2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE

GLOBAL CCS INSTITUTE

BRUSSELS, BELGIUM

15 JUNE 2023

AGENDA
2023 Europe Forum on Carbon Capture and Storage

TIME (CEST)	SESSION	SPEAKER
8:30 - 9:30	**Registration and Coffee**	Sign in, grab some coffee and network with fellow attendees
9:30 - 9:35	**Welcome and Housekeeping**	A warm welcome to all attendees, a preview of the days agenda, followed by a few housekeeping items to note
9:35 - 10:00	**Opening Remarks: A Global Perspective on CCS** • Progress of CCS around the world • CCS going into COP28 • How Europe's CCS market is placed globally • CCS facility pipeline	**Global CCS Institute** – Jarad Daniels, CEO
10:00 - 11:00	**Panel: CCS Policy and Regulatory Frameworks** • Tackling timescales: how to balance CO_2 capture projects with CO_2 storage development • Regulatory clarity and fairness regarding access to cross border transport and storage services • Regulatory challenges and opportunities tied to CO_2 transport • Lessons learned from CO_2 storage licensing and permitting experiences in Europe • Addressing regulatory or policy gaps to scale up deployment of CCS in Europe	**Government of the Netherlands, Ministry of Economic Affairs and Climate Policy** – Joëlle Rekers, Coordinating Policy Advisor, Subsurface Energy Transition **ArcelorMittal** – Stéphane Tondo, Head of Climate Change – Government Affairs **UK Government, Department of Energy Security and Net Zero** – Matt Taylor, Deputy Director for Transport and Storage **Government of Denmark, Ministry of Climate, Energy and Utilities, Danish Energy Agency** – Pil Krogh Tygesen, Chief Advisor **Global CCS Institute –** Guloren Turan, General Manager, Advocacy and Communications (Moderator)
11:00 - 11:30	**Keynote: Supportive CCS Policy Instruments in Europe**	**European Commission** – Kurt Vandenberghe, Director General, DG Climate Action
11:30 - 11:35	**Breakout Sessions Introduction**	
11:35 - 12:00	BREAK	
12:00 - 13:00	**Four breakout sessions will be held, covering the following topics:** **Group 1:** CDR Frameworks in Europe **Group 2:** CCS Markets: Comparisons and Contrasts between the US and Europe **Group 3**: Public Perception and Societal Value of CCS **Group 4:** Expectations for CCS at the UNFCCC COP 28	**Breakout Session Facilitators and Speakers:** Per - Olof Granström, Secretary General, **Zero Emissions Platform (group 1)** Paul Zakkour, Director **Carbon Counts, (Group 1)** Christina Staib, Global Finance Sector Lead, **Global CCS Institute (Group 2)** Eadbhard Pernot, Policy Manager, **Clean Air Task Force (Group 2)** Andrei Marcu, Executive Director, **European Roundtable on Climate Change and Sustainable Transition (Group 3)** Jonas Helseth, Director, **Bellona (Group 3)** Tim Dixon, General Manager, **IEAGHG (Group 4)** Noora Al - Amer, Senior International Climate Change Policy Advisor, **Global CCS Institute (Group 4)**

13:00 - 14:00	**LUNCH**	
14:00 - 14:30	**CCS Insights from the International Energy Agency (IEA)** • The role of CCS in limiting global warming to 1.5°C • The application of CCS in various industries • Policy supports that will drive the scale - up of CCS • Unpacking CCS infrastructure needs	**IEA** – Carl Greenfield, Energy Analyst
14:30 - 15:30	**Panel: Key Conditions of CCS Financing and Investment** • Building financial best practices and regulatory structures for CCS • Financing CCS – balancing public and private sector funding • Developing a commercially viable CCS market in Europe • The impact of Europe's EU ETS system on CCS deployment	**European Commission** – Daniel Kitscha, Investment Policy Officer **Bank of America** – Julian Mylchreest, Executive Vice Chairman **US Department of Energy, Office of Fossil Energy and Carbon Management** – Adam Wong, Senior International Advisor **Equinor** – Torbjørg Klara Fossum, VP, Global CCS Solutions **Royal Bank of Canada (RBC), Capital Markets** – Eduardo Famini Silva, Director, Renewables and Energy Transition **Global CCS Institute –** Ellina Levina, Senior Manager Finance and European Affairs (Moderator)
15:30 - 16:00	**BREAK**	
16:00 - 16:30	**Presentation and Q&A: Carbon Dioxide Removal**	**Imperial College London** – Niall Mac Dowell, Professor
16:30 - 17:00	**Breakout Session Findings Presented by** **Zero Emissions Platform** – Per - Olof Granström, Secretary General (group 1) **Global CCS Institute** – Christina Staib, Global Finance Sector Lead (group 2) **European Roundtable on Climate Change and Sustainable Transition** – Andrei Marcu, Executive Director (group 3) **IEAGHG** – Tim Dixon, General Manager (group 4)	
17:00 - 17:15	**Closing Remarks**	**Global CCS Institute** – Jarad Daniels, CEO

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A GLOBAL PERSPECTIVE ON CCS

GLOBAL CCS INSTITUTE

OPENING REMARKS

Jarad Daniels
CEO, Global CCS Institute

15 JUNE 2023

A GLOBAL PERSPECTIVE ON CCS

2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE

JARAD DANIELS
CEO, GLOBAL CCS INSTITUTE

GLOBAL CCS INSTITUTE

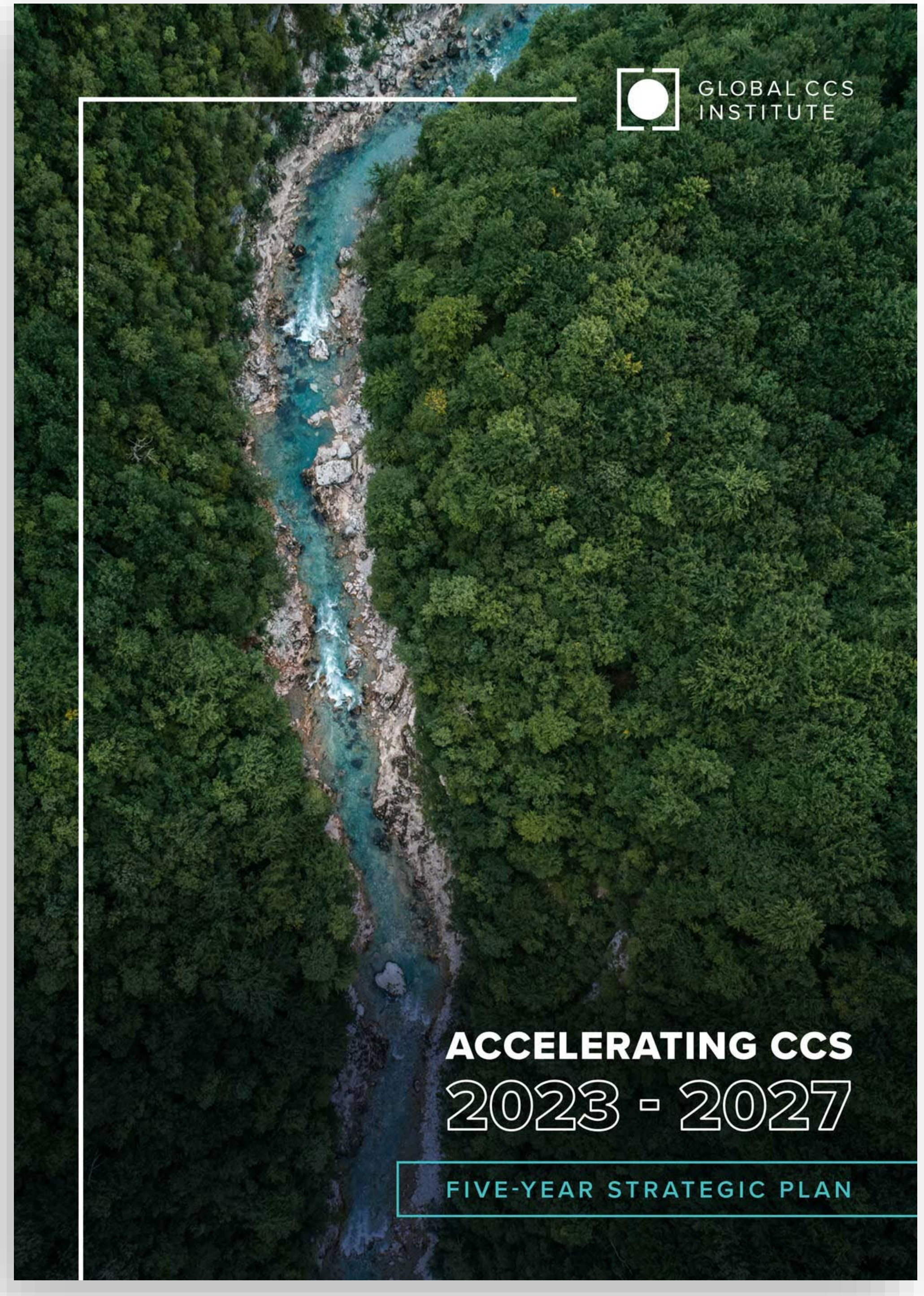
THE GLOBAL CCS INSTITUTE

Accelerating the deployment of CCS for a net-zero emissions future.

WHO WE ARE
International CCS think tank with offices around the world.

Over 200 members across governments, global corporations, private companies, research bodies and NGOs, all committed to a net-zero future.

WHAT WE DO
Fact-based influential advocacy, catalytic thought leadership, authoritative knowledge sharing.



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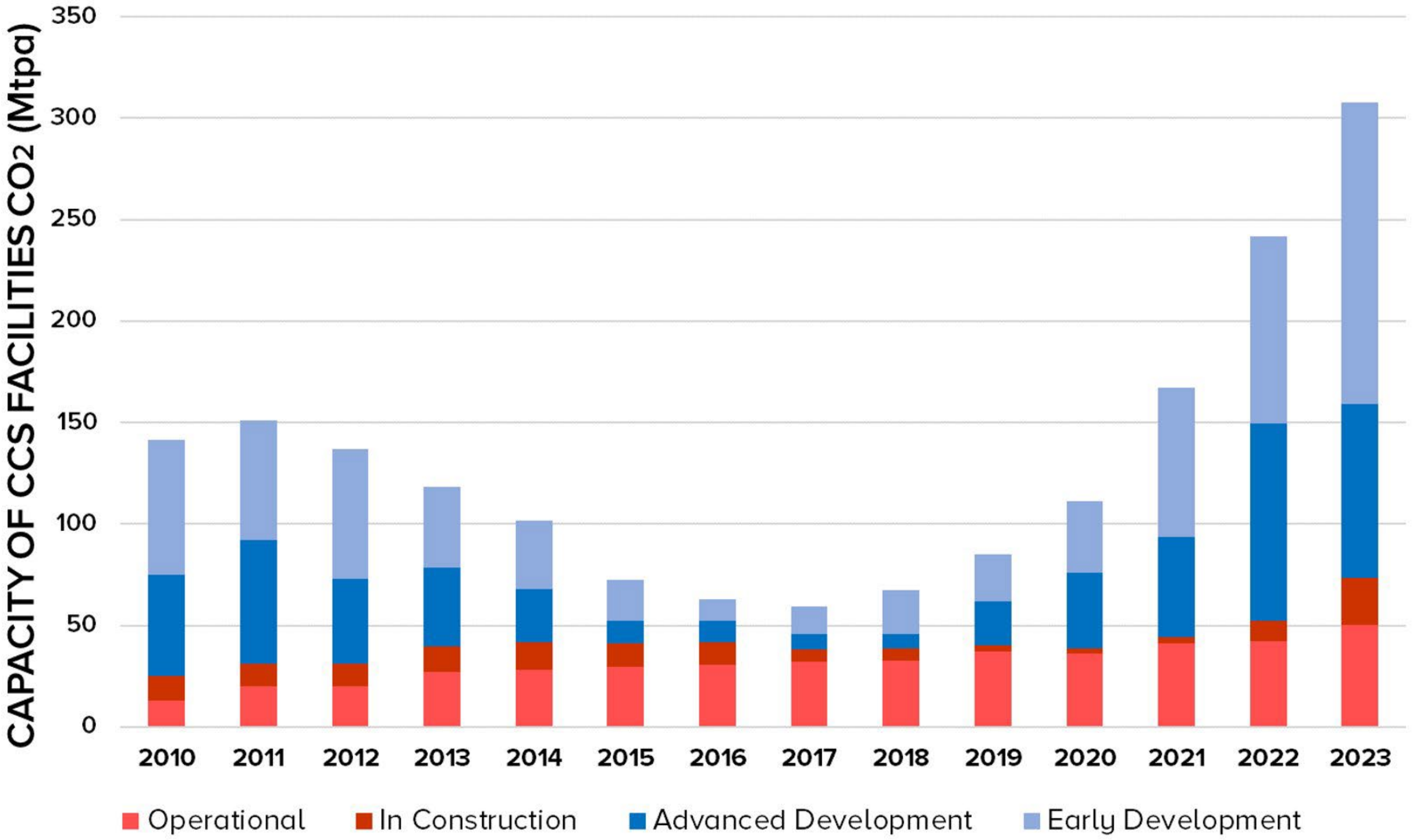
CCS FACILITY PIPELINE GROWING



Status	GSR 2022	CO2RE 2023
Operation	30	37
Construction	11	20
Adv Dev	78	97
Early Dev	75	103
Total	194	257

* By capture capacity

COUNTRIES SHOWING INCREASING AMBITION

- **The EU** needs to have 300 to 550 mtpa of installed CCUS capacity by 2050 to meet its NZE target. Net-Zero Industry Act aims to have **50 mtpa** storage developed by 2030.

- **The UK's** CCUS roadmap foresees **20 to 30 mtpa** of installed capacity by 2030.

- **The US,** through the Inflation Reduction Act (IRA), has given immense stimulus to the deployment of CCUS and Direct Air Capture (DAC) and could increase the deployment of CCS by 13-fold* compared to existing policy to between **200 and 250 mtpa** of capacity by 2030.

- **The KSA** has announced the target of capturing and storing **44 mtpa** by 2035.

- In **Brazil,** Petrobras injected more than 10 mt of CO_2 in 2022, a world record for a company, and aims to inject **40 mtpa** between 2023 and 2025.

* According to analysis carried out by REPEAT project

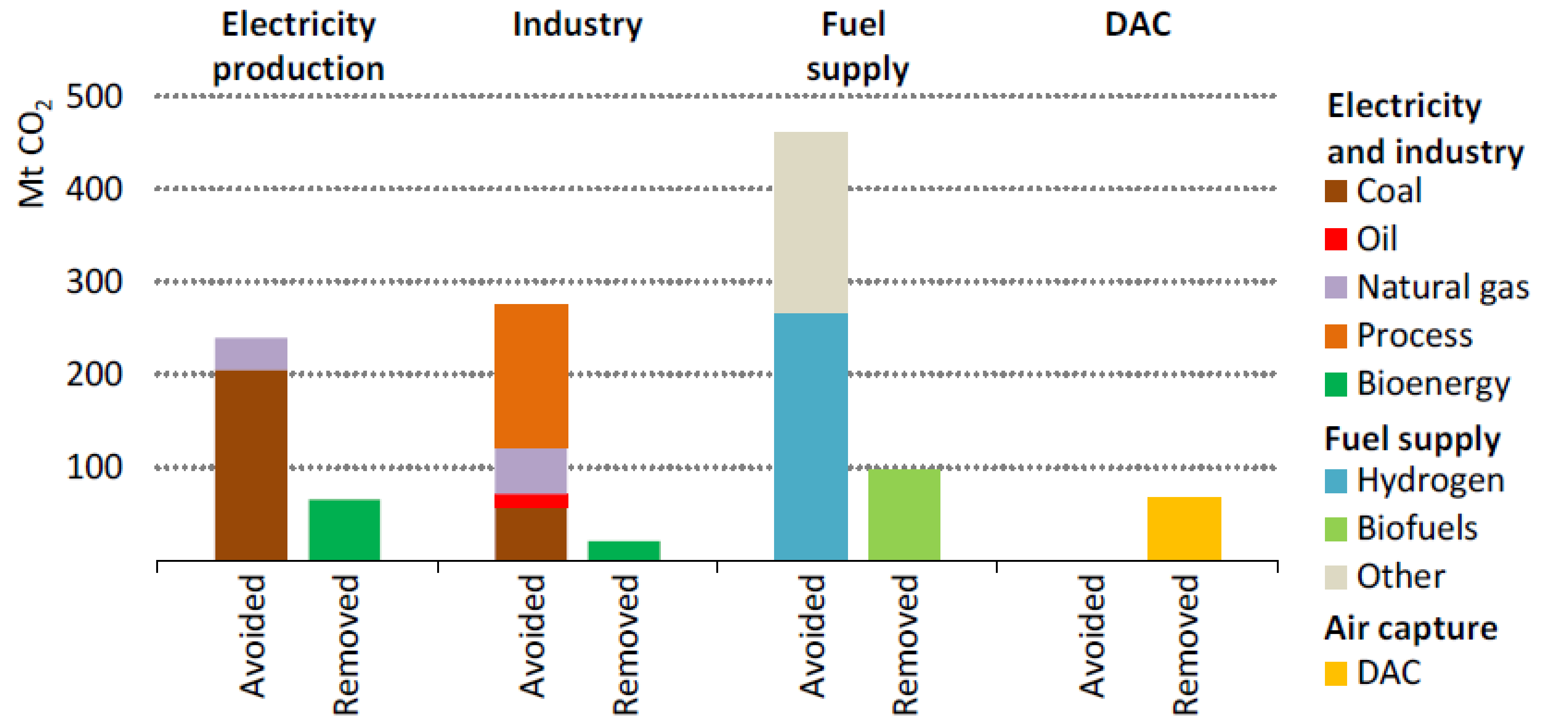
GLOBAL ACTION GOING INTO COP28

- Global Carbon Management Challenge
  - Australia, Canada, Egypt, EU, Japan, Saudi Arabia, United Arab Emirates, United States, United Kingdom as well as Norway and Denmark.
- Global Decarbonisation Alliance
  - Private sector initiative under the COP28 Presidency
- IEA's *Credible pathways to 1.5°C Four pillars for action in the 2020s*
- CEM-14 in July 2023
  - Potential side events on Cement and CCS, Financing CCS and Carbon Management Challenge

SCALING UP THROUGH 2030

- According to IEA NZE, 1.2 GtCO_2 per annum should be captured by 2030, including for removals.
- Capturing 1.2 GtCO_2 by 2030 as modelled, requires 25-fold increase over current operational capacity and 4 times increase over the current pipeline.
- CCUS is required across diverse sectors and is increasingly important to industry.
- Stronger policy to incentivise rapid CCS investment is needed.

Total CO_2 capture by sector and type in the NZE, 2030



Carbon capture technologies play an important role across the whole energy sector, but particularly in mitigating process emissions from industrial and fuel production

CASE STUDY: US POLICY AND PROJECT PROGRESS

- **Bipartisan Infrastructure Law included** over $12 billion in investments in next-generation carbon capture, direct air capture, integrated CCUS demonstrations, and industrial emissions reduction demonstration projects, as well as CO_2 transport and storage infrastructure.

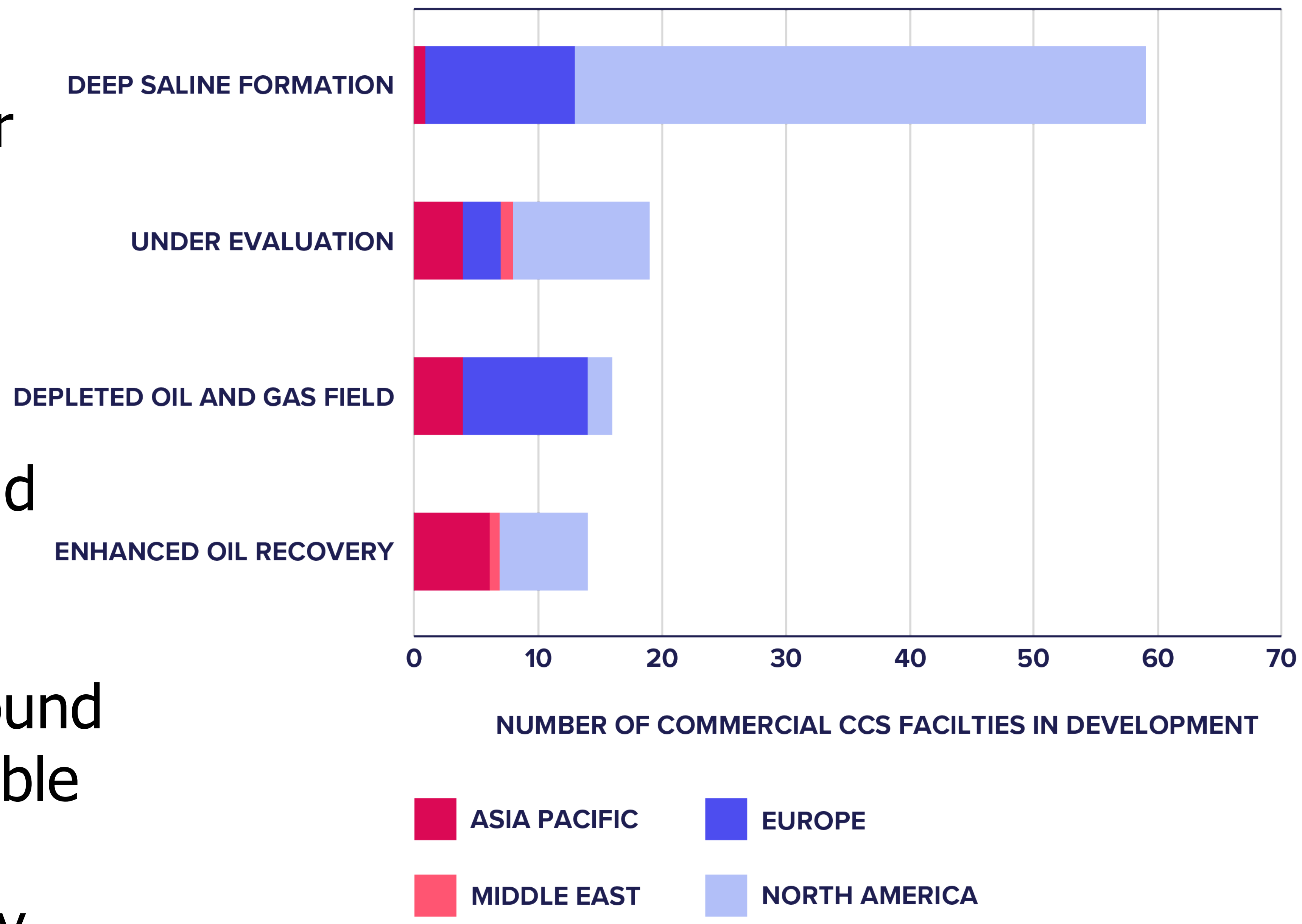
- **Inflation Reduction Act** provides tax credits of $85 per tonne of CO_2 captured and stored and $180 for every tonne of CO_2 removed through direct air capture and permanently stored.

