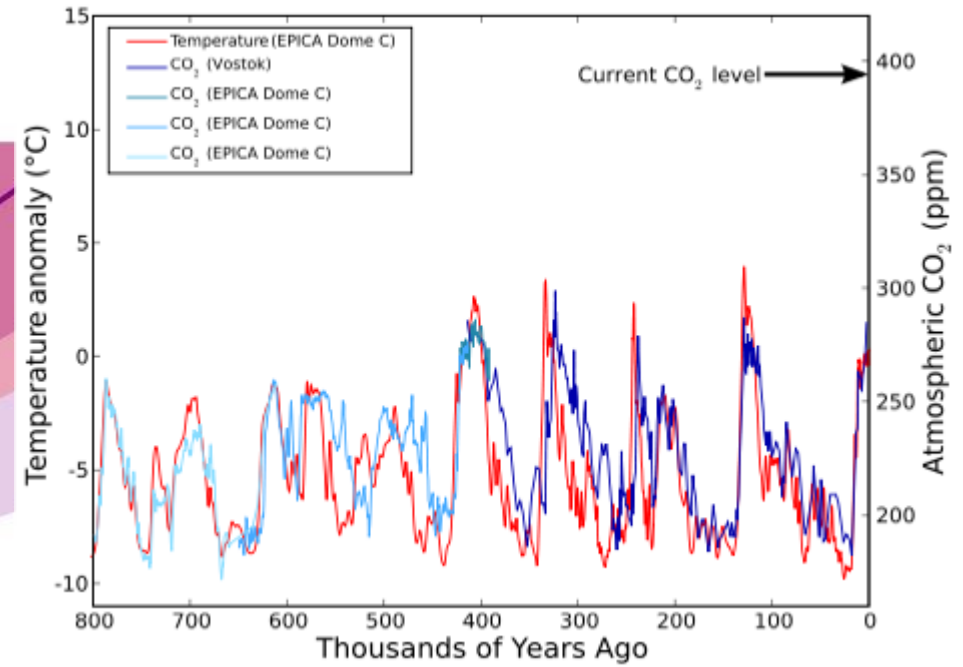
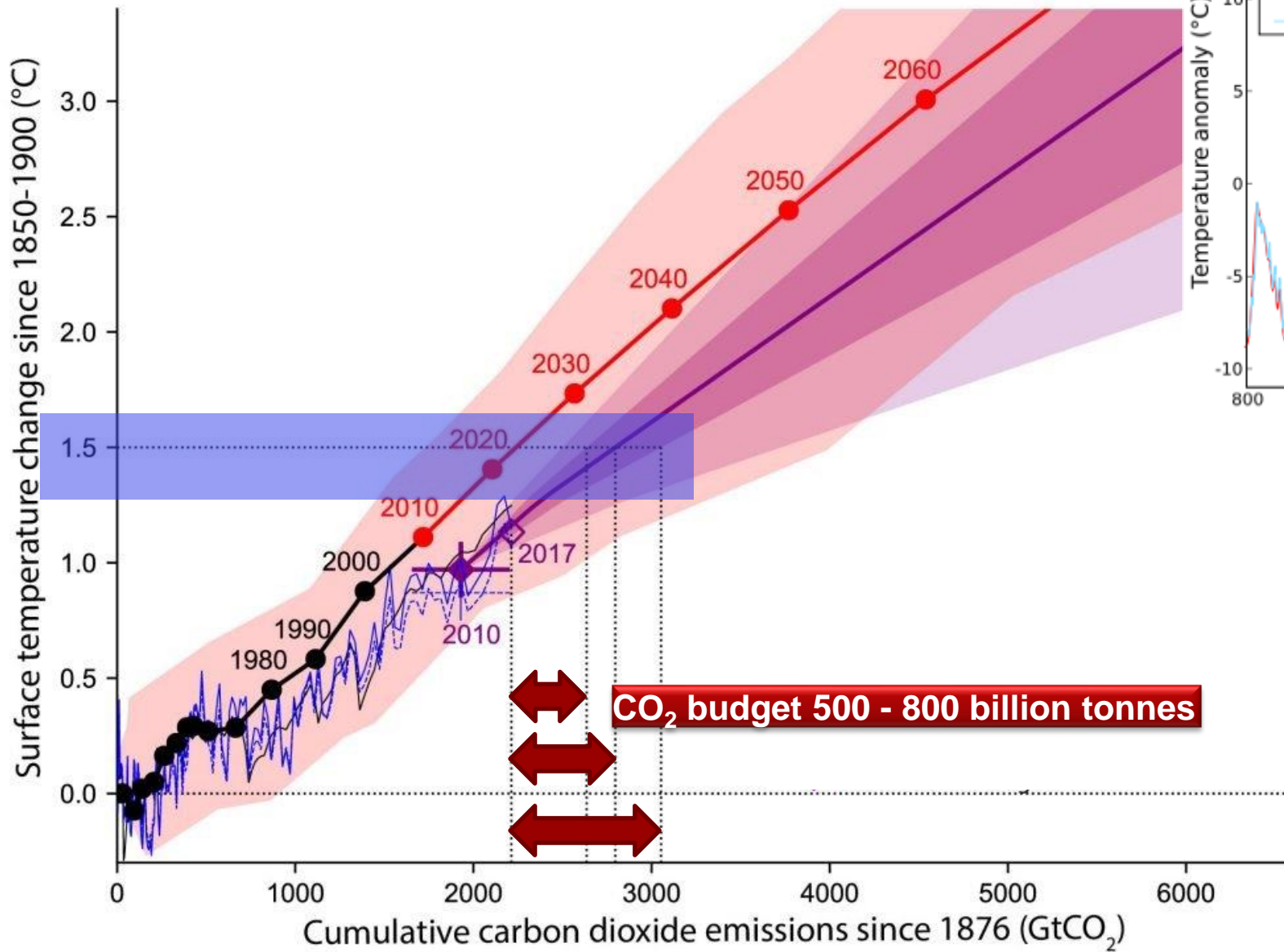


