THE ROLE OF CCS IN ENABLING CLEAN HYDROGEN

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1. Security of supply

ENERGY

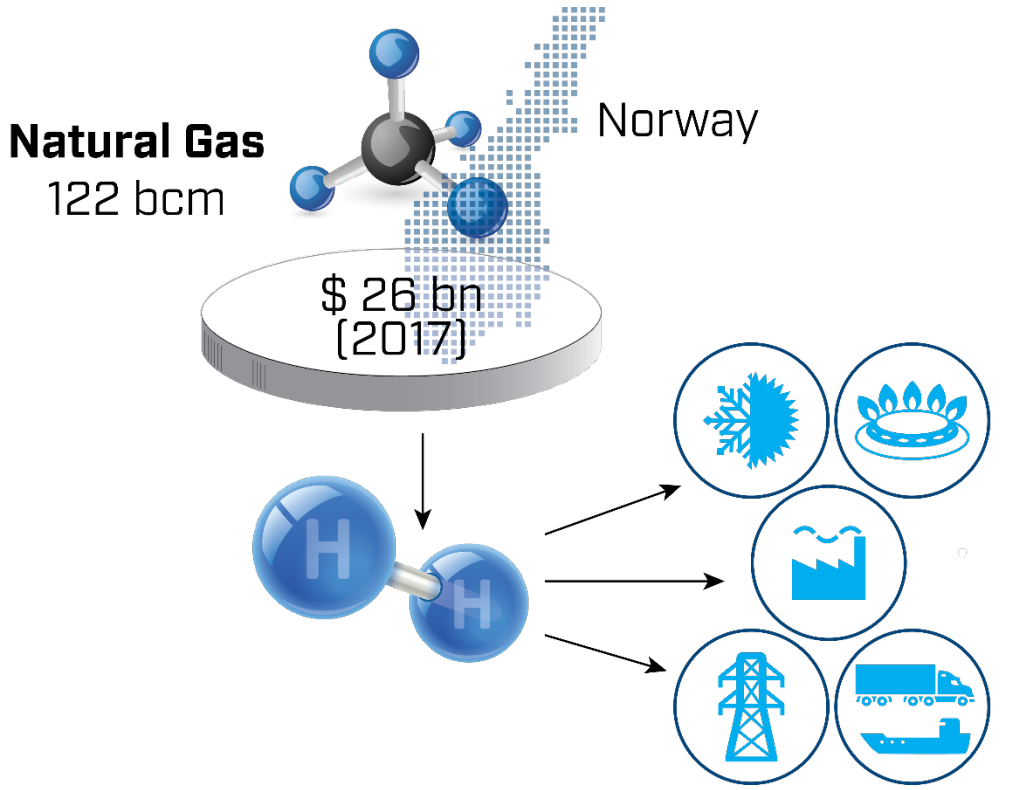
2. Cost

3. Environmental footprint

Where can we use hydrogen?

A true cross sectorial enabler – in hard to decarbonise sectors

- Industry
- Heating/cooling/cooking
- Power- also zero emission backup for intermittent power
- Transportation- land, rail – possibly aviation-hybrid, marine
- Energy storage- on longer timescales



