POWER-TO-PLASTICS

Is it possible to produce plastics with negative global warming impacts by using electricity and CO_2?

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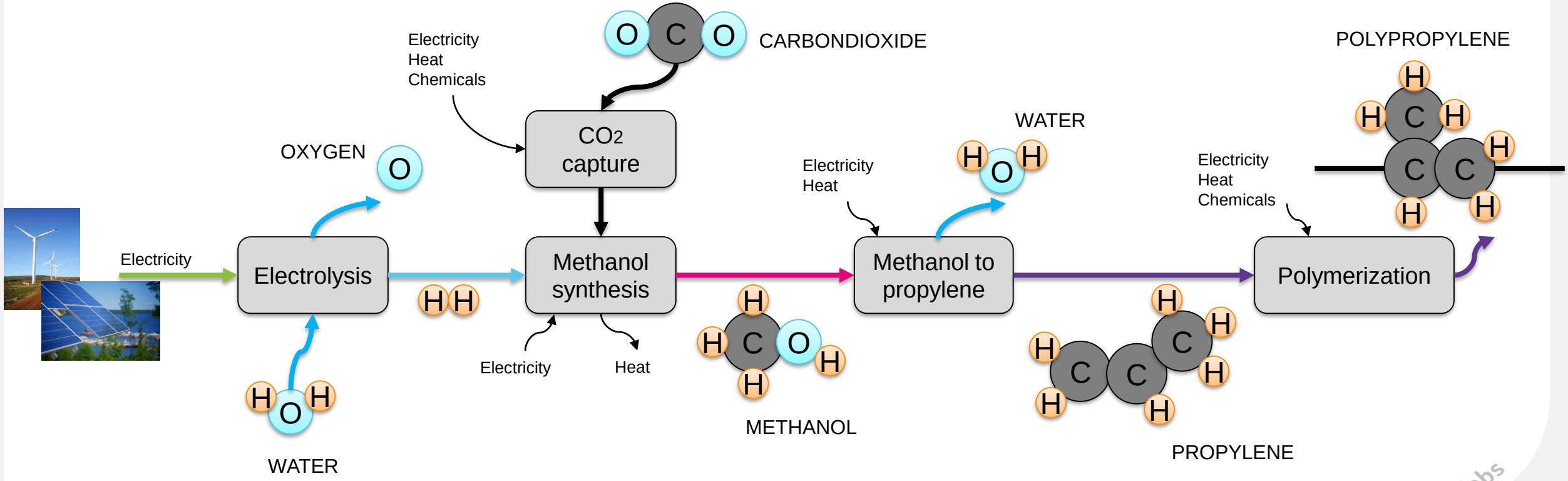
WHY POWER-TO-PLASTICS?

- Growing plastic production is heavily dependent on fossil feedstocks and energy thus contributing to climate change
- Bio-based plastics are limited by available waste and residue feedstocks or suitable land
- Renewable electricity production is increasing and prices are decreasing
- Power-to-fuels are gaining increasing interest and have a potential to outperform biofuels in terms of costs and CO_2 (Siemens Energy 2020)
- IPCC's 1.5 degree target reguires also CO_2 removal from atmosphere

