CLEAN clinKER by calcium looping for low-CO_2 cement

CO_2 industrial emissions: strategies for Capture, Utilization and Storage

Stefano Consonni
Politecnico di Milano – President of LEAP

The
energy situation

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In the media

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By Hyonhee Shin and Hanna Song

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Stefano Rizzuti 13 Gennaio 2023 - 16:39

Germany's Energy Crisis Sends It Tumbling Down Investment Rankings

By Irina Slav - Jan 16, 2023, 2:48 AM CST

Scenari

Sudafrica ostaggio della crisi energetica, verso i 100 giorni consecutivi di blackout

Il colosso locale Eskom impone tutti i giorni blackout fino a 12 ore al giorno per salvare il sistema dal collasso. Una carenza energetica che rischia di affondare l'economia più industrializzata del Continente

ANSA.it › Ambiente&Energia › Energia › Per zero emissioni servono cattura carbonio, idrogeno,biogas

Per zero emissioni servono cattura carbonio, idrogeno,biogas

Ricerca Ambrosetti-Eni, vale principio di neutralità tecnologica

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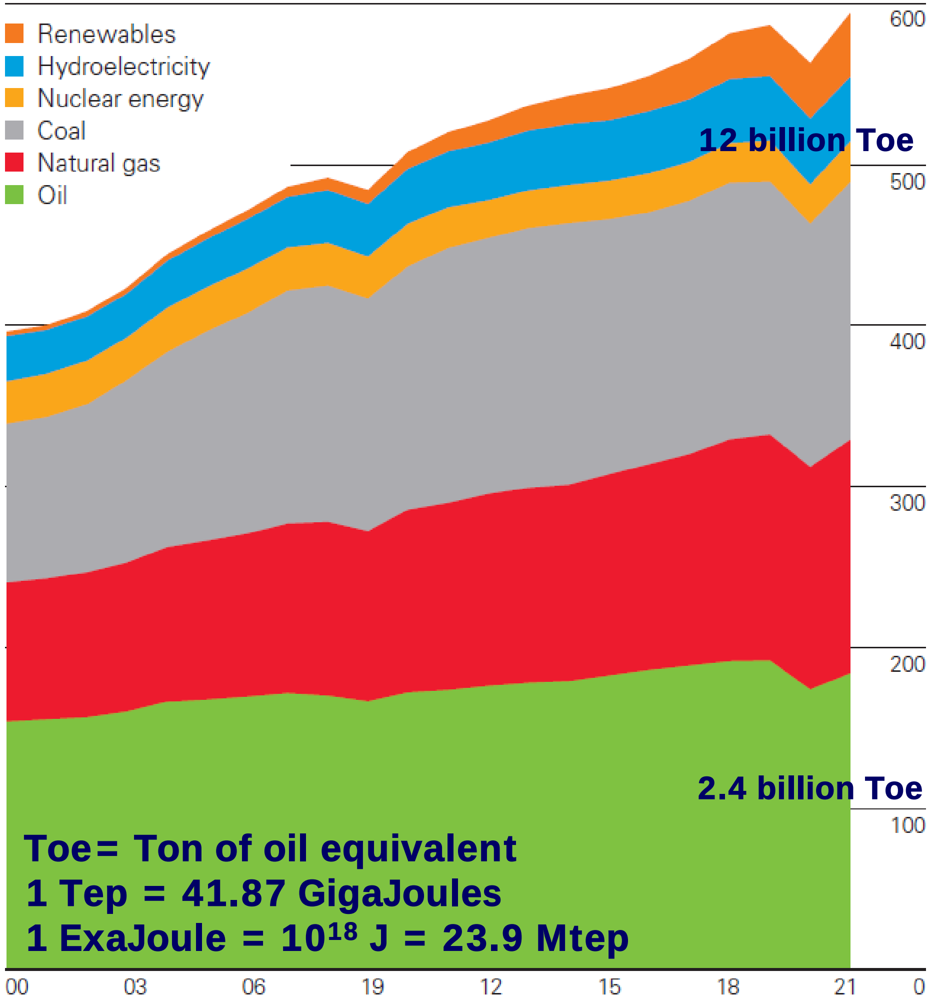
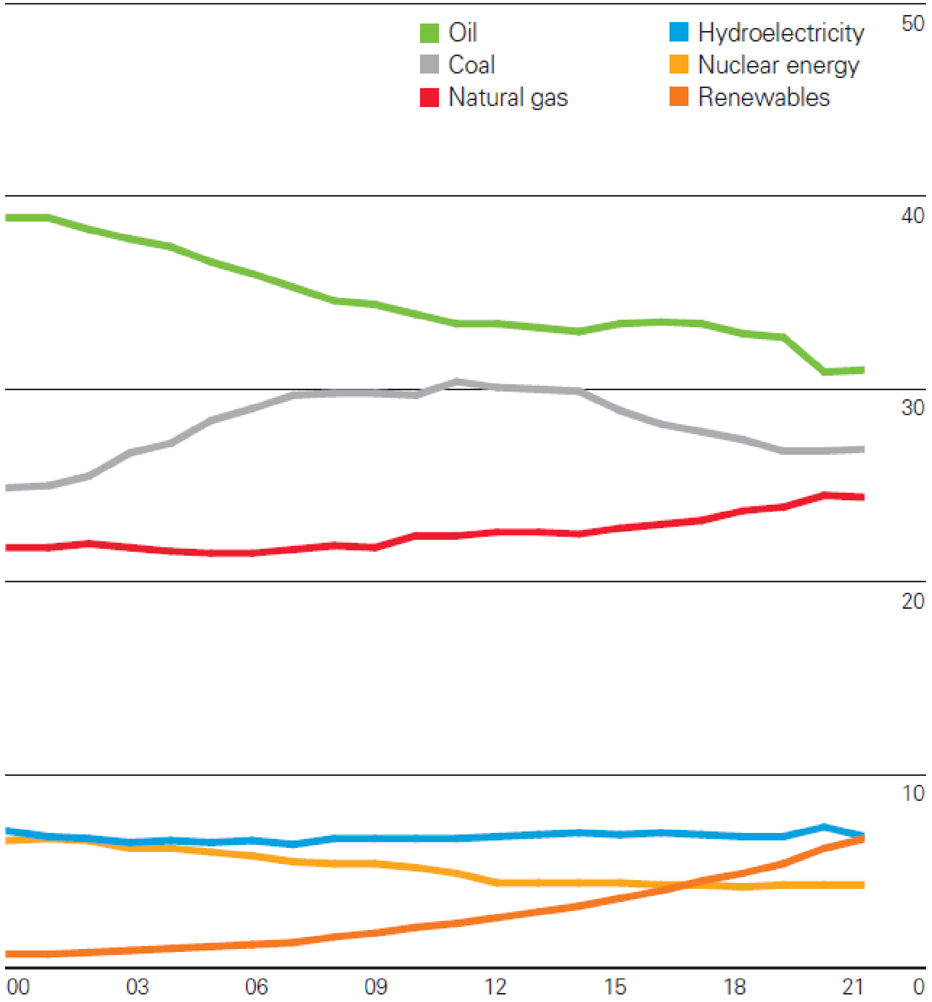
Current energy scenario

