

# Towards an EU Agenda for low-carbon buildings

## Keynote

Mining the atmosphere –  
Making the built environment a  
carbon sink

**Peter Richner**

Deputy Director, EMPA Schweiz



Willkommen  
Welcome  
Bienvenue



Mining the Atmosphere

CEPS Construction Day  
November 27, 2024, Brussels

Dr. Peter Richner  
Deputy Director Empa

# Klima- und Innovationsgesetz



Volksabstimmung vom 18. Juni  
2023

OECD/G20-Mindestbesteuerung

Am 18. Juni 2023 haben die Schweizer Stimmberechtigten über das Bundesgesetz über die Ziele im Klimaschutz, die Innovation und die Stärkung der Energiesicherheit (indirekter Gegenvorschlag zur Gletscher-Initiative) abgestimmt.

Yes 59.07%

## Art. 3 Ziel der Verminderung von Treibhausgasemissionen und der Anwendung von Negativemissionstechnologien

<sup>1</sup> Der Bund sorgt dafür, dass die Wirkung der in der Schweiz anfallenden von Menschen verursachten Treibhausgasemissionen bis zum Jahr 2050 Null beträgt (Netto-Null-Ziel), indem:

- a. die Treibhausgasemissionen so weit möglich vermindert werden; und
- b. die Wirkung der verbleibenden Treibhausgasemissionen durch die Anwendung von Negativemissionstechnologien in der Schweiz und im Ausland ausgeglichen wird.

<sup>2</sup> Nach dem Jahr 2050 muss die durch die Anwendung von Negativemissionstechnologien entfernte und gespeicherte Menge an CO<sub>2</sub> die verbleibenden Treibhausgasemissionen übertreffen.

