CLIMACT

Décarboniser l'industrie en Wallonie :

« le défi de l'infrastructure »

insights from the

www.PathwaysExplorer.org

Agenda

- **Climact**
- L'ambition attendue pour réduire les émissions
- Les leviers pour réduire
- Insights sur base de roadmaps

CLIMACT

Our vision

A zero-carbon sustainable society by 2050

Our mission

Empower our clients to act on climate change

What we do

Energy & climate change services

Strategy Consulting

Legal & Regulatory Advisory

Project Development

CLIMACT

Our team is

- **Multidisciplinary**
- **Engaged**
- **Dedicated**

We value

- **Collaboration**
- **Impact**
- **Coherence**

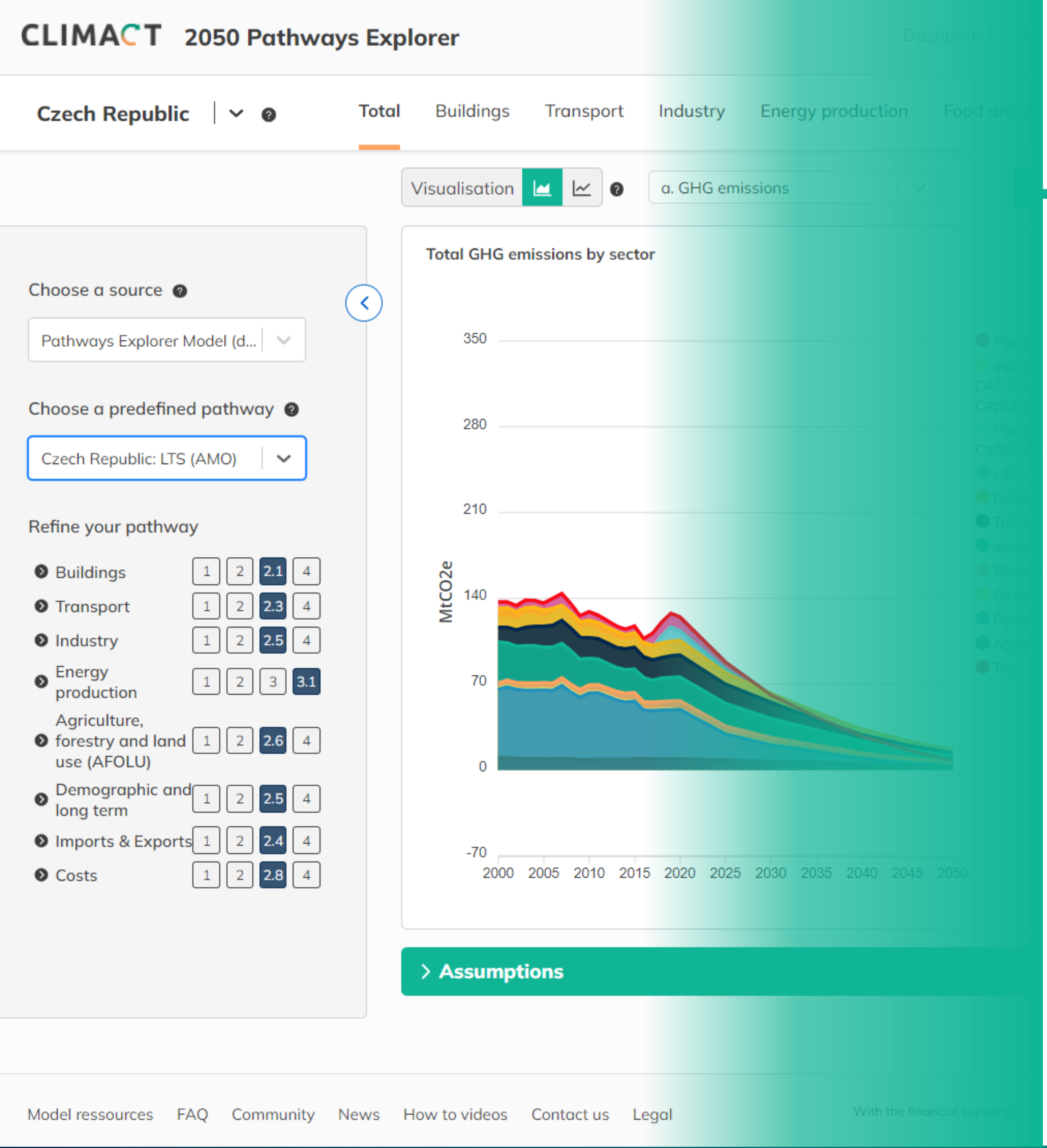
We provide

Energy & climate change services

Strategy Consulting

Legal & Regulatory Advice

Prospective Studies



www.PathwaysExplorer.org

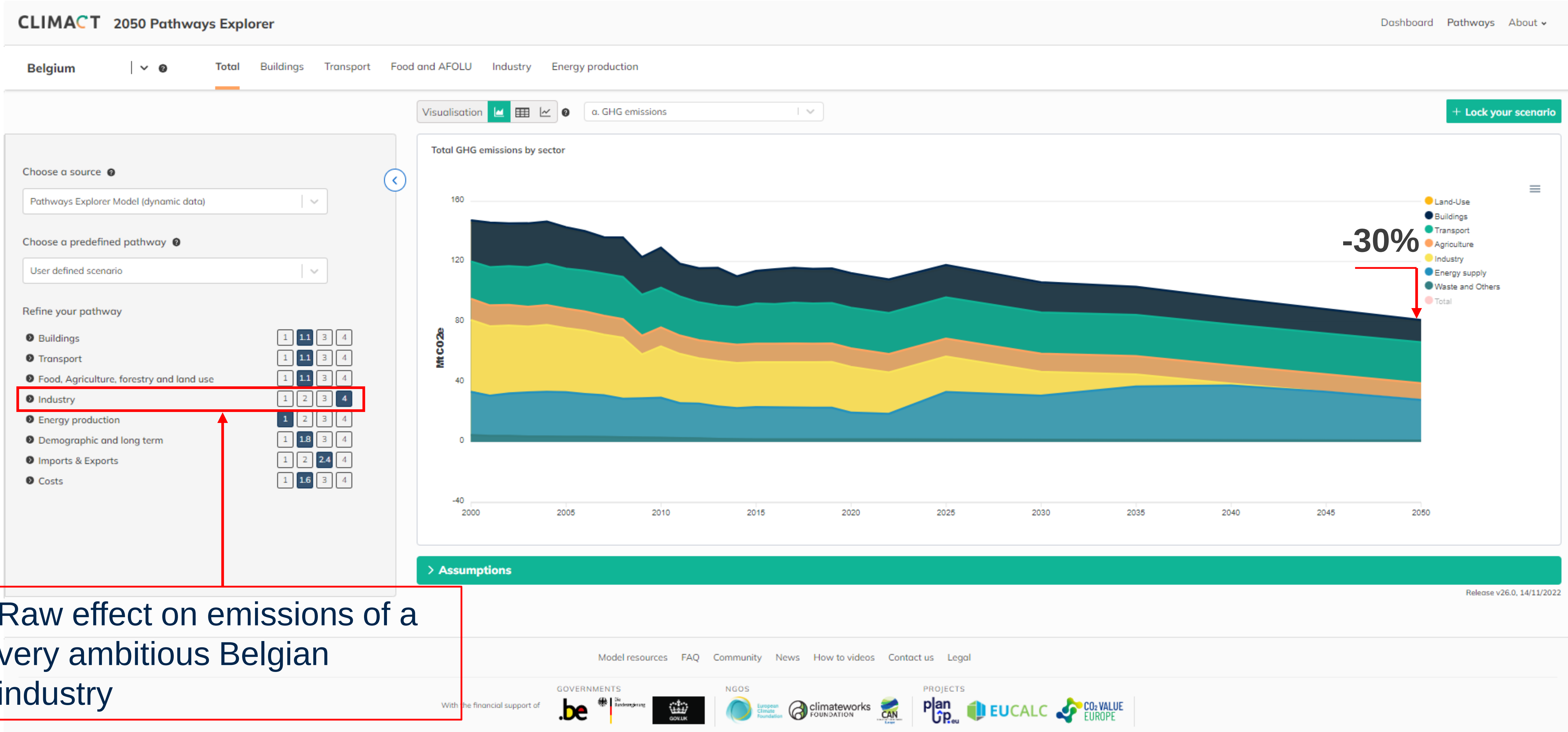
The Pathways Explorer is a **step-by-step solution** supporting organisations, and **equipping them with a robust analytical foundation**, enabling the development of **country energy transition scenarios** based on credible and transparent assumptions.

Behind the process is **a web-based tool** which enables to explore possible futures and assess the implications and trade-offs of their choices.

Simulations can be **performed in real time**, offering a direct understanding of the key levers of the low carbon transition.

