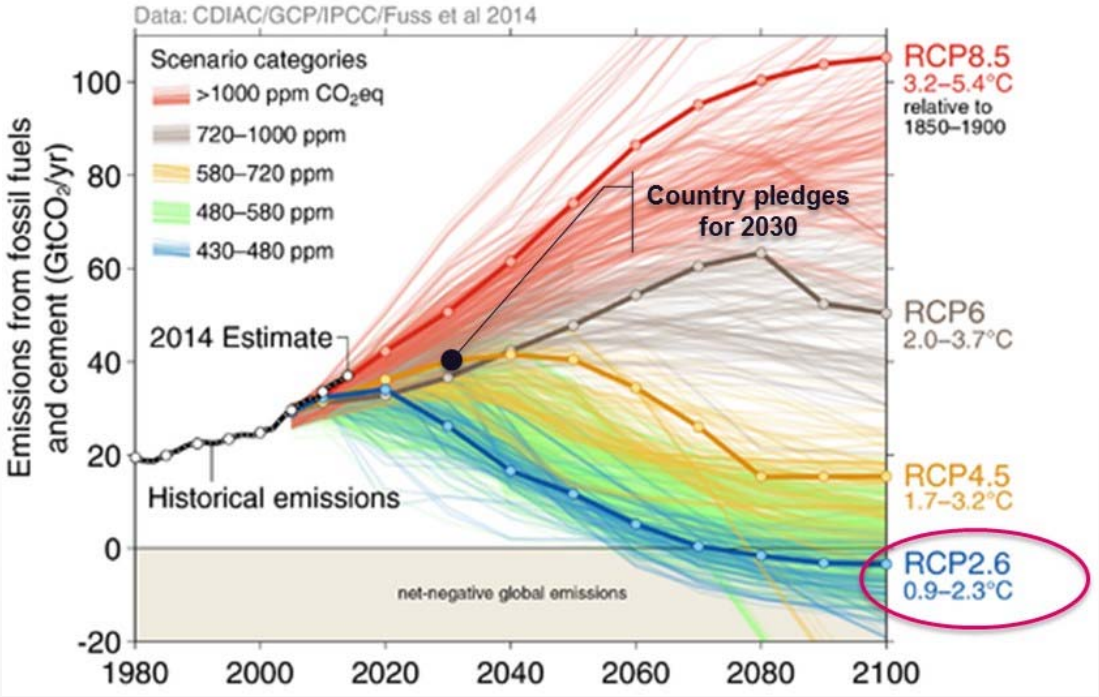

LUT
University

Power-to-X -sektorin nykytilanne ja näkymät

Antti Kosonen

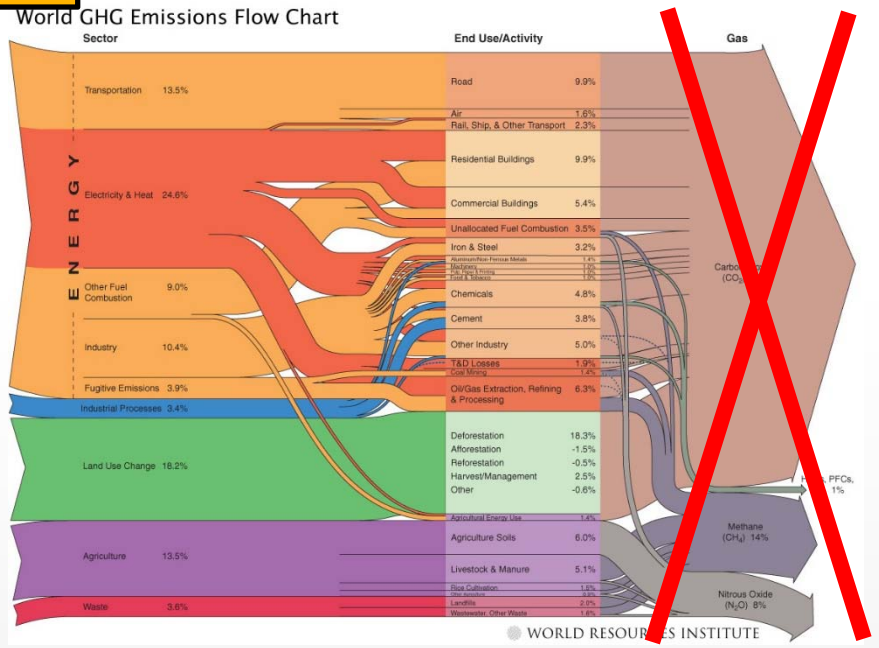
Why we are talking about emissions?



Net-zero CO_2 emissions needed by 2050 in order to reach < +2°C target

CO_2 emissions distribution

- Transportation 13.5%
- Electricity & heat 24.6%
- Industry + others 26%
- Land use change 18%
- Agriculture & waste 17%



Renewable, emission free electricity based technology

Fossiiliset CO_2-päästölähteet, 30 suurinta päästökaupassa Suomessa

- Terästeollisuus
- Öljyjalostamot
- Voimalaitokset
- Sementtiteollisuus
- Paperiteollisuus

Yritysten päästöjen muutos 2014-2018

Hiilidioksidia tonneissa

	Yritys	2014	2018
1	SSAB Europe	3 851 105	4 102 455
2	Helen	3 157 019	3 287 734
3	Neste	3 090 764	2 910 996
4	Fortum Power and Heat	2 123 629	1 482 492
5	Finnsementti	717 060	891 409
6	Turun Seudun Energiantuotanto	1 316 455	812 737
7	Vaskiluodon Voima	1 261 276	731 146
8	Outokumpu Stainless	697 749	705 234
9	Alholmens Kraft	688 131	657 861
10	Seinäjoen Voima	-	624 945