World consumption
Exajoules



Toe= Ton of oil equivalent
1 Tep = 41.87 GigaJoules
1 ExaJoule = 10^{18} J = 23.9 Mtep

Shares of global primary energy
Percentage



Source: BP Statistical Review of World Energy 2022

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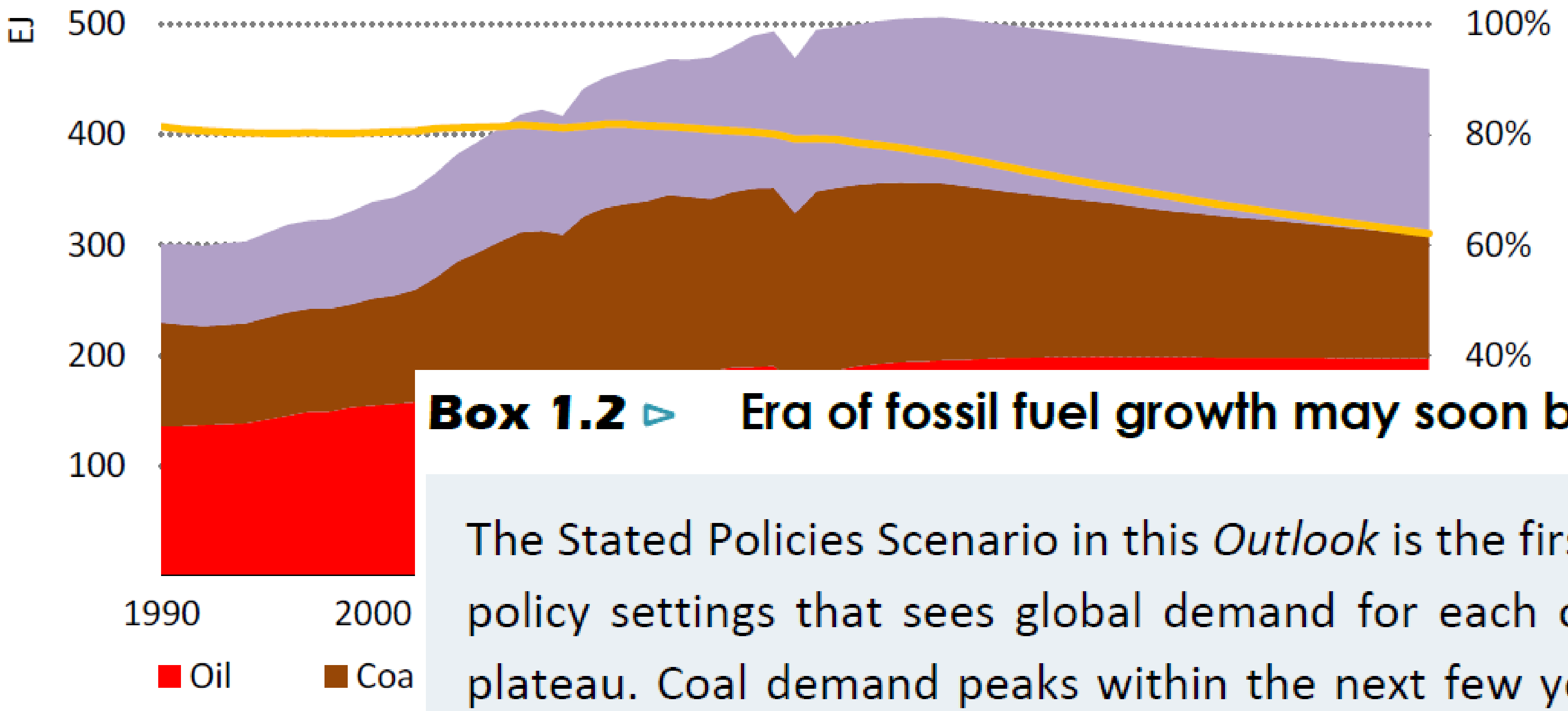
Predictions



Source: World Energy Outloc

Box 1.2 ⊳ Era of fossil fuel growth may soon be over

The Stated Policies Scenario in this *Outlook* is the first *WEO* scenario based on prevailing policy settings that sees global demand for each of the fossil fuels exhibit a peak or plateau. Coal demand peaks within the next few years, natural gas demand reaches a plateau by the end of the decade, and oil demand reaches a high point in the mid-2030s before falling. The result is that total demand for fossil fuels declines steadily from the mid-2020s by around 2 exajoules (EJ) (equivalent to 1 million barrels of oil equivalent per day [mboe/d]) every year on average to 2050 (Figure 1.9).

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CO_2 emissions

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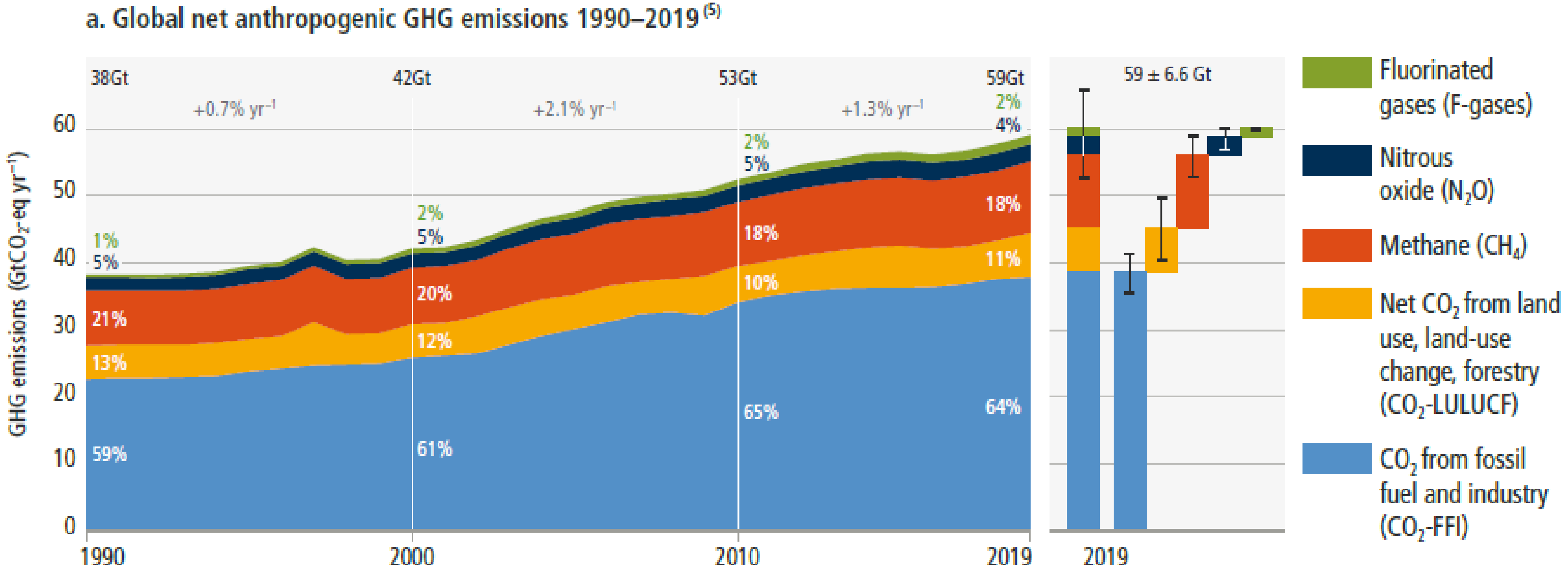
Global anthropogenic emissions CONTINUE TO RISE