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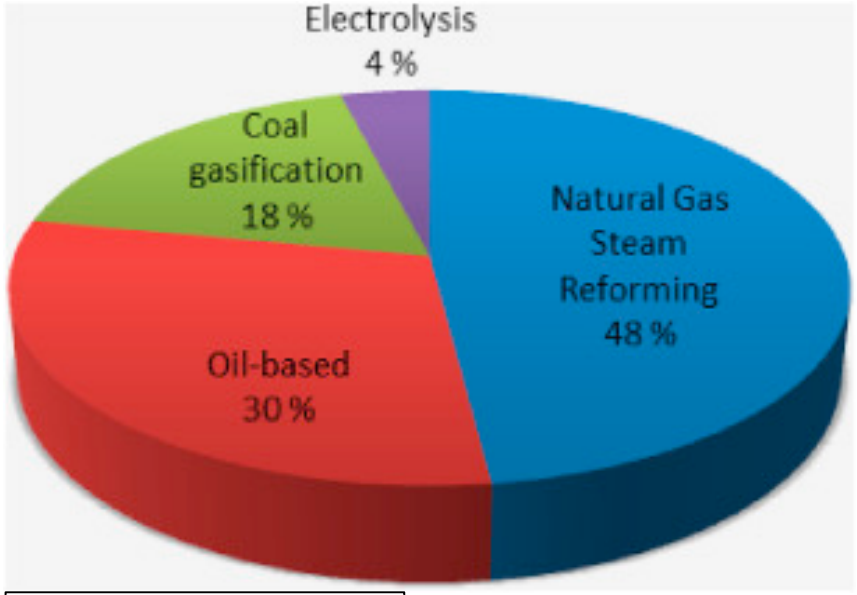
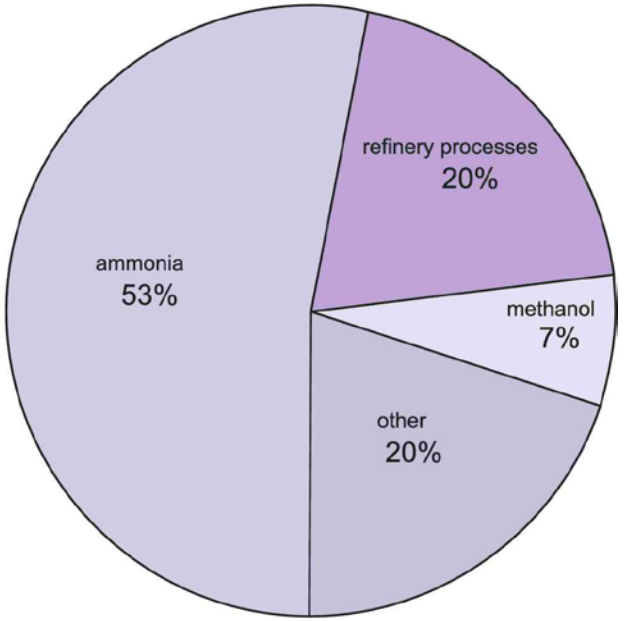
Hydrogen by source and consumption



Source: International Journal of Hydrogen Energy, Voldsund et al.



