Luonnonvara- ja Biotalouspäivät

Lappeenranta 20.9.2023

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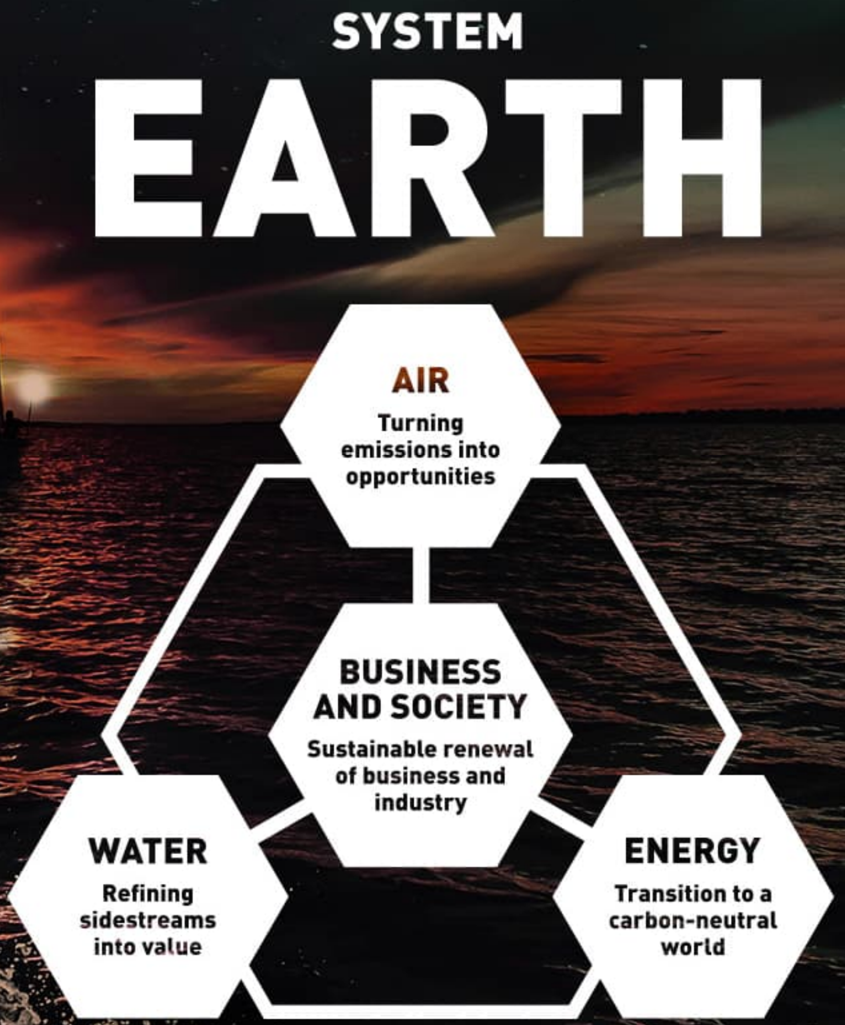
LUT UNIVERSITY STRATEGY 2030 • TRAILBLAZERS – Science with a Purpose

Puhdas energia – Suuri kasvumahdollisuus Suomelle



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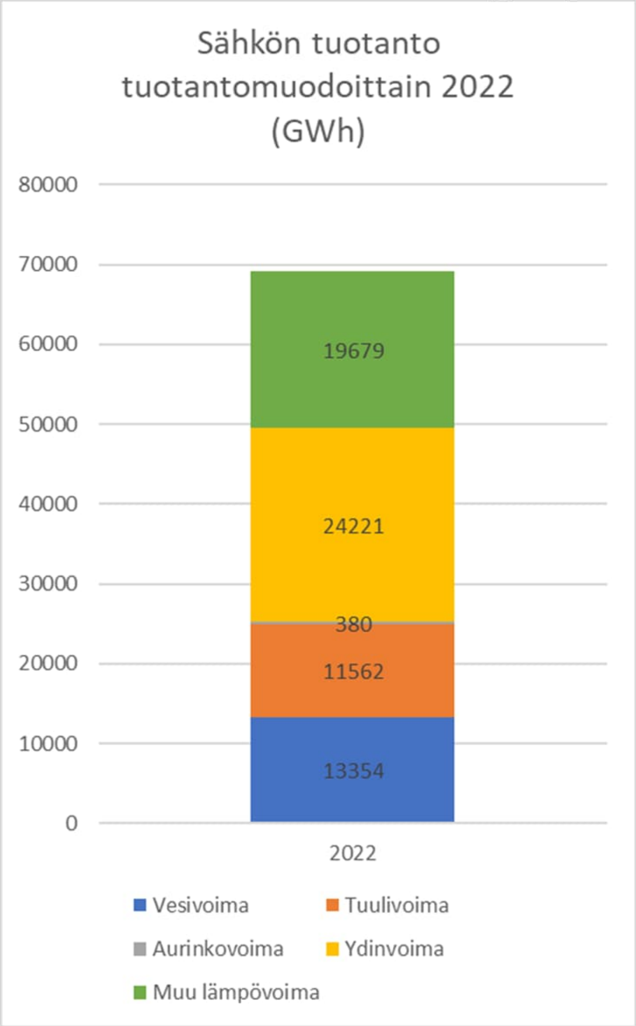
LUT University
LUT is among the world's
TOP 11
best small universities
THE WORLD UNIVERSITY RANKINGS