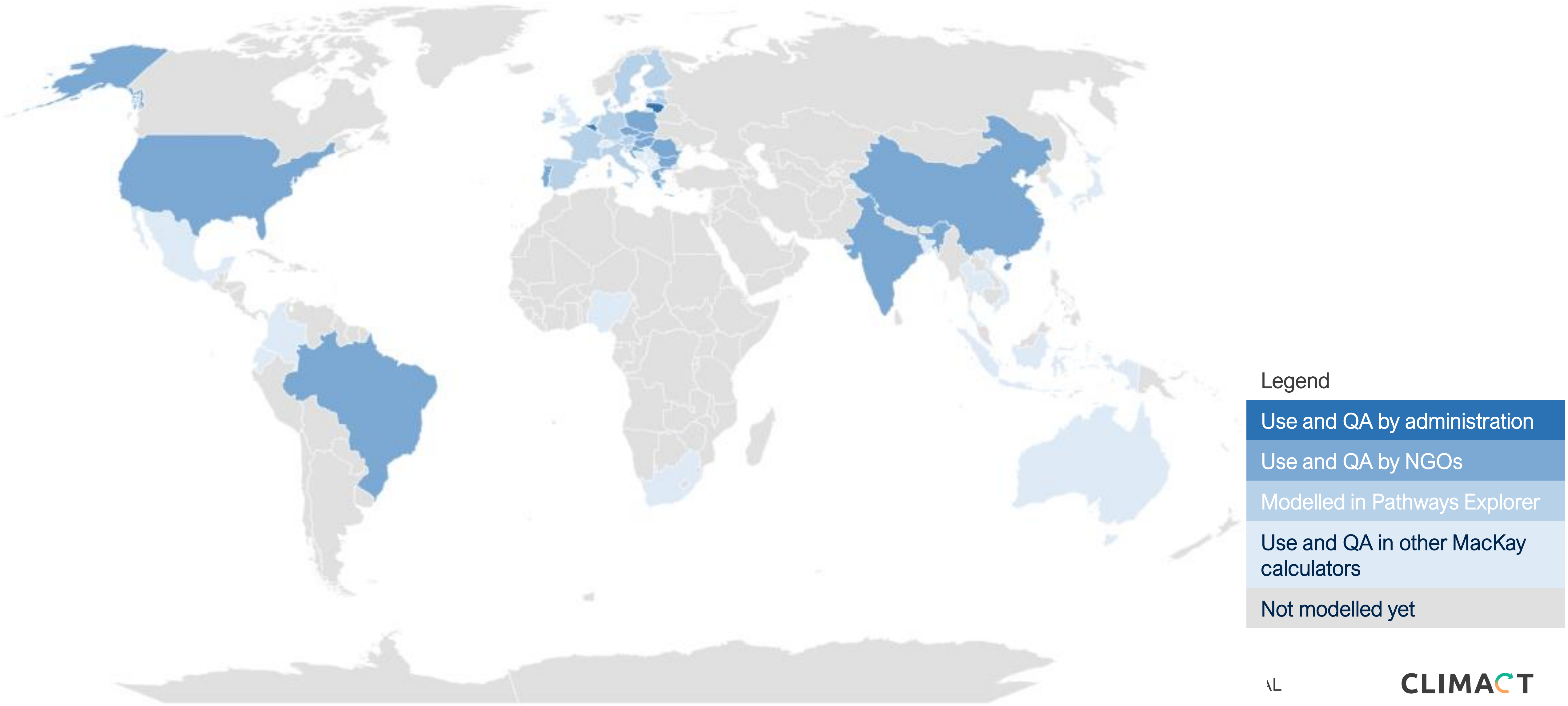
The exploration scope encompasses **the energy system and its dynamics, all GHG emissions**, and the associated resources and socio-economic impacts.

How does it work ? Simplified example



Raw effect on emissions of a very ambitious Belgian industry

The Pathways Explorer is being used throughout the world



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  - **La perspective Climact**
  - L'ambition totale
  - La déclinaison de cette ambition par secteur
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10 years of roadmaps and tool developr global, European, national, regional anc

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Project
Global Calculator (for DECC)
Climate Transparency Initiative (CW Foundation)
Science Based Targets
EUCalc (H2020 project for the commission)
Climate Transparency Initiative (for ECF)
Low Carbon group (Bruegel)
2050 Pathways explorer at country level
Various national analysis (a.o., SPF, BE.FIN, Heinrich Böll Stiftung, Greenpeace)
2050 regional calculators & analysis
Sector roadmaps
Regional analysis (AWAC, DGO4, IBGE)
City roadmaps EU-City-Calc Neighbourhood engagement

(1) Non-exhaustive list: Europe: the EU-27 + UK, Albania, Bosnia, Kosovo, Macedonia, Montenegro, Serbia

Sector roadmaps

Federation	Sector
AGORIA	Technology
INDUFED Sustainable goods	Pulp, Paper & Cardboard (was Cobelpa)
Febelgra united in graphics	Graphics industry
Fedustria	Textile, Wood and furniture
INDUFED Sustainable goods	Paper and cardboard(was Fetra)
FEFCO Corrugated Packaging	Corrugated Packagin
INDUFED Sustainable goods	Glass (wasFIV)
GSV	Steel

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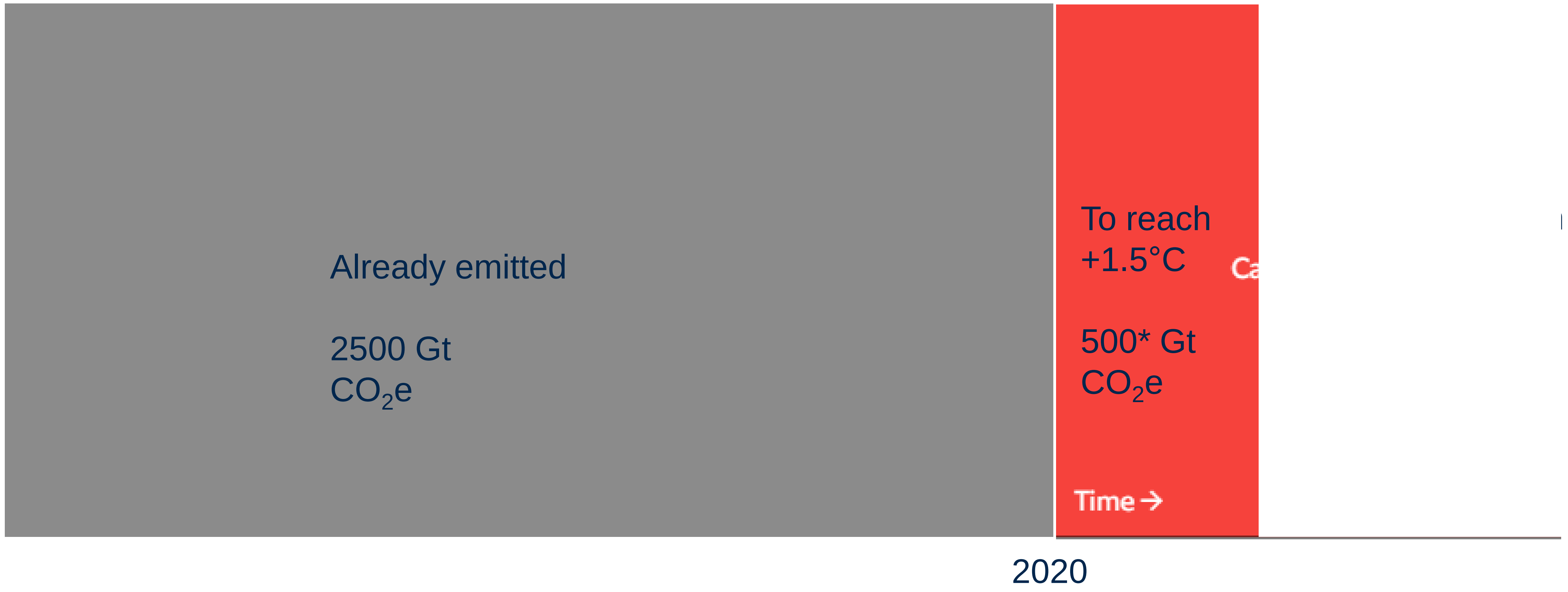
Trois messages

- Pour ne pas augmenter la température de plus de 1.5°
  - les objectifs deviennent plus ambitieux
  - le CCU/S a un role de plus en plus central
  - le CCU/S est adapté à l'urgence à laquelle nous sommes confrontés car il permet des cycles d'investissements plus courts
    (par rapport aux standards industriels)

Des infrastructures soutenant le CCU/S
doivent être implémentées maintenant

Le monde dispose d’un budget carbone pour limiter l’augmentation de la température

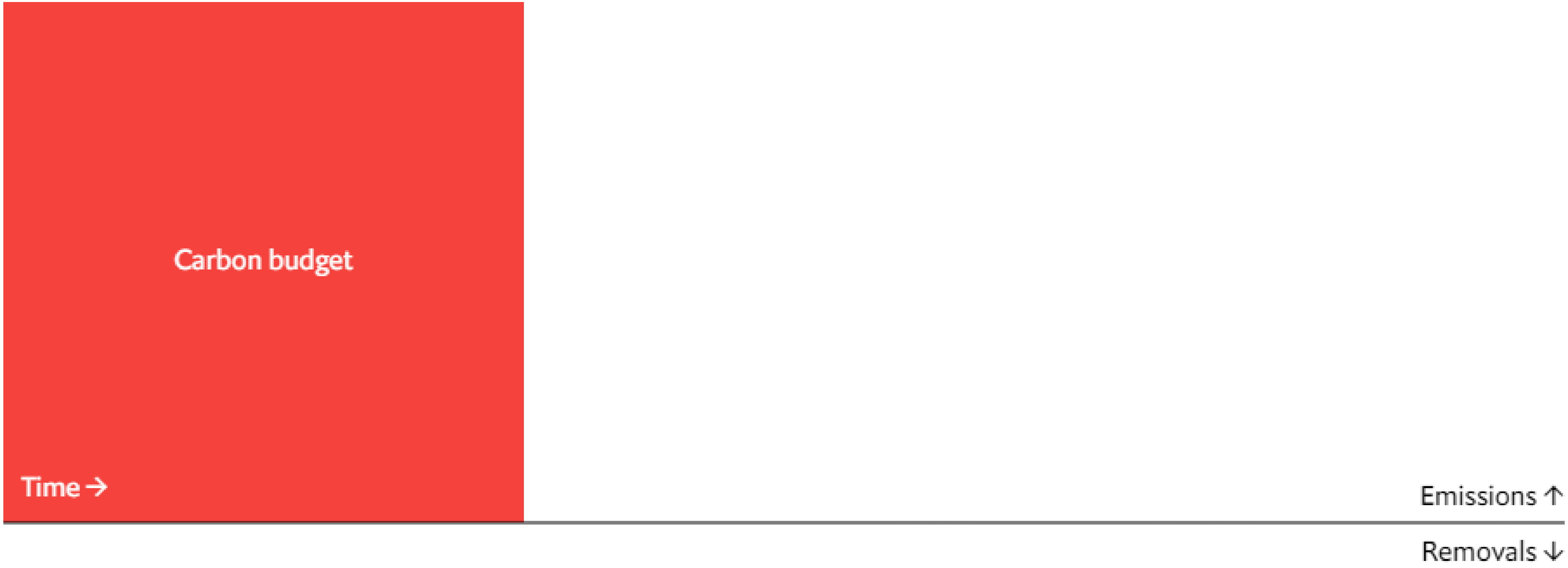


Each year we emit ~50GtCO2e**

* Source GIEC. Le budget carbone correspond à 50% de chance de limiter la temperature globale à ces valeurs.
** Our World in Data (https://ourworldindata.org/emissions-by-sector), 30Gt only CO2, 20Gt rest (CH4, N2O, deforestation, etc)

