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17 October 2024

Competence in the transition of process industry

IKP 75-year Jubilee Seminar

The Department of Chemical Engineering

NTNU

Eivind Berstad, Team Lead Carbon Capture and Storage, The Bellona Foundation

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From process operator to MSc Chemical Engineering to Environmental NGO

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Focus areas:

- Environmental protection
- Maritime
- Carbon capture and storage
- Ocean
- Bio economy
- Internation cooperation

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Green transition of process industry

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CCS

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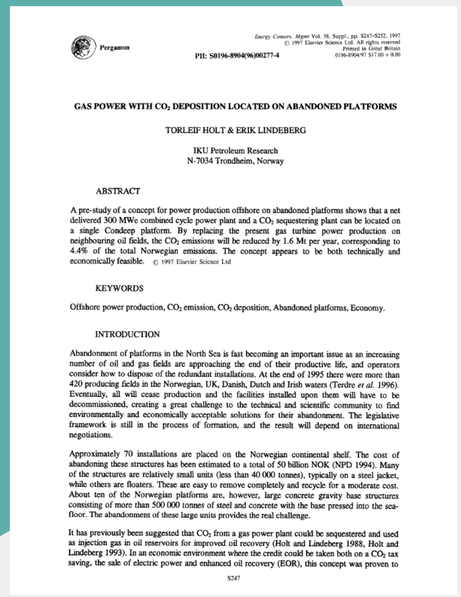

Pergamon

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GAS POWER WITH CO_2 DEPOSITION LOCATED ON ABANDONED PLATFORMS

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ABSTRACT

A pre-study of a concept for power production offshore on abandoned platforms shows that a net delivered 300 MWe combined cycle power plant and a CO_2 sequestering plant can be located on a single Condeep platform. By replacing the present gas turbine power production on neighbouring oil fields, the CO_2 emissions will be reduced by 1.6 Mt per year, corresponding to 4.4% of the total Norwegian emissions. The concept appears to be both technically and economically feasible. © 1997 Elsevier Science Ltd

KEYWORDS

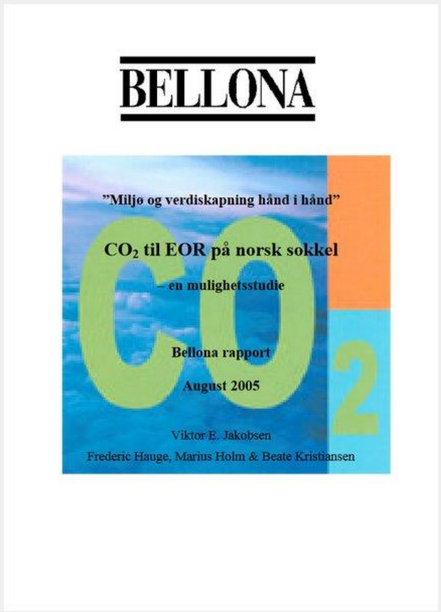
Offshore power production, CO_2 emission, CO_2 deposition, Abandoned platforms, Economy.

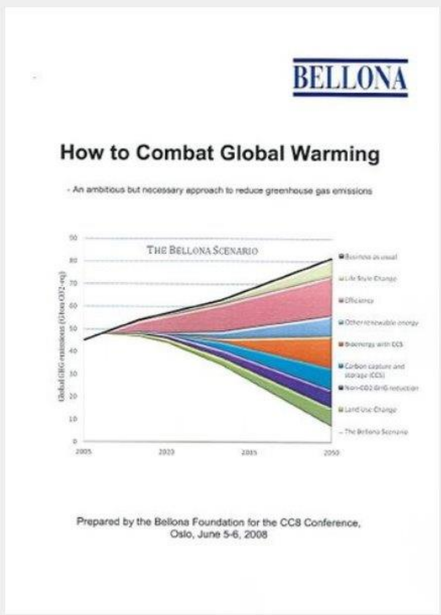
INTRODUCTION

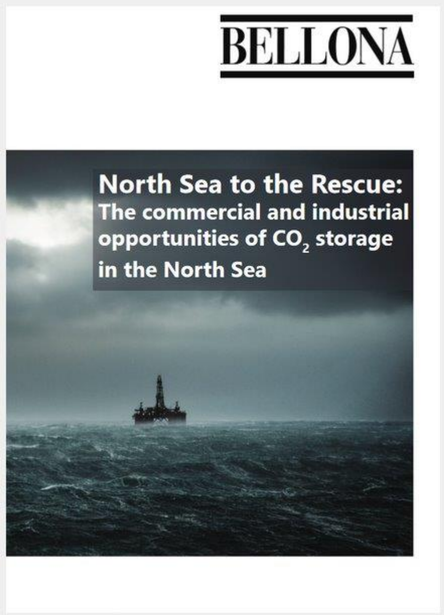
Abandonment of platforms in the North Sea is fast becoming an important issue as an increasing number of oil and gas fields are approaching the end of their productive life, and operators consider how to dispose of the redundant installations. At the end of 1995 there were more than 420 producing fields in the Norwegian, UK, Danish, Dutch and Irish waters (Tendre *et al.* 1996). Eventually, all will cease production and the facilities installed upon them will have to be decommissioned, creating a great challenge to the technical and scientific community to find environmentally and economically acceptable solutions for their abandonment. The legislative framework is still in the process of formation, and the result will depend on international negotiations.

