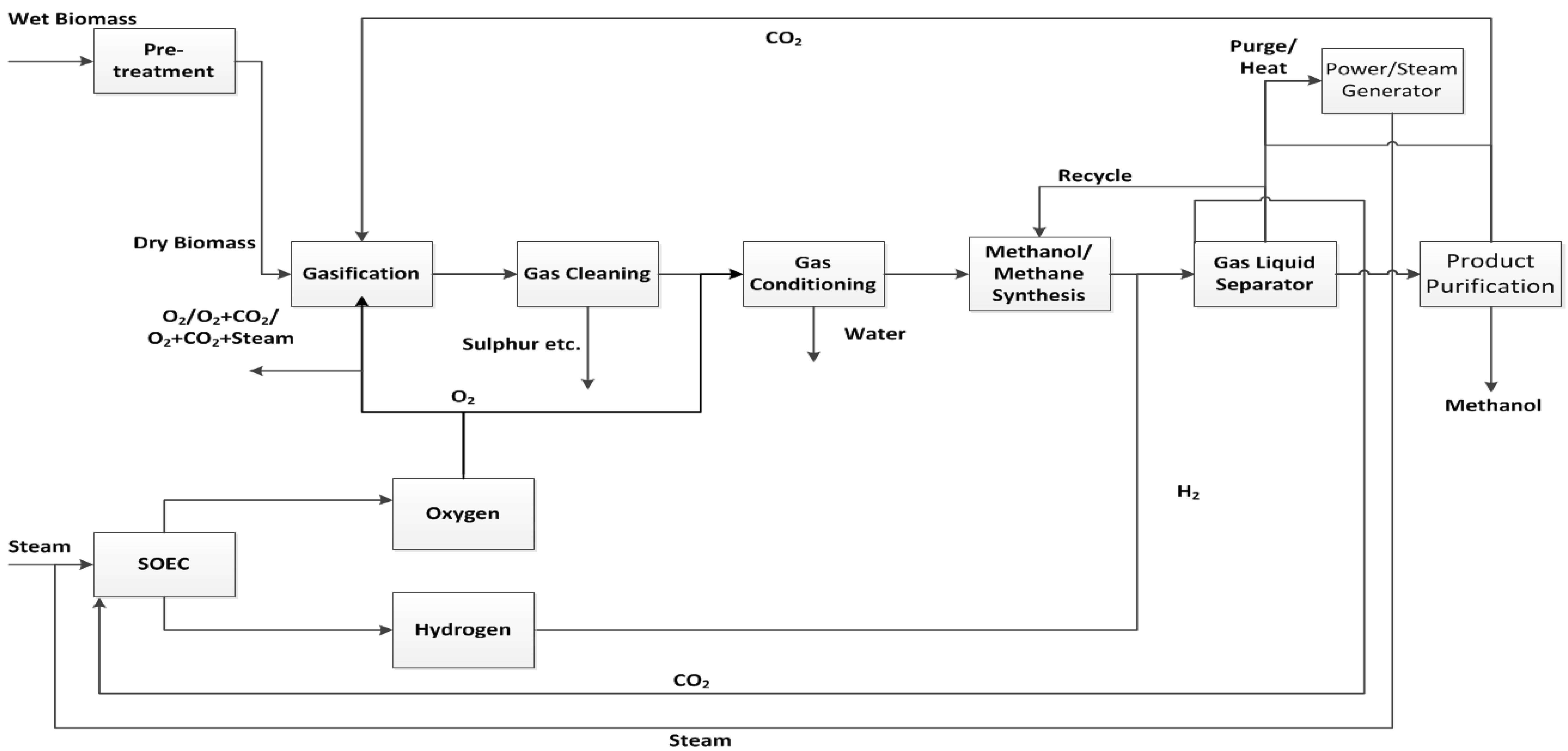
- High purity and an adaptable flow rate of syngas to suit the fluctuating demand
- Temperature, Pressure, recycle ratio to control the syngas composition
- Gasifying agent - O_2 /O_2+CO_2/ O_2+CO_2+ Steam