IPCC – Climate Change 2022: Mitigation

Global net anthropogenic GHG emissions by region

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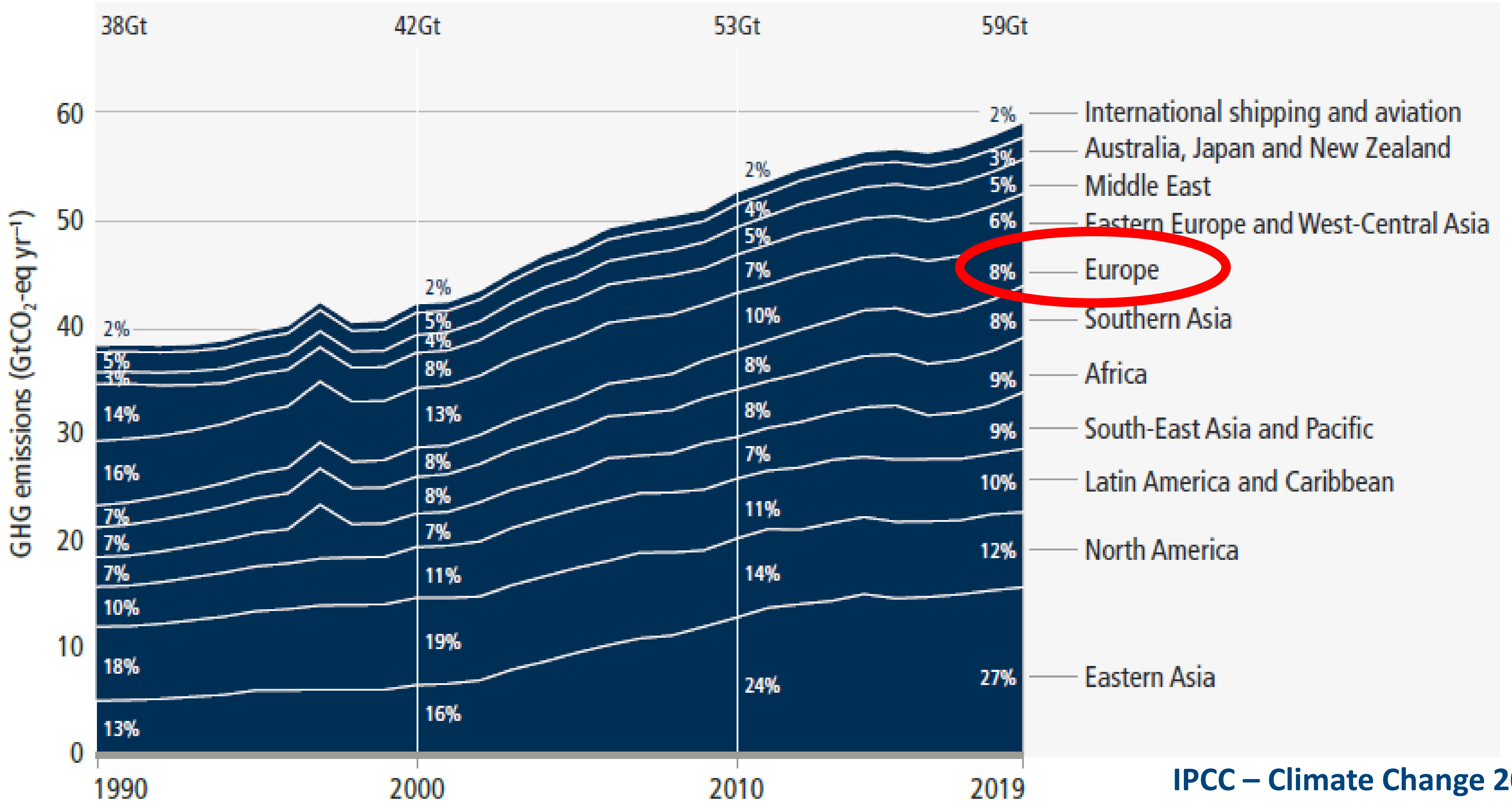

