Green competitiveness in Norway

Presentation at Circular Economy Conference,
Trondheim, Norway 30 May 2018,

By dr Per Sandberg, Equinor New Energy Solutions,
Ex- head of secretariat Norwegian Expert Commission on Green Competitiveness

Norwegian Government's Expert Committee on Green Competitiveness

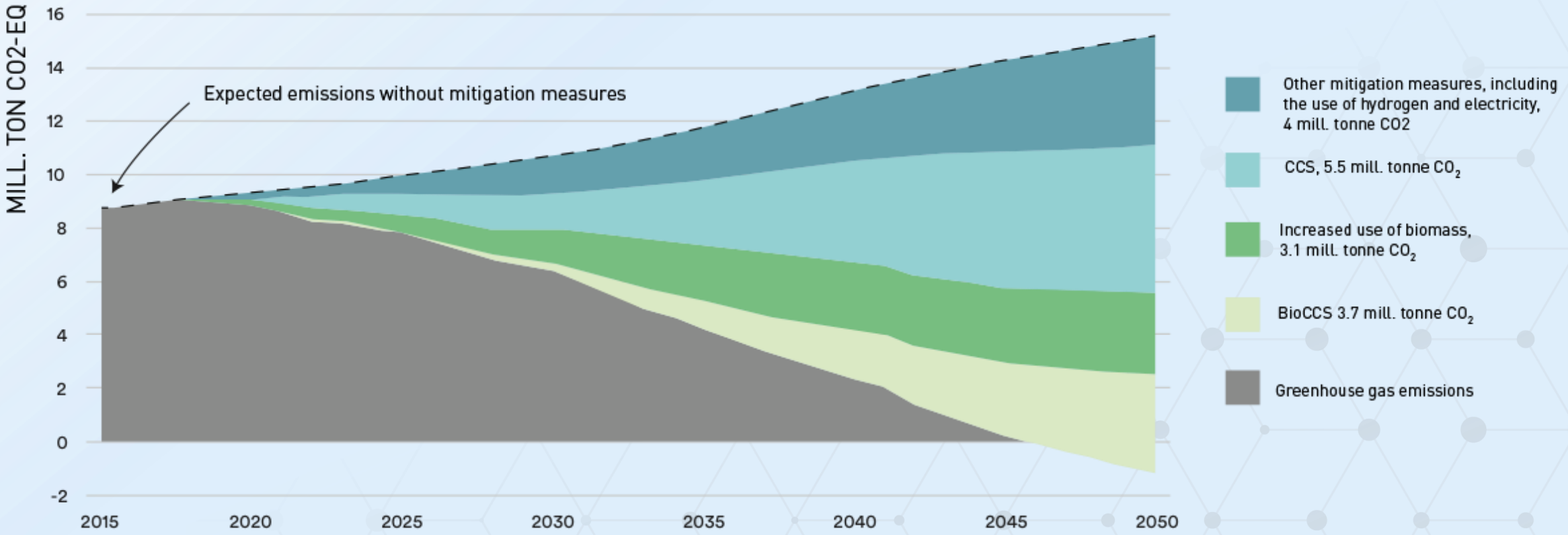
- Expert Committee:
  Connie Hedegaard, Idar Kreutzer
- Assignment from the
  Prime Minister in June 2015:
  Propose a national strategy for green competitiveness
- Secretariat with representatives from 5 ministries and Norwegian EPA, led by Per Sandberg
- Report delivered to Prime Minister October 28th 2016

Expert Committee challenged "all of Norway"

- 8 industry meetings, 45 one-to-one meetings and 40 conferences
- «How can we cut emissions, create jobs and create value?
- Tremendous response
- **Received 11 roadmaps from different industries**
- Circular economy focused in one, stressed in many

Processing industry roadmap

- Aims for double production & negative emissions in 2050
- Need ambitious, long-term technology development programs – Process21
- Requires CCS - national effort to build industrial CCS value chain should continue
- Requires sustainable biomass – opportunity for Norwegian industry



Sea map for coastal shipping

VISION FOR 2050

Our vision is for Norway to establish the world's most efficient and environmentally friendly coastal shipping, powered partly or entirely by batteries and other environmentally friendly fuels. By 2030, greenhouse gas emissions from domestic shipping shall be cut by 40% compared to current levels, and we shall have zero emissions by 2050.