+ Show 5 more

Lähde: Energiavirasto

Ei mukana:
Finnair 3 200 000

Päästökaupan 30 suurinta Suomesta 2018

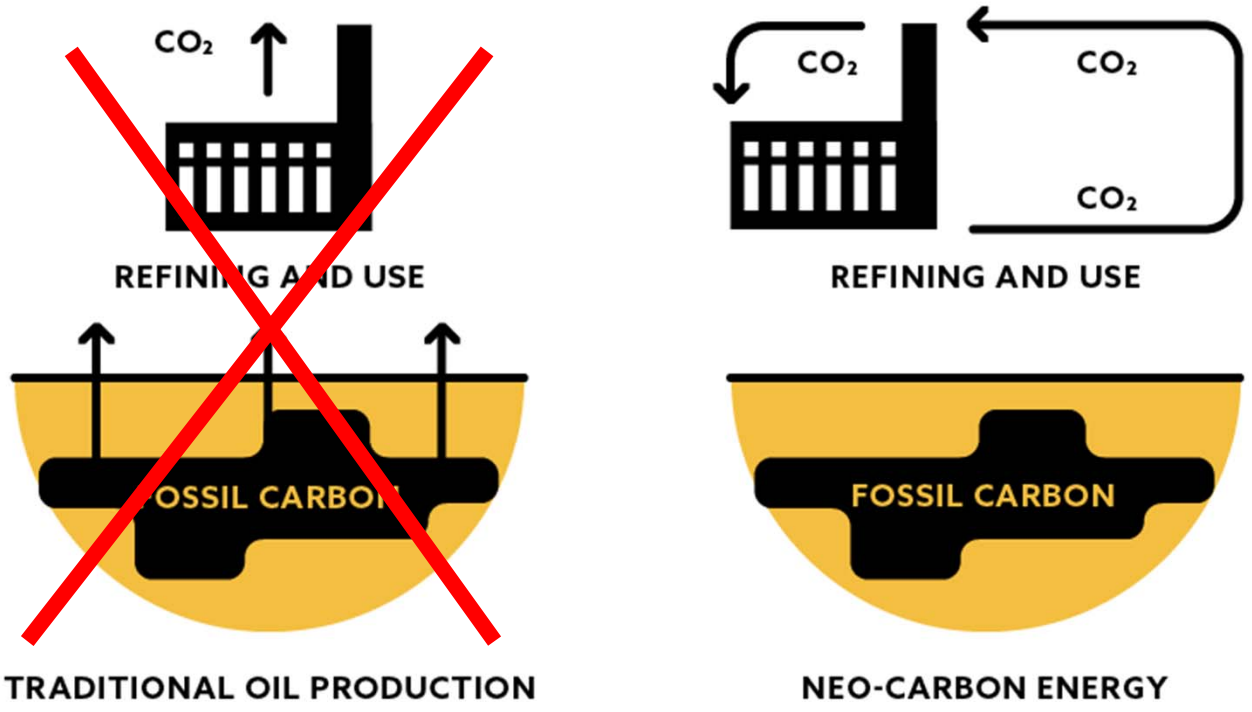
Laitoksen todennetut hiilidioksidipäästöt tonneissa

Laitos	päästöt
Raahen terästehdas	4 025 353
Porvoon jalostamo	2 709 561
Hanasaari B - voimalaitos	1 270 179
Salmisaaren B - voimalaitos	864 730
Vuosaaren B-voimalaitos	839 447
Naantalin voimalaitos	812 737
Suomenojan voimalaitos	765 650
Vaskiluoto 2 - voimalaitos	731 146
Outokumpu Tornion tehtaat	705 234
Pietarsaaren voimalaitos	657 861
Seinäjoen voimalaitos	624 945
Borealis Polymers :n tuotantolaitokset	548 245
Paraisten sementtitehdas	542 210
Meri-Porin voimalaitos	525 673
Toppilan voimalaitokset	483 023
Martinlaakson voimalaitos	457 972
Kymijärven voimalaitos	457 796
Lappeenrannan sementtitehdas	349 199
Keljonlahden voimalaitos	344 633
Tornion voimalaitos	329 615
Kilpilahden vetylaitos	264 230
Naistenlahden voimalaitos	260 667
Kirkniemen paperitehdas	260 607
Stora Enso Oulu	260 351
Haapaniemen voimalaitos	247 919
Stora Enso Veitsiluoto	240 315
Kotkan tehtaat	237 768
Naantalin jalostamo	201 435
Imatran tehtaat	199 593
Vuosaaren A-voimalaitos	197 447

Lähde: Energiavirasto

NEO CARBON ENERGY

No new CO_2 emissions – switching to a circular carbon economy



Renewable electricity-based hydrogen as an energy carrier and industrial feedstock