Energy demand and Environmental impact of the CCS value chain

Francesco Piovesan, Ali A. Eftekhari, DTU Offshore

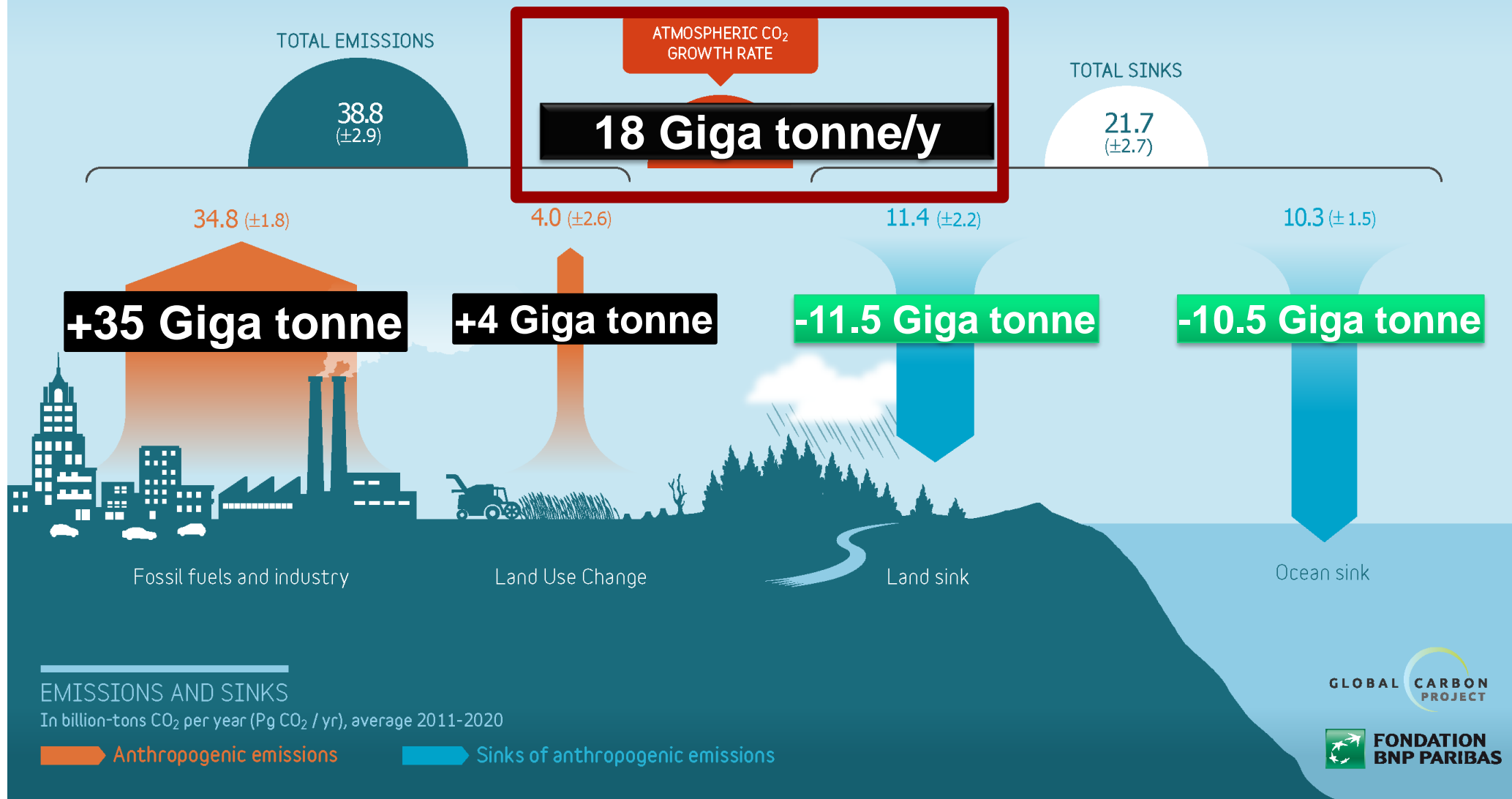
CCS Conference 2023, Rungsted, Denmark

Motivation

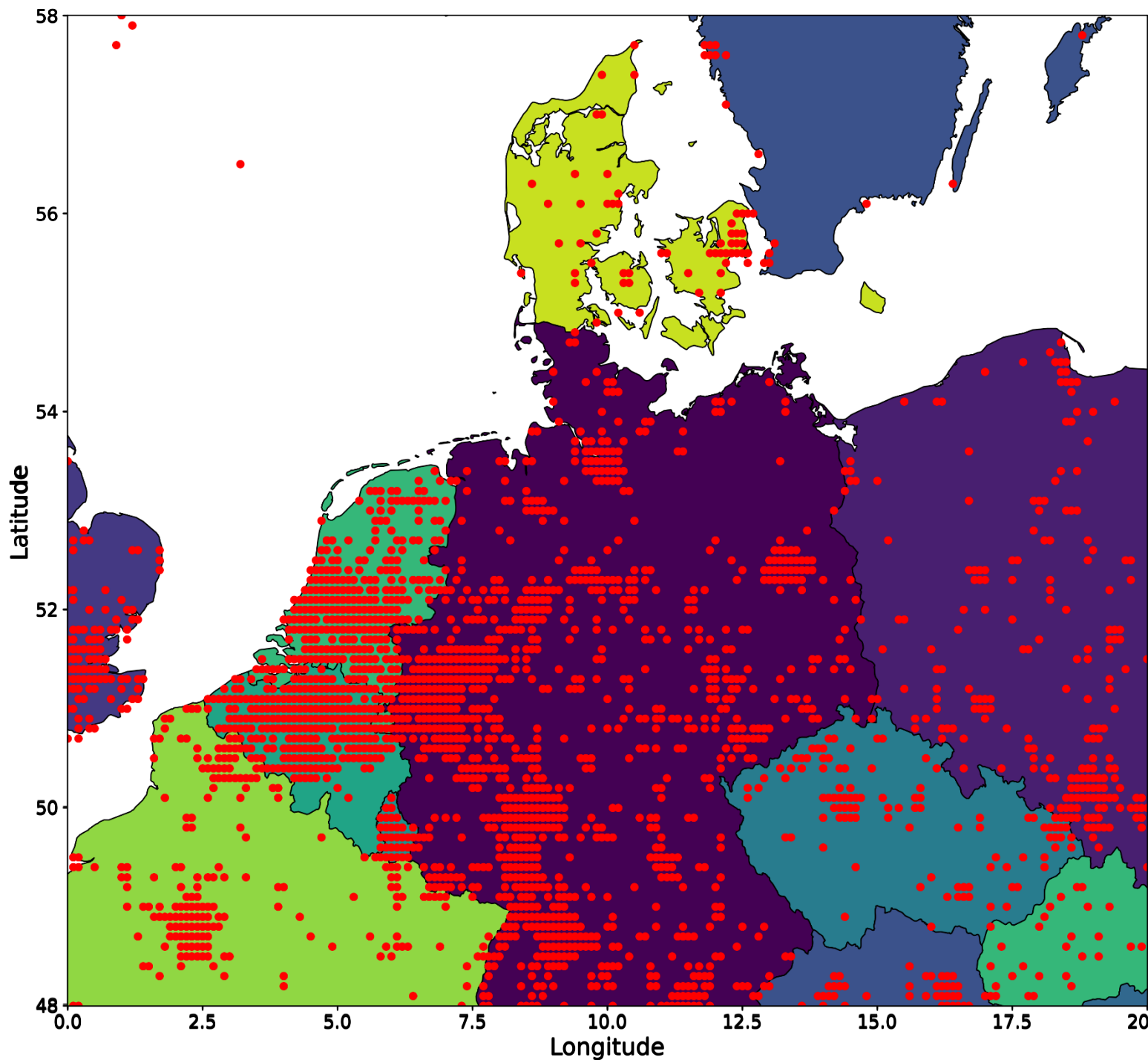


<https://www.ipcc.ch/sr15/chapter/chapter-2/2-2/2-2-2/2-2-2-1/figure-2-3/>

GLOBAL CARBON BUDGET 2011-2020



<http://globalcarbonatlas.org/en/content/global-carbon-budget>