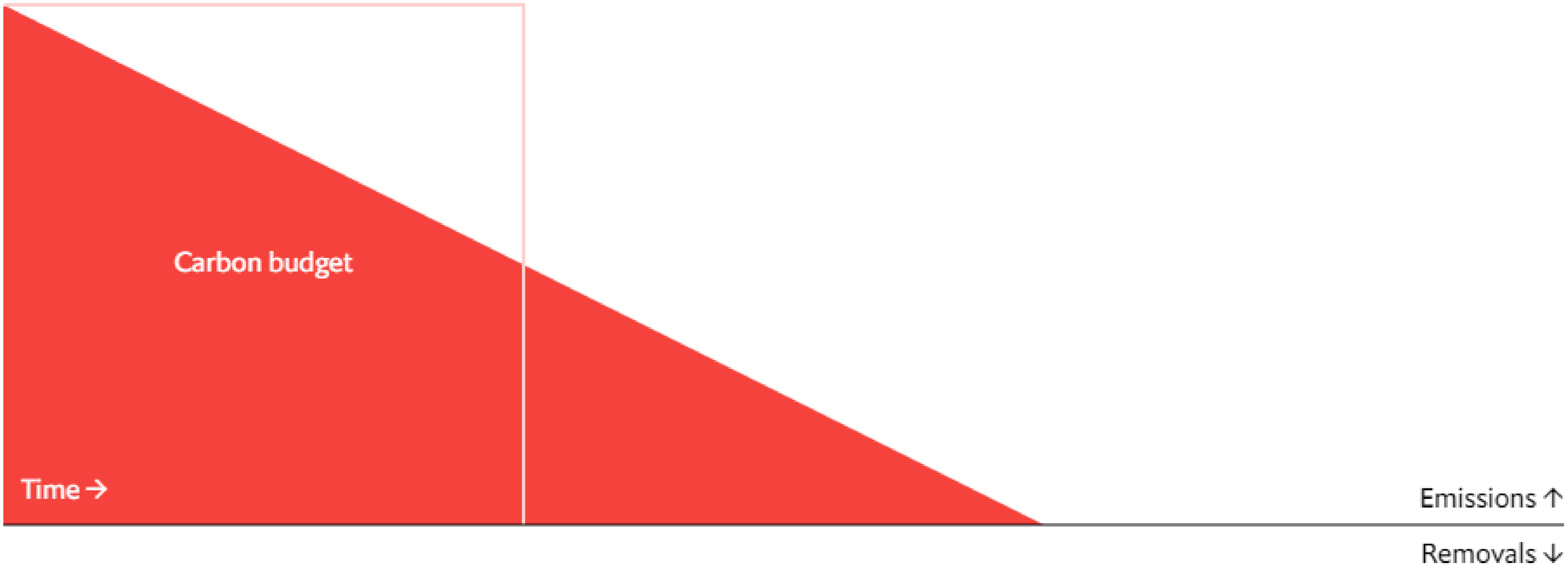
SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

Le monde dispose d’un budget carbone pour limiter l’augmentation de la température



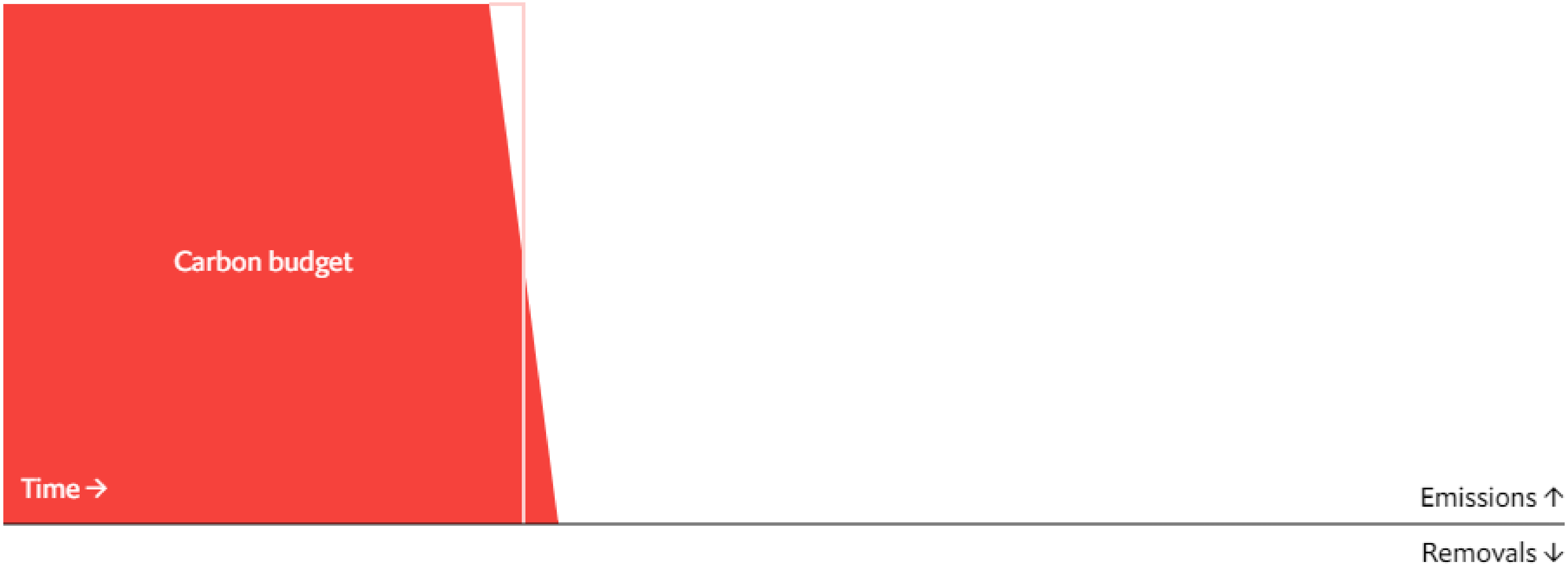
SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

Idéalement, la réduction se réparti dans le temps



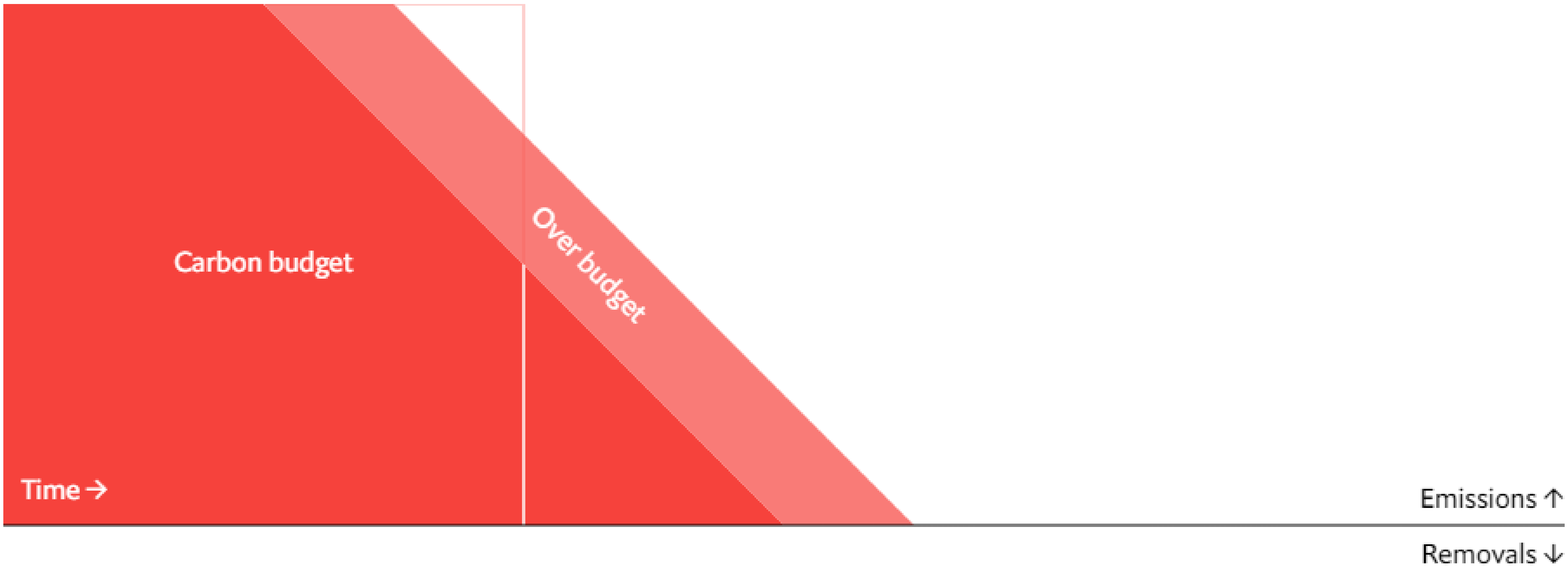
SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

Il ne nous reste plus que 7 ans, donc la pente devra être raide si on attend



SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

Aplanir la pente requiert de dépasser le budget



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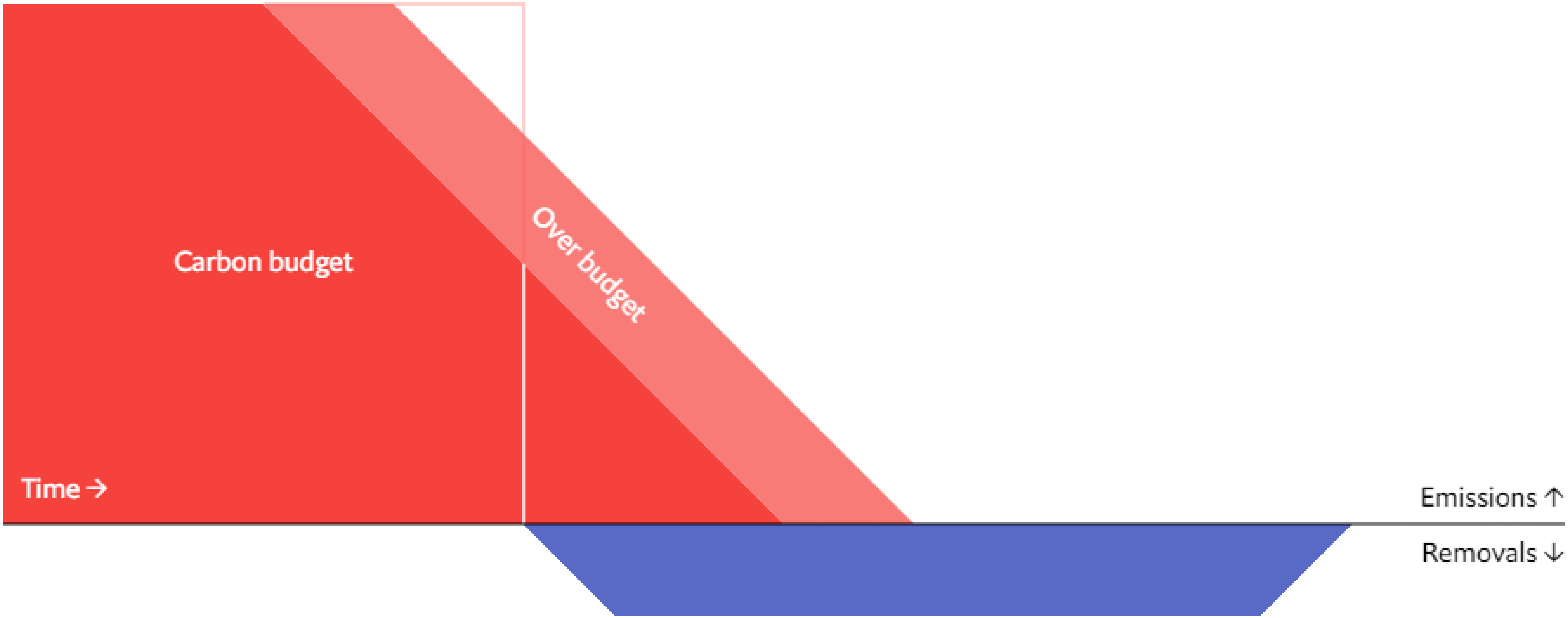
Dépassement qui peut être “neutralisé” par des captures



SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

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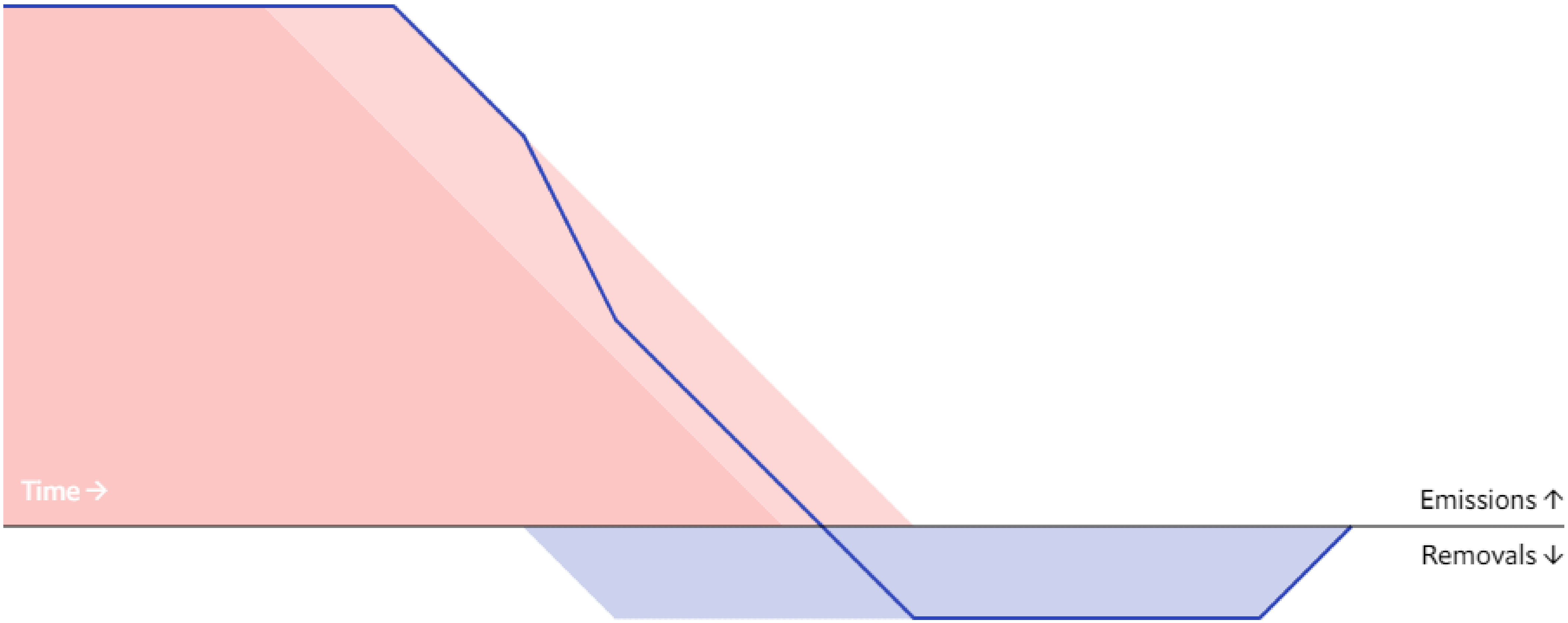

SOURCE: The economist :The world is going to miss the totemic 1.5c climate target, Briefing (2022/11/05/)

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The standards requires companies to reduce emissions by 50% every 10 years

Upcoming standard for all companies is the Science Based Targets "Net zero"	• Requires ~90% reduction by 2050 • Tolerates max 10% neutralisation

Recommended methodology for most sectors is Science Based Target "Absolute contraction"	• Requires every 10 years a reduction of
	  • 50% on scopes 1& 2
	  • 25% on scope 3
	• Independent of growth

Sectors progressively can follow a sectoral decarbonisation guideline	• Sector specific decarbonisation pathways are currently being developed

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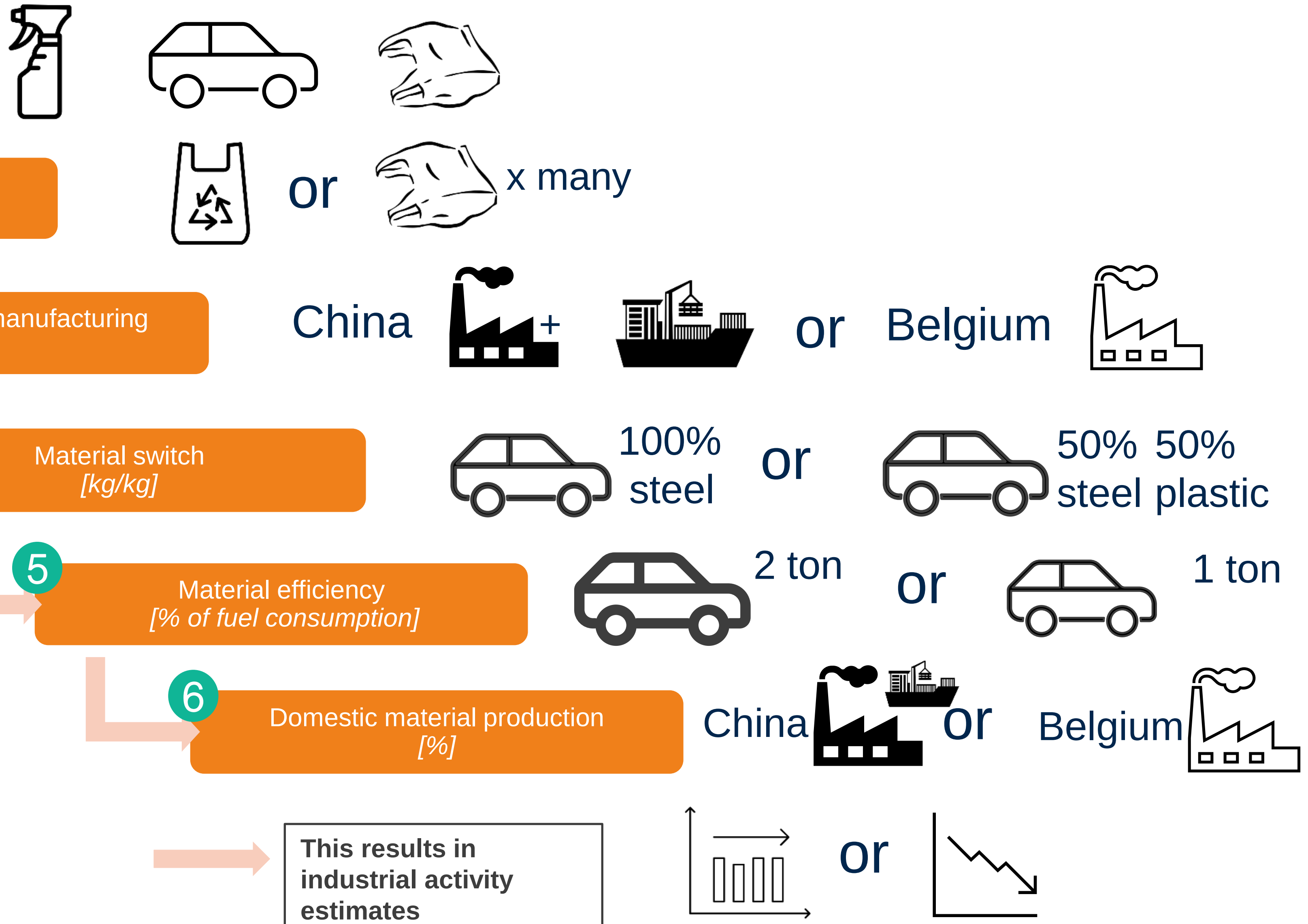
6 levers specify the Walloon industrial activity

Backup

1. Product related activity from other sectors *[# product]*
2. Product substitution rate *[%]*
3. Domestic product manufacturing *[%]*
4. Material switch *[kg/kg]*
5. Material efficiency *[% of fuel consumption]*
6. Domestic material production *[%]*

This results in industrial activity estimates



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4 more levers then decarbonize the industrial processes