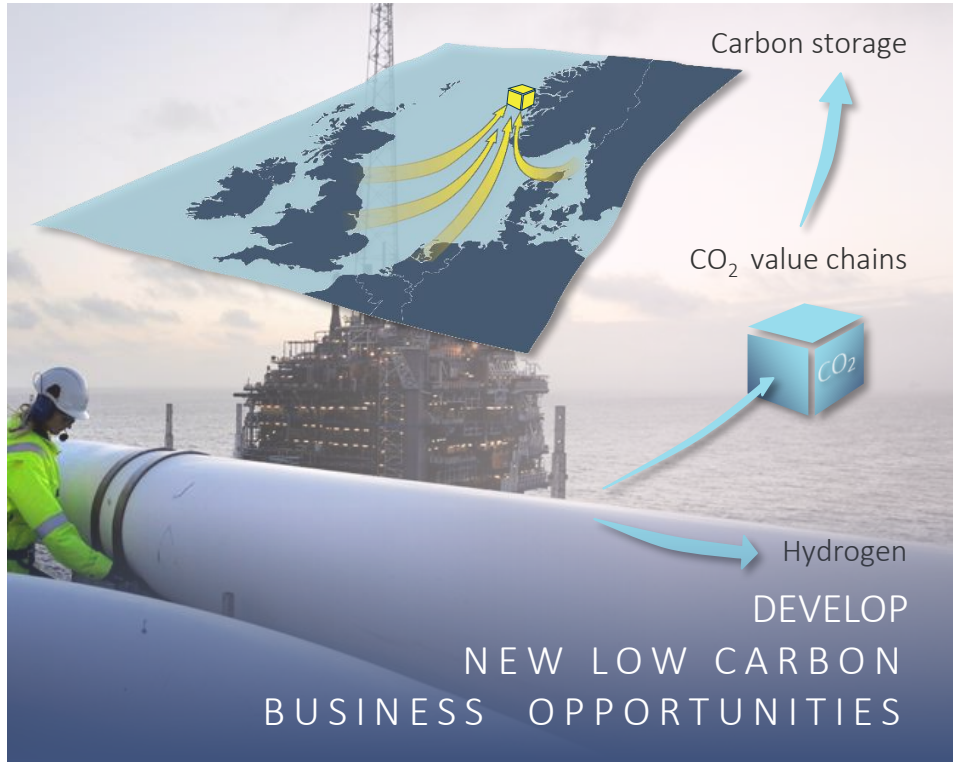
- Increase collaboration in value chain
- Create markets for green technology
- Reinforce shipowners financial capacity
- Establish CO2 fond for transport sector
- Establish adequate fuel infrastructure

This will transform Norwegian coastal shipping into a showcase to the world, an incubator and a platform for the Norwegian export of environmental technologies and green transport services, making a considerable contribution to reducing global shipping emissions.

Why are roadmaps made by industry so important?

- States that combining growth and climate action is normal business, and so is circular economy
- Most opportunities require public – private partnerships to get going
- Transparent dialogue between private and public actors
- New insights on what are realistic goals – and industry takes ownership to them
- Clarify needs for knowledge, infrastructure and investments
- Clarify relationship between need for push and pull from policy-makers