- A study from Princeton shows that the total volume of CO_2 captured for transport and geologic storage across energy & industry could reach **200 million** tons per year by 2030, a **13-fold increase** compared to previous policy.

- Currently there are 14 commercial facilities in operation in the US, and close to **90 facilities under development.**

EVOLUTION OF STORAGE

- 13 of the 37 facilities currently operating use dedicated geological storage with the remainder using EOR.
- 70% of the commercial CCS projects in development aim to use dedicated geological storage (deep saline formations, depleted oil and gas fields).
- Operational facilities, on average, can inject around 1 mtpa CO_2. That average could more than double within a decade. Many storage sites associated with the development of CCS networks generally have rates of around 5 Mtpa.



* Analysis of 108 facilities in development with dedicated storage sites

CARBON DIOXIDE REMOVAL

- CDR continues to gain momentum and is viewed as critical to net-zero.
- Engineered-CDR costs, specifically of DACCS, are currently relatively high but projected to fall over time.
- The extent to which costs fall will determine deployment.
- CDR can play an important role in drawing down historical emissions even after we reach net-zero and provides a safety net.

Image: Carbon Engineering

FINANCE AND INVESTMENT

- Private finance with government incentivization is key to deploying at scale.
- Capital investment of $655 billion - $1.28 trillions required over the next 30 years.
- Taxonomies emerging in various jurisdictions – efforts to adopt common principles key to a consistent approach.
- Carbon Markets – Compliance and Voluntary- becoming increasingly important. Convergence expected, but time frame uncertain.
- ESG-related reporting remains important to commercial activity:
  - Demand for detailed disclosure remains critical for investors.
  - Companies with significant emissions under pressure to report.
  - Although CCS not excluded, a clearer reporting pathway would be beneficial

CCS DEVELOPMENTS AROUND THE WORLD

- **EUROPE**
  - CCUS in Net-Zero Industry Act; EC developing CCUS strategy
  - The EU through, the Innovation Fund, to invest in 11 CCS and CCU projects (and counting)
  - Netherlands, Denmark, the UK are progressing their CCS policies and projects.
- **NORTH AMERICA**
  - The US leads globally with project and policy development.
  - In Canada, CCUS Strategy under development and CCUS investment tax credit in federal budget.
- **MENA**
  - 3 facilities in operation in the region, equivalent to ~10% of global capture capacity.
  - Ambition and momentum going into COP28.
- **APAC**
  - China's first 1 Mtpa CCUS facility started operations in 2022, with several other projects now in construction or in development.
  - Project progress in Malaysia, Indonesia, and Australia

EUROPE – WHAT TO LOOK OUT FOR

- EU CCUS Strategy
- Regulatory Framework for CO_2 Infrastructure
- Review of the CCS Directive Guidance Documents
- Carbon Removal Framework
- Closer cooperation and CO_2 transport between North Sea countries
- Evolution of the EU ETS

LESSONS LEARNED

- Despite significant progress since 2017, more is required, urgently.
- CCS capacity needs to scale from 50 million tons today to multiple gigatons by mid-century.
- Capital investment of $655 billion - $1.28 trillion is required over the next 30 years.
- Governments to establish appropriate policies; Industry to build, own, and operate CCS facilities at scale and the Finance Sector to include CCS in their portfolios, ESG and green taxonomies.
- Stronger policy coupled with strong action by 2030 is crucial.

WHAT IS NEEDED GLOBALLY?

- Define the role of CCS and CDR in meeting national climate strategies and plans, set and communicate targets.
- Create a long-term, high value on the storage of CO_2.
- Support the identification and appraisal of geological storage resources.
- Develop specific CCS laws and regulations.
- Identify opportunities for CCS networks and facilitate the establishment of transport and storage infrastructure.
- Enable investment in CCS through appropriate policy and market mechanisms.

THANK YOU

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CCS POLICY AND REGULATORY FRAMEWORKS

Guloren Turan
Global CCS Institute

MODERATOR

Joëlle Rekers
Government of the Netherlands, Ministry of Economic Affairs and Climate Policy

Stéphane Tondo
ArcelorMittal

Matt Taylor
UK Government, Department of Energy Security and Net Zero

Pil Krogh Tygesen
Danish Energy Agency

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SUPPORTIVE CCS POLICY INSTRUMENTS IN EUROPE

KEYNOTE SPEAKER

Kurt Vandenberghe
Director General of DG Climate Action, European Commission

Breakout Sessions

Group 1: Carbon Dioxide Removal Frameworks in Europe
Room: Thalys 3

Group 2: CCS Markets: Comparisons and Contrasts Between Europe and the US
Room: Thalys 4

Group 3: Public Perception and Societal Value of CCS
Room: Eurostar 2

Group 4: Expectations for CCS at COP 28
Room: Eurostar 1

Check your name badge for the breakout session selected

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BREAKOUT SESSIONS

GROUP 1
Frameworks in Europe
Per - Olof Granström
Zero Emissions Platform

GROUP 2
CCS Markets: Comparisons and Contrasts between the US and Europe
Christina Staib
Global CCS Institute

GROUP 3
Public Perception and Societal Value of CCS
Andrei Marcu,
European Roundtable on Climate Change and Sustainable Transition

GROUP 4
Expectations for CCS at the UNFCCC COP 28
Tim Dixon
IEAGHG

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CCS INSIGHTS FROM THE IEA

GLOBAL CCS INSTITUTE

SPEAKER

Carl Greenfield

International Energy Agency (IEA)

International Energy Agency

The role of CCUS in reaching net zero

Carl Greenfield, IEA

2023 Europe Forum on Carbon Capture & Storage

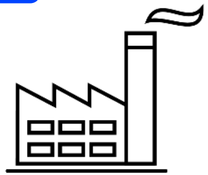
15 June 2023

Four strategic roles for CCUS in energy transitions

1

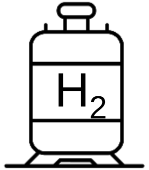
Tackling emissions from existing infrastructure

2



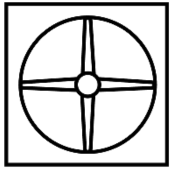
A solution for hard-to-abate emissions

3



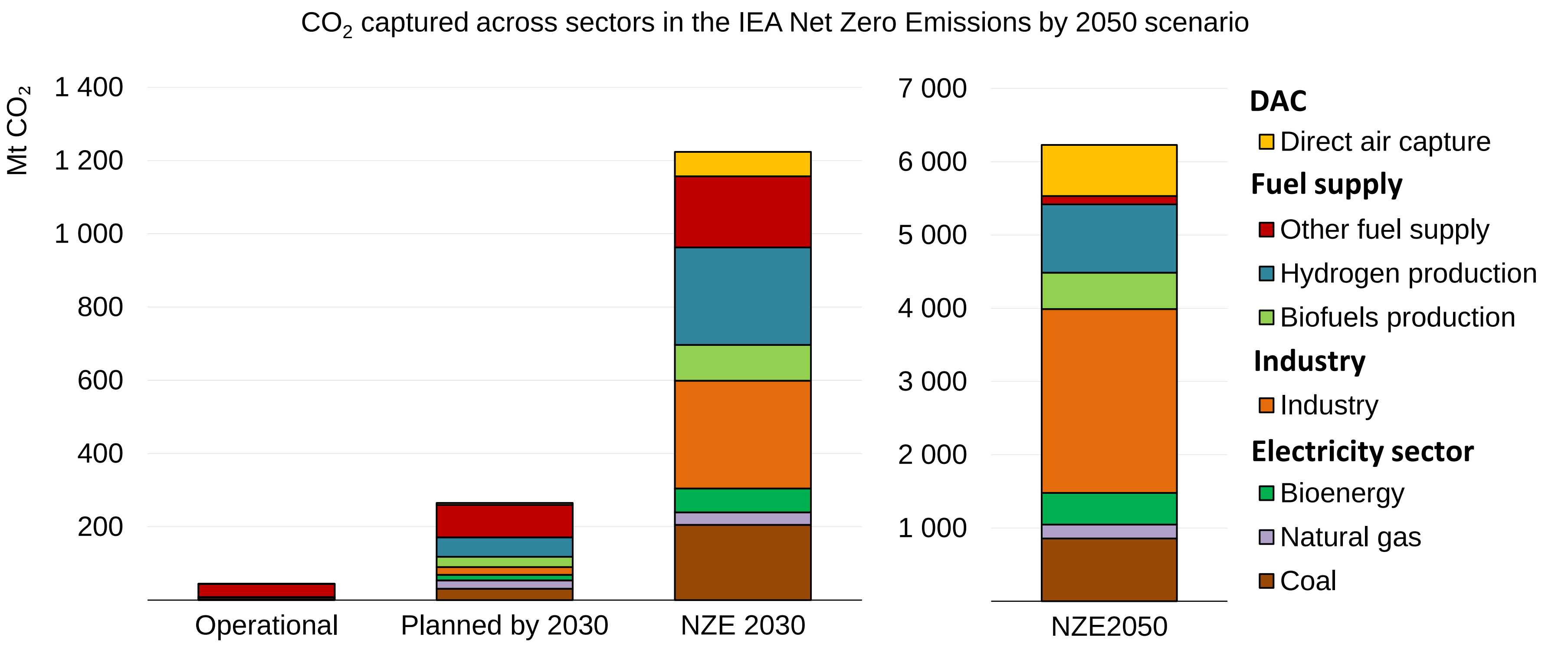
Platform for low-carbon hydrogen production

4



Carbon removal

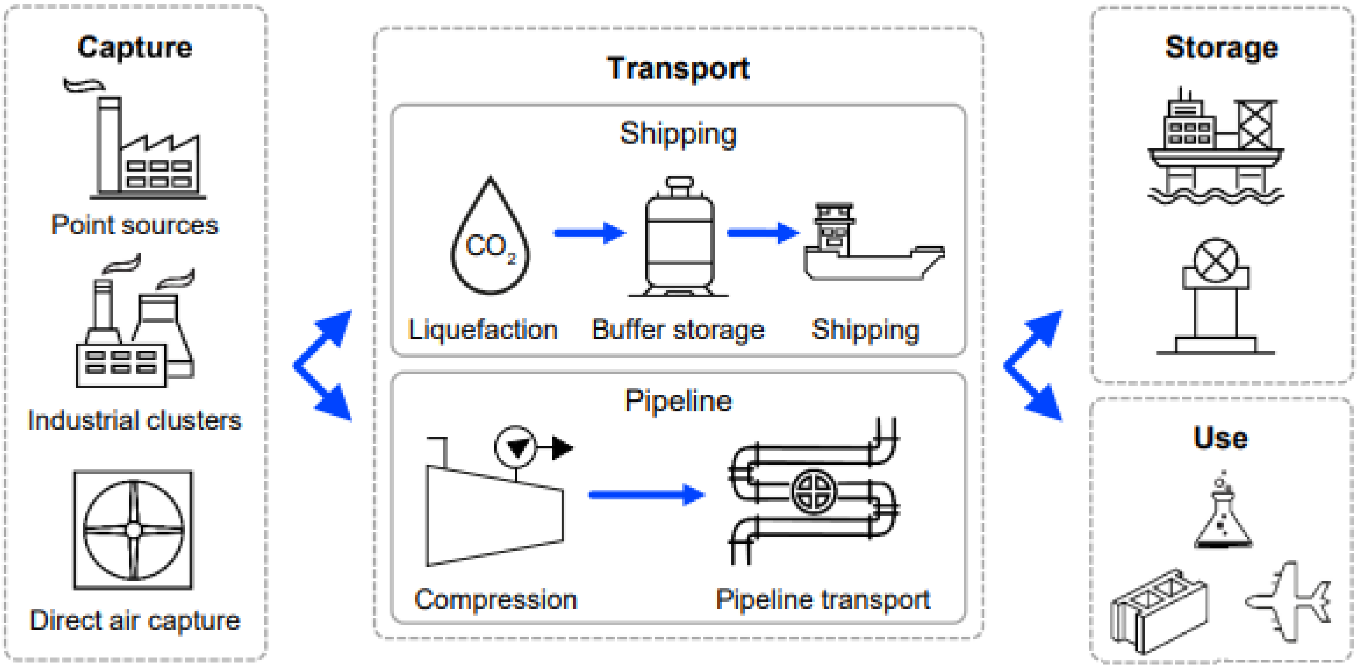
CCUS in reaching net zero emissions by 2050



By 2030, 1.2 Gt of CO_2 is captured per year, with sources diversifying from natural gas processing to power, industry, hydrogen-based fuel production, and removals. CCUS increases to 6.2 Gt CO_2 by 2050.

Infrastructure deployment is constrained by lead times

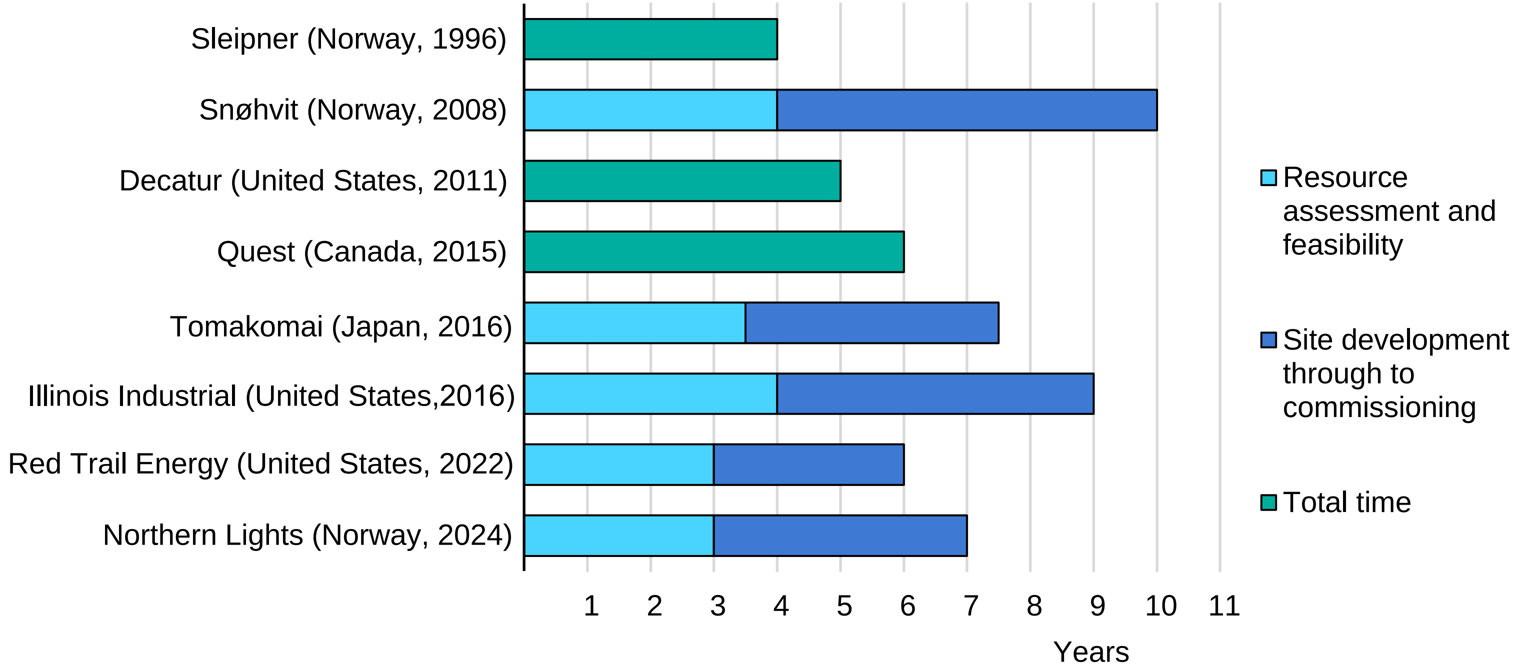
CO_2 flows through the CO_2 management value chain



Once captured, CO_2 can be used on site or transported, in most cases by pipeline or ship, either to a point of use or to a permanent underground storage site

Infrastructure deployment is constrained by lead times

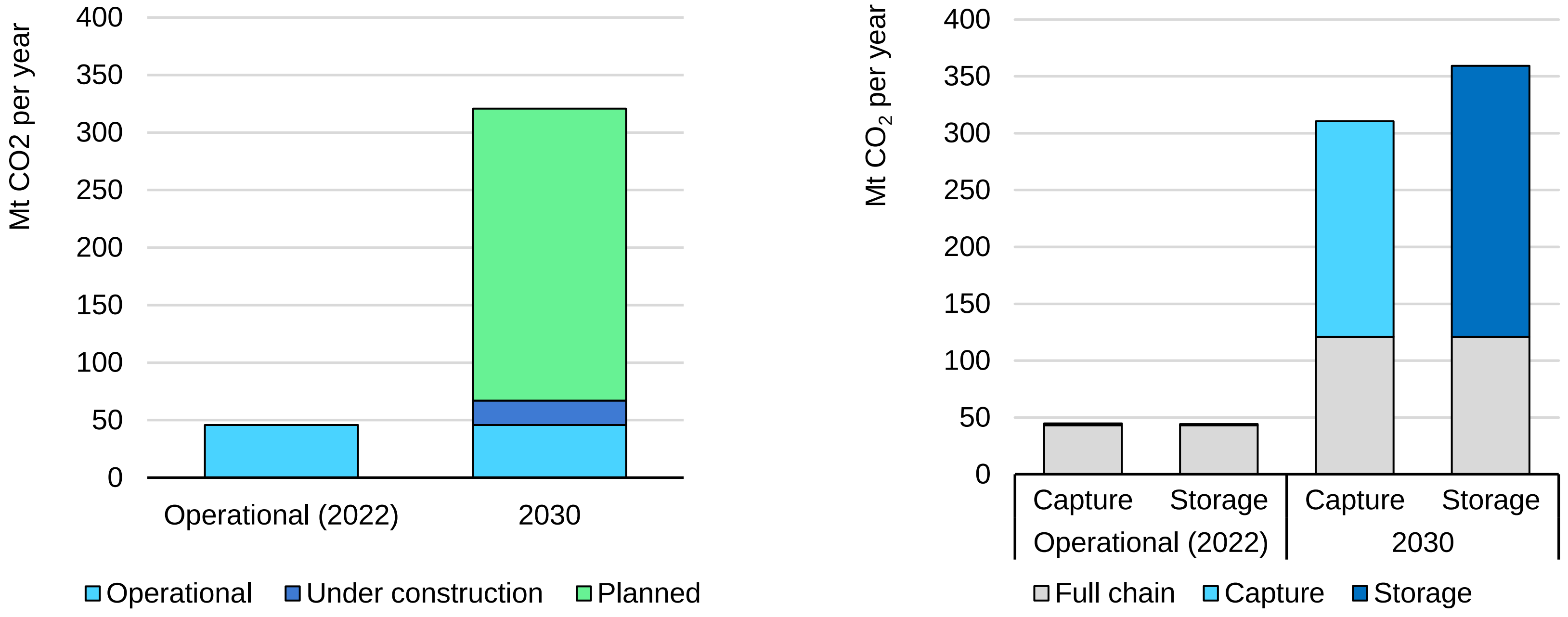
Lead times for the CO_2 storage component of selected CCUS projects with dedicated storage



Resource assessment makes up a significant portion of CO2 storage project lead times

New business models are boosting momentum on CCUS

Operational and planned capacity by project status (left) and type (right)



In 2022, more than 140 new projects were announced, increasing planned capture capacity by 30% and storage capacity by 80%. The storage gap is closing as plans for CCUS hubs multiply.