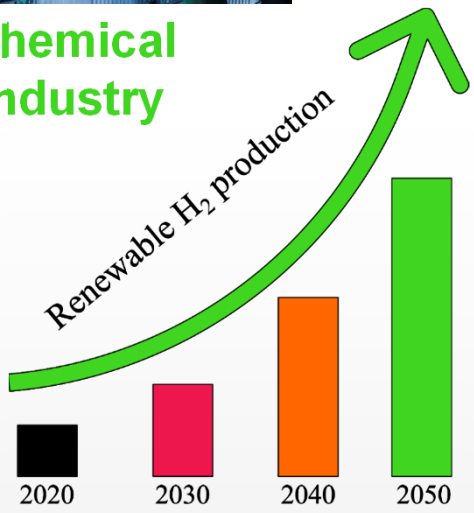
Transportation

Synthetic fuels

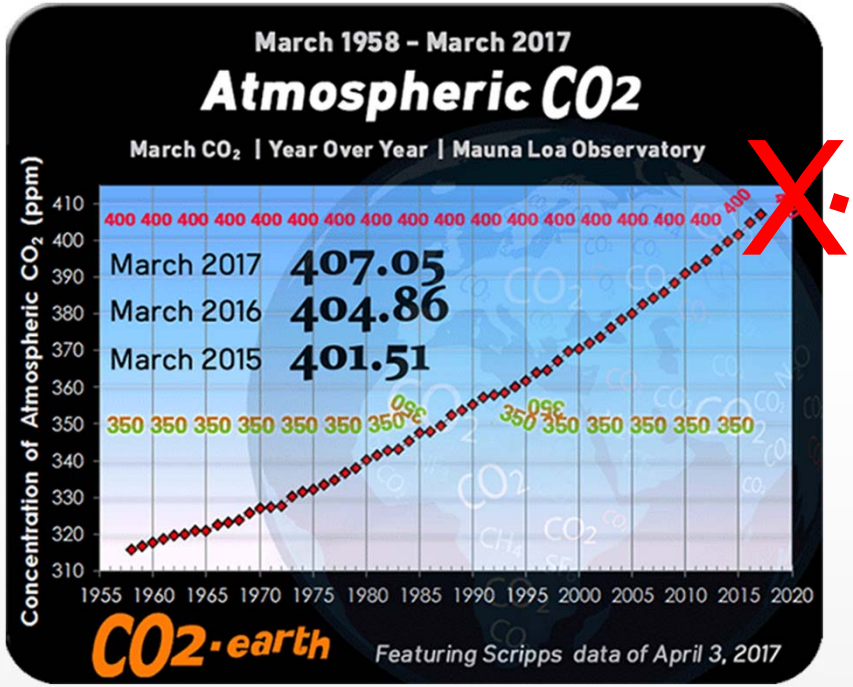
Seasonal energy storage

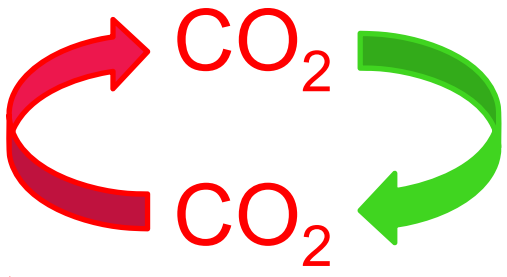
Steelmaking industry

Chemical Industry



CO_2 direct capture

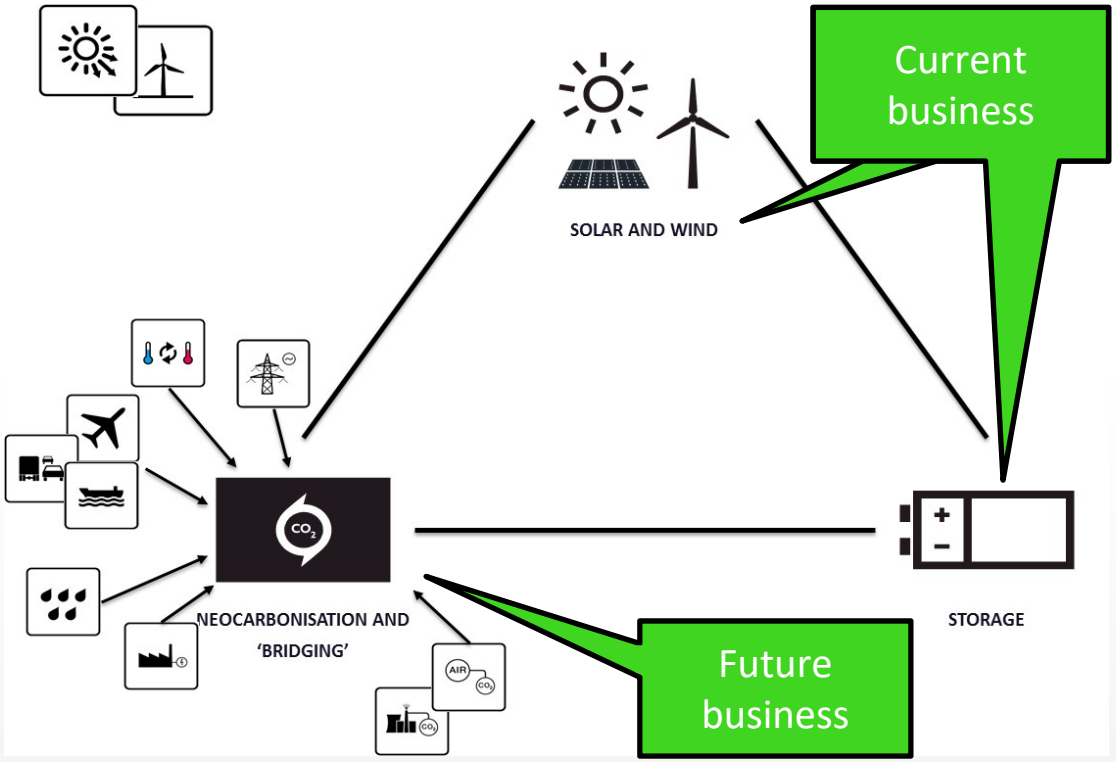




1. **Direct air capture**
2. **Direct sea water capture**
3. Pipe sources from biomass

2050

CO_2 circulation and end products as a future business



Solar PV electricity is cheapest almost everywhere in the world

Utility-scale PV LCOE (€/MWh) based on average 1Q2019/Y2030/Y2050 CAPEX

Yield 2018/2030 (h)	
Helsinki	1000/1070
München	1160/1270
Toulouse	1330/1430
Malaga	1750/1890
India	1770/1910
Texas	1840/1990
Australia	1910/2070
South Africa	2050/2210
Chile	2530/2720

Applied to all locations:	
CAPEX 2019/2030/2050	480/280/190 €/kW$_p$ (base case 50 MWp)
OPEX 2019/2030/2050	8/6/4 €/kW$_p$/a (base case 50 MW$_p$)
Discount factor	6%
Inflation	2,0%
Lifetime	30 years
Initial degradation	2,0%
Continued degradation	0,5%/a

Source: ETIP PV, Fortum Solar Technology Team

LCOE with 6% nominal WACC; w/o taxes in 2018 real €/MWh

How Bill Gates aims to clean up the planet

▲ An artists impression of what Carbon Engineering's ambitious direct air capture project would look like when completed. Photograph: Carbon Engineering

It's a simple idea: strip CO2 from the air and use it to produce carbon-neutral fuel. But can it work on an industrial scale?

It's nothing much to look at, but the tangle of pipes, pumps, tanks, reactors, chimneys and ducts on a messy industrial estate outside the logging town of Squamish in western Canada could just provide the fix to stop the world tipping into runaway climate change and substitute dwindling supplies of conventional fuel.