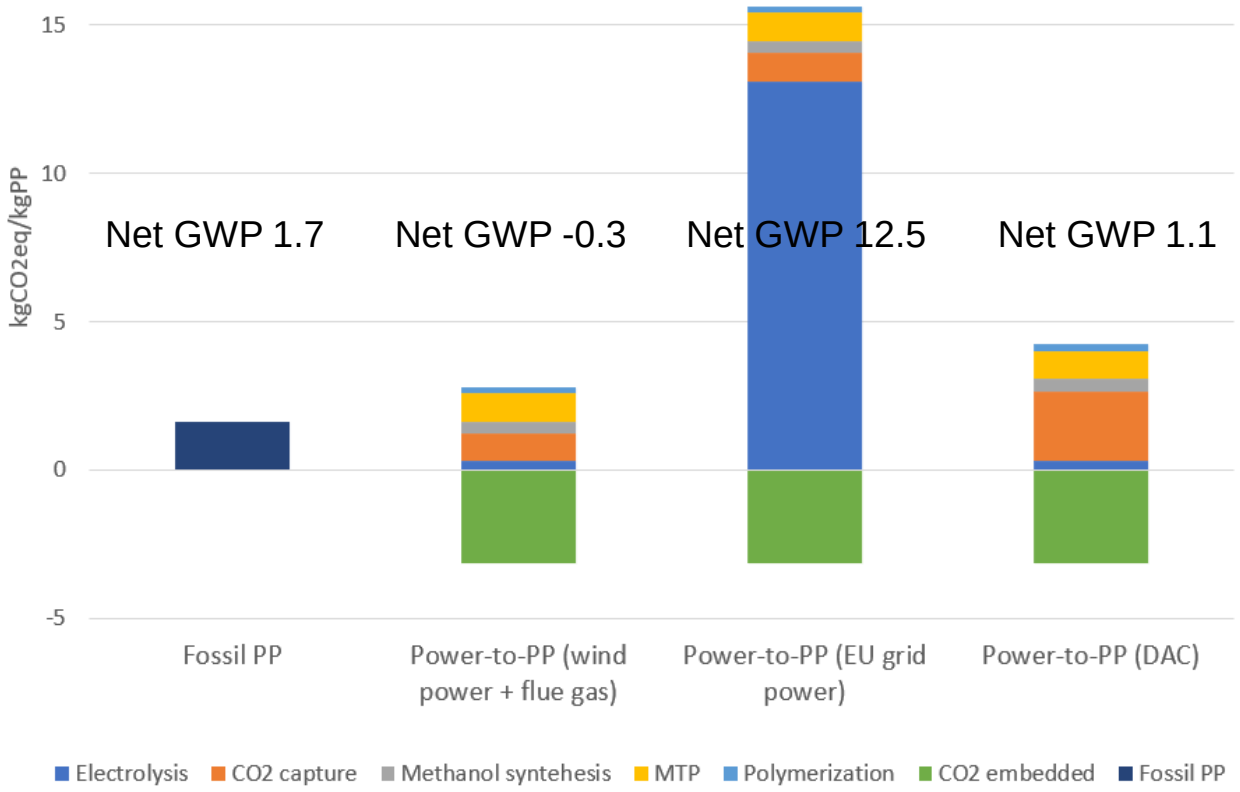
CORE IDEA OF POWER-TO-PLASTICS



MATERIALS, METHODS AND ASSUMPTIONS

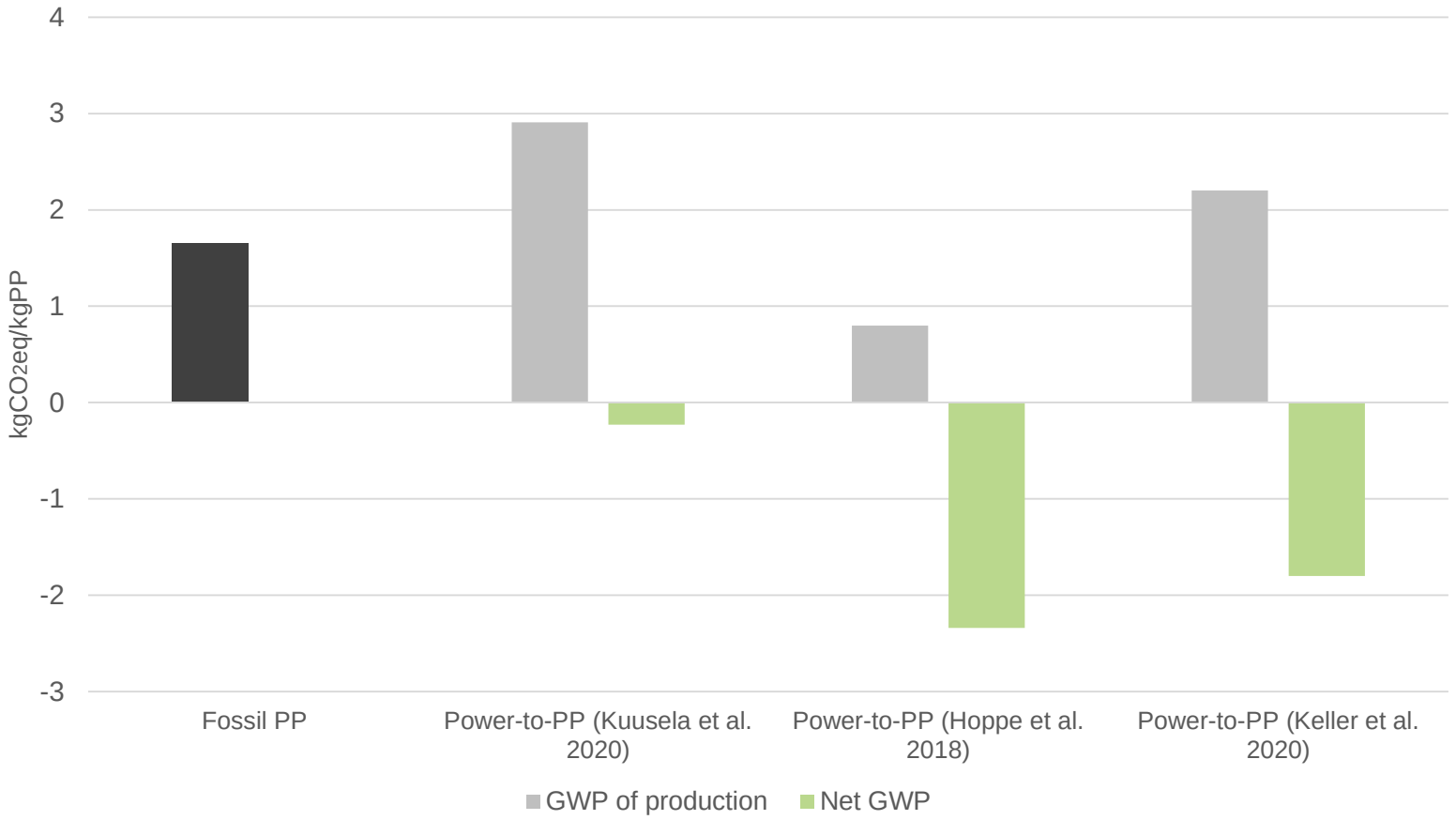
- A Life cycle assessment model was created using the GaBi software to assess global warming potential (GWP) of power-to-polypropylene (PP)
- Initial data is based on literature and GaBi databases
- Functional unit is 1 kg polypropylene
- Basic assumptions:
  - Electricity for electolysis is produced by wind power
  - PEM electrolyzer is utilized to produce hydrogen
  - CO_2 is captured from flue gas flow using amine technology
  - Methanol conversion is modelled based on previous simulations
  - Propylene is produced by MTP process

GWP OF POWER-TO-PP



(Kuusela, K., Uusitalo, V., Ahola, J., Levänen, J. 2020. Not yet published, in a review process)

GWP COMPARISON TO OTHER STUDIES



- Electrolysis is utilizing wind power
- CO2 is captured from flue gas flows
- Net GWP in Hoppe et al. 2018 is not presented in the article
- Relatively high variation in GWPs but all lead to net negative GWP

CONCLUSIONS

- It could be possible to produce polypropylene with negative global warming impacts if:
  - Electrolysis is based on renewable electricity
  - Waste CO_2 is captured from flue gas
- This could provide a carbon sink if plastic is used in long lasting solutions
- From LCA methodological perspective it is not clear how CO_2 from flue gas flow should be considered e.g. between power plant and plastic producer
- There can be additonal possibilities to reduce GWP of power-to-plastics e.g. by heat integrations
- There are still open questions related to future feasibility and technical implementation of required processes and to their integration especially methanol conversion
- Power-to-plastics does not solve end-of-life challenges related to plastics
- Power-to-plastics provides an interesting option to reduce climate impacts of plastic industry

Key materials

- European Commission. 2020. A hydrogen strategy for climate-neutral Europe
- Hoppe, W., et al. (2018). Life Cycle Assessment of Carbon Dioxide–Based Production of Methane and Methanol and Derived Polymers. *Journal of Industrial Ecology*
- Keller, F., et al. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany, *Journal of Cleaner Production*
- Kuusela. K. Carbon footprint of CO2-based polypropylene via methanol-to-olefins route. Master's Thesis
- Kuusela, K., Uusitalo, V., Ahola, J., Levänen, J. 2020. The transformation of plastics from carbon source to carbon sink: an environmental sustainability assessment of CO_2-based polypropylene. *in a review process*
- Siemens Energy. 2020. Power-to-X: The crucial business on the way to a carbon-free World