Government and industry action this decade is crucial

Four high-level priorities for governments and industry would accelerate the progress of CCUS:

1 Create the conditions for investment

2 Target the development of industrial hubs with shared CO_2 infrastructure

3 Identify and develop CO_2 storage

4 Boost innovation for key technologies

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CCS INSIGHTS FROM THE IEA

Carl Greenfield
International Energy Agency (IEA)

Ellina Levina
Global CCS Institute

MODERATOR

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KEY CONDITIONS OF CCS FINANCING & INVESTMENT

Ellina Levina
Global CCS Institute

MODERATOR

Daniel Kitscha
European Commission

Julian Mylchreest
Bank of America

Adam Wong
US Department of Energy, Office of Fossil Energy and Carbon Management

Torbjørg Klara Fossum
Equinor

Eduardo Famini Silva
Royal Bank of Canada (RBC), Capital Markets

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CARBON DIOXIDE REMOVAL

PRESENTER

Niall Mac Dowell
Imperial College London

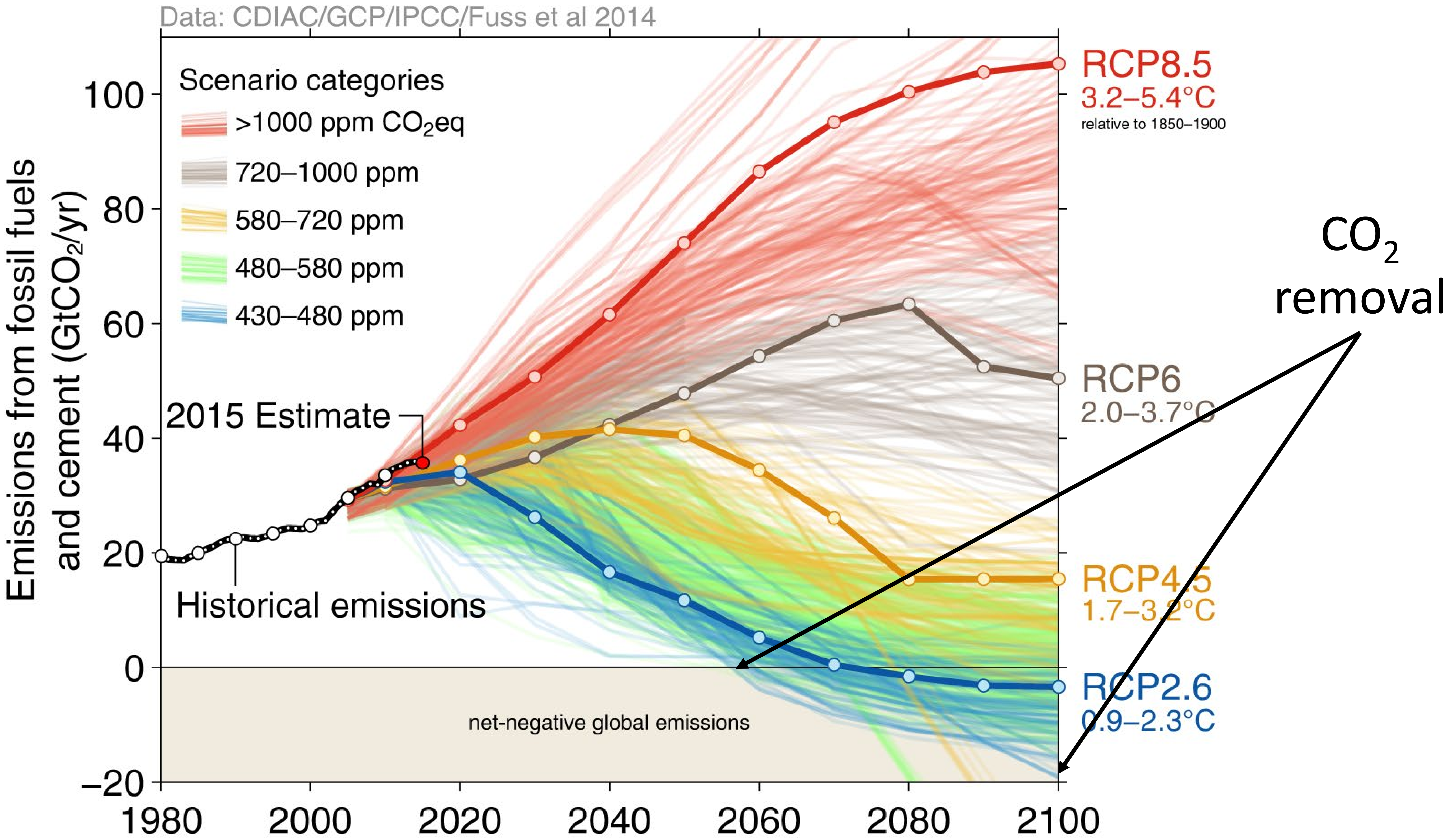
Imperial College London

Comparing approaches for carbon dioxide removal (CDR)

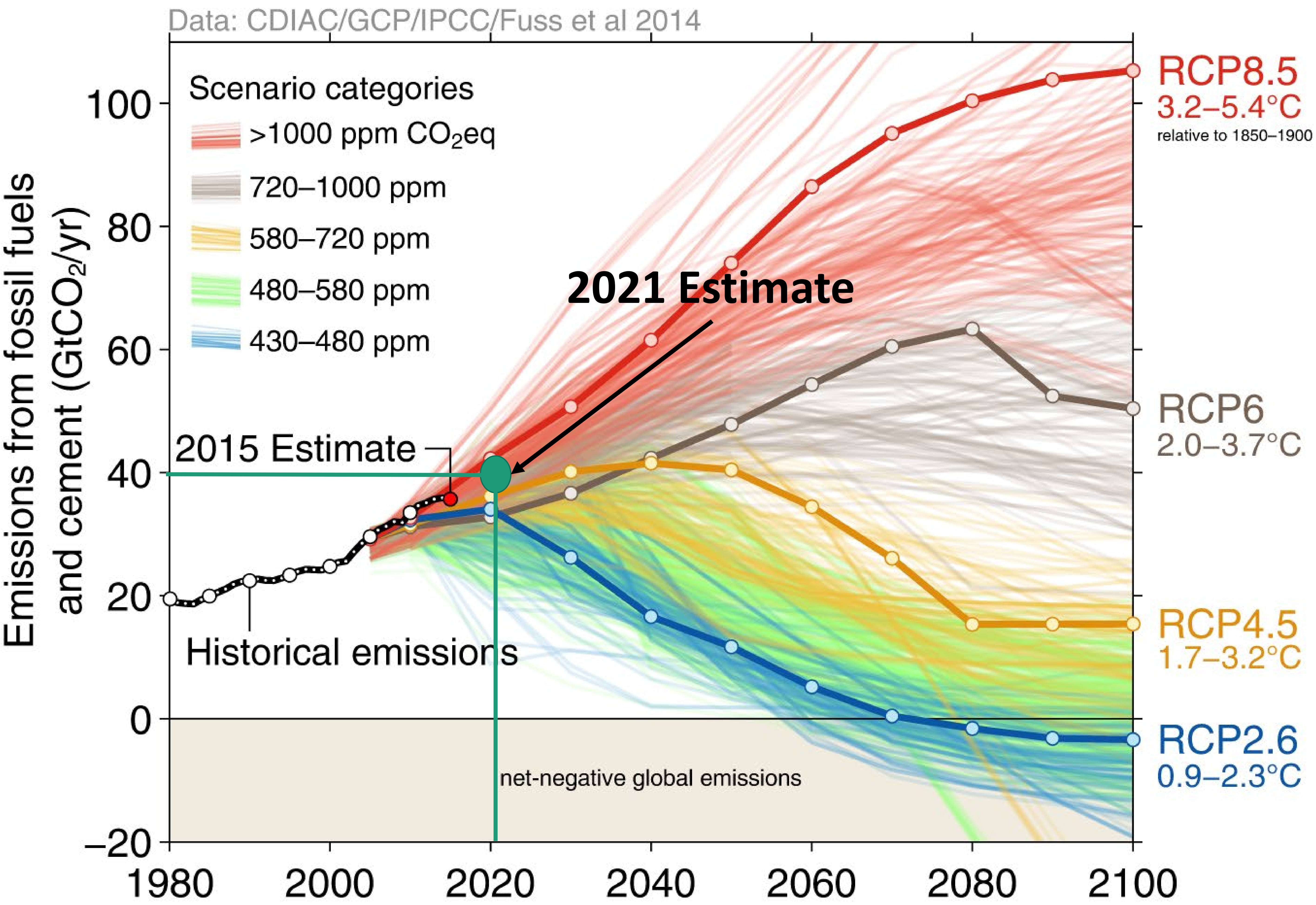
Niall Mac Dowell

Imperial College London

niall@imperial.ac.uk

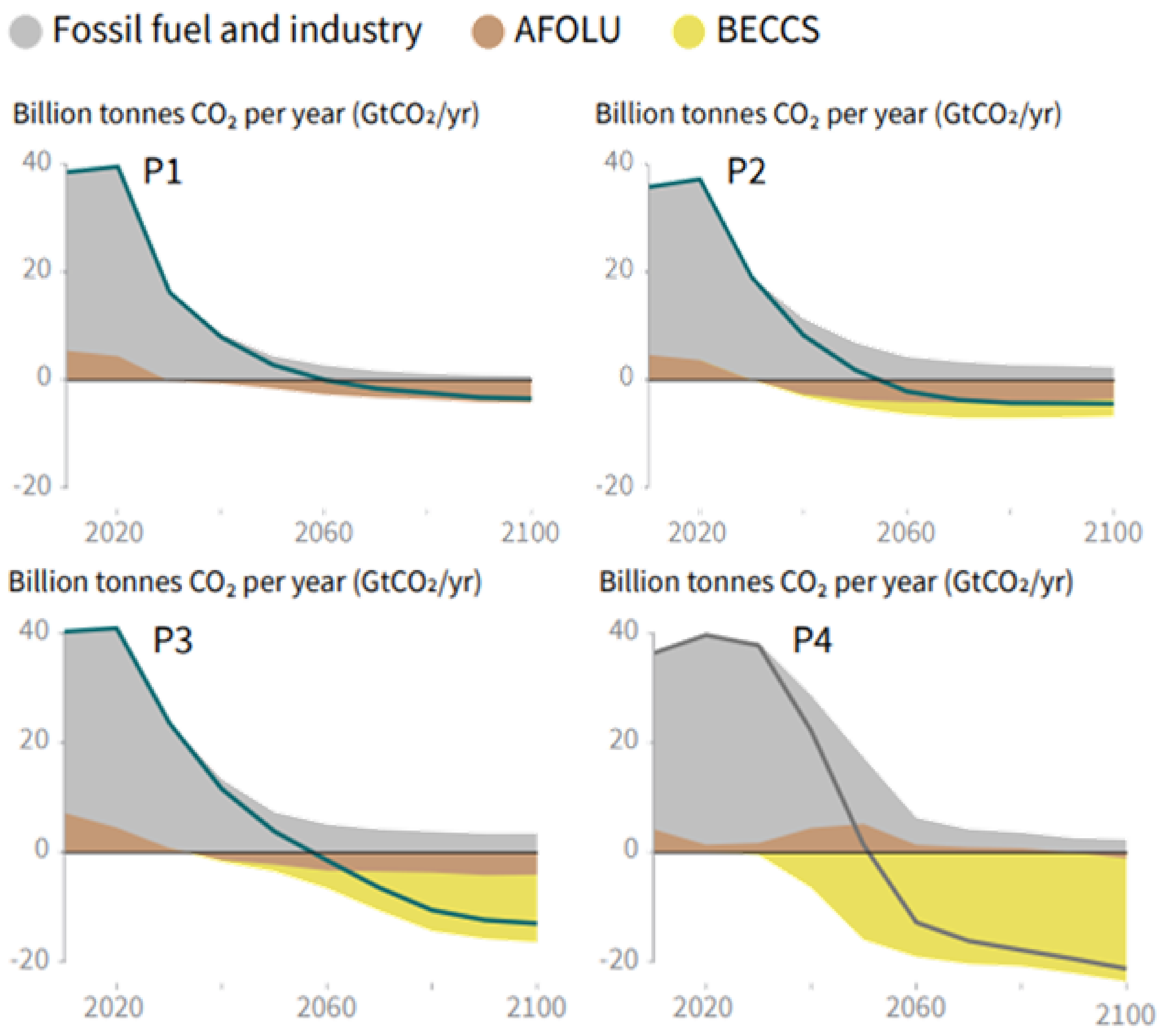


Mac Dowell, GCCSI, 2023



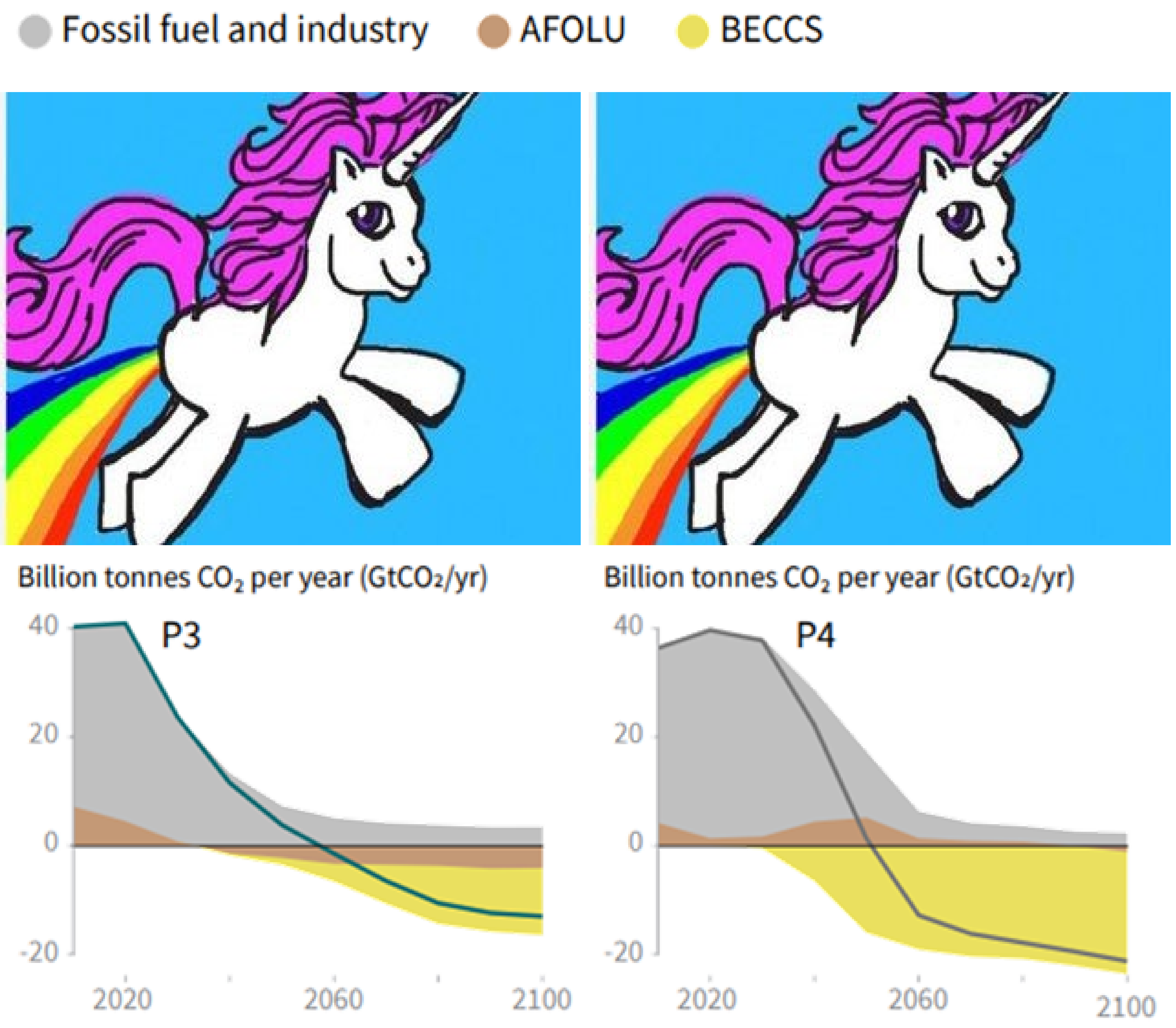
Mac Dowell, GCCSI, 2023

Likely paths to 1.5°C…



Source: IPCC, 2018, Global warming of 1.5°C

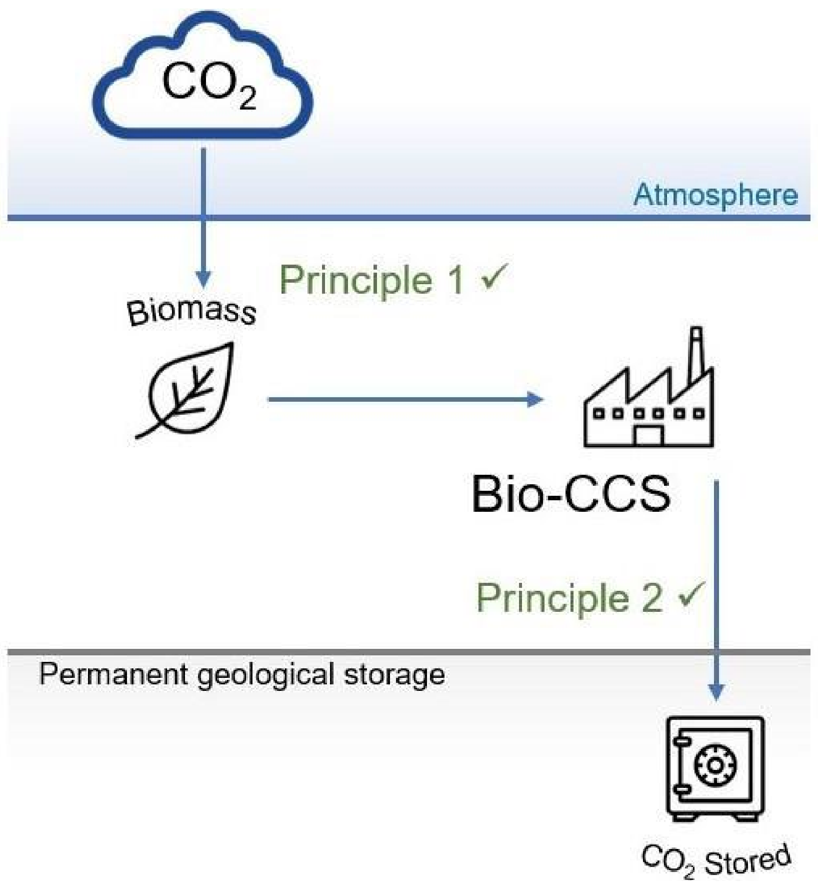
Likely paths to 1.5°C...



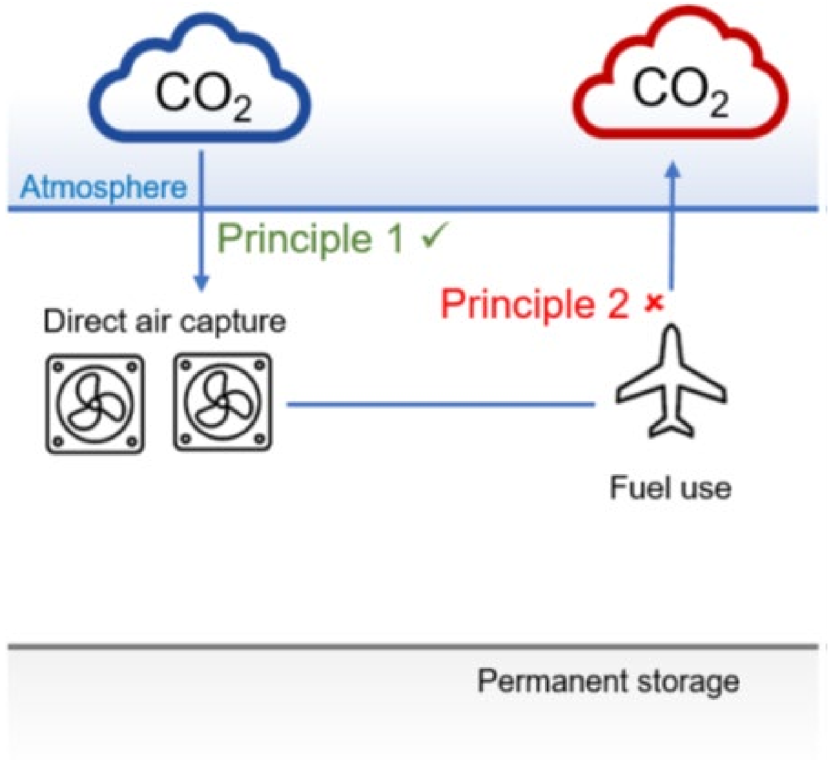
Mac Dowell, GCCSI, 2023

Source: IPCC, 2018, Global warming of 1.5°C

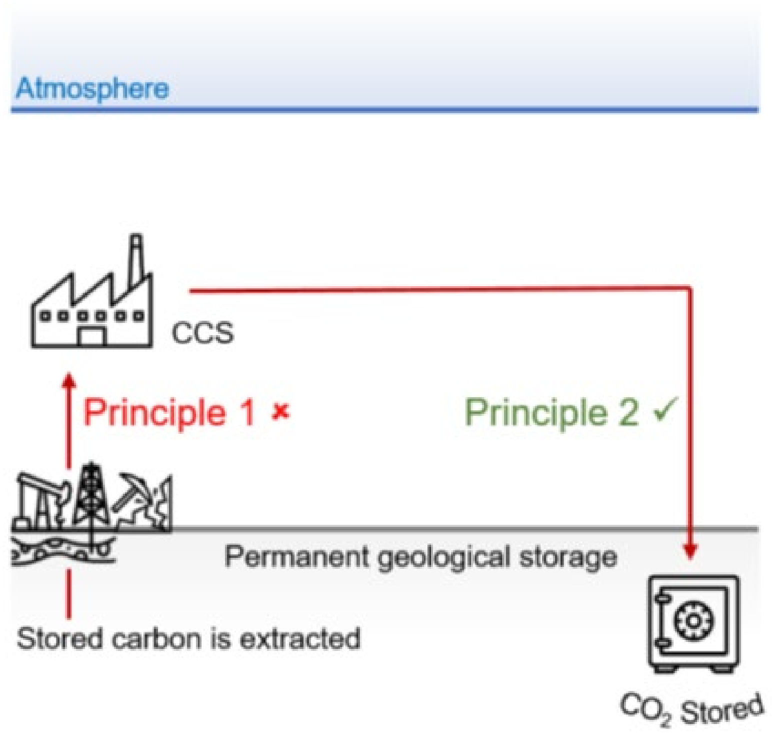
What is CDR?