Source: The essential chamical industry - online

Global annual production: ~65M metric tons / ~2200 TWh

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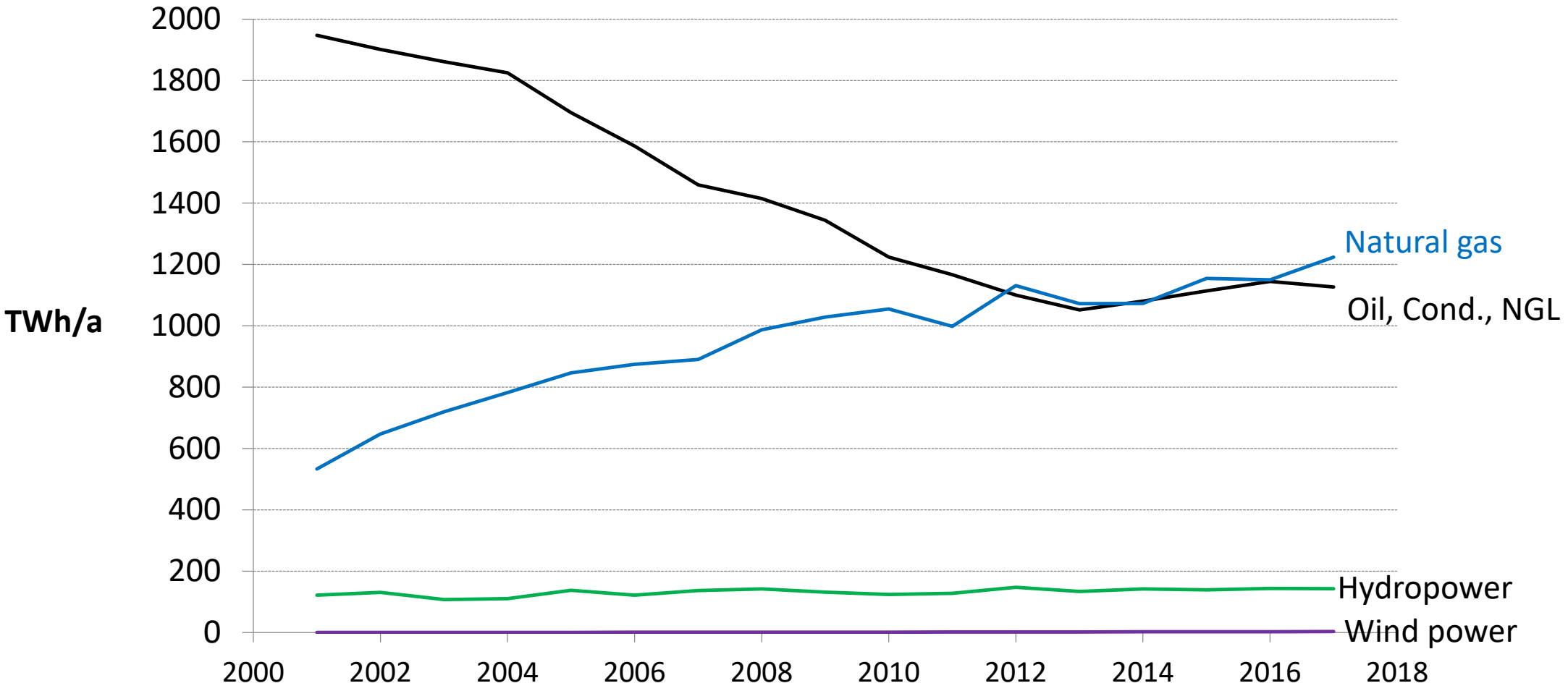
Norway: Renewable power and fossil energy



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A thought example from Norway