Backup

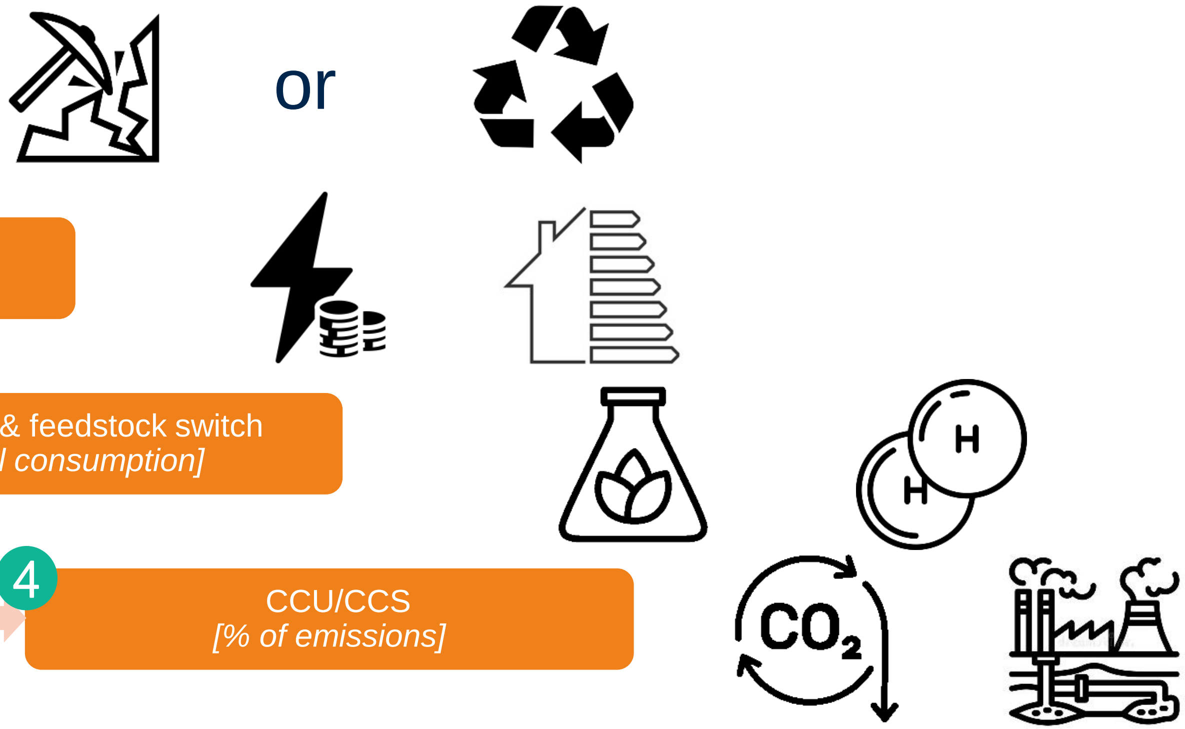
Industrial activity
[kt]

1 Technology switch & recycling
[%]

2 Energy efficiency improvement
[%]

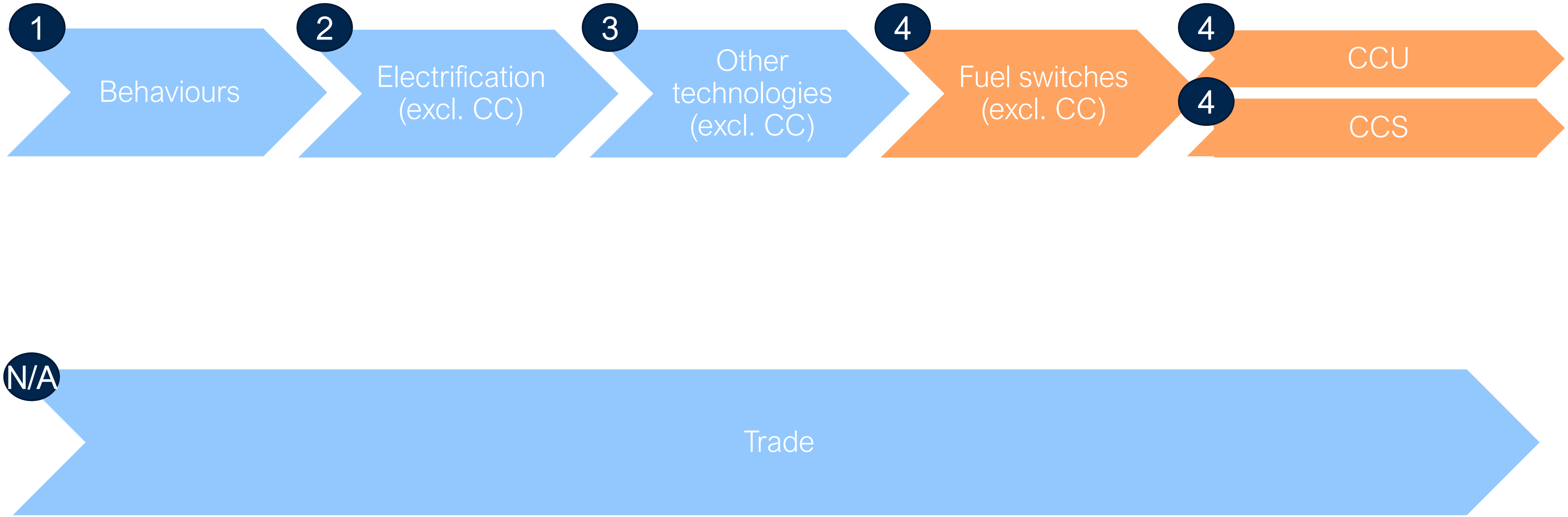
3 Fuel switch & feedstock switch
[% of fuel consumption]

4 CCU/CCS
[% of emissions]



This results in industrial emissions

Depending the on the location, sector and technology, the prioritisation will change between fuels switches, CCU and CCS



Some less prioritized levers will need to be leveraged, e.g. because they can be deployed faster

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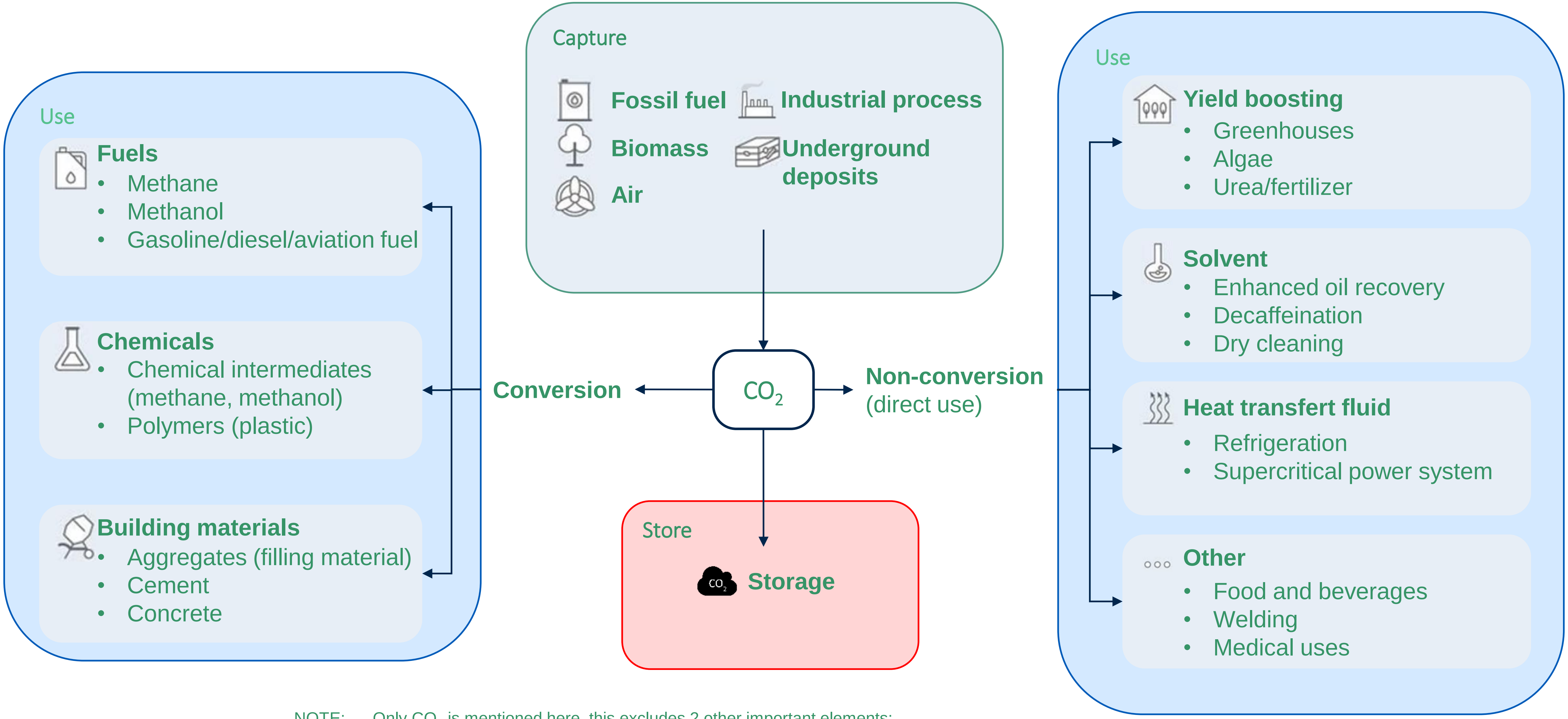
Carbon captured can be either used or stored



NOTE: Only CO_2 is mentioned here, this excludes 2 other important elements:
- the capture and use of other gases, and
- the collection, transformation and reuse of other materials embodying the gases (e.g. recycled plastics)

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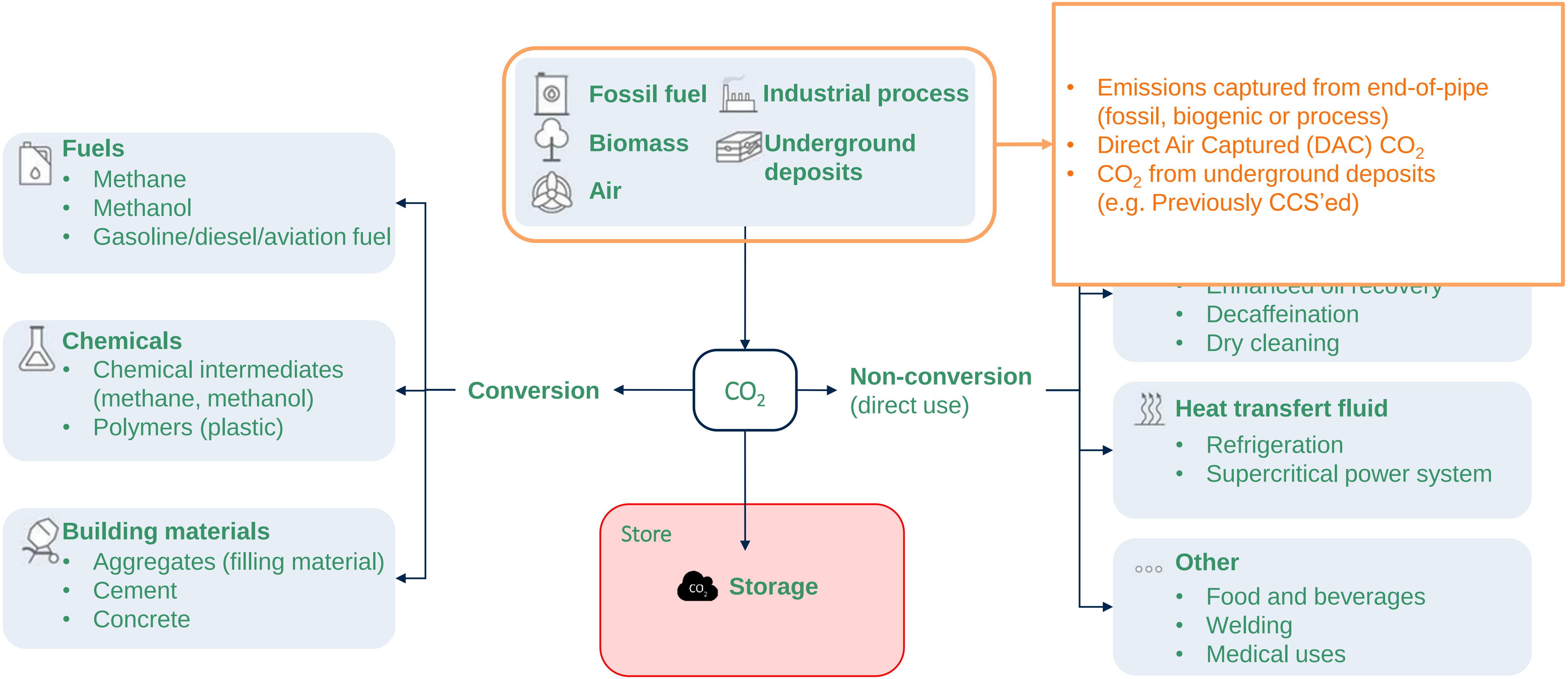
CO_2 can be captured from multiple sources