Removing CO_2



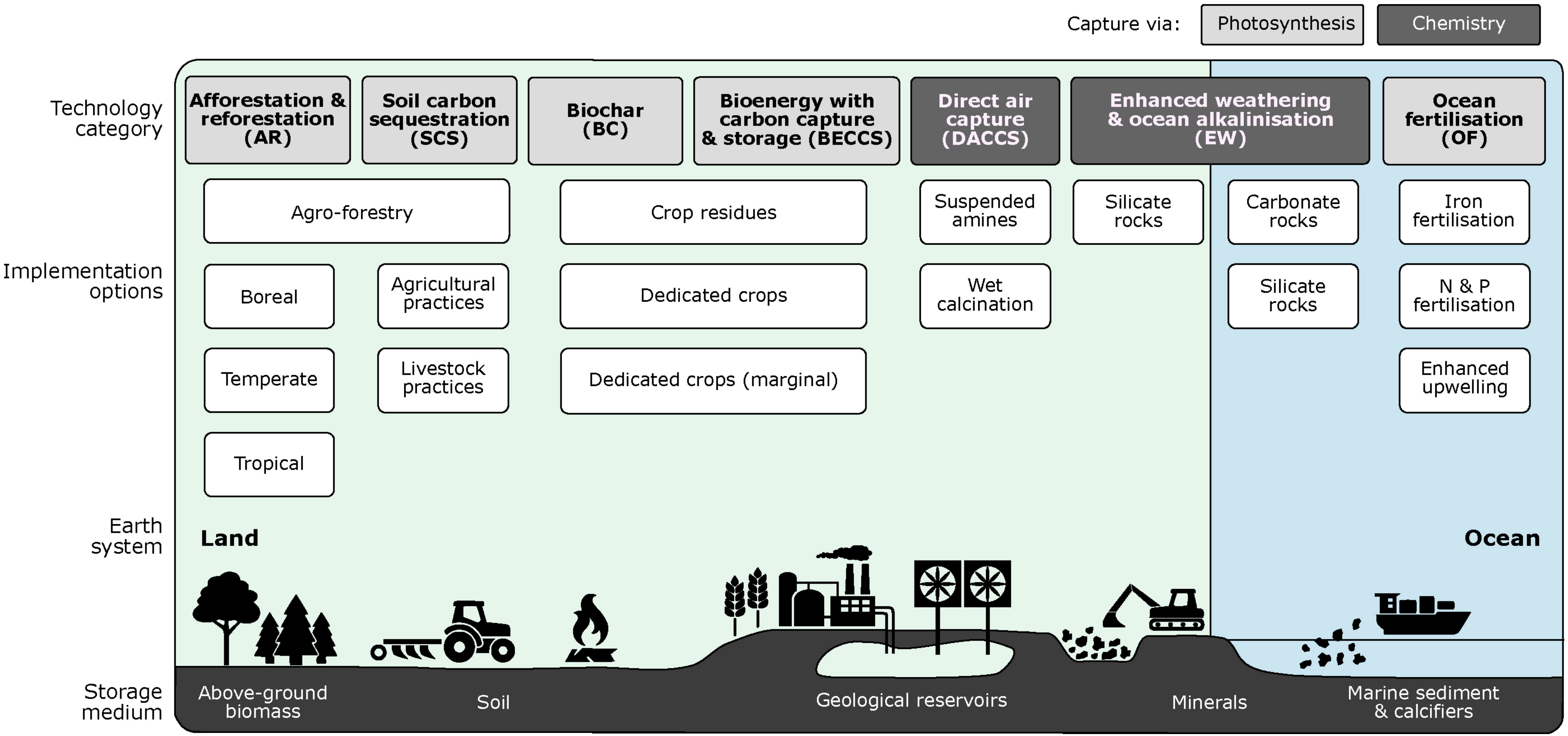
Using CO_2



Avoiding CO_2

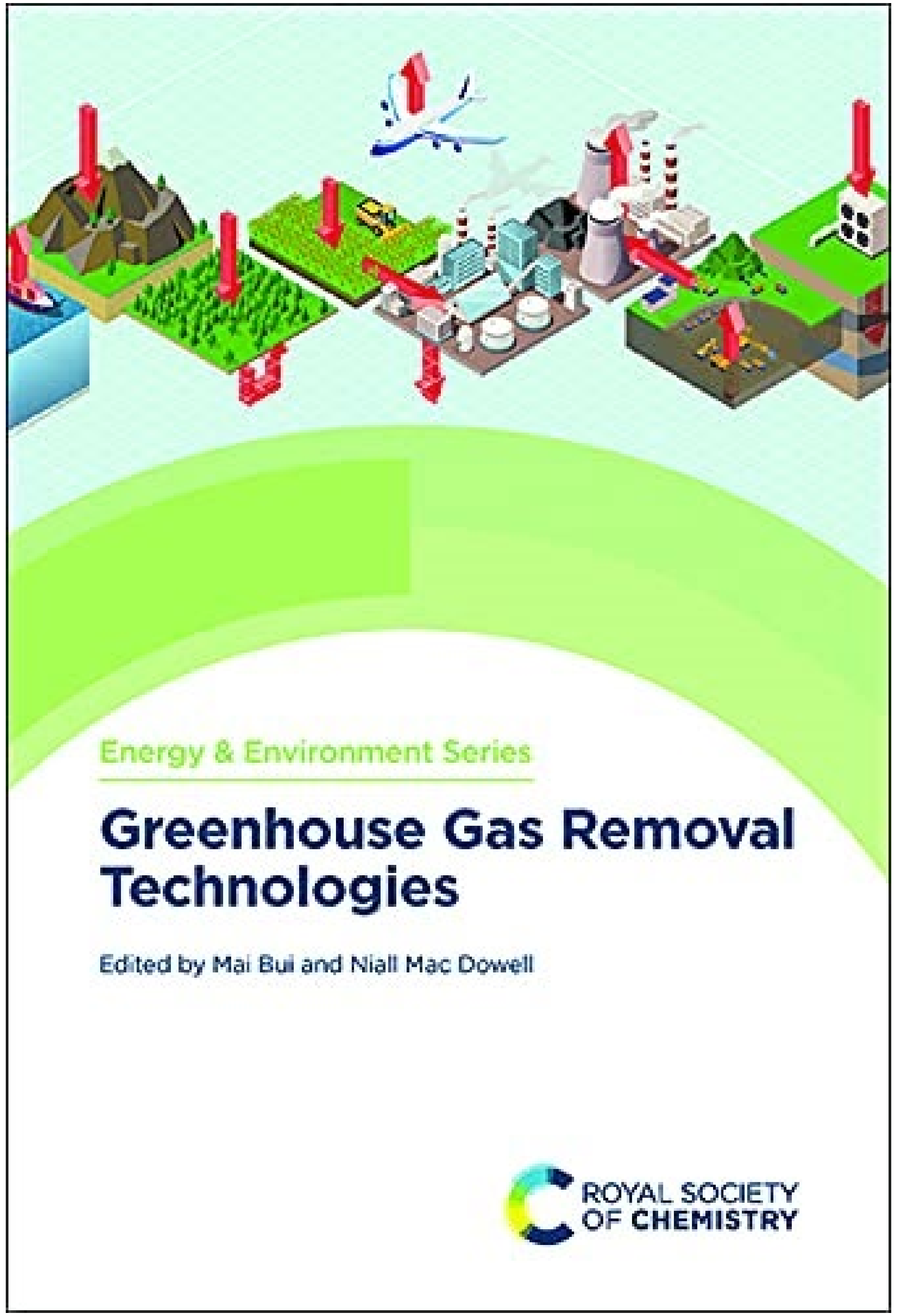
Mac Dowell, GCCSI, 2023

ZEP, "Europe needs a definition of carbon dioxide removal", 2020



Minx *et al*, Environ. Res. Lett., 2018

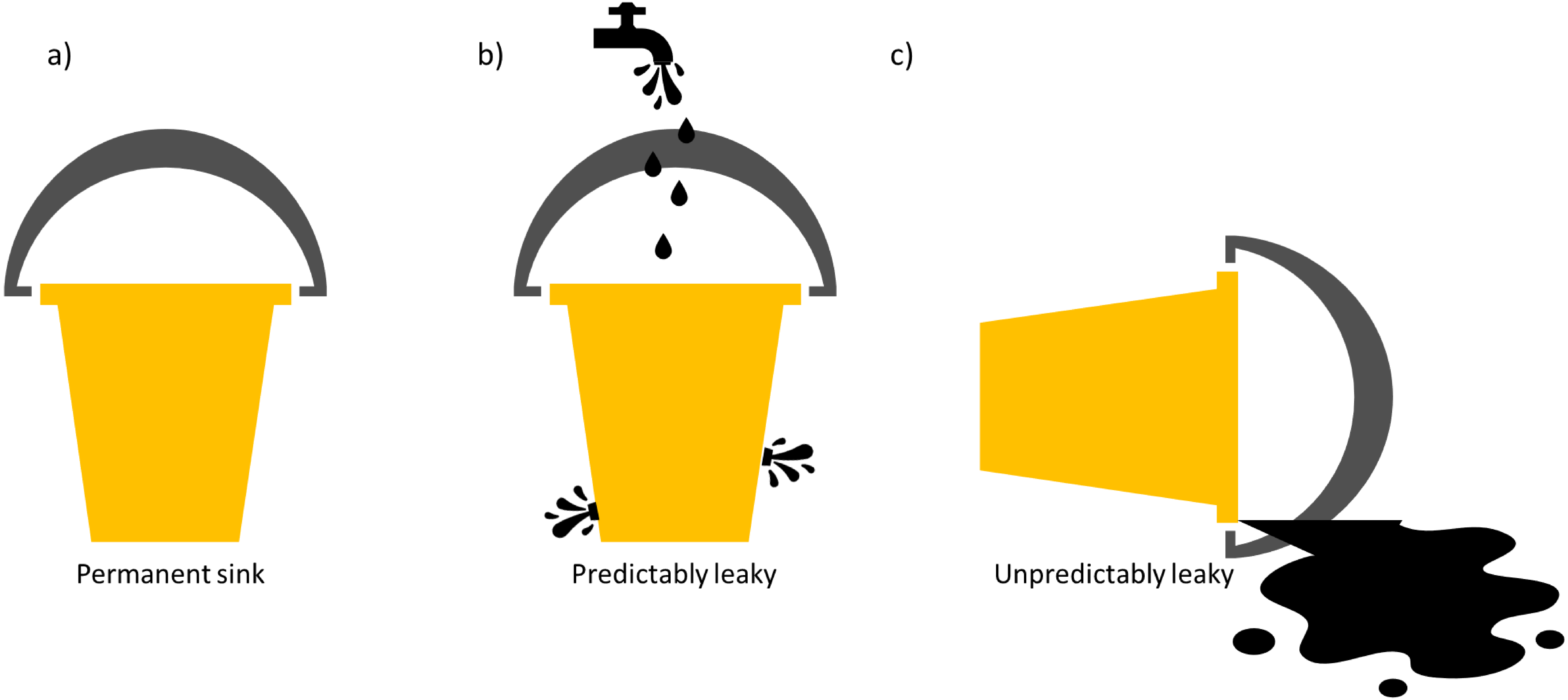
What is CDR?



Minx *et al*, Environ. Res. Lett., 2018

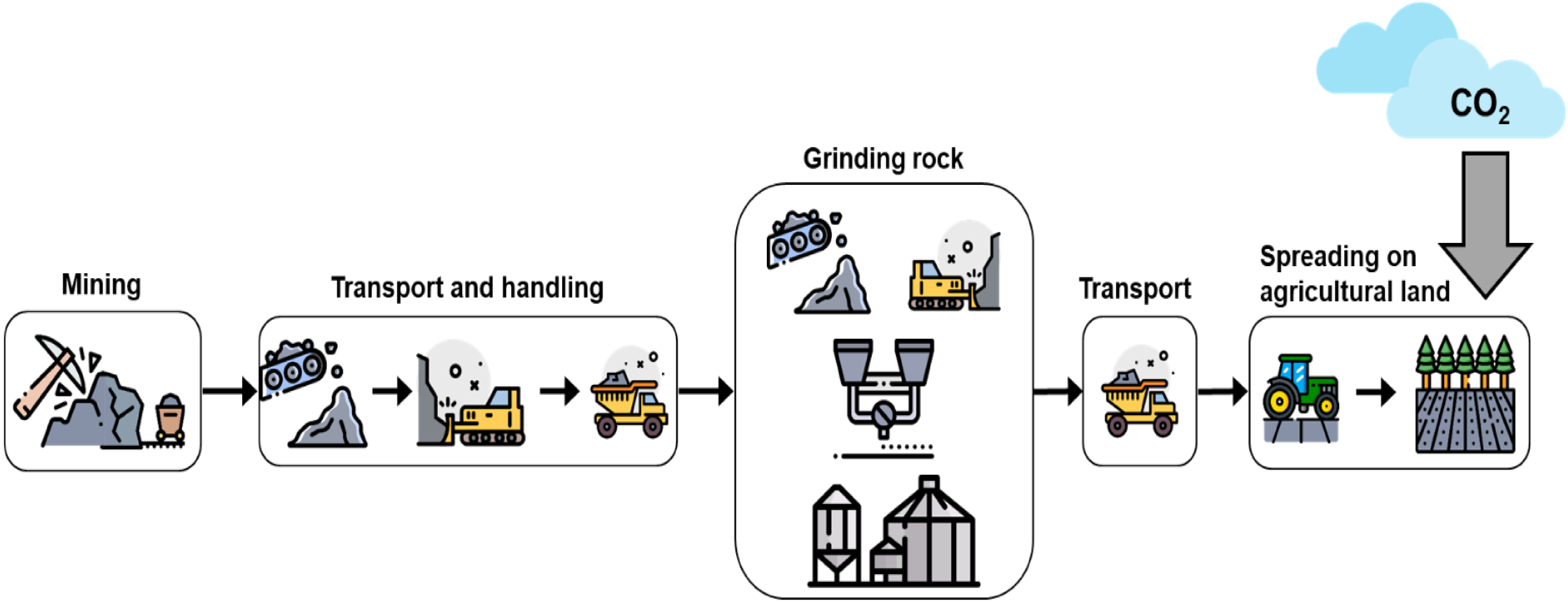
Trees ≠ rocks

How useful can leaky buckets be..?



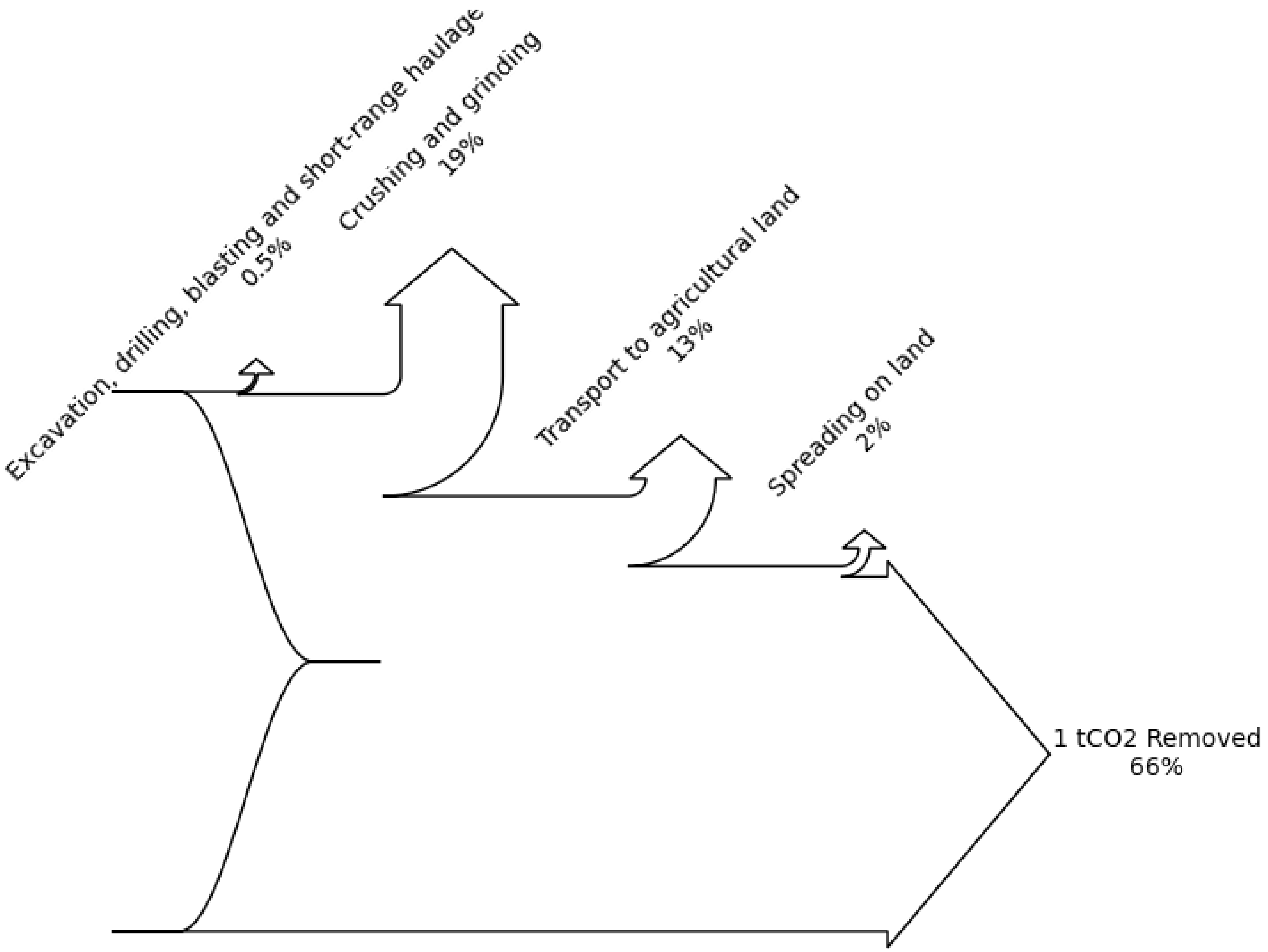
Mac Dowell, Reiner, Haszeldine, Joule, 2022