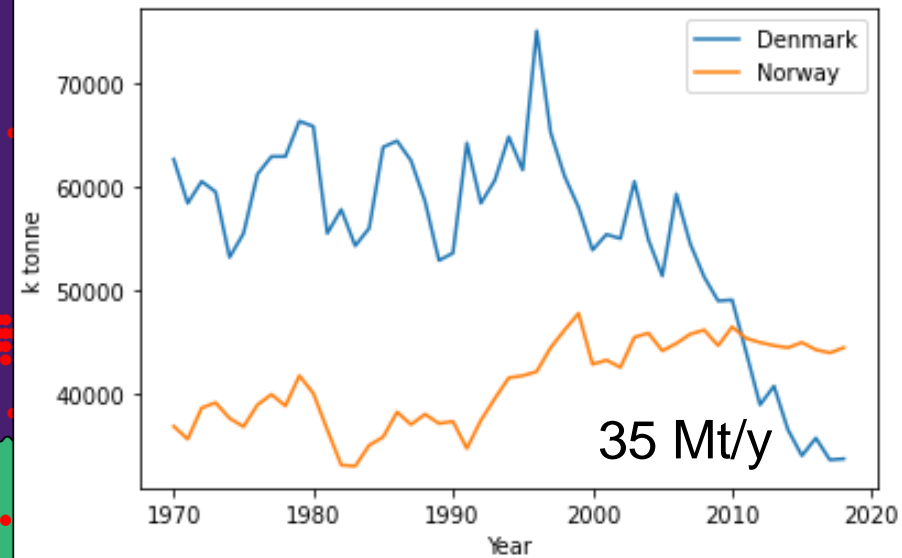


CO₂ emission map

> 1 Mt/y

> 0.3 Mt/y

> 0.1 Mt/y



Data from EDGAR project

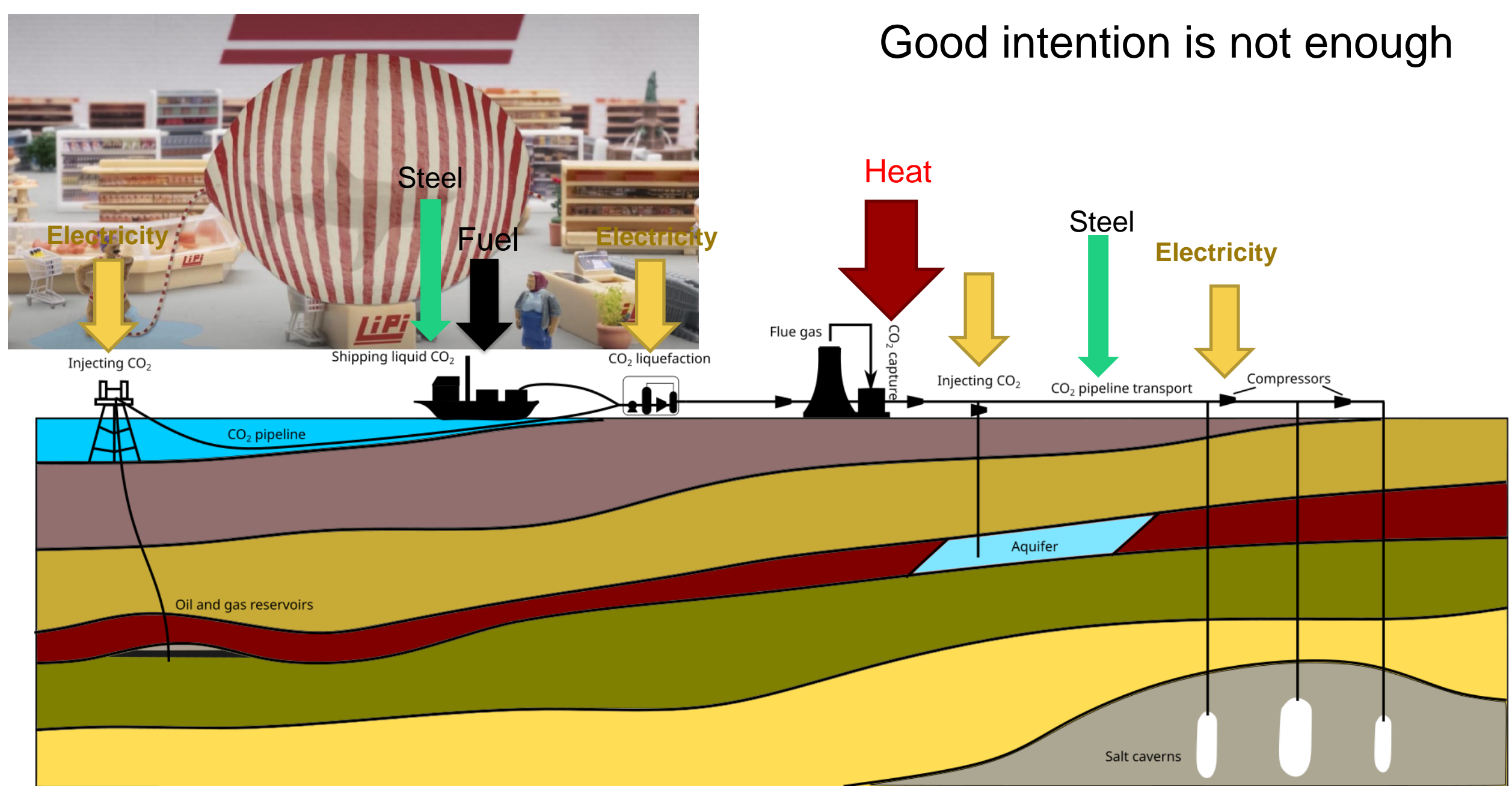
CCS in a Danish market has limited (read NO) mitigating impact

unless

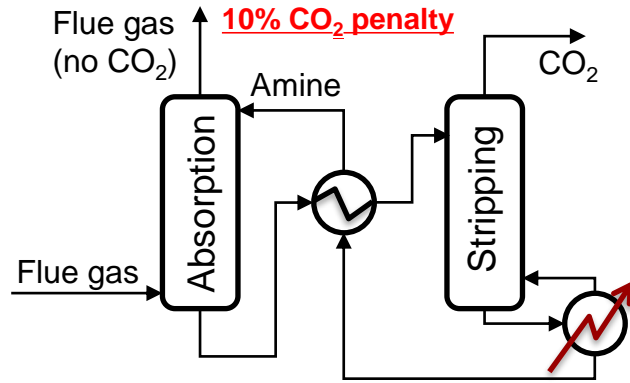
Scaled up

What are the **environmental impacts** and **energy demand** for a scaled-up CCS value chain?