NOTE: Only CO_2 is mentioned here, this excludes 2 other important elements:
- the capture and use of other gases, and
- the collection, transformation and reuse of other materials embodying the gases (e.g. recycled plastics)

Used CO_2 can be used directly or converted first

Fossil fuel
Industrial process
Biomass
Underground deposits
Air

CO_2

Conversion

Fuels
- Methane
- Methanol
- Gasoline/diesel/aviation fuel

Chemicals
- Chemical intermediates (methane, methanol)
- Polymers (plastic)

Building materials
- Aggregates (filling material)
- Cement
- Concrete

- Conversion is a new area. TRL's are lower but potential volumes are much higher than for direct use

Store

Storage

Non-conversion (direct use)

Yield boosting
- Greenhouses
- Algae
- Urea/fertilizer

Solvent
- Enhanced oil recovery
- Decaffeination
- Dry cleaning

Heat transfert fluid
- Refrigeration
- Supercritical power system

Other
- Food and beverages
- Welding
- Medical uses

- Direct use is already common today (e.g. greenhouses, urea production, food and beverages industry) but overall volumes are low

mentioned here, this excludes 2 other important elements:
and use of other gases, and
on, transformation and reuse of other materials embodying the gases (e.g. rec

BACKUP

Within the 'conversion' applications, there are 3 main types of CCU

	e-Fuels	Chemicals	Building materials
Basic principle	• Combine CO_2 with (green) H_2 to make CCU hydrocarbons • E.g. synthetic methane, synthetic (m)ethanol, Fischer-Tropsch fuels	• Combine CO_2 with (green) H_2 to CCU-based chemicals. Mostly CO_2+H_2 to (m)ethanol, which can then be used as a feedstock for olefins, formaldehyde,	• CO_2 is stored in building materials through mineralisation
Pros	• Can function in existing infrastructure • Fuels with high energy density, can provide solution for sectors which are hard to electrify or cannot run on pure hydrogen (e.g. aviation, maritime)	• Can provide substitute for fossil feedstocks (naphtha and propane) • CO_2 is stored for longer period of time compared to fuels (only released if end-product is incinerated at end of life) • Chemical processes based on (m)ethanol are not new, and have high TRL. Main novelty is to make (m)ethanol based on CO_2 rather than CO.	• CO_2 is stored for a long time • No high energy/green H_2 requirements, even exothermic (generates carbon-free heat) • Minerals can be provided via other waste streams (e.g. steel slag, recycled concrete) • Can substitute other, carbon intensive products
Cons	• A lot of green H_2 needed (lots of energy losses along the process) • CO_2 eventually still ends up in the atmosphere.	• a lot of green H_2 needed (lots of energy losses along the process)	• TRL is relatively low and only now reaching commercial scales

Three other technologies provide alternative ‘carbon neutral’ solutions

BACKUP

	e-Fuels	Chemicals	Building materials
1 Biomass	• Biofuels	• Biobased chemicals (often implies biomass is ‘gasified’ to obtain a syngas ($CO + H_2$), which is then transformed into (m)ethanol.	• No direct competitor, but increased use of wood in constructions could be seen as competing technology
2 Plastic waste	• Alternatives for chemicals is mechanical recycling, or chemical recycling via chemolysis or catalytic reforming • Pyrolysis: plastic waste is transformed into a naphtha-like substance, which can then be used to produce fuels or chemicals • Gasification: plastic waste is gasified to obtain $CO + H_2$, which can then be turned into (m)ethanol which can be used as fuel or as platform molecule for chemicals production		• n.a.
3 Other waste streams	• Use of waste streams with CO (e.g. Blast furnace gas) to turn it into (m)ethanol. Advantage of making (m)ethanol with CO instead of CO_2 is that you need far less H_2 (125 kg per t MeOH under the CO route vs. 192 kg per t MeOH under the CO_2 route).		• n.a.

SOURCE: Climact

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Overview of the technologies implemented to capture the carbon

<table>
<tr><th colspan="3" rowspan="2">Groups</th><th colspan="3">Technology</th></tr>
<tr><th>Origins</th><th>Descriptions</th><th>Energy demand</th></tr>
<tr><td rowspan="3">Carbon capture from exhaust s</td><td rowspan="2">Combustion emissions</td><td>Bio/e-Fuel</td><td>Biomass/e power plants and industry (Solid, gas)</td><td rowspan="3">Carbon capture from the exhaust emissions (combustions or process)</td><td rowspan="3">• Across industry and energy supply
• High concentration exhausts lead to lower energy/t CO_2
• Lower concentration exhausts lead to higher energy/t CO_2</td></tr>
<tr><td>Fossil fuel</td><td>Fossil fuel power plants and industry (coal, liquid, gas)</td></tr>
<tr><td colspan="2">Process emissions</td><td>Industrial processes</td></tr>
<tr><td colspan="3">Carbon capture from the Air</td><td>Direct Air Capture (DAC)</td><td>Carbon Direct Air Capture for the energy supply sector</td><td>Highest energy/t CO_2</td></tr>
</table>

Overview of technologies modelled to use/capture carbon

Groups		Technology			
		Name	Description	Container	Replacement
Usage	e-Fuels	e-Methanation	through methanation ⚡ $+H_2+$ ☁ → CH_4	in synthetic methane	replaces natural gas
		Fischer-Tropsch process	through Fischer-Tropsch process ⚡ $+H_2+$ ☁ → Synthetic fuel	In synthetic liquid fuel	replaces liquid fossil fuels
		e-Methanol	through methanol synthesis ⚡ $+H_2+$ ☁ → Synthetic methanol	In synthetic methanol	replaces maritime fuels
	Chemicals	e-MTO	MTO with synthetic methanol ⚡ $+H_2+$ ☁ → Synthetic methanol → Olefins	In Olefins	Fossil based olefins
		e-Dehydration	Dehydration of synthetic ethanol ⚡ $+H_2+$ ☁ $+CO_2$ → ⚡ +Synthetic ethanol → Olefin	In Olefins	Fossil based olefins
	Buildings materials	Cement CO_2 curing	Curing to store carbon in the concrete Cement+ ☁ → Concrete	In concrete	Concrete with water based curing
		Carbstone	Carbon bricks ⚡ + ☁ + Ca/Mg+… → Ceramic	In ceramics	Ceramic bricks
Storage	Industry	CCS	Capture of industrial emissions	stored	/
	Energy supply	CCS	Capture of energy supply emissions	stored	/

Legend	
⚡	Power
☁	CO_2
H_2	Hydrogen

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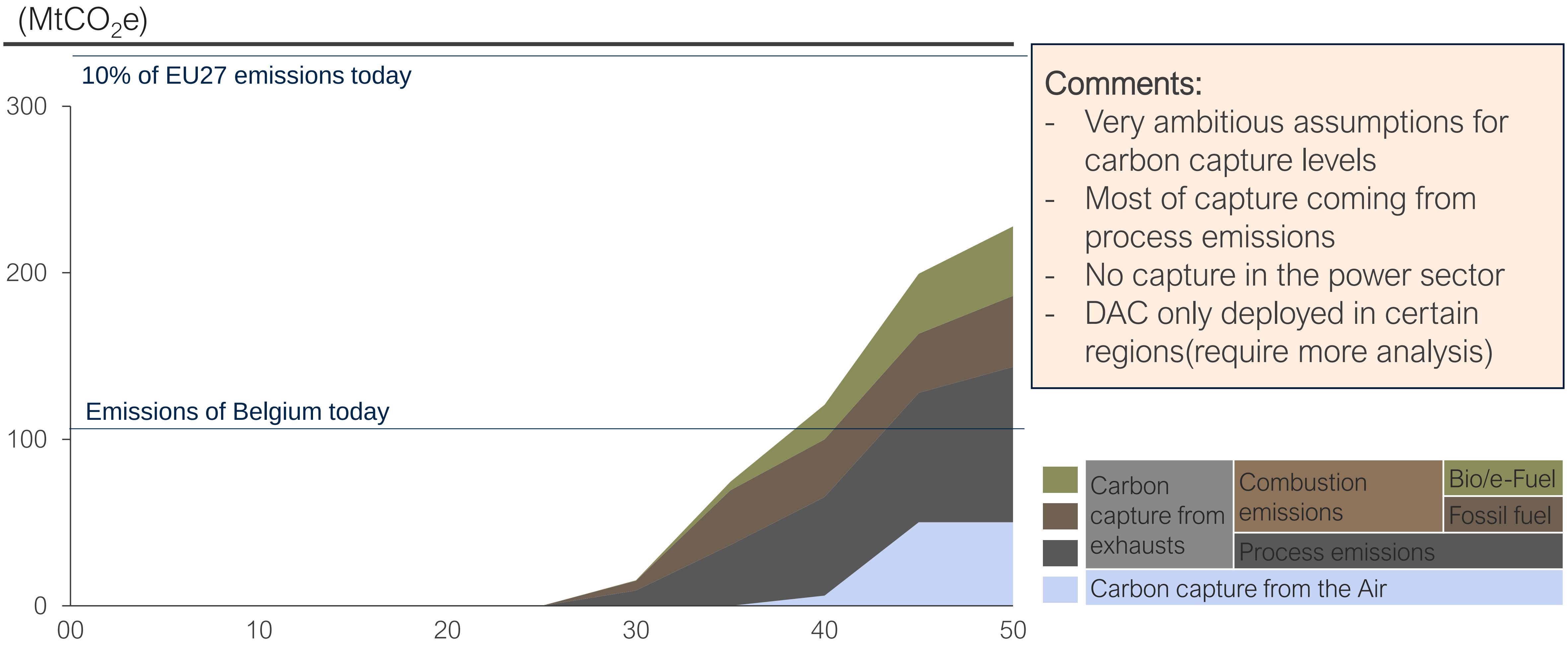
In a high CCU scenario (a scenario supporting CCU), ~230 $MtCO_2e$ is captured of per year (EU27)

