



| ICAO

STOCKTAKING 2021



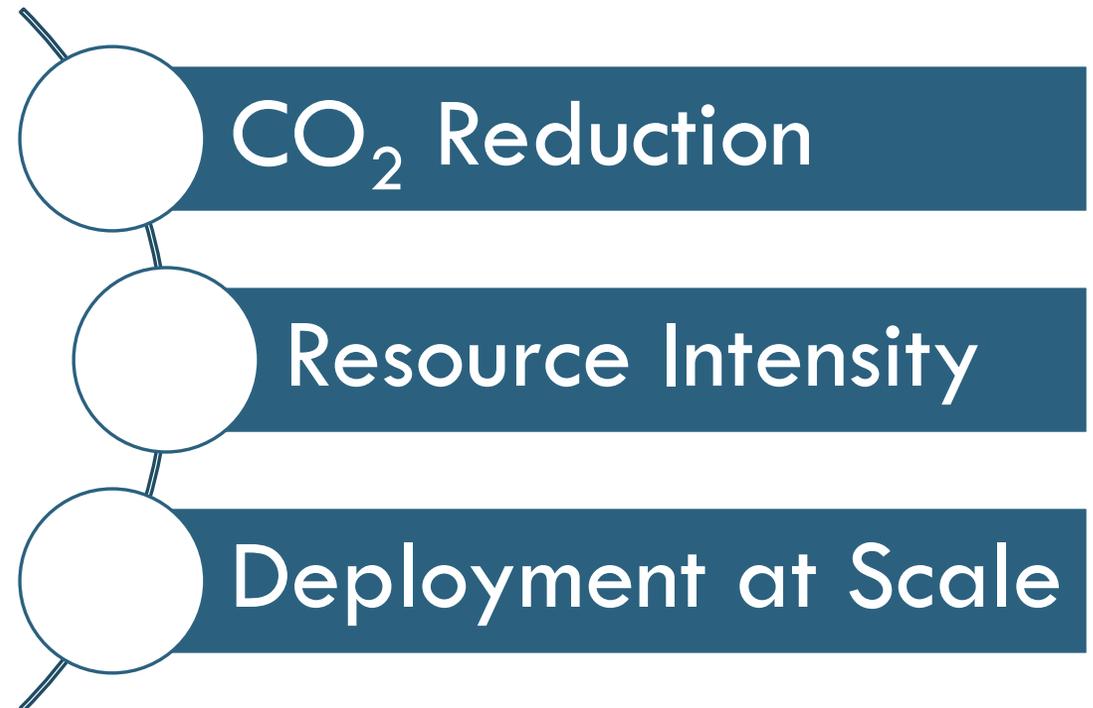
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BELLONA

Sustainability and Climate Action Considerations:

- E-Fuel
- Power to Liquid (P2L)
- CO₂ Utilisation (CCU)
- CO₂ Recycle

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THE RECIPE OF E-FUELS

*How is the hydrogen produced?
Where is the energy from?
At what scale can it be produced?*

Hydrogen
 H_2

*Where is the CO_2 from?
Is the CO_2 fossil ?
Is the CO_2 atmospheric ?*

**Carbon
Dioxide**
 CO_2

E-Fuel
Synthetic fossil fuel

Hydrocarbon
 $H_2 + CO_2$



EMISSIONS MAY GO UP / AS WELL AS DOWN

Hydrogen is produced from Electricity

- The hydrogen is as clean as the electricity used to produce it
- Dirty electricity = dirty hydrogen and even dirtier E-Fuel

E-Fuel can increase emissions over conventional fossil fuels

- Low efficiency and energy loss

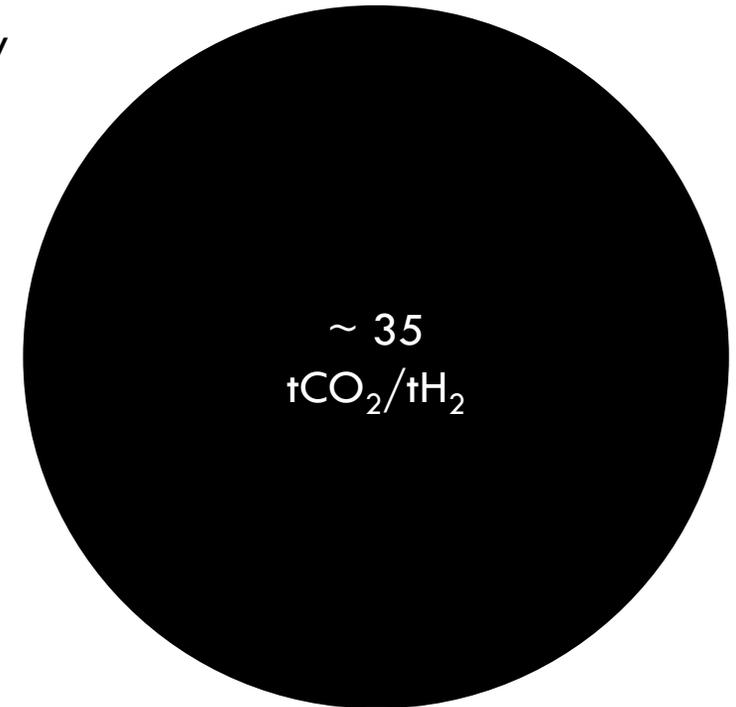
E-Fuel production nearly-exclusively requires Renewable Electricity to reduce emission