GREEN ELECTRIFICATION & P2X ECONOMY

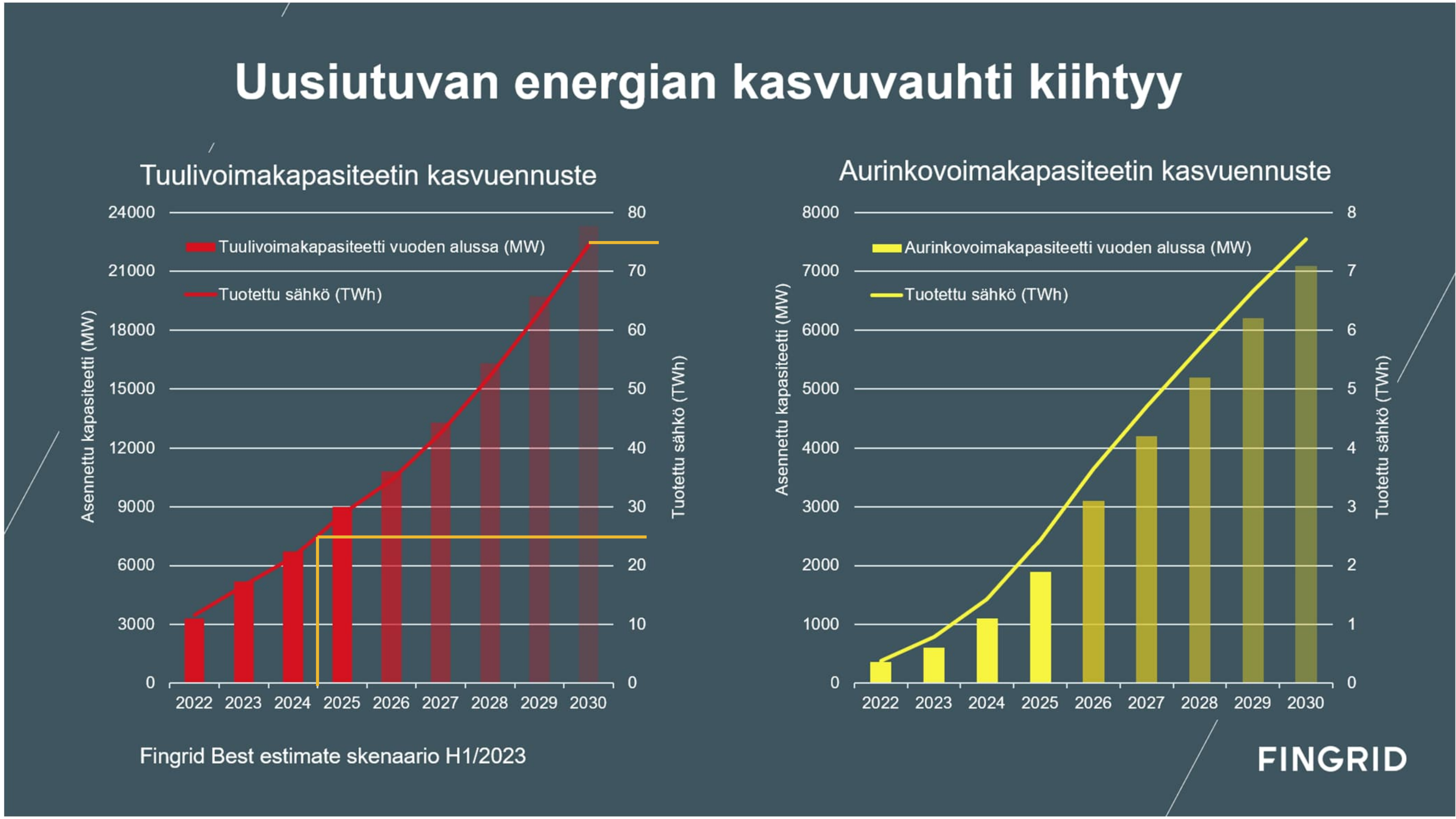
Competitive advantages for Finland in P2X

- Large and sparsely populated country
- Raw material availability
  - Bio based CO_2 raw material (20+ MtCO2 annually), equals to 150 Mt MeOH & 15 BEUR/a revenue
  - Cheap electricity compared to rest of the Europe
    - Very big potential for new production (wind and solar) and fast to ramp-up
- Educated people, good education system
- Process industry heritage and skills
  - Steel
  - Chemical
  - Pulp and paper
- Robust infrastructure
- Good reputation within investors
- Fast permitting processes (some exceptions)

Electricity production in Finland



Electricity production in 2022 69 TWh. Nuclear is the biggest source of electricity.



Wind power will pass nuclear 2024
In 2023 wind power exceeds exsiting production

Solar power will support the renewable production will be approximately +10% in 2030

