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Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Sanchez, E. M. L., Pedersen, T. H., & Rosendahl, L. (2019). *Modelling of the integration of HTL with CCS for the production of drop-in biofuels*. Poster presented at 27th European Biomass Conference and Exhibition (EUBCE 2019), Lisbon, Portugal.

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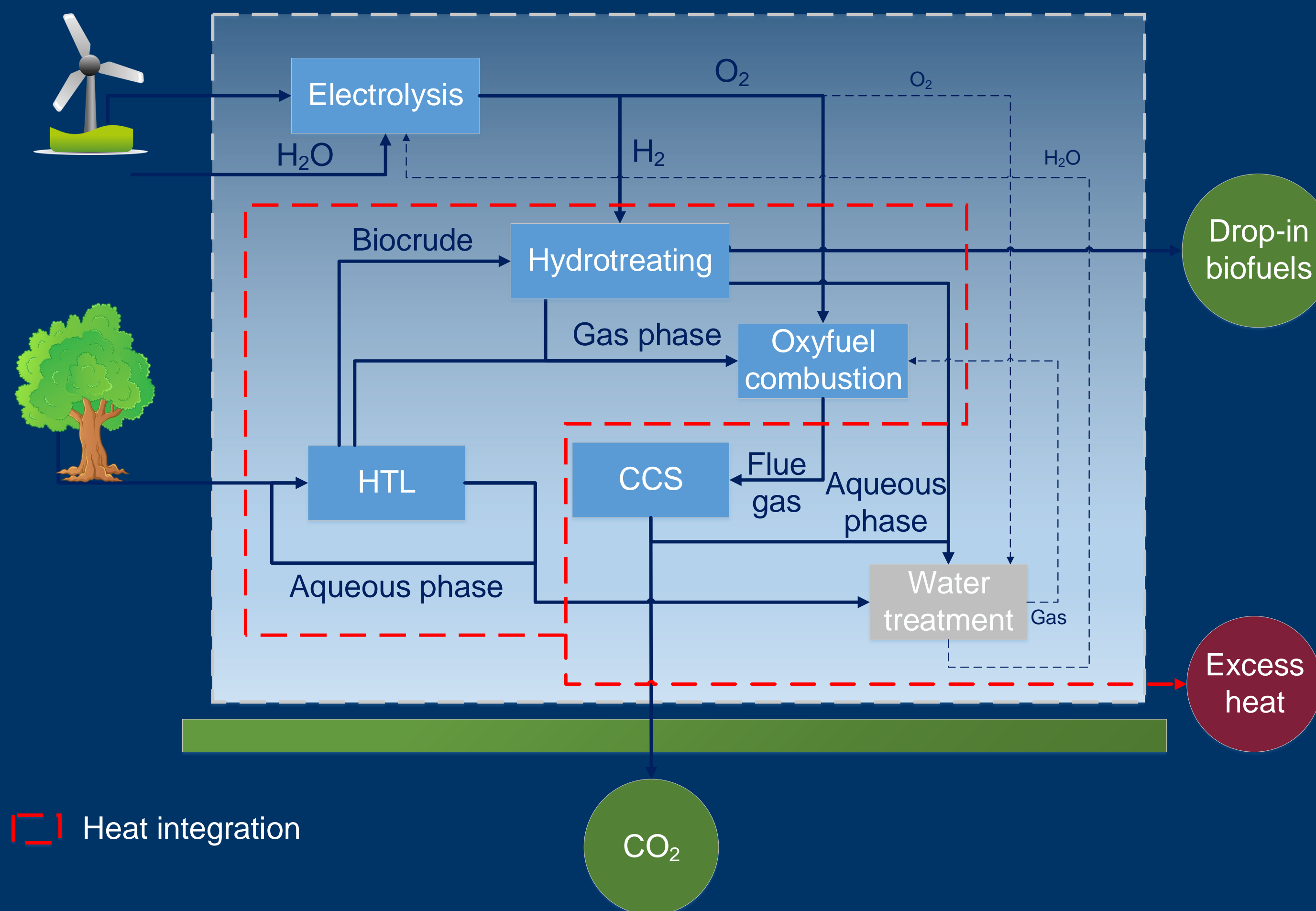
Modelling of the integration of HTL with CCS for the production of drop-in biofuels