ENERGIA | Tuula Laatikainen 12.4. klo 14:47

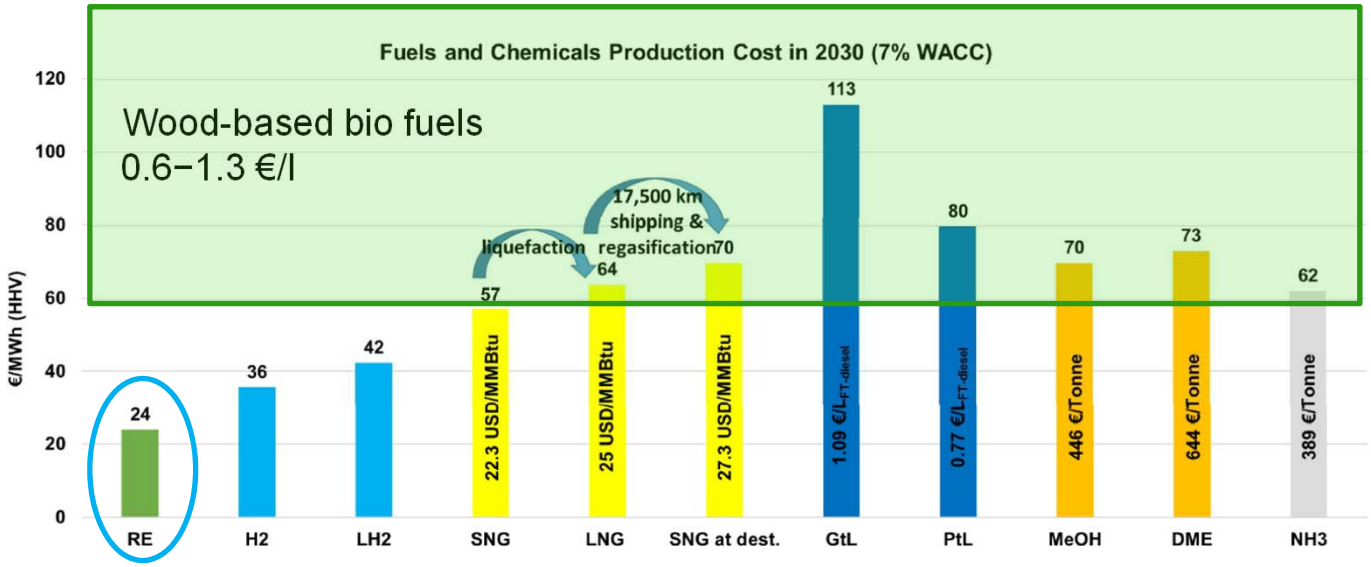
Shell aikoo maailman suurimmaksi sähköyhtiöksi - synteettisten polttoaineiden tuotanto kiinnostaa

JAA ARTIKKELI

Öljy-yhtiönä tunnettu Shell visioi kasvavansa maailman suurimmaksi sähköyhtiöksi 2030-luvulle mennessä. Se tavoittelee erityisesti uusiutuvan sähköntuotannon omistajaksi.

Tavoitteeseen päästäkseen yhtiön on tosin hankittava vuosittain omistukseen valtavia määriä uusiutuvaa sähköntuotantoa tavalla tai toisella. Vuosittain Shellin pitäisi kasvattaa sähköntuotantoaan arviolta runsaat 200 terawattituntia pitääkseen kiinni linjauksestaan.

Synthetic electric fuels are coming – bio-based fuels are not enough

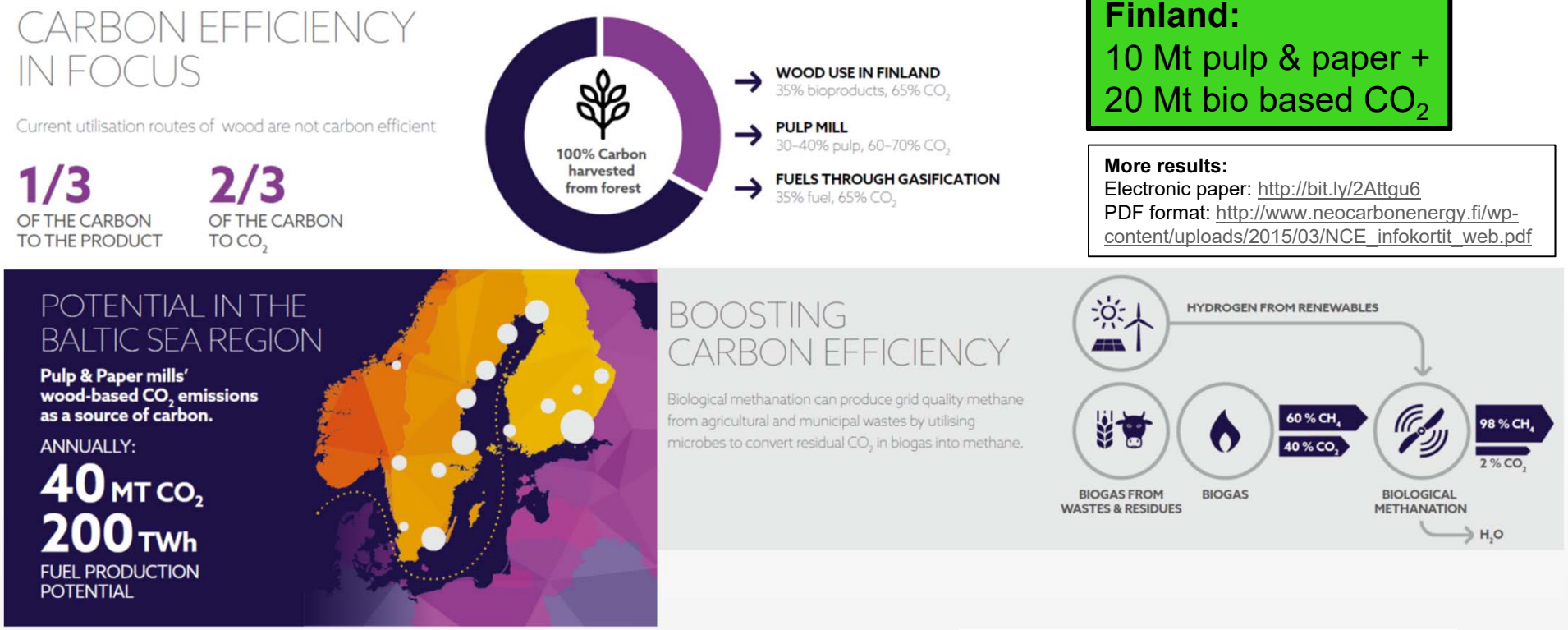


- SNG and PtG-GtL are the cheapest and the most expensive synthetic fuel, respectively.
- the production cost of RE-diesel, RE-methanol and RE-DME are close to each other, however the fuel-parity (cost competitiveness) depends on their respective market price and CO_2 emission cost.

