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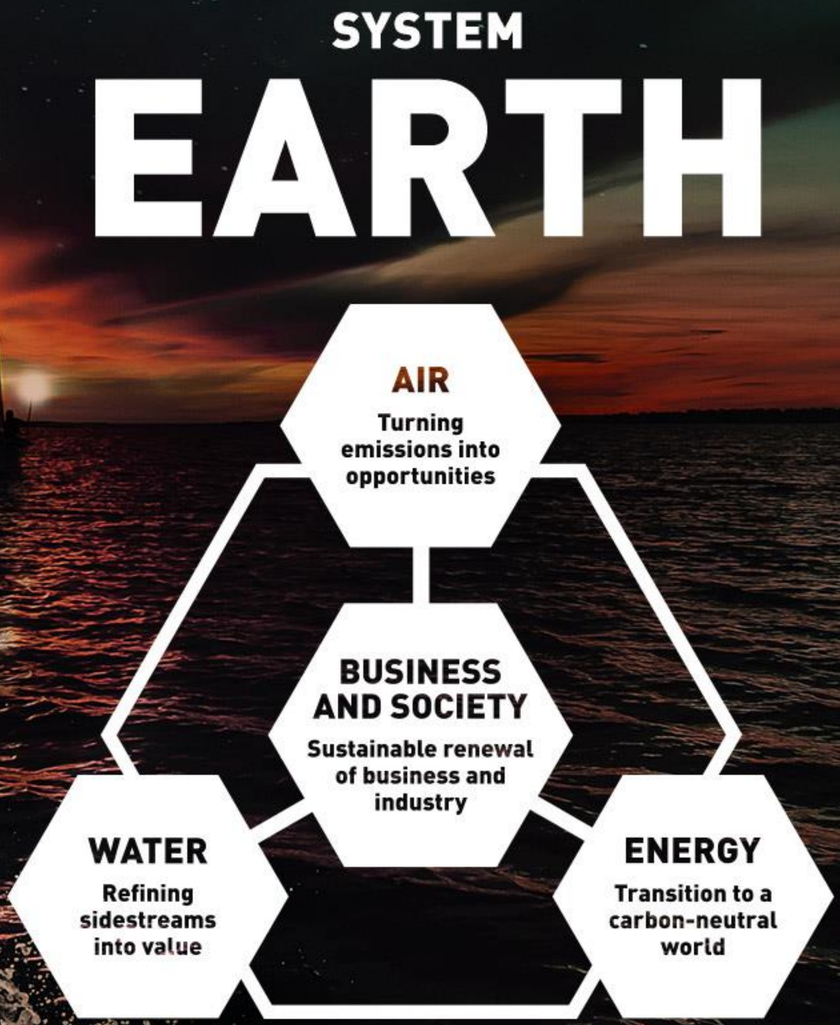
LUT UNIVERSITY STRATEGY 2030 • TRAILBLAZERS – Science with a Purpose