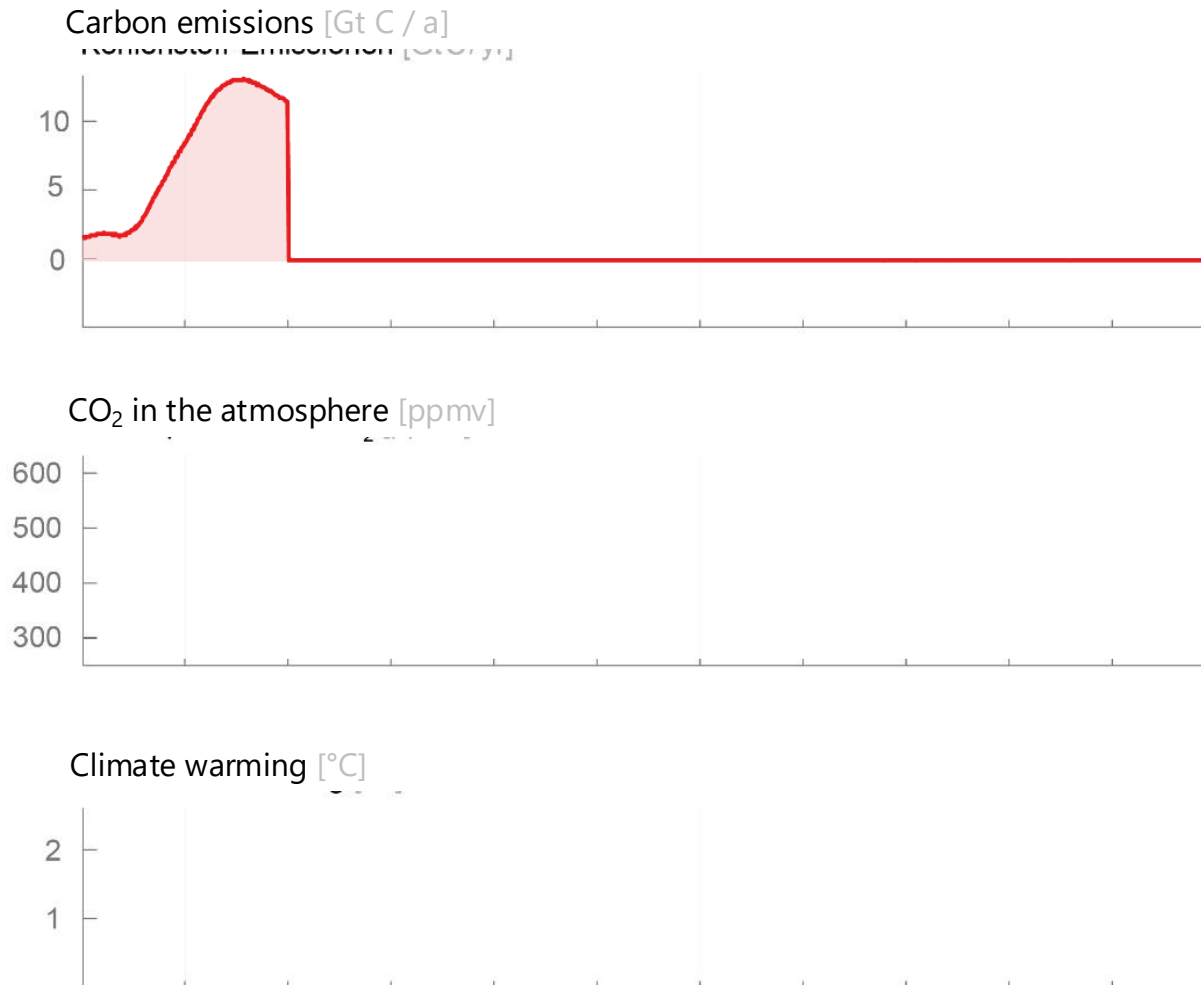
# Our CO<sub>2</sub>-Emissions

## A burden for the future



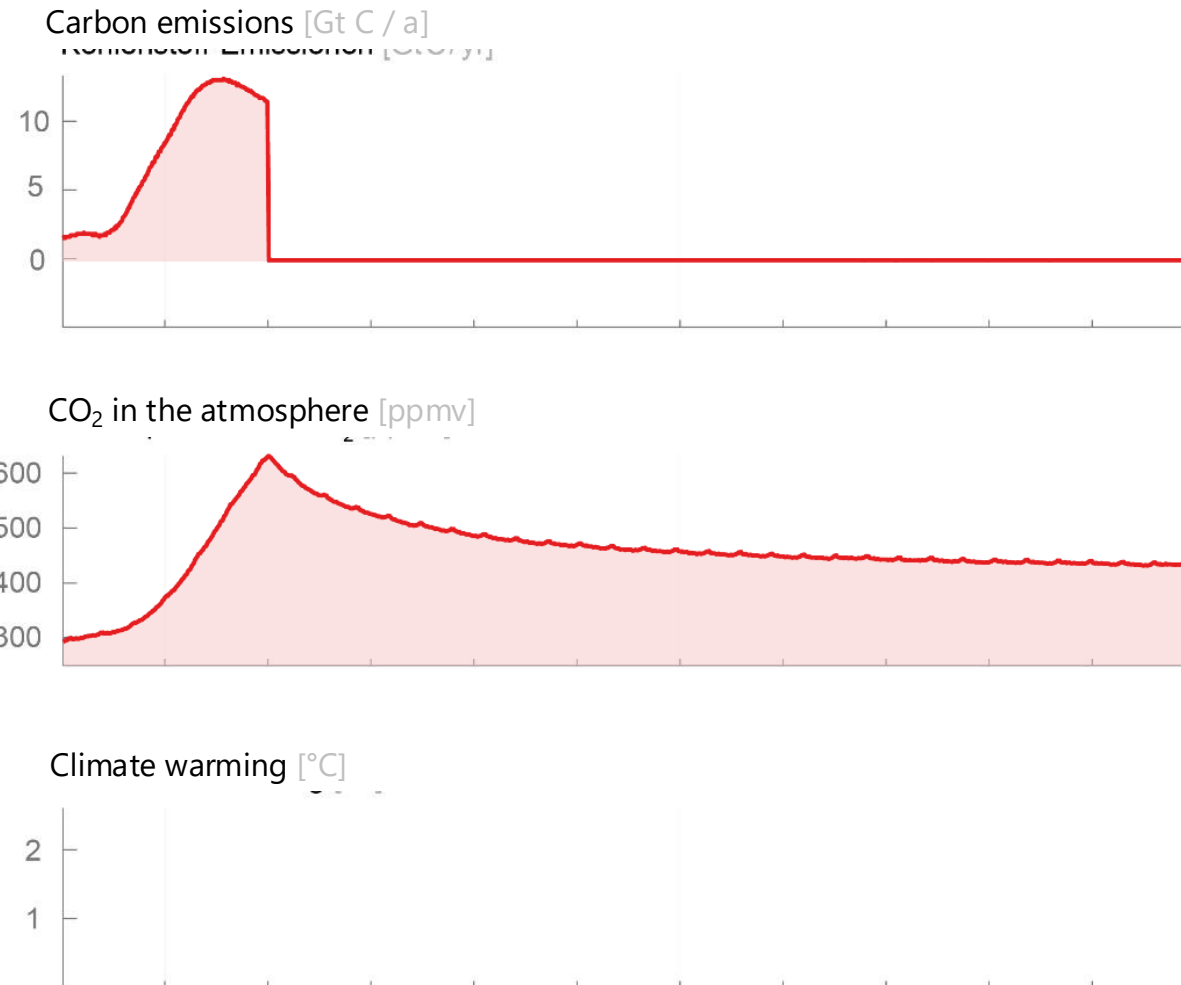
# Our CO<sub>2</sub>-Emissions

## A burden for the future



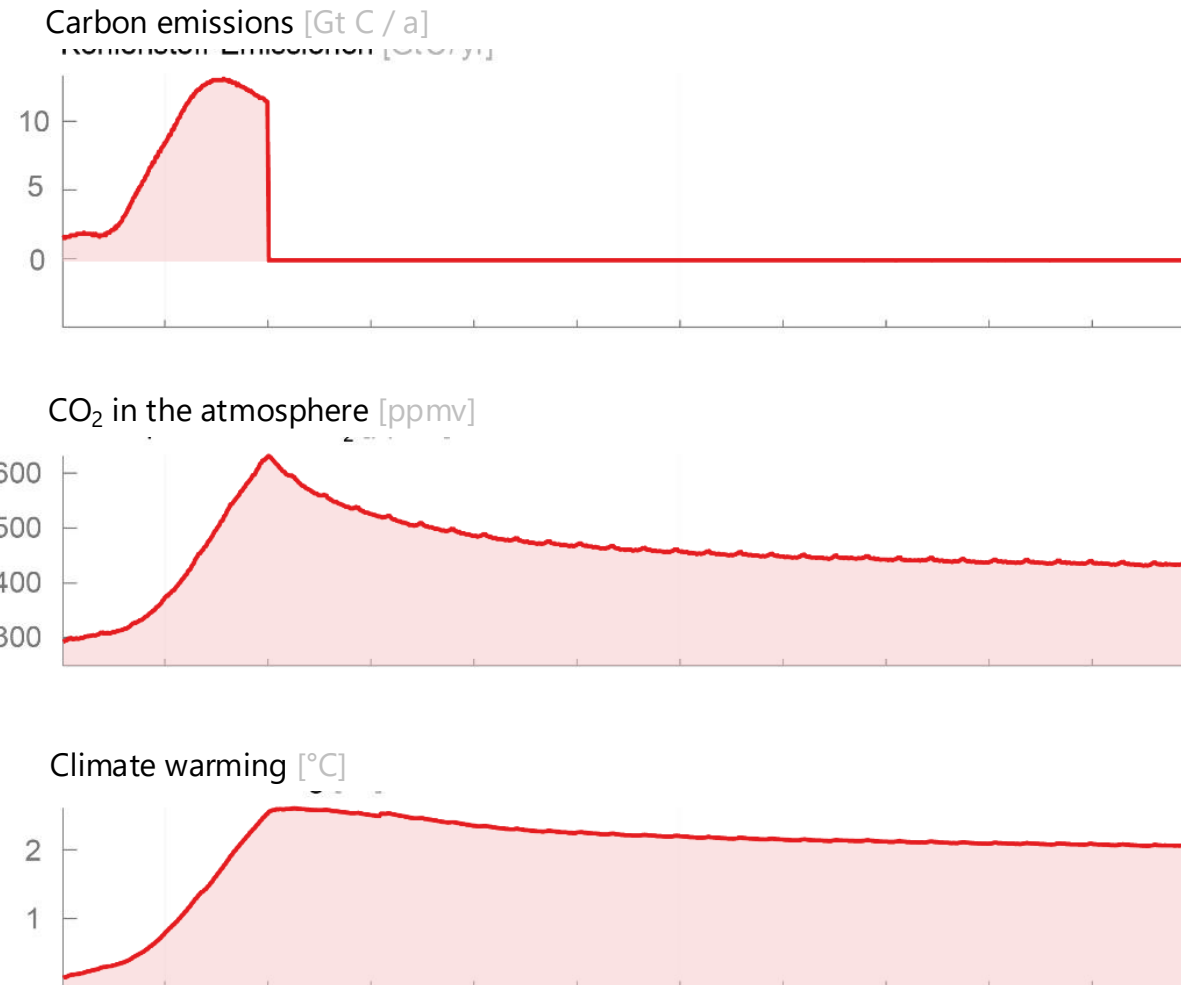
# Our CO<sub>2</sub>-Emissions

## A burden for the future



# Our CO<sub>2</sub>-Emissions

## A burden for the future



**Is this a Problem?**



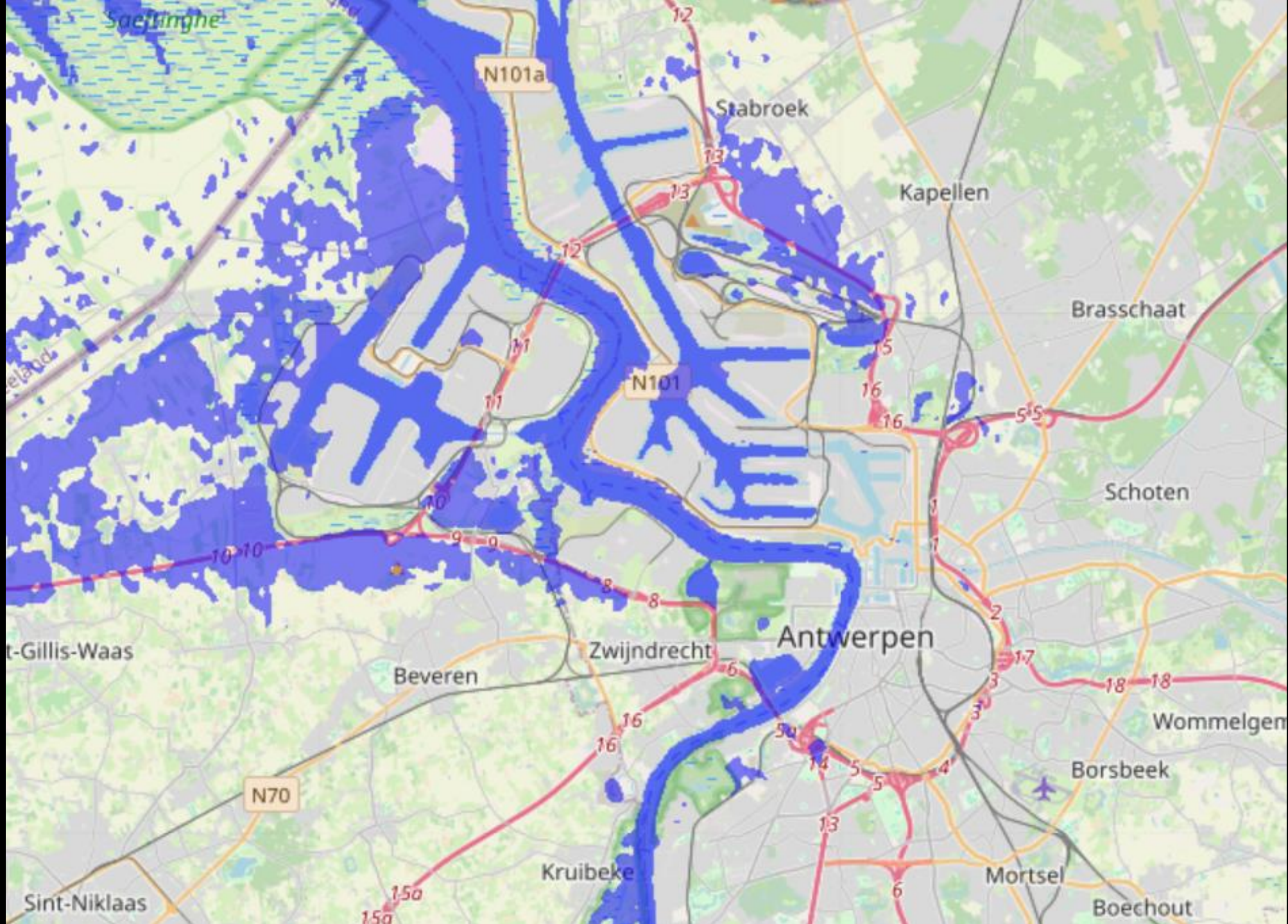


**Greenland ice shield**

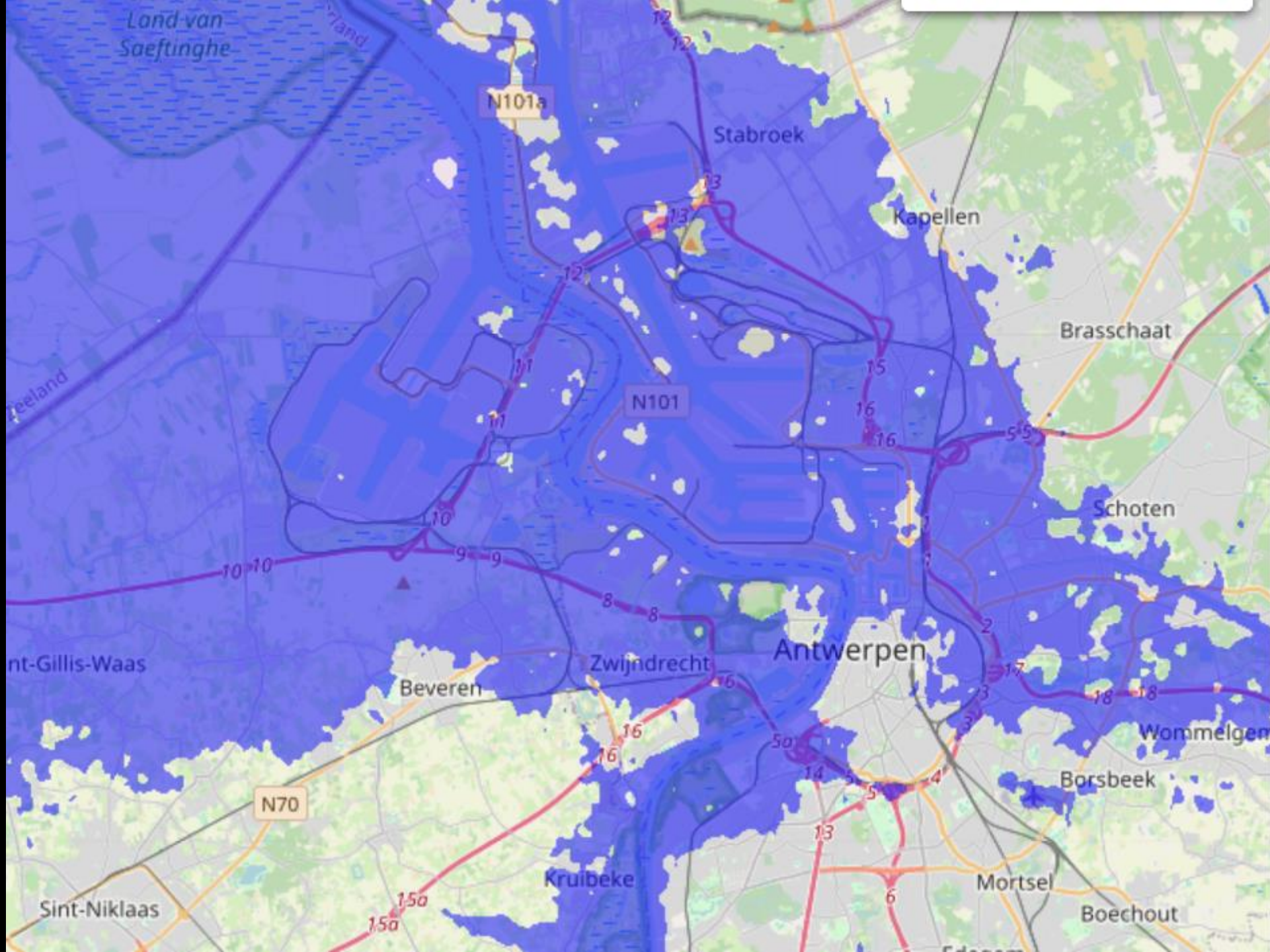
**≈**

**Sea level increase  
by 7 m**











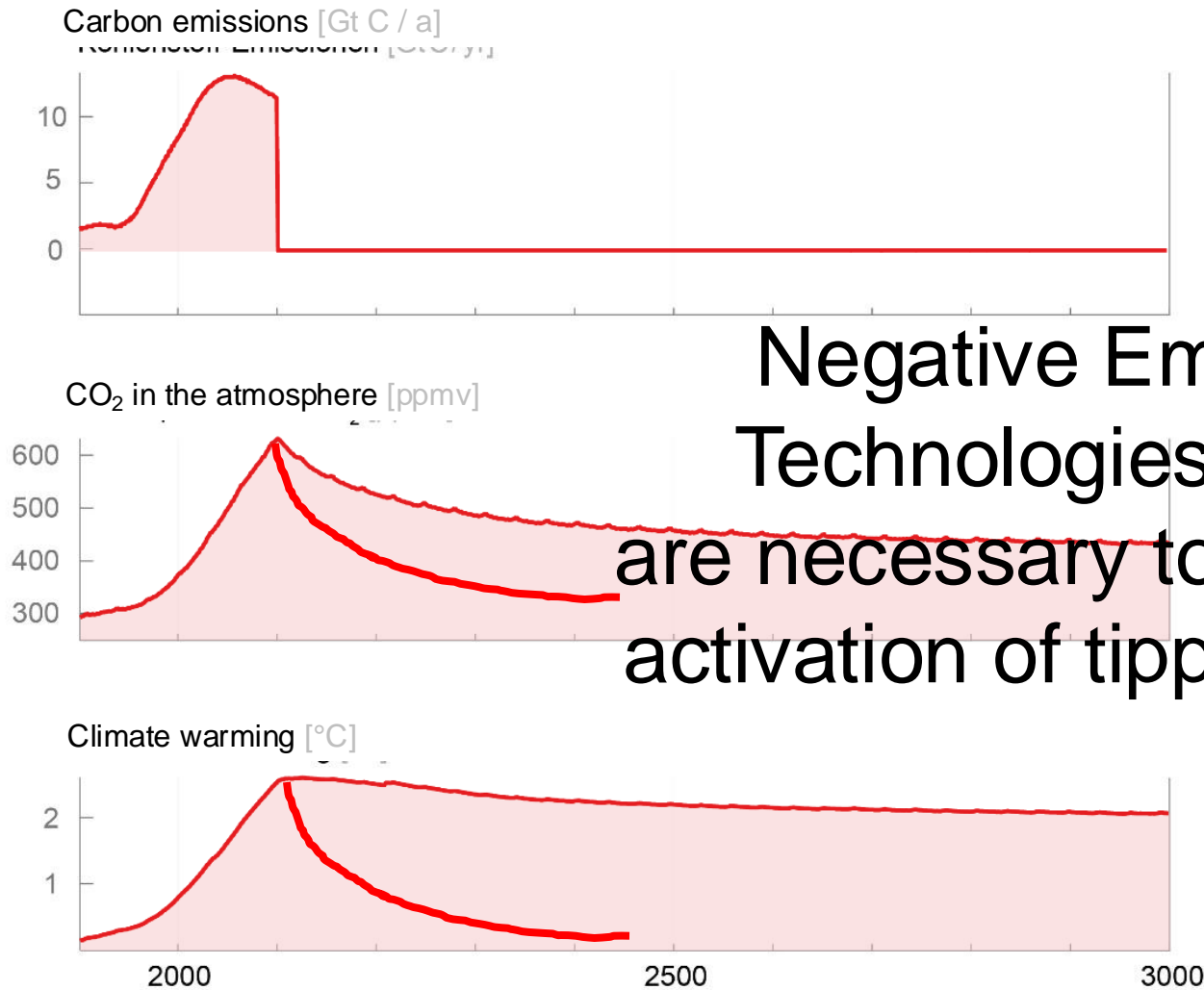
Valencia  
Region  
October  
2024



**+1°C = + 7% water in the atmosphere**

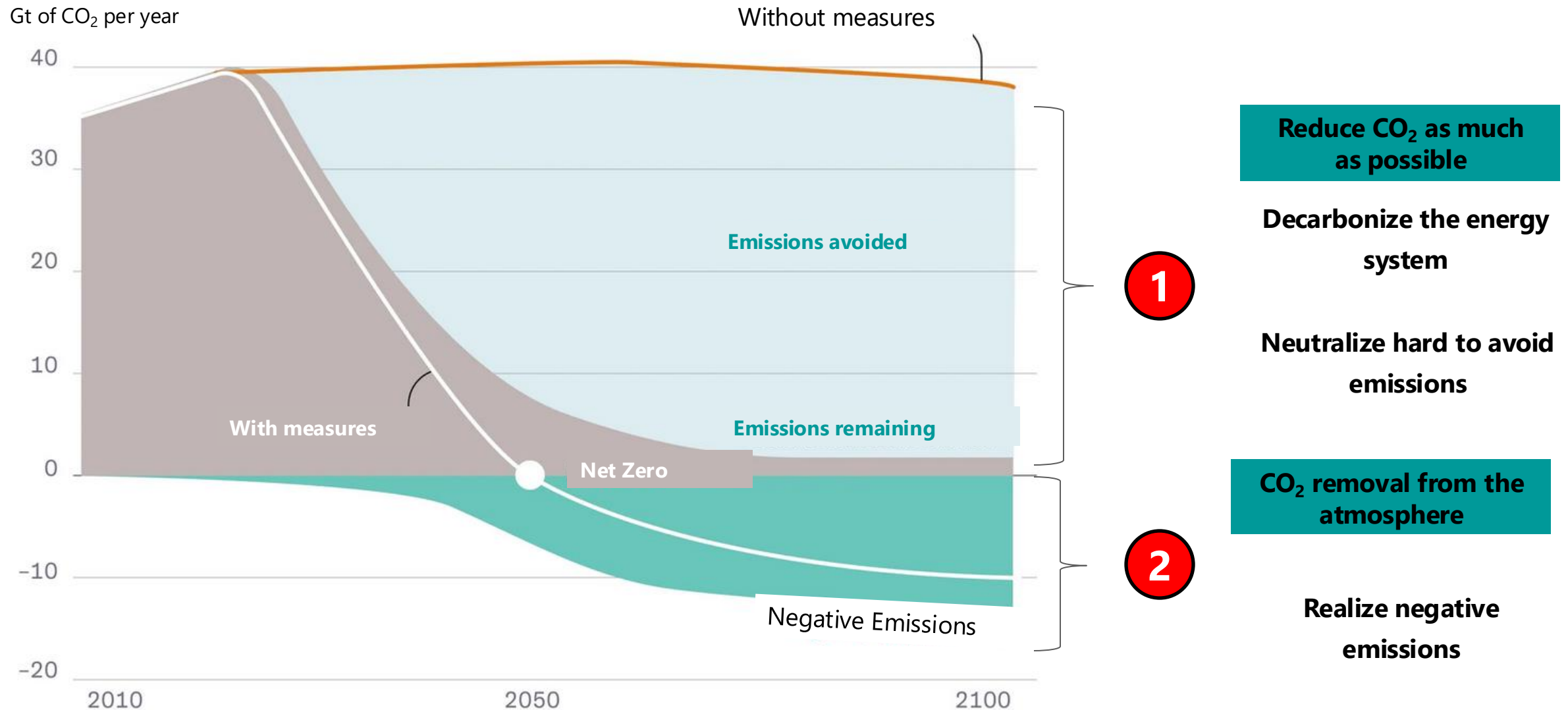
# Our CO<sub>2</sub>-Emissions

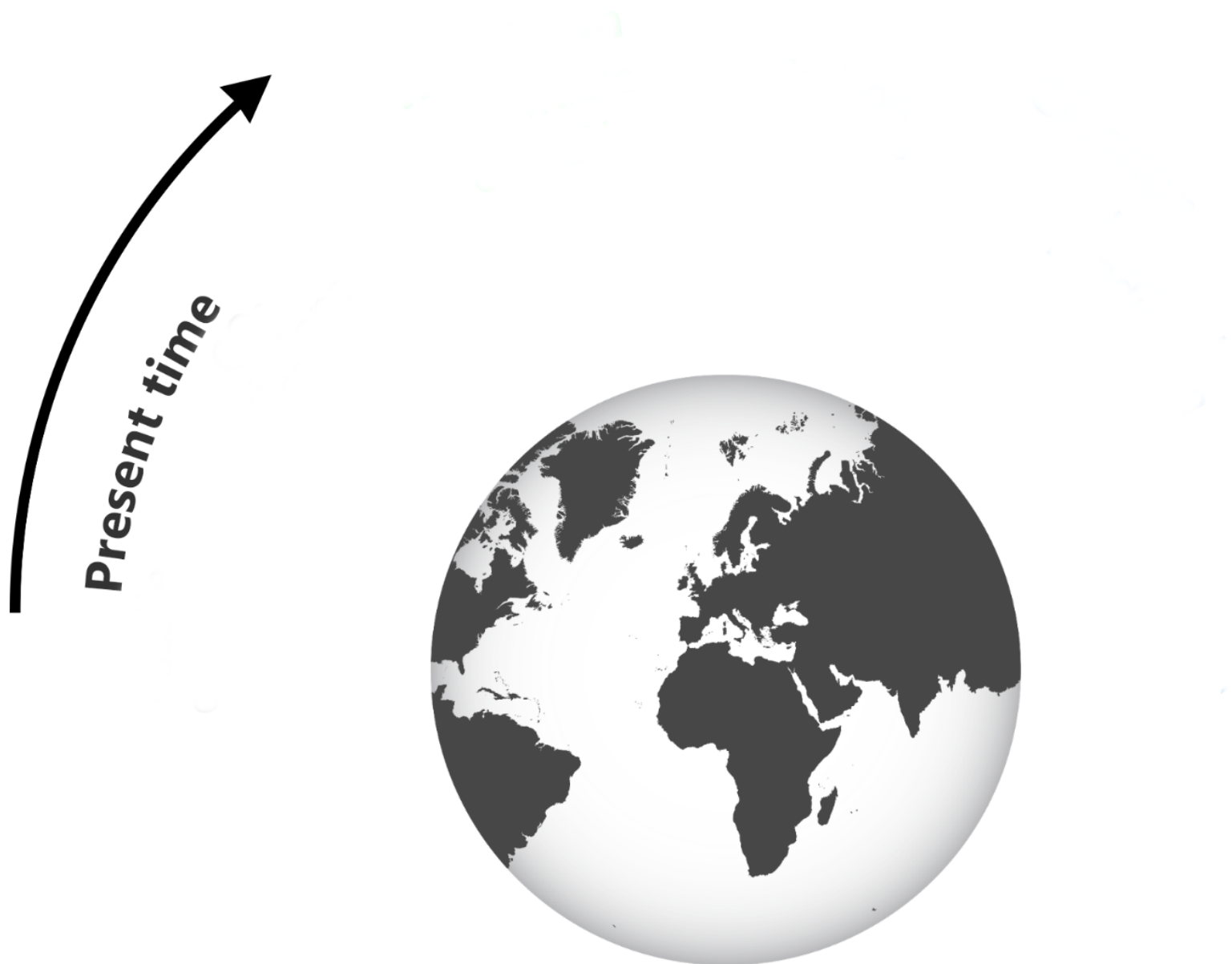
## A burden for the future



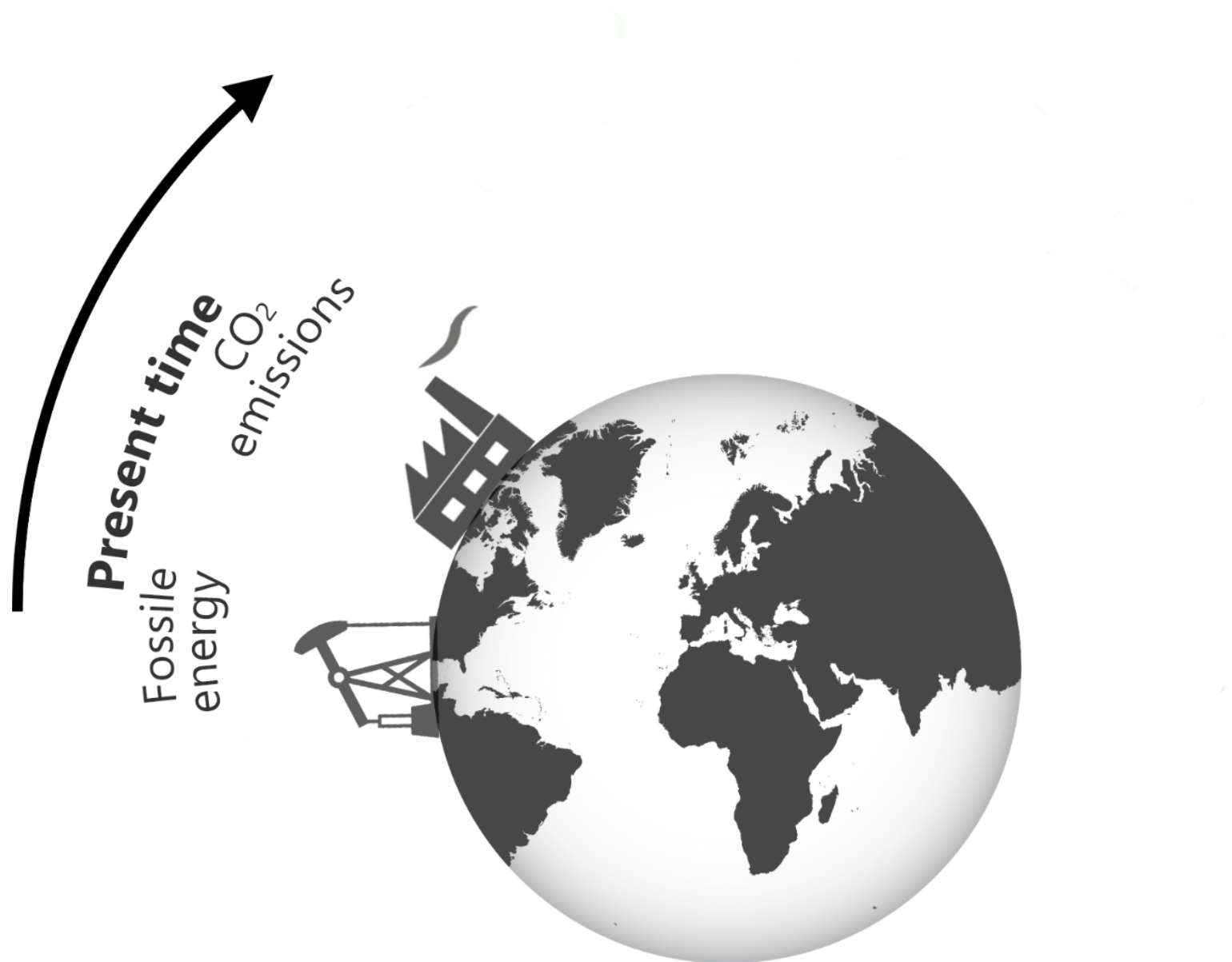
Negative Emission Technologies (NET) are necessary to avoid the activation of tipping points