Approximately 70 installations are placed on the Norwegian continental shelf. The cost of abandoning these structures has been estimated to a total of 50 billion NOK (NPD 1994). Many of the structures are relatively small units (less than 40 000 tonnes), typically on a steel jacket, while others are floaters. These are easy to remove completely and recycle for a moderate cost. About ten of the Norwegian platforms are, however, large concrete gravity base structures consisting of more than 500 000 tonnes of steel and concrete with the base pressed into the sea-floor. The abandonment of these large units provides the real challenge.

It has previously been suggested that CO_2 from a gas power plant could be sequestered and used as injection gas in oil reservoirs for improved oil recovery (Holt and Lindeberg 1988, Holt and Lindeberg 1993). In an economic environment where the credit could be taken both on a CO_2 tax saving, the sale of electric power and enhanced oil recovery (EOR), this concept was proven to







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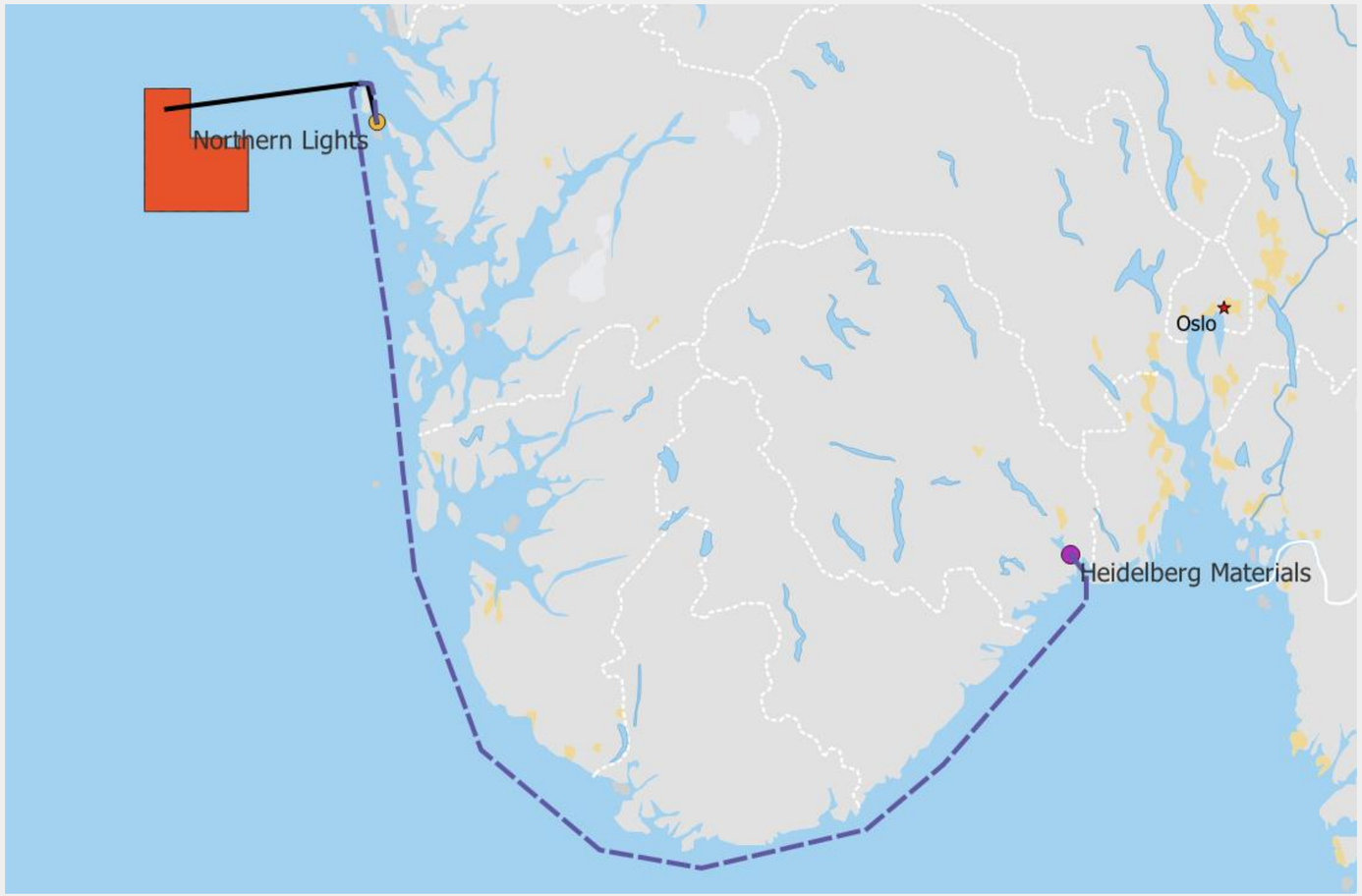
2025