Norway's
natural gas production
1400 TWh/a

→ 14% -> 200 TWh/a NG → 137 TWh/a LH_2

↓ 33,8 Mton CO_2/year storage

↓ One 160.000 m^3 ship/day

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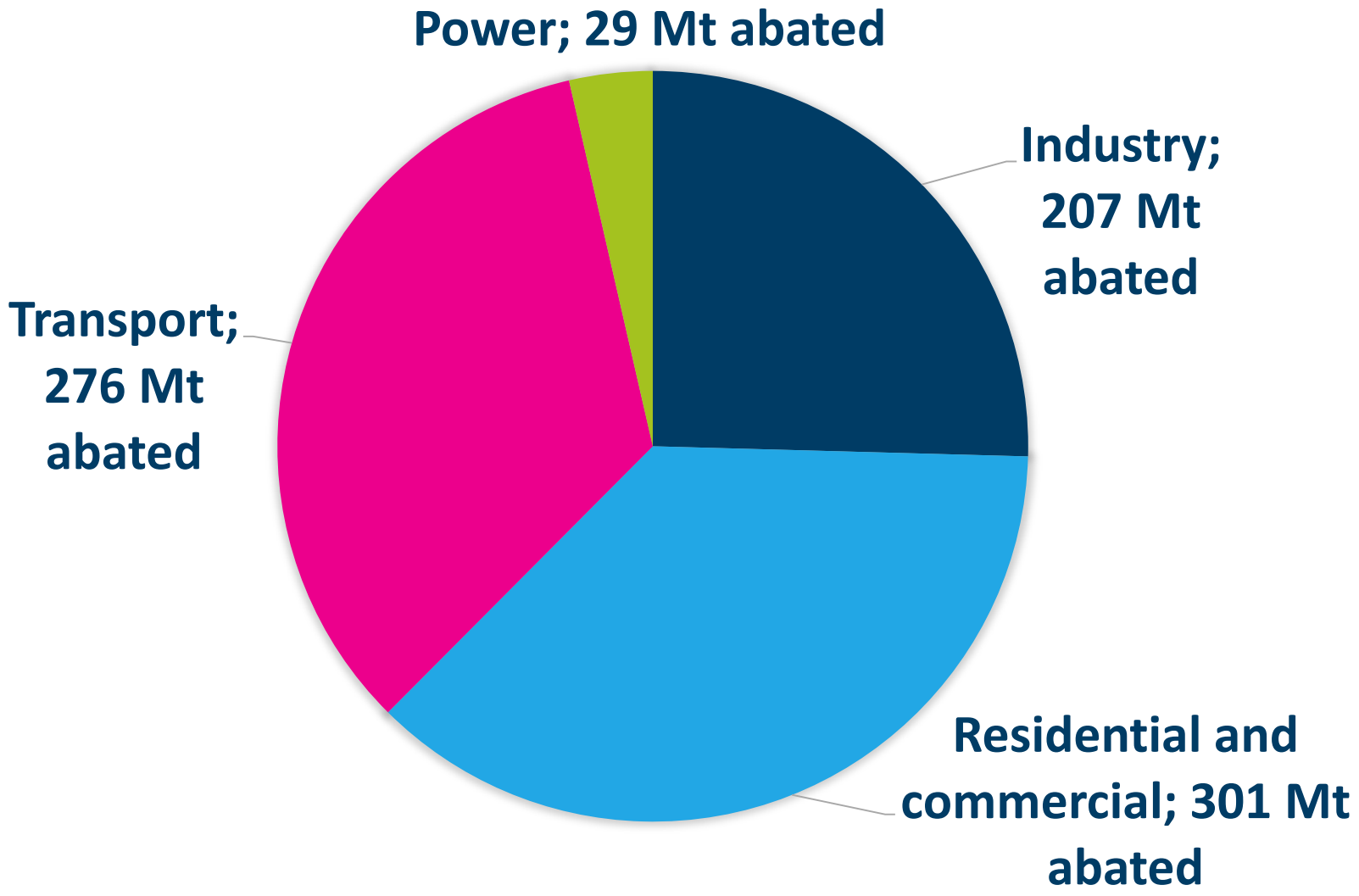
Almost 20% of current European CO_2 emissions can be abated by clean hydrogen in 2050



Key research challanges - for closing the gap

- Reforming and capture with (near) zero emissions
- Gigawatt scale transport and storage of hydrogen:
  - Compressed and liquefied
- Industrial use of hydrogen:
  - As reducing agent
  - For heating
- Whole system perspective:
  - Energy systems and value chains
  - LH_2 – CH_2 – NH_3

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Hydrogen from natural gas with CCS
is an opportunity for Europe.