Illustration of emissions captured in an European high CCU scenario

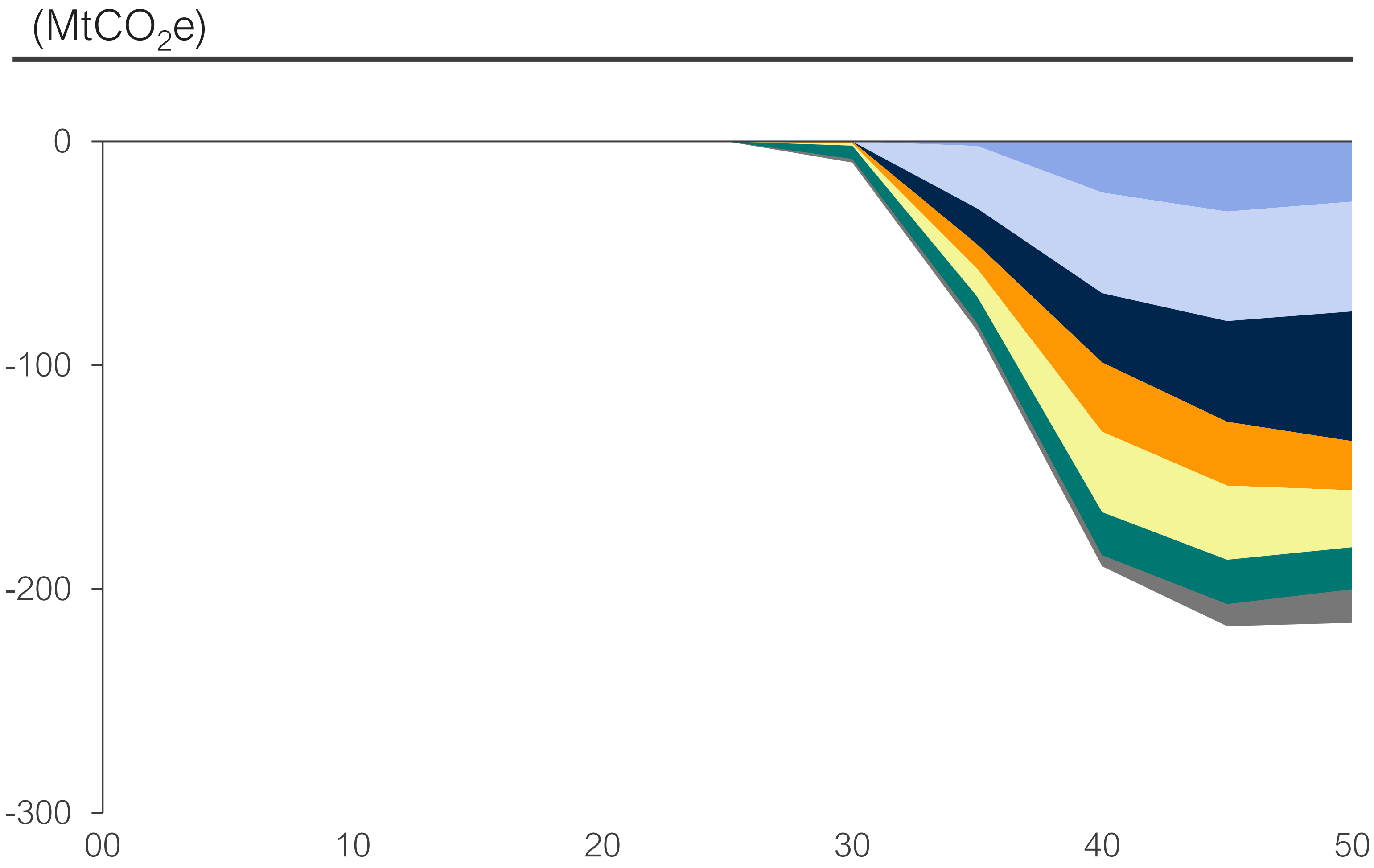


Comments:
- Very ambitious assumptions for carbon capture levels
- Most of capture coming from process emissions
- No capture in the power sector
- DAC only deployed in certain regions(require more analysis)

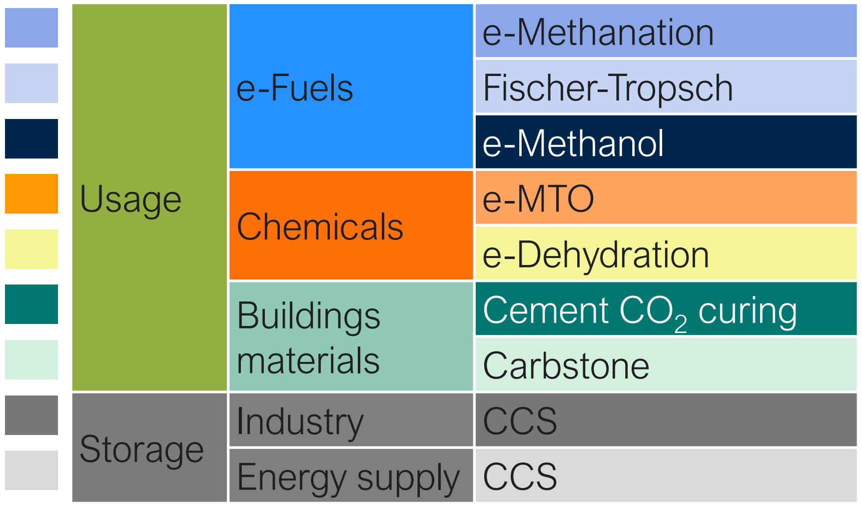
NOTE: Emissions of the EU27 today equal 3380 $MtCO_2e$
SOURCE: www.pathwaysexplorer.org, preliminary scenario designed by Climact, in line with strong CCU demand

In a high CCU scenario, CCU would use almost all the potential supply of CO_2

Illustration of carbon used in an European High CCU scenario



- Share of CCS vs CCU varies along scenarios
- In high CCU scenario
  - High ambition in CO_2 use
  - CO_2 demand is close to the CO_2 supply
    - 100% of e-fuels in aviation (decrease ~50% in demand) and marine sector
    - 25% of CCU plastics in a circular economy
    - 100% cement uses CO_2 curing



SOURCE: www.pathwaysexplorer.org, preliminary scenario designed by Climact, in line with strong CCU demand

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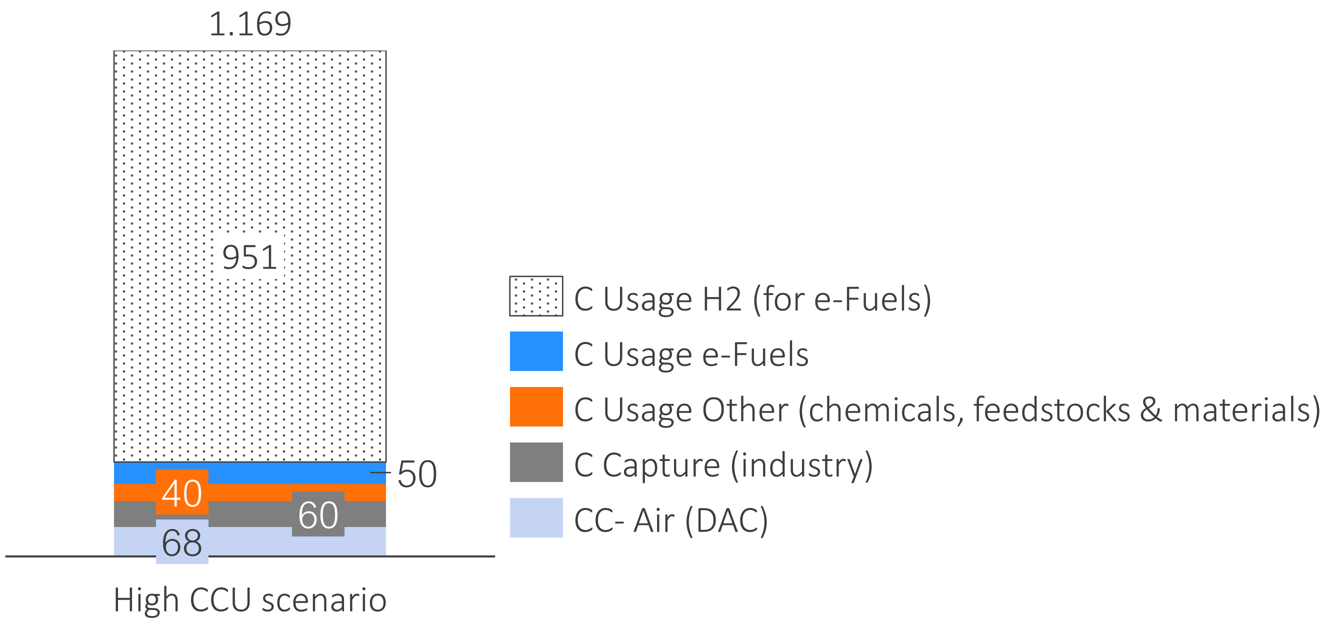
In a European high CCU scenario, ~30% of RES is allocated to CCU

Electricity consumption of CCU related technologies
(TWh, in 2050 unless specified)



RES production [TWh]	4200
% RES used for CCU	27.8%[2]

- Hydrogen production is the most electro-intensive process
- CCU development relies on massive RES production