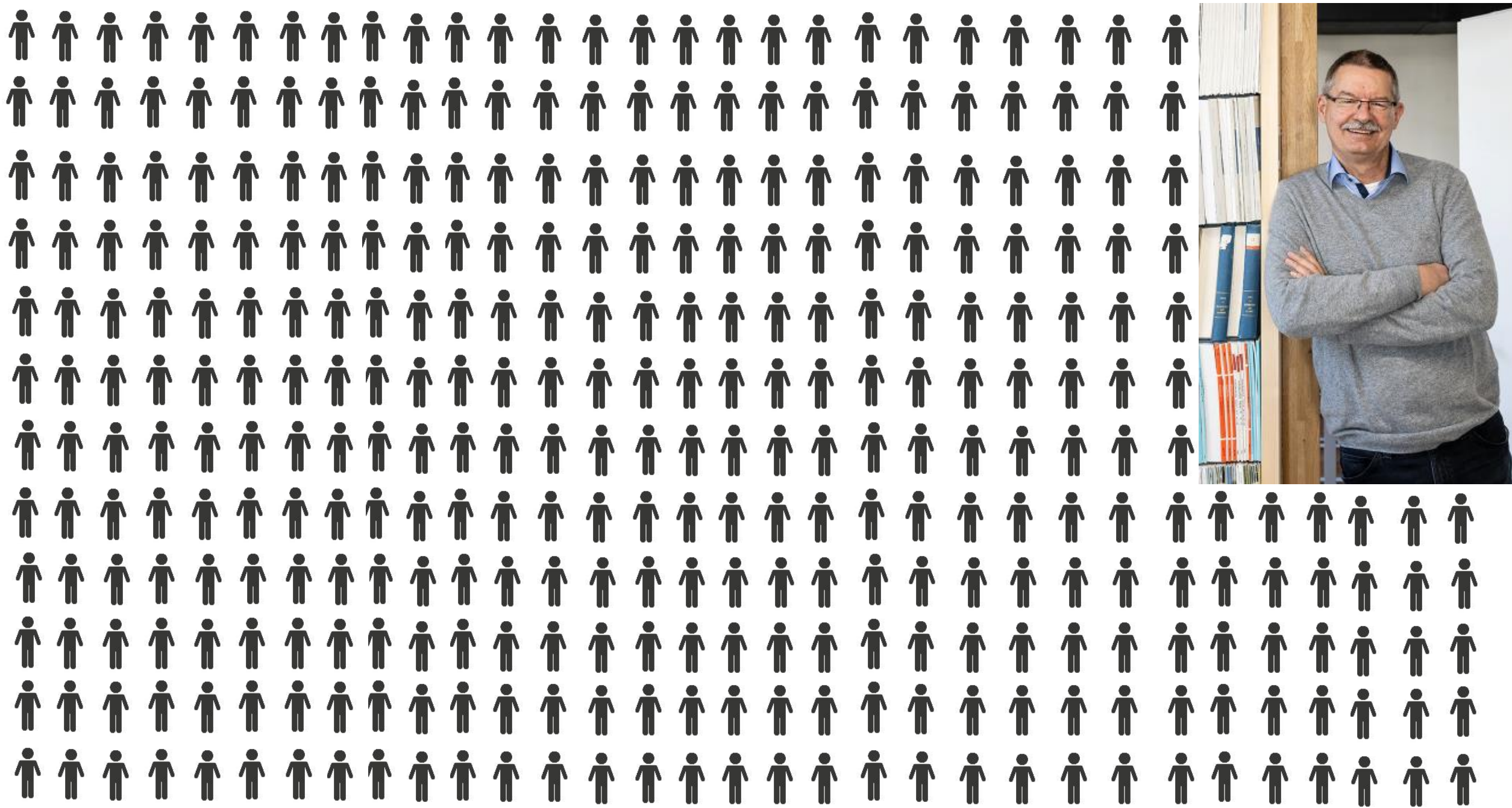
# NET ZERO is just the beginning





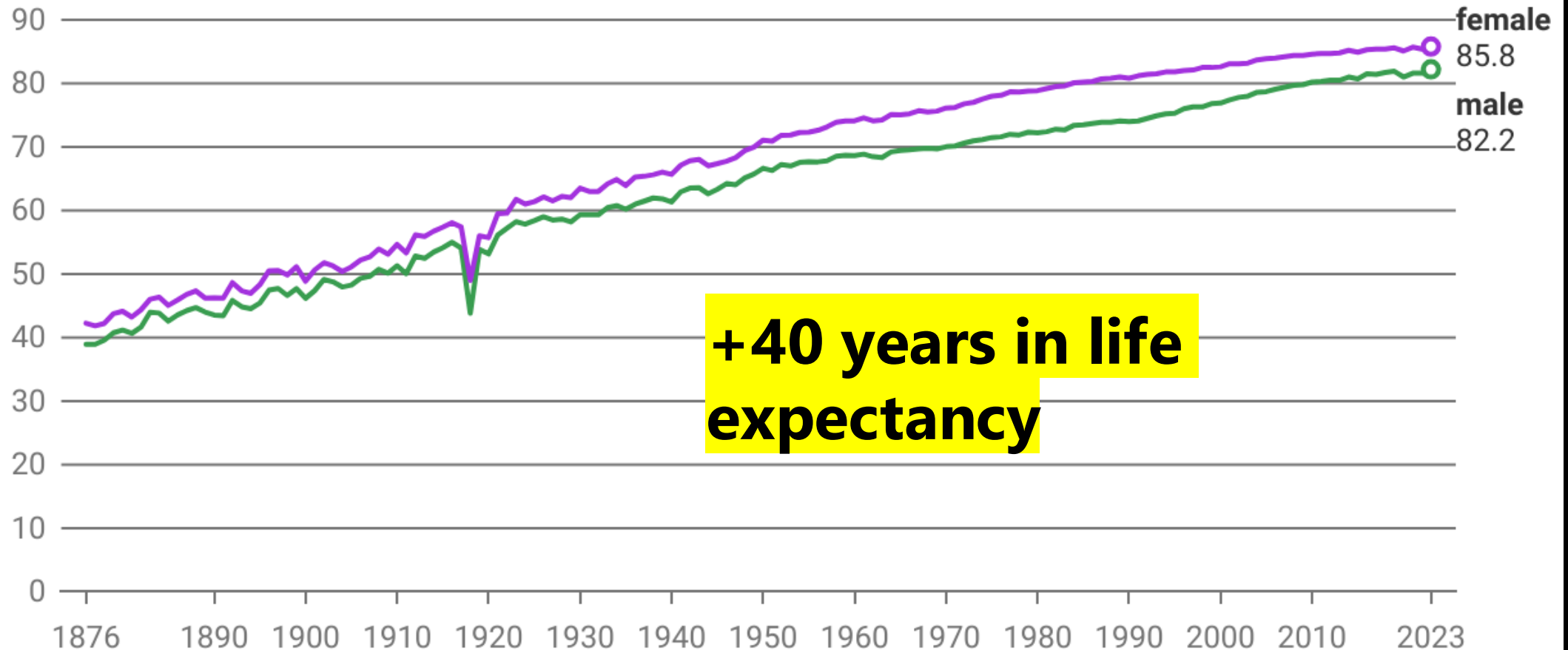






# Life Expectancy at Birth in Switzerland

In years

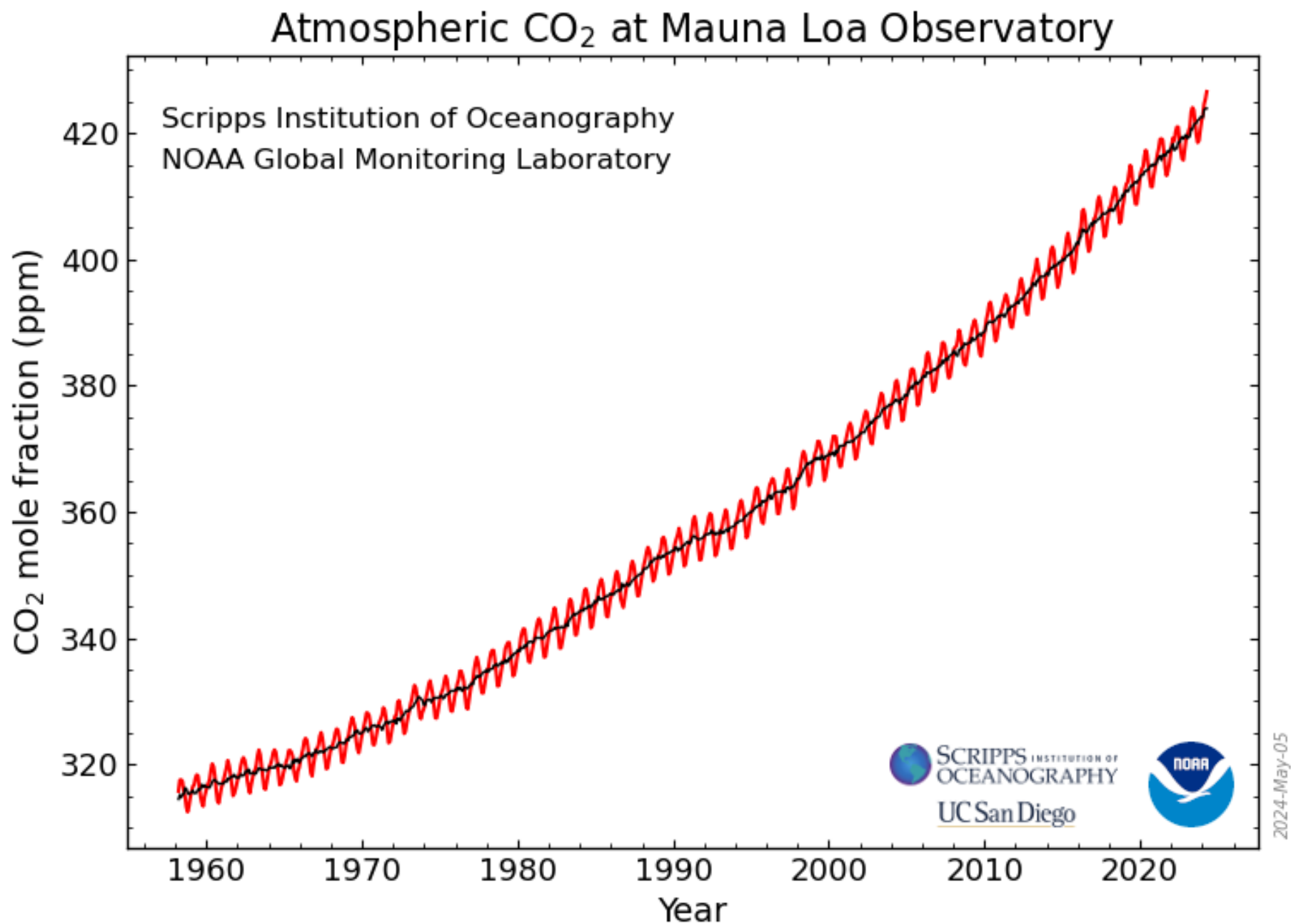


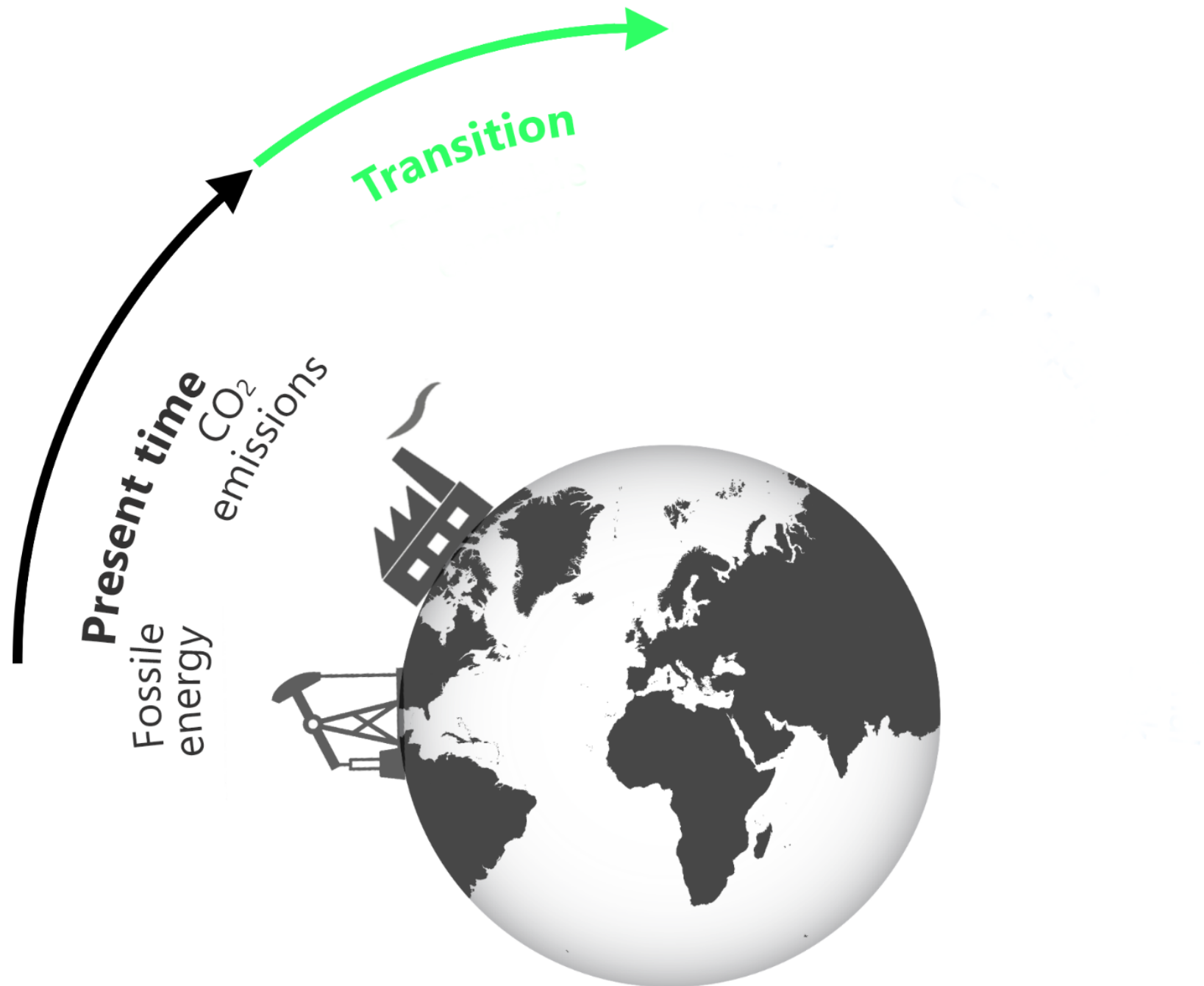
Data as on: 05.06.2024

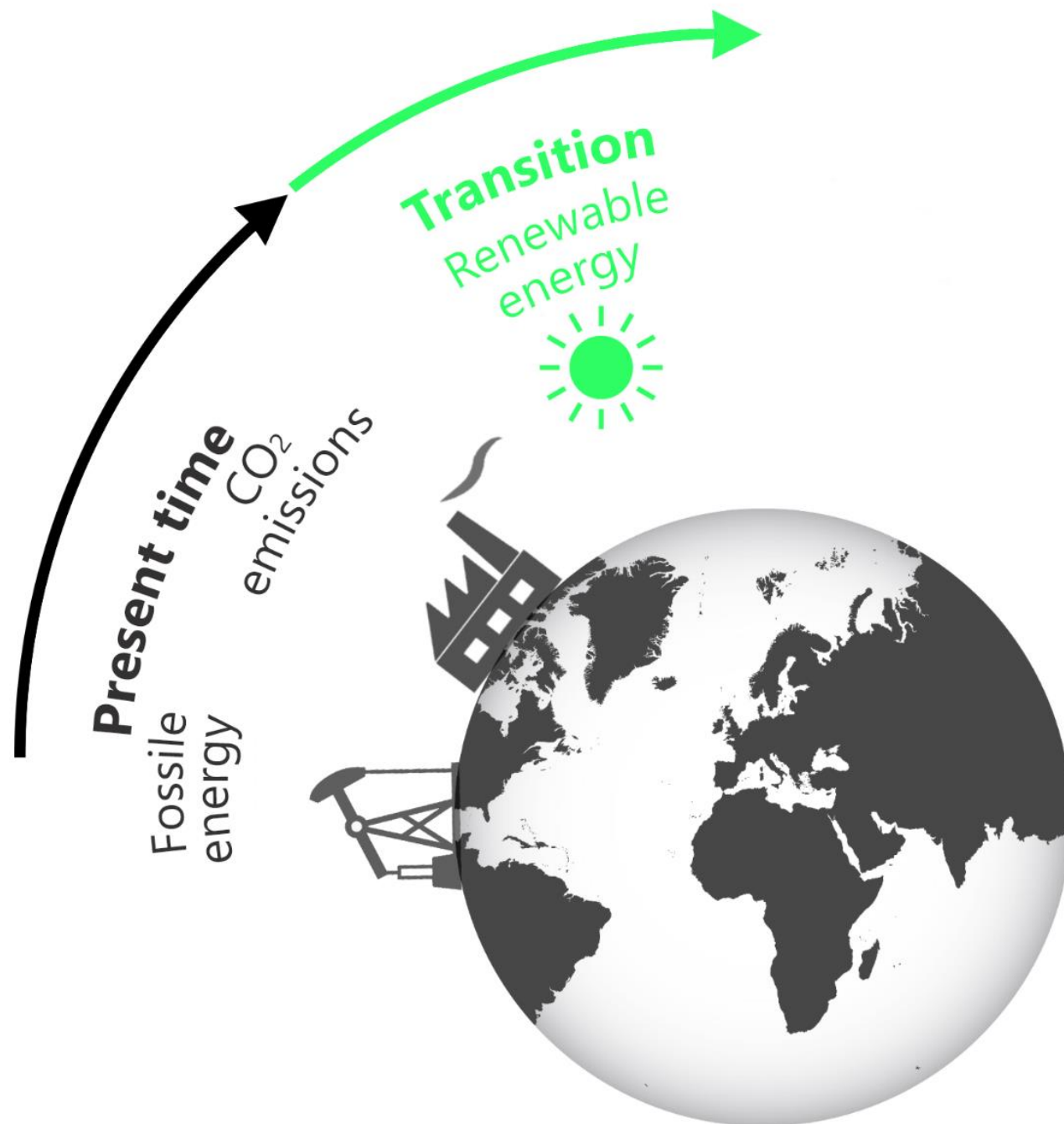
Source: FSO – BEVNAT, ESPOP, STATPOP

gr-e-01.04.02.03.08-su

© FSO 2024



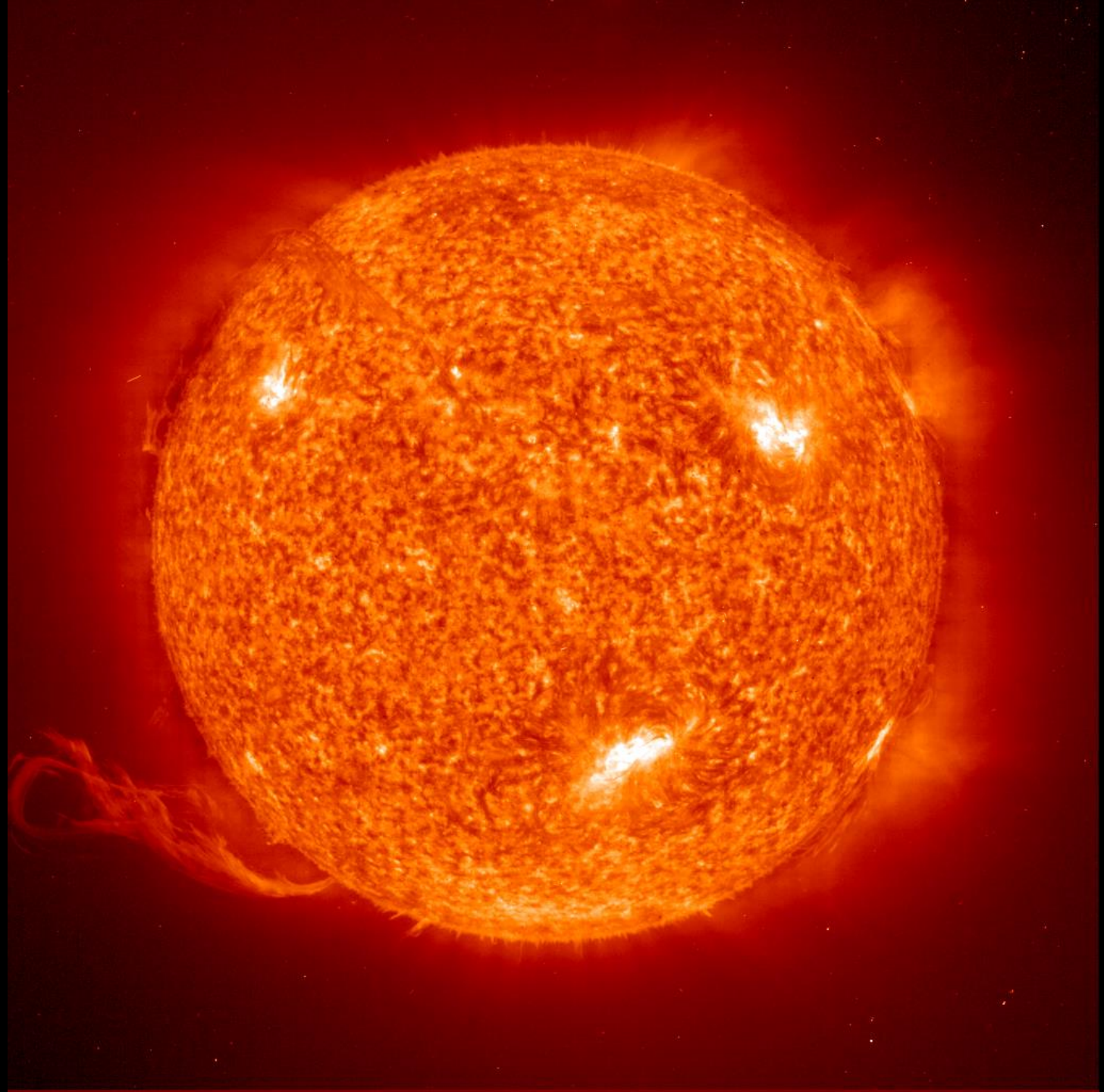






Solar Energy:  
 $1,5 \cdot 10^{18}$  kWh/a

Global energy demand:  
 $1,7 \cdot 10^{14}$  kWh/a  
 $\approx 0.01\%$



# Rollout of PV in the Sun Belt of the Earth

- Oman plans the installation of 4 GW PV until 2030 (500 MW already in operation)
- Production cost: **1-2 Ct/kWh**

## Oman kicks off tender for 500 MW of PV

The Omani authorities aim to develop a 500 MW solar project in Ibri, in northwestern Oman, where other PV facilities are located.

JANUARY 9, 2024 **EMILIANO BELLINI**

**MARKETS** **UTILITY SCALE PV** **OMAN**



Sterling and Wilson Solar built this 125 MWp project in Oman

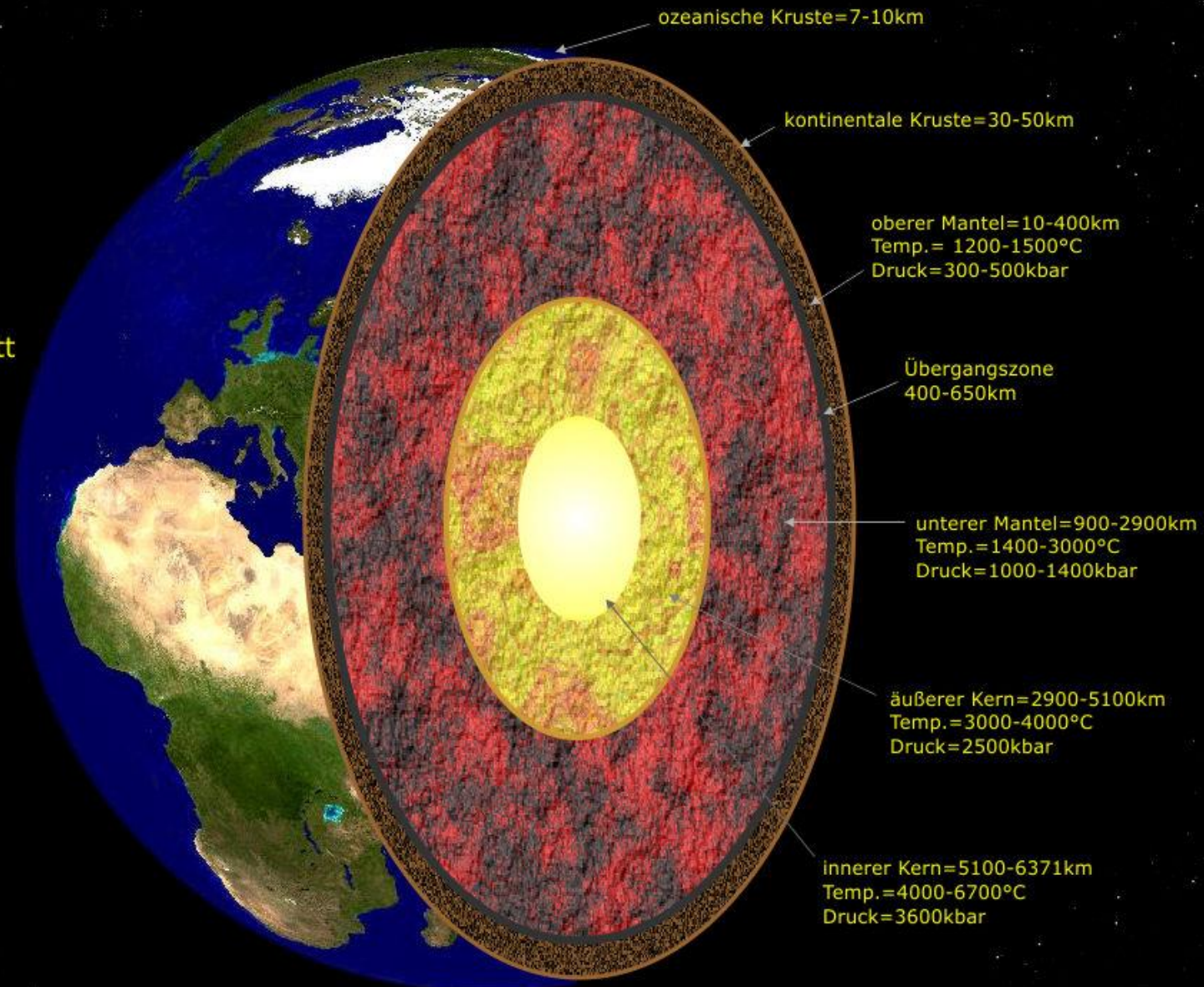
*Image: Sterling and Wilson Solar*

Share     

Oman Power and Water Procurement Co. (OPWP) has launched a [tender](#) to select independent power producers (IPP) to build a 500 MW solar park.