Good intention is not enough



Capture energy of CO₂



**2.5 – 3.6 GJ heat (at 150°C)
per tonne CO₂**

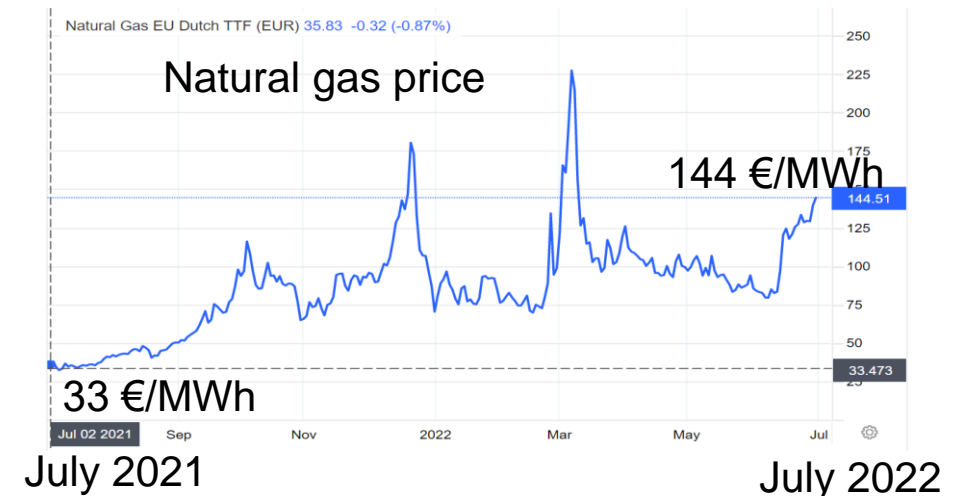
0.1 – 0.4 GJ electricity/t CO₂

Min separation work: $Ex_{sep} = -RT_0 \ln x_{CO_2}$

$$\text{Efficiency} = \frac{\text{minimum separation work}}{\text{State of the art separation process exergy}} = 8\% - 14\%$$

Capture cost of CO₂

Reported cost **15 – 95 – 200 €/t CO₂**



The Economics of CO₂ Storage

Gemma Heddle, Howard Herzog & Michael Klett

August 2003, MIT

“All my economic studies are obsolete.”

Howard Herzog, personal communication, GHGT 16, 2022

The capture and compression cost was 80 \$/ton CO₂ when we did the study; now it is 180 \$/ton.

Gary Rochelle, FEED study session, GHGT 16, 2022

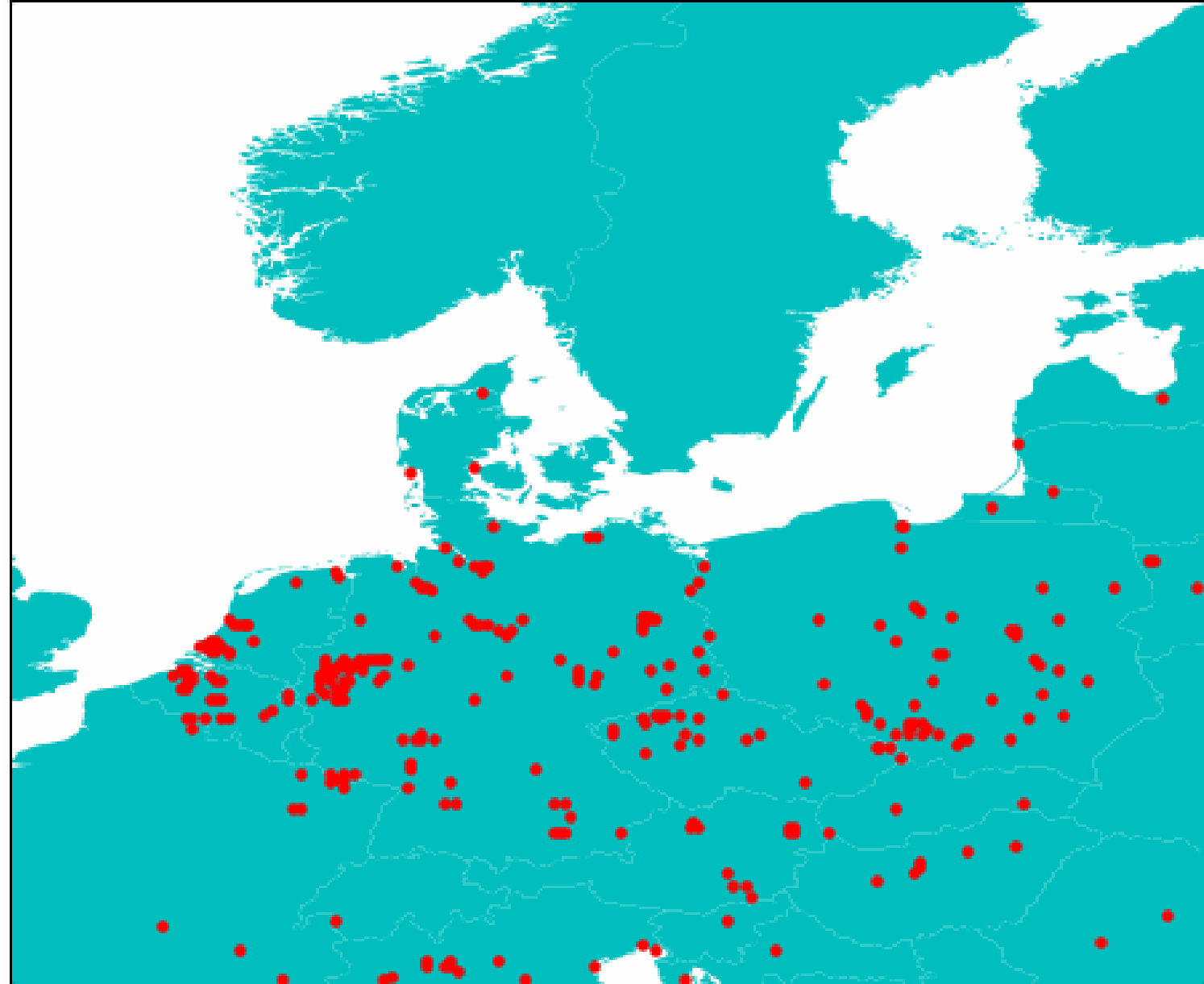
We propose:

A user-friendly software codenamed EnCO2age

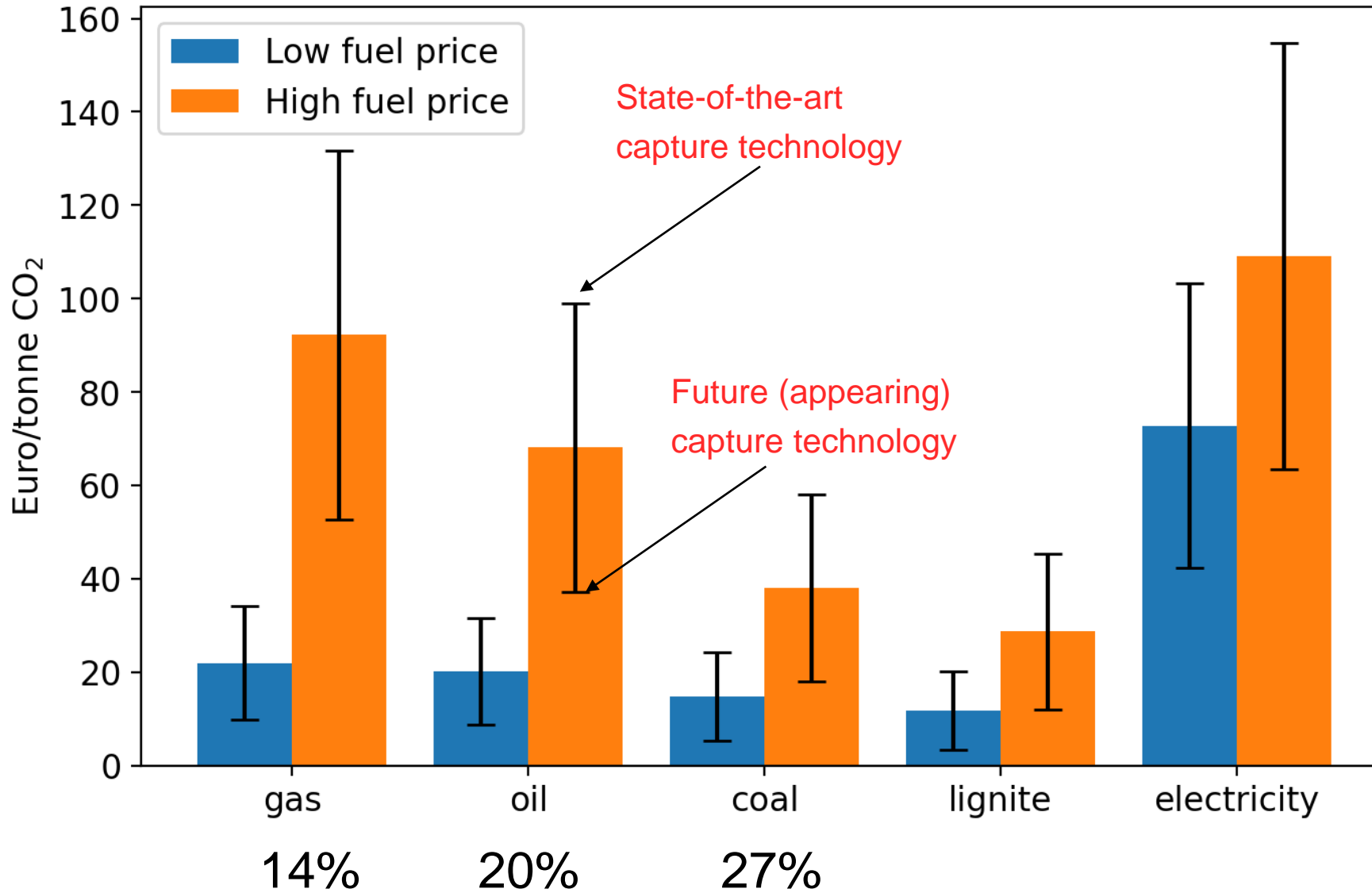
Database of all the emitters across Europe