KesTech - Roundtable



Petteri Laaksonen, D.Sc., Research Director

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LUT-yliopisto on

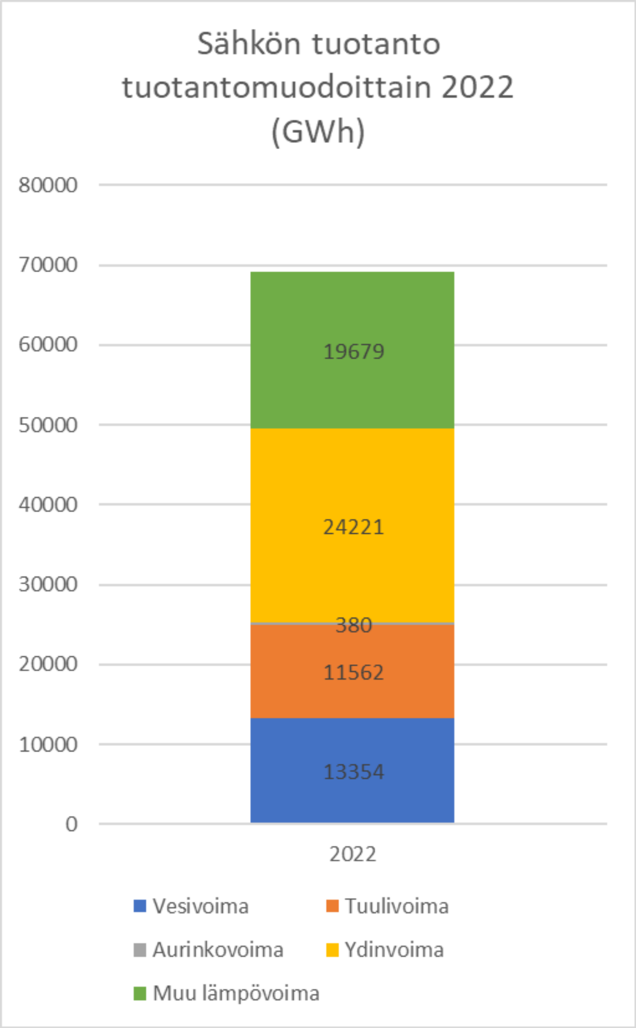
WORLD’S 9.TH

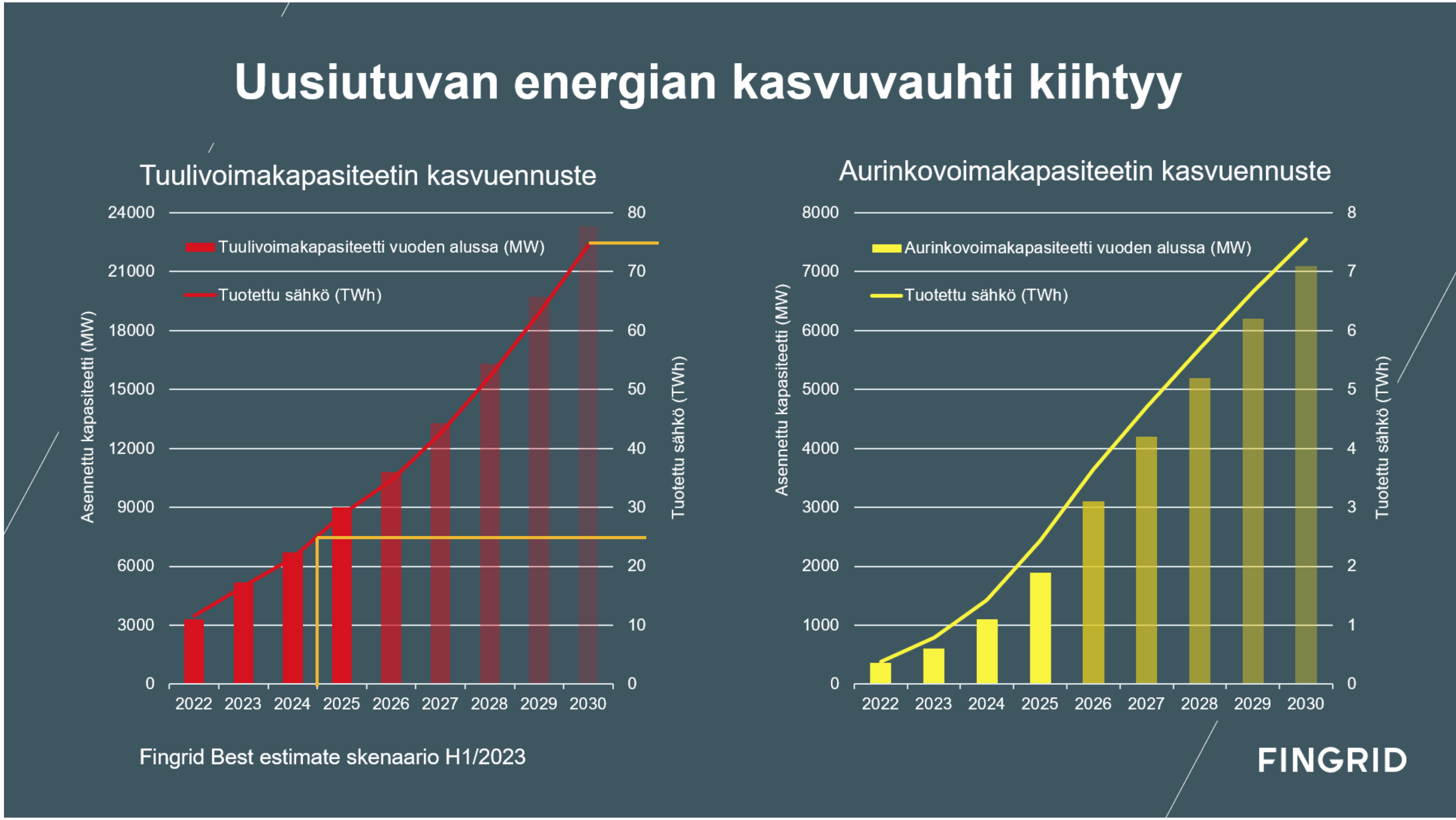
University – SDG 13.

Times Higher Education Impact Rankings 2022 arvioi yliopistojen sosiaalista ja taloudellista vaikuttavuutta YK:n kestävän kehityksen tavoitteiden edistämisen kautta.

GREEN ELECTRIFICATION & P2X ECONOMY

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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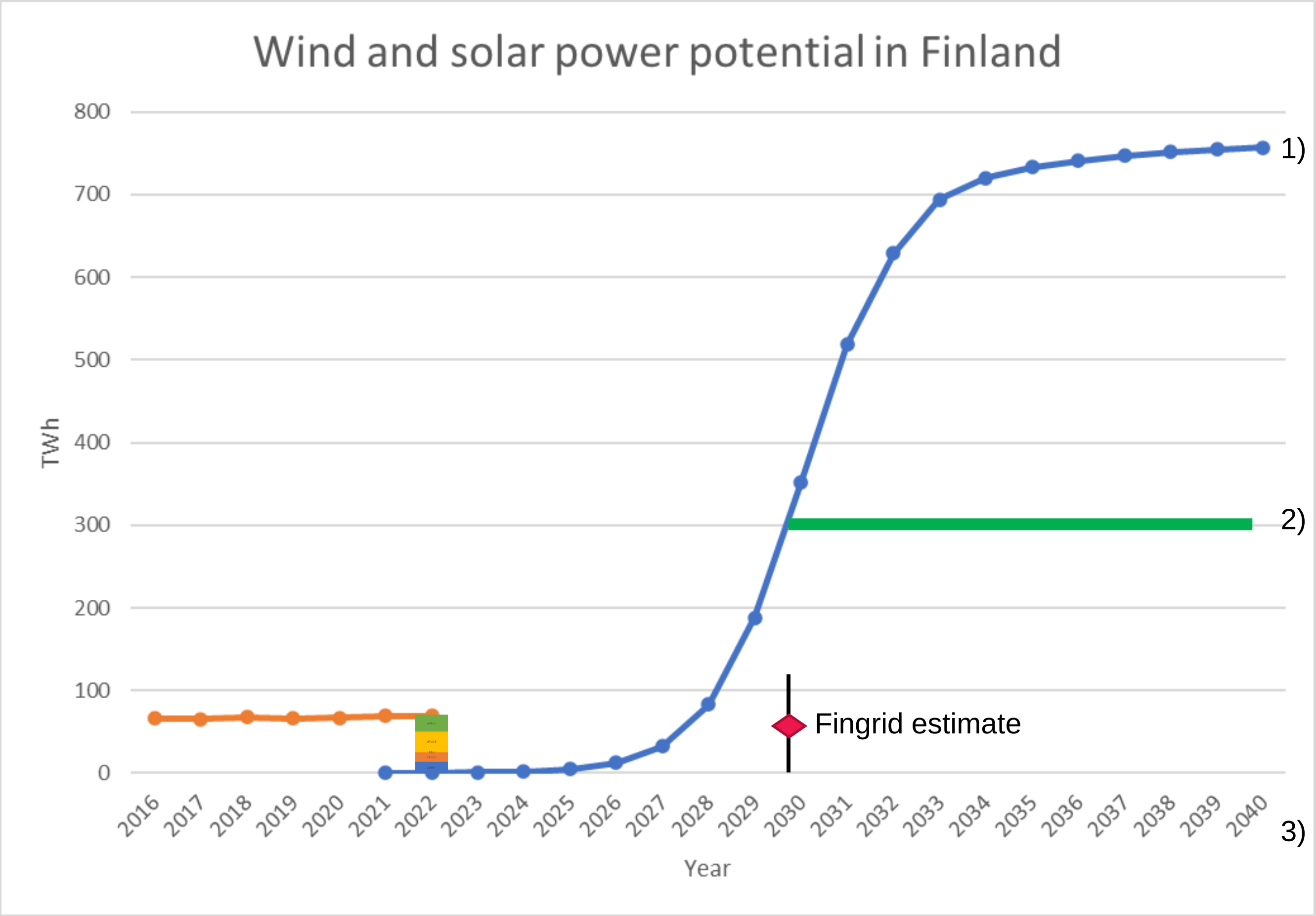
POTENTIAL OF GREEN ELECTRICITY PRODUCTION