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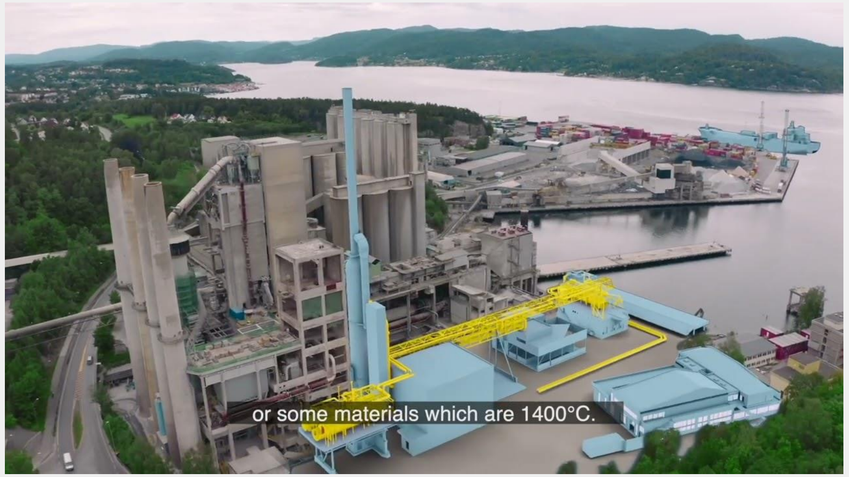