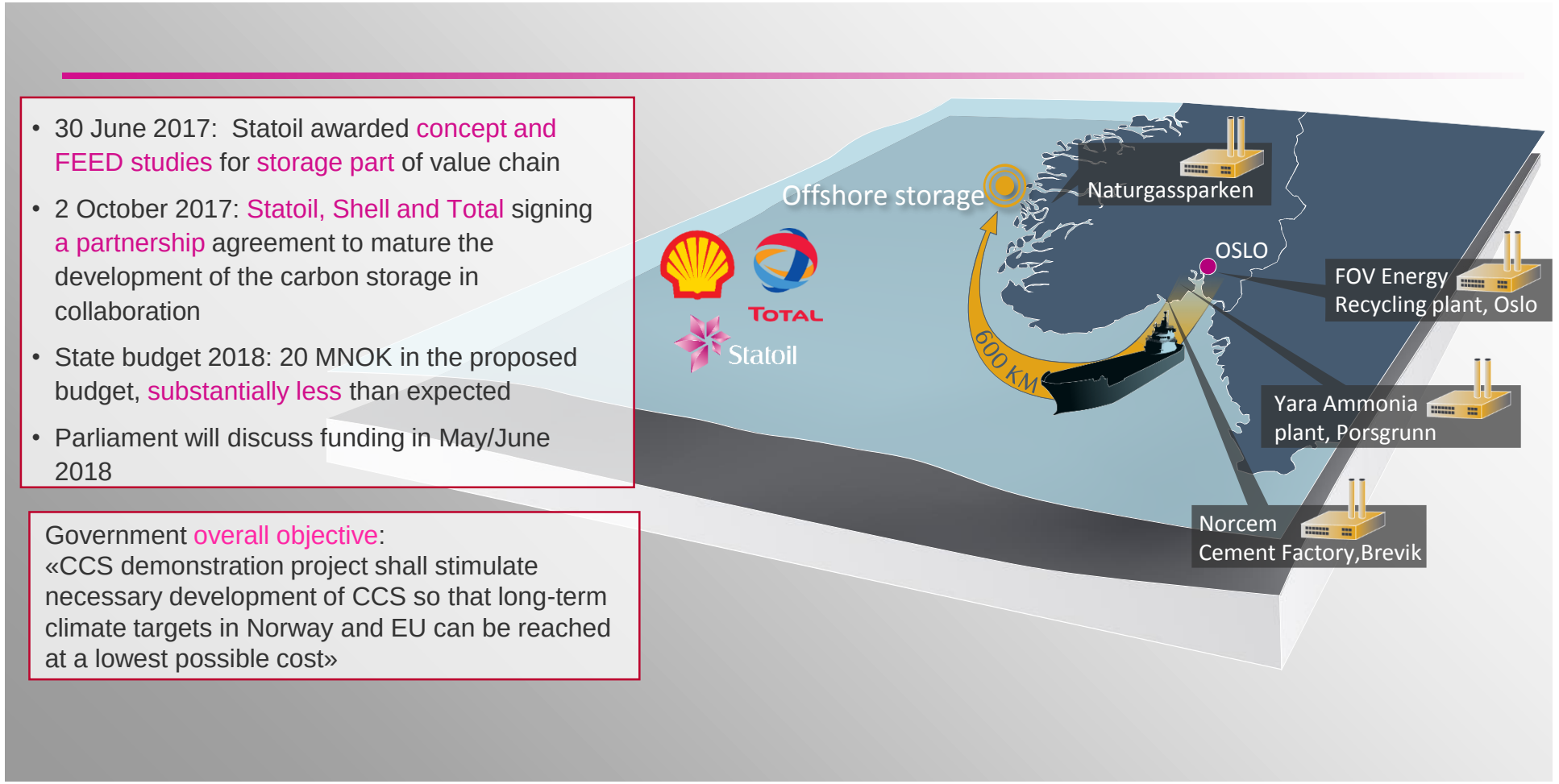
New Energy Solutions is a key vehicle in Equinor's low carbon strategy



Norwegian CCS value chain project

- 30 June 2017: Statoil awarded concept and FEED studies for storage part of value chain
- 2 October 2017: Statoil, Shell and Total signing a partnership agreement to mature the development of the carbon storage in collaboration
- State budget 2018: 20 MNOK in the proposed budget, substantially less than expected
- Parliament will discuss funding in May/June 2018