Graph theory for a basic transport path optimization

Database of storage sites in Europe



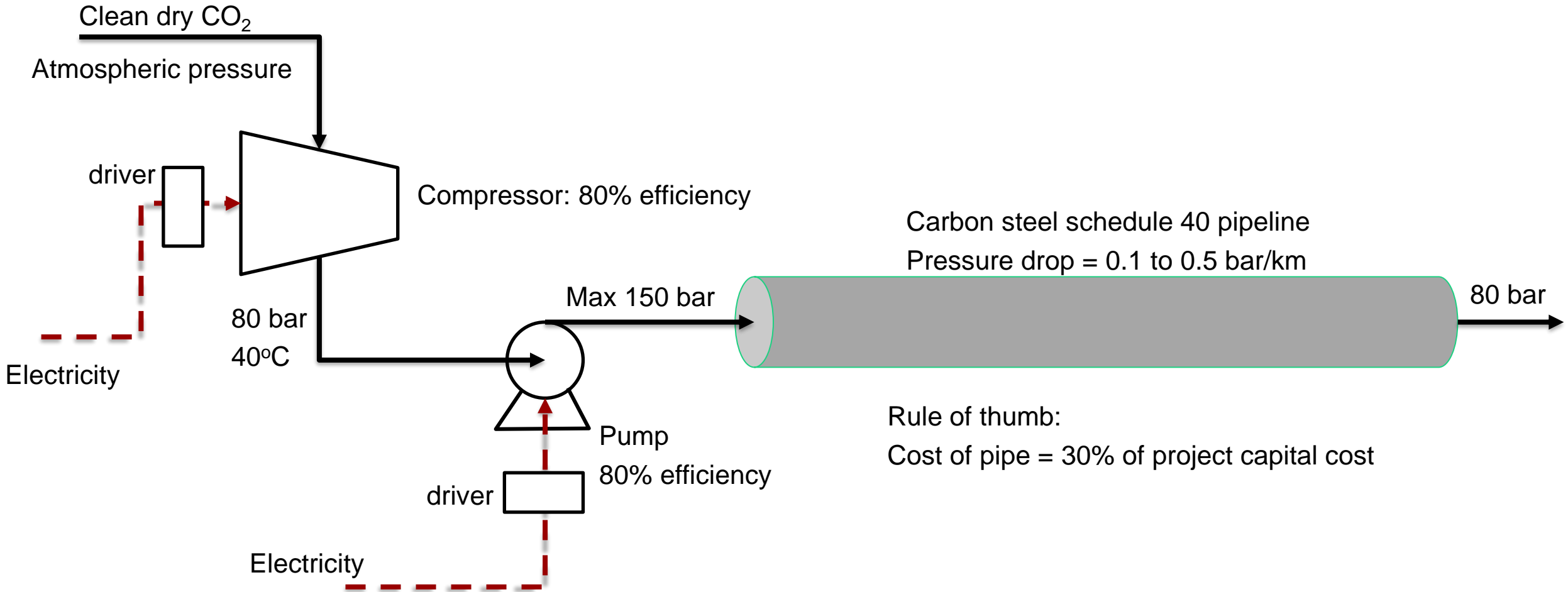
Energy  cost



Capacity/efficiency:
Maximum CO₂ capture:
90%

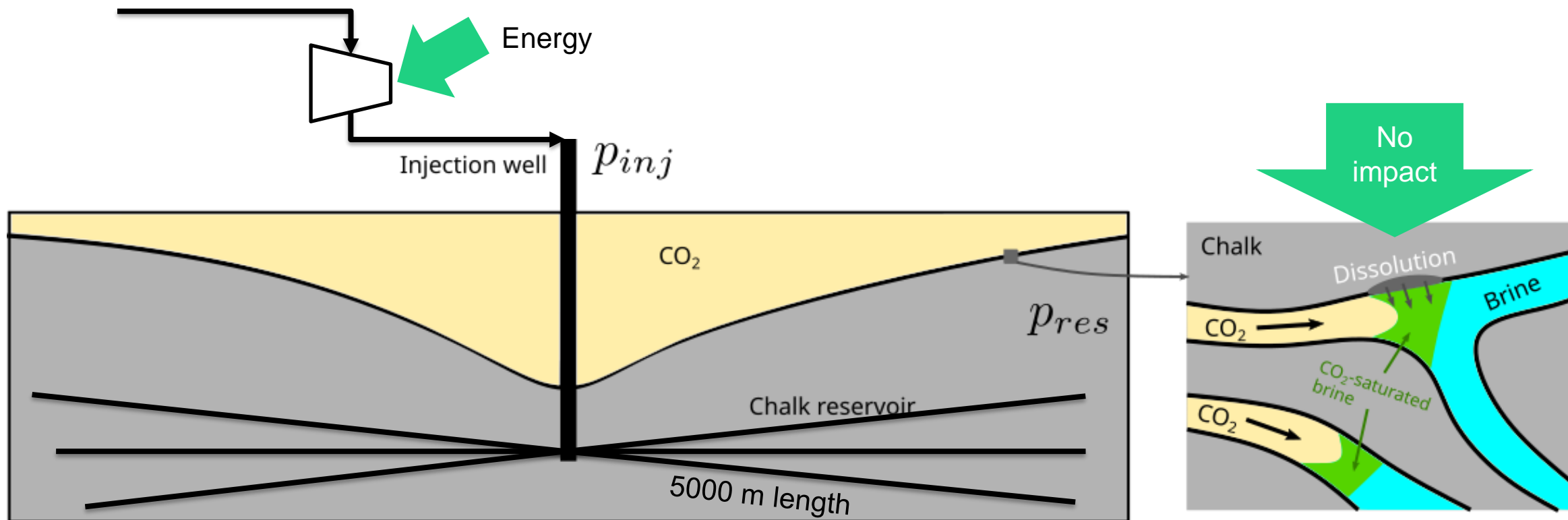
Energy demand depends on flue gas composition

Pipeline transport



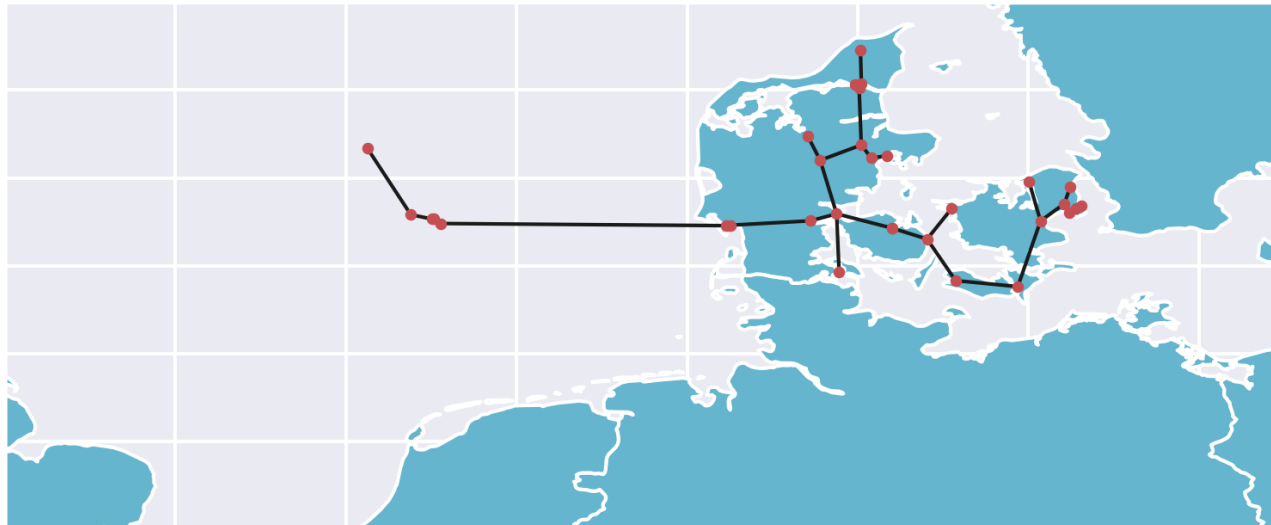
CO₂ Injection

Geophysical and petrophysical properties of storage sites
1D, 2D, 3D finite volume solver