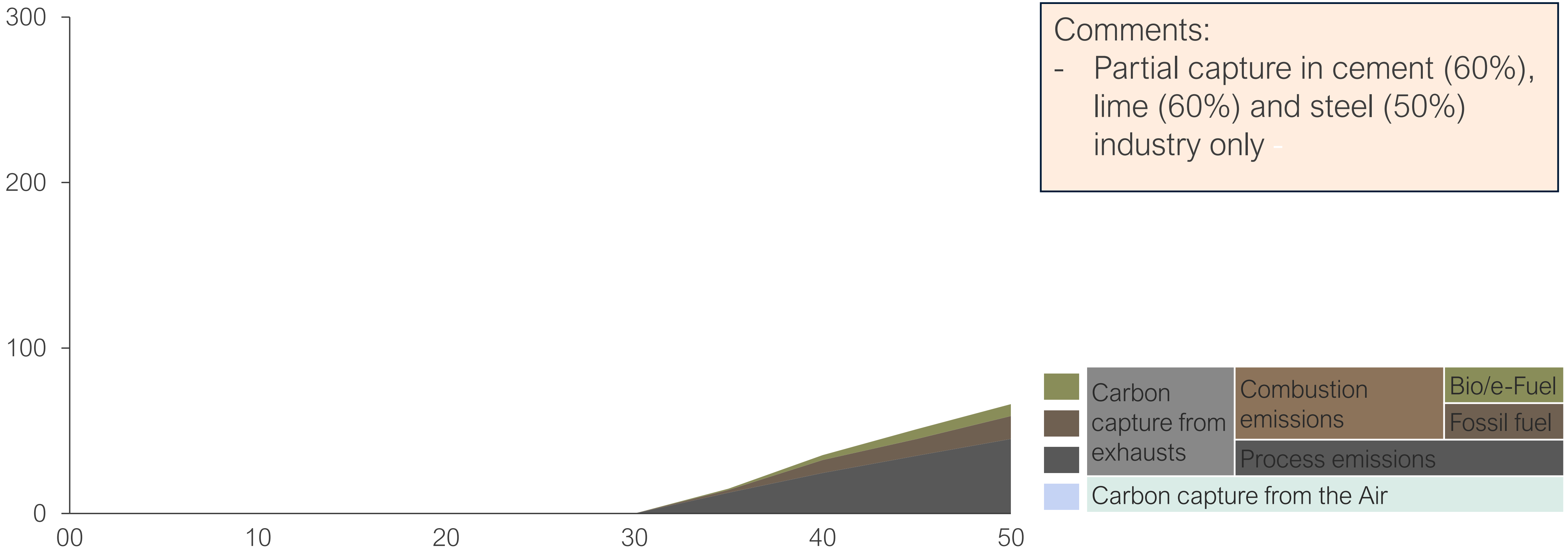
Further investigation needed to answer following questions:
- Availability of RES for CCU?
- Competition with other needs and storage/back-up technologies?
- Potential reliance on imports from other regions?

NOTES: (1) Bunker energy is considered as 50% of the energy needed for international travel (inland share)
(2) This can be reduced by importing a higher share of e-fuels (30% imports for now), or reducing the e-fuel demand

In a more conservative CC scenario, ~65 $MtCO_2e$ is captured of per year

Illustration of emissions captured in an European high CCU scenario

($MtCO_2e$)



Comments:

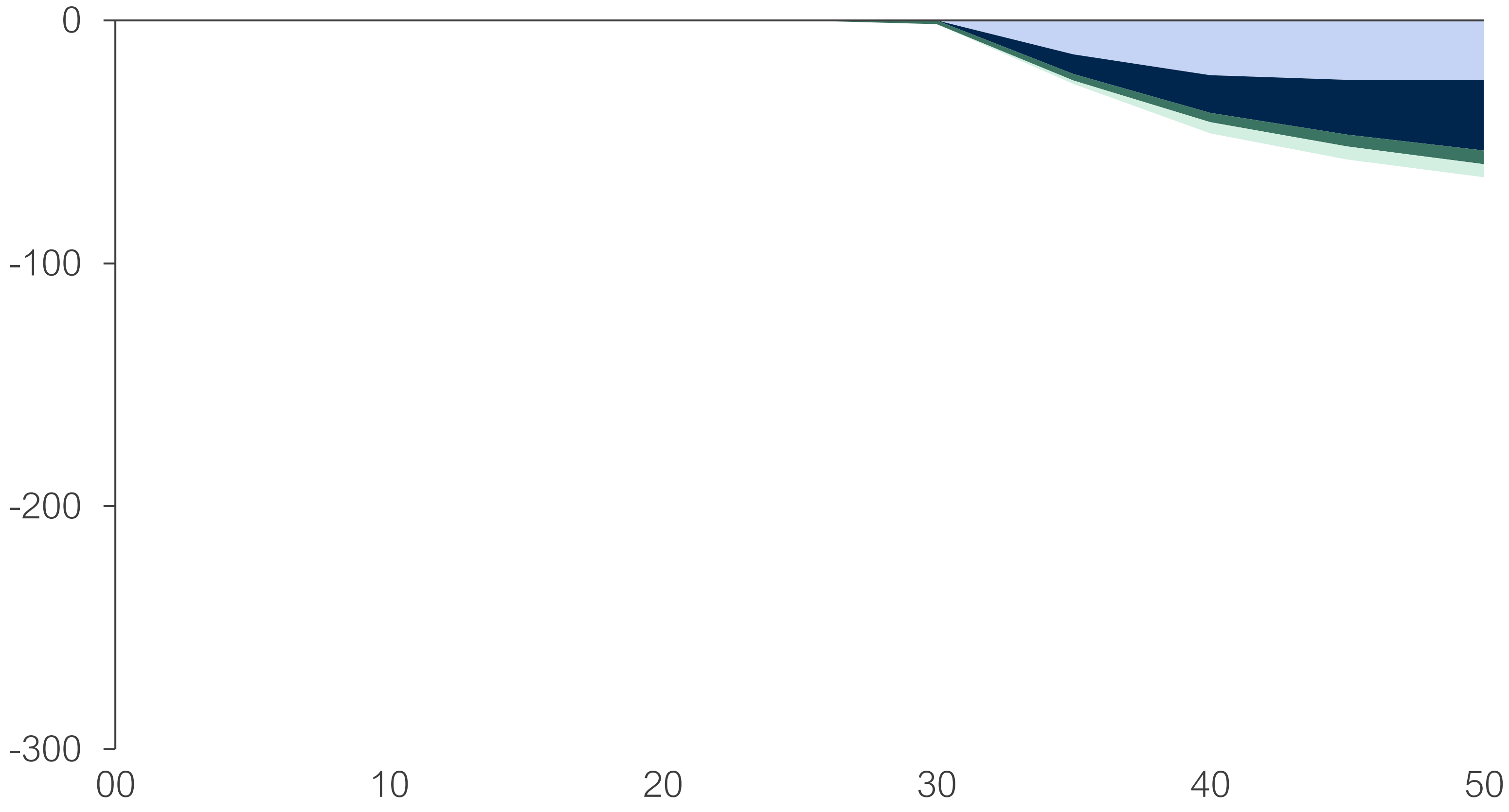
- Partial capture in cement (60%), lime (60%) and steel (50%) industry only

SOURCE: www.pathwaysexplorer.org, preliminary scenario designed by Climact, in line with strong CCU demand

In a more conservative CC scenario, CCU would use a higher share of the CO_2 captured

Illustration of carbon used in an European scenario with less CC

(MtCO_2e)



Usage	e-Fuels	e-Methanation
		Fischer-Tropsch
		e-Methanol
	Chemicals	e-MTO
		e-Dehydration
	Buildings materials	Cement CO_2 curing
		Carstone
Storage	Industry	CCS
	Energy supply	CCS

Supply of CO_2 could cover:
- 50% of e-fuels for aviation and marine
- 100% ceramics production
- 20% CO_2 curing in cement

SOURCE: www.pathwaysexplorer.org, preliminary scenario designed by Climact, in line with strong CCU demand

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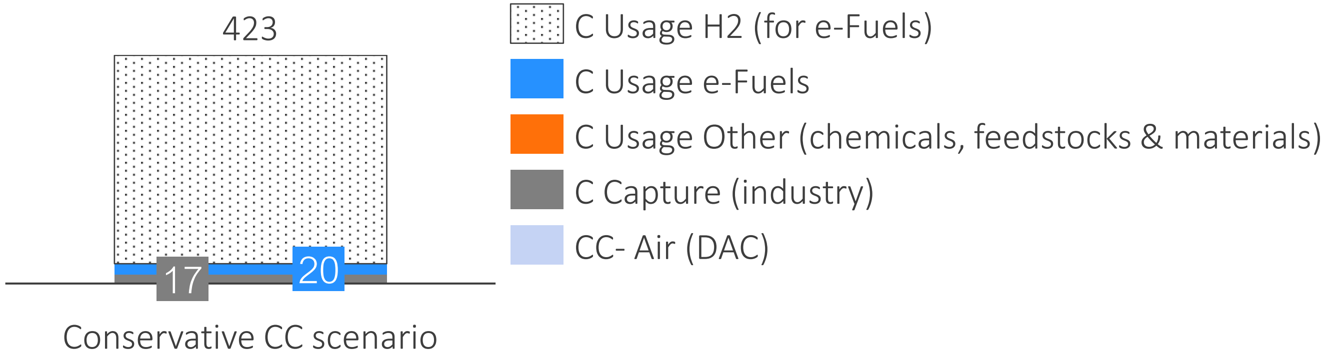
In a more conservative CC scenario ~10% of RES is allocated to CCU

Electricity consumption of CCU related technologies
(TWh, in 2050 unless specified)



RES production [TWh]	4200
% of RES used for CCU	~10%[2]

NOTES:
(1) Bunker energy is considered as 50% of the energy needed for international travel (inland share)
(2) This can be reduced by importing a higher share of e-fuels (30% imports for now), or reducing the e-fuel demand

CLIMACT | Empowering **you** to act on **climate change**

Do you have any question?

Thank you.

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Agenda

- Backup

CCU CO_2 emissions/removals are accounted for downstream

There are 2 options to account the climate benefit of CCU: upstream or downstream

Option A (downstream accounting of climate benefit)

- When CO_2 is captured and used, the reduction/removal is accounted downstream
  - E.g. A steel plant captures 1 t of fossil CO_2, which is captured and turned into synthetic kerosene. The steel plant still reports 1 t of CO_2, and synthetic kerosene is considered zero-emission
  - E.g. A steel plant captures 1 t of fossil CO_2, which is captured and turned into a CCU construction material. The steel plant still reports 1 t of CO_2. The CCU construction material is considered to have removed 1 t of CO_2
- CO_2 is considered to be ‘emitted’ at its point of origin

Option B (upstream accounting of climate benefit)

- When case CO_2 is captured, its reduction/removal is accounted at the point where it is captured
- CO_2 is then considered to be ‘emitted’ at its point of release into the atmosphere