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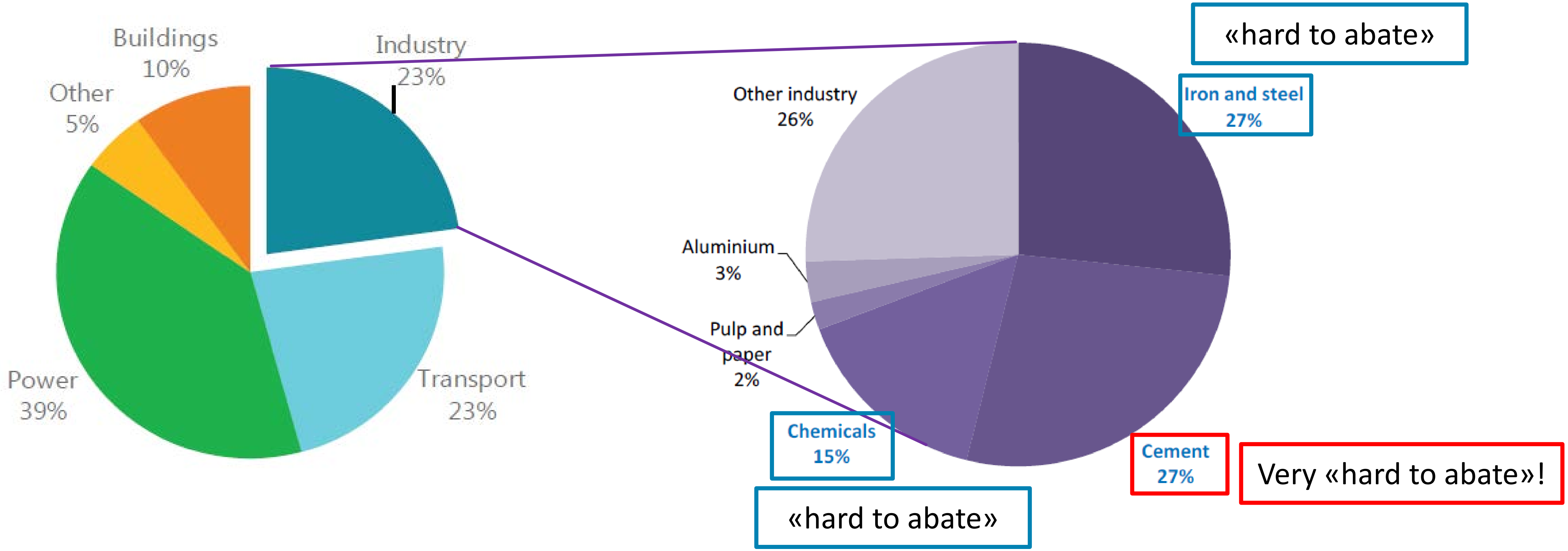
Breakdown by sector (2017)



IEA, 2019. *Transforming Industry through CCUS.*

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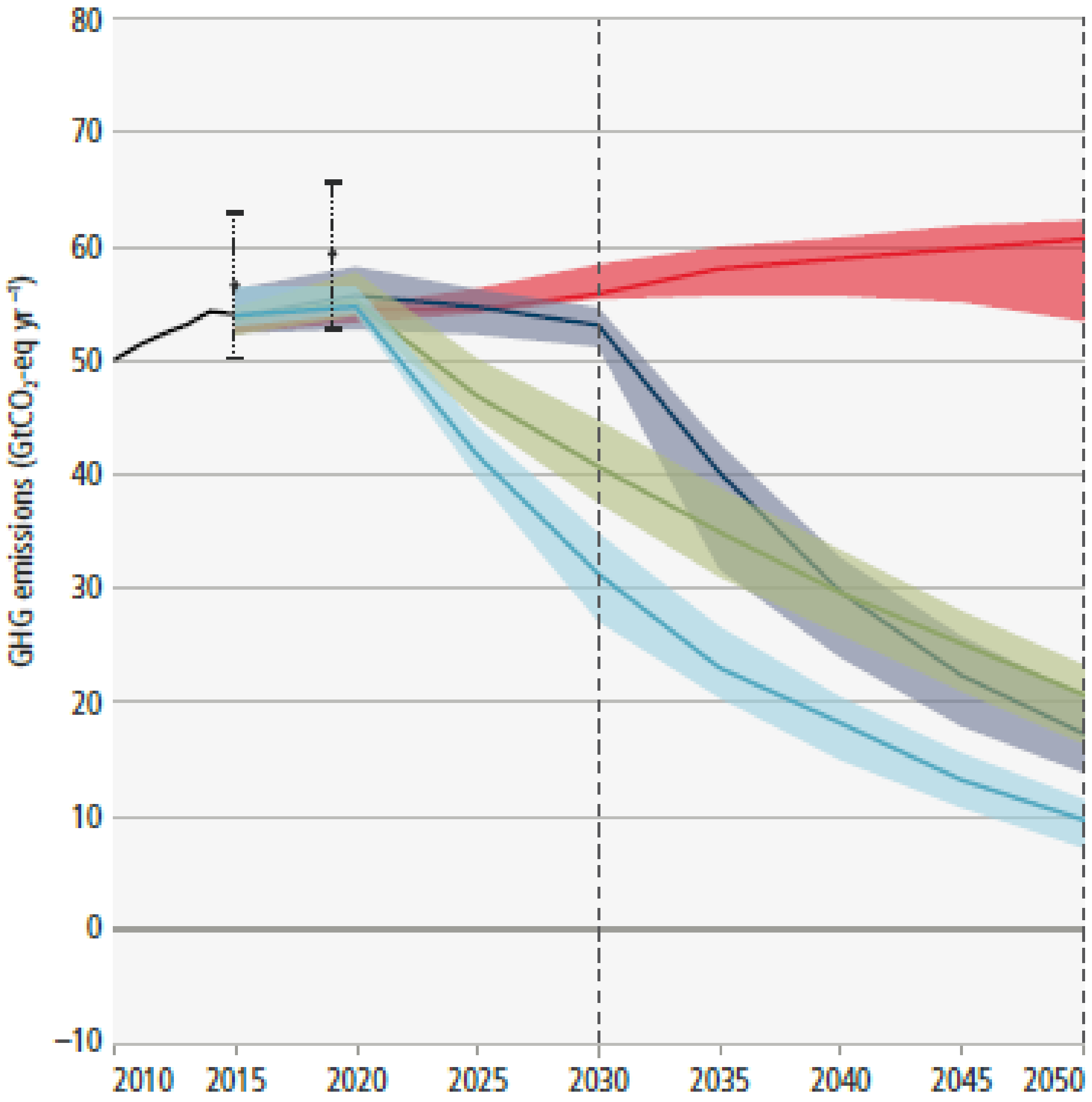
Projected global CO2 emissions



Modelled pathways:

- Trend from implemented policies
- Limit warming to 2°C (>67%) or return warming to 1.5°C (>50%) after a high overshoot, NDCs until 2030
- Limit warming to 2°C (>67%)
- Limit warming to 1.5°C (>50%) with no or limited overshoot
- Past GHG emissions and uncertainty for 2015 and 2019 (dot indicates the median)

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Envisioning a Wonderful World