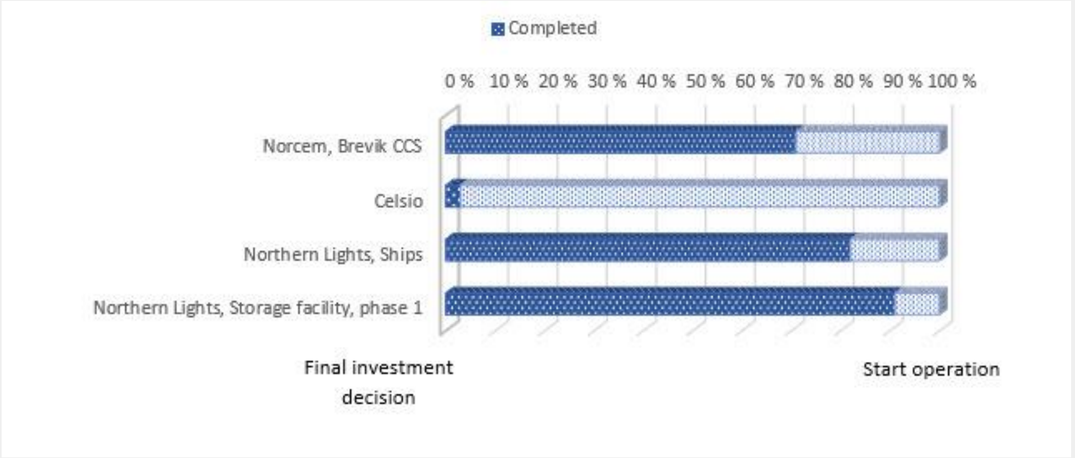
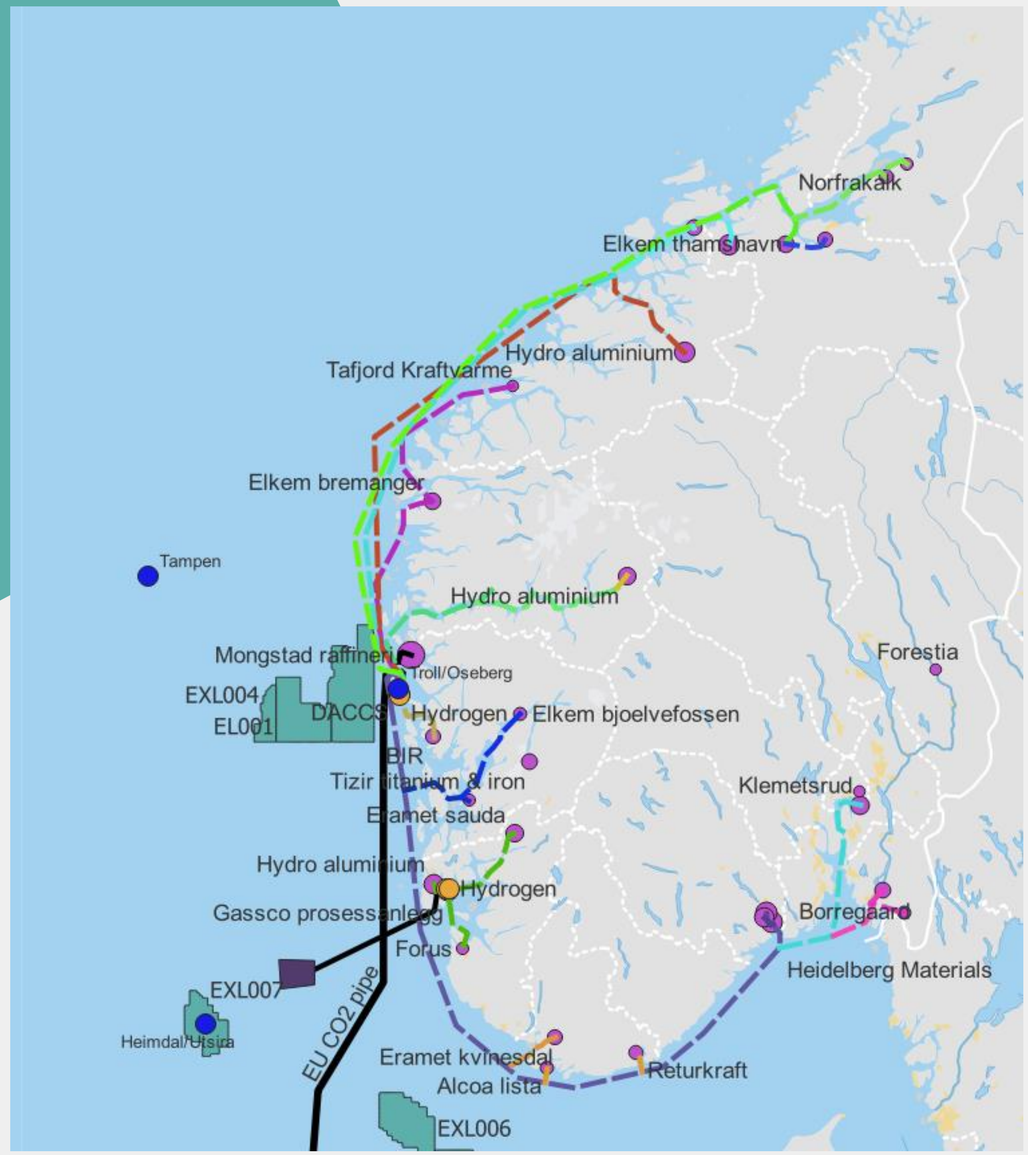
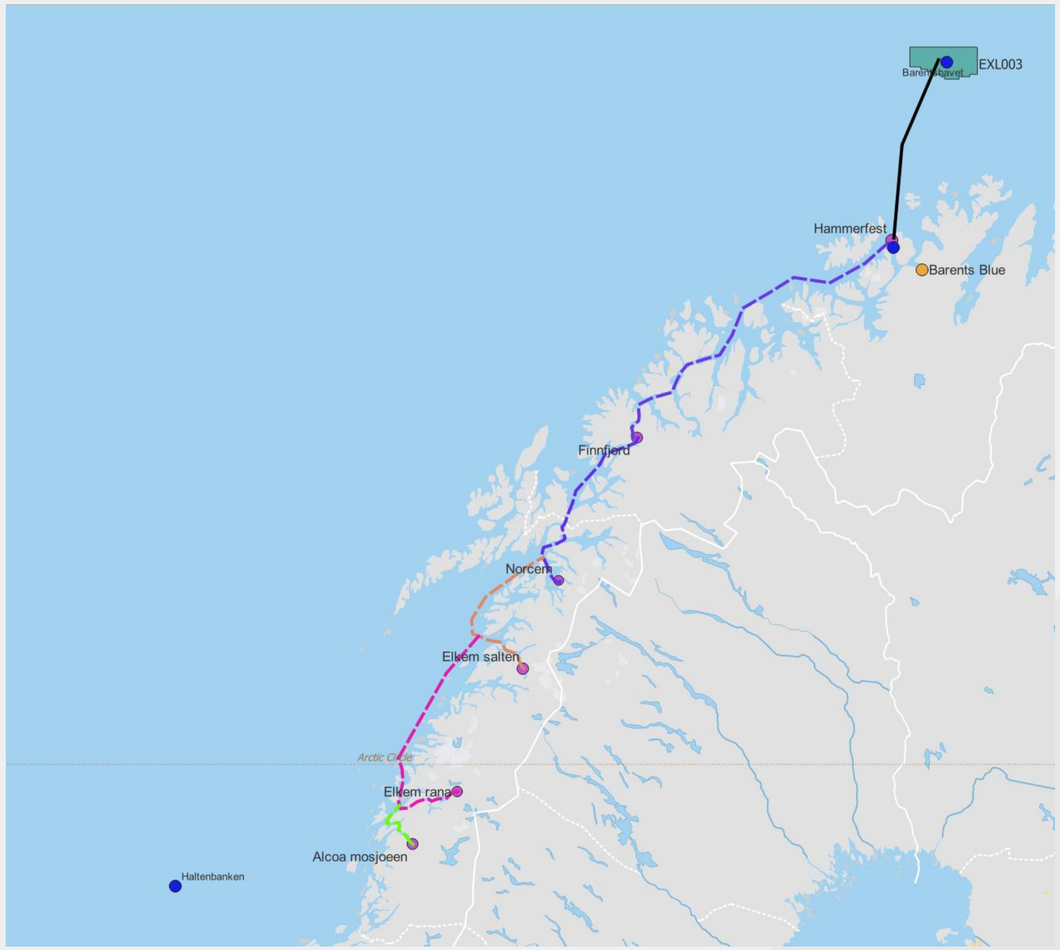