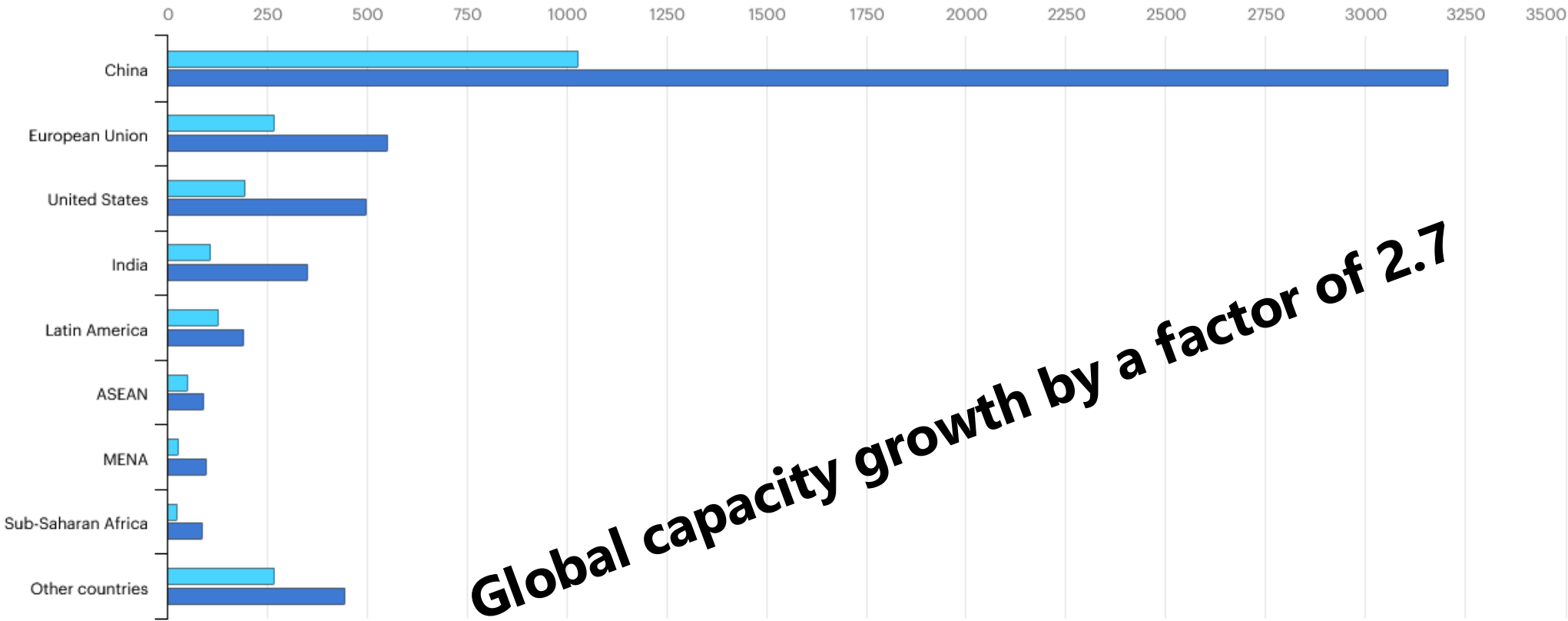
Querschnitt  
der Erde



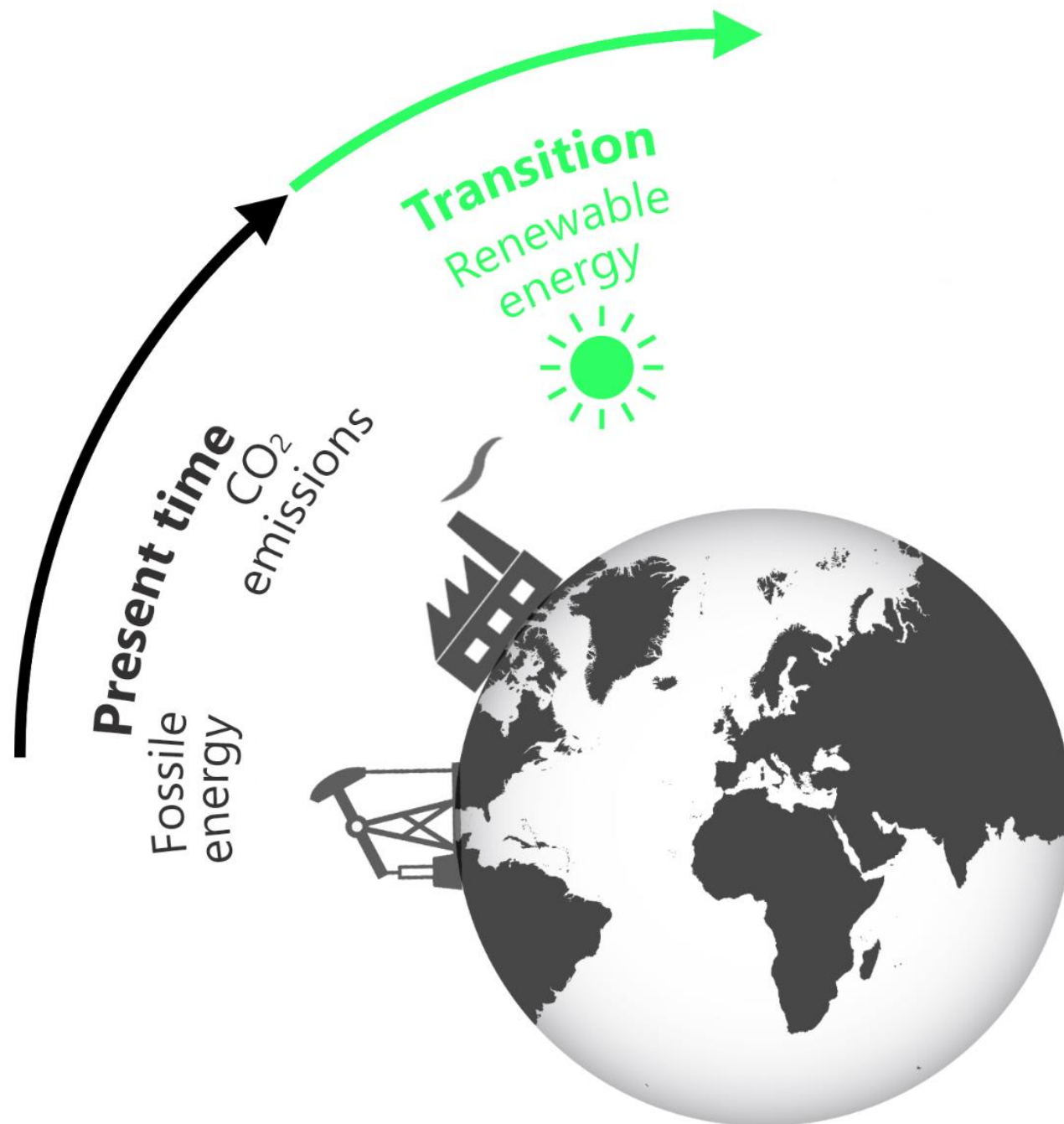
**99% of the earth are hotter than 1'000°C ...**

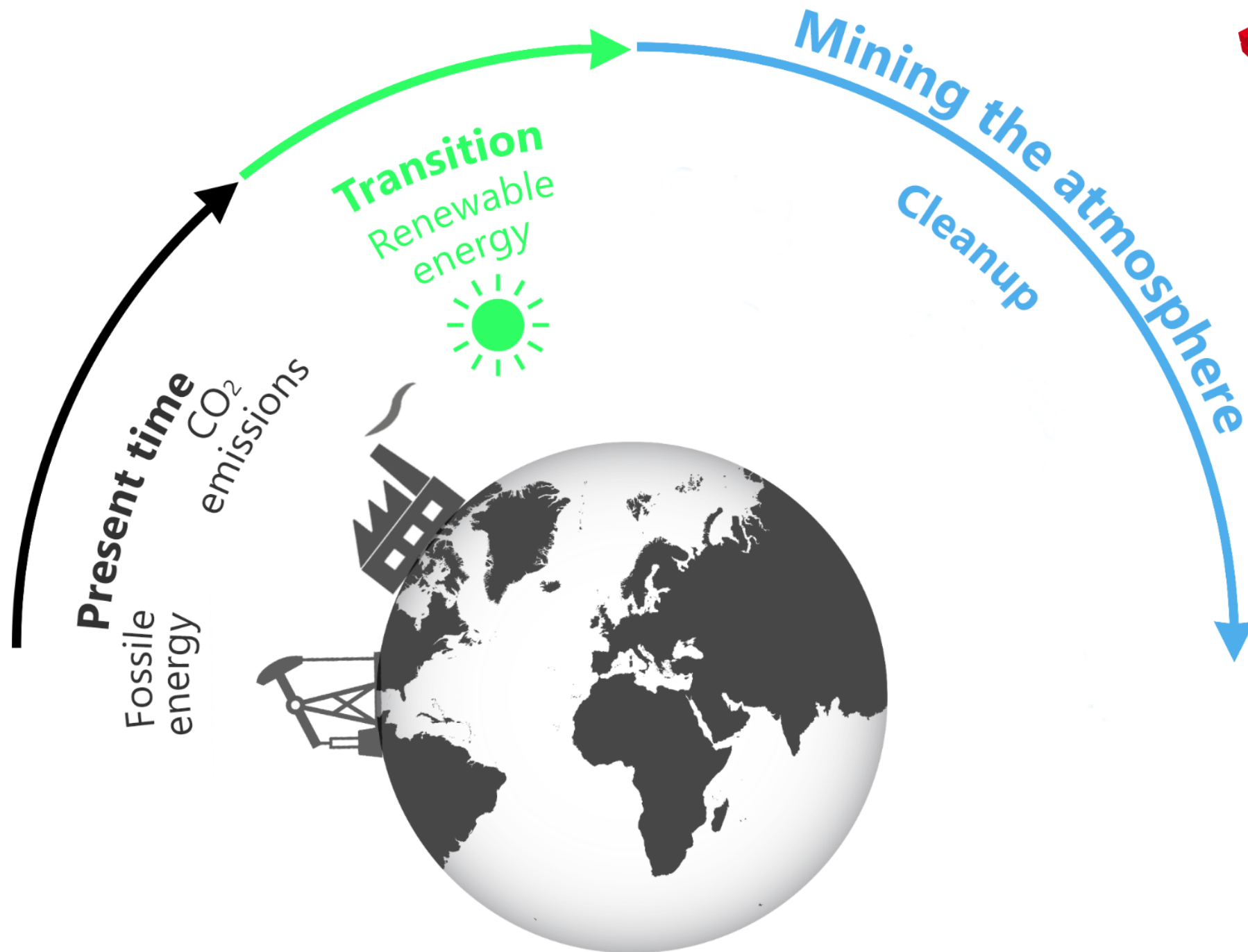
# Renewable electricity capacity growth by 2017-2030

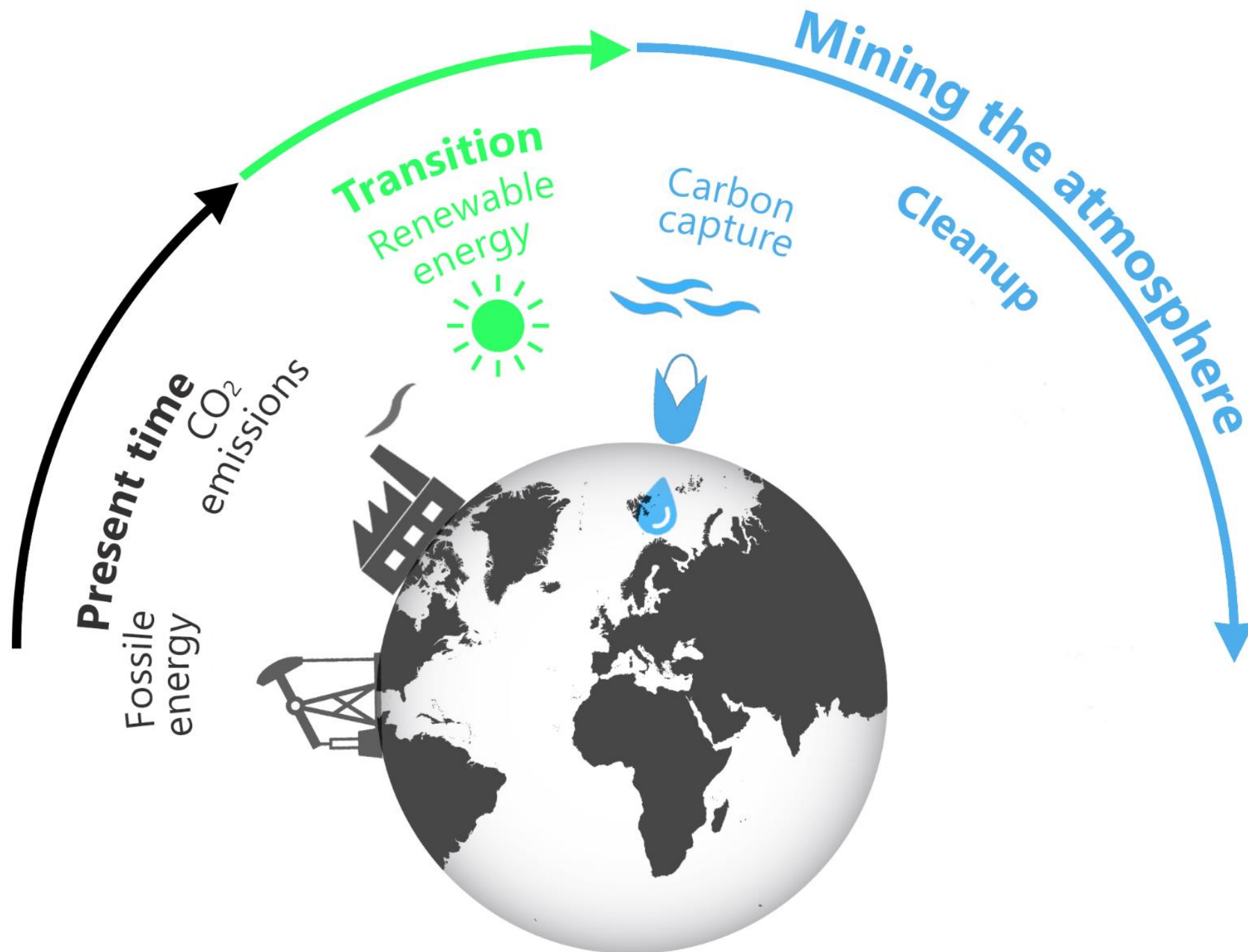
GW



**Global capacity growth by a factor of 2.7**



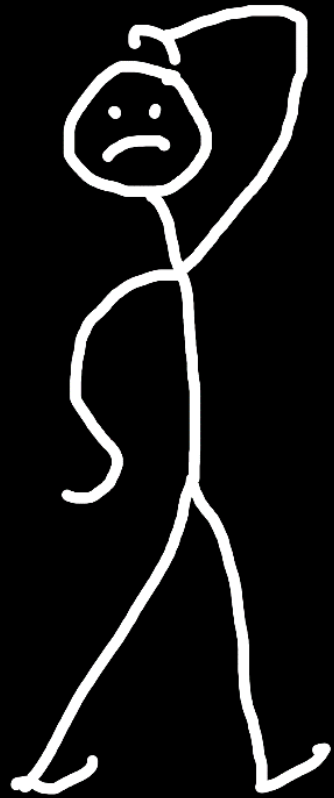






# Sources for CO<sub>2</sub> Capture





**And who should  
pay for this?**



## Atmosphere

1'280 Gt CO<sub>2</sub> 1850-2022

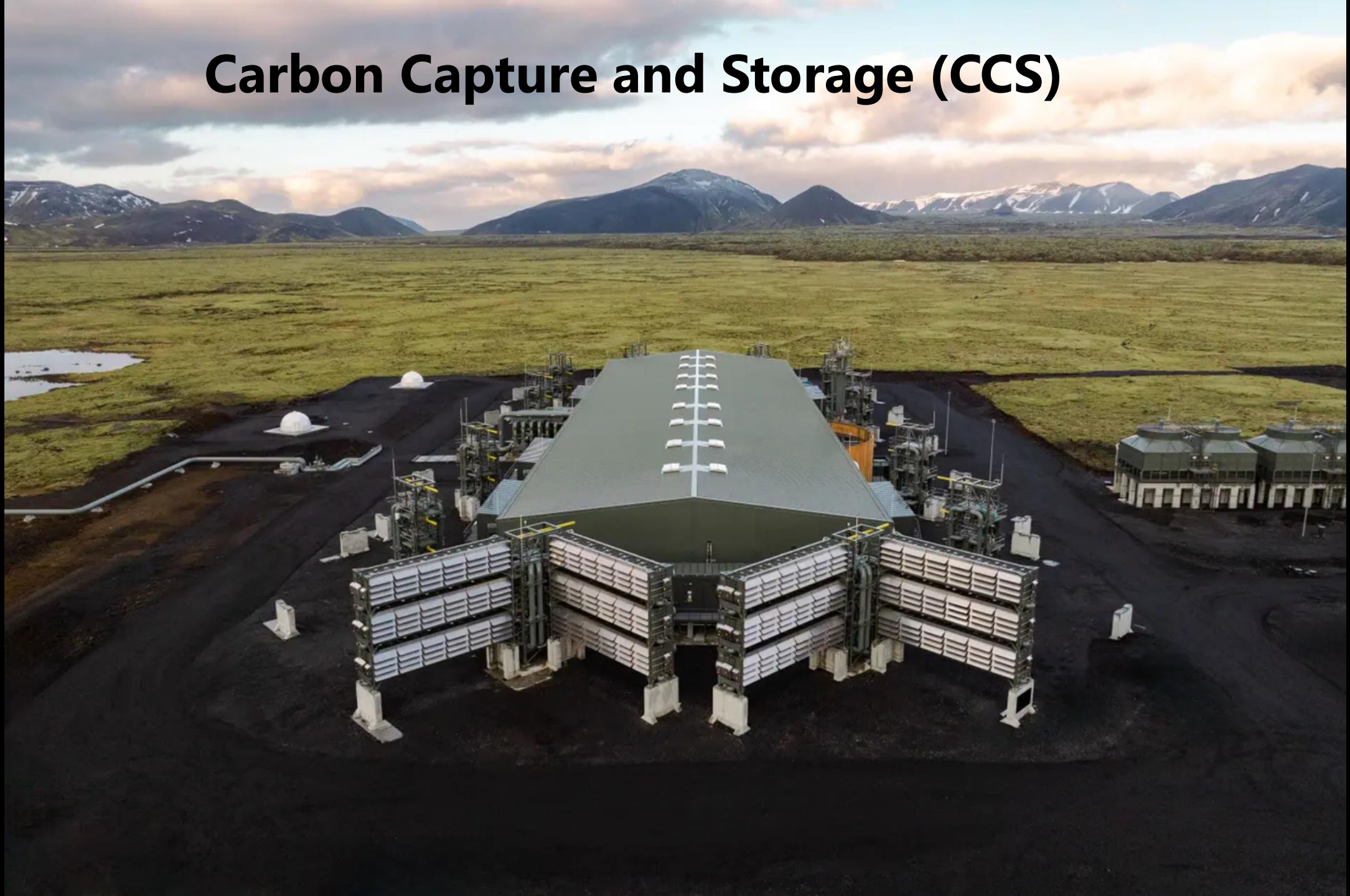
~ 600 Gt CO<sub>2</sub> have to be  
removed





# Carbon Capture and Storage (CCS)

Mammoth-Facility of Climeworks in Iceland





# Atmosphere

1'280 Gt CO<sub>2</sub> 1850-  
2022

~ 600 Gt CO<sub>2</sub> have  
to be  
removed

Cost estimation  
Climeworks





## Hasardous waste landfill Kölliken

664'000 t contaminated  
material had to be  
removed

Total cost € 850 Mio

€ 1'280/t





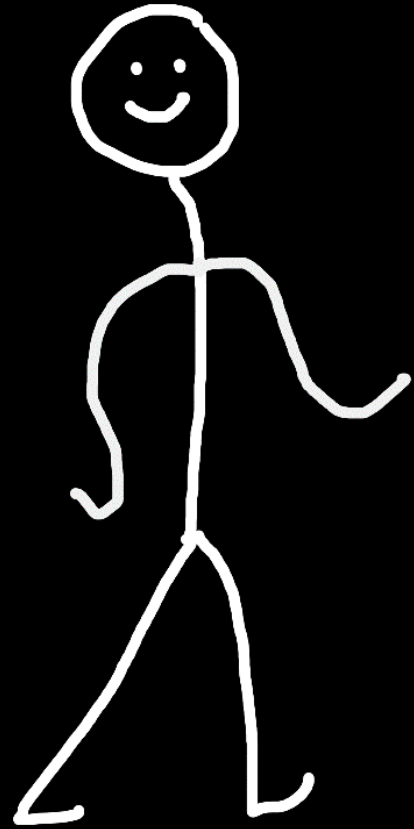
# Atmosphere

1'280 Gt CO<sub>2</sub> 1850-  
2022

~ 600 Gt CO<sub>2</sub> have to  
be  
removed

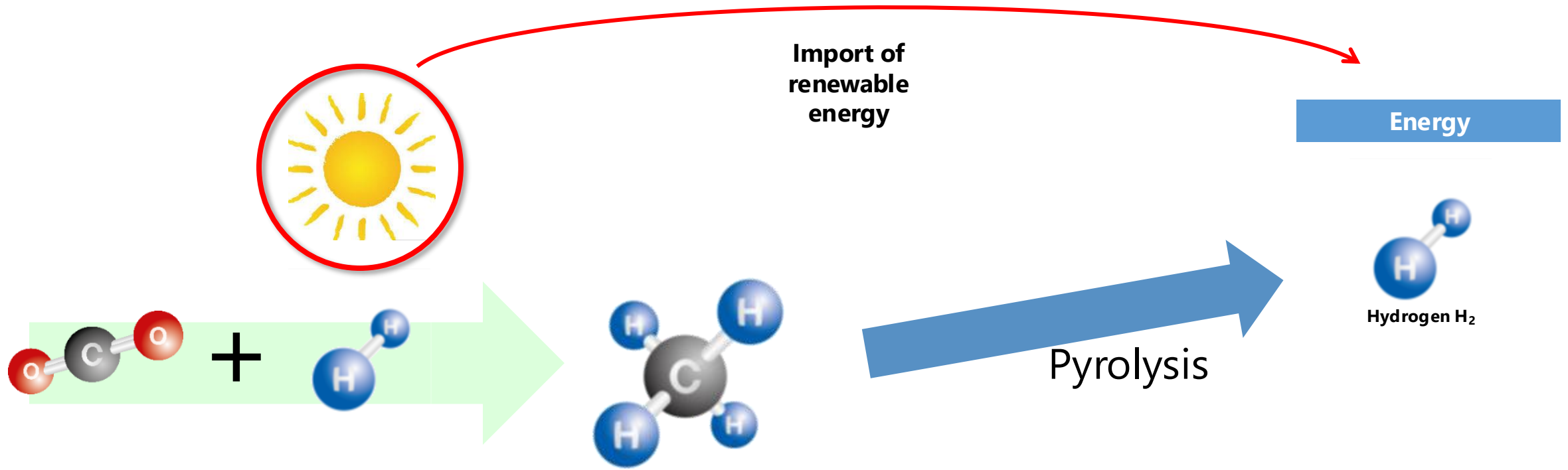
Cost estimation  
Climeworks





**Generating Added Value!**

# Carbon Capture and Use



# Covering the CH-Electricity Deficit in Winter of 8 TWh

- 1.5 TWh in a LNG-Tanker with 250'000 m<sup>3</sup>
- 50% loss due to pyrolysis -> 20 Tankers to import 8 TWh of electricity in winter