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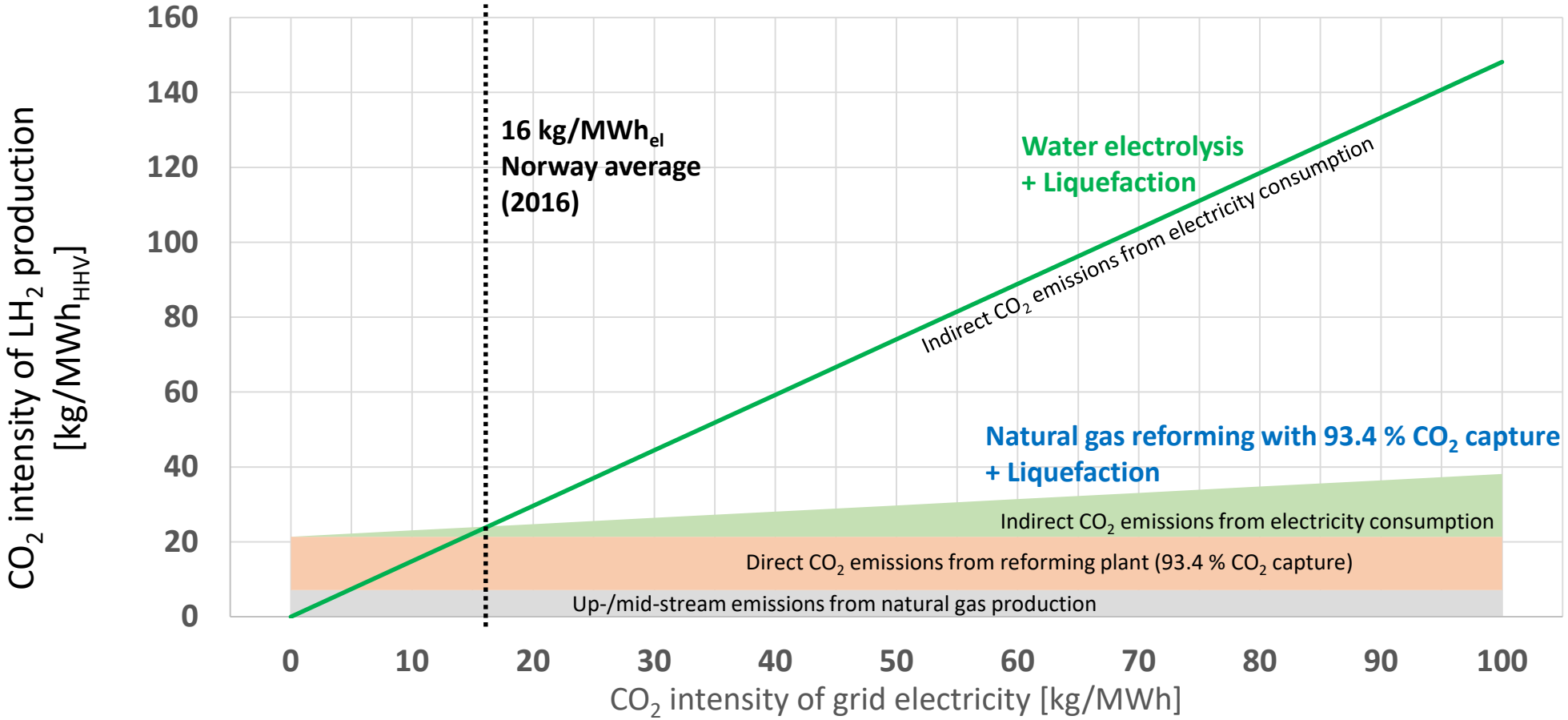
Teknologi for et bedre samfunn

Mythbusting: "Blue hydrogen" vs. "Green hydrogen"

Post-commissioning CO_2-eqivalent emissions:

CO_2-intensity of hydrogen from electrolysis vs. from autothermal reforming with 93.4 % CO_2 capture intersect at approximately 16 gCO_2/kWh_{el}