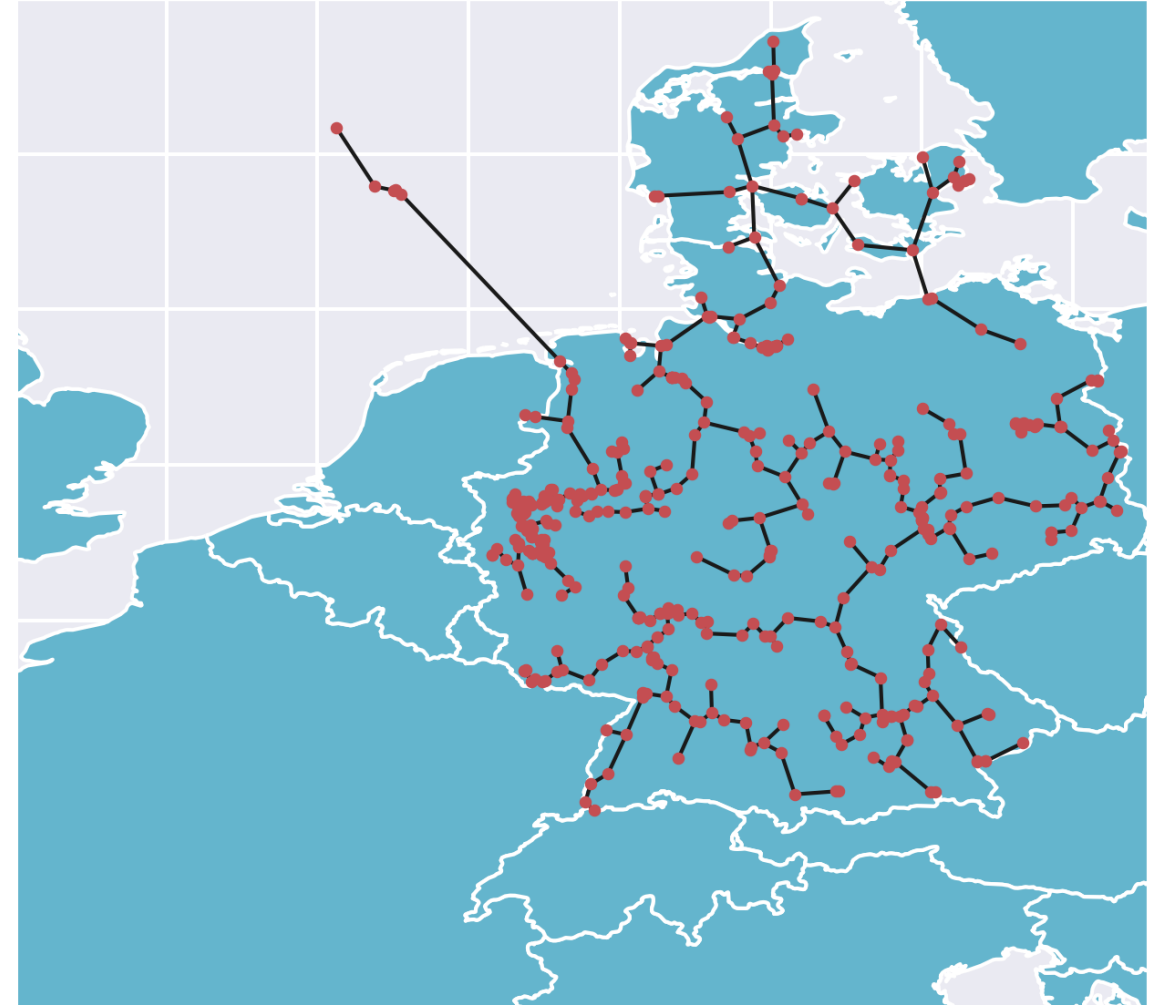
Results

- Point sources with a minimum emission of 50,000 tonnes/year
- total electricity consumption is 243.6 MW
- CCS electricity demand is 4.9 percent of Danish electricity consumption
- total capture heat = 930 MW
- heat demand of CCS is around 2.4 percent of average Denmark heat demand
- total CO₂ storage is 10.7 Mt/y

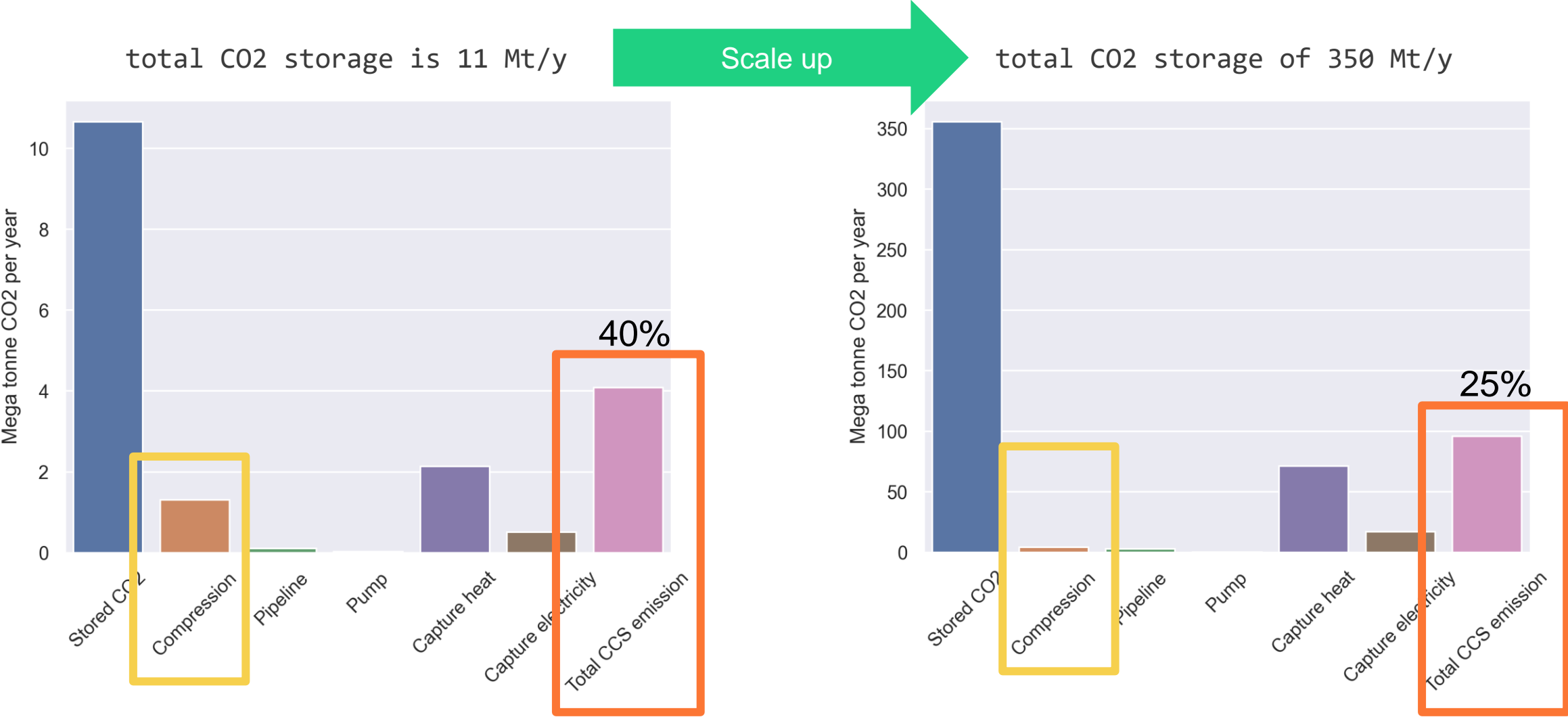


Upscaling to a German market

- Total electricity consumption is 2900 MW
- CCS electricity demand is **58% of Danish electricity consumption**
- total capture heat = 31 GW
- Heat demand of CCS is around **80% of average heat demand**
- total CO₂ storage is 350 Mt/y