or some materials which are 1400°C.


Completed
0 % 10 % 20 % 30 % 40 % 50 % 60 % 70 % 80 % 90 % 100 %
Norcem, Brevik CCS
Celsio
Northern Lights, Ships
Northern Lights, Storage facility, phase 1
Final investment decision
Start operation

2035?


Norfrakalk
Elkem thamshavn
Hydro aluminium
Tafjord Kraftvarme
Elkem bremanger
Tampen
Hydro aluminium
Mongstad raffineri
Troll/Oseberg
Forestia
EXL004
EL001
DACC3
Hydrogen
Elkem bjoelvefossen
BIR
Tizir titanium & iron
Klemetsrud
Eramet sauda
Hydro aluminium
Hydrogen
Gassco prosessanlegg
Borregaard
Forus
Heidelberg Materials
EXL007
EU CO2 pipe
Heimdal/Utsira
Eramet kvinesdal
Alcoa lista
Returkraft
EXL006


EXL003
Hammerfest
Barents Blue
Finnfjord
Norcem
Elkem salten
Arctic Circle
Elkem rana
Alcoa mosjoen
Haltenbanken

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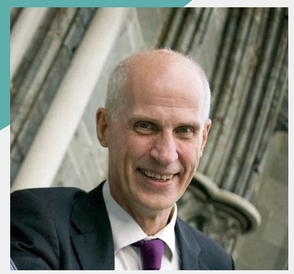

1 036 NOK/tCO_2

In between

3 271 NOK/tCO_2

6 500 NOK/tCO_2

- Given these favorable circumstances, one may ask: If Equinor cannot do CCS for an affordable price on Melkøya, why would anyone else think they can do it?

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Hydrogen

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What is efficient?

What is sexy?

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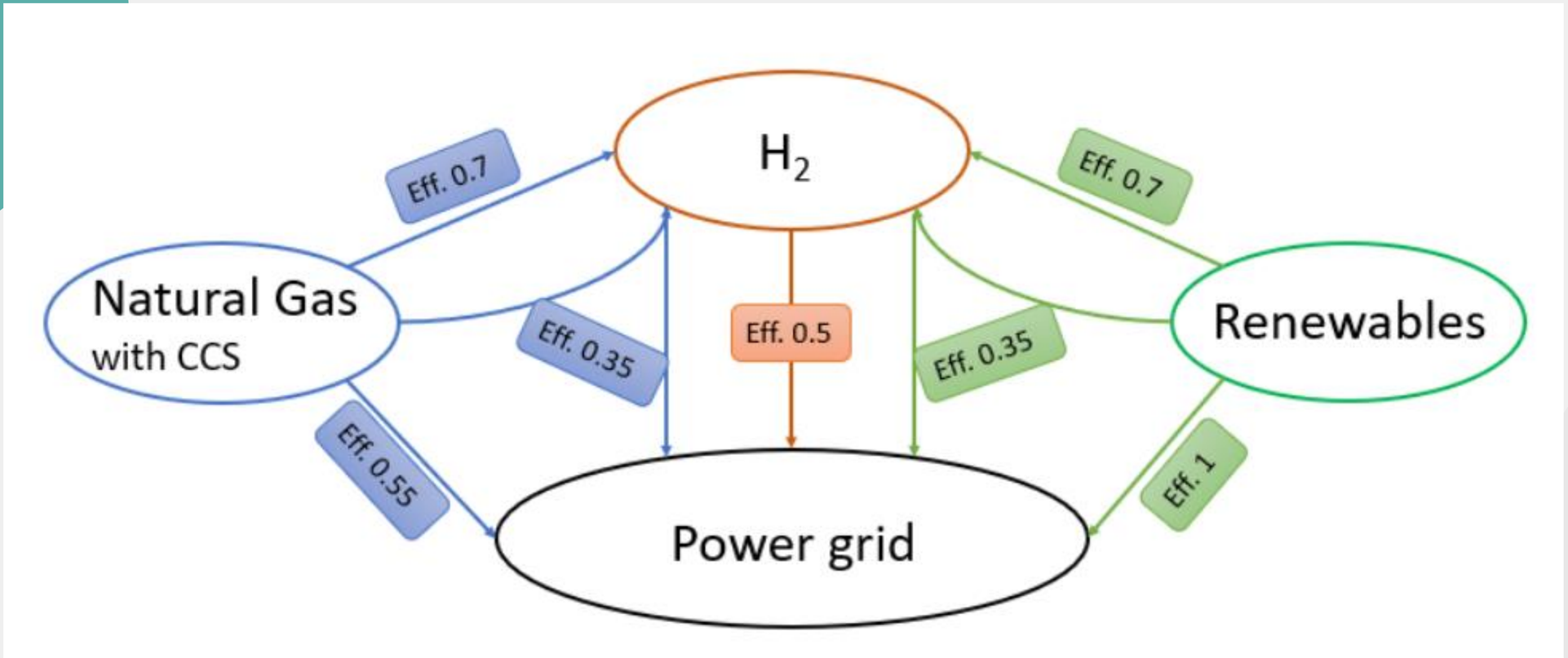
H_2 to power is stupid