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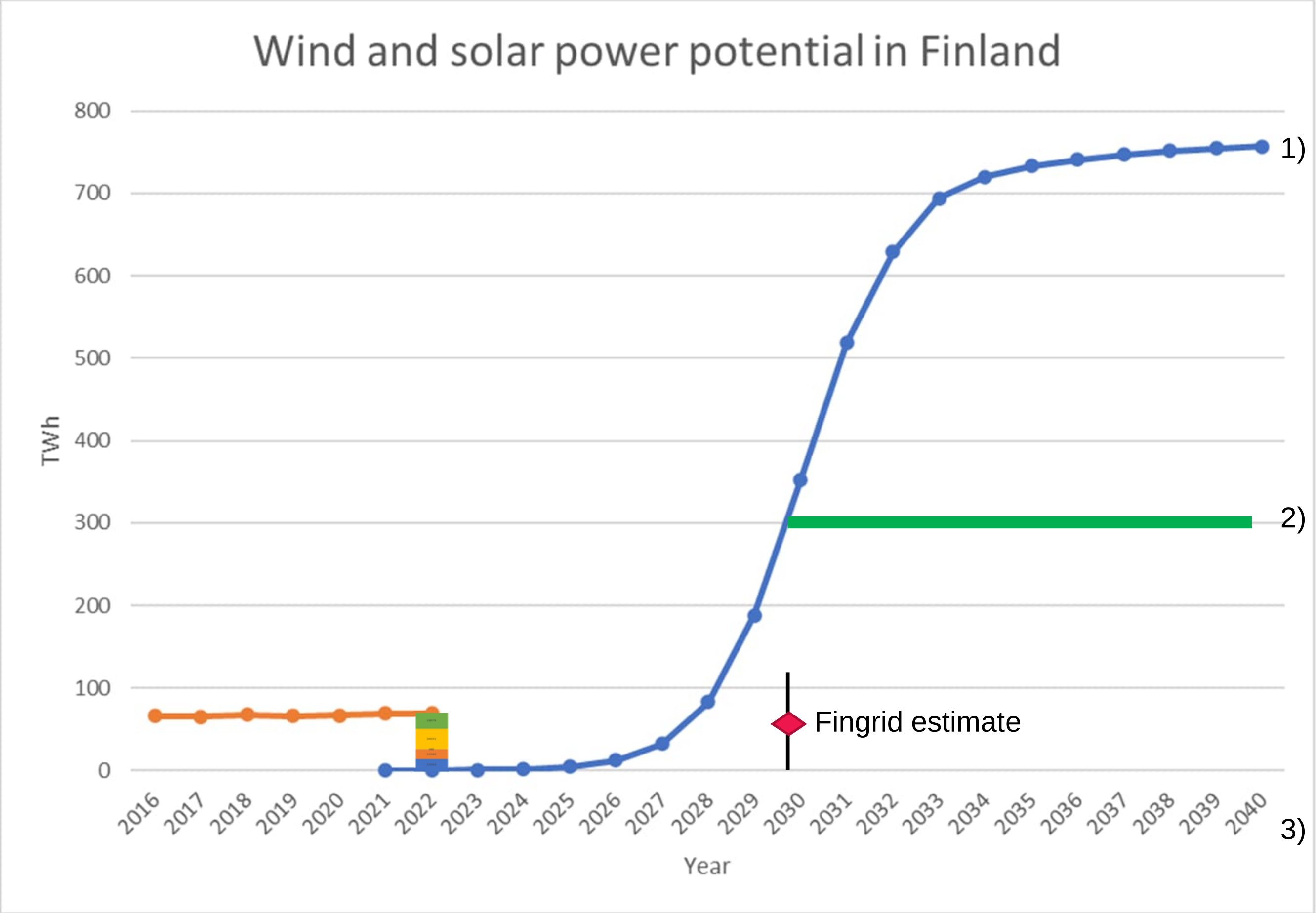
POTENTIAL OF GREEN ELECTRICITY PRODUCTION