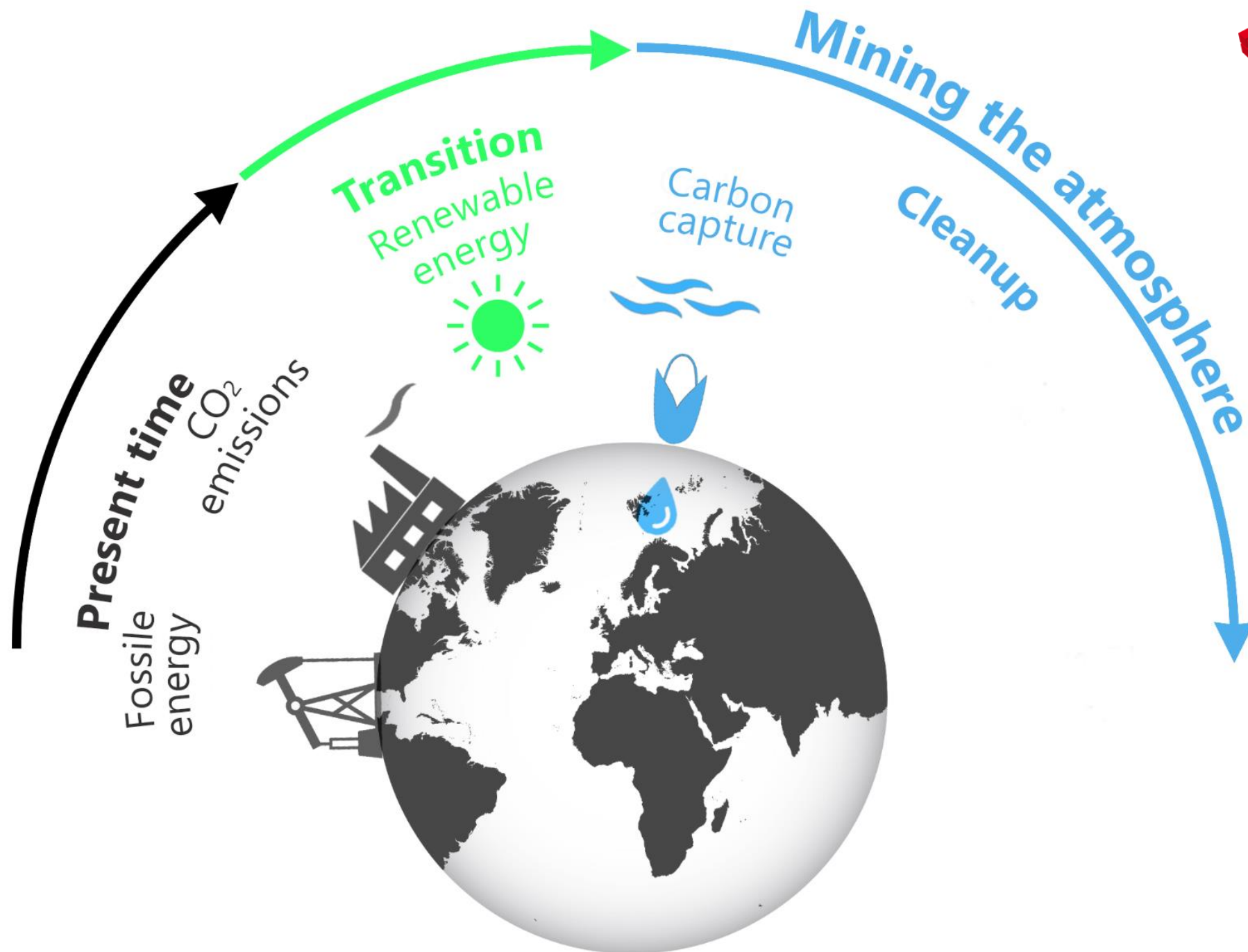


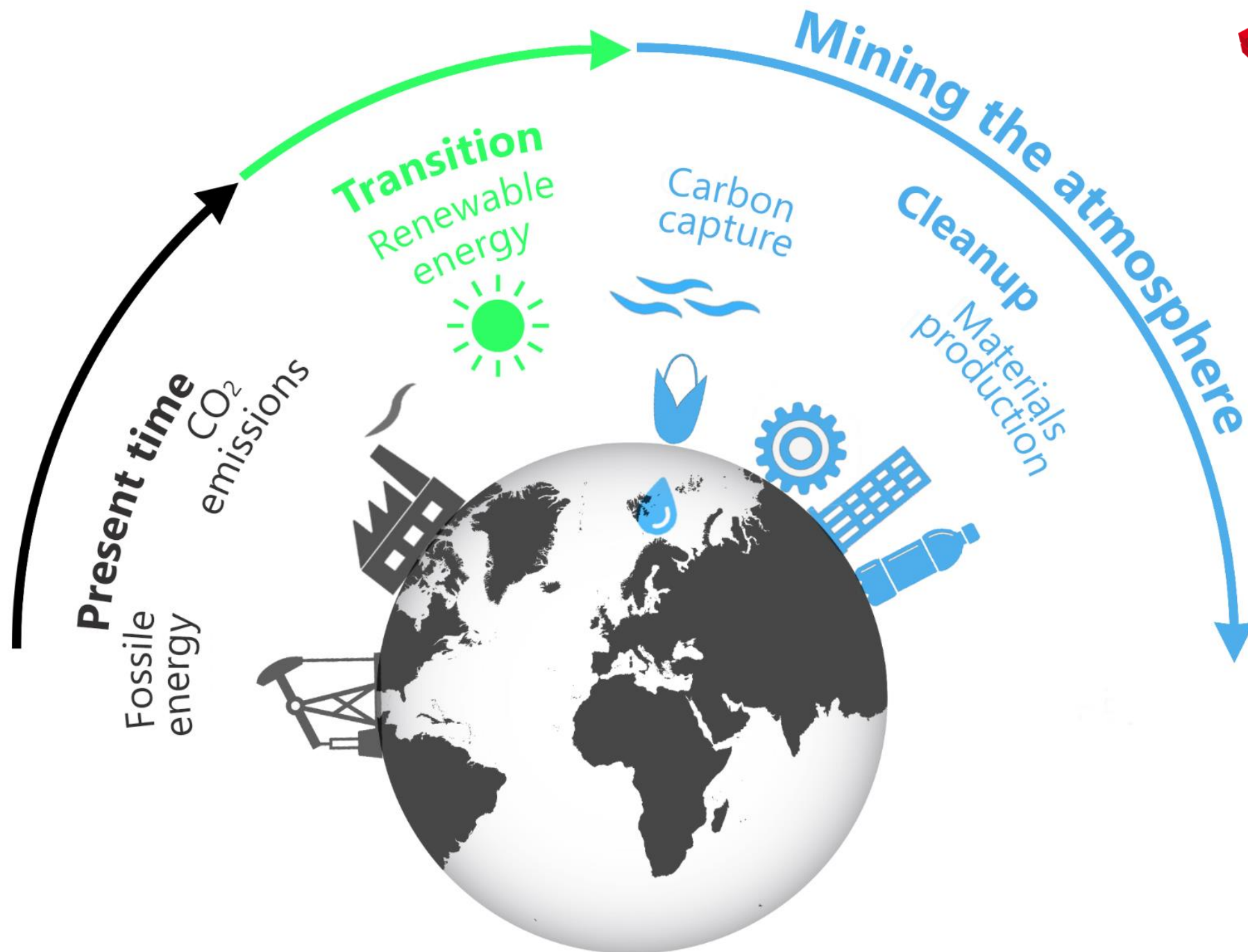
# Covering the CH-Electricity Deficit in Winter of 8 TWh

- 1.5 TWh in a LNG-Tanker with 250'000 m<sup>3</sup>
- 50% loss due to pyrolysis -> 20 Tankers to import 8 TWh of electricity in winter  
*(today: ~ 90 tankers of crude oil over the year)*

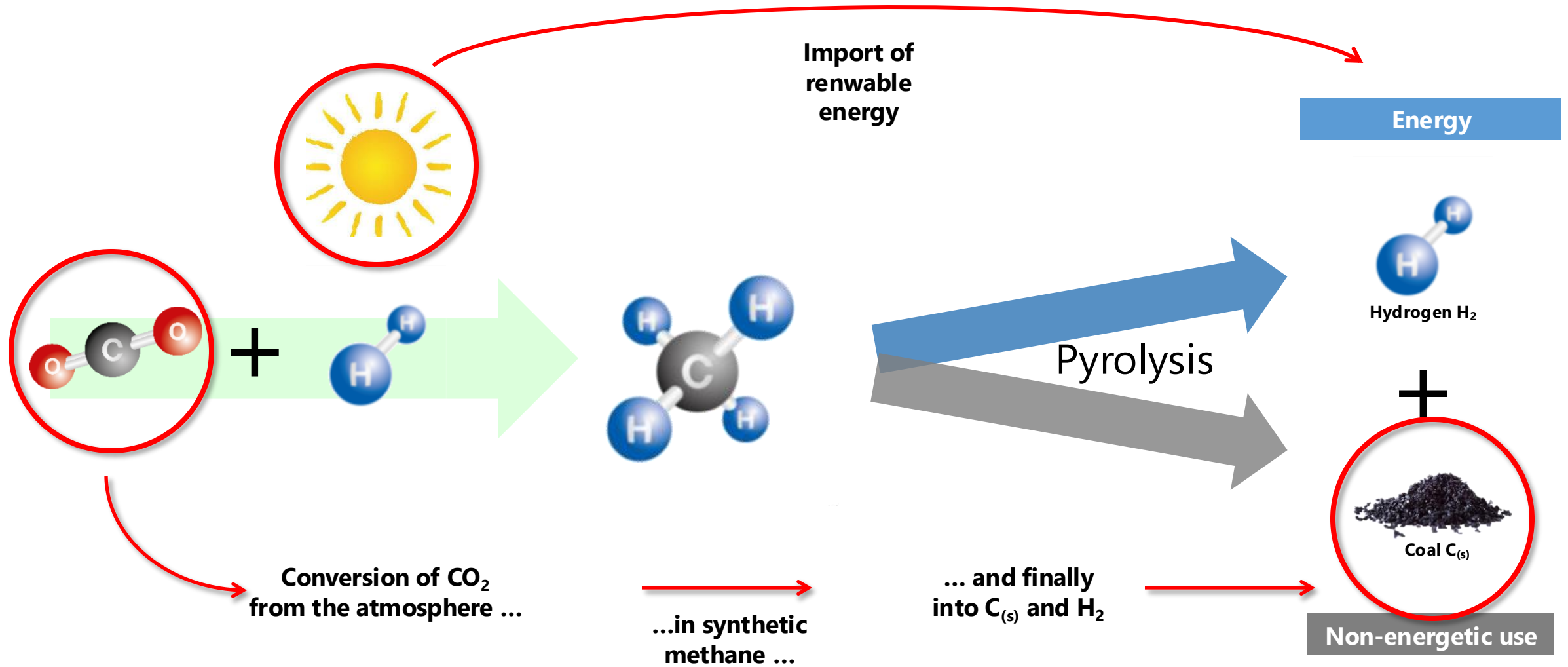








# Carbon Capture and Use



## Article

# Global human-made mass exceeds all living biomass

<https://doi.org/10.1038/s41586-020-3010-5>

Received: 1 November 2019

Accepted: 9 October 2020

Published online: 9 December 2020



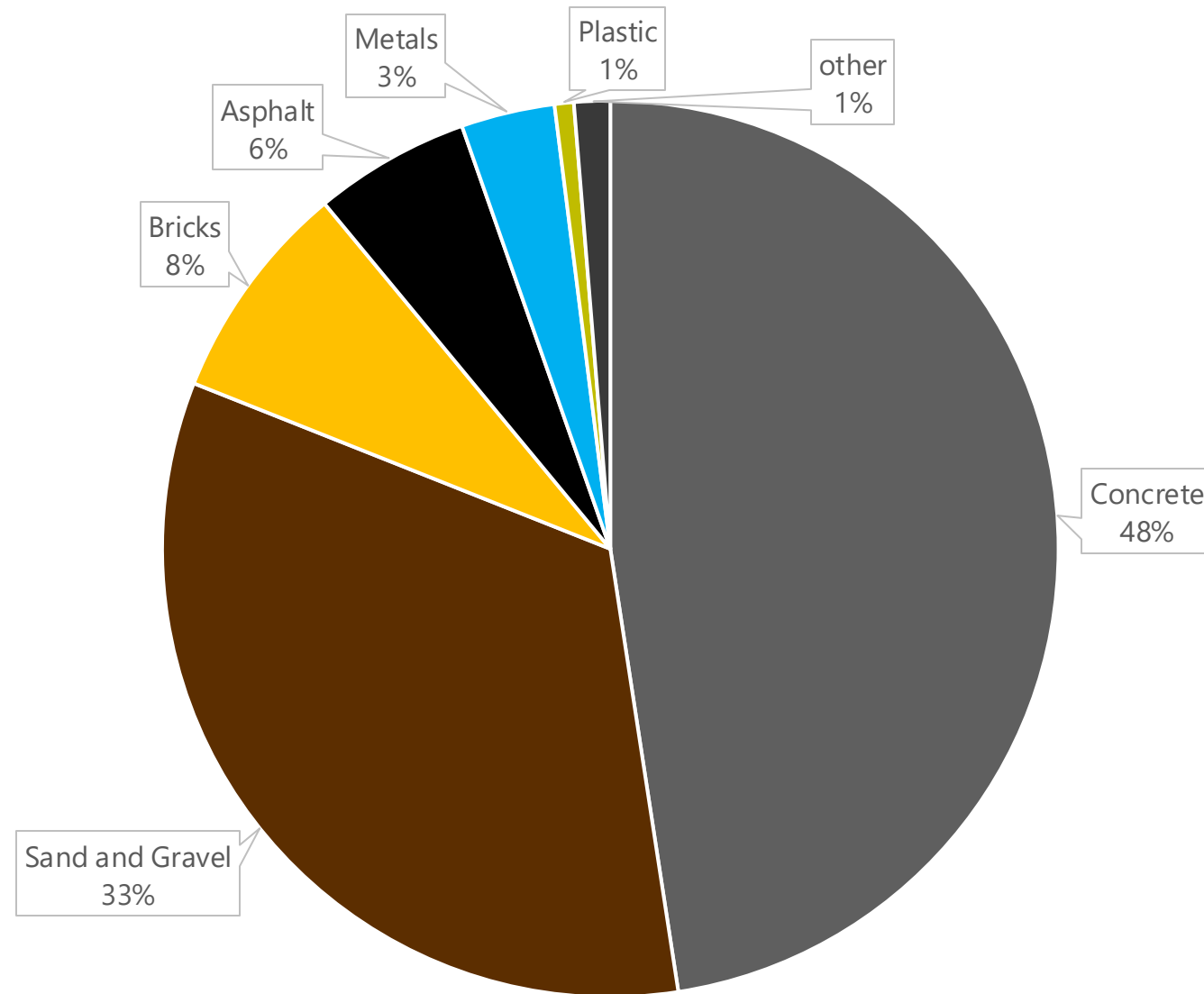
Check for updates

Emily Elhacham<sup>1</sup>, Liad Ben-Uri<sup>1</sup>, Jonathan Grozovski<sup>1</sup>, Yinon M. Bar-On<sup>1</sup> & Ron Milo<sup>1</sup>✉

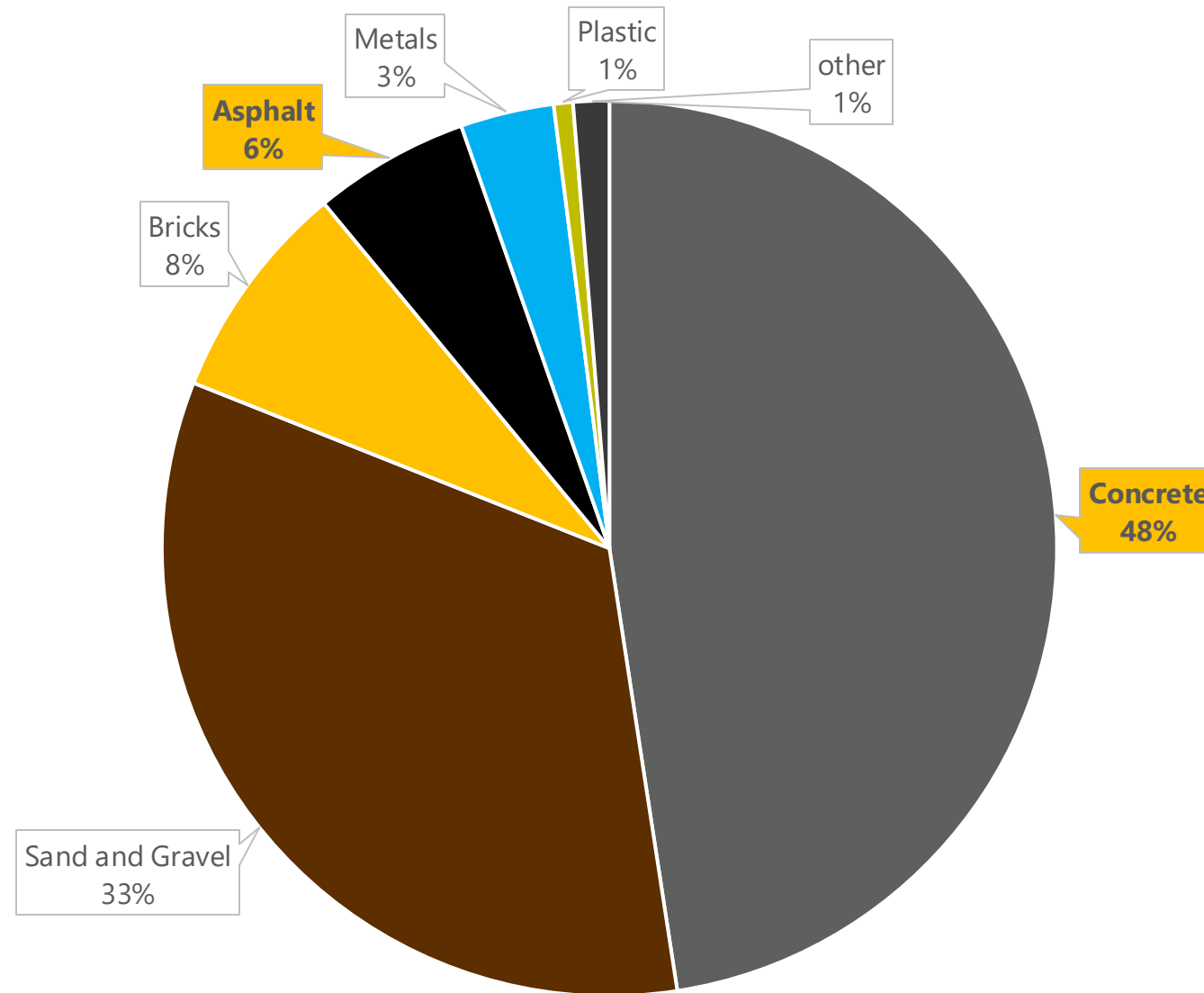
Humanity has become a dominant force in shaping the face of Earth<sup>1–9</sup>. An emerging question is how the overall material output of human activities compares to the overall natural biomass. Here we quantify the human-made mass, referred to as ‘anthropogenic mass’, and compare it to the overall living biomass on Earth, which currently equals approximately 1.1 teratonnes<sup>10,11</sup>. We find that Earth is exactly at the crossover point; in the year 2020 ( $\pm 6$ ), the anthropogenic mass, which has recently doubled roughly every 20 years, will surpass all global living biomass. On average, for each person on the globe, anthropogenic mass equal to more than his or her bodyweight is produced every week. This quantification of the human enterprise gives a mass-based quantitative and symbolic characterization of the human-induced epoch of the Anthropocene.



# Composition of man-made materials



# Composition of man-made materials



# Carbon-rich pellets as LWA for concrete (C-LWA)

*M. Wyrzykowski, N. Toropovs, F. Winnefeld, P. Lura*

Net CO<sub>2</sub> intensity of the pellets: **-1.05 kg CO<sub>2</sub>/kg pellet** (CO<sub>2</sub> sink!)