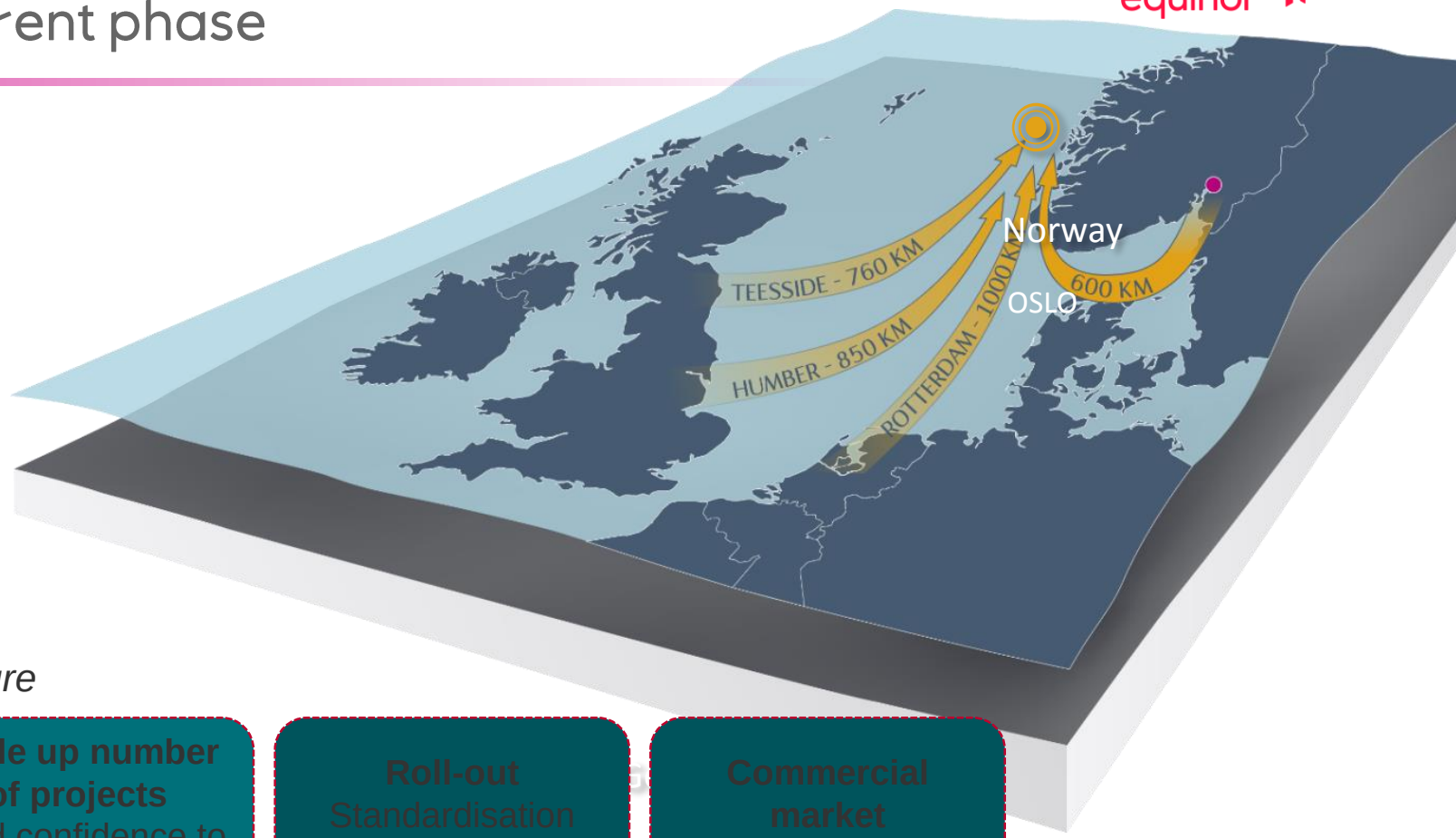
Government overall objective:
«CCS demonstration project shall stimulate necessary development of CCS so that long-term climate targets in Norway and EU can be reached at a lowest possible cost»



Building confidence is key in current phase

Scale-up phase;

- prove to stakeholders that the technology can apply to a future market
- proving technical, operational, regulatory and commercial set-up of CCS value chains
- builds trust and reduces risk



Past

Demonstration
Technology works!