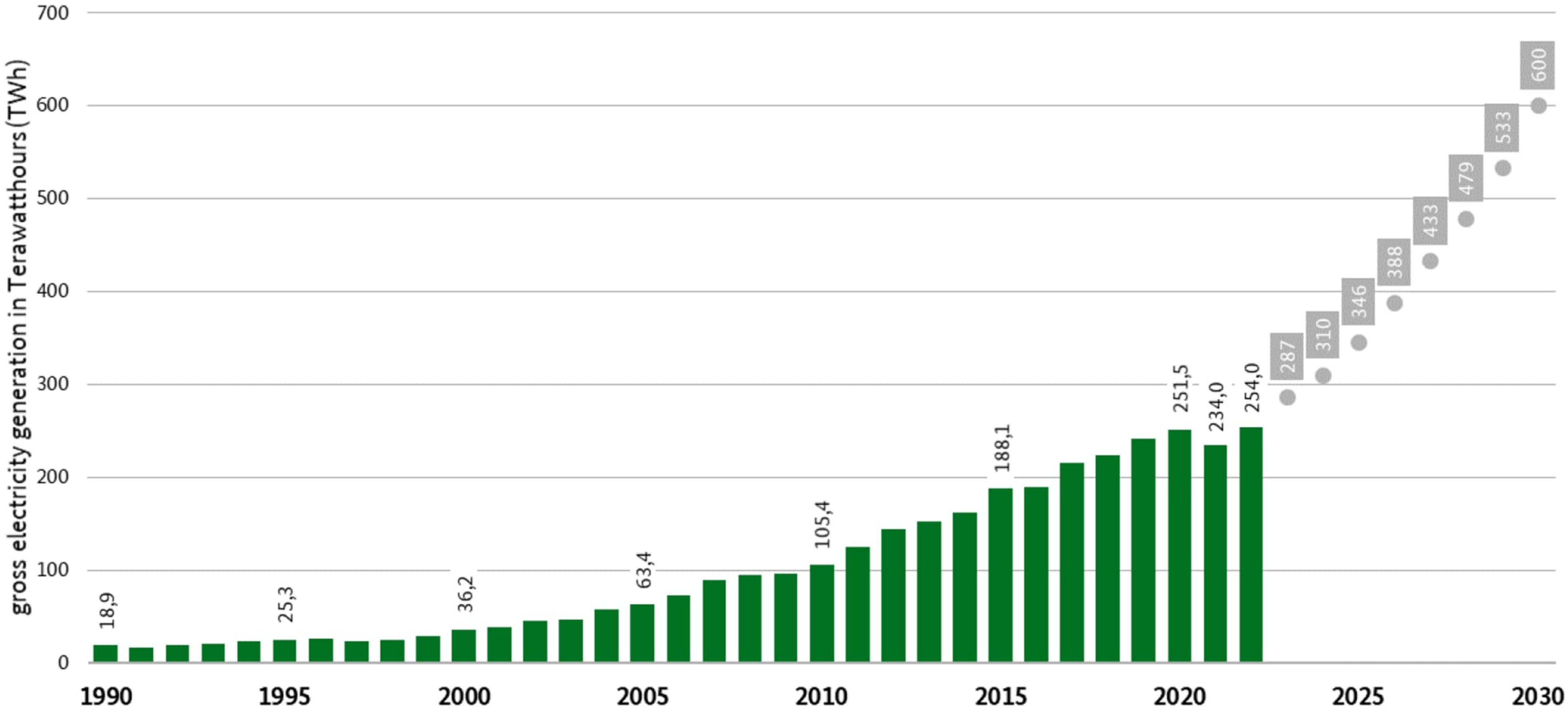


Investments in energy production approximately 400 BEUR

1) Based on Actual Grid Connection Request in Finland. Source: Energy transmission infrastructure as enabler of hydrogen economy and clean energy system. Fingrid and Gasgrid Finland's joint project, 15 March 2022. Updated 10.1.2023, Mikko Heikkilä, Fingrid 200 GW+.
2) Fingrid estimates 300 TWh wind production to Finnish system (Mikko Heikkilä, Bryssels, 9/2022)
3) Timeline not real estimate, just referential.

Gross electricity production from renewable energy sources in Germany

and target values accoring to new renewable energy law (EEG 2023)

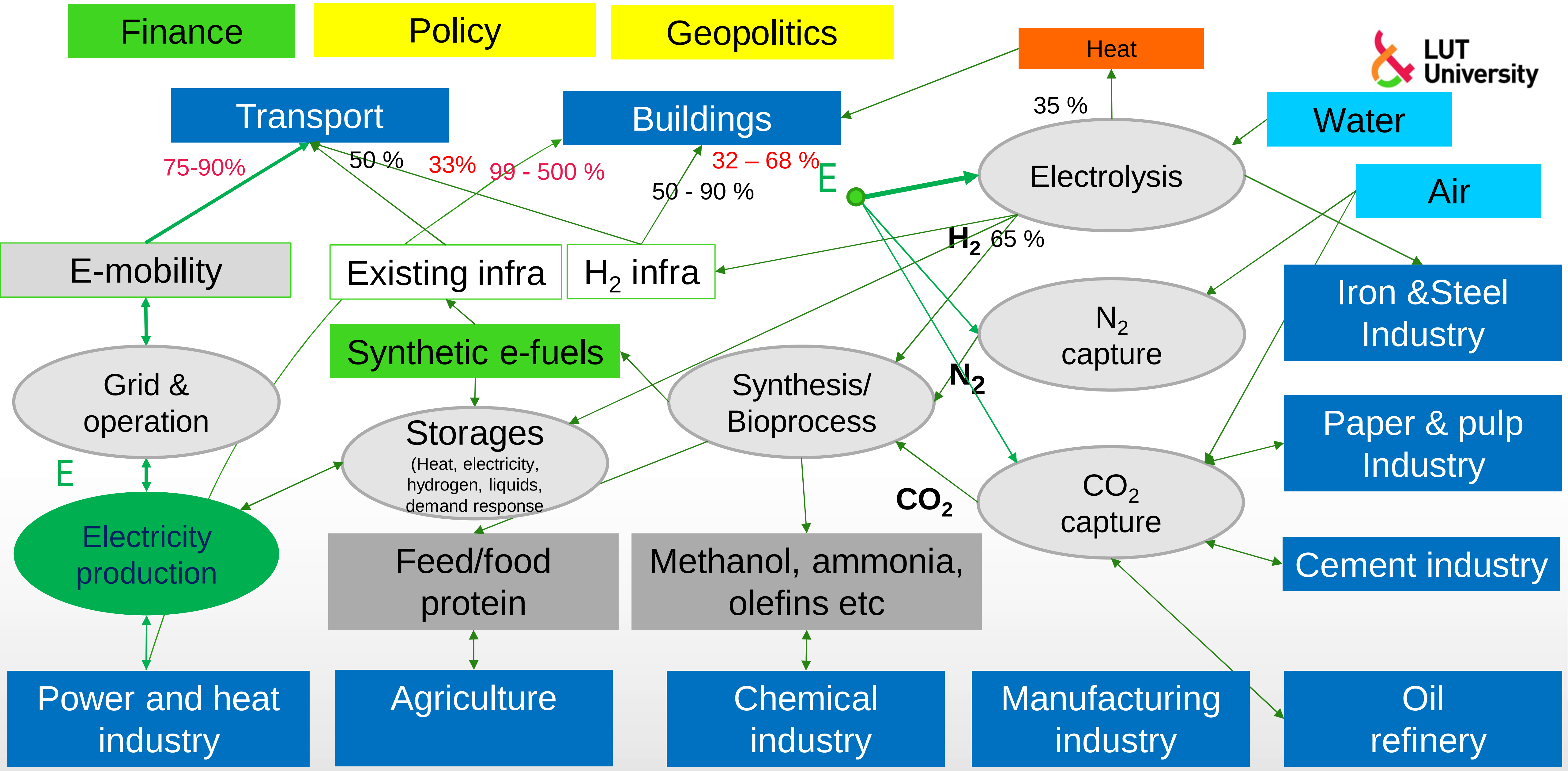


target values for the years 2021 and 2022 according to EEG 2021, target values for the years 2023 to 2030 according to EEG 2023

Source: Working Group on Renewable Energy-Statistics (AGEE-Stat); as of February 2023

NORDIC ELECTRICITY SUPERPOWERS

- Total renewable electricity potential in **Finland exceeds 1000 TWh, representing 10% of the electricity demand in EU.**
- Combined with Sweden and Norway, the potential could be 3500 – 4500 TWh, **covering 35- 45%% of the European electricity demand** of 10 000 TWh
- New P2X **investments will be located neat the electricity production**. Investments in synthesis of methanol, ammonia and other P2X products exceed investments in electricity generation.
- **Total investments exceed 1000 BUER** in Nordic countries.