Synthetic price is decreasing:

a) Solar PV is getting cheaper
b) Technology is developing

Potential of bio-based CO_2 utilization



Finland:
10 Mt pulp & paper +
20 Mt bio based CO_2

More results:
Electronic paper: http://bit.ly/2Attgu6
PDF format: http://www.neocarbonenergy.fi/wp-content/uploads/2015/03/NCE_infokortit_web.pdf

www.soletair.fi

VTT

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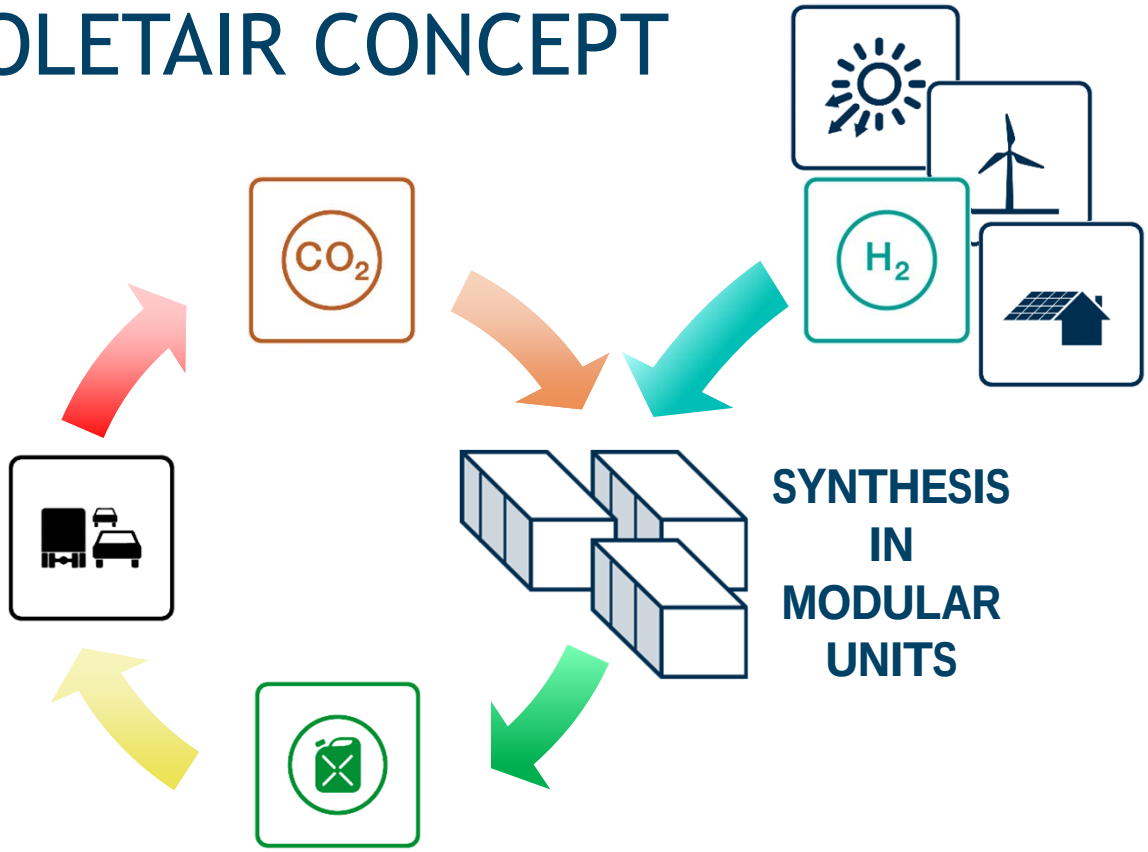
100% sustainable future available:
SOLETAIR