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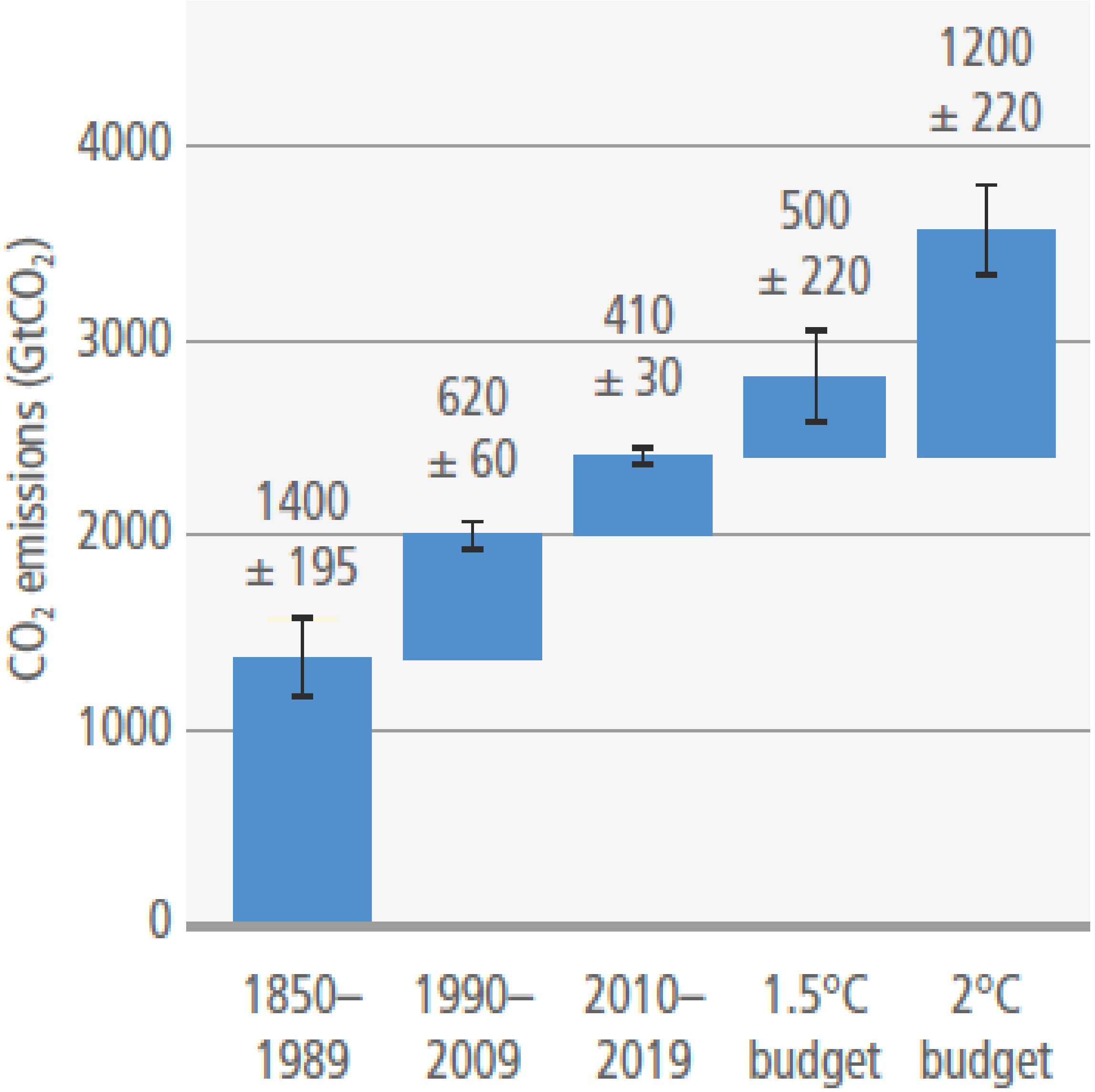
Historical cumulative CO_2 emissions vs budgets for limiting temperature increase