Enhanced Weathering



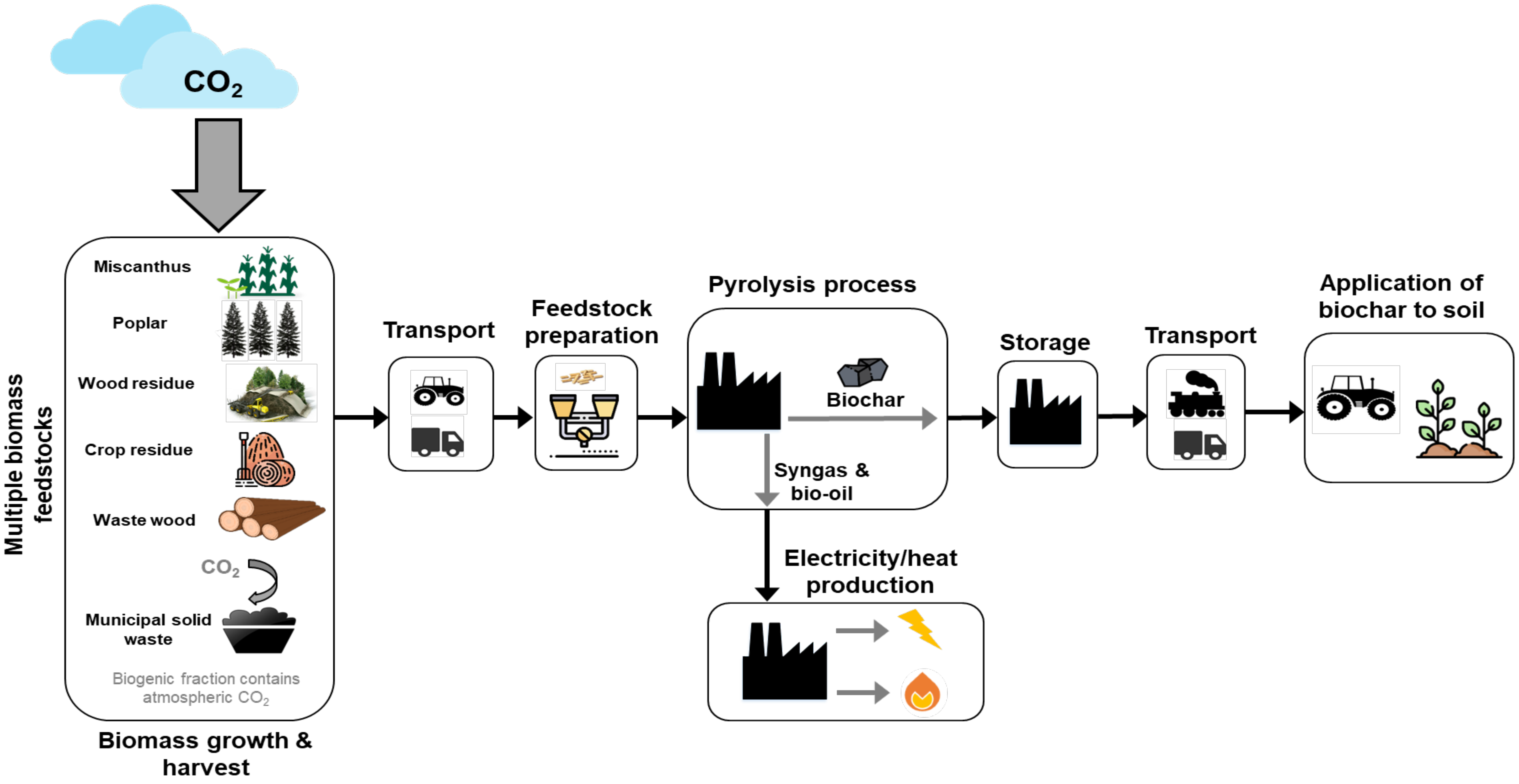
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Enhanced Weathering



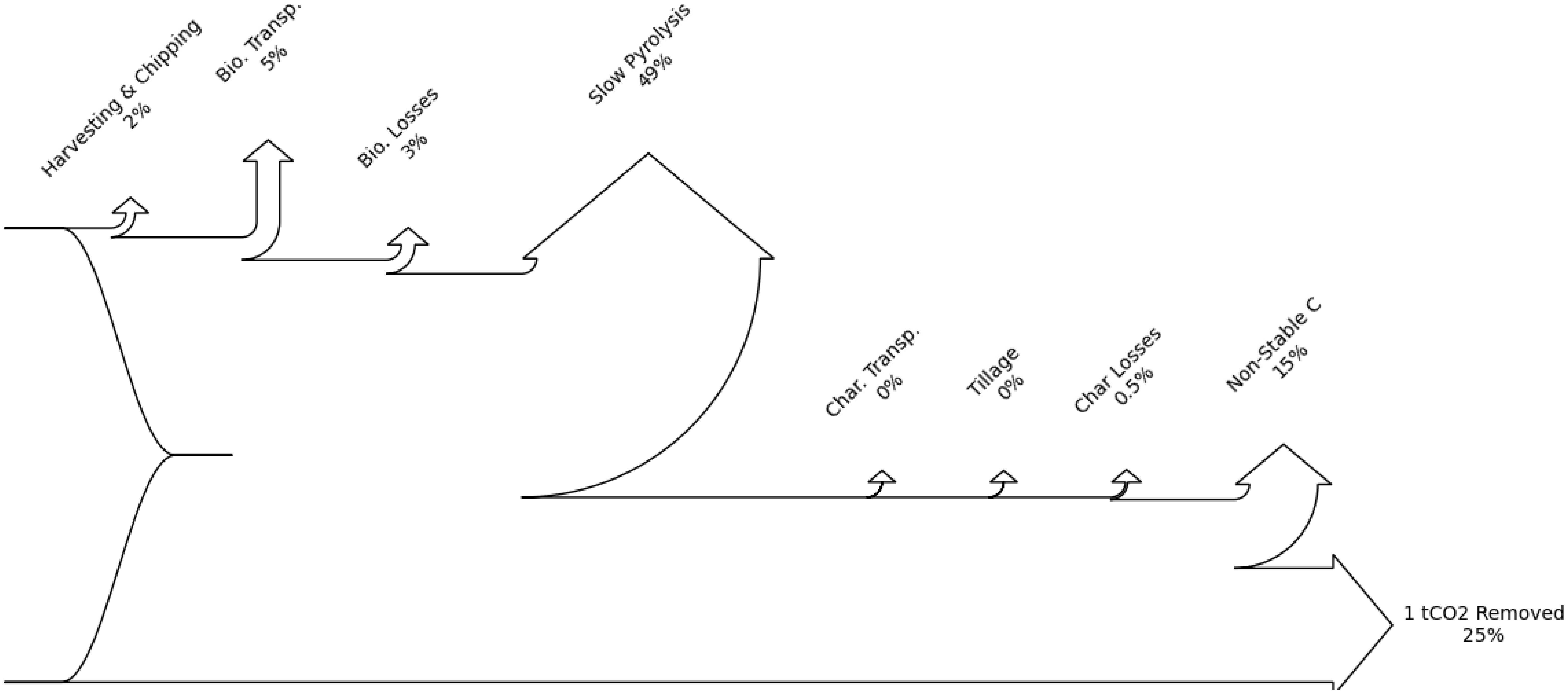
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Biochar



Mac Dowell, GCCSI, 2023

Biochar



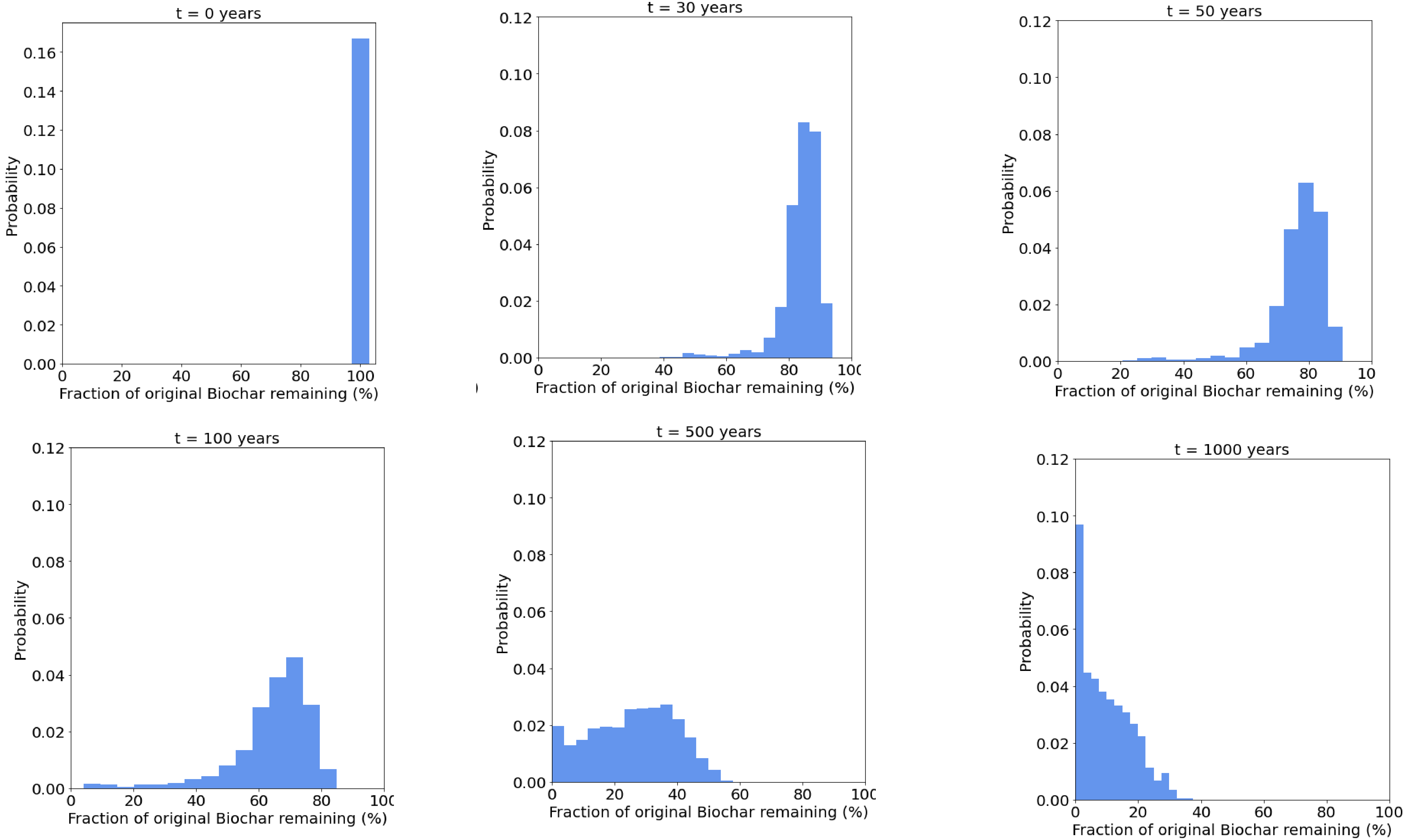
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Biochar degrades with time…

$$DR(t) = L\,exp\left(-\frac{\ln(2)}{t_{1/2L}}t\right) + R\,exp\left(-\frac{\ln(2)}{t_{1/2R}}t\right)$$

- where:
  - L is the labile fraction of biochar (mean: 15, range: [5–30]%),
  - R = 1-L is the recalcitrant fraction of biochar (mean: 85, range: [70–95]%),
  - t1/2L is the labile half-time (mean: 20, range: [1–30] years),
  - t1/2R is the recalcitrant half-time (mean: 300, range: [50–1,000] years),

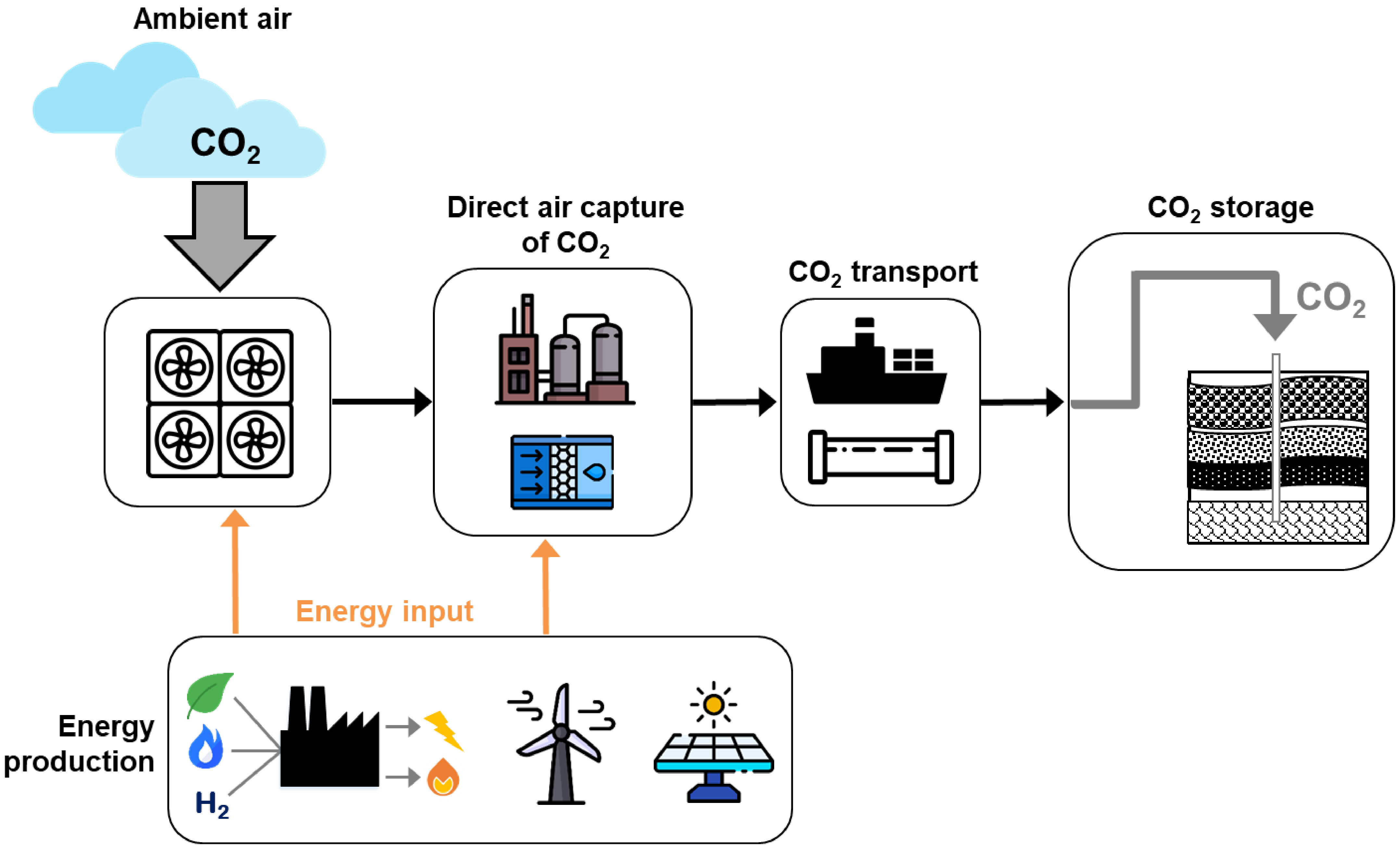
…after 1,000 years, there may be very little left!



Mac Dowell, GCCSI, 2023

Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

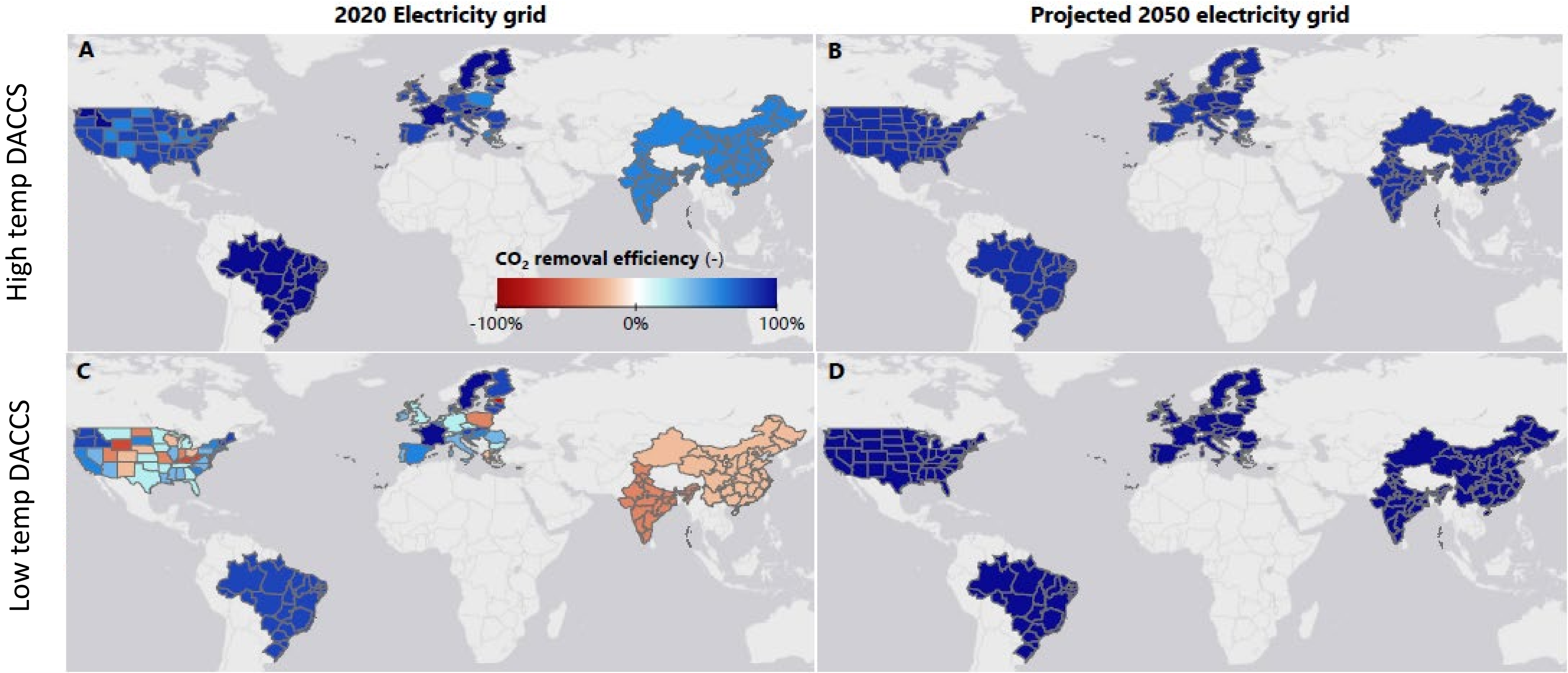
Direct air CO_2 capture and storage (DACCS)



Mac Dowell, GCCSI, 2023

Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

DACCS is not automatically carbon negative



Whilst the grid is not decarbonised, what is the best use of energy?

Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

DACCS ≠ trees

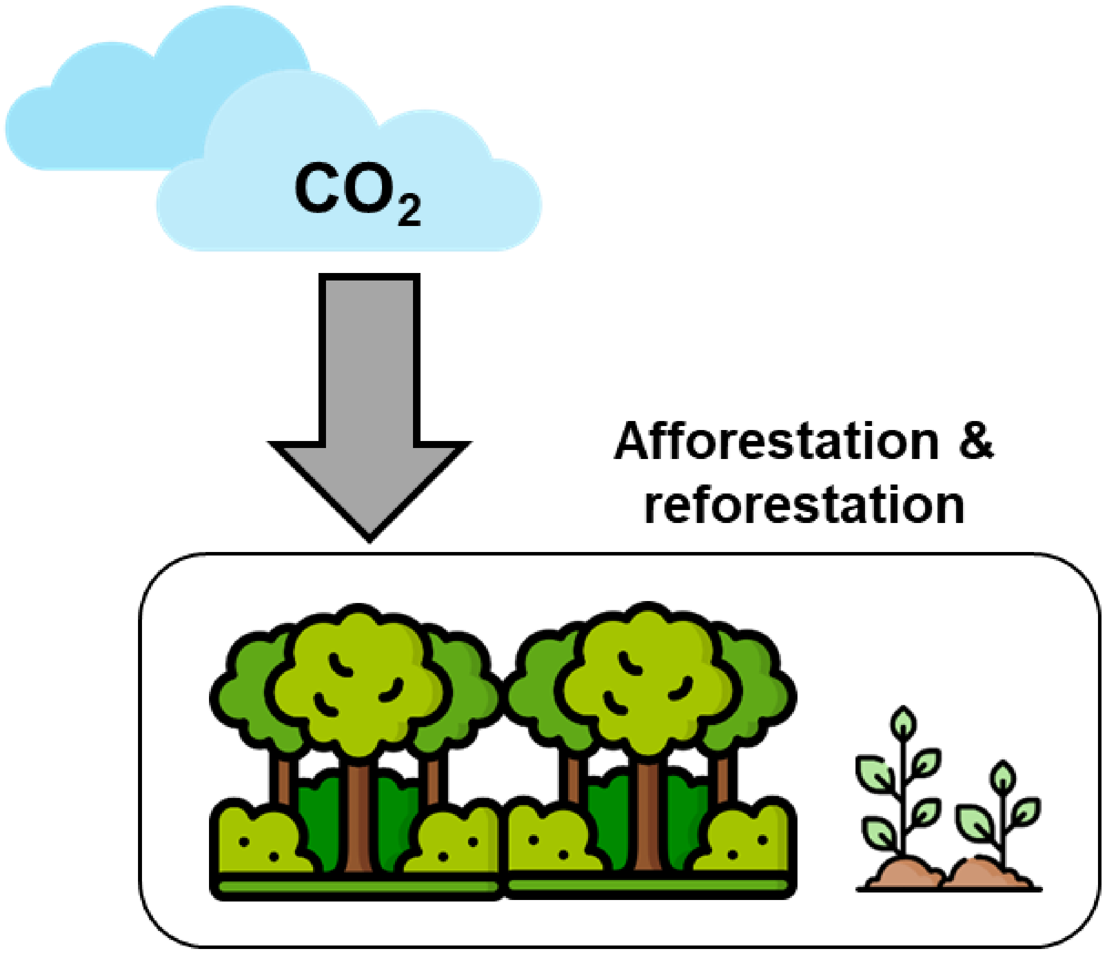
Different CDR pathways provide a range of services

	GGR Pathway				
Service	AF	BC	EW	BECCS	DACCS
CDR	✓	**?**	✓	✓	✓
Energy System				✓	
Crop yield enhancement		✓	✓		
Soil enhancement		✓			
Air quality	✓				
Water quality	✓				
Biodiversity	✓				
Ecosystem services	✓				

It is vital to value each discrete service – its not just "carbon"