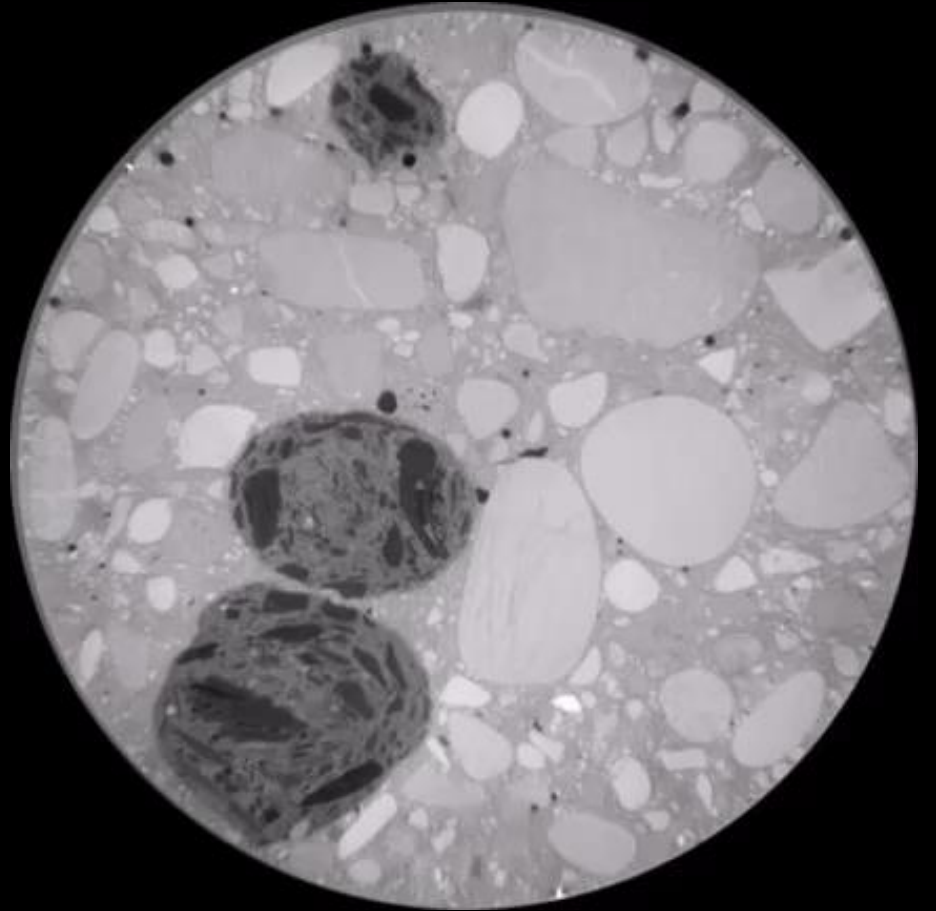
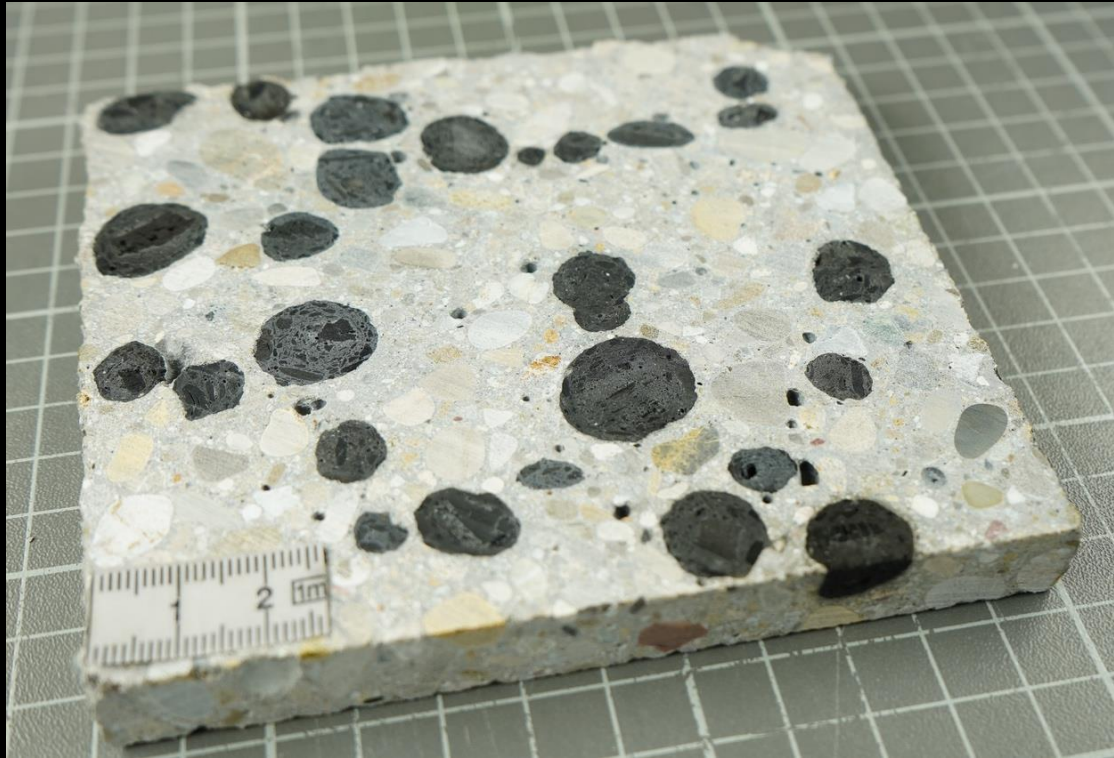
Physical properties:

- Sizes: 4-32 mm
- Density in cured state: 1.0-1.5 g/cm<sup>3</sup>



**Pelletization + cold-bonding with cement**

*Wyrzykowski, Lura et al.*  
*Journal of Cleaner Production (2024)*



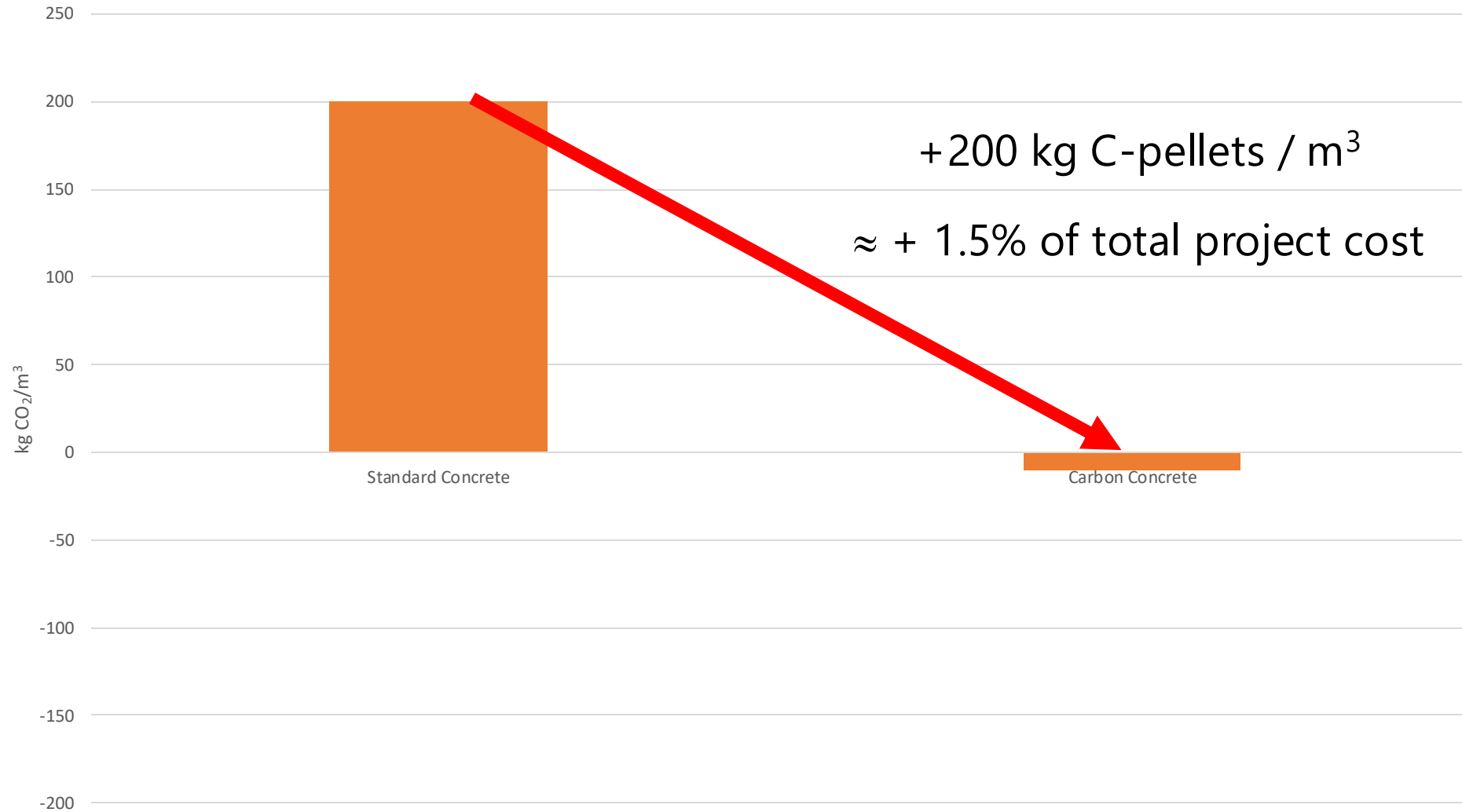




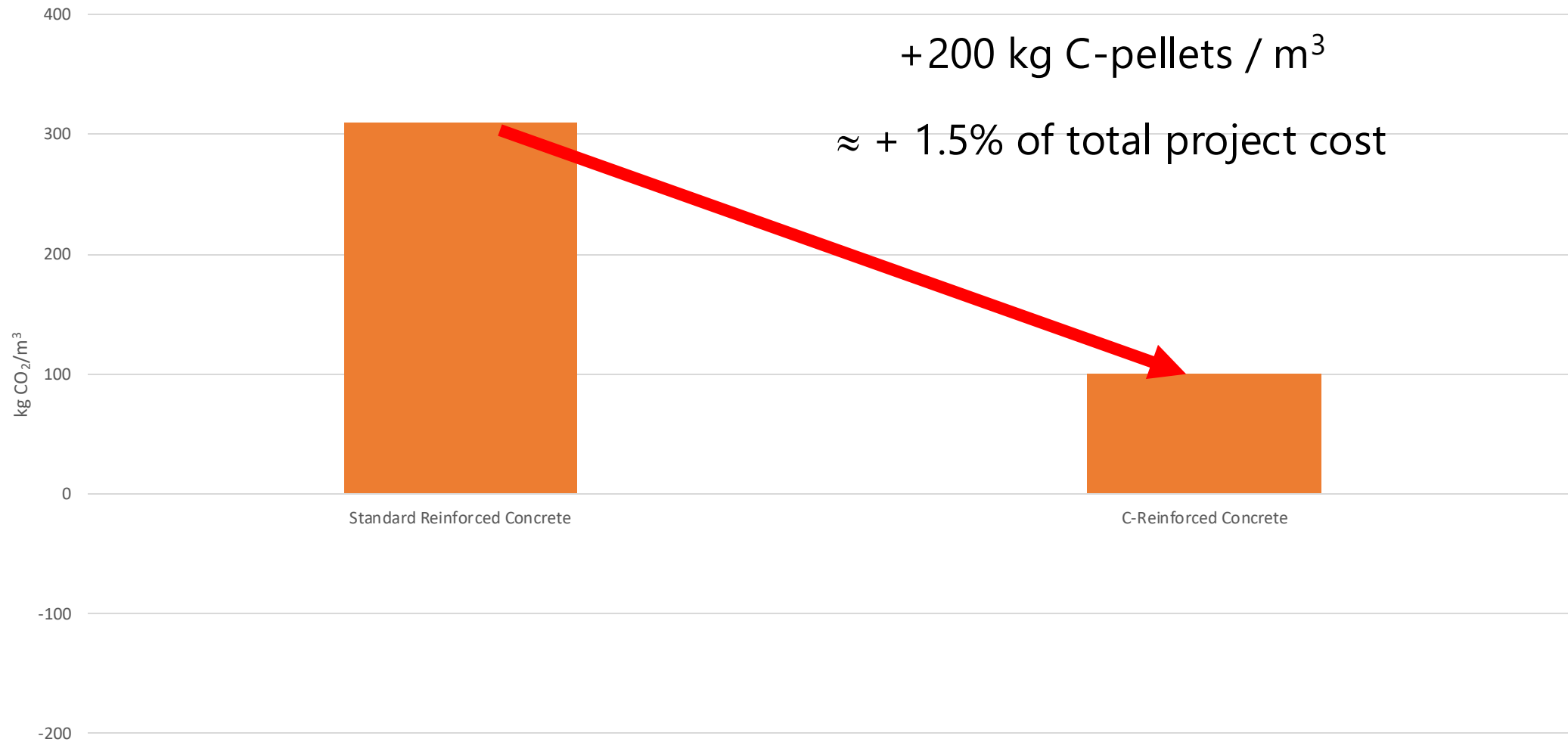
Empa Campus Dübendorf – 3 new buildings with a total volume of 15,000 m<sup>3</sup> concrete



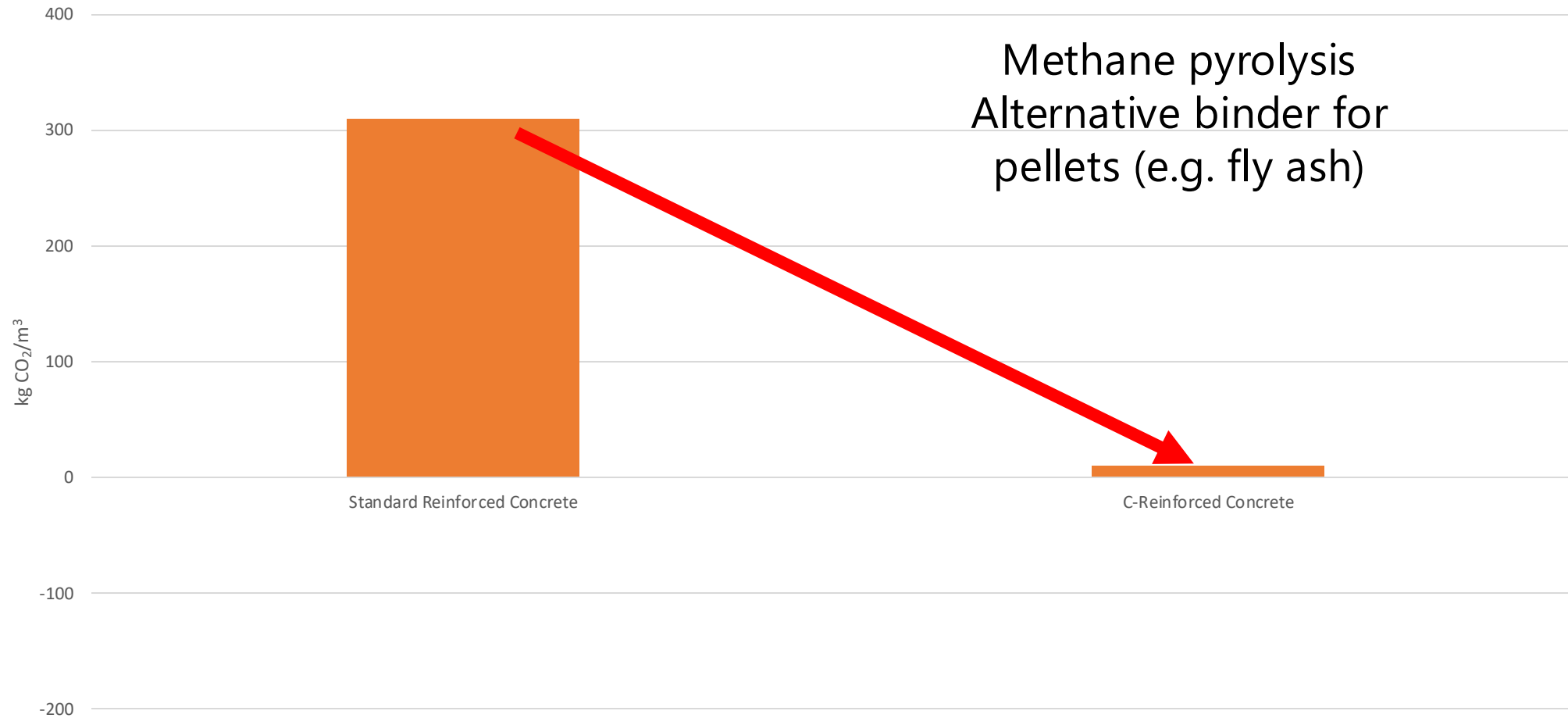
# CO<sub>2</sub>-Balance and Costs Concrete



# CO<sub>2</sub>-Balance and Costs Reinforced Concrete

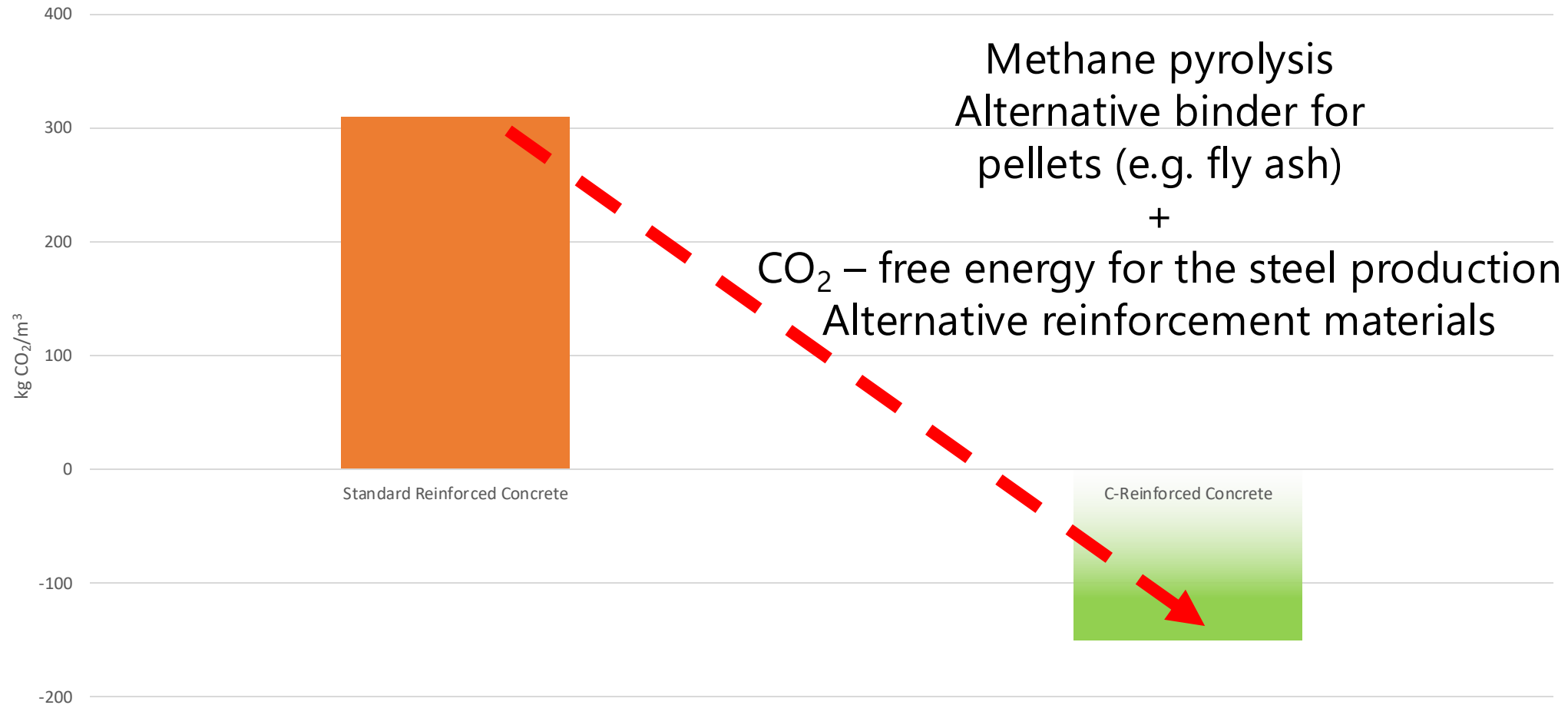


# CO<sub>2</sub>-Balance Reinforced Concrete





# CO<sub>2</sub>-Balance Reinforced Concrete



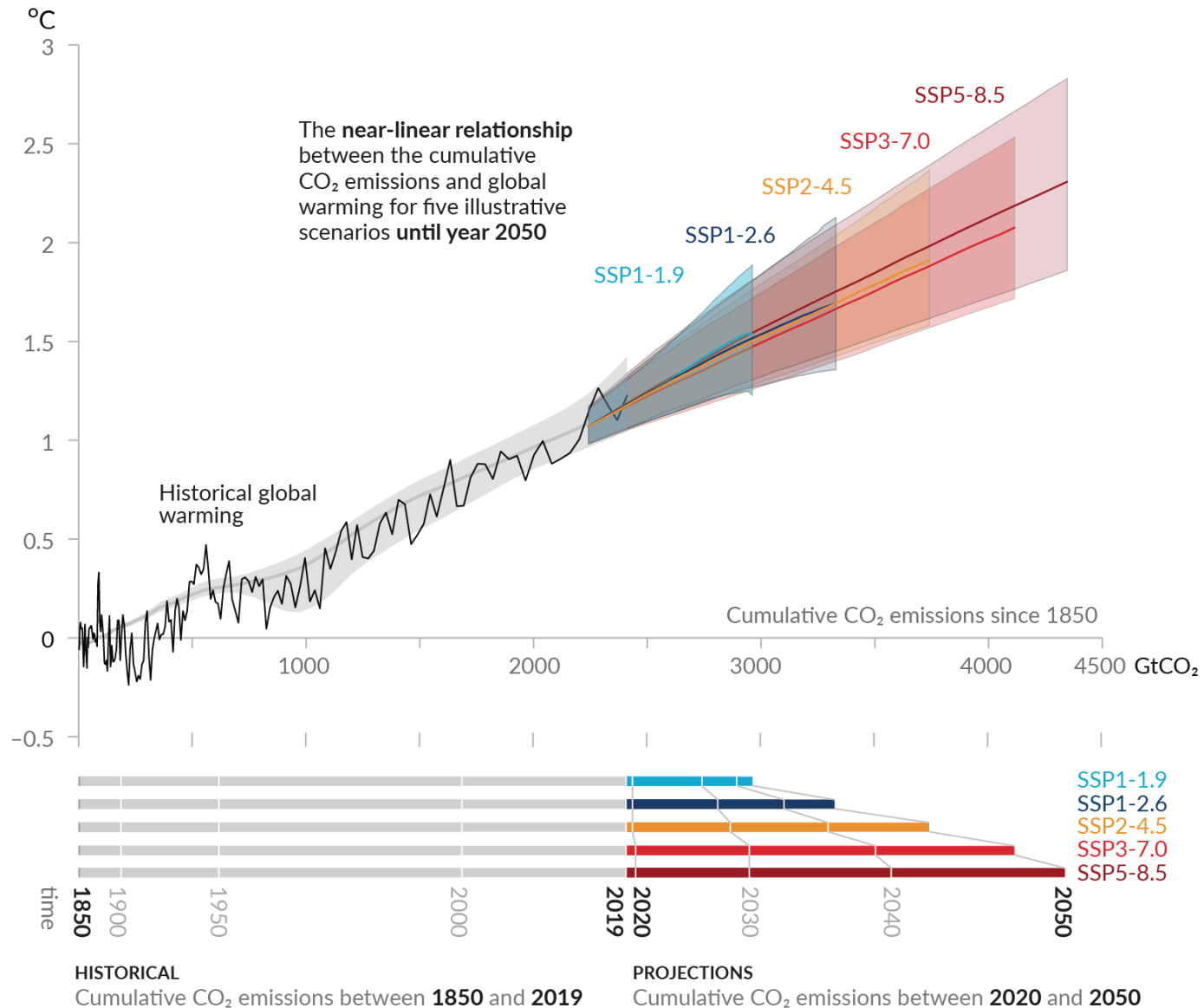
# Concrete as a permanent sink for carbon