SOLETAIR CONCEPT



7 KEYWORDS

CO_2 UTILIZATION

CLOSED CO_2 CYCLE

SURPLUS ELECTRICITY UTILIZATION

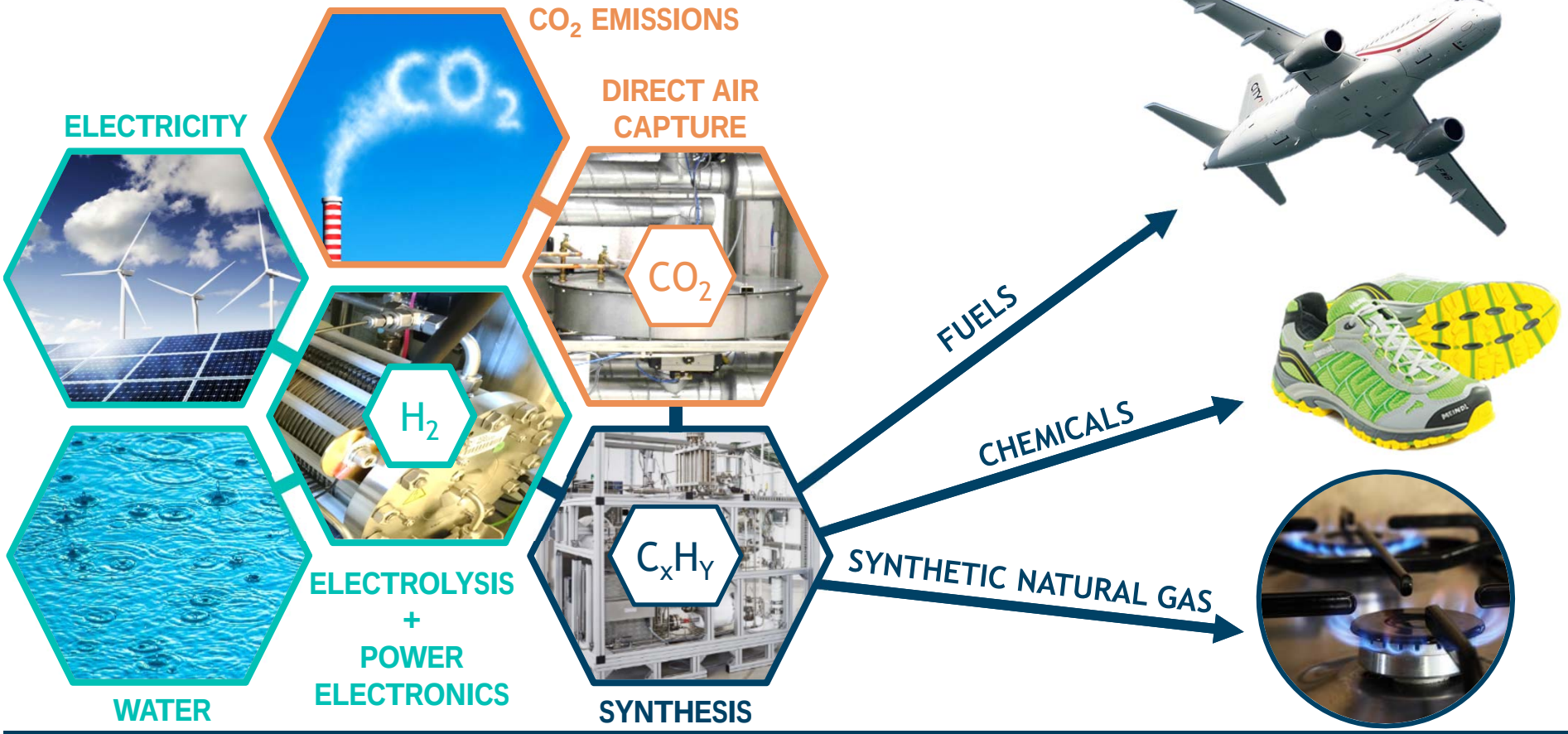
DECENTRALIZED PRODUCTION

MODULAR UNITS

PROCESS INTENSIFICATION

SUSTAINABLE PRODUCTS

SOLETAIR PROCESS



SOLETAIR PILOT SITE

SOLETAIR SITE WAS OPERATED IN SHOWCASE MODE DURING SUMMER 2017

3. Electricity

SOLAR PV PLANT

1. Air

DAC

2. Water

ELECTROLYSIS

4. H_2 + CO_2

SYNTHESIS

SUPPLEMENTARY GAS

SOLETAIR TIME-LAPSE VIDEO

Processes in operation

SOLAR POWER PLANT

Carport

206.5 kWp

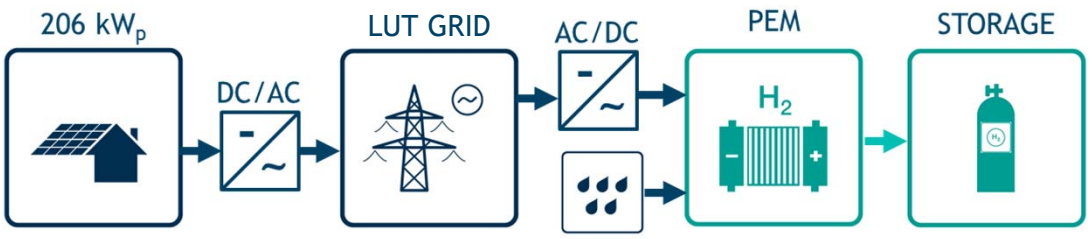
Flat roof

Wall

Tracking

Production figures: www.lut.fi/solar
Real time production: solar.cc.lut.fi

ELECTROLYSIS



4.5 kW PEM water electrolyzer

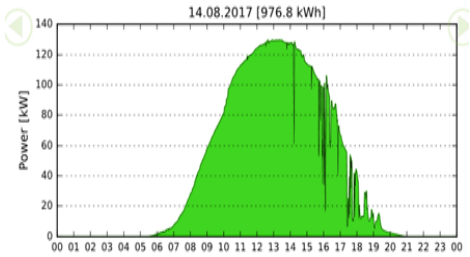
Hydrogen outlet pressure 40 bar

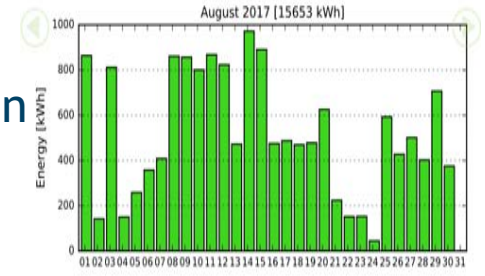
Stack voltage 61 V_{DC}

Stack current 70 A_{DC}

Stack specific energy consumption 4.4 kWh/Nm^3 (48.8 kWh/kg)

363 total operational hours

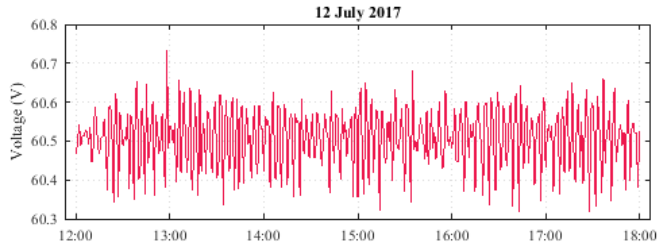


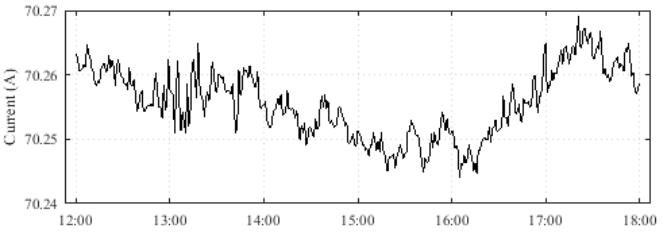


OPERATION STABILITY

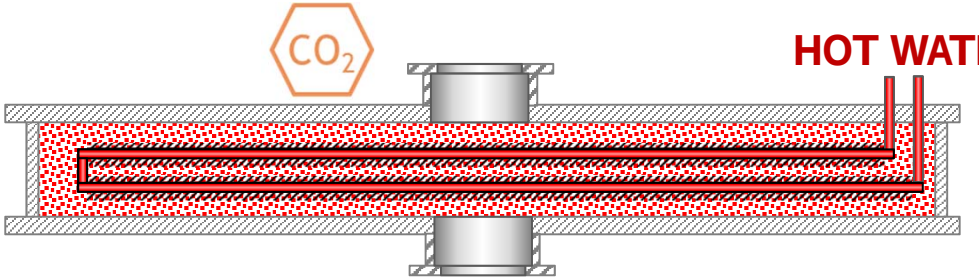
Constant load during each test week.