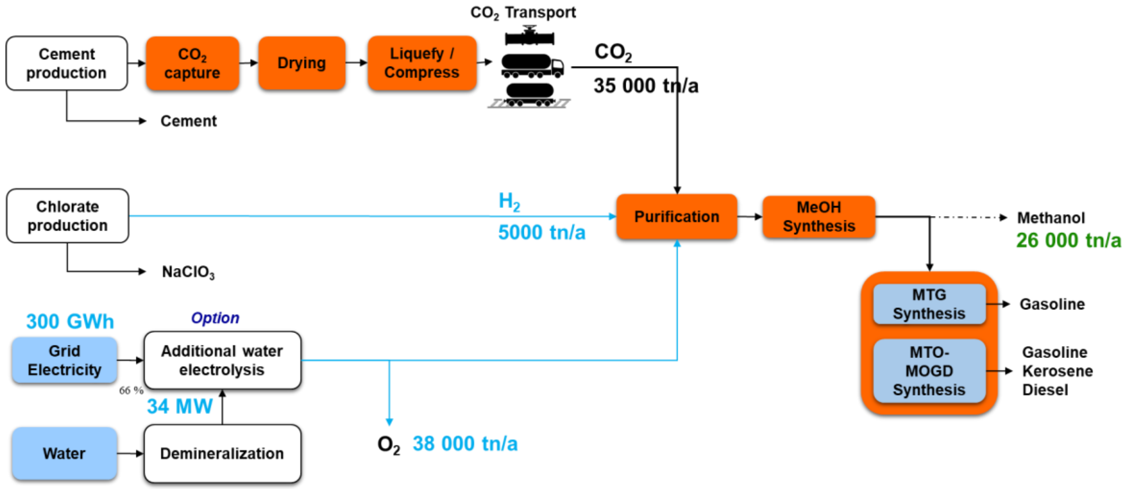


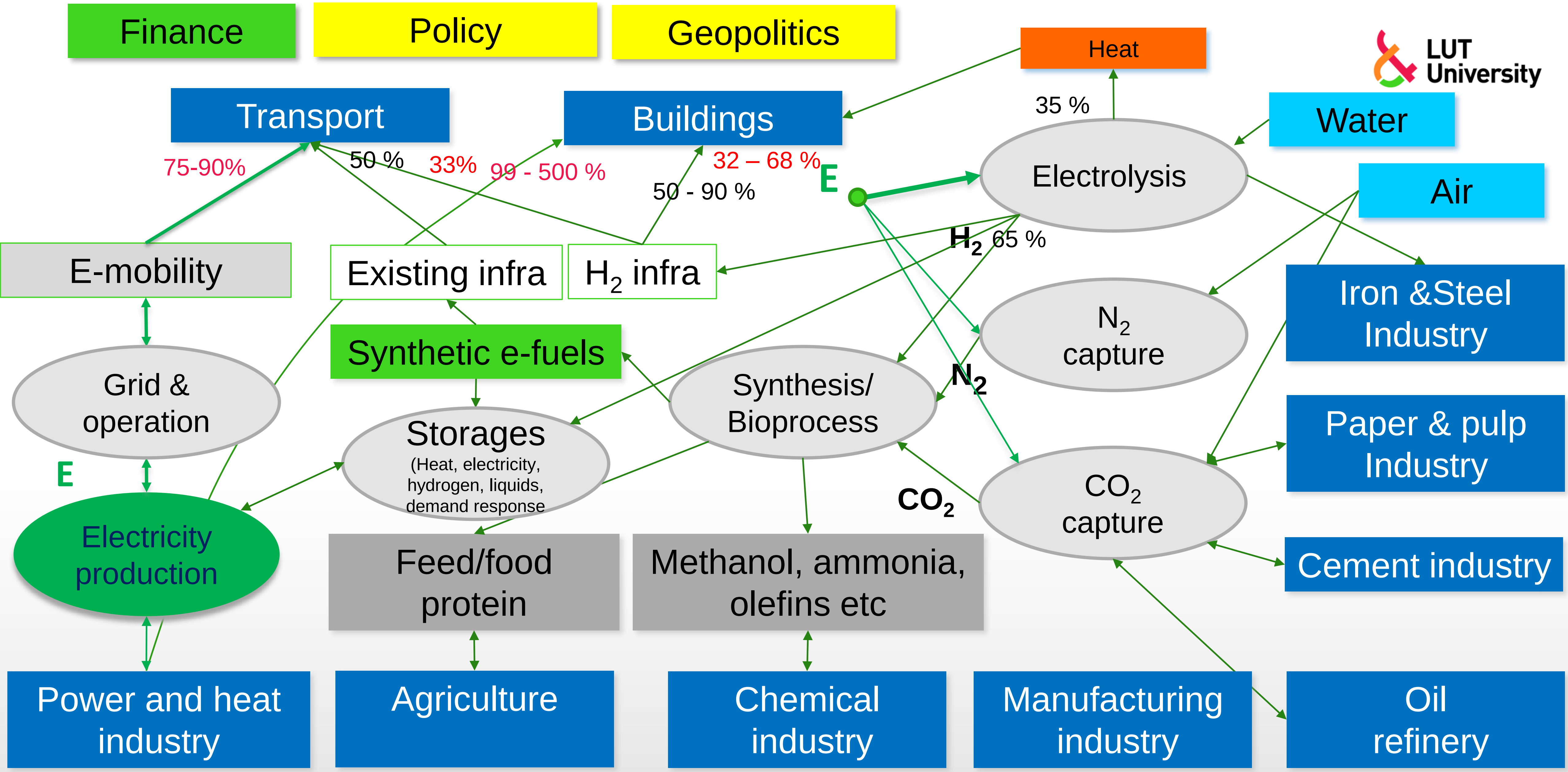
Investments in energy production approximately 400 BEUR

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.