Hydrogen produced with **WIND** electricity



~ 0.5
tCO₂/tH₂

Hydrogen produced with **COAL** electricity



~ 35
tCO₂/tH₂

RENEWABLE ELECTRICITY FOR E-FUELS

E-Fuel require large amounts of renewable electricity (Hydrogen)

- Low CO₂ reduction per unit of Renewable electricity used
- E-Fuels when deployed will not be powered by Excess / Curtailed / Marginal electricity

New/Additional electricity demand from E-fuel production

- Over and above the current concept of “greening the grid”
- New E-fuel production should be matched by new/ additional renewable generation

Example:

Denmark



Replacing all aviation fuel sold in Denmark with equivalent E-Fuel

- ~25 TWh (unit of electricity)
- 70% of total electricity
- ~ 3 Million tonne CO₂ saved (best case)

Replacing all cars with Electric Vehicle (equivalent km)

- ~ 8 TWh
- ~ 6.5 Million tonnes of CO₂ saved

Using electricity in EVs ~6 times more efficient on a climate measure

CO₂ SOURCE / CO₂ DESTINATION

Taking Carbon from the ground and adding it to the atmosphere is Climate Change

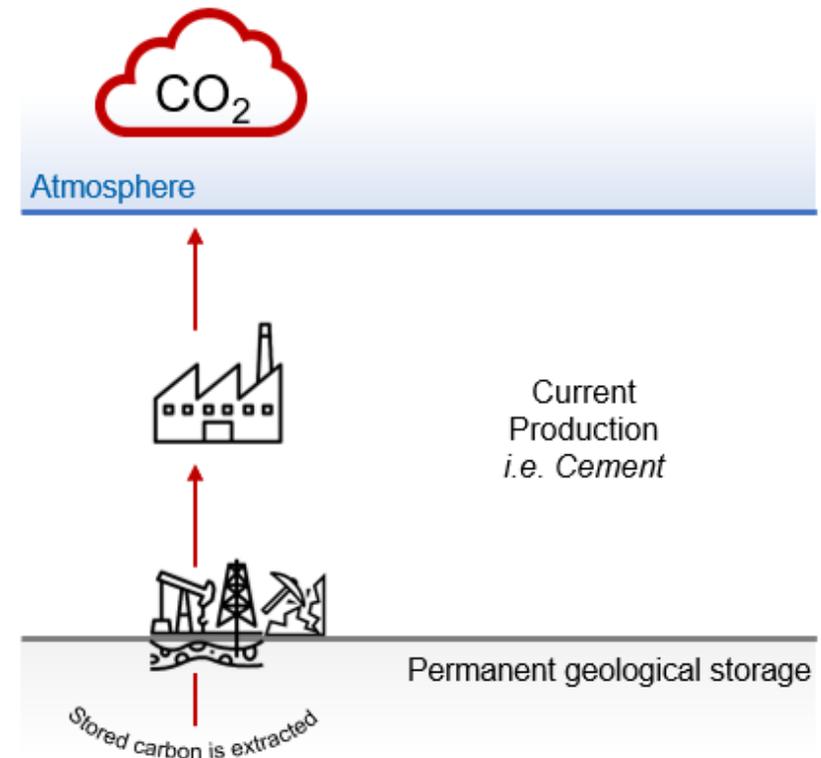
CO₂ concentration in the atmosphere

- Now – **417** ppm
- In 1990 it was **353** ppm

Using CO₂ to make E-fuels raises questions

- Where has the CO₂ come from?
- Where will it end up?
- Whose responsibility is it?