## Potential as a sink

- Global demand for concrete ~ 35 Bio t/y
- 10% m/m C in concrete 3.5 Bio t C or 13 Bio t CO<sub>2</sub>

# Every tonne of CO<sub>2</sub> emissions adds to global warming

Global surface temperature increase since 1850–1900 (°C) as a function of cumulative CO<sub>2</sub> emissions (GtCO<sub>2</sub>)



Slope approx.  
 $0.45^{\circ}\text{C} / 10^{12} \text{ t CO}_2$

Future cumulative CO<sub>2</sub> emissions differ across scenarios and determine how much warming we will experience.

Quelle:

*Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the IPCC*

# Concrete as a permanent sink for carbon

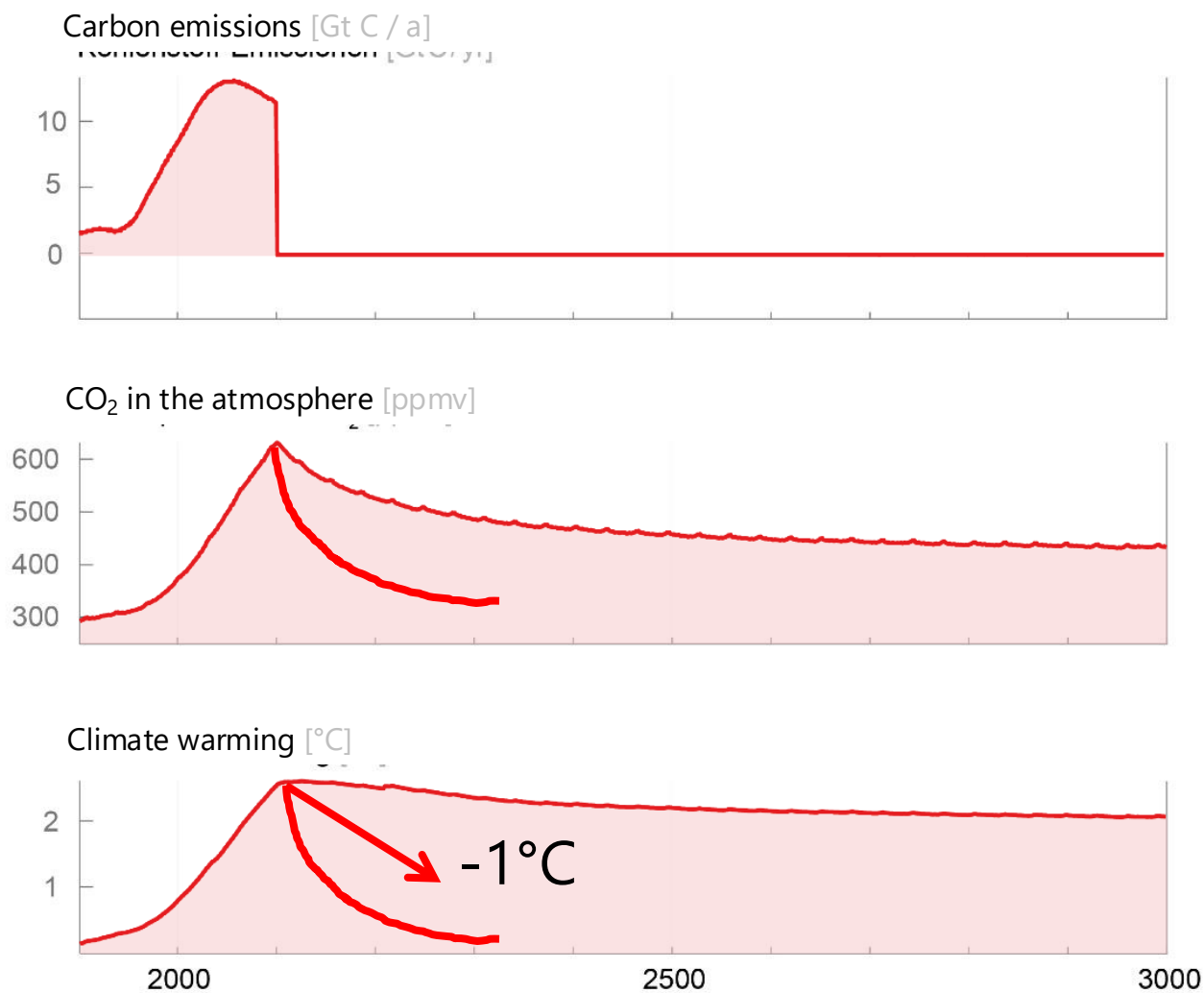
## Potential as a sink

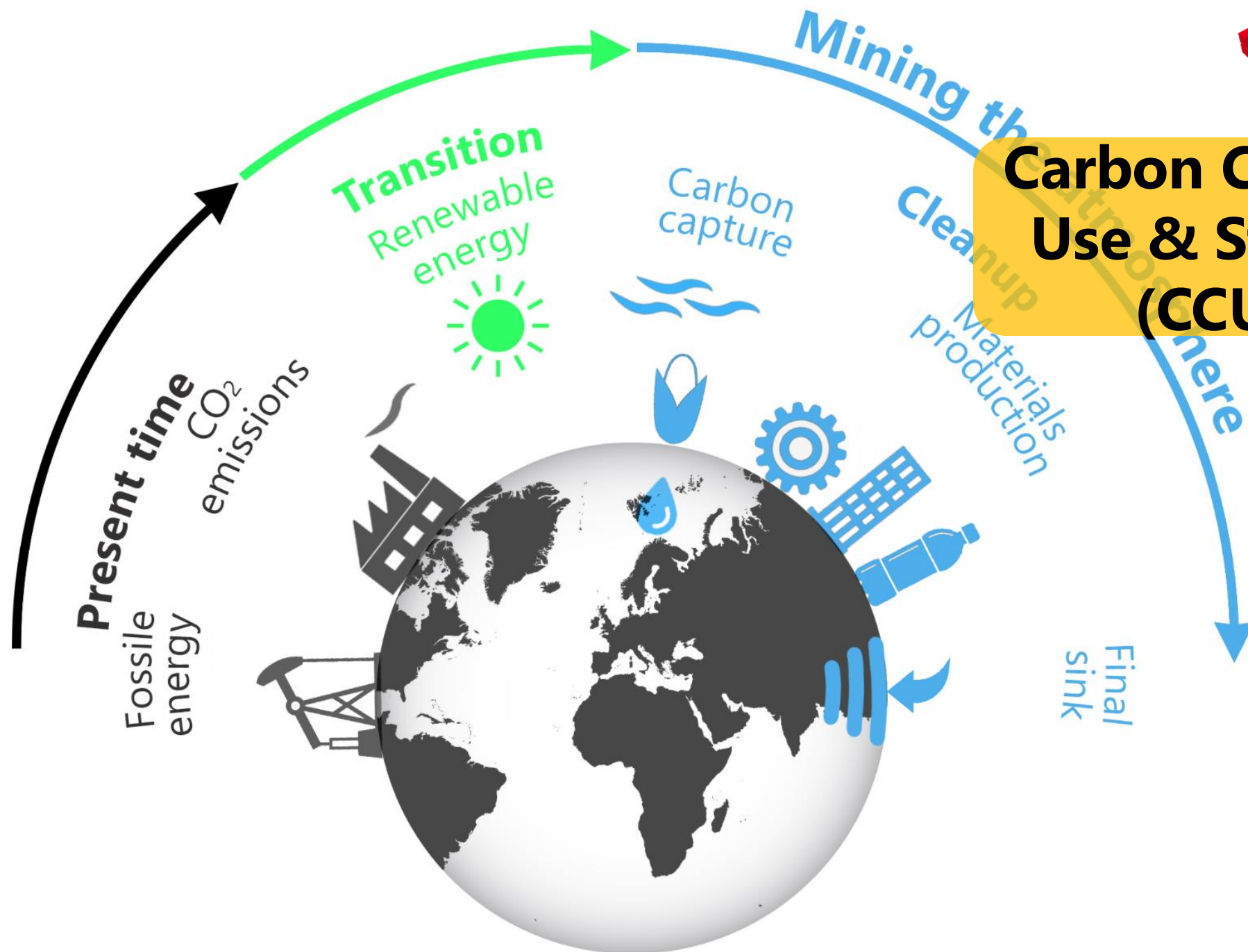
- Global demand for concrete ~ 35 Bio t/y
- 10% m/m C in concrete 3.5 Bio t C or 13 Bio t CO<sub>2</sub>
- Temperature reduction - 0.006°C / y
  - 0.06°C / decade
  - 0.6°C / century
  - **1°C in 170 years**