P2X

From electricity & hydrogen to products





Finance
Policy
Geopolitics
Heat
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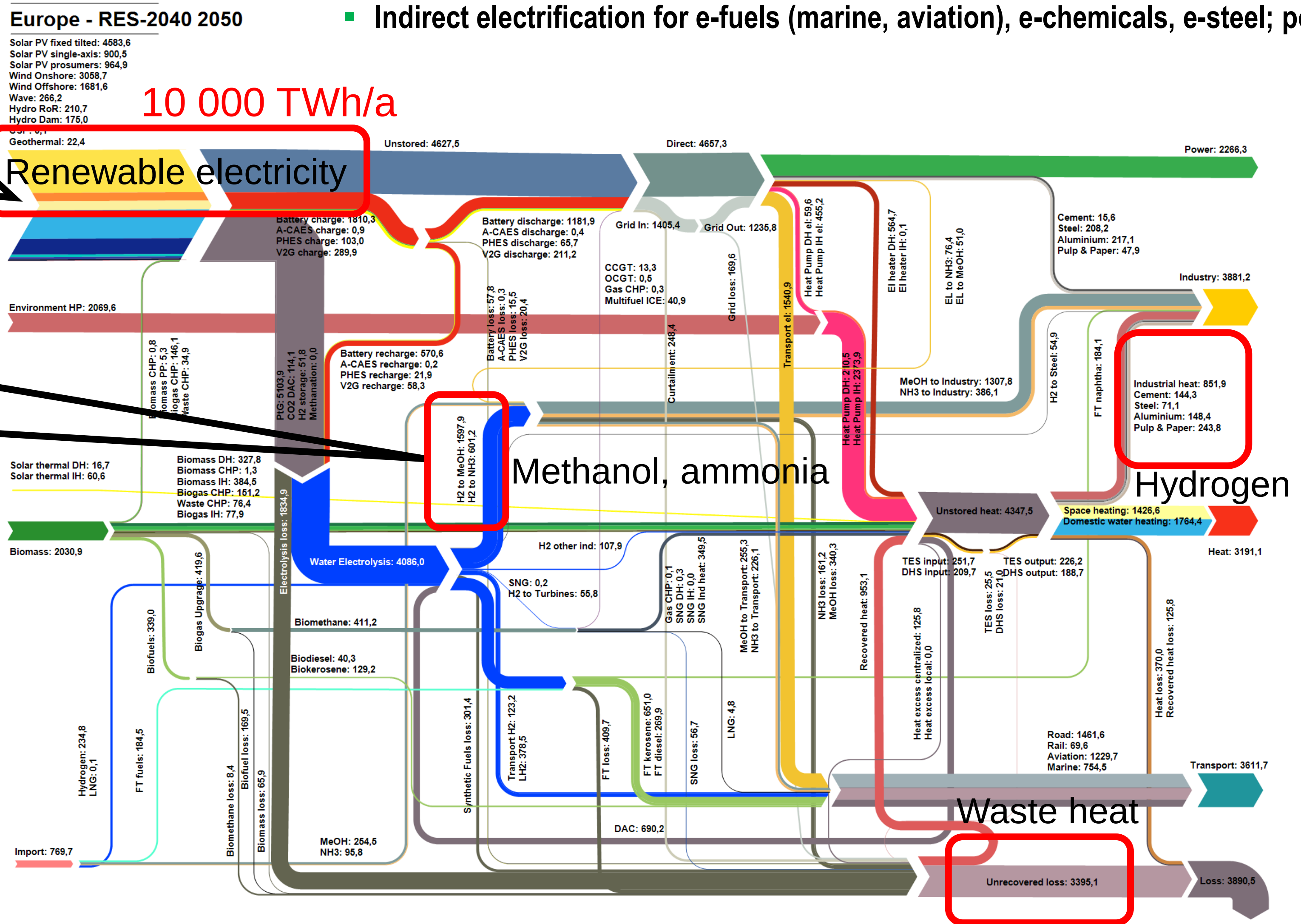
Transport
Buildings
35 %
Water
75-90%
50 %
33%
99 - 500 %
32 – 68 %
50 - 90 %
E
Electrolysis
Air
H_2 65 %
E-mobility
Existing infra
H_2 infra
N_2 capture
Iron &Steel Industry
Synthetic e-fuels
Grid & operation
Synthesis/ Bioprocess
N_2
Paper & pulp Industry
Storages
(Heat, electricity, hydrogen, liquids, demand response
E
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