Its about climate change – this point is critical



ATMOSPHERIC CO₂ / DAC

Air fuels / E-Fuel from Sun and Air

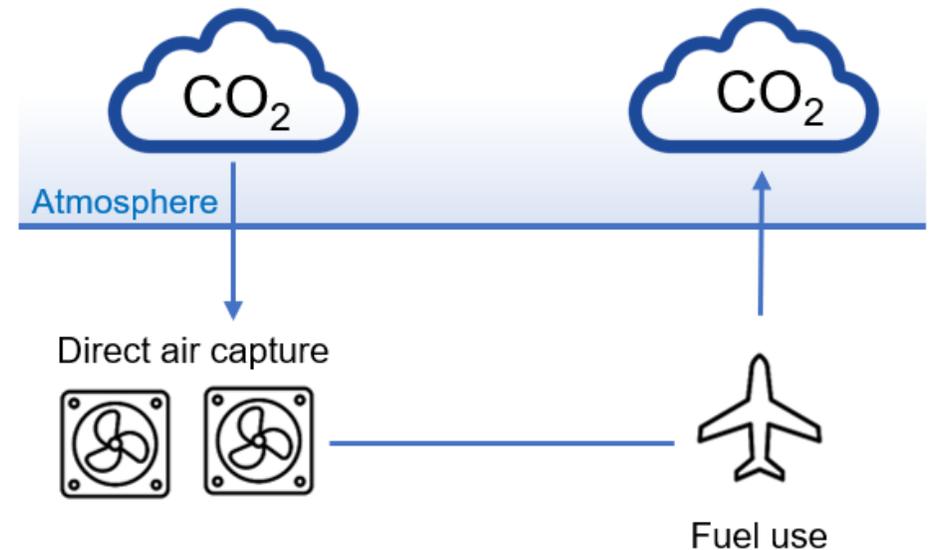
DAC + E-Fuel can be carbon neutral

- CO₂ in the atmosphere is unchanged

Capturing CO₂ from the atmosphere is difficult

- Concentration of CO₂ in atmosphere comparatively low
- Direct Air Capture (DAC) is energy intensive

Atmospheric Carbon + Emissions to Atmosphere =
Climate Neutral



Permanent storage

FOSSIL CO₂ AND LOW-CARBON E-FUELS ?

Point Source CO₂ Capture

- Cement, Fertilisers, Coal many choices

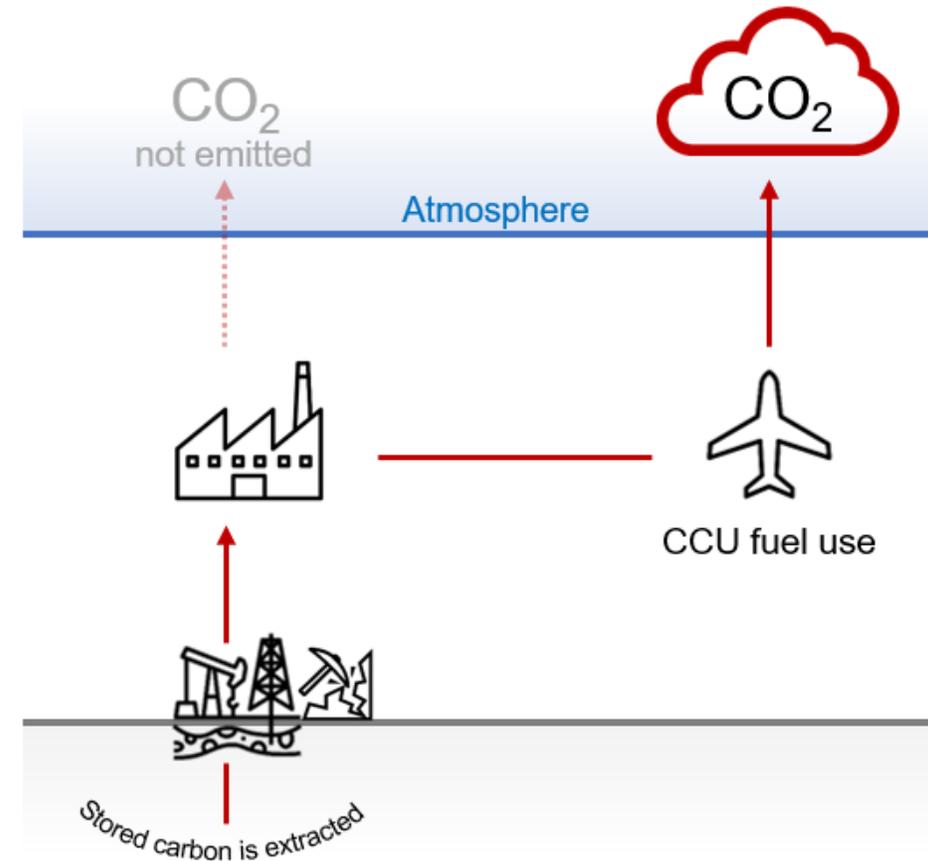
The CO₂ provider would like to take the credit