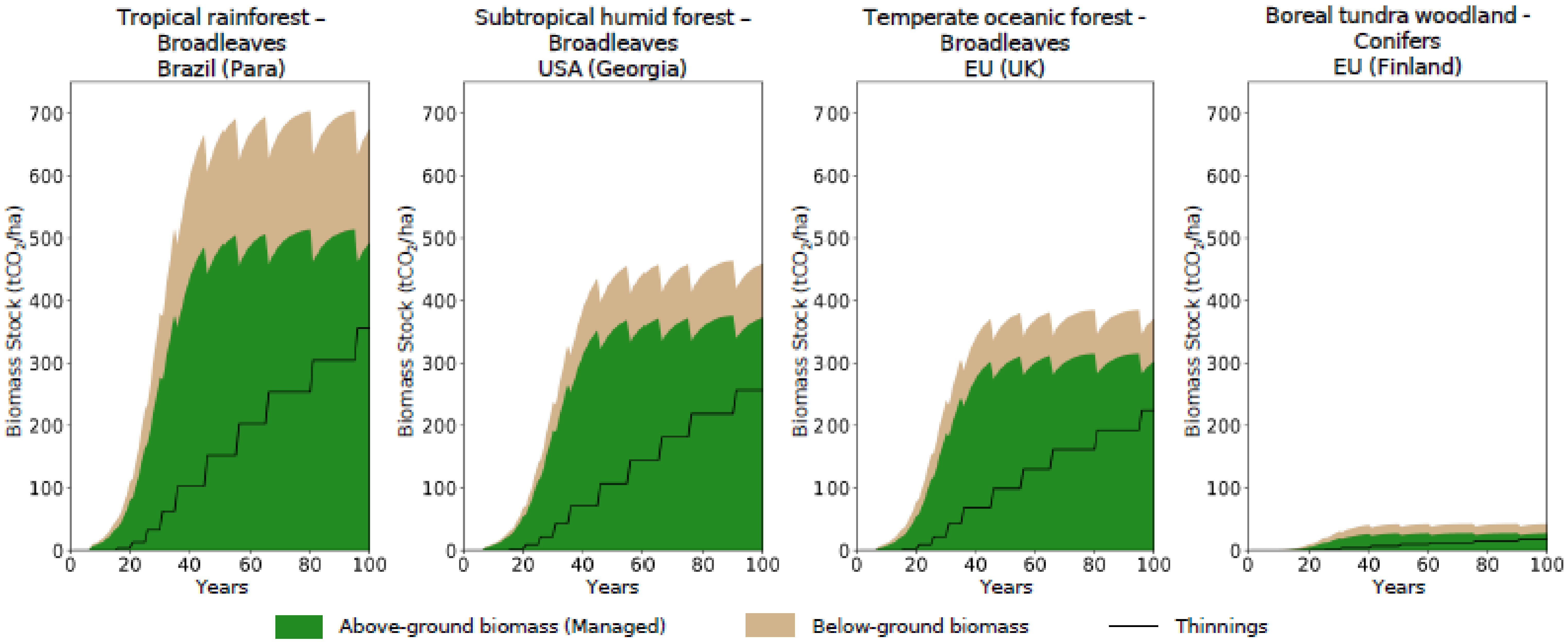
Mac Dowell, Reiner, Haszeldine, Joule, 2022

Afforestation and reforestation (AR)



Mac Dowell, GCCSI, 2023

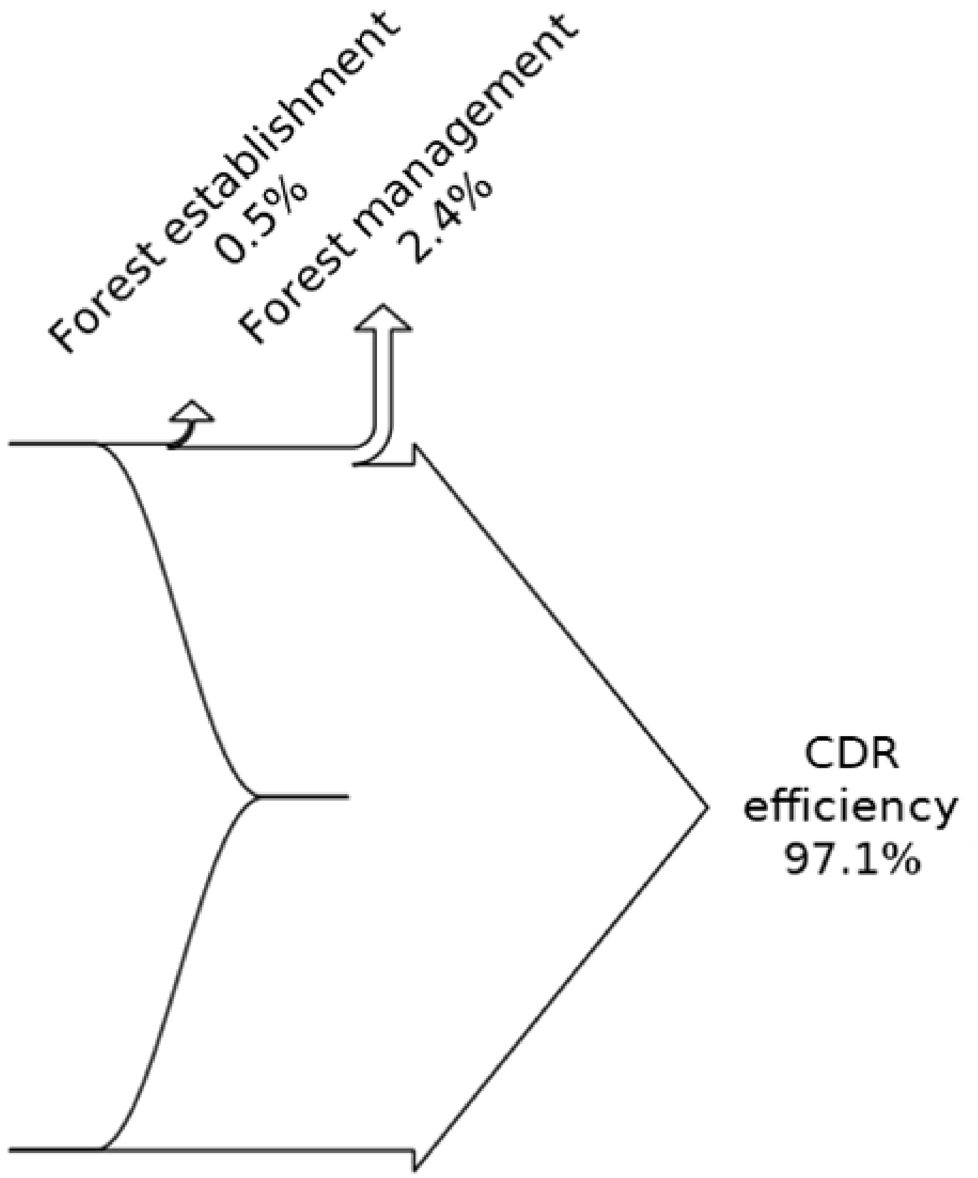
Forest growth curves



Regardless of location, a given area will “saturate” with carbon after ~ 30 – 50 years, but this carbon stock must be managed and maintained **in perpetuity**.

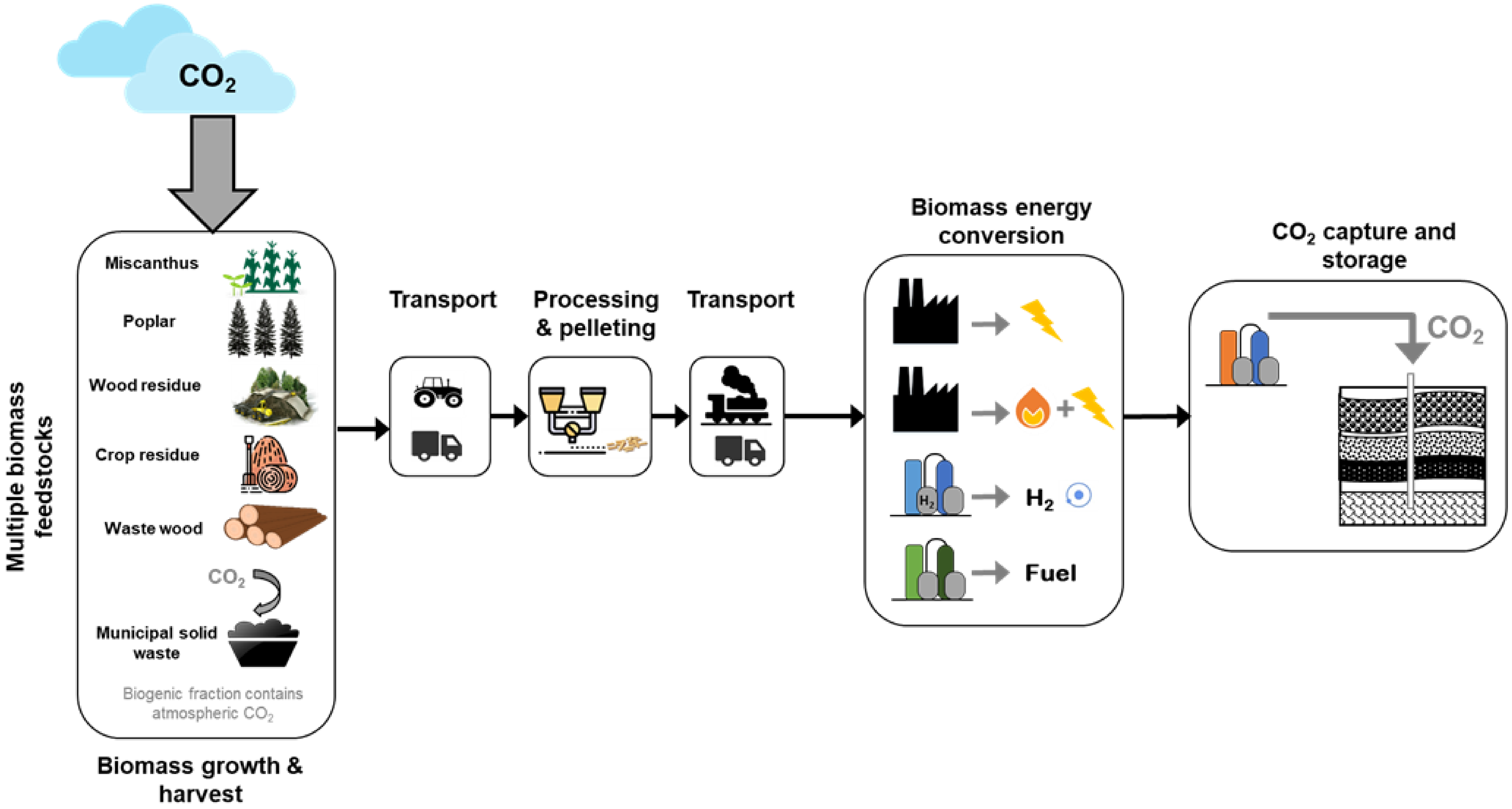
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

AR carbon removal efficiency



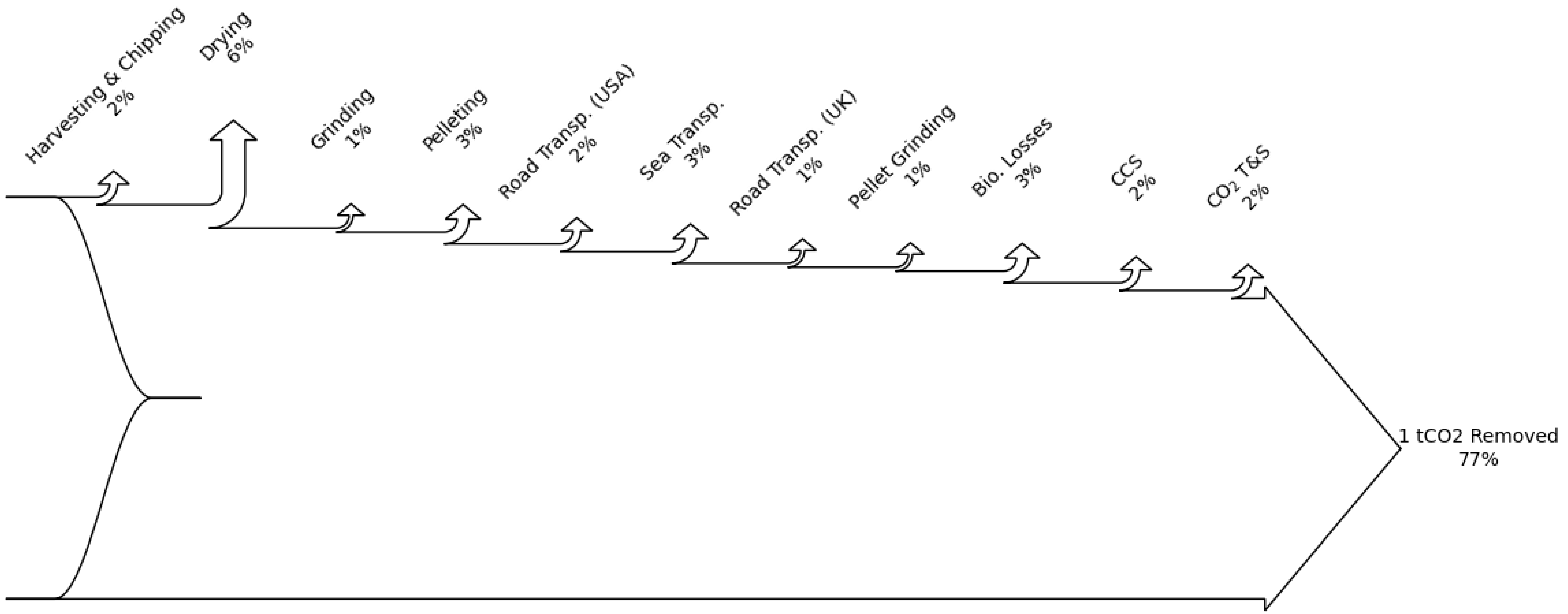
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Bioenergy with CCS (BECCS)



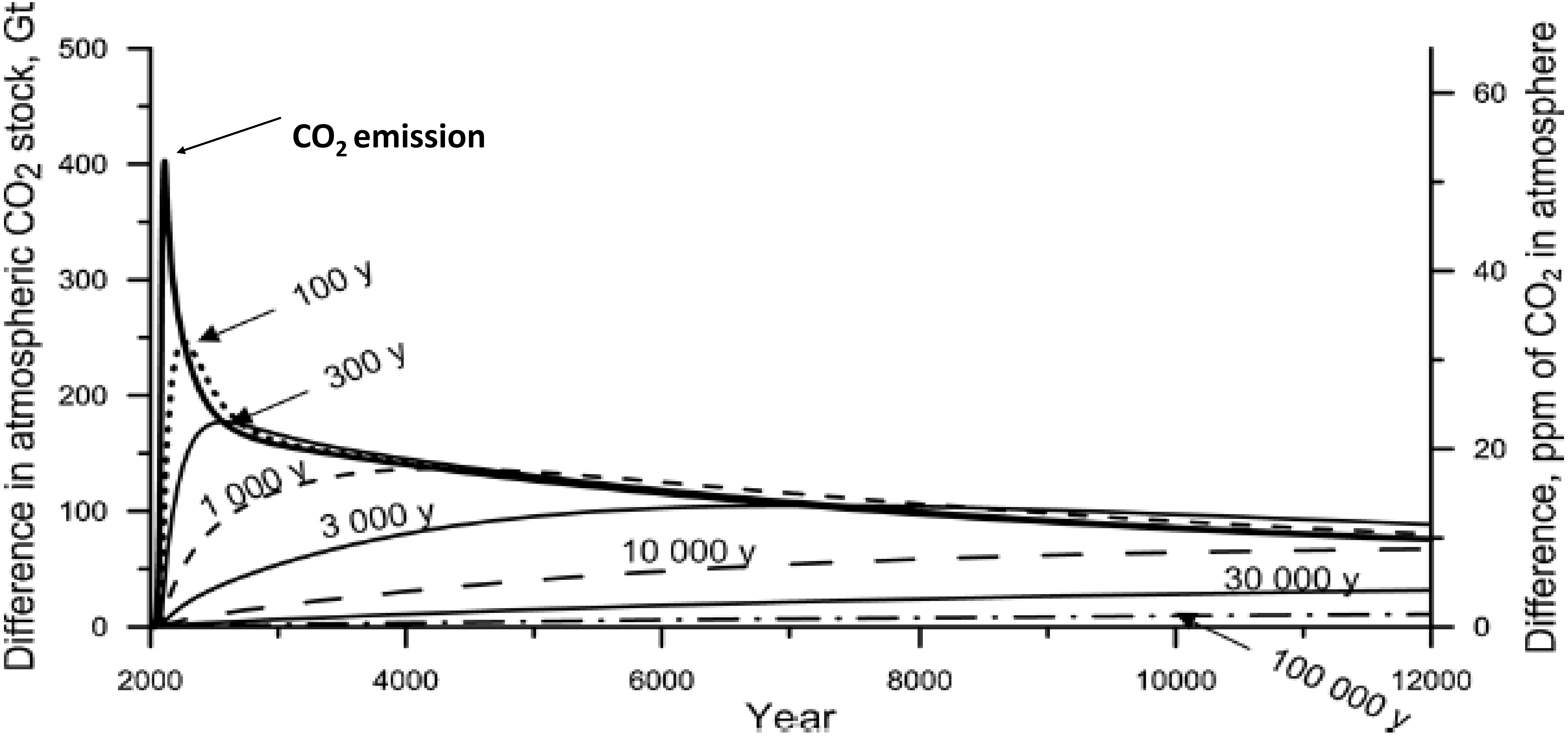
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Carbon removal efficiency of BECCS



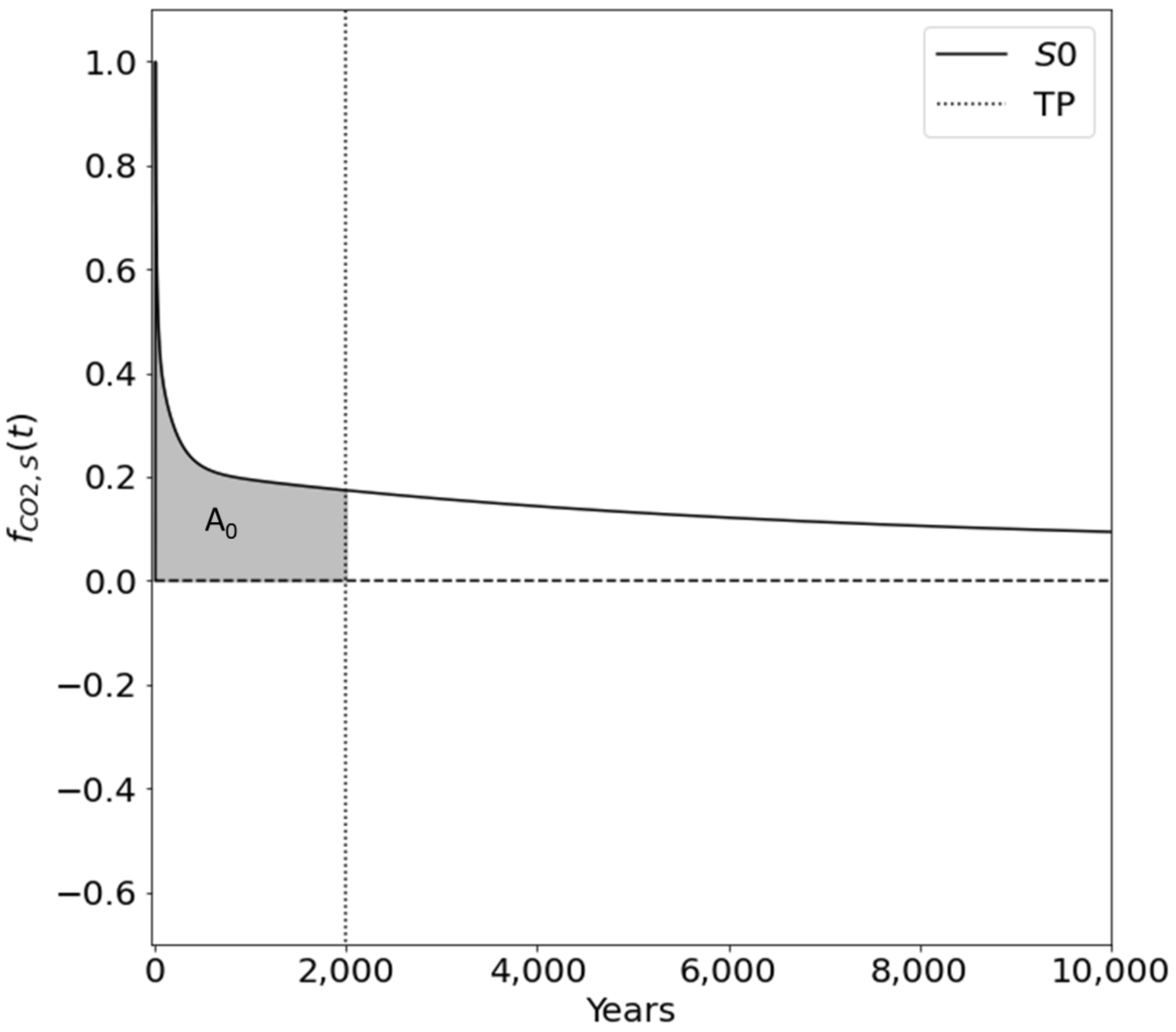
Chiquier, Fajardy, Mac Dowell, Energy and Environmental Science, 2022