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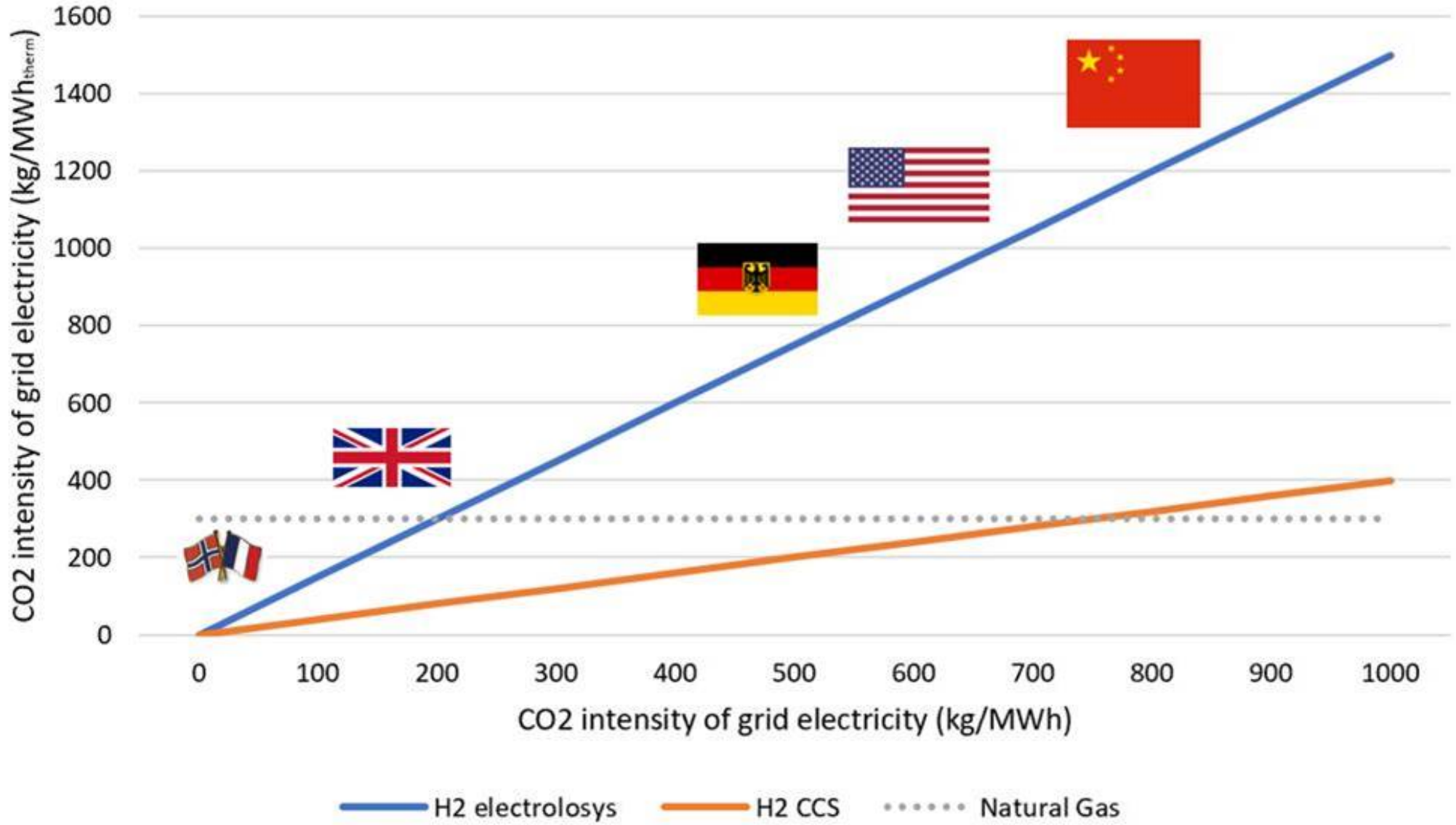
CO2 grid intensity for different countries (Bellona)



