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P2X - Carbon neutral fuels

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Drivers

- Climate and air quality
 - Transition to electricity as primary energy source is taking place
 - Transition to full electric mobility in 20 years, however, is not possible (ships, airplanes, heavy duty, and cars)
 - Biofuels are insufficient in global scope
 - Recycling of CO₂ reduces the use oil and coal
- Cheap, unlimited electricity (solar and wind)
 - Cheap hydrogen
 - Renewable electricity requires system balancing, peak power & seasonal variation. Balancing of power can be done by engines and turbines running carbon neutral fuels
- CO₂ Emission trading costs on fossil fuels
- Production of synthetic, carbon neutral fuels (P2X) is profitable is certain “sweetspots” (cheap hydrogen, cheap electricity)



P2X Fuels

Emerging demand

P2X Fuels



Source:
<https://www.ft.com/content/87cfc31e-44e7-11e9-b168-96a37d002cd3>



Source:
<https://www.ft.com/content/44b8ba50-f7cf-11e8-af46-2022a0b02a6c>



<https://www.lufthansagroup.com/en/responsibility/climate-environment/environmental-strategy-and-measures.html>

- Shell aims to become world's largest electricity company (Financial Times 13.3.2019)
- Maersk will cut carbon emissions to zero by 2050
- British Airways to offset carbon emissions from 2020, IAG invests in sustainable aviation fuels¹⁾
- Lufthansa pilots synthetic kerosene production ²⁾
- Shell, Neste, Wärtsilä, Finnair, St1, Kemira, Finnsementti and LUT university work together in project Industrial Pilot P2X Fuels at Joutseno
- Carbon Recycling International (CRI) signed an agreement for CRI's first CO₂-To-Methanol Plant in China to produce 180,000 tons of methanol and LNG annually.
- LUT
 - Wärtsilä, LUT University and Nebraska Public Power District to develop business case for alternative fuels. Final report delivered.
 - LUT Feasibility study on investment of recycling CO₂ at Joutseno P2 Fuels with leading Nordic firms
 - LUT preliminary study on recycling CO₂ at St1 Göteborg refinery (delivered and continues on Feasibility Study)

1) <https://biofuels-news.com/news/british-airways-to-offset-carbon-emissions-from-2020-iag-invests-in-sustainable-aviation-fuels/>
 2) <https://www.lufthansagroup.com/en/responsibility/climate-environment/sustainable-aviation-fuel.html> 04 Promote alternative fuels

<https://www.moneyweb.co.za/news-fast-news/shell-says-it-can-be-worlds-top-power-producer-and-make-> https://www.lut.fi/web/en/news/-/asset_publisher/Gh4SAywhcPu/content/wartsila-lut-university-and-nebraska-public-power-district-to-develop-business-case-for-alternative-fuels
<https://www.carbonrecycling.is/news/co2-to-methanol-plant-china>



P2X Fuels

Timing and profitability

P2X Fuels - Timing of the demand

■ Pricing

- Methanol
 - Fossil approximately 400 EUR/tn
 - Renewable approximately 700 EUR/tn
- Methanol to (total yield around 45%) of which
 - Diesel 50%
 - Kerosene 20%
 - Gasoline 20%
- Aviation Kerosene
 - Fossil approximately 700 EUR/tn
 - Renewable approximately 2100 – 2800 EUR/tn ¹⁾

■ Conclusion

- Production of green drop-in fuels is very profitable
- Demand is unlimited for the years to come

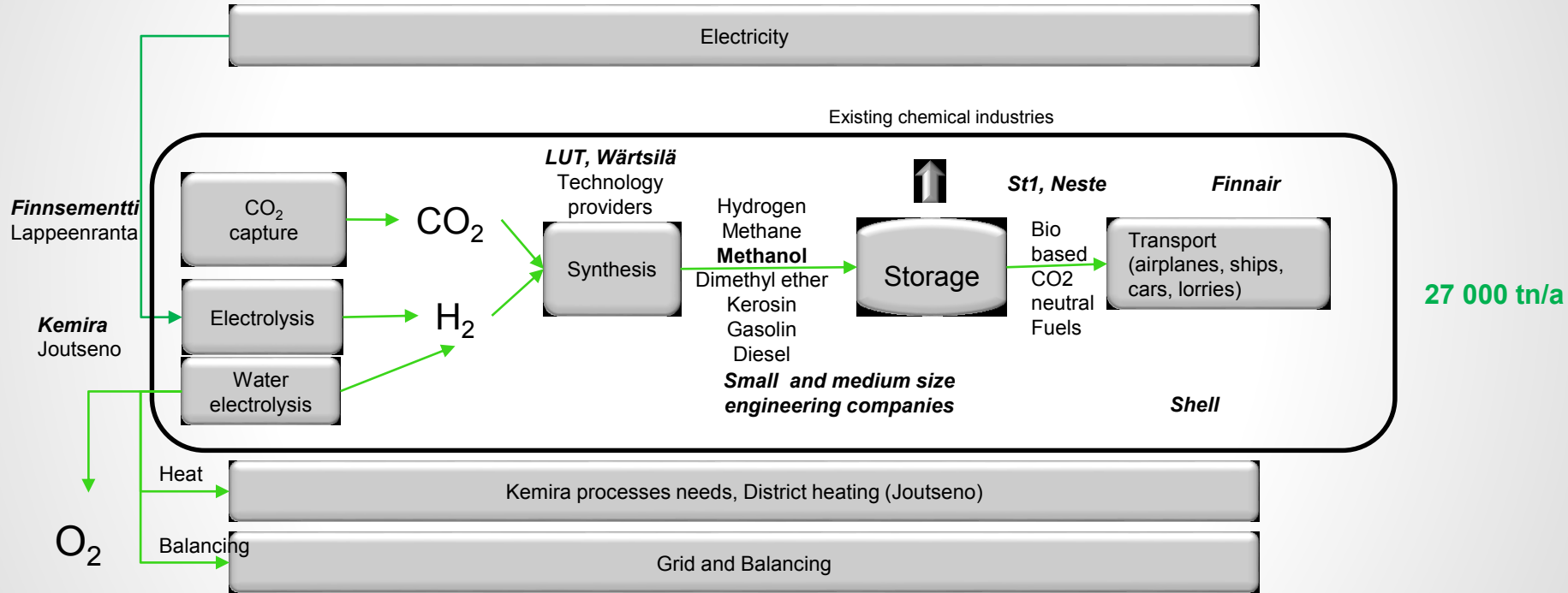
¹⁾ Andreas Teir, Renewable products -business area, development director



P2X Fuels

Production process – Industrial Pilot

P2X Joutseno Industrial Pilot





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