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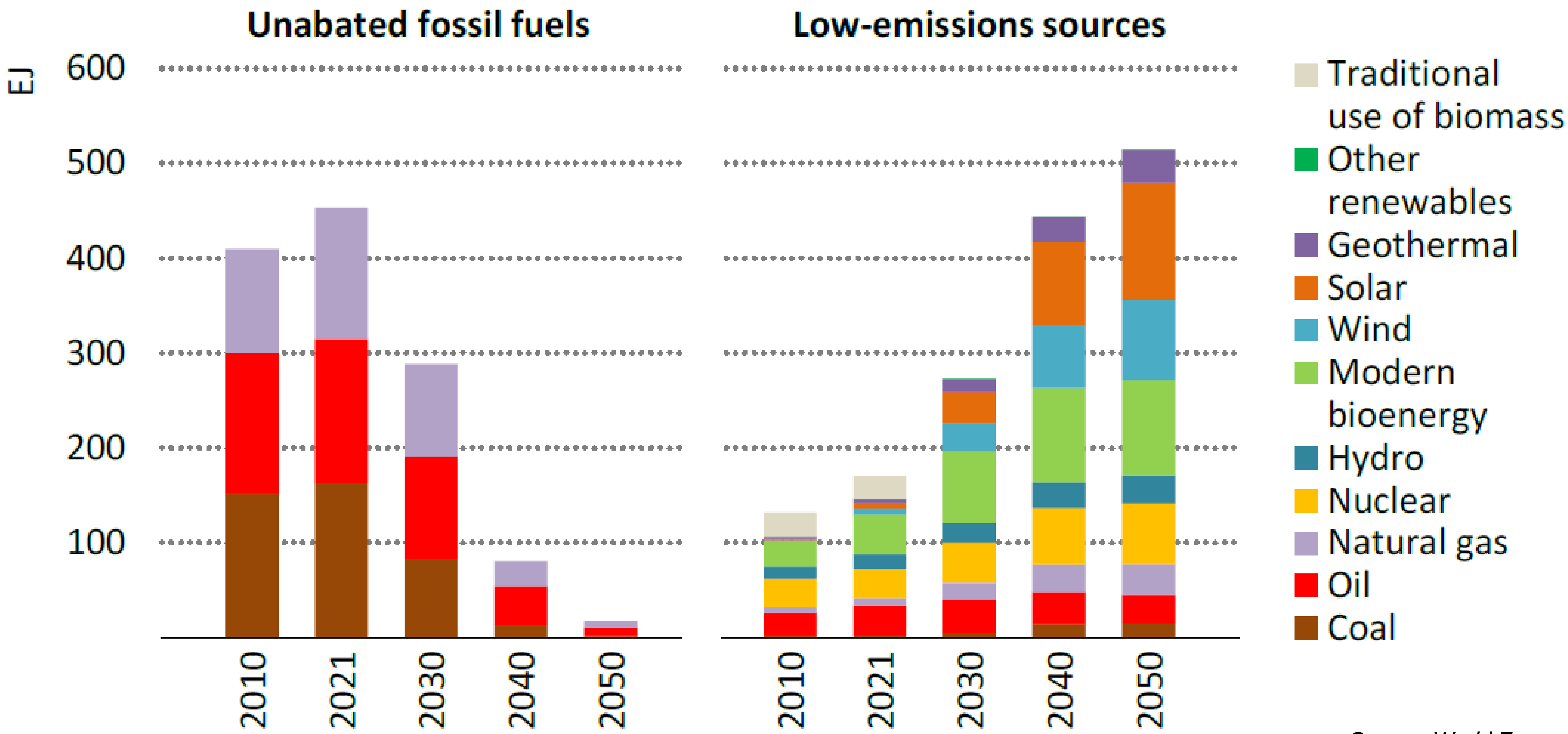
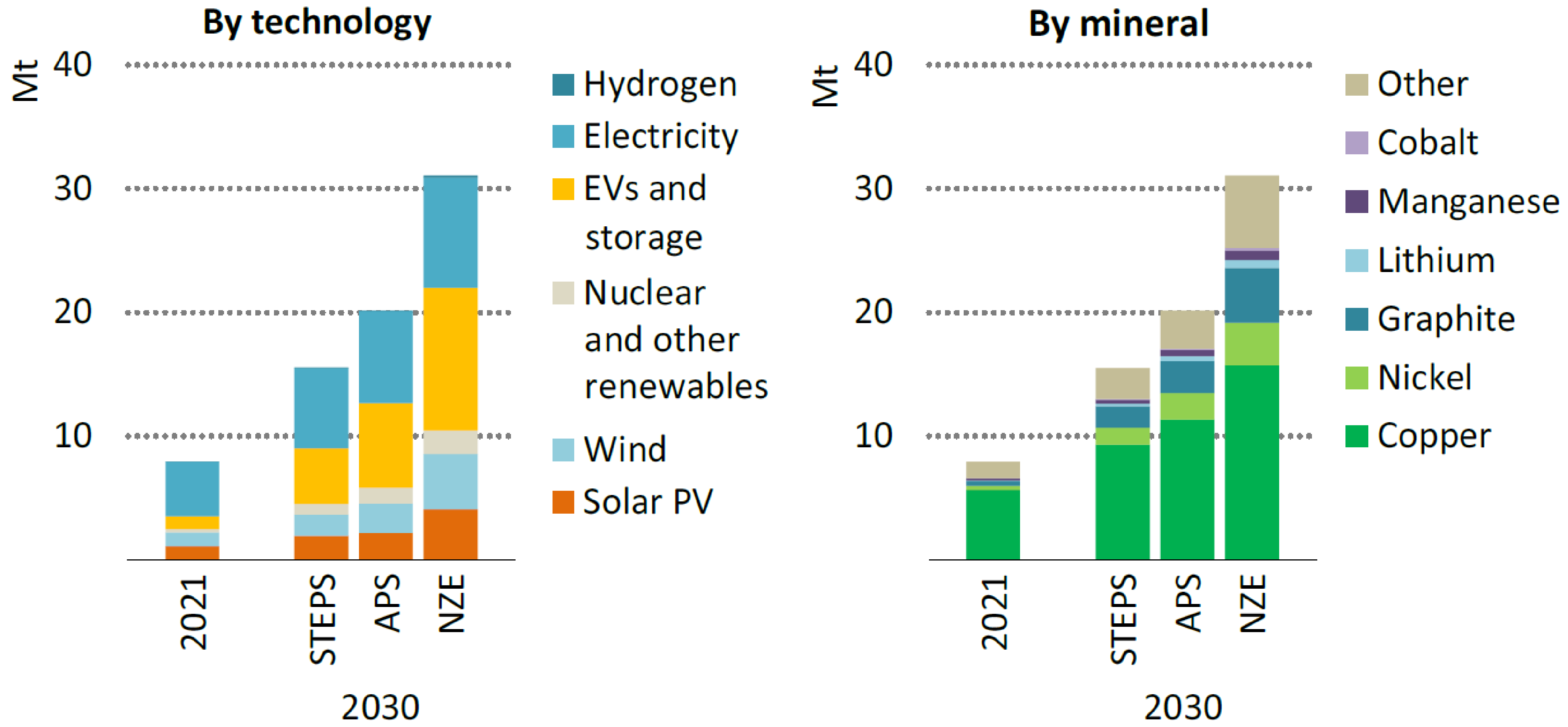
Net Zero Emission (NZE) scenario (i.e. what is needed to limit warming to 1.5°C)



Source: World Energy Outlook 2022

Mineral requirements



STEPS = Stated Policies scenario
APS = Announced Pledeges scenario
NZE = Net Zero Emission scenario

Source: World Energy Outlook 2022

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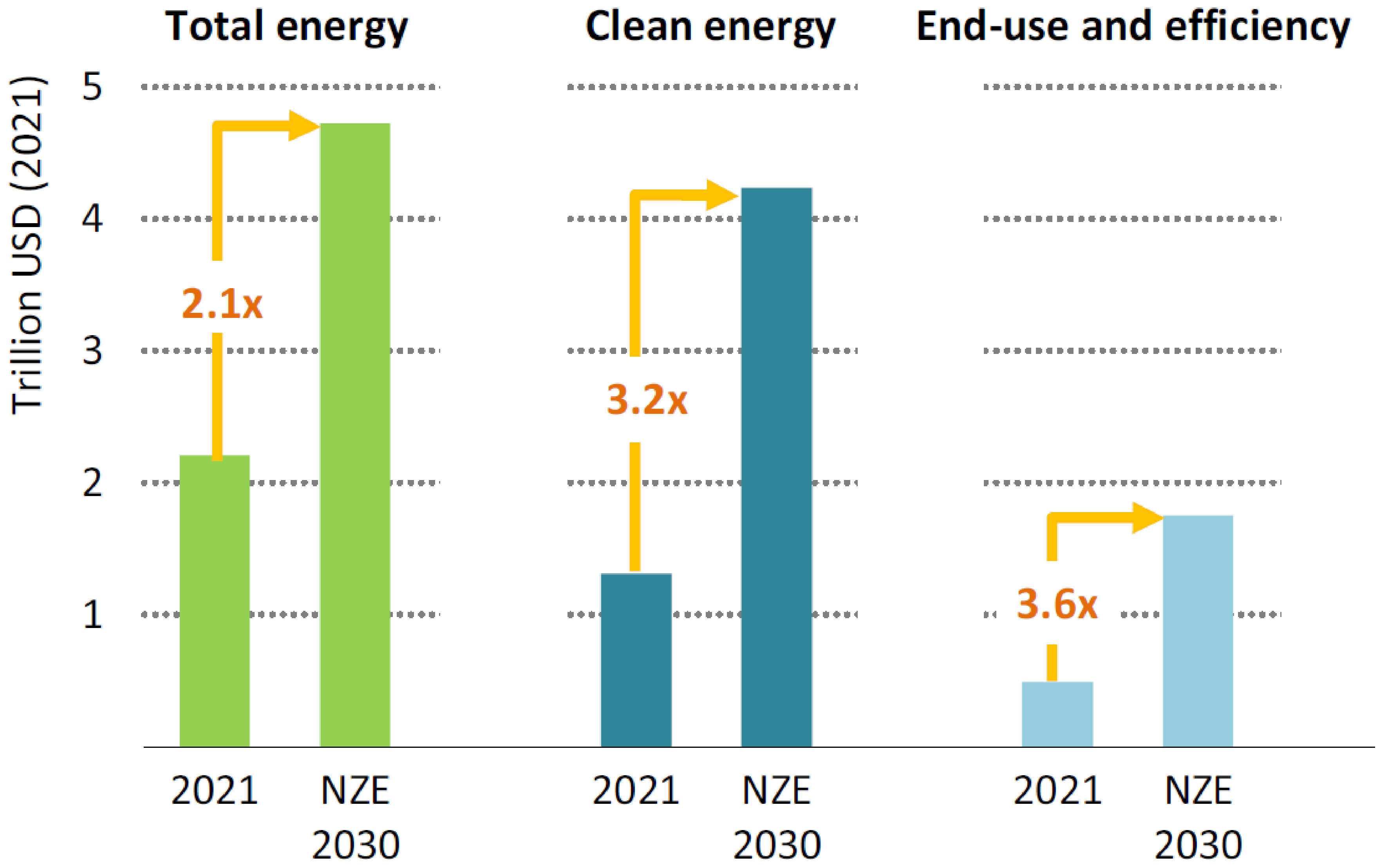
Energy investments