Finance
Policy
Geopolitics
Heat
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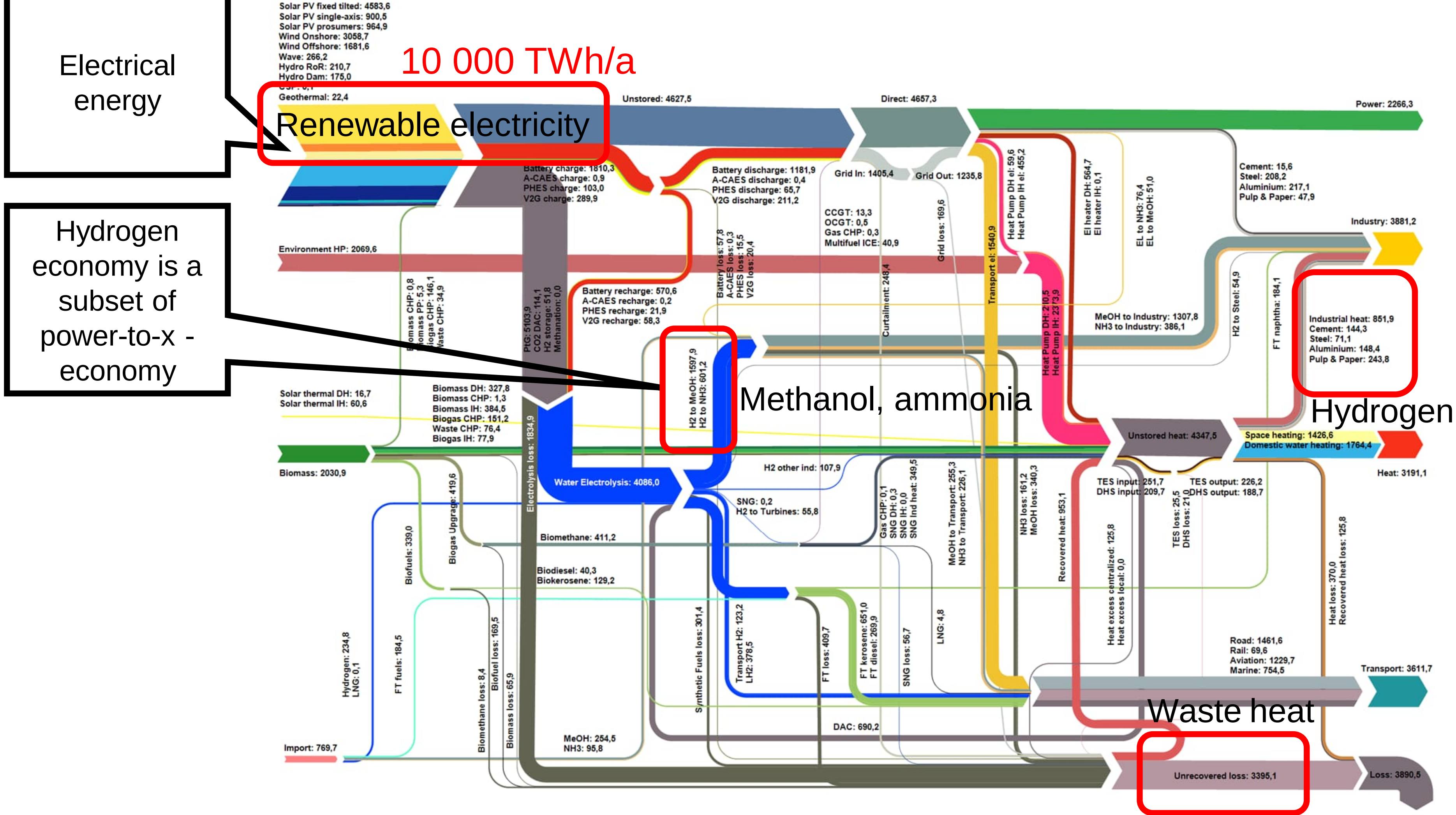
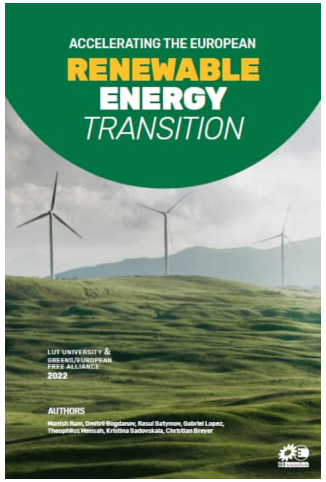
Transport
Buildings
35 %
Water
75-90%
50 %
33%
99 - 500 %
32 – 68 %
E
50 - 90 %
Electrolysis
Air
H_2 65 %
E-mobility
Existing infra
H_2 infra
Iron &Steel Industry
N_2 capture
Synthetic e-fuels
Grid & operation
Synthesis/ Bioprocess
N_2
Paper & pulp Industry
E
Storages
(Heat, electricity, hydrogen, liquids, demand response
CO_2
CO_2 capture
Electricity production
Feed/food protein
Methanol, ammonia, olefins etc
Cement industry
Power and heat industry
Agriculture
Chemical industry
Manufacturing industry
Oil refinery