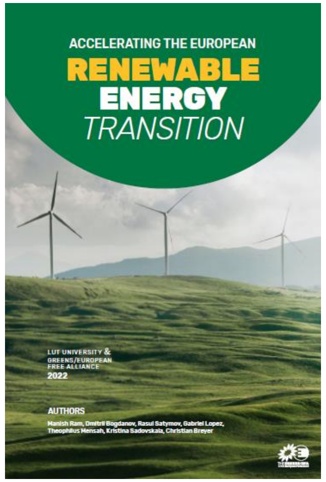
Energy system transition in Europe

- 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

Electrical energy

Hydrogen economy is a subset of power-to-x - economy

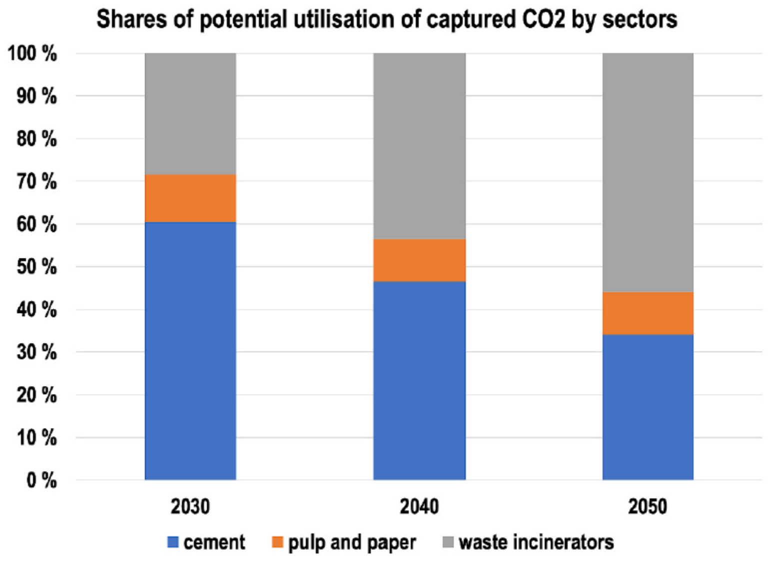


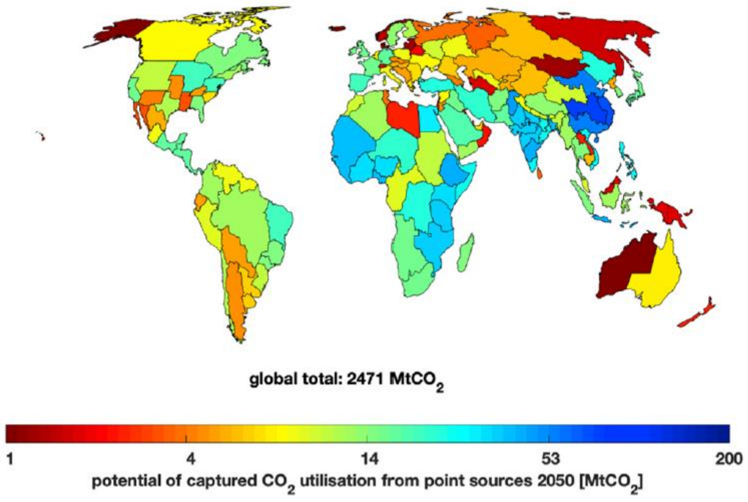


Greens/EFA, 2022

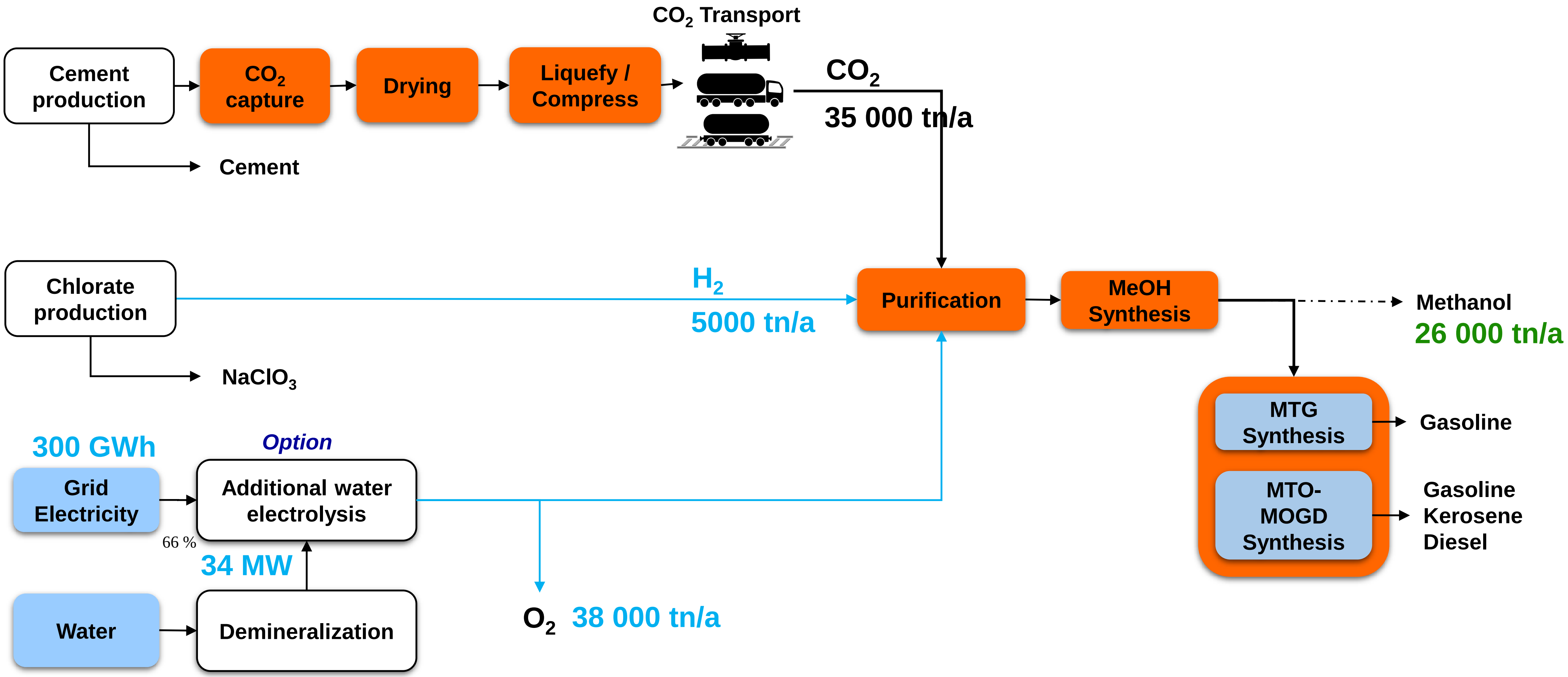
GLOBAL DEMAND FOR CO_2

In 2030, the total potential of captured CO2 from point sources that could be utilised is 2112 Mt annually (T. Galimova et al.(2022))





Production of Carbon Neutral Fuels - P2X



Utilization time 7500 h/a

St1 P2Methanol Production

LUT University

St1 is planning a synthetic methanol pilot plant in Lappeenranta, Finland

RELEASE 04.10.22

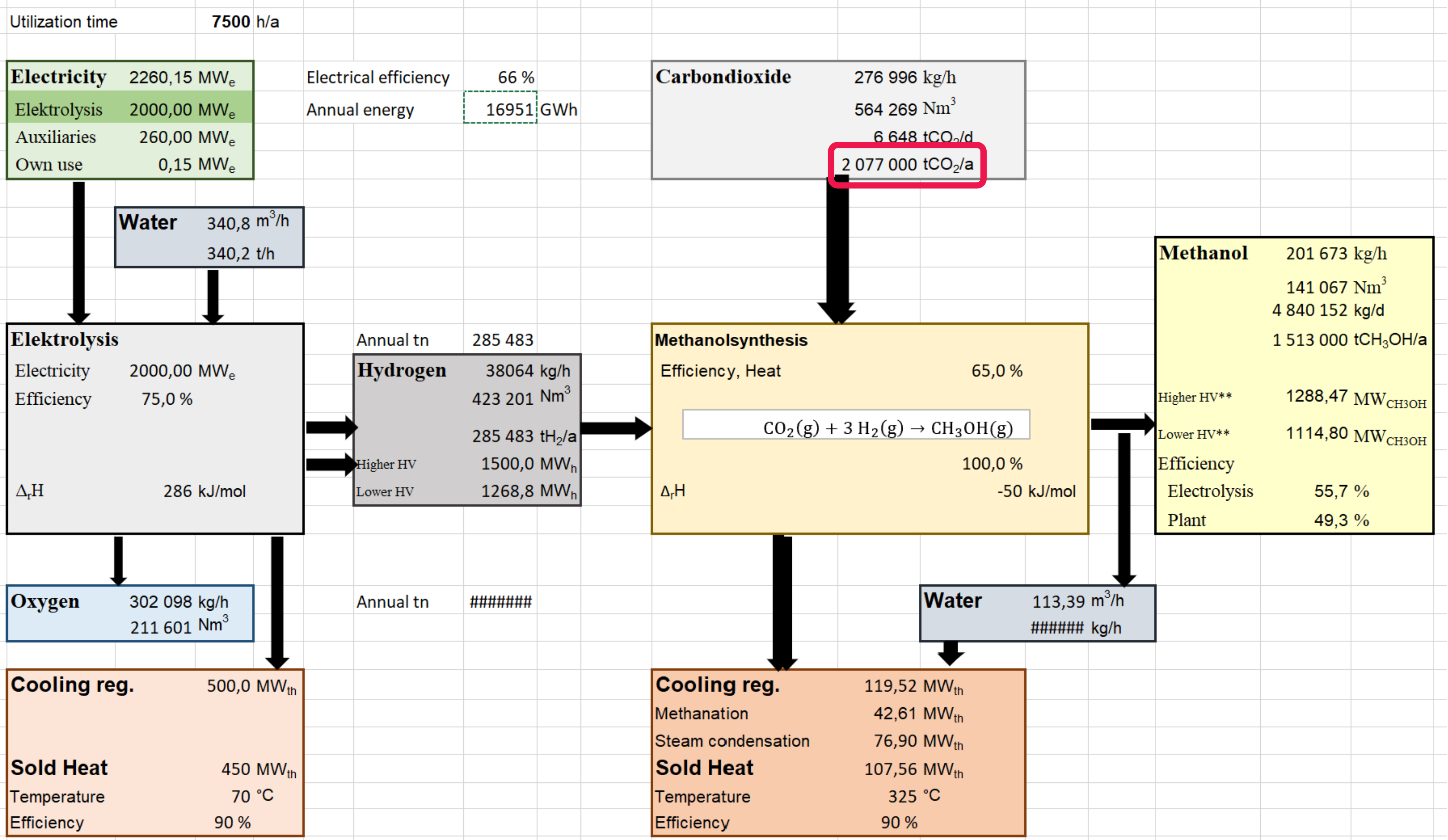
The energy company St1 is planning the first synthetic methanol plant in Finland next to the Finnsementti factory at the Ihalainen industrial site in Lappeenranta. The Ministry of Economic Affairs and Employment has granted a funding of EUR 35.4 million to St1's Power-to-Methanol Lappeenranta project, which aims to produce renewable synthetic methanol to replace fossil fuels used in maritime and road transport. St1's goal in the commercial-scale pilot project is to develop a replicable and scalable synthetic methanol production concept.