Temporary removals do not solve this problem



Lyngfelt, et al., Int J GHG Con, 2019

What is the climate repair value (CRV) of CDR?



$$IRF_{CO_2}(t) = A_0\left(\sum_{j=1}^{3} B_j\, e^{-\frac{t}{\gamma_j}}\right) + \sum_{j=1}^{3} A_j\, e^{-\frac{t}{\tau_i}}$$

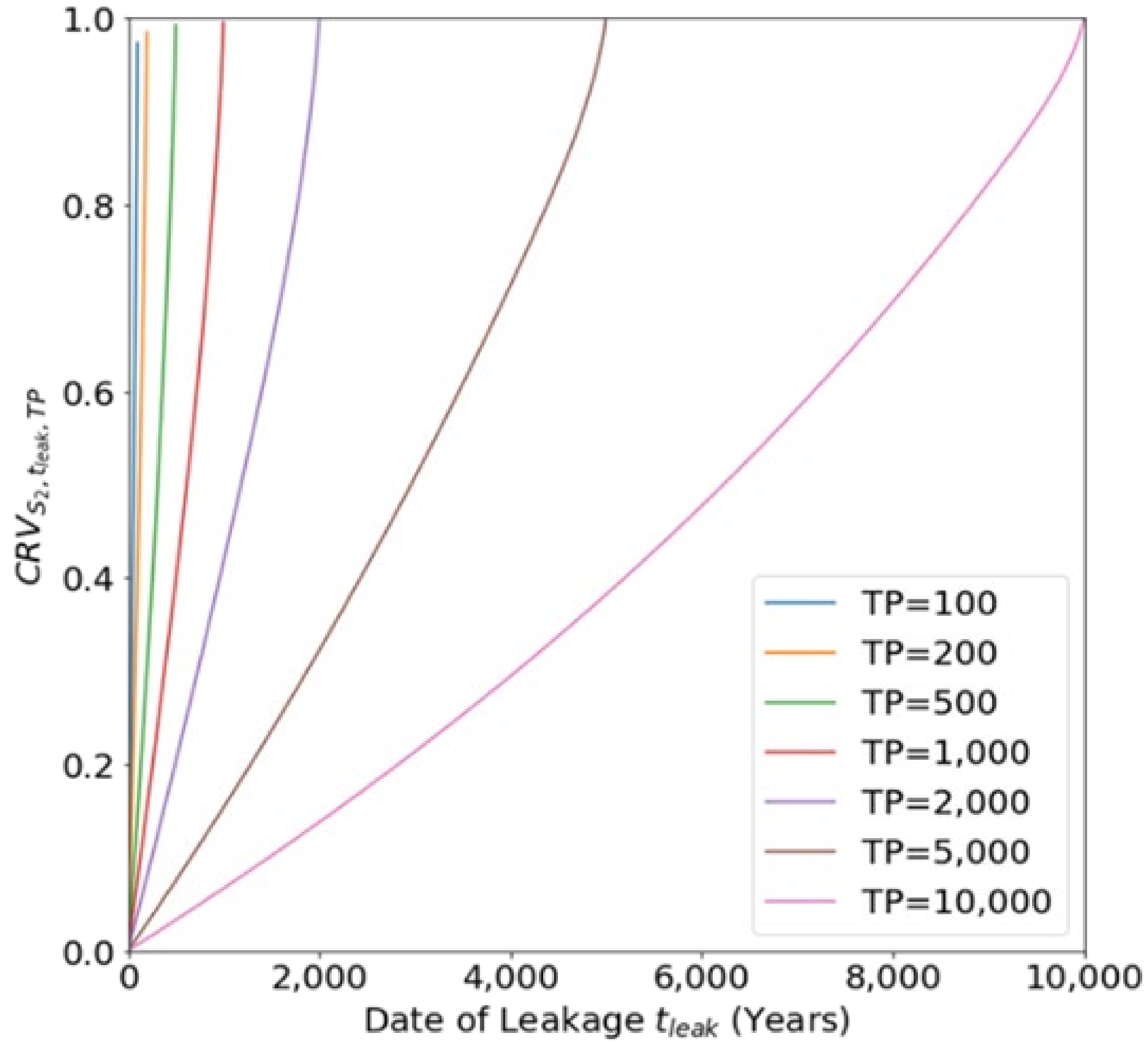
i,j	0	1	2	3
A_i (-)[12]	0.2173	0.2763	0.2824	0.224
τ_i (-)[12]	-	4.3	36.54	394.4
B_j (-)[13]	-	0.54	0.14	0.32
γ_j (years)[13]	-	5.5k	8.2k	200k

NB: CO_2 concentration takes ~ 200,000 years to decay to < 2% of the original emission

Prado and Mac Dowell., Joule, 2023

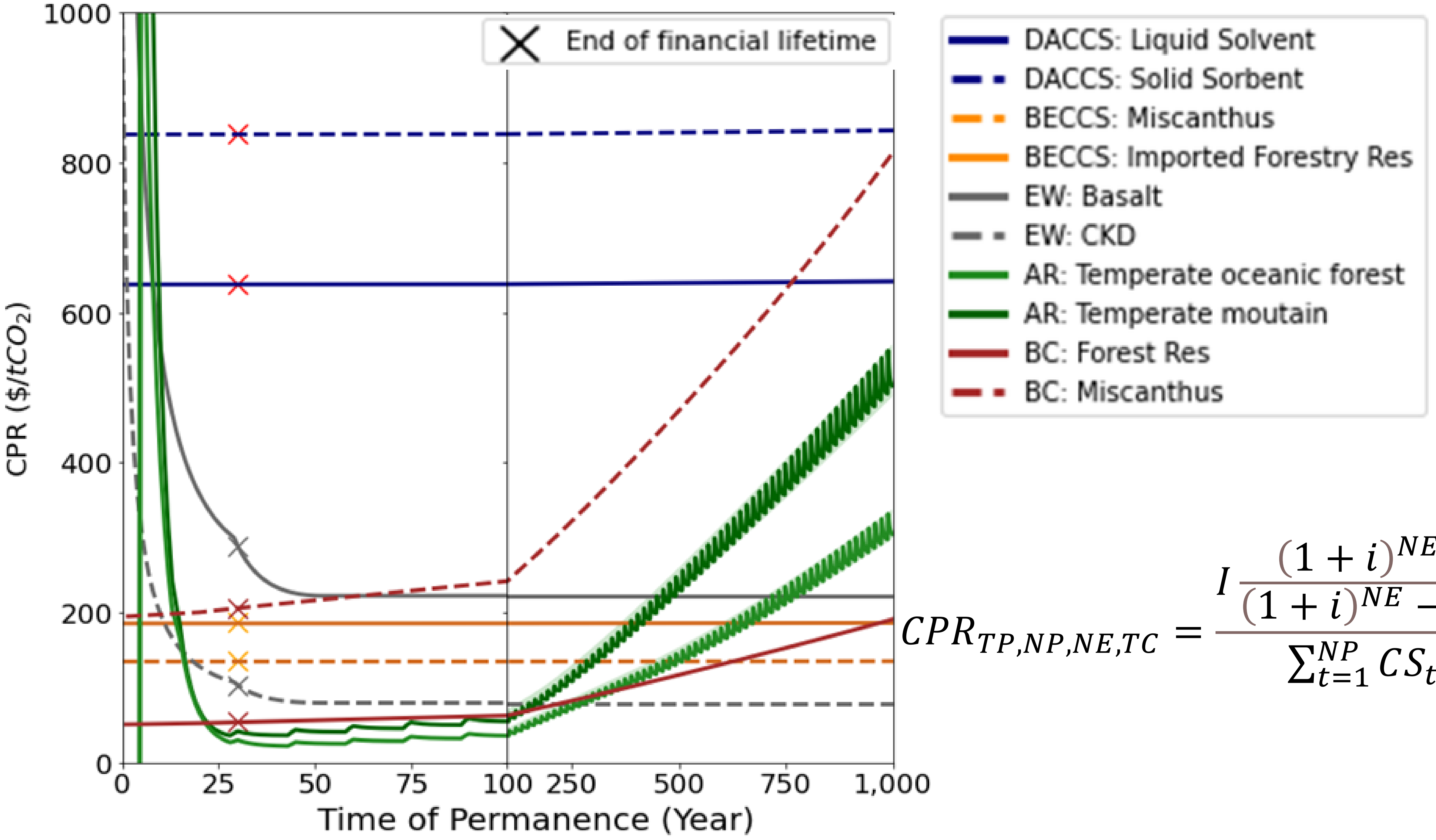
Evaluating a the CRV of temporary storage

TP (years) Leakage year t_{leak}	10	50	100	200	500	1,000
0	0	0	0	0	0	0
10	1	0.14	0.06	0.03	0.012	0.007
50	1	1	0.4	0.18	0.07	0.037
100	1	1	1	0.4	0.14	0.075
200	1	1	1	1	0.3	0.15
500	1	1	1	1	1	0.4
1,000	1	1	1	1	1	1
2,000	1	1	1	1	1	1
5,000	1	1	1	1	1	1
10,000	1	1	1	1	1	1



Prado and Mac Dowell., Joule, 2023

What is the cost of permanent CO_2 removal?



$$CPR_{TP,NP,NE,TC} = \frac{I\frac{(1+i)^{NE}}{(1+i)^{NE}-1} + \sum_{t=1}^{NP}\frac{OM_t - Rev_t}{(1+r)^t} + \sum_{t=1}^{TC}\frac{MRV_t}{(1+r)^t}}{\sum_{t=1}^{NP} CS_t - \sum_{t=1}^{TP} CE_t + CL_t * (1 - CRV_{t,TP})}$$

Prado and Mac Dowell., Joule, 2023

Some conclusions

1. We will need a portfolio of individually distinct options for CDR.
2. The permanent removal of CO_2 is key, and MRV is essential.
3. Not all forms of CDR are equivalent, or fungible with fossil emissions.
4. The perception that impermanent removal is cheap is wrong.
5. Many nature-based emissions deliver more services than “just” carbon
6. Afforestation is *much* more complex and costly than “just” planting trees.
7. As the economy decarbonises, carbon removal efficiency will improve.

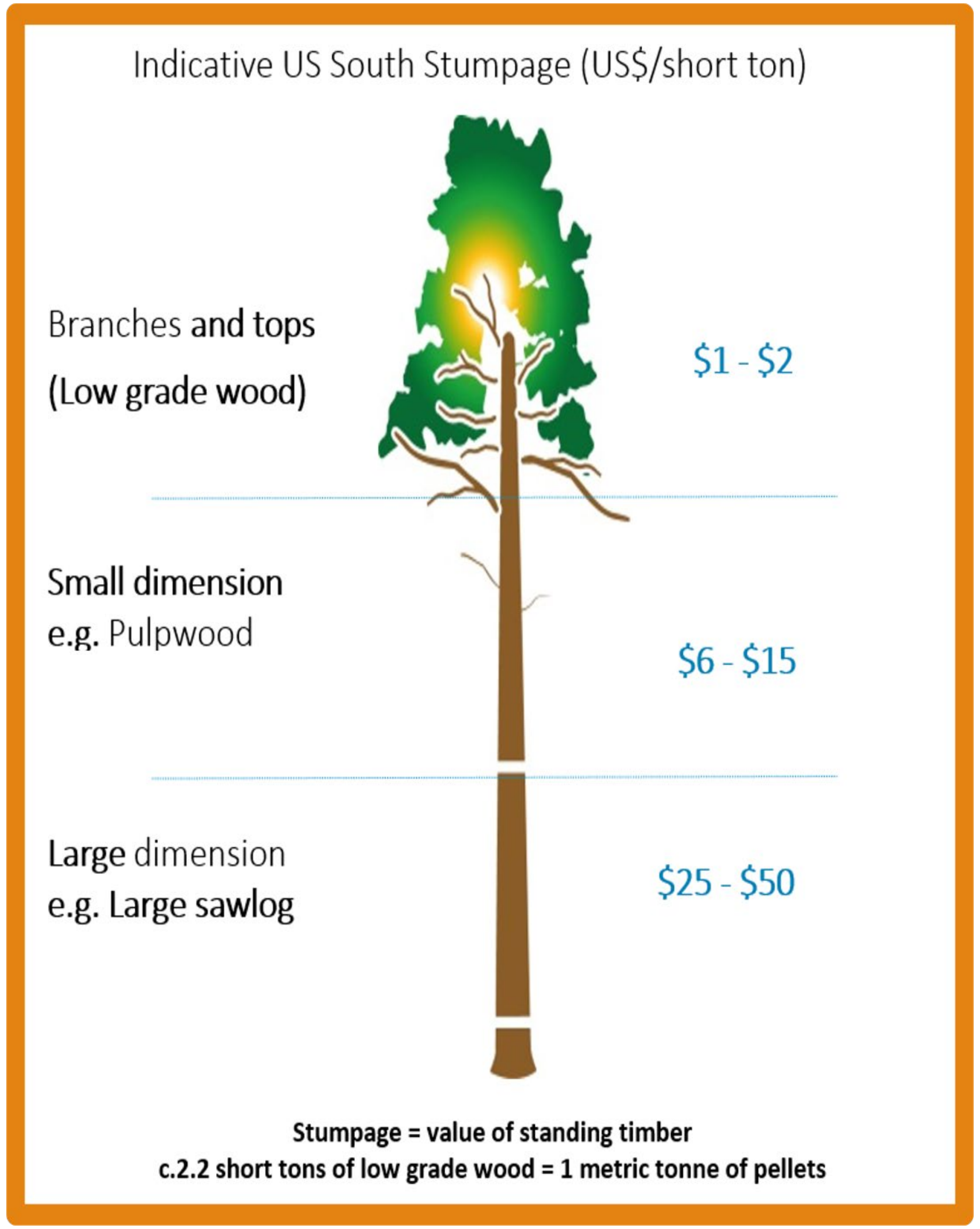
(finally) some recommendations

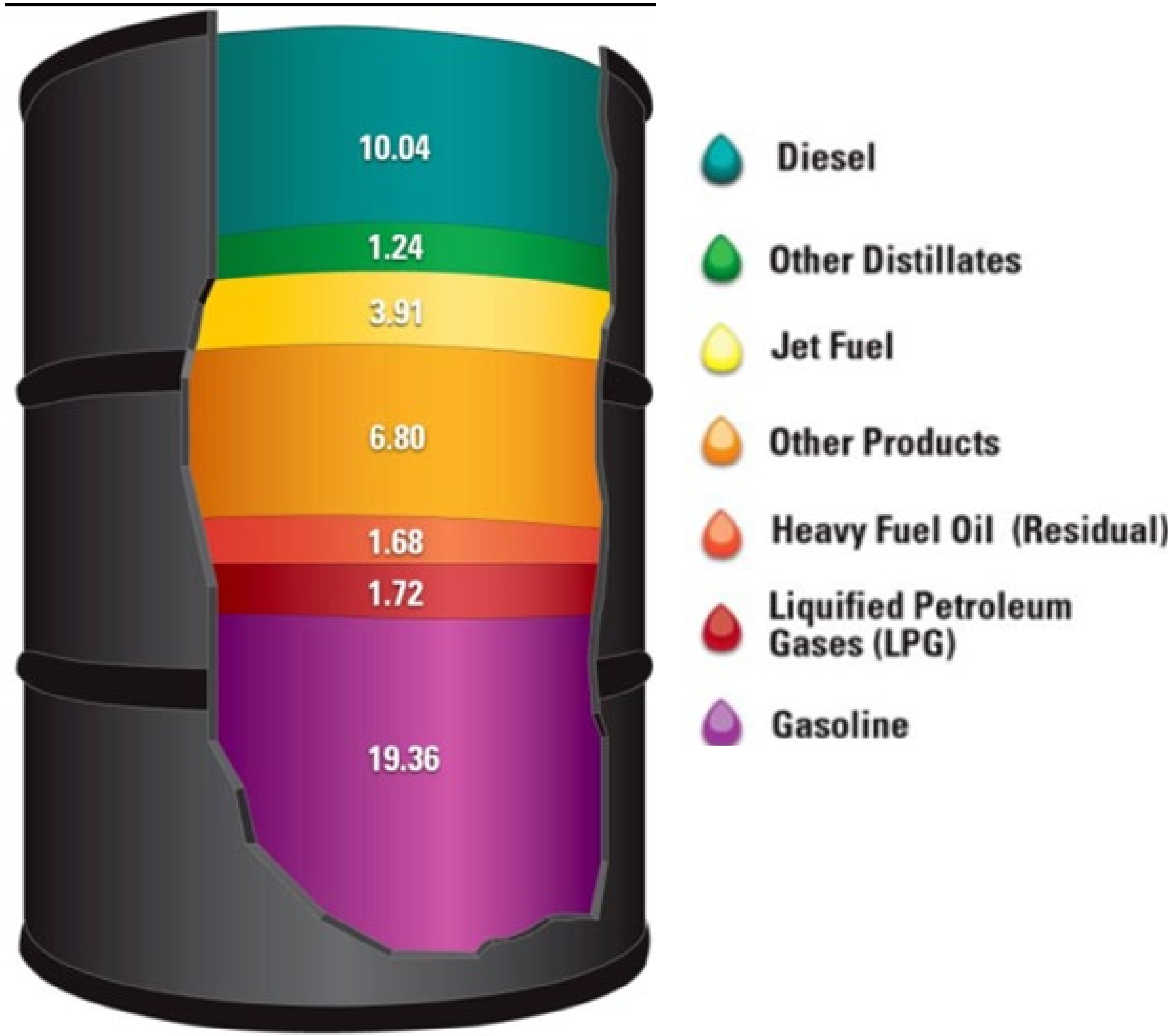
We should

1. Clarify liability value chain associated with carbon removal.
2. Agree on a level of removal credit as a function of permanence.
3. Develop detailed MRV protocols for each GGR approach, in parallel with initial commercial demonstration.
4. Establish an independent regulatory function to sit between project developers and Government, be responsible for an independent MRV regime to ensure that the amount and permanence of removals are quantified, robustly and transparently.
5. Develop a regulatory framework to enable the participation of GGR in an Emissions Trading Scheme.

When is a tree like a barrel of oil?

When is a tree like a barrel of oil?





Mac Dowell, GCCSI, 2023

Tree data from Carly Whittaker, BEIS, oil data: https://www.energy.gov/articles/hows-and-whys-replacing-whole-barrel

Trees are "distilled" into various fractions…

Forest Products

Used in pellets

Sawlogs
Highest value, must be large and straight

n/a

Pulpwood
Lower value, can be random size and shape

21%

12%

25%

Sawmill Residues

Wood Chips
Highest value residues, often used in pulp industry

40%

Sawdust
Lower value, **often used on site in kilns or biomass boilers**

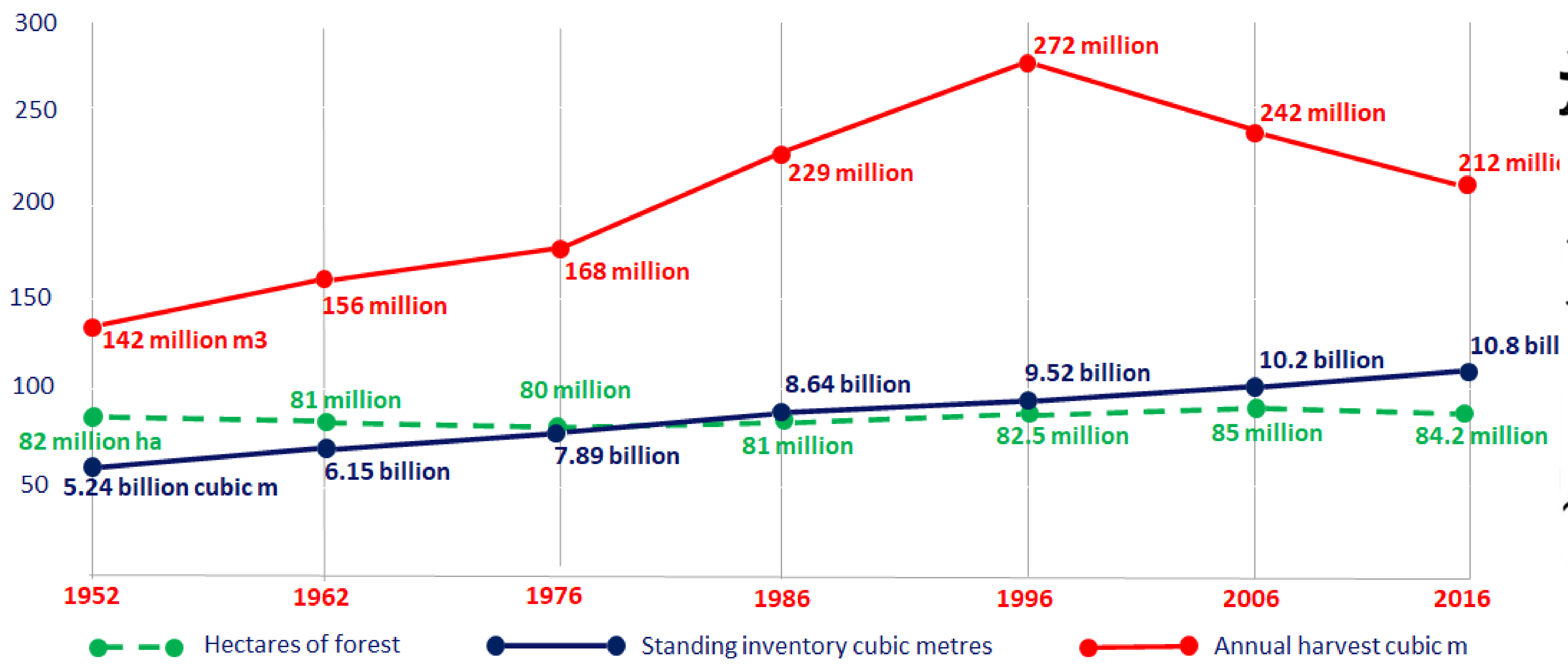
Slab-wood
Limited value as requires additional processing and contains bark- **often burnt**

Slide from Carly Whittaker, BEIS

Sustainable biomass: seeing the wood for the trees

Forests of the US South – growth, inventory, and harvesting.