Future

Scale up number of projects
Build confidence to CCS

Roll-out
Standardisation and efficency

Commercial market

2017 2030

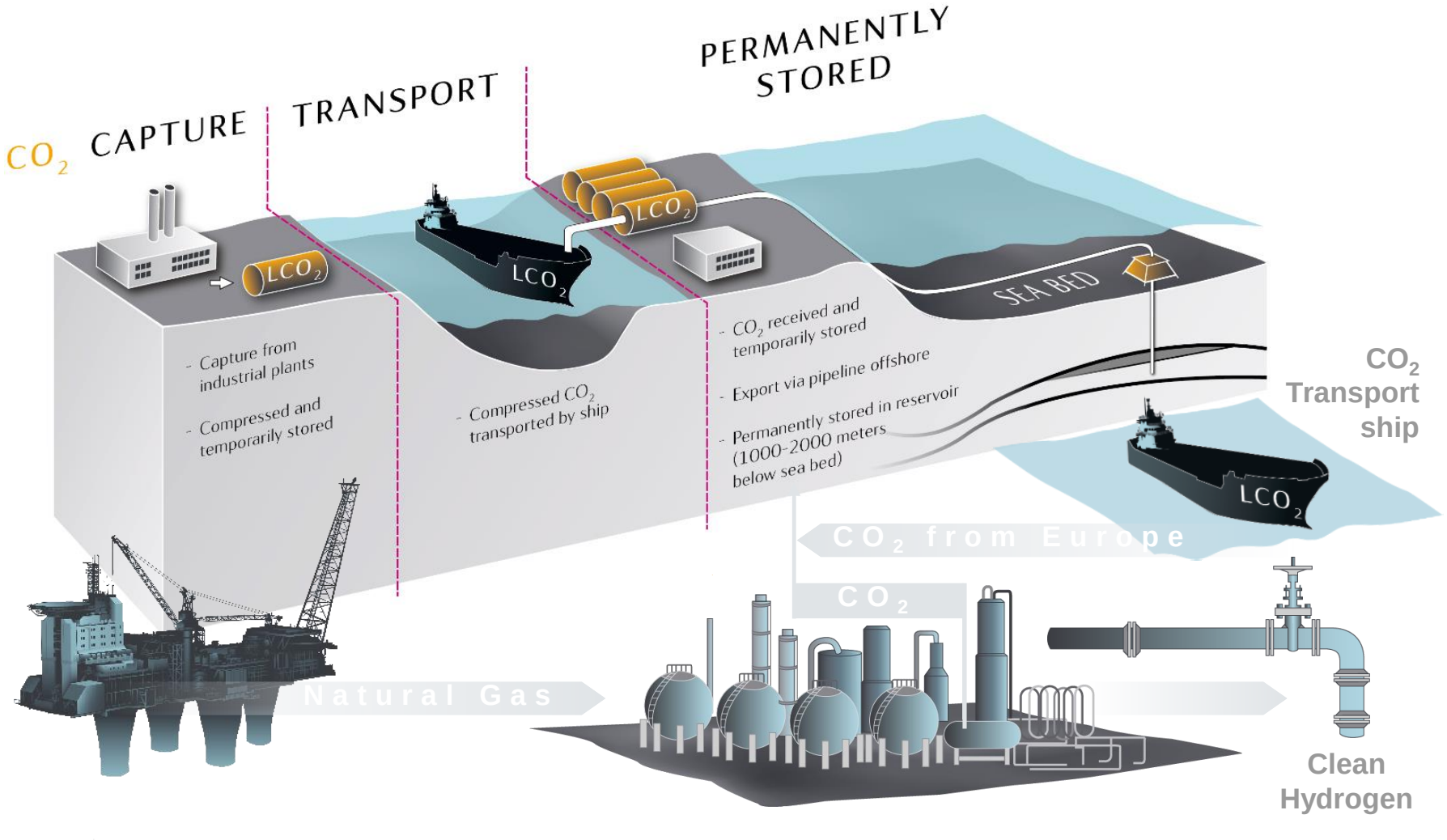
CCS value chain as enabler for clean Hydrogen production

Step 1

Establish CCS infrastructure

Step 2

Utilize CCS infrastructure to produce clean hydrogen from natural gas and/or import CO2 from Europe



Decarbonising Energy Systems

Easy ⟵ complexity to decarbonise ⟶ Hard

Transport

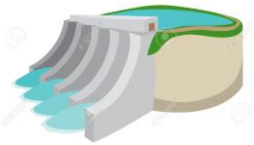
Battery (mostly) plus Hydrogen for Heavy Duty

Hydrogen Fuel-Cell Trains

Liquid Hydrogen and Fuel-Cells for long haul Big Ships

Power

Large Battery Systems for Daily Swing (night-to-day)



Hydro-Power as Battery for Small Scale Intermittency

Hydrogen fired CCGTs Back-Up Power for Large Scale Intermittency

Industry

Light Industry powered by Renewable

Heavy Industry powered by Hydrogen from Natural Gas + CCS

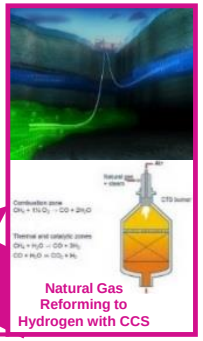
CCS for Industry without other Alternatives