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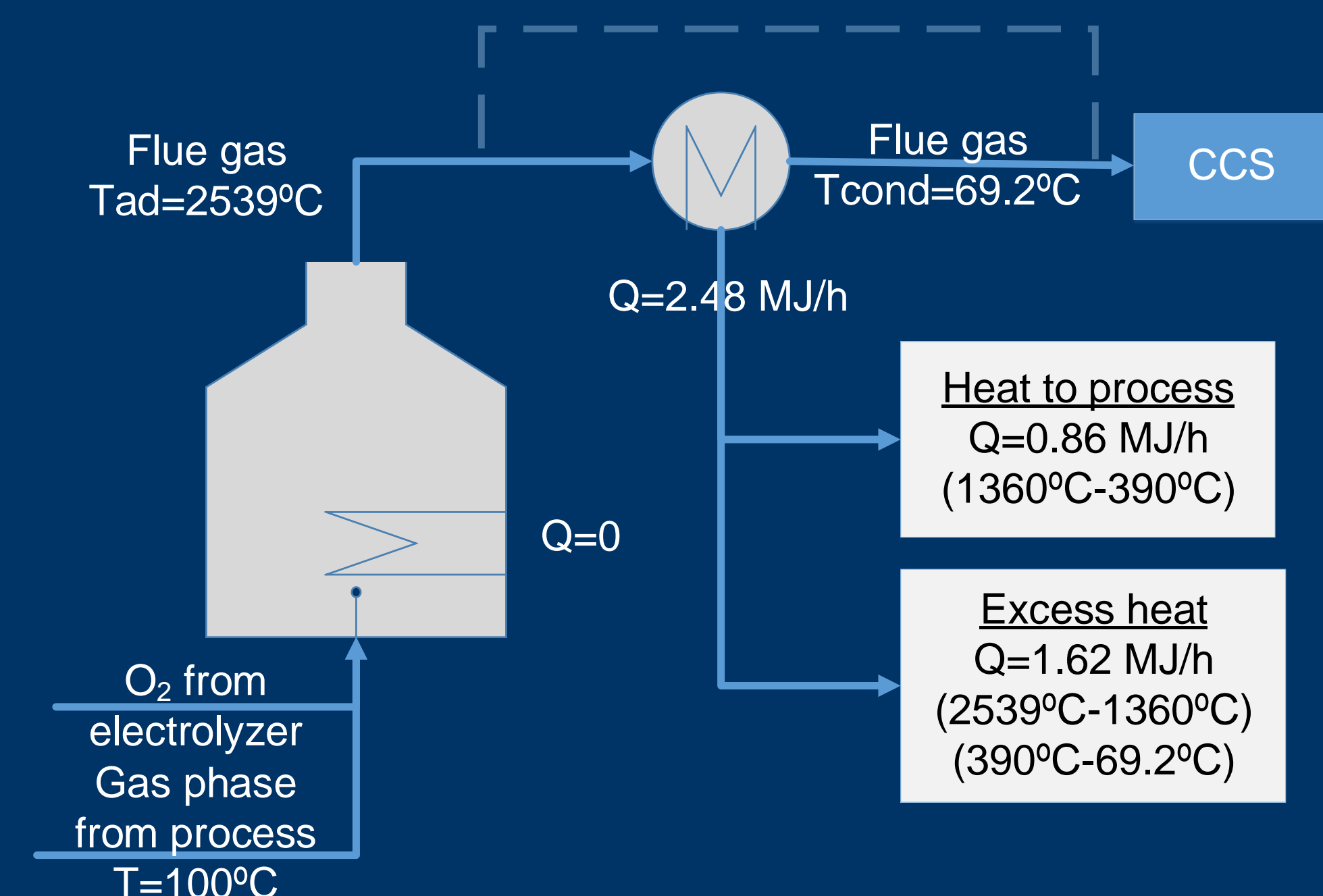
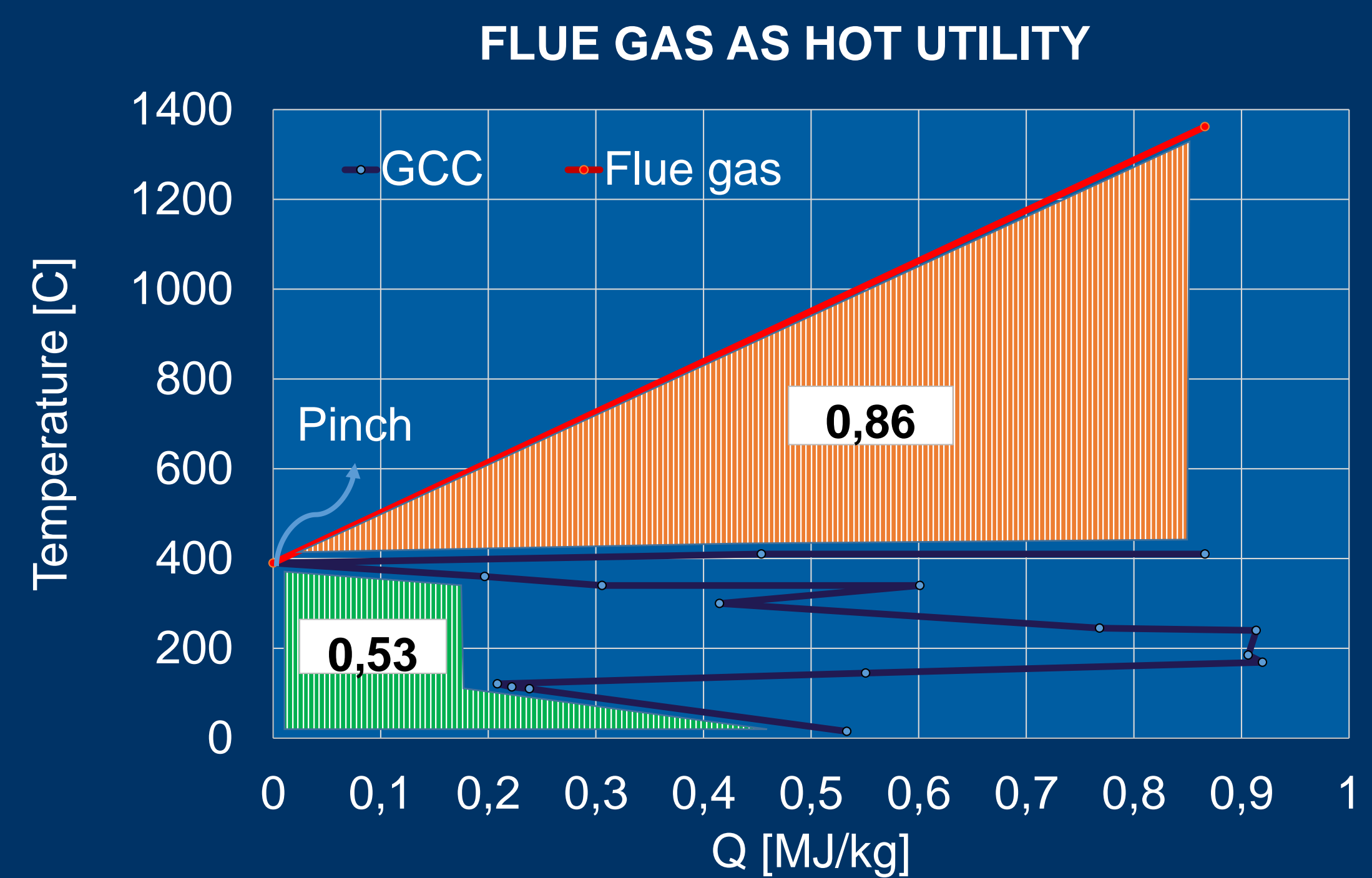