❑Combined System

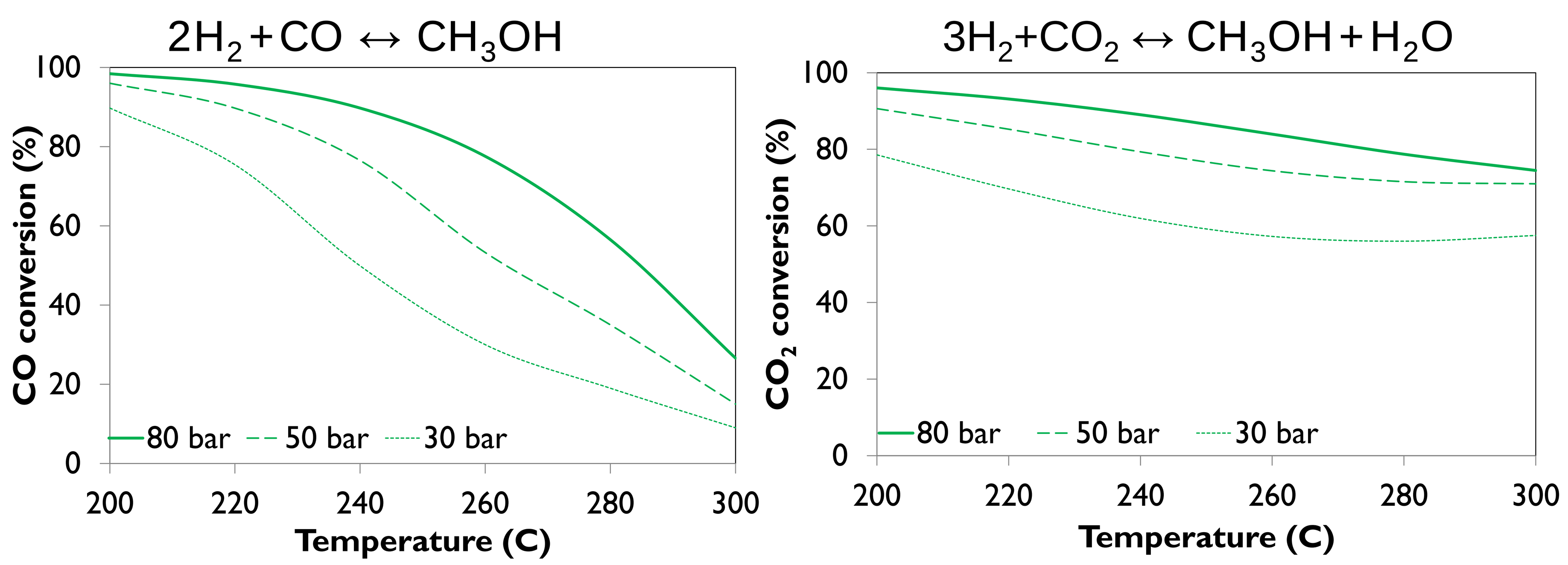
- Integration and optimization of the components for combined process

System Modeling

- Models for Sub-systems i.e. Biomass Gasification, Solid Oxide Electrolysis (SOEC), Synthesis Reactor etc. using Aspen plus
- Complete model combining all components



Synthesis Reactions



CO (L) and CO_2 (R) conversion as a function of methanol synthesis reactor outlet temperature and reactor pressure

System Efficiency

LHV efficiency %	Gasifier + SOEC	Only Gasifier
Methanol	71,54	55,59
SNG	72,73	59,87

Conclusion

- Syngas composition produced from gasification is comparable with literature
- Cold gas efficiency of gasifier is around 85%
- Better energy efficiency for the processes with SOEC
- No CO_2 removal unit for the processes with H_2 (saving cost and environment)
- Excess heat available for steam production

Future Work

- Optimization methodology on the combined system
  - Pinch Analysis
  - Development of mathematical programming models for heat exchanger network design
  - Exergy Analysis
- Economic Analysis
  - Potential to store heat over varying electricity prices
  - Cost analysis for the components
  - Cost analysis for complete combined system

References

1) Synthesis of Methanol from Biomass/CO_2 Resources. Specht, M., et al., et al. Amsterdam : s.n., 1999. Greenhouse Gas Control Technologies. p. 723.

2) Hydrogen from renewable electricity: An international review of power-to-gas pilot plants for stationary applications. Gahleitner, Gerda. s.l. : International Journal of Hydrogen Energy, 2013, Vol. 38, pp. 2039-2061.

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