Finnsementti factory

CASE LARGE PULP MILL – METHANOL PRODUCTION

- Annual biobased CO2 emissions 2,1 Mt (2017)
- Chemical scrubbing (amine, 40 - 140 C)
  - CO2 capture efficiency 98%
  - CO2 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



SOUTH - EAST FINLAND HYDROGEN VALLEY

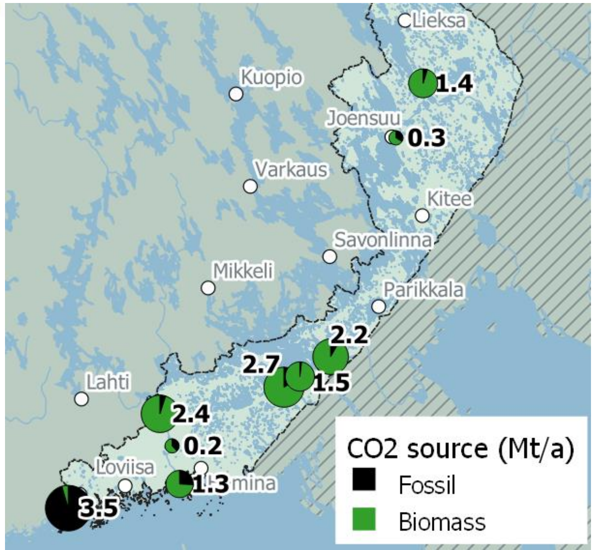
Petteri Laaksonen

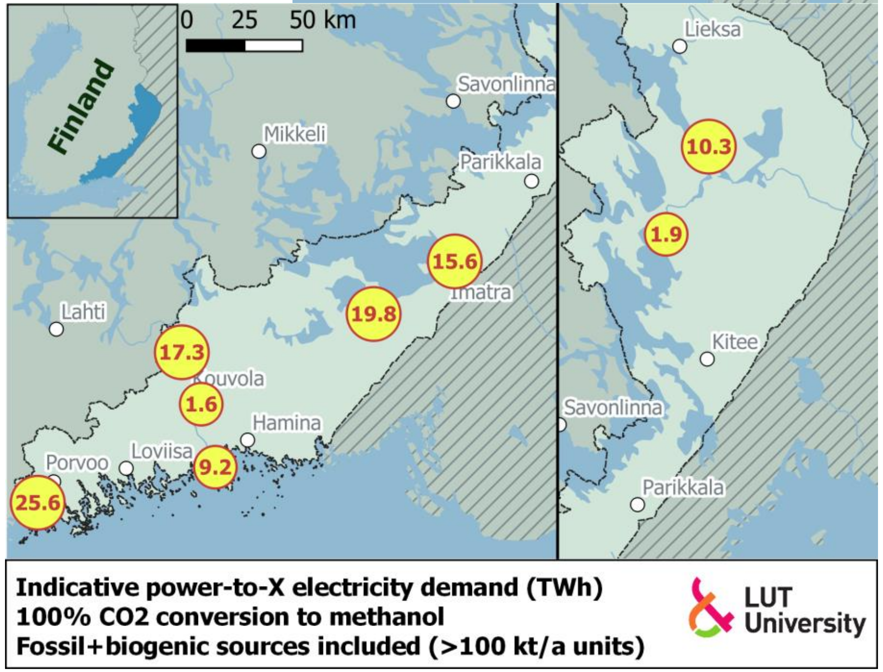
Research Director, School of Energy Systems, LUT University

BIOGENIC CO_2 SOURCES

- Mainly biobased emissions (10.8 Mt/a), located in the southern part of the area

Scenario	**Base**			
CO_2 emission facility type	(All)	(All)	Pulp and paper	(All)
CO_2 type	Total	Biogenic	Biogenic	Biogenic
Portion of CO_2 utilized	100 %	100 %	100 %	20 %
CO_2 utilized (Mt)	15.5	10.8	9.5	2.2
Methanol production (Mt)	11.3	7.8	6.9	1.6
Hydrogen demand (Mt)	2.1	1.5	1.3	0.3
Electrolyser electricity demand (TWh)	**112**	**78**	**69**	**16**