Heat

Heat Pumps For Efficient Use of Electricity in Homes

Hydrogen for Efficient Transfer of Energy from Production to End-Users

Hydrogen for Large Scale Seasonal Storage



Multiple technologies to address the challenge

Equinor Hydrogen Portfolio

Power Generation

- Utilize existing gas power-plants
- Switch fuel from gas to hydrogen
- Clean baseload electricity
- Clean back-up for solar and wind
- Launch large-scale H2 economy
- Enables H2 to transport later

Heat

- Large energy sector in UK
- Difficult (and expensive) to de-carbonize with electricity
- Utilize existing gas network
- Synergies with industry/power gen
- Enables H2 to transport later

Maritime

- Battery solutions not sufficient
- Utilize existing gas processing plant to provide low cost H2; compressed and/or liquid
- Centralize CO_2 emissions which provides CCS optionality
- Promising applications:
  - ✓ Trondheim – Kristiansund express, 2021
  - ✓ Cruise

Financing CCS value chains – three possible phases

First: Public risk-sharing and financing of early technology & projects – *Public and private investment in CCS infrastructure*

Then: Innovative procurement, financing and business models – *Creating markets and friendly investment climate for products of CCS*

Finally: CO2 cost and competitive solutions – *CCS runs by itself*

CCS can be financed – if we look at the right number!

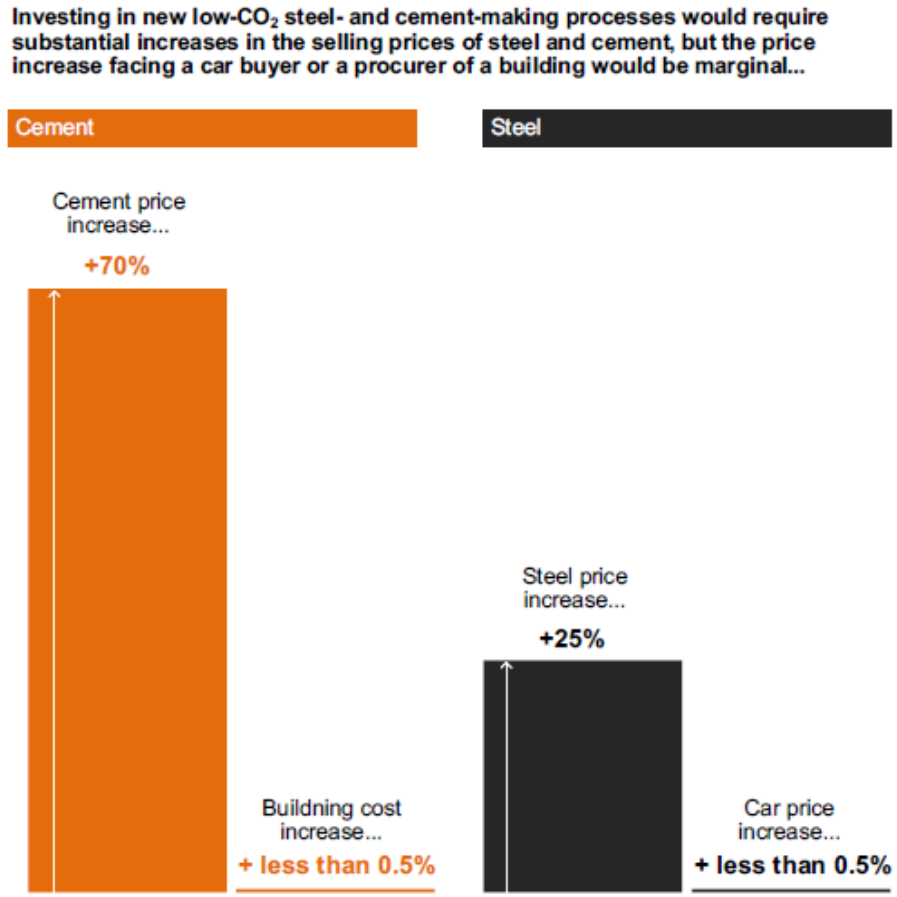


Figure 2. Cost impacts along the supply chains of steel and cement of investing in new low-CO_2 steel- and cement-making processes in primary production. Adapted from Rootzén and Johnsson (2015; 2016a; 2016b).