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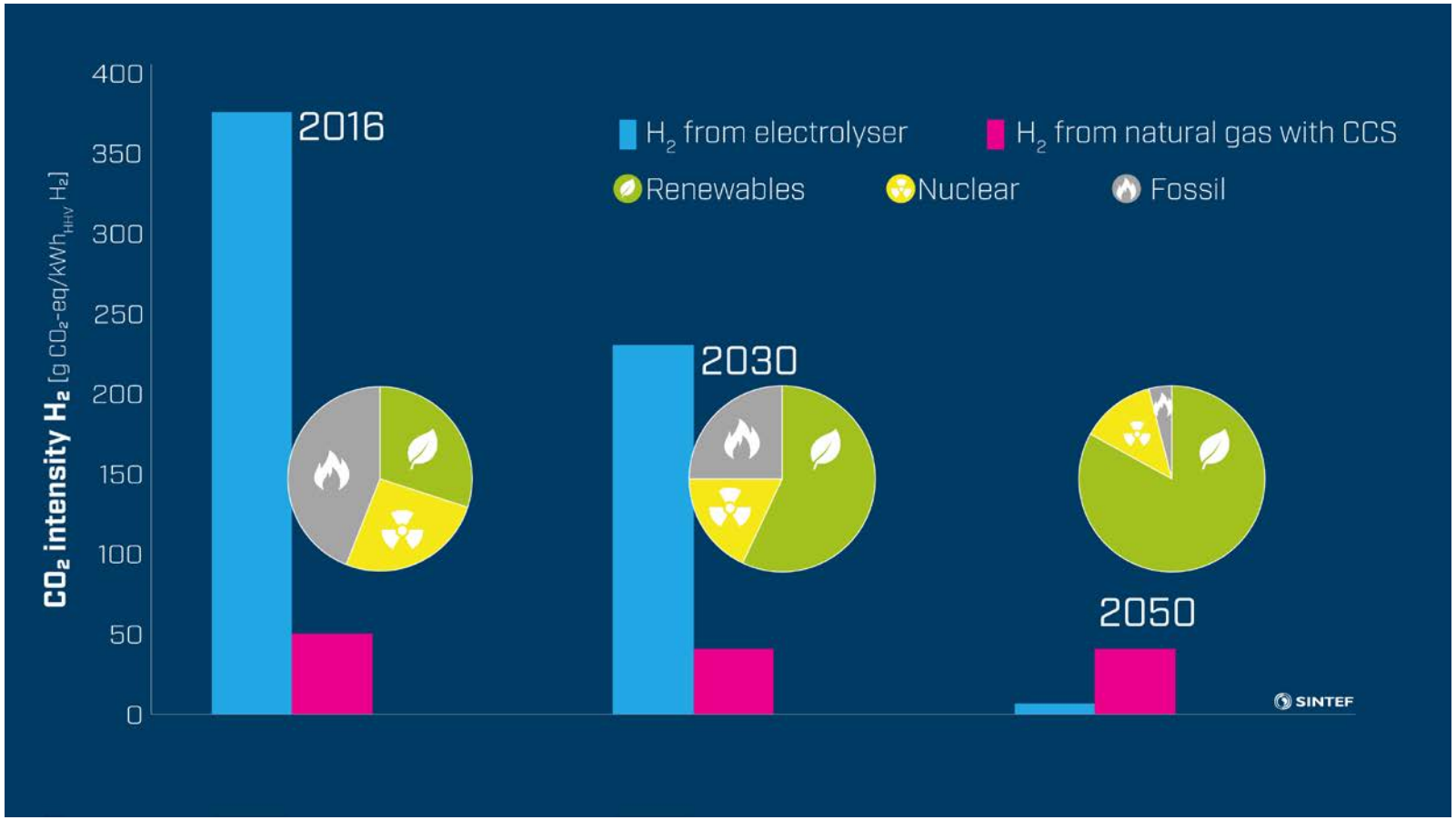
Hydrogen produced from natural gas with CCS will have lower GHG emissions than hydrogen from electricity in the EU grid for decades



- Comparison of greenhouse gas emissions related to production of hydrogen from
  - European grid electricity via electrolysers
  - Natural gas with carbon capture
- Hydrogen production from natural gas using autothermal reformers with 93 % (2016) to 96 % (2030 - 2050) CO_2 capture ratio
- European grid electricity mix shown in the pie-chart – forecasts based upon the IRENA REmap case for 2030 and the decarbonised scenarios from "A Clean Planet for All" for 2050
- Without deep decarbonization of the European power generation, emissions from production of hydrogen from dedicated renewably based electricity must account for potentially reduced emission reductions of the power sector

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IFP Energies nouvelles

Hydrogen

from natural gas with CCS could generate

NOK 220 billion annually in 2050

25,000 – 35,000 jobs

SINTEF,
April 2018

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From the SINTEF report:
Industrielle muligheter og arbeidsplasser ved CO_2-håndtering i Norge