- Stable production rate
- Stable energy consumption



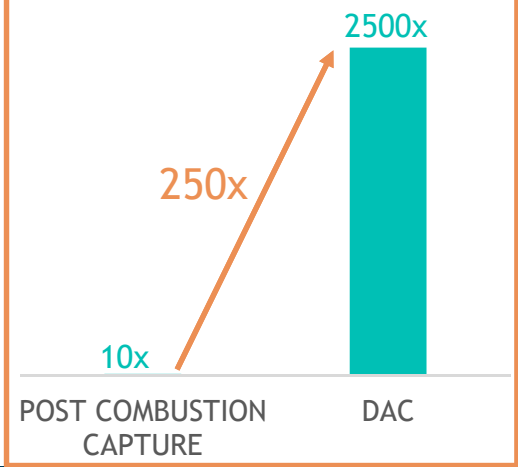


DIRECT AIR CAPTURE

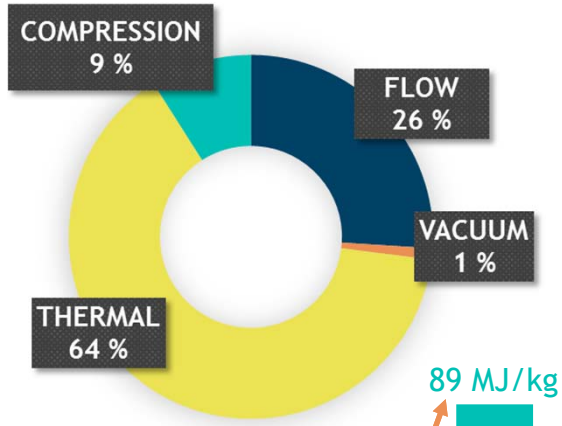


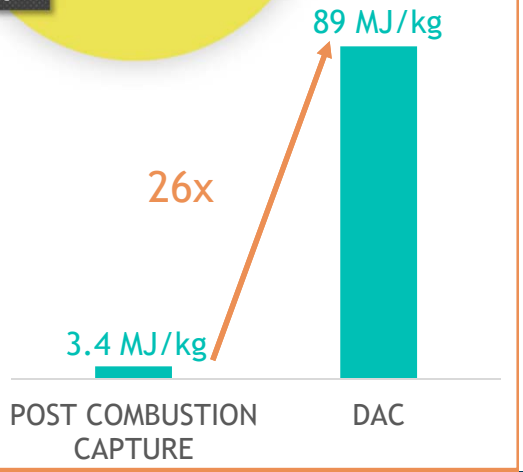
- Amine-based adsorber
- Adsorption and desorption phases
- Gas stored in 5–5.7 bar(g) bundles
- 312 total operational hours
- CO_2 concentration 97 – 99%