Energy system transition in Europe

- Zero CO_2 emission low-cost energy system is based on electricity
- Core characteristic of energy in future: Power-to-X Economy
  - Primary energy supply from renewable electricity: mainly solar PV and wind power
  - Direct electrification wherever possible: electric vehicles, heat pumps, desalination, etc.
  - Indirect electrification for e-fuels (marine, aviation), e-chemicals, e-steel; power-to-hydrogen-to-X

Europe - RES-2040 2050

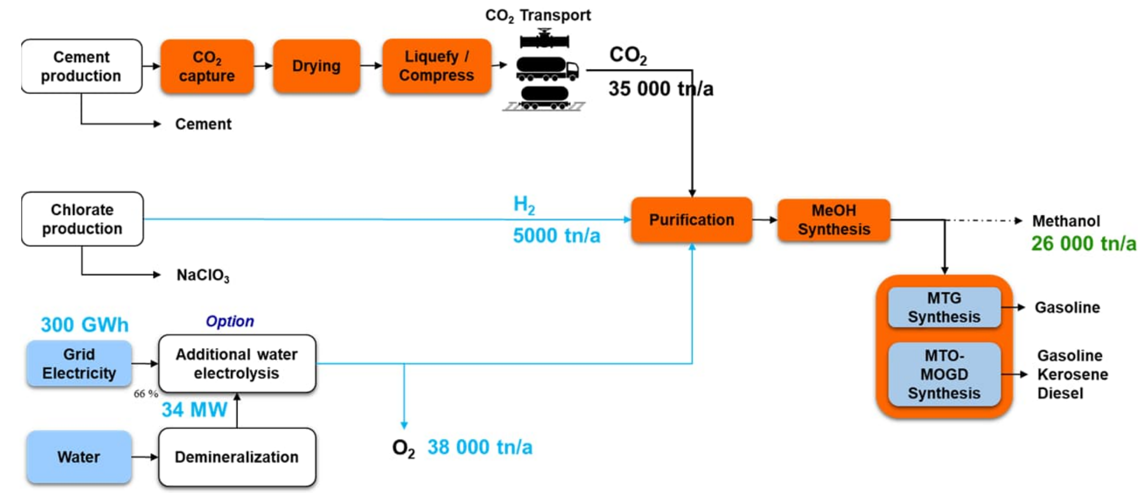




Greens/EFA, 2022

P2X

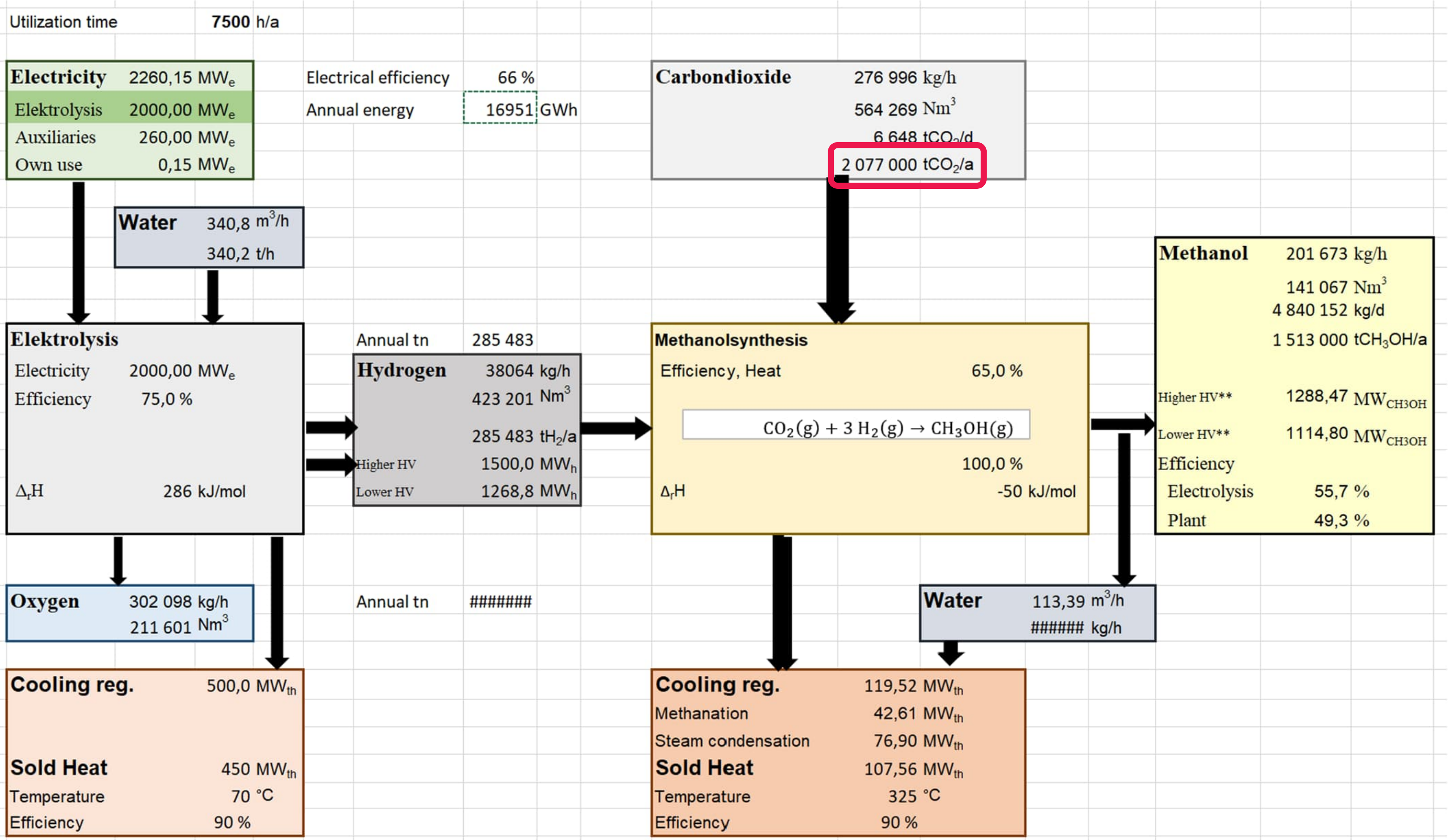
Case Pulp Mill

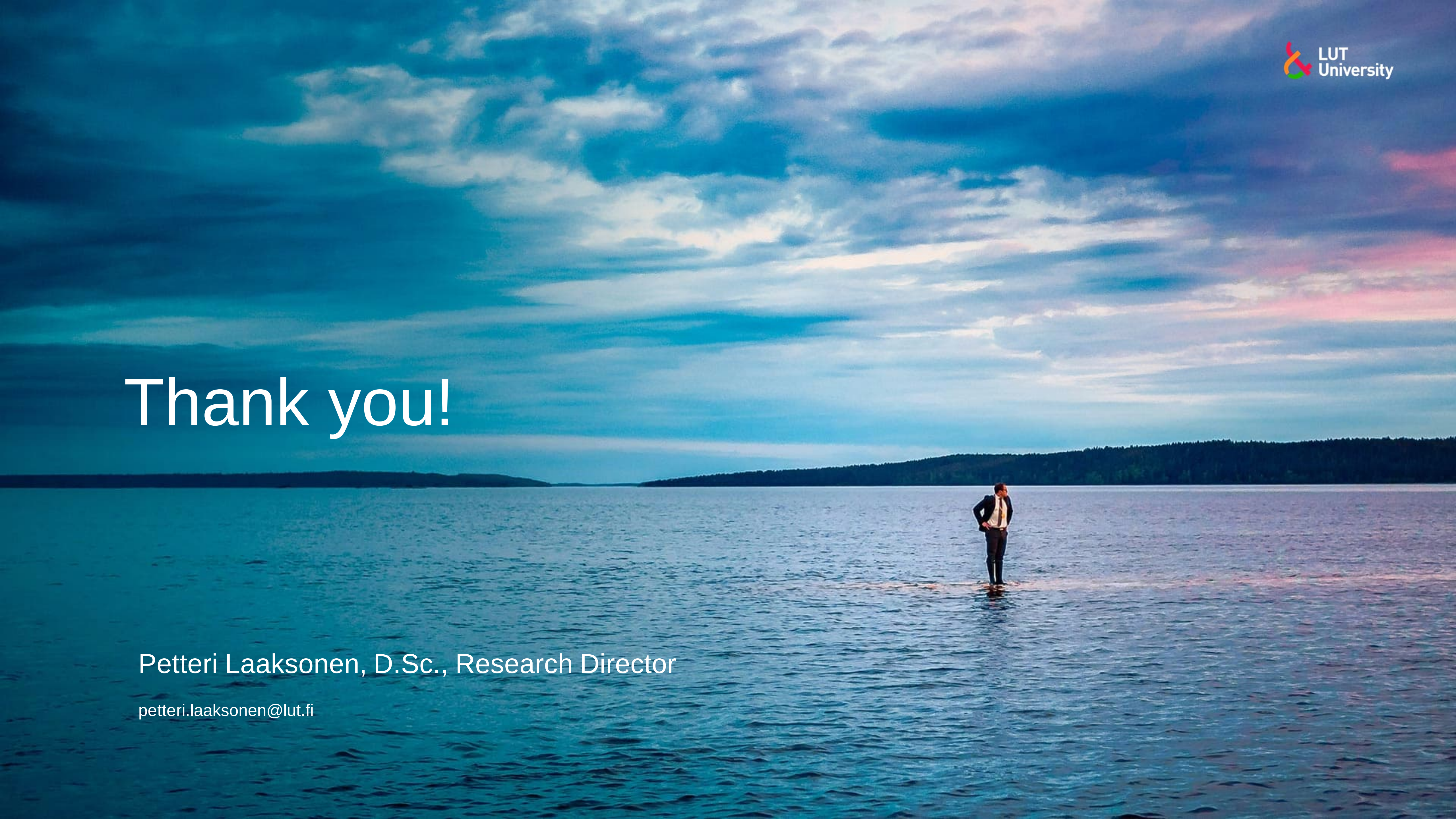


CASE IMATRA MILLS – METHANOL PRODUCTION

- Annual biobased CO_2 emissions 2,1 Mt (2017)
- Chemical scrubbing (amine, 40 - 140 °C)
  - CO_2 capture efficiency 98%
  - CO_2 capture purity >99
- Electrolyser 2 GW
- Annual electricity 17 TWh
- Green Methanol production 1,5 Mt/a
- Value á 1000 EUR/tn

→ 1,5 Mrd EUR/a





Thank you!