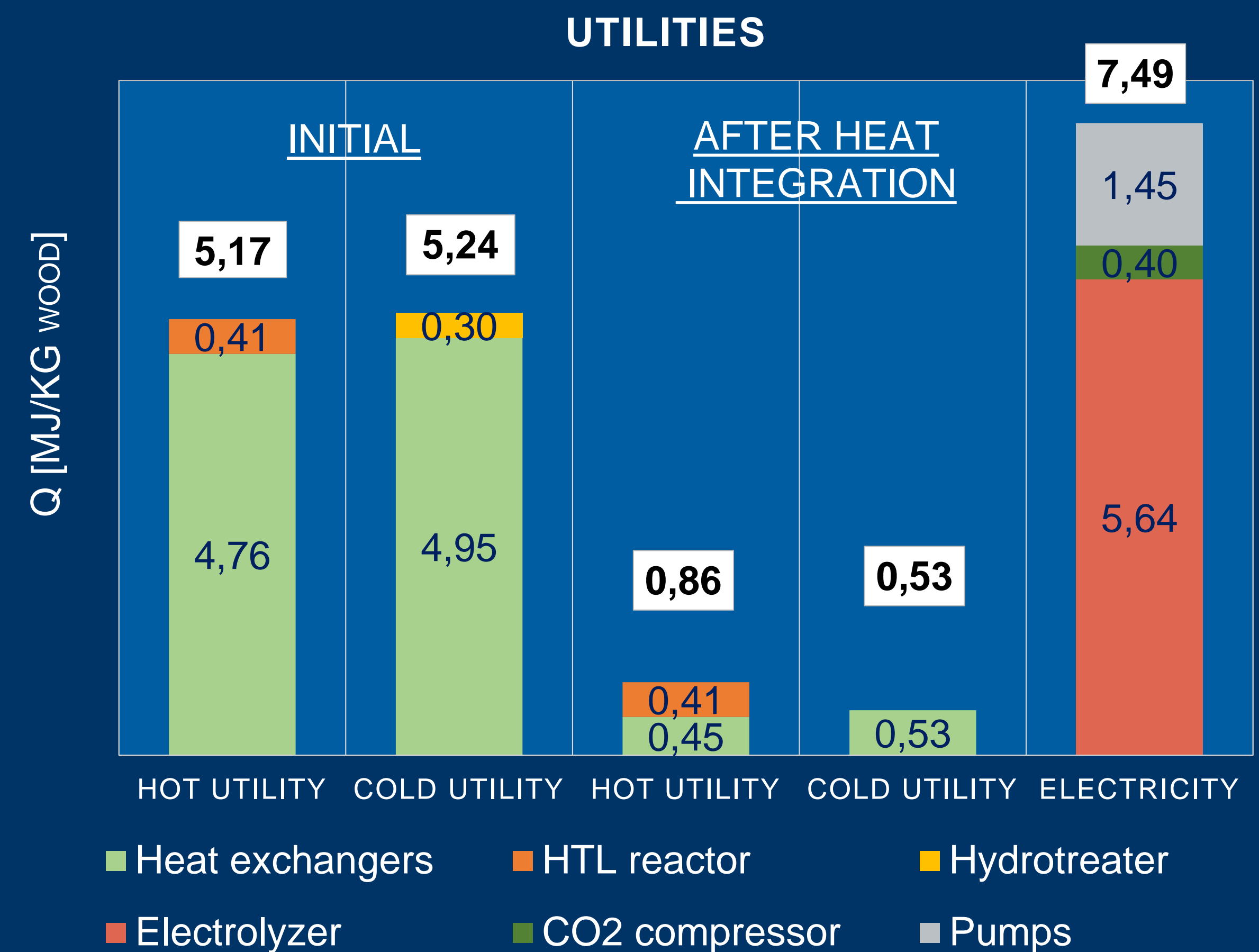
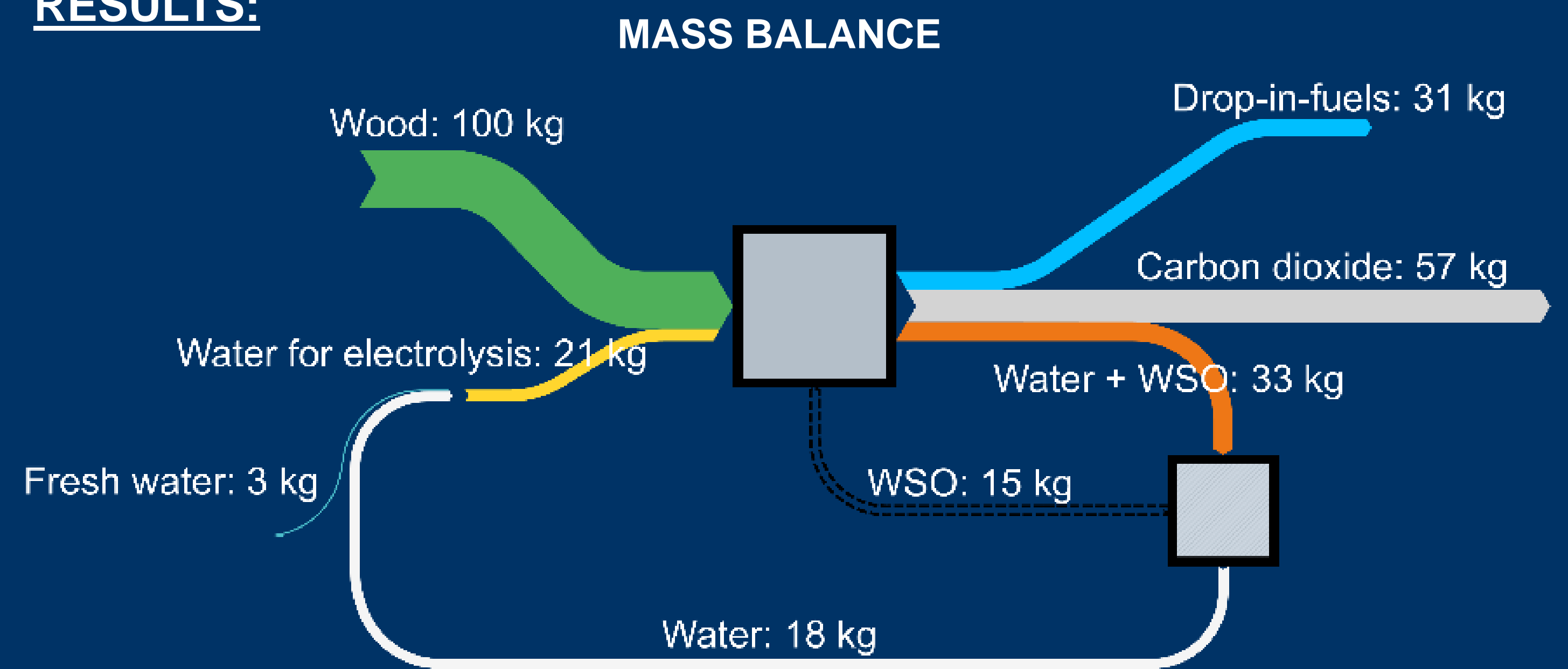