CO_2 CONCENTRATION CAPABILITY

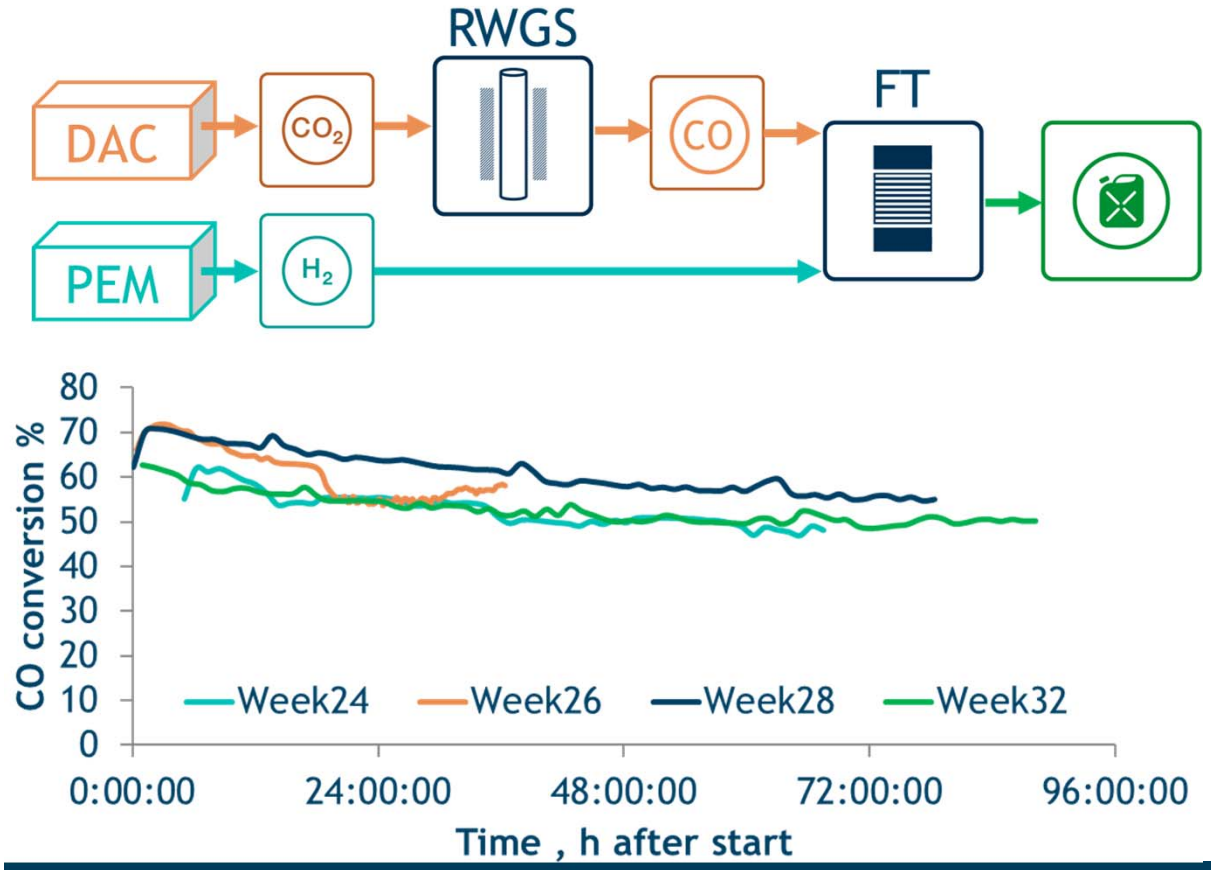


ENERGY REQUIREMENT: 89 MJ/kg





MOBILE SYNTHESIS UNIT



OPERATION FACTS

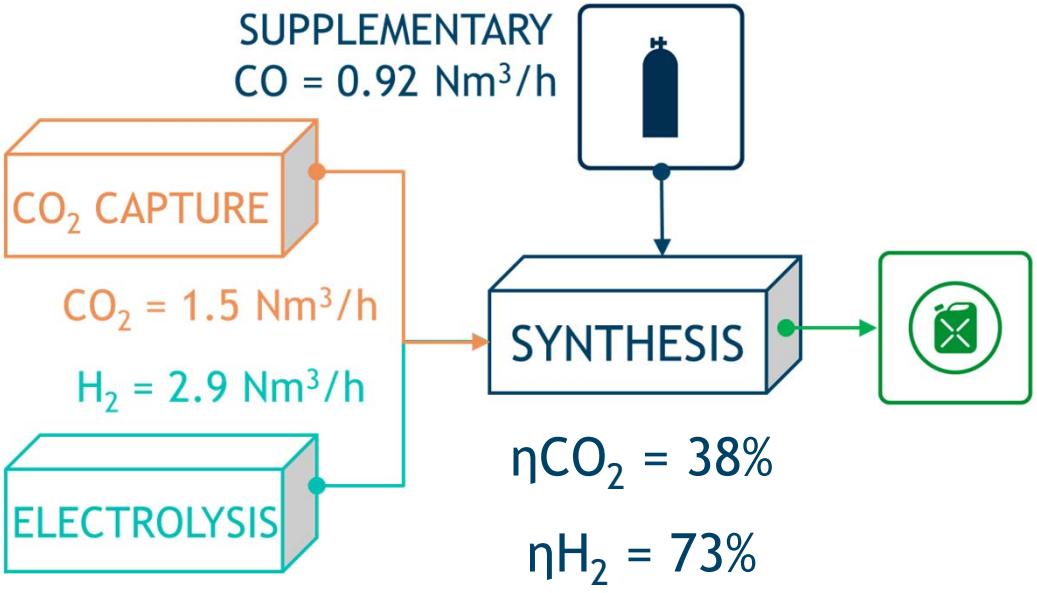
Catalytic reverse-water-gas-shift (RWGS) reactor:
800 °C and 4 bar(a)
0.7 ln/min CO_2 feed

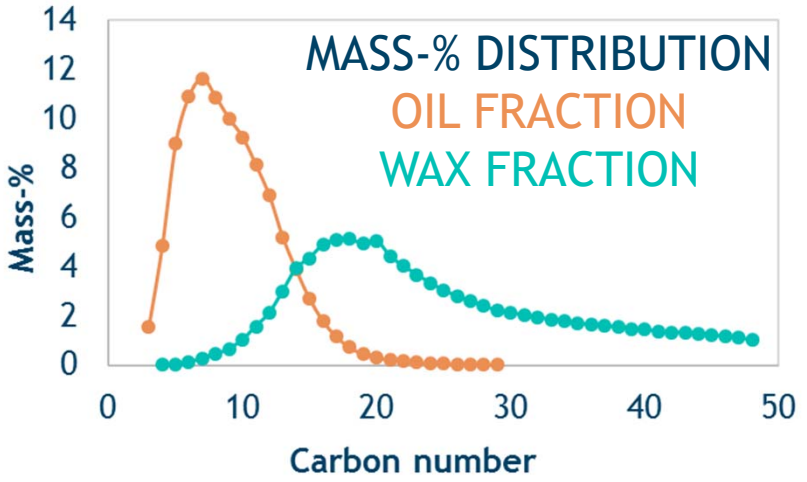
Fischer-Tropsch reactor with Co catalyst:
230 °C and 20 bar(a)
15 ln/min CO feed

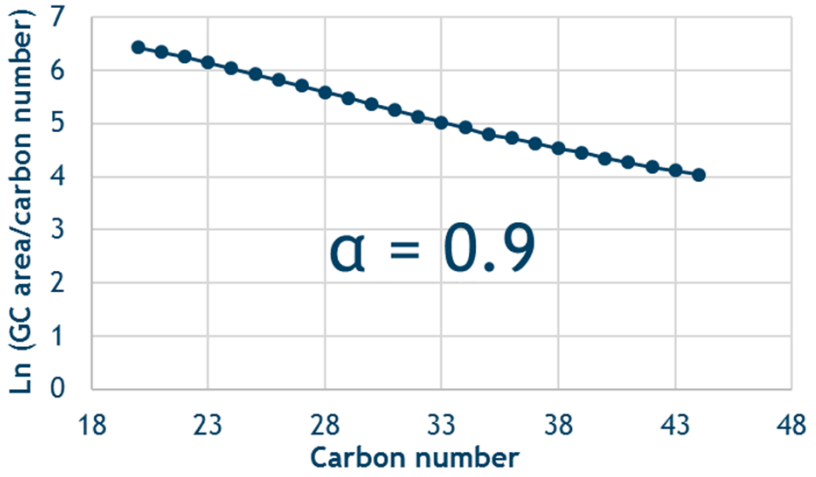
276 total operational hours

100 kg of Fischer-Tropsch products

FINAL PRODUCT







Fischer-Tropsch products total
100 kg during test campaigns

SOLETAIR LAUNCH ON 14.6.2017

SOLETAIR END PRODUCTS

Oil-fraction

Wax

Water from air

Candle from wax

Site: www.soletair.fi, so far at least 35 Finnish media hits and more than 100 international media hits.

Discussions: *Breakthrough Energy Ventures*, *Impossible Labs*, *Suez*, *Shell*, *Andes Mining & Energy Corporate S.A.*, *Nordic Blue Crude AS*, *other smaller*.

SOLETAIR TEAM

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More about the project:

www.soletair.fi

Pictures and videos:
https://lut.pictures.fi/kuvat/LUT+Press+Images/Soletair/
https://lut.pictures.fi/kuvat/LUT+Press+Images/Neo-Carbon+Energy/

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