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P2X in Finland – some LUT research

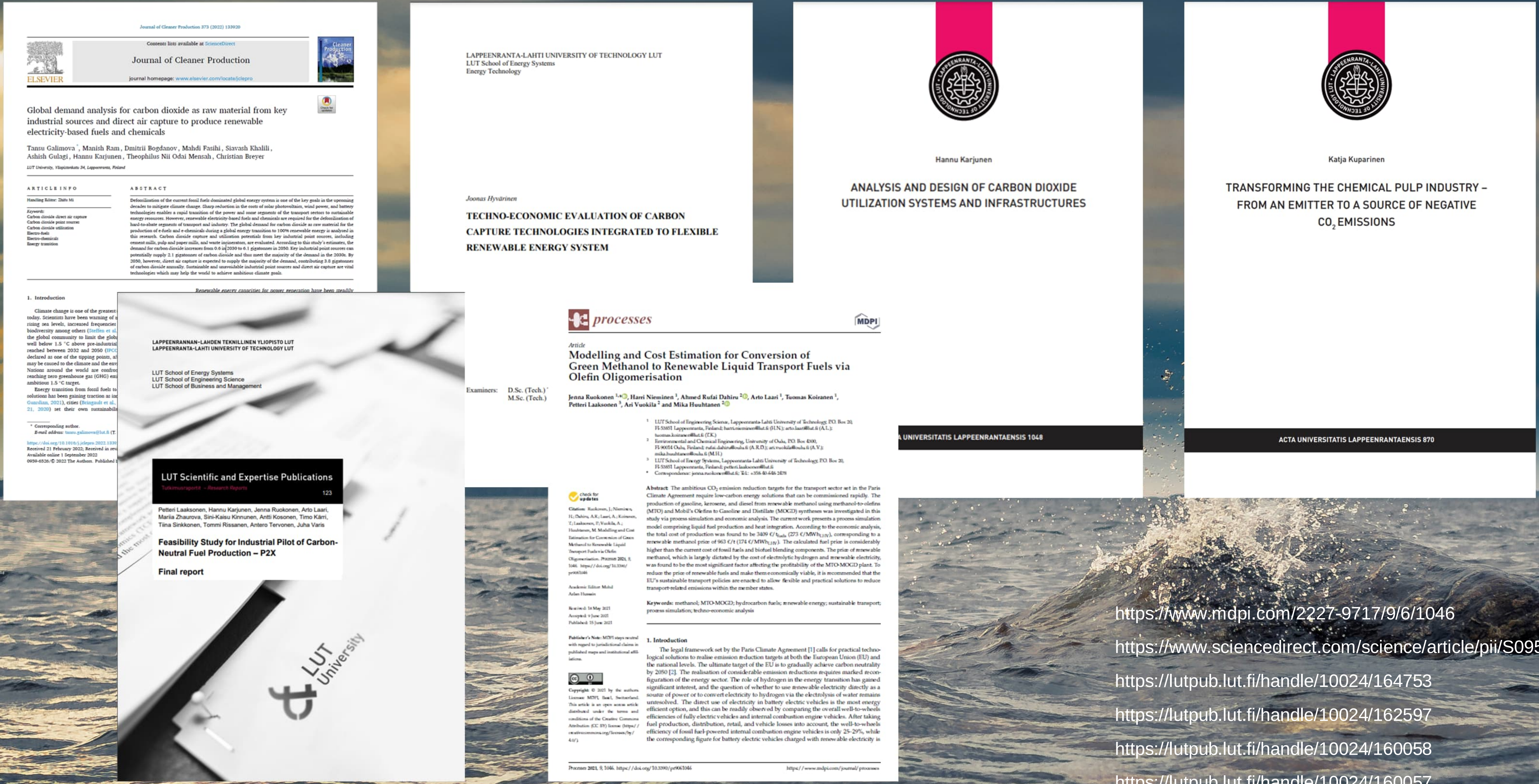
- Carbon Negative Åland: Strategic Roadmap https://lutpub.lut.fi/handle/10024/163456
- Bothnian Bay Hydrogen Valley – Research report https://lutpub.lut.fi/handle/10024/163667
- South-East Finland Hydrogen Valley – Research report https://lutpub.lut.fi/handle/10024/164642
- Feasibility Study for Industrial Pilot of Carbon-Neutral Fuel Production – P2X https://lutpub.lut.fi/handle/10024/162597

P2X TECHNOLOGIES

- Commercially available
- Technology Readiness Level 9

Technology	Supplier	Technology type	Reference
Electrolysis	Cummins	Alkaline, PEM	[21]
	Green Hydrogen Systems	Alkaline	[22]
	Hydrogen Pro	Alkaline	[23]
	ITM Power	PEM	[24]
	McPhy	Alkaline	[25]
	NEL Hydrogen	Alkaline, PEM	[26]
	Siemens	PEM	[27]
	Sunfire	Alkaline, SOEC	[28]
CO_2 capture	Air Liquide Engineering & Construction	Cryogenic	[29]
	Aker Carbon Capture	Amine	[30]
	Carbon ReUse	Water	[31]
	GE Power	Amine, oxy-combustion	[32]
	Mitsubishi Heavy Industries	Amine	[33]
	Shell	Amine	[34]
	Toshiba Energy Systems & Solutions Corporation	Amine	[35]
MeOH synthesis	Air Liquide Engineering & Construction	Syngas/CO_2 to MeOH	[29]
	BSE Engineering	n.a.[15]	[36]
	Carbon Recycle International	CO_2 to MeOH	[37]
	Johnson Matthey	Syngas to MeOH	[38]
	Mitsubishi Gas Chemical	Syngas to MeOH	[39]
Fuel synthesis	Chemieanlagenbau Chemnitz	MTG	[40]
	ExxonMobil	MTG	[41]
	Haldor Topsøe	MTG, syngas to gasoline	[42]
	Sunfire	Fischer-Tropsch	[28]

P2X & Carbon Dioxide



https://www.mdpi.com/2227-9717/9/6/1046

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https://lutpub.lut.fi/handle/10024/160058

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