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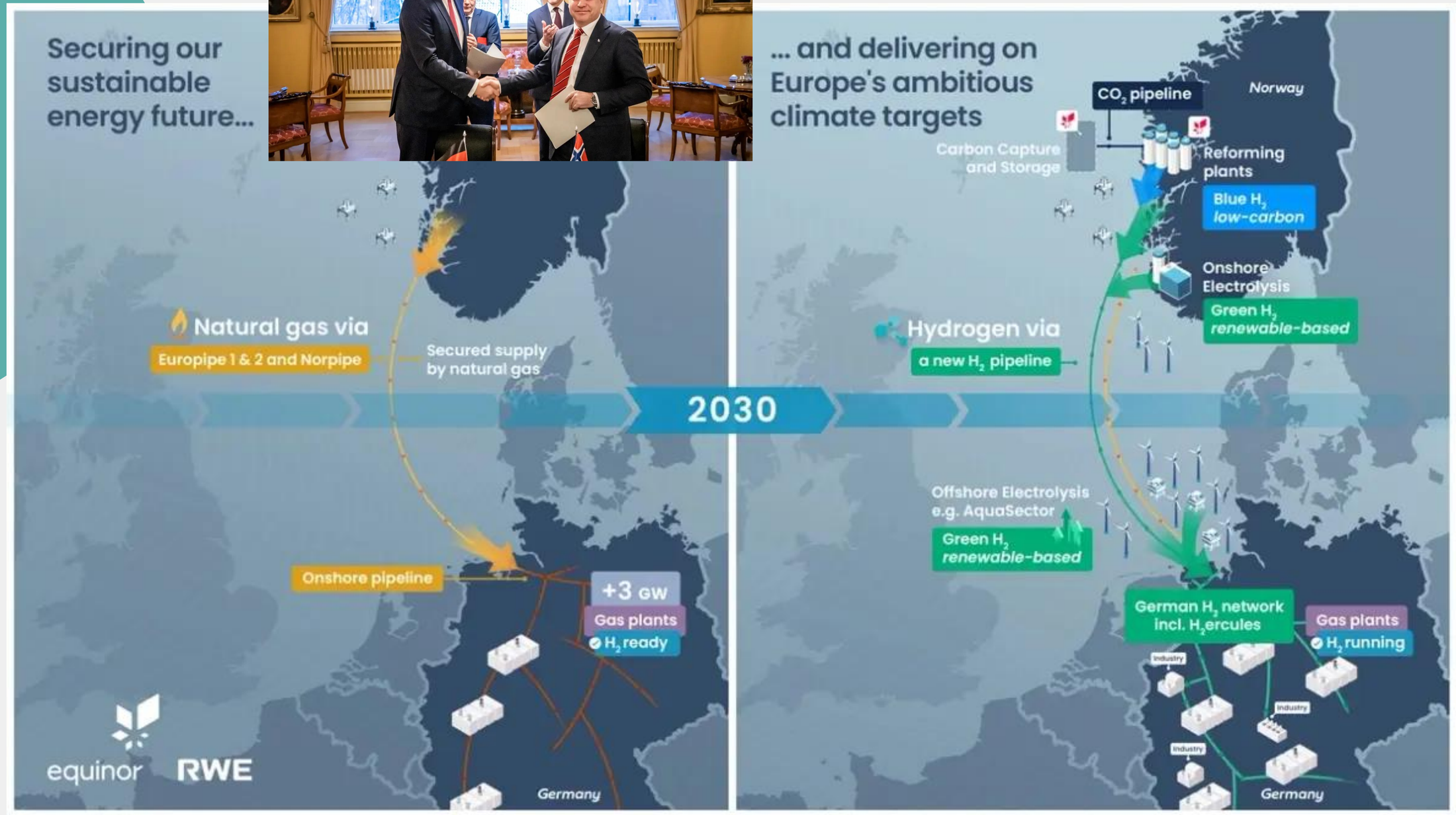
Securing our sustainable energy future...
... and delivering on Europe's ambitious climate targets
CO_2 pipeline
Norway
Carbon Capture and Storage
Reforming plants
Blue H_2 low-carbon
Onshore Electrolysis
Green H_2 renewable-based
Natural gas via
Europipe 1 & 2 and Norpipe
Secured supply by natural gas
Hydrogen via
a new H_2 pipeline
2030
Offshore Electrolysis e.g. AquaSector
Green H_2 renewable-based
Onshore pipeline
+3 GW
Gas plants
H_2 ready
German H_2 network incl. H_2ercules
Gas plants
H_2 running
Industry
Industry
Industry
equinor
RWE
Germany
Germany