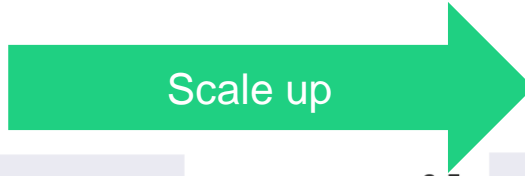


Energy demand and environmental impact

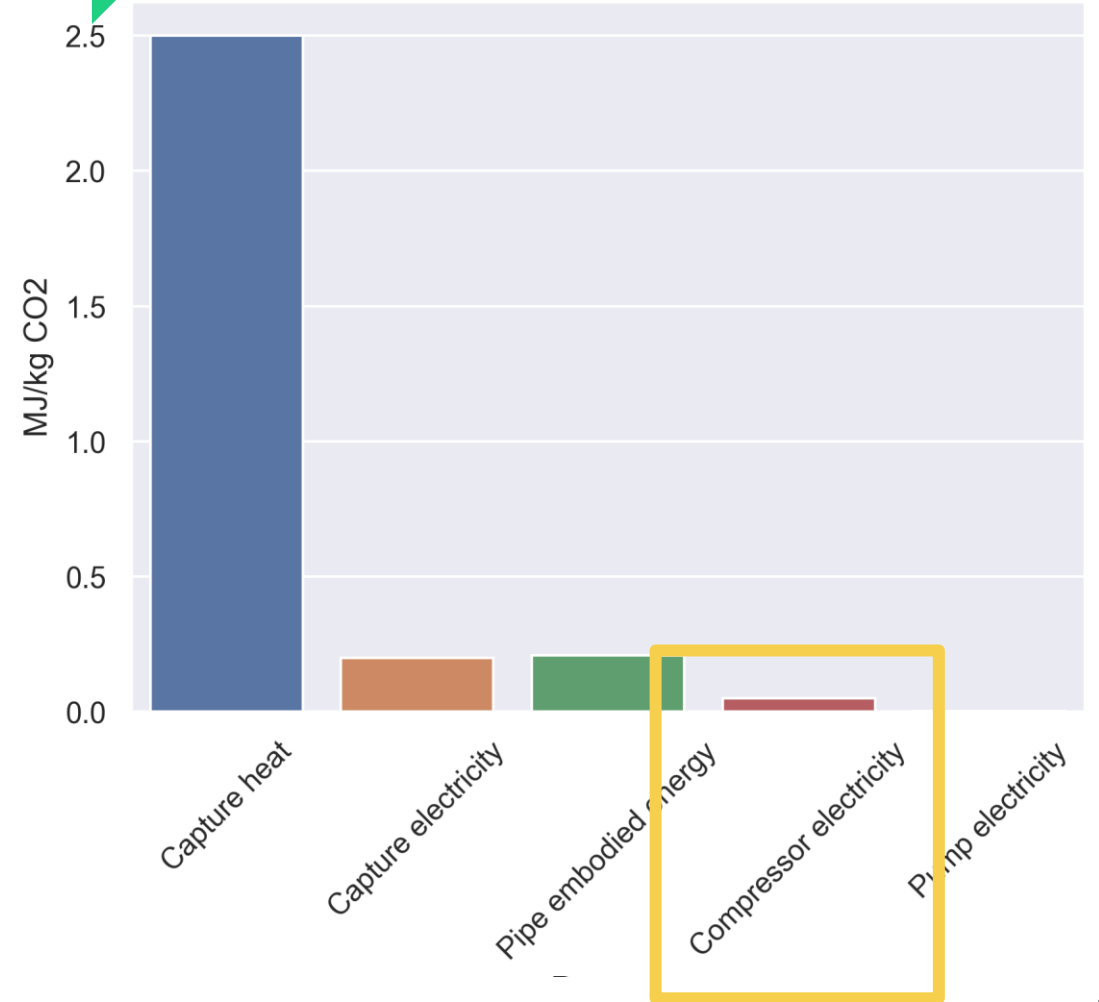
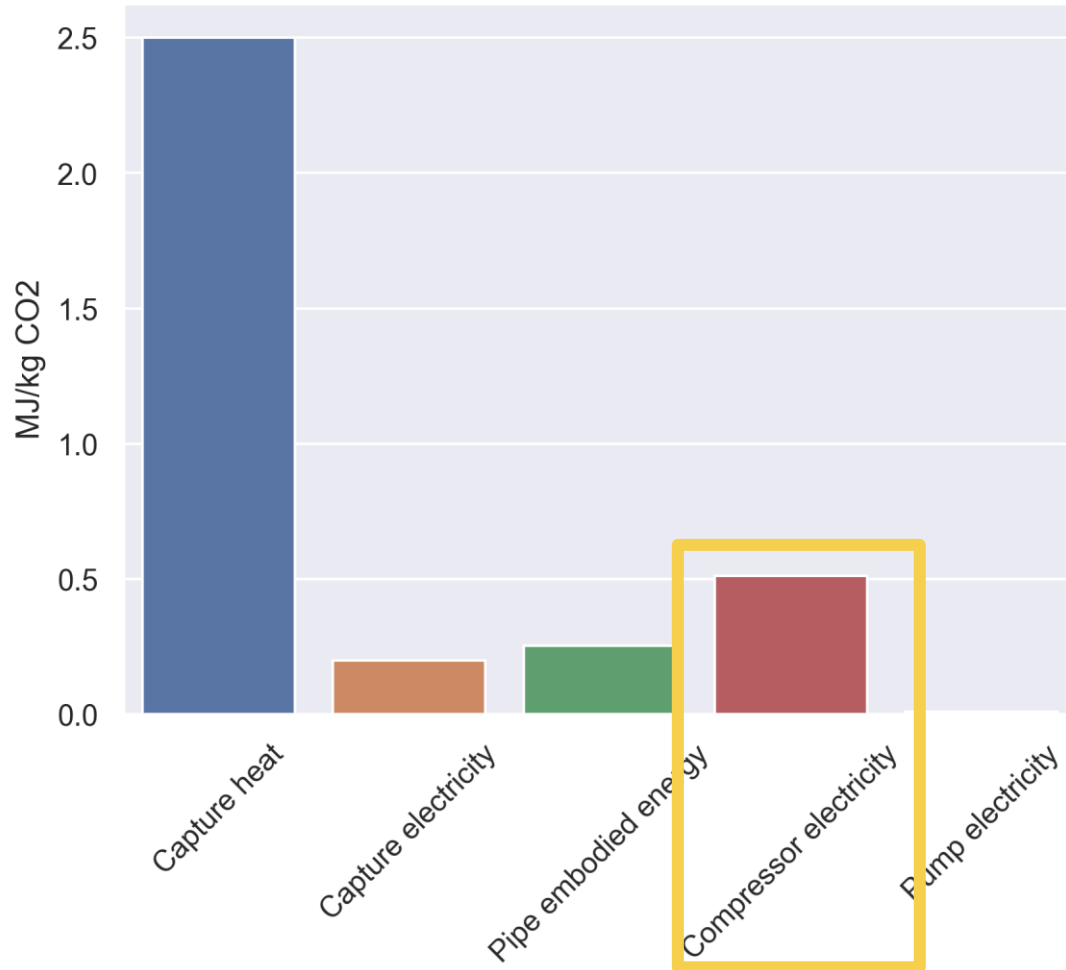


Energy demand

total CO2 storage 11 Mt/y



total CO2 storage 350 Mt/y



More to come

Heat integration for capture energy

Impurities

Other transport methods

Multiple storage sites

...