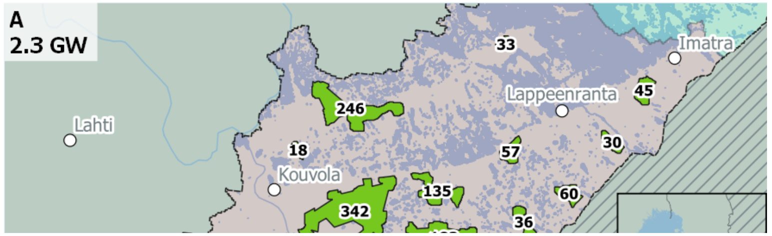




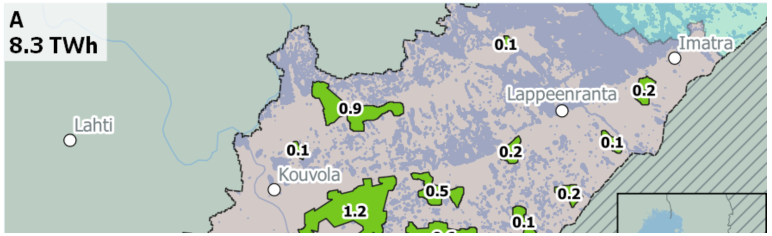
WINDPOWER POTENTIAL

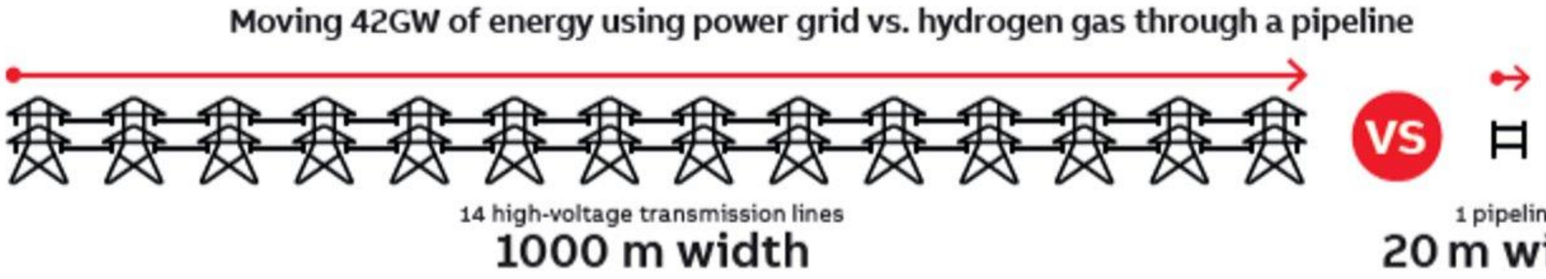
- Scenario approximately 50 % will be built
- Mainly located in the northern part of the area
- Energy transfer volume of 78 TWh between north and south is huge

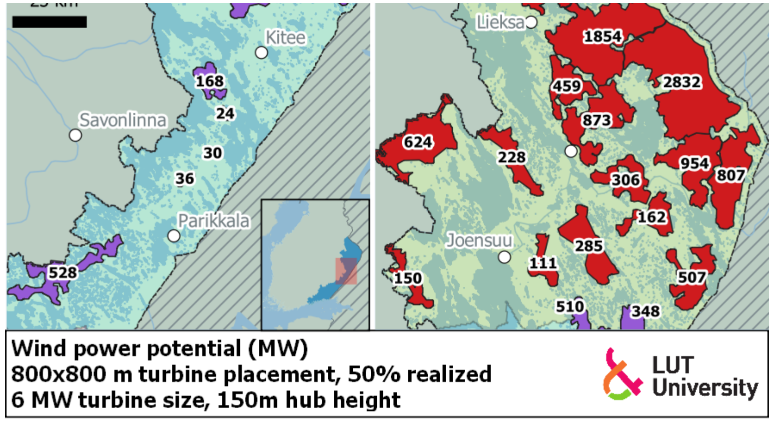
TOTAL 17 GW

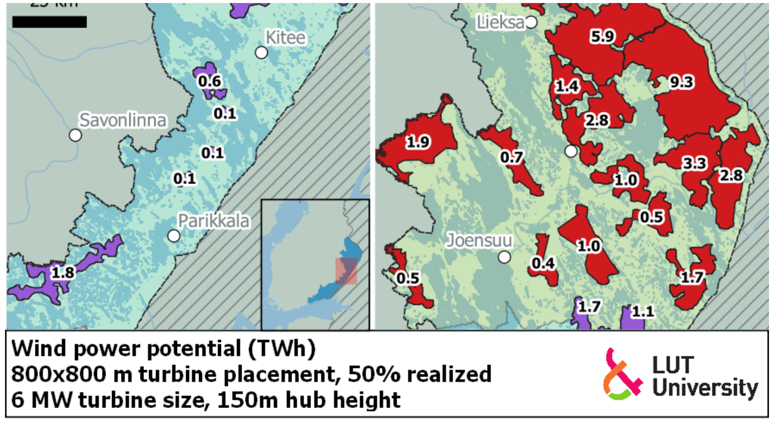


TOTAL 57 TWh









NORDIC COUNTRIES ELECTRICITY SUPERPOWERS

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.

Thank you!