Syntethic fuels

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Ceci n'est pas un diesel.*

**This is a car powered by e-diesel, using five times more electricity than an electric car. E-diesel cars keep things as they are, such as the engine, NOx and CO2. E-diesel has many names; electrofuels, CCUF, synthetic fuels, power to fuels, Wunder-Diesel. Natural gas variety also available.*

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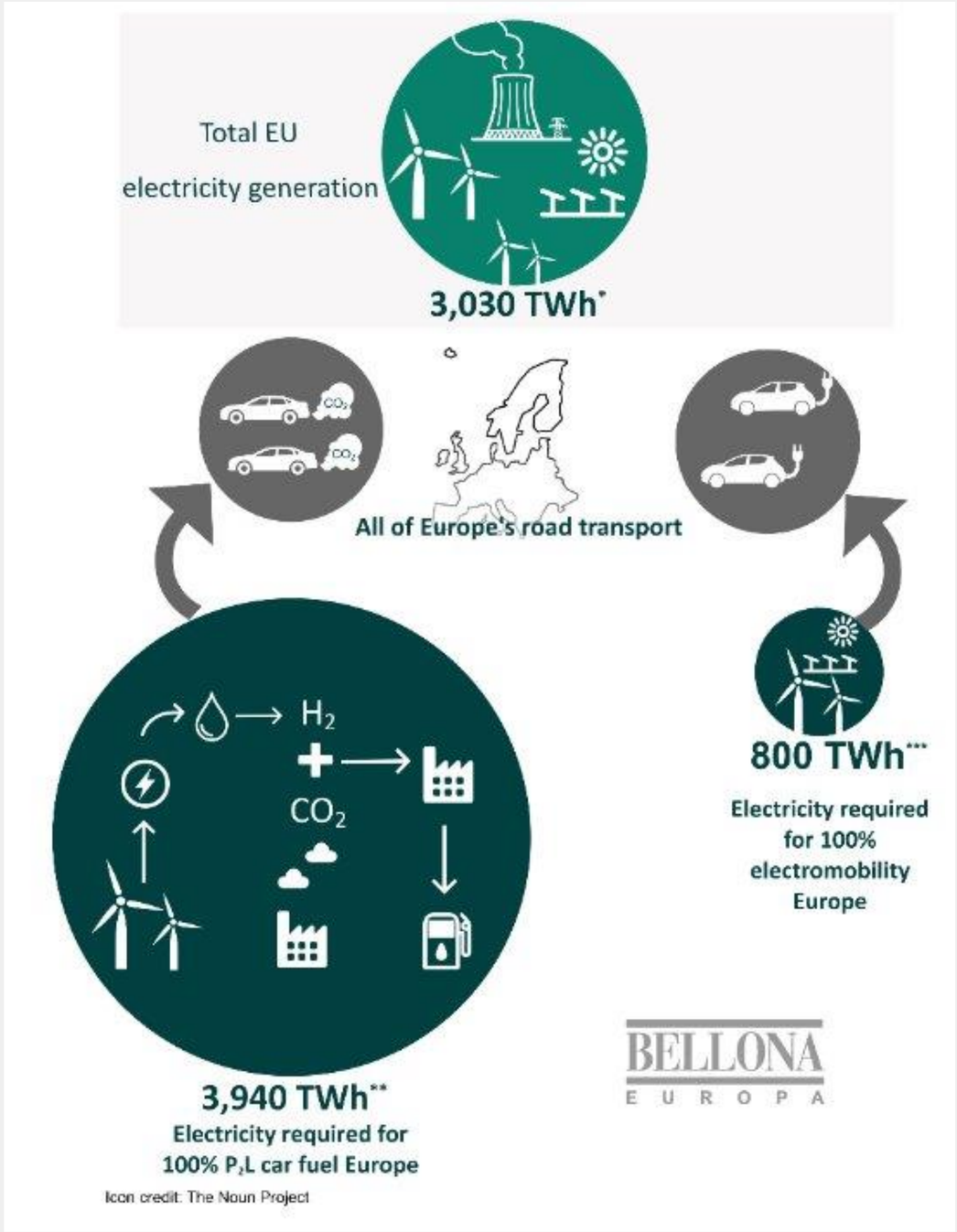
Total EU
electricity generation
3,030 TWh*
All of Europe's road transport
800 TWh***
Electricity required for 100% electromobility Europe
H_2
CO_2
3,940 TWh**
Electricity required for 100% P₂L car fuel Europe
Icon credit: The Noun Project
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EUROPA