Source: World Energy Outlook 2022

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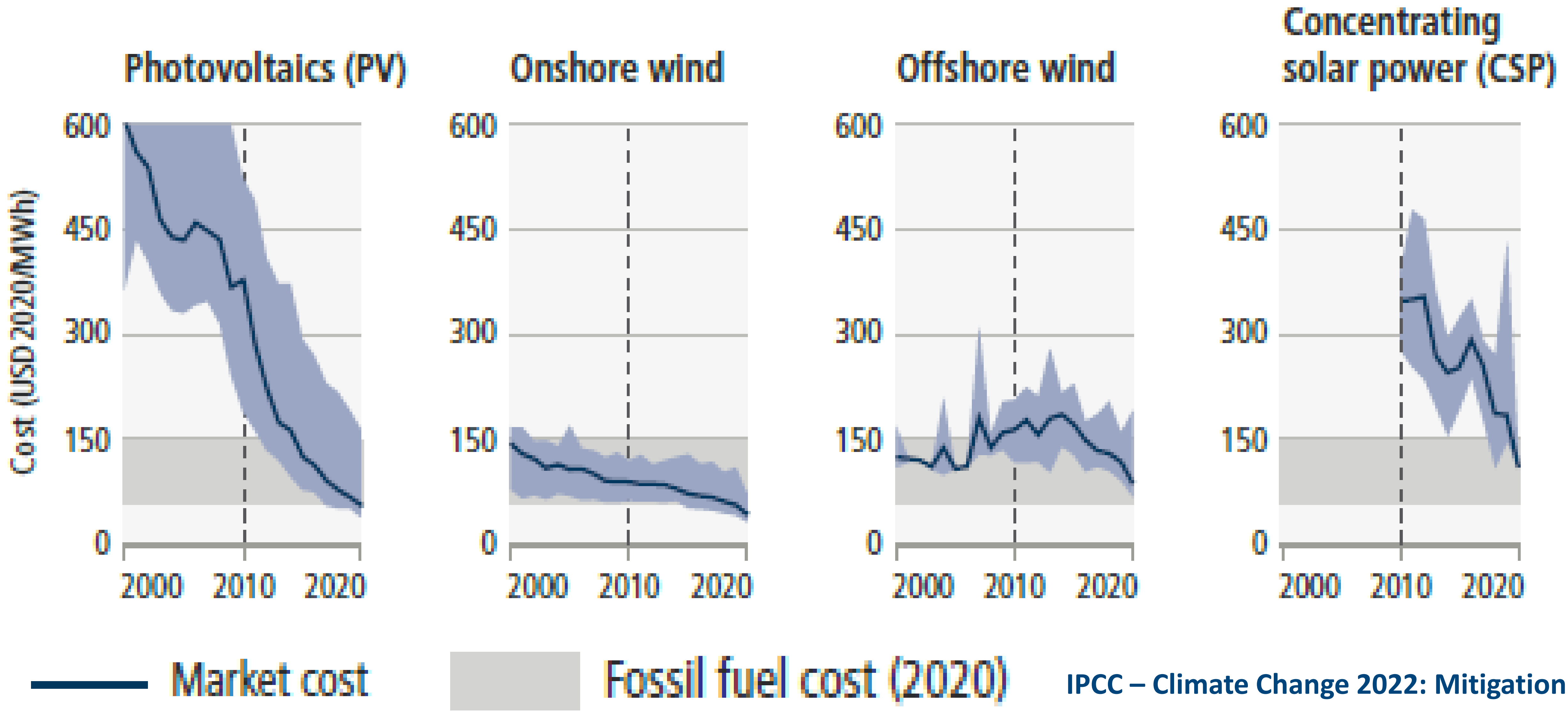
Good news: unit cost of renewable energy continues to decrease