# Our CO<sub>2</sub>-Emissions

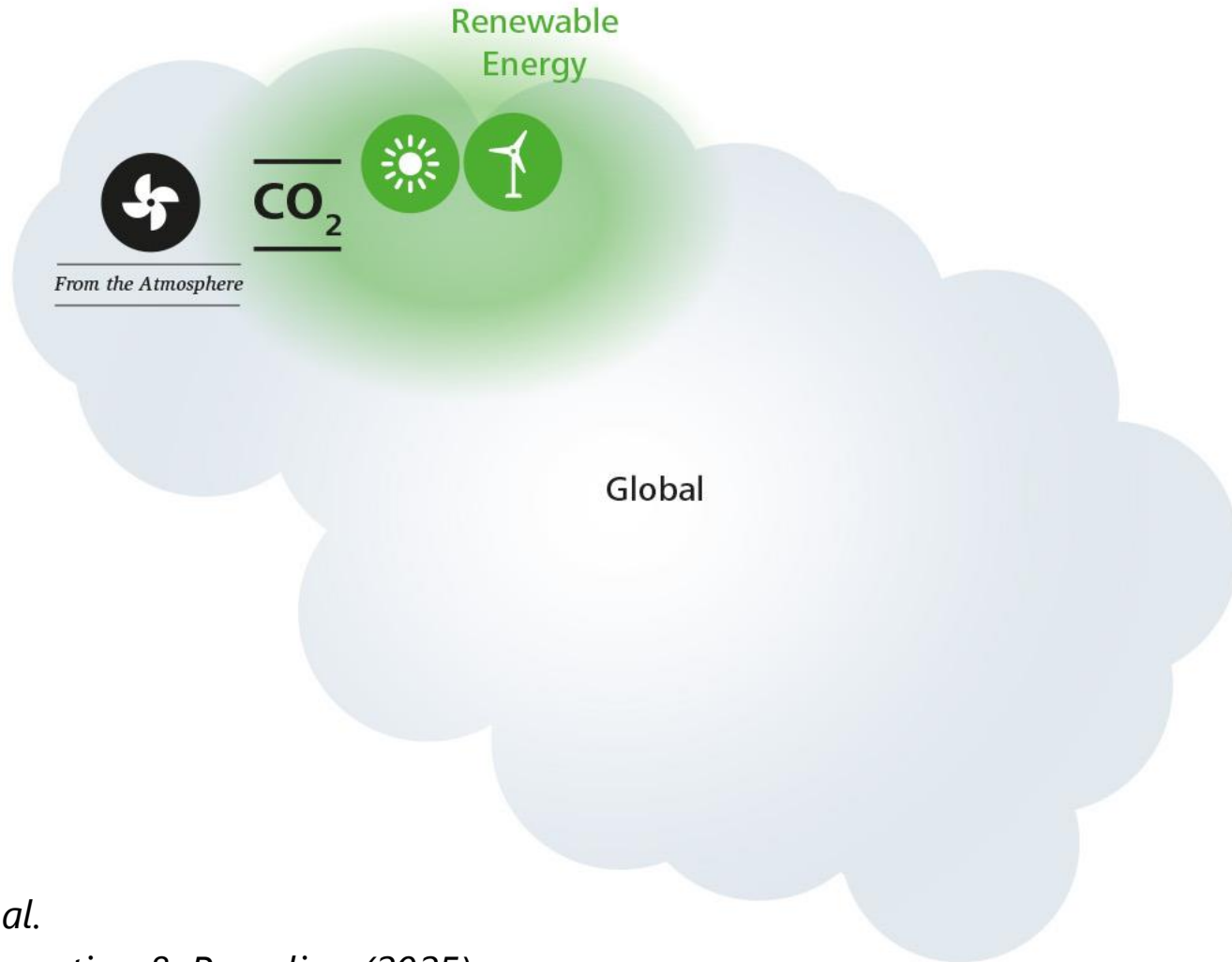
## A burden for the future





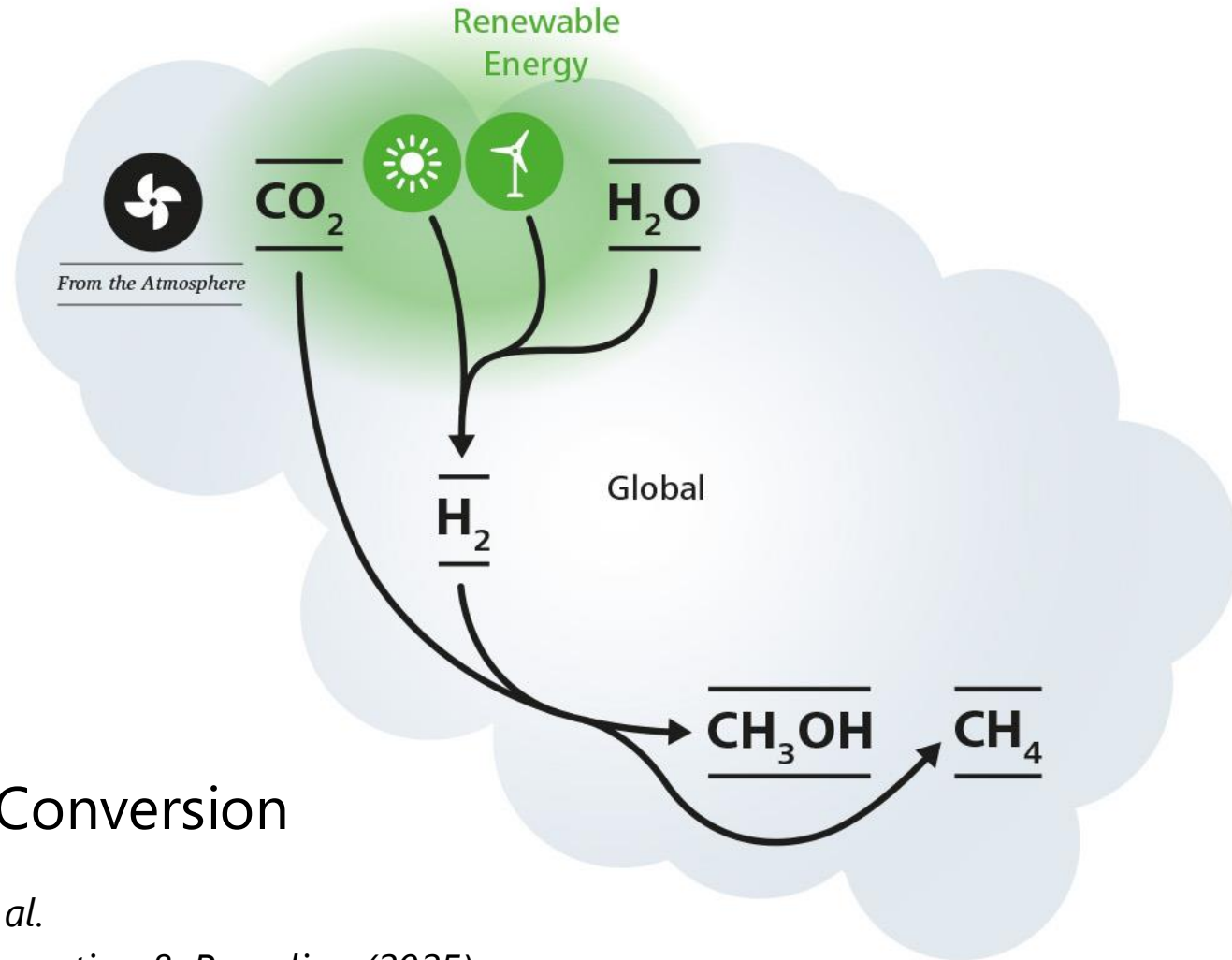
# Research Agenda Mining the Atmosphere

CO<sub>2</sub> Capture



# Research Agenda Mining the Atmosphere

CO<sub>2</sub> Capture

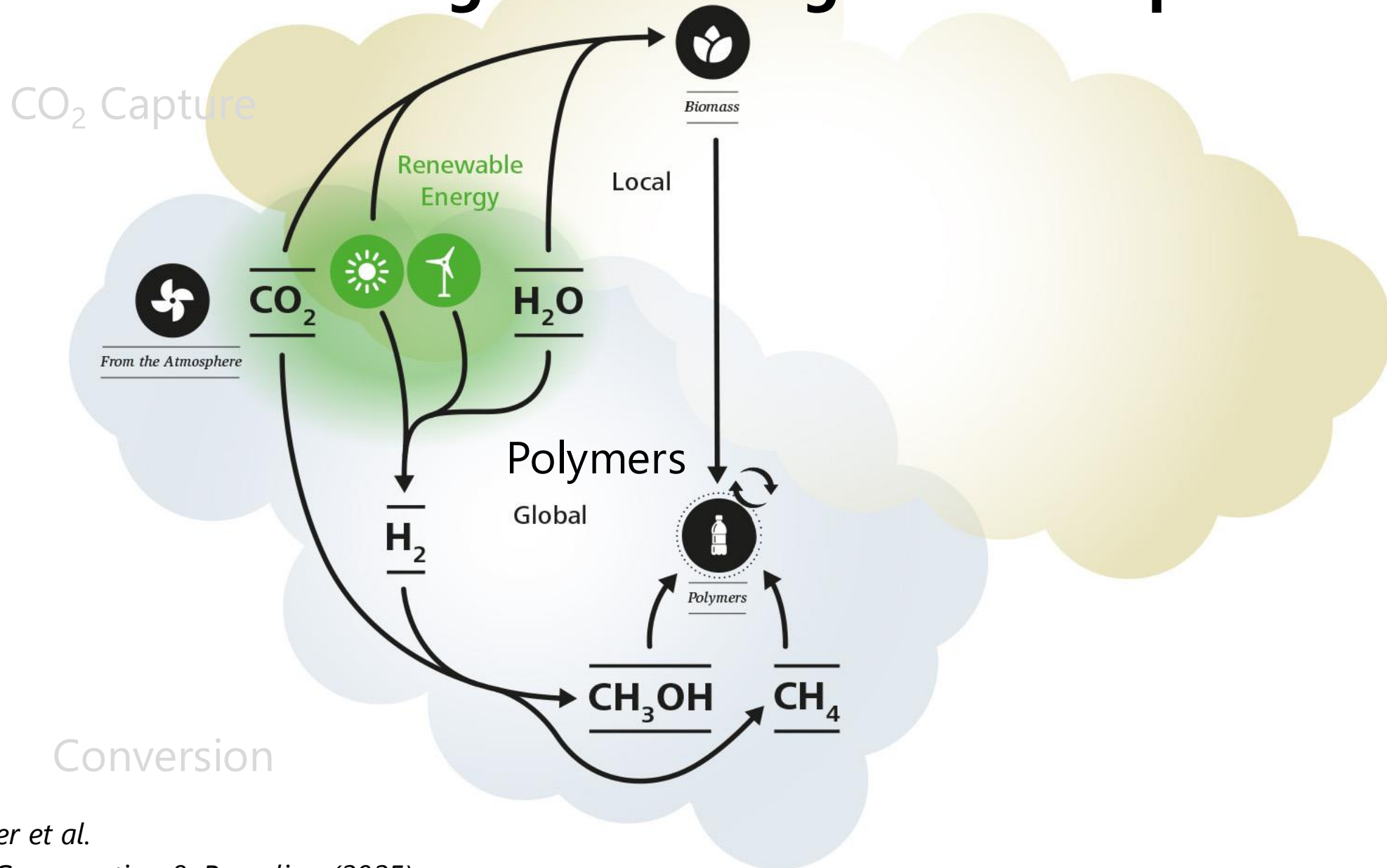


*Lura, Richner et al.*

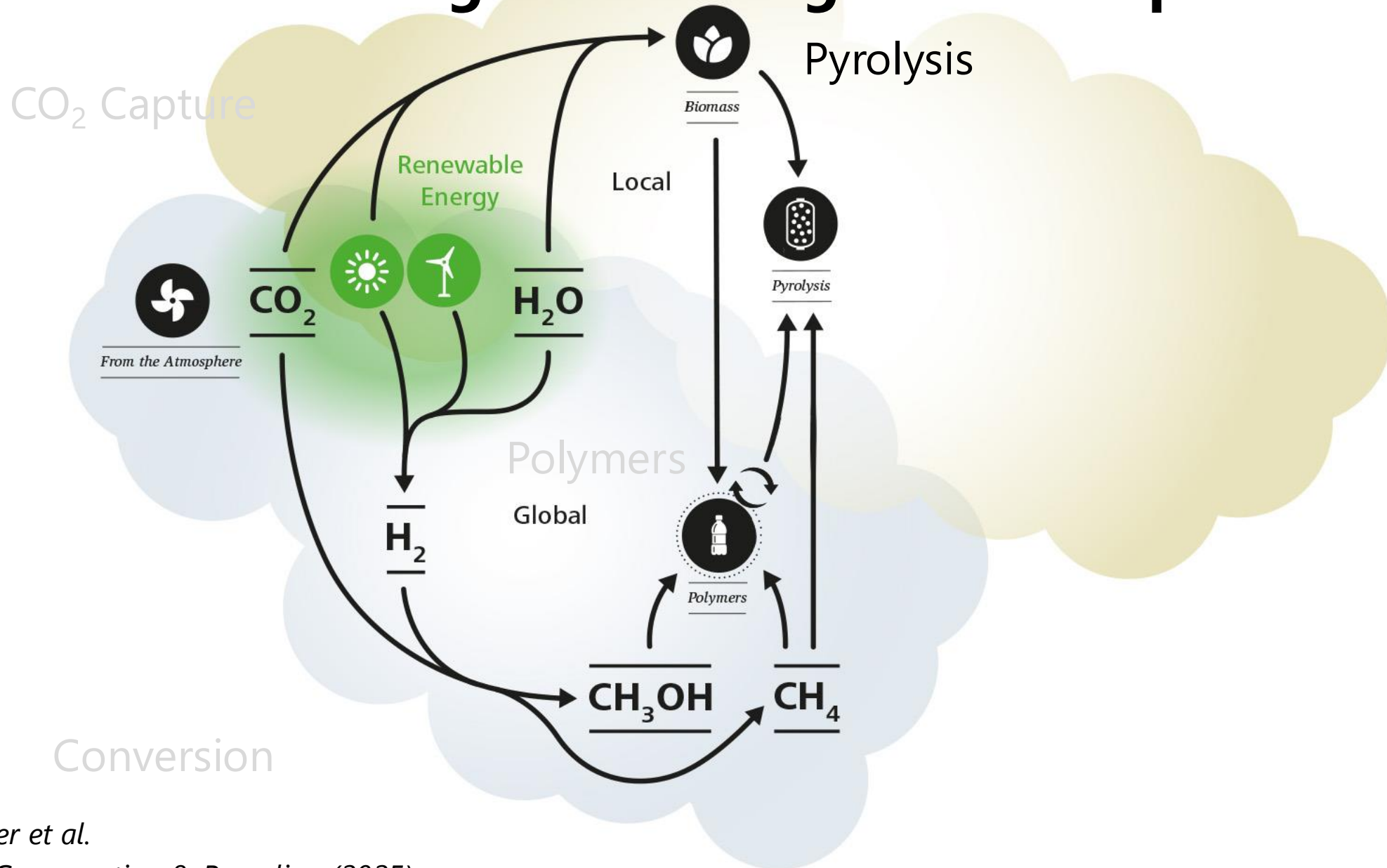
*Resources, Conservation & Recycling (2025)*



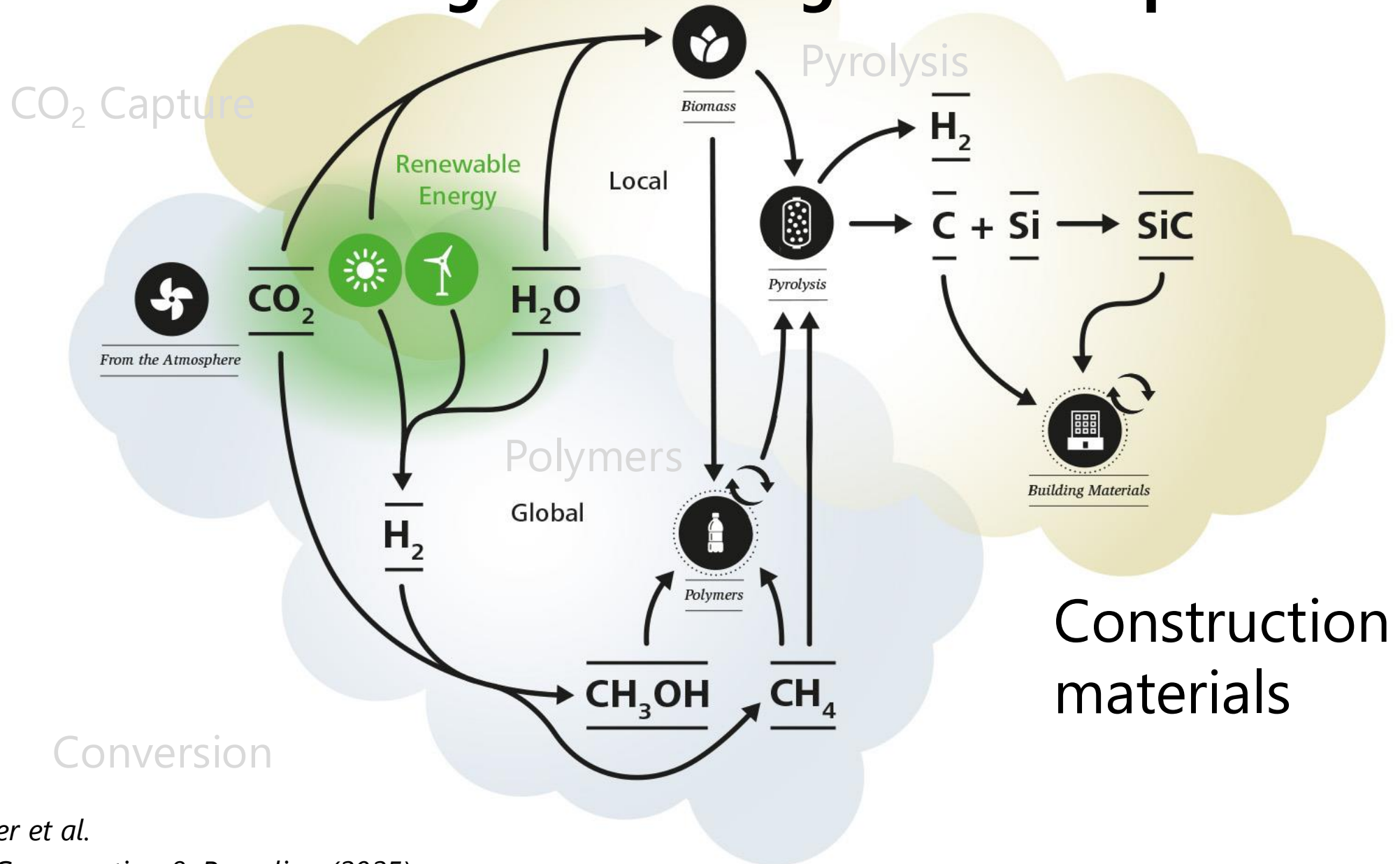
# Research Agenda Mining the Atmosphere



# Research Agenda Mining the Atmosphere



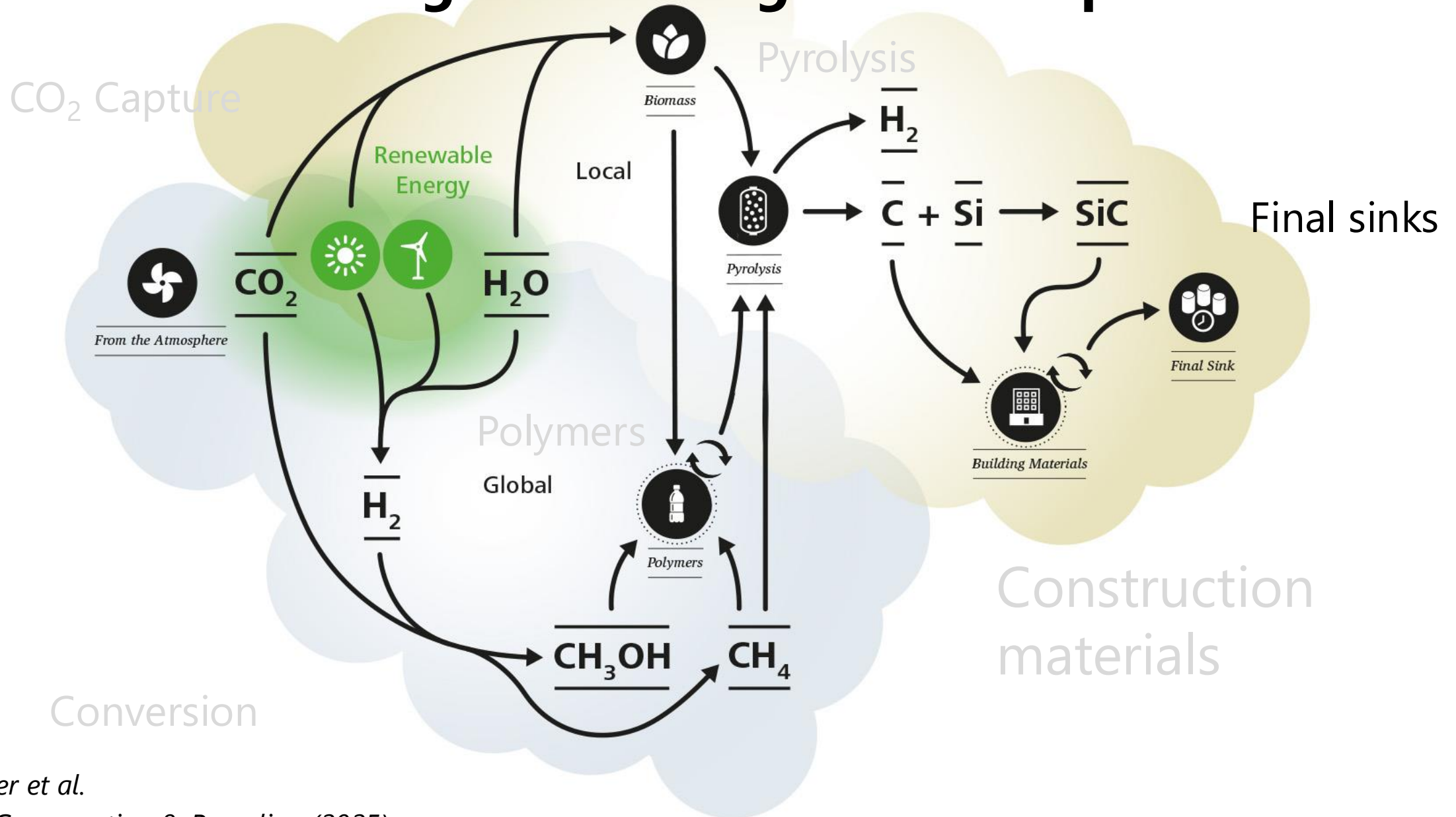
# Research Agenda Mining the Atmosphere



Lura, Richner et al.

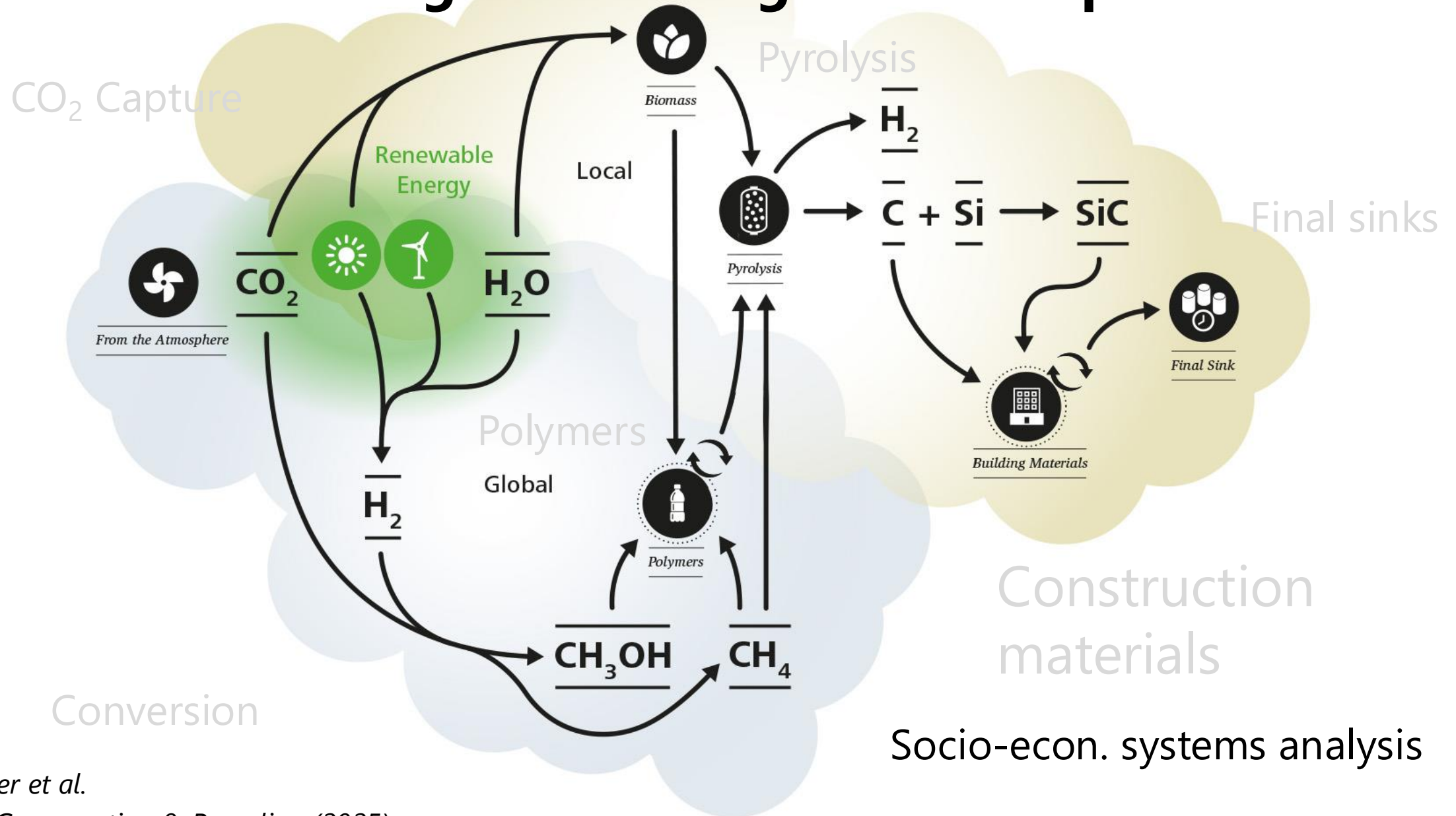
Resources, Conservation & Recycling (2025)

# Research Agenda Mining the Atmosphere

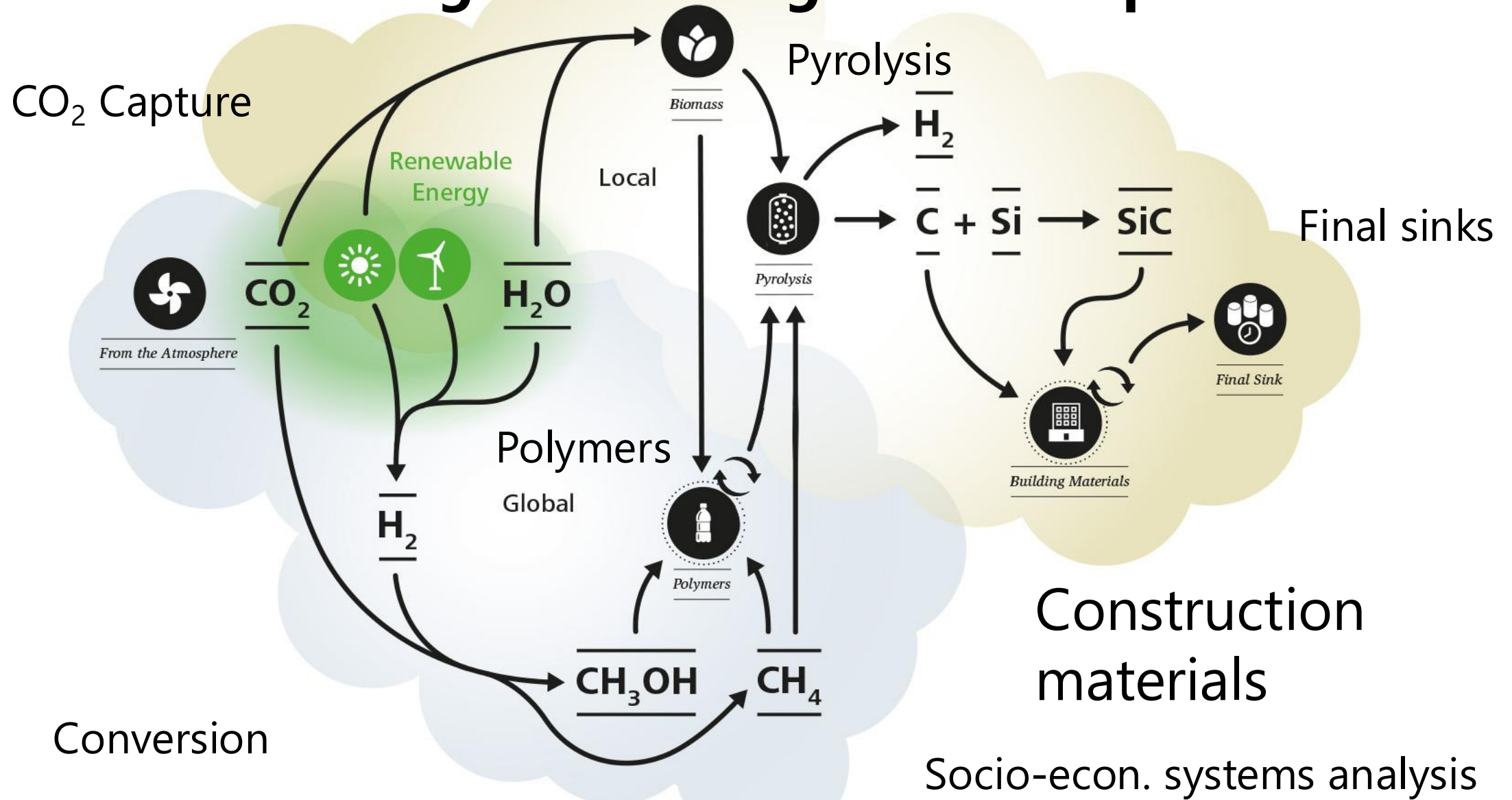




# Research Agenda Mining the Atmosphere



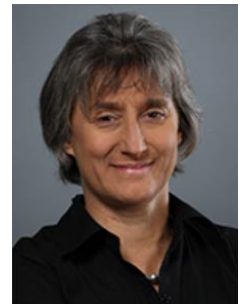
# Research Agenda Mining the Atmosphere





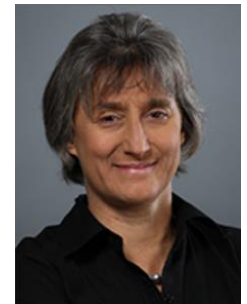


We can only do it as a team –





We can only do it as a team—  
are you with us?



# Vision

## Mining the Atmosphere



**We are developing materials and processes to enable the transition from a CO<sub>2</sub>-emitting to a CO<sub>2</sub>-binding society.**