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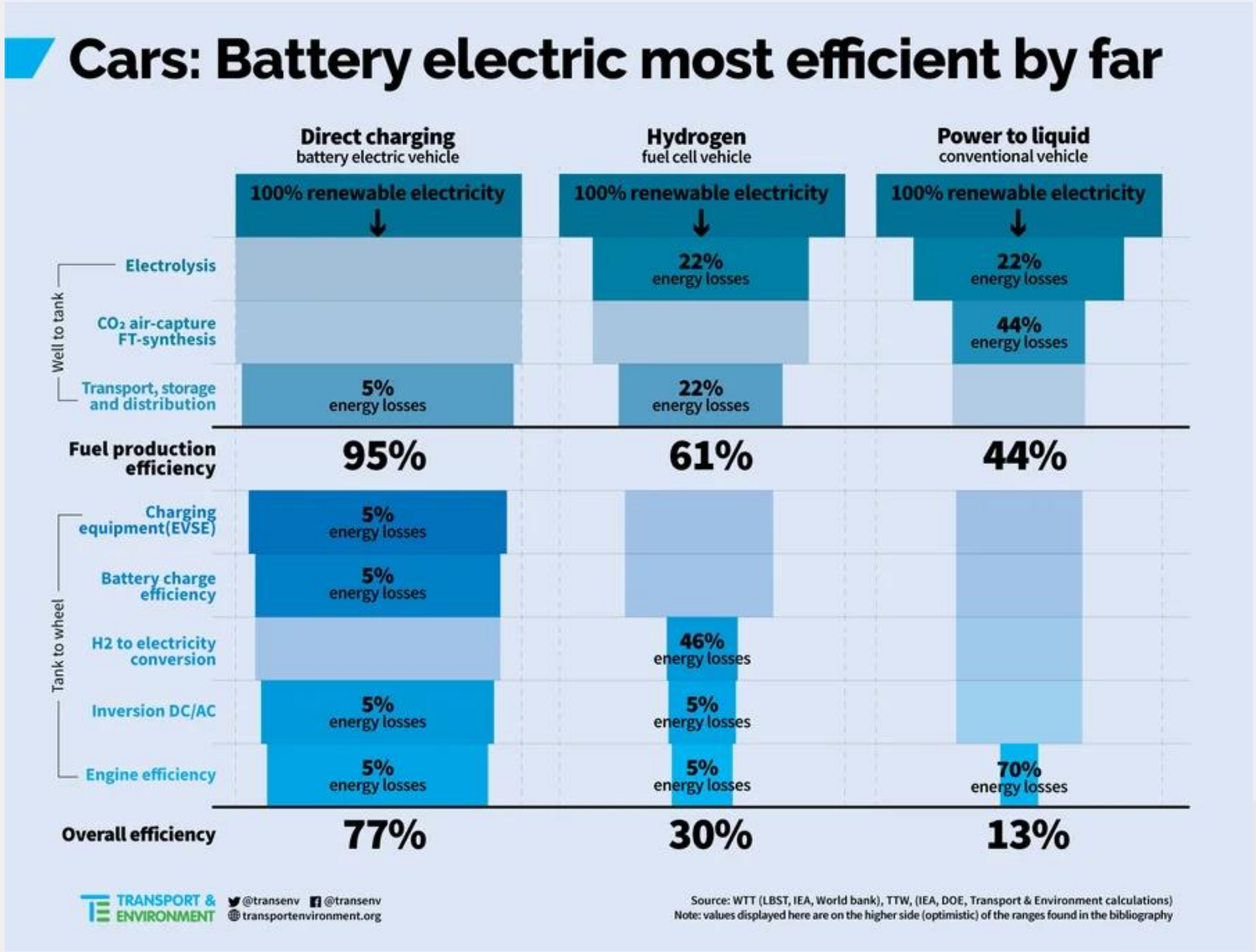
Cars: Battery electric most efficient by far
Direct charging
battery electric vehicle
Hydrogen
fuel cell vehicle
Power to liquid
conventional vehicle
100% renewable electricity
100% renewable electricity
100% renewable electricity
Well to tank
Electrolysis
22%
energy losses
22%
energy losses
CO₂ air-capture
FT-synthesis
44%
energy losses
Transport, storage
and distribution
5%
energy losses
22%
energy losses
Fuel production
efficiency
95%
61%
44%
Tank to wheel
Charging
equipment(EVSE)
5%
energy losses
Battery charge
efficiency
5%
energy losses
H2 to electricity
conversion
46%
energy losses
Inversion DC/AC
5%
energy losses
5%
energy losses
Engine efficiency
5%
energy losses
5%
energy losses
70%
energy losses
Overall efficiency
77%
30%
13%
TRANSPORT &
ENVIRONMENT
@transenv
@transenv
transportenvironment.org
Source: WTT (LBST, IEA, World bank), TTW, (IEA, DOE, Transport & Environment calculations)
Note: values displayed here are on the higher side (optimistic) of the ranges found in the bibliography

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The expert interview: Skeptical of e-fuel

Synthetic fuel made from captured CO_2, hydrogen and electricity can be filled directly into the tanks of planes, cars and boats. Is this the climate solution we have been waiting for? Professor Edd Anders Blekkan at NTNU is not convinced.

Ekspertintervjuet

Edd Anders Blekkan er professor med fagfelt katalyse ved Institutt for kjemisk prosessteknologi, NTNU.

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Thank you!

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