- CCU (CO₂ utilisation) / CO₂ Valorisation
- “We can decarbonise our industrial sector by using our CO₂ to manufacture fuel”

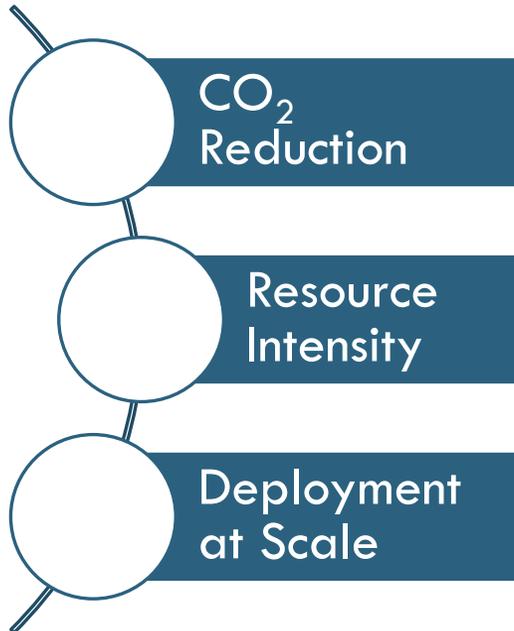
How do we allocate of the CO₂ reduction?

- Double Counting / Creative accounting
- CO₂ is ultimately dumped in the atmosphere
- One party can be low carbon – the other must be full carbon

Carbon Fossil (Geological) + Emissions to Atmosphere
= Global Warming



KEY TAKEAWAYS FOR E-FUELS



Hydrogen: Needs to be Renewable

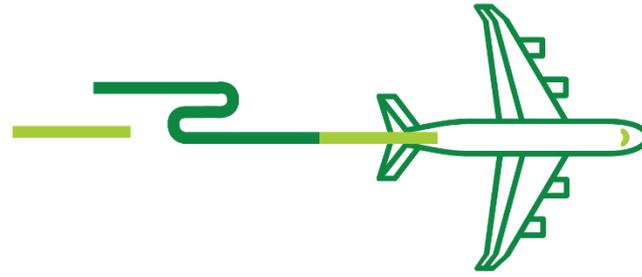
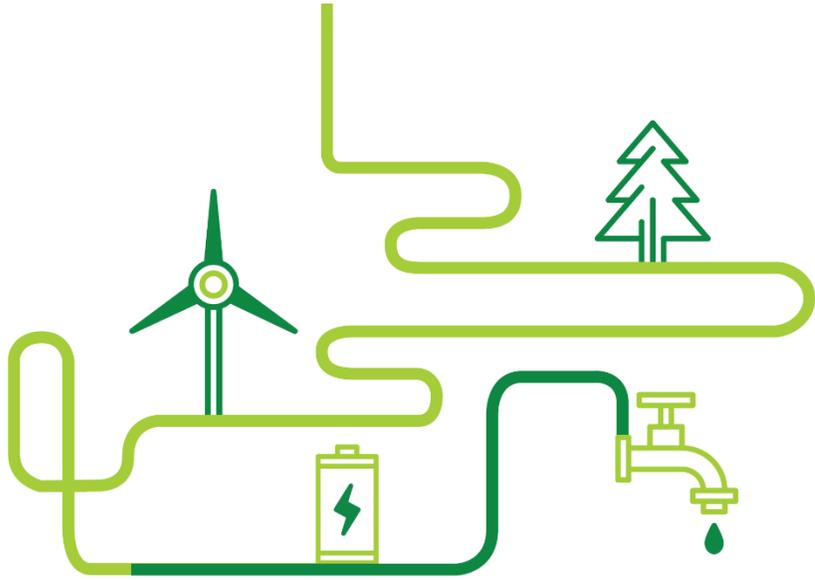
CO₂ Used: Needs to be Atmospheric for Net-Zero

Low CO₂ reduction per unit of renewable electricity used

Only to be used where other solutions are absent

Very large new electricity requirements for aviation alone

Renewables must be additional



AVIATION CO₂ REDUCTIONS



PRE-STOCKTAKING WEBINARS

TECHNOLOGY · OPERATIONS · SUSTAINABLE AVIATION FUELS