Forest area, annual harvest and inventory changes

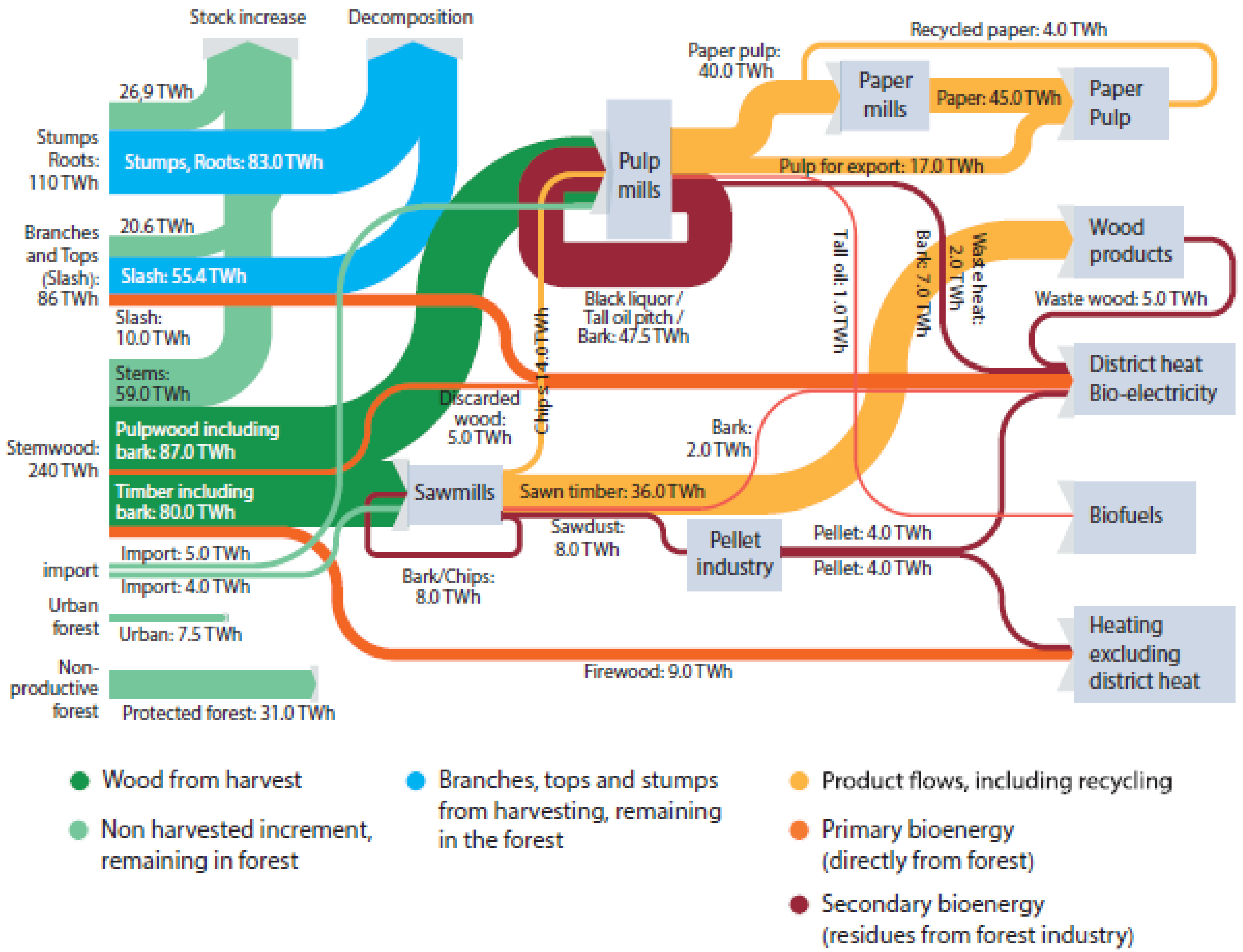


Production of sustainable biomass for BECCS, biochar, bio-H2-CCS, etc

- Managed afforestation will necessarily increase supplies of inherently sustainable biomass
- Cultivation of bioenergy crops, e.g., lignocellulosic, or short-rotation coppice, is also a key option
- Advanced options, e.g., algal biomass also highly promising, though currently low TRL

Mac Dowell, GCCSI, 2023

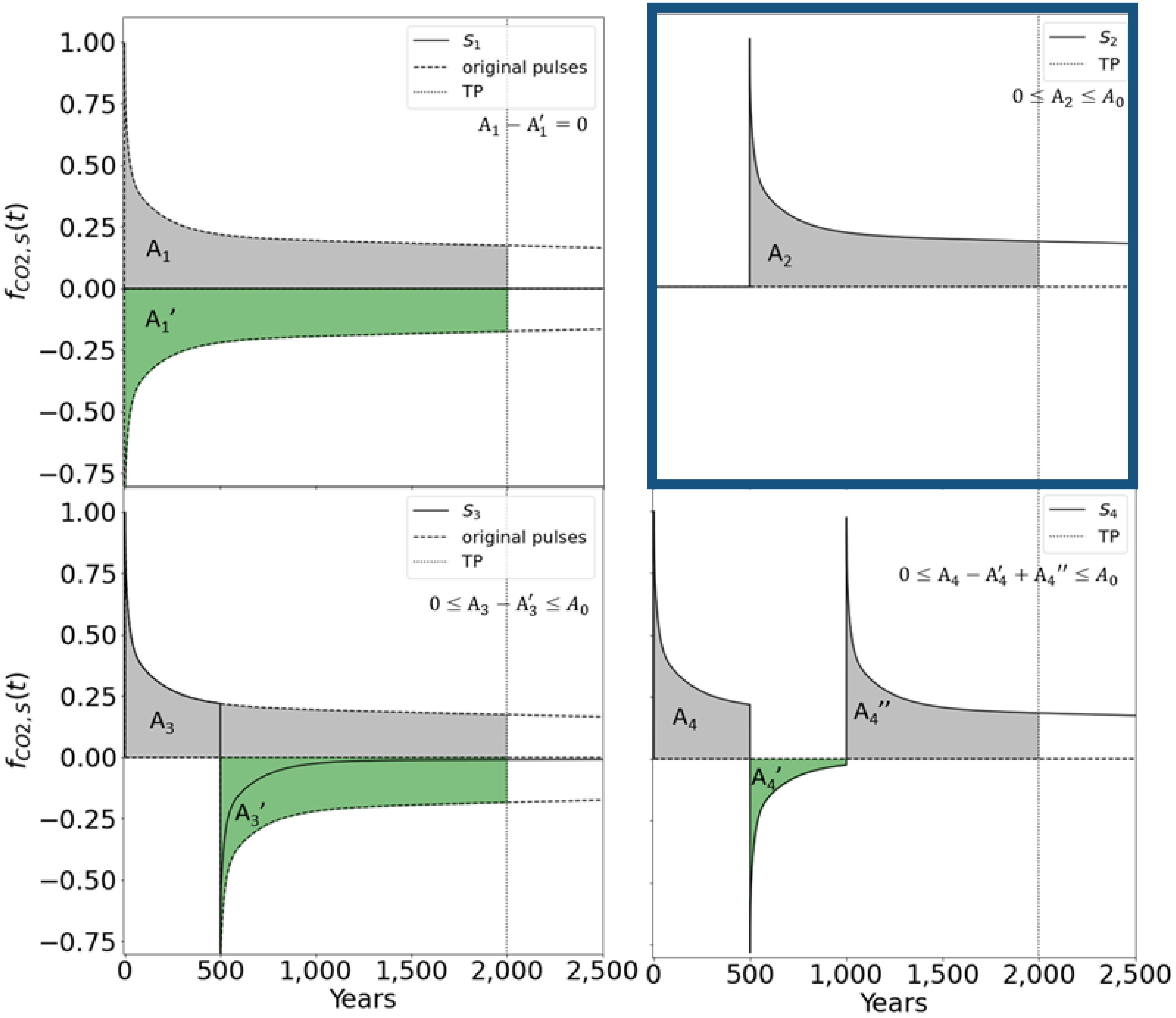
A forest is part of a complex economic system



Mac Dowell, GCCSI, 2023

Cowie, et al., GCB Bioenergy, 2021, 13, 1221 -1231

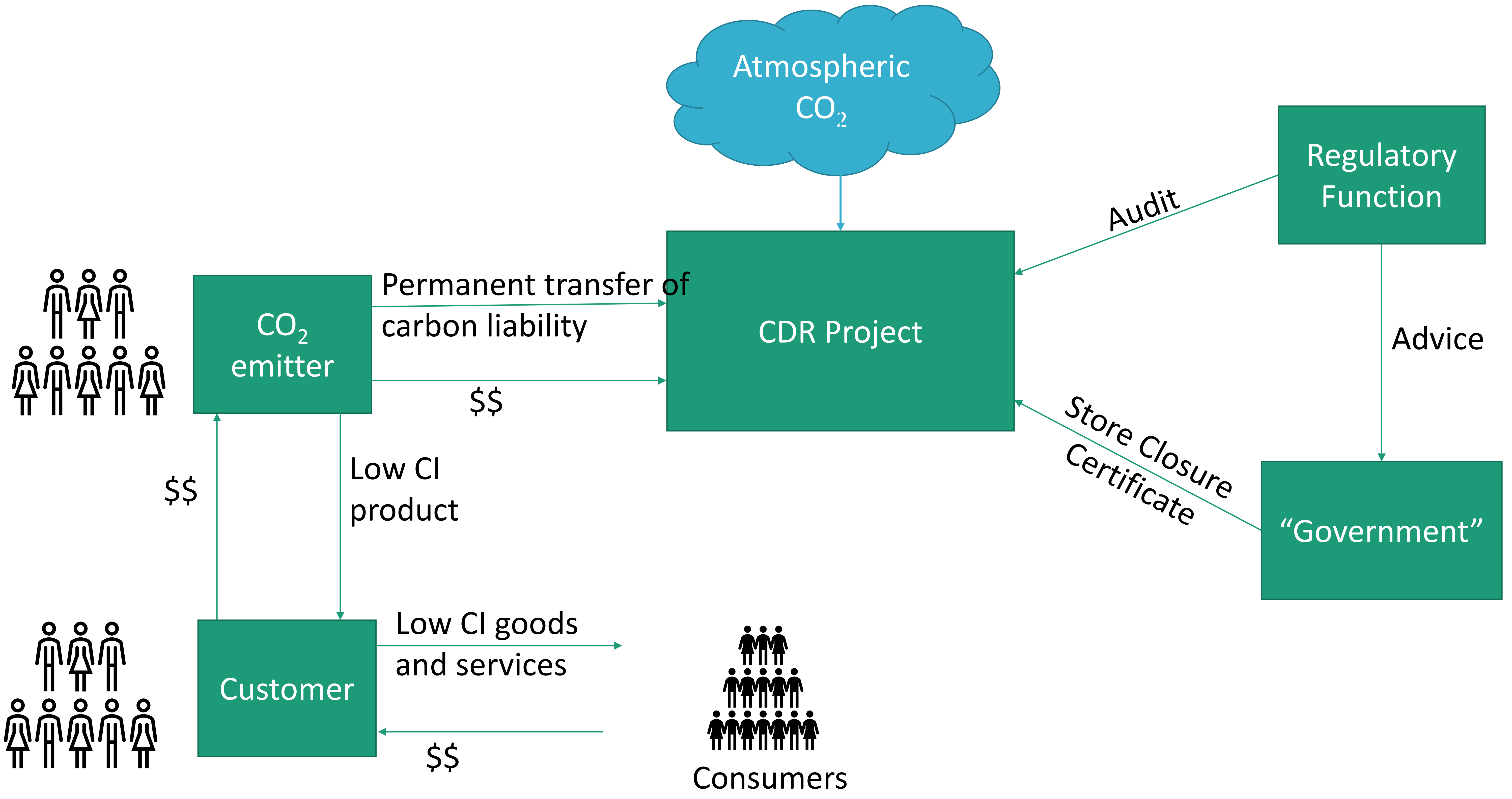
Four archetypal scenarios



- $f_{CO_2,S_i}(t) = S_i * IRF_{CO_2}(t)$
- $f_{CO_2,S_2,t_{leak}}(t) = \delta_{t_{leak}} * IRF_{CO_2}(t) = IRF_{CO_2}(t - t_{leak})$
- $CRV_{t_{leak},TP} = 1 - \int_0^{TP} f_{CO_2,S_2,t_{leak}}(t)dt \;/\; \int_0^{TP} f_{CO_2,S_0}(t)dt$

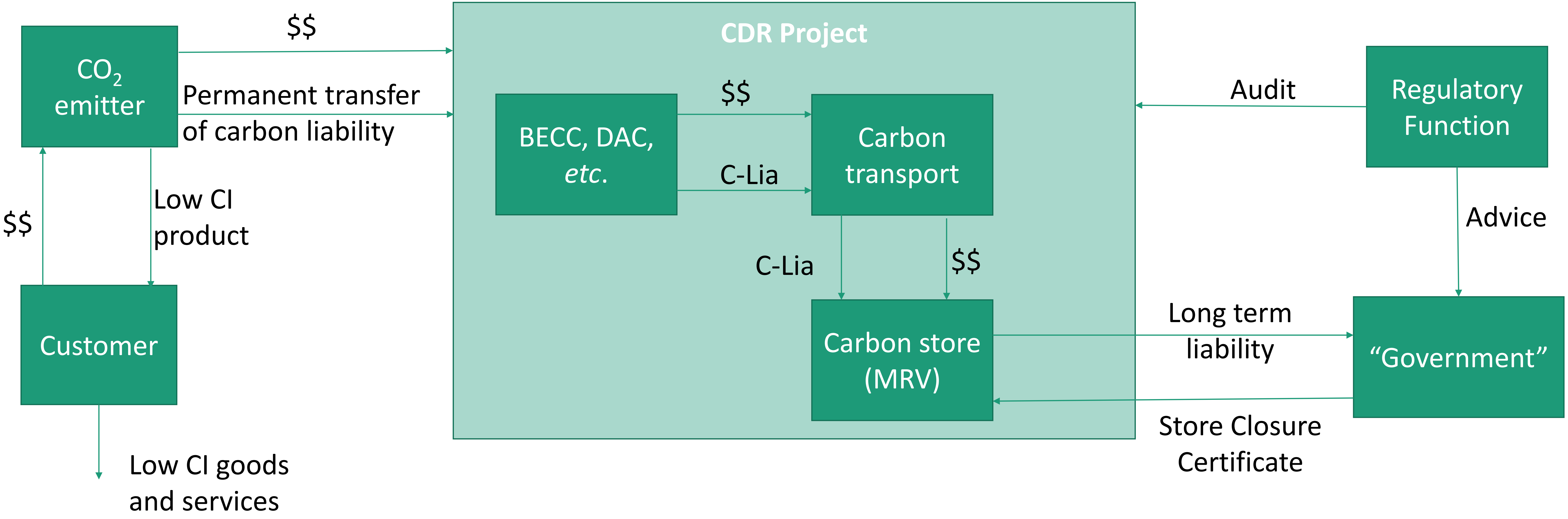
Prado and Mac Dowell., Joule, 2023

Business models for permanent CDR



Mac Dowell, GCCSI, 2023

Business models for permanent CDR



Mac Dowell, GCCSI, 2023

2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE

GLOBAL CCS INSTITUTE

Q&A: CARBON DIOXIDE REMOVAL

Niall Mac Dowell
Imperial College London

Dominic Rassool
Global CCS Institute

MODERATOR

2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE
BREAKOUT SESSION FINDINGS

GLOBAL CCS INSTITUTE

GROUP 1: CDR FRAMEWORKS IN EUROPE

GROUP 2: CCS MARKETS - US AND EUROPE

GROUP 3: PUBLIC PERCEPTION AND SOCIETAL VALUE OF CCS

GROUP 4: EXPECTATIONS FOR CCS AT COP 28

15 JUNE 2023

2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE

GLOBAL CCS INSTITUTE

BREAKOUT SESSION REPORT BACK

GROUP 1: CDR FRAMEWORKS IN EUROPE

Per-Olof Granström,
Zero Emissions Platform

CDR FRAMEWORKS IN EUROPE

ISSUES DISCUSSED:

- Role of BECCS and DACCS: experiences, challenges, expectations
- EC proposal for CDR certification
- Incentives for CDR in Europe
- CDR certificates in voluntary carbon markets and the EU ETS
- CDR in Paris Agreement Article 6.4 and harmonisation with approaches and methodologies in the EU

CDR FRAMEWORKS IN EUROPE

KEY INSIGHTS AND FINDINGS:

- Need for CDR is clearly established.
- When it comes to having a target, the group voting suggests there should be separate targets for reductions and removals; they should be in parallel; and targets for nature-based vs. technology-based CDR should also be separate.
- Article 6.4: Governments should be more involved. Harmonisation is the end goal.
- Need time before 2026 to do the necessary homework and assess if technologies are suitable for inclusion in the EU ETS.
- Need to get incentives right, particularly as BECCS and DACCS have different business models.

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BREAKOUT SESSION REPORT BACK

GROUP 2: CCS MARKETS - COMPARISONS & CONTRASTS BETWEEN THE US AND EUROPE

Christina Staib,
Global CCS Institute

CCS MARKETS: COMPARISONS AND CONTRASTS BETWEEN THE US AND EUROPE

ISSUES DISCUSSED:

- Policy conditions needed to scale up the deployment of CCS
- Experiences with CCS projects in Europe and in the US
- Lessons learned on the combination of carrot and stick approaches
- Policies and strategies for global deployment of CCS

CCS MARKETS: COMPARISONS AND CONTRASTS BETWEEN THE US AND EUROPE

KEY INSIGHTS AND FINDINGS:

1. Need for business case in Europe
2. Support for infrastructure is lacking
3. Reconsider parameters of the Innovation Fund
4. Value chain integration and risk management
5. Member states differences
6. More regulatory clarity is needed (e.g., CDR, CO_2 pipelines and other transport specifications, CO_2 specifications)

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BREAKOUT SESSION REPORT BACK

GROUP 3: PUBLIC PERCEPTION AND SOCIETAL VALUE OF CCS

Andrei Marcu, European Roundtable on Climate Change and Sustainable Transition

PUBLIC PERCEPTION AND SOCIETAL VALUE OF CCS

ISSUES DISCUSSED:

- Varied national experiences as it relates to the public perception of CCS and observed trends
- Key concerns cited by those opposing CCS
- Positive ways to address concerns about CCS; highlighting actions and efforts that have worked to change negative perceptions and have helped to form positive ones
- Steps to take to destigmatise CCS

PUBLIC PERCEPTION AND SOCIETAL VALUE OF CCS

KEY INSIGHTS AND FINDINGS:

- There is public mistrust in CCS, either because of lack of trust in the government or lack of trust in the technology.
- Societal value of CCS changes the conversation.
- In Europe we don’t see countries actively trying to block CCS, but also not supporting it enough.
- Increased political leadership from the EU in the past 2 years is making a difference.
- More transparency (e.g. of injection status) will help.
- Ensure local population shares in project benefits.
- Need to collaborate more; bring academia into the fold. Public-private partnership model also helps.

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BREAKOUT SESSION REPORT BACK

GROUP 4: EXPECTATIONS FOR CCS AT COP 28

Tim Dixon,
IEAGHG

EXPECTATIONS FOR CCS AT COP 28

ISSUES DISCUSSED:

- CCS topics to highlight at COP 28 side events
- Ways to support the Carbon Management Challenge proposed by the US
- Coordination and alignment of planned CCS-related events at COP 28
- Race to Zero campaign and the role it can play in promoting CCS

EXPECTATIONS FOR CCS AT COP 28

KEY INSIGHTS AND FINDINGS:

Topics for COP28

- Storage safety
- How to create an international market for CCS
- Highlight NDCs and country choice based on national circumstances
- Risks of not deploying CCS
- Energy security linkages
- The role of CCS in the Just Energy Transition
- North-South/South-South cooperation

Ways to support CMC

- German National CCS Strategy?

Coordination at COP28

- Master list of CCS events sourced and shared with community
- CCS roundtable through Presidency

2023 EUROPE FORUM ON CARBON CAPTURE & STORAGE BREAKOUT SESSION FINDINGS

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GROUP 1: CDR FRAMEWORKS IN EUROPE

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CLOSING REMARKS

SPEAKER

Jarad Daniels
CEO, Global CCS Institute

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