Comparison of fuel production costs for future transportation
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ABSTRACT
The purpose of this poster is to provide an overview of fuel production costs for two types of synthetic fuels – methanol and methane, along with comparable costs for first and second generation biodiesel, two types of second generation bioethanol, and biogas. The model analysed is a 100% renewable scenario of Denmark for 2050, where the data for the transport sector has been changed to estimate the fuel production costs for eight different fuel pathways.

METHODOLOGY
• The scenarios have been analyzed using the energy system analysis tool EnergyPLAN. EnergyPLAN was chosen because it includes the balancing of the energy system in its fuel costs calculations.
• This aspect was important because electrolyzers enable high share wind integration; therefore the costs are more accurate when including balancing costs. All scenarios were analyzed with technical optimization, meaning that the fuel consumption is minimized. This is important due to the level of biomass resource used in the scenarios.
• The scenarios vary depending on the pathways implemented in the transport sector, but in terms of primary energy supply the variations are mainly the ability to integrate wind capacity and the biomass demand for fuel.

THE SYNTHETIC FUEL PATHWAYS
The fundamental difference between synthetic fuel pathways is in the carbon source.

Biomass hydrogenation uses direct input of biomass in the gasification process, and the produced gas is later on boosted with hydrogen produced from steam electrolysis.

\[ \text{Biomass hydrogenation} \]

\[ \text{CO}_2 \text{ recycling pathways (CO}_2 \text{ hydrogenation and co-electrolysis) do not require any direct biomass input, instead they use emissions from the biomass used in the heat and power sector combined with electrolysis.} \]

\[ \text{• The CO}_2 \text{ hydrogenation pathway combines hydrogen from the steam electrolysis with recycled carbon dioxide to form a syngas.} \]

\[ \text{• The Co-electrolysis pathway is using combined process of steam and CO}_2 \text{ electrolysis called co-electrolysis, and the produced synthetic gas can afterwards be catalyzed.} \]

\[ \text{CO}_2 \text{ hydrogenation} \]

\[ \text{Co-electrolysis} \]

THE BREAKDOWN OF COSTS
Figures below show the breakdown of costs for biofuels, biogas and synthetic fuels to the production units, feedstock and fuel handling costs, together with the CO2 emissions cost:

CONCLUSION
• The pathways with higher share of biomass in their production process are not as flexible in terms of wind integration and the fuel output as other proposed scenarios. The synthetic fuel pathways enable the wind integration which varies from lowest for the biomass hydrogenation pathways to highest for CO2 recycling pathways.
• Synthetic fuel production enables flexible fuel choice, which was shown by the production of both methanol and methane. These pathways have higher production costs due to the technologies that they use for the production process, yet they are still lower than the costs of second generation bioethanol.
• The major findings was that the production costs of synthetic fuels are comparable with petrol production costs when the associated CO2 emissions are accounted for. Taken together, these results suggest that these fuels have a potential to be a future fossil fuel replacements in the transport sector.