PURPOSE AND MOTIVATION:

- Modeling of combined production of drop-in biofuels through hydrothermal liquefaction (HTL) of forestry residues with carbon capture and permanent underground storage (CCS) to provide net removal of CO₂ from the atmosphere.
- Assessment of the energy requirements and excess heat production for district heating application.
- Base study for further analysis on biofuel production via HTL as sink of renewable electricity fluctuations.



RESULTS:



METHODS AND ASSUMPTIONS:

Assumptions:

- Steady state operation: Recirculation of aqueous phase in HTL avoids use of fresh water.
- Hydrogen produced in stoichiometric quantity for hydrotreating step.
- Solids/coke production is not considered.

The process was modeled in the software Aspen Plus®.

Unit	Approach	Description	References
HTL reactor	Ryield	Thermodynamic approach based on improved biomass and biocrude models from experimental data	[1*]
Hydrotreater	User model	Thermodynamic approach based on experimental carbon yields. HBO modeled with petro-characterization tools in Aspen Plus®	[2]
Electrolyzer	User model	Available model in literature	[3]
Adsorption unit	User model	Available model in literature	[4]
Oxufyel	Rstoic	Mass and energy balance based on stoichiometry of combustion reactions	--

[1] Lozano, E., Pedersen, T.H., Rosendahl, L. (2019). Generic approach for the modeling of liquefied thermochemical products and biomass heat of formation. Case study: HTL biocrude, Pyrolysis oil and assessment of energy requirements. Applied Energy. (In review process)

[2] Jensen, C. (2018). PIUS - Hydrofaction(TM) Platform with Integrated Upgrading Step. Aalborg Universitetsforlag.

[3] Shen, et al. (2011). A concise model for evaluating water electrolysis. International Journal of hydrogen energy, 36, 14335- 4341.

[4] Ferreira, et al. (2011) Effective adsorption equilibrium isotherms and breakthroughs of water and CO₂ on different adsorbents. Ind. Eng. Chem. Res, 50, 10201–10210.

ACKNOWLEDGMENTS:

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant no. 727531 (4refinery) and grant no. 765515 (Marie Skłodowska-Curie ITN, ENSYSTR).



EUBCE 2019
27th EUROPEAN BIOMASS
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CONCLUSIONS:

- More reliable estimation of the heat requirement in the HTL reactor allows a better assessment of the heat integration in the process.
- From the total carbon fed to the process, approximately 54% ends in the drop-in biofuels while 32% is captured for permanent underground storage. The recovery of the remaining carbon in aqueous phase/solid residue will be further analyzed together with water recovery and reuse.
- A reduction of 83% and 90% in hot utility and cold utility respectively were obtained through heat integration.
- The use of flue gas in the process allows to cover the hot utility demand with excess heat production for possible district heating use.