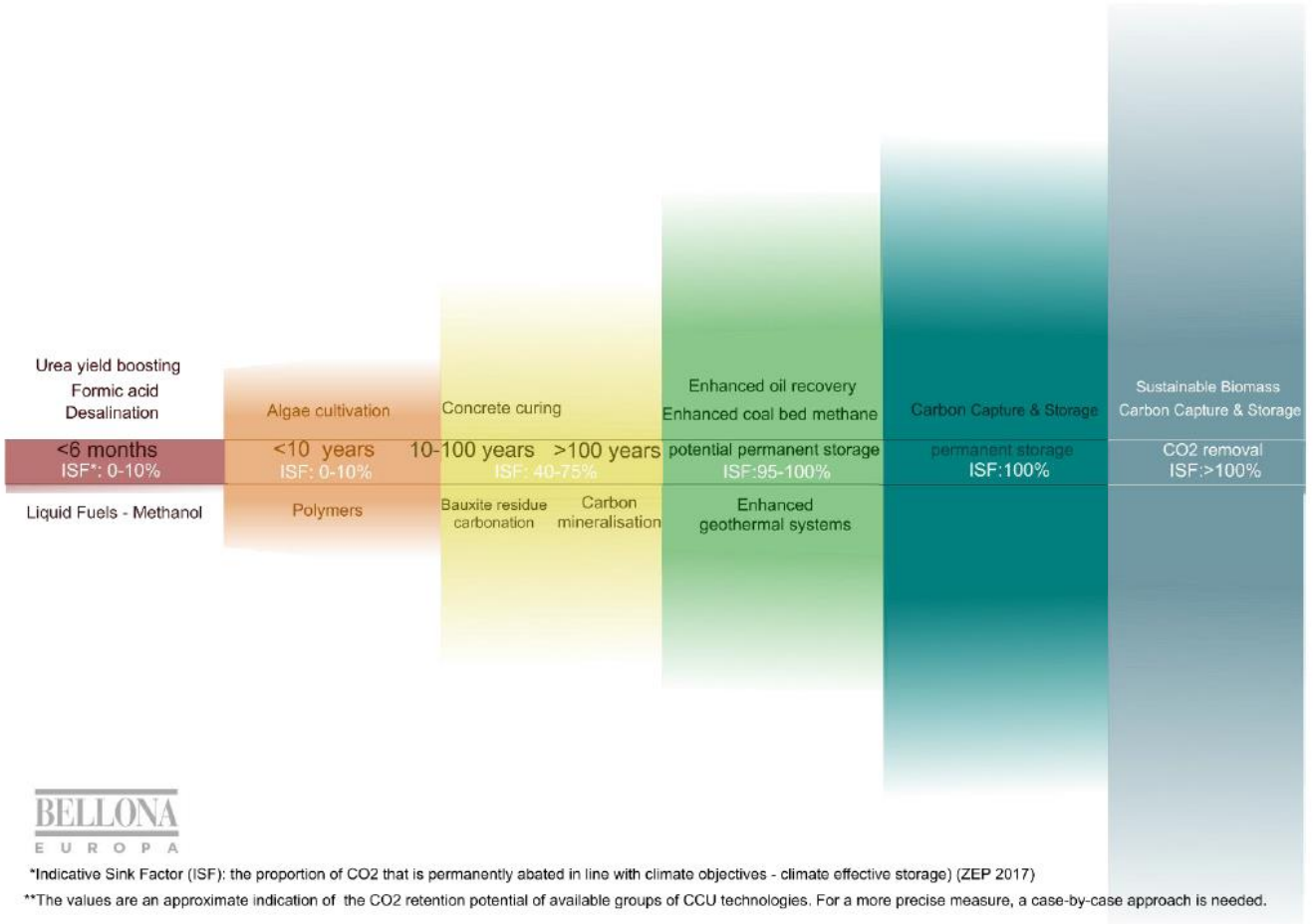
Kilde: Rootzen and Johnsson, 2017

We should get the cycles right – not all ideas for circular use of CO2 are equally good

…we discuss the potential contribution of carbon capture and utilization (CCU). Owing to the scale and rate of CO_2 production compared to that of utilization allowing long-term sequestration, it is highly improbable the chemical conversion of CO_2 will account for more than 1% of the mitigation challenge, …

Therefore, whilst CO_2-EOR may be an important economic incentive for some early CCS projects, CCU may prove to be a costly distraction, financially and politically, from the real task of mitigation

Mac Dowell et al, *Nature Climate Change* volume 7, pages 243–249 (2017)



Source: ZEP and Bellona 2017