Petteri Laaksonen, D.Sc., Research Director

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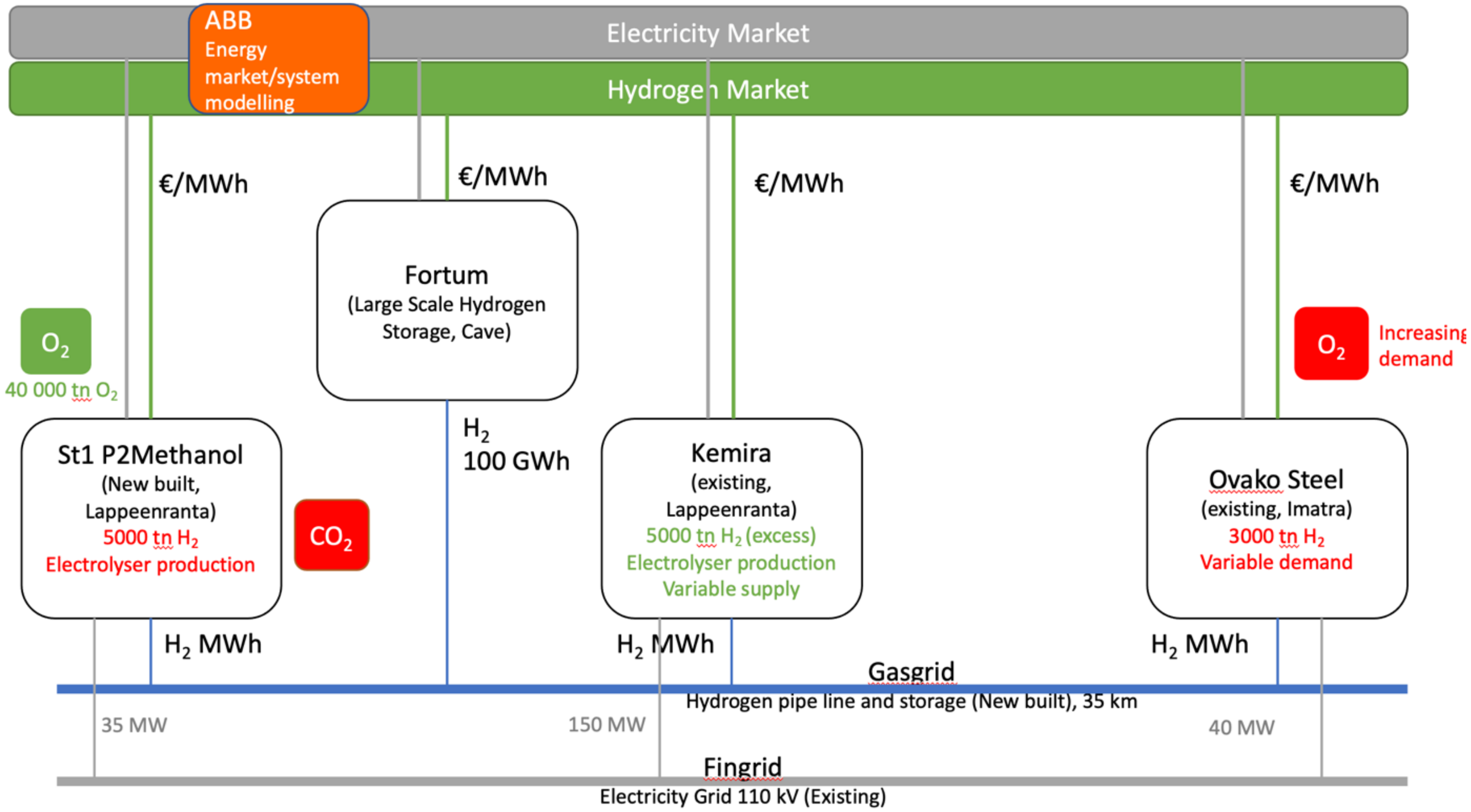
Renewable Energy in Finland

LUT University

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)

SOUTH-EAST FINLAND HYDROGEN VALLEY EU-PROJECT



EU Large Hydrogen Valley

Finance for 20 MEUR, majority into industrial investments

P2X in Finland – some LUT research

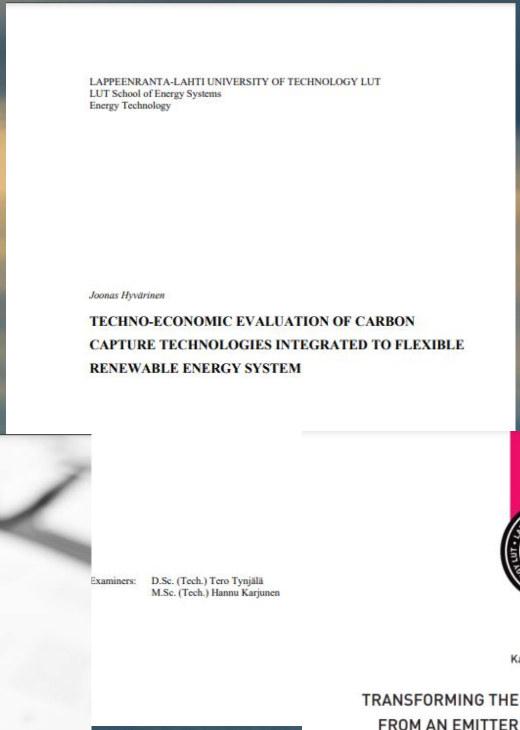
- Carbon Negative Åland: Strategic Roadmap https://lutpub.lut.fi/handle/10024/163456
- Bothnian Bay Hydrogen Valley – Research report https://lutpub.lut.fi/handle/10024/163667
- South-East Finland Hydrogen Valley – Research report https://lutpub.lut.fi/handle/10024/164642
- Feasibility Study for Industrial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

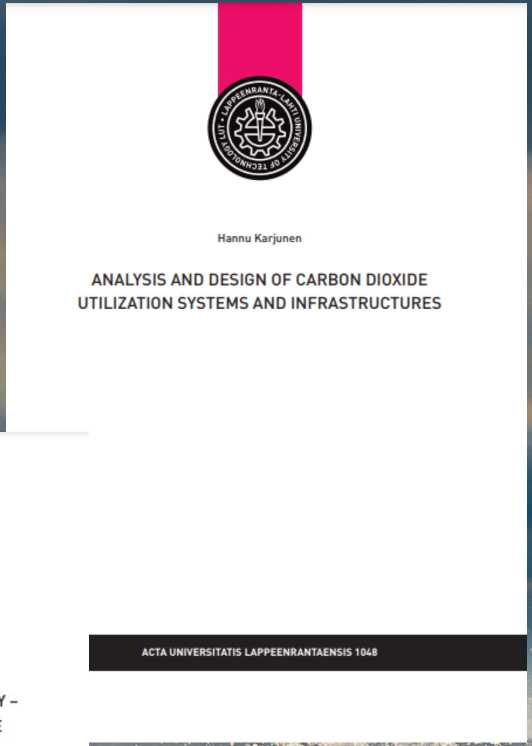
P2X TECHNOLOGIES

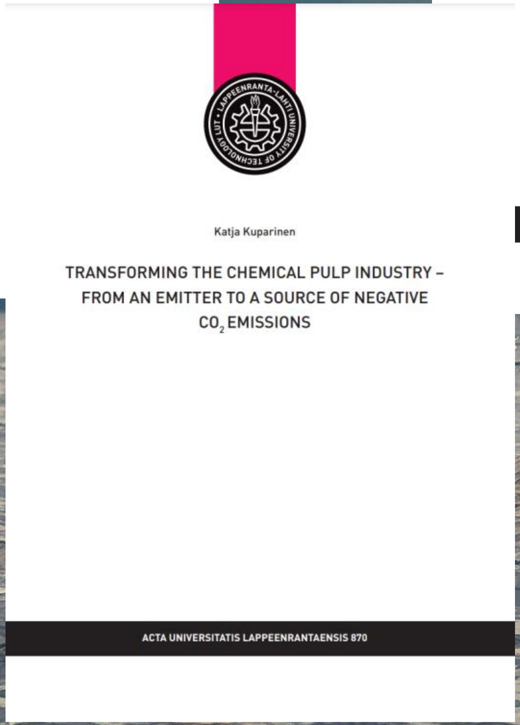
- Commercially available
- Technology Readiness Level 9

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.sciencedirect.com/science/article/pii/S0959652622034928

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