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Mitigation strategies

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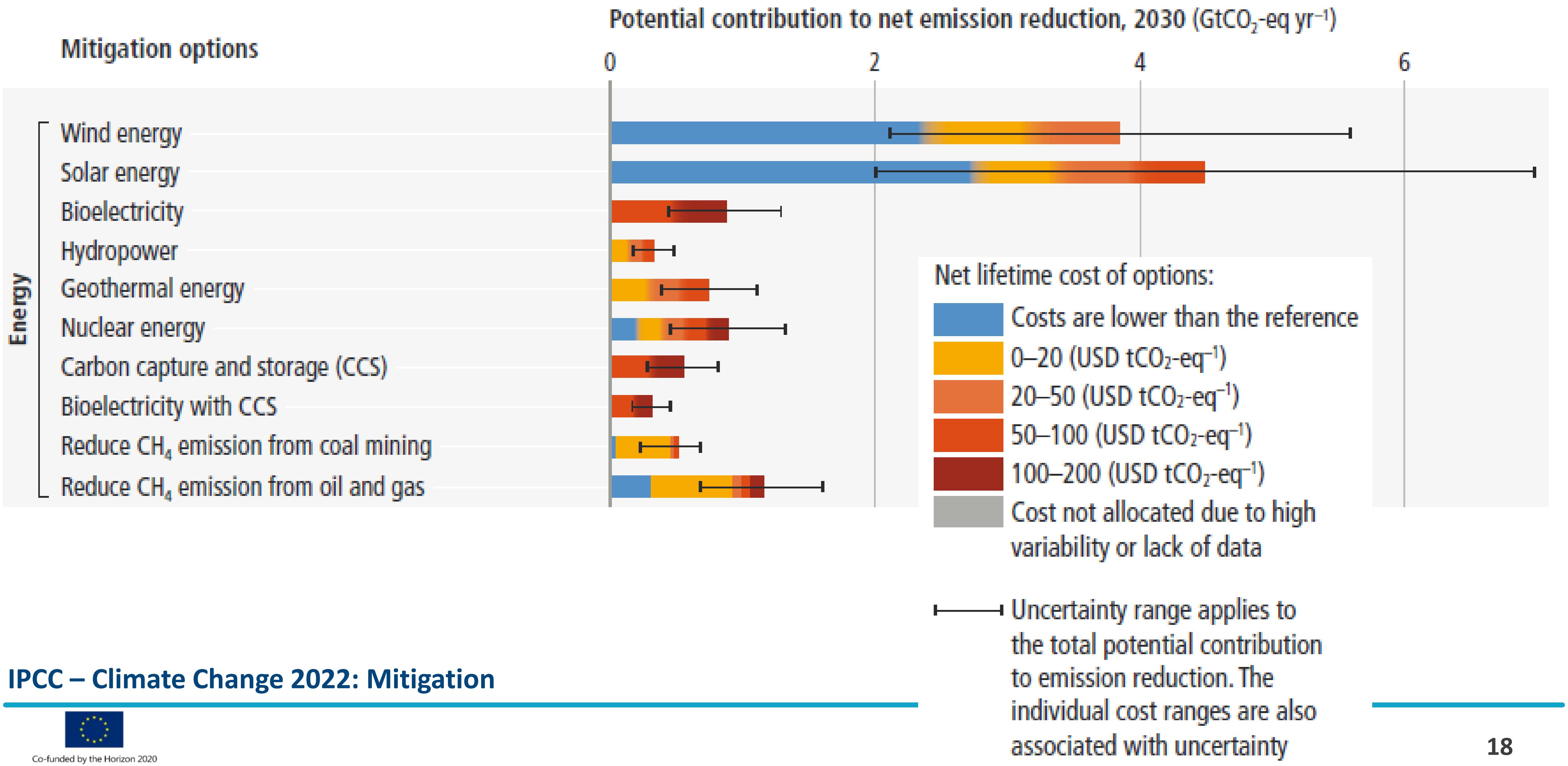
Potential contribution to reduction of CO2 emissions by 2030: Energy



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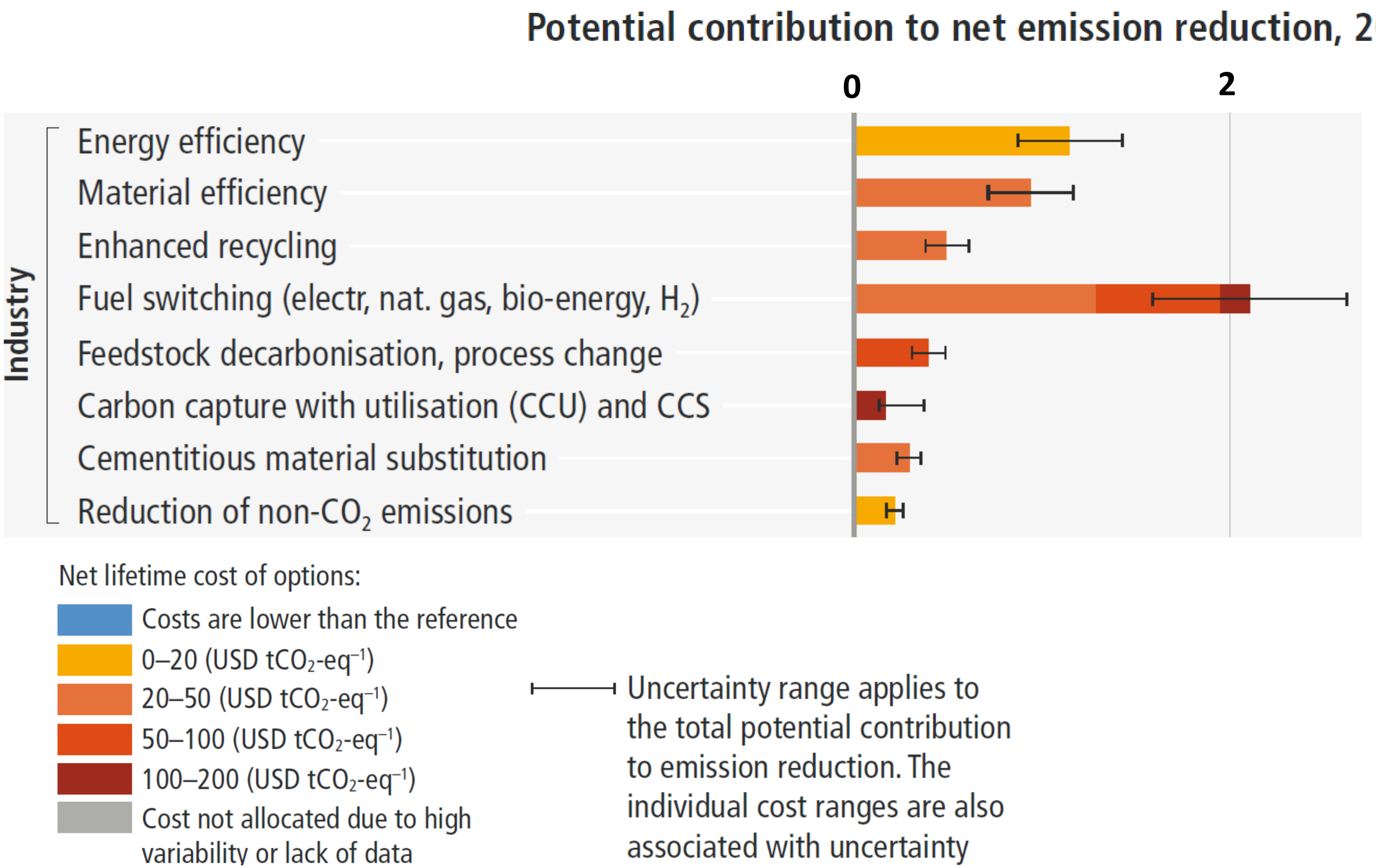
Potential contribution to reduction of CO2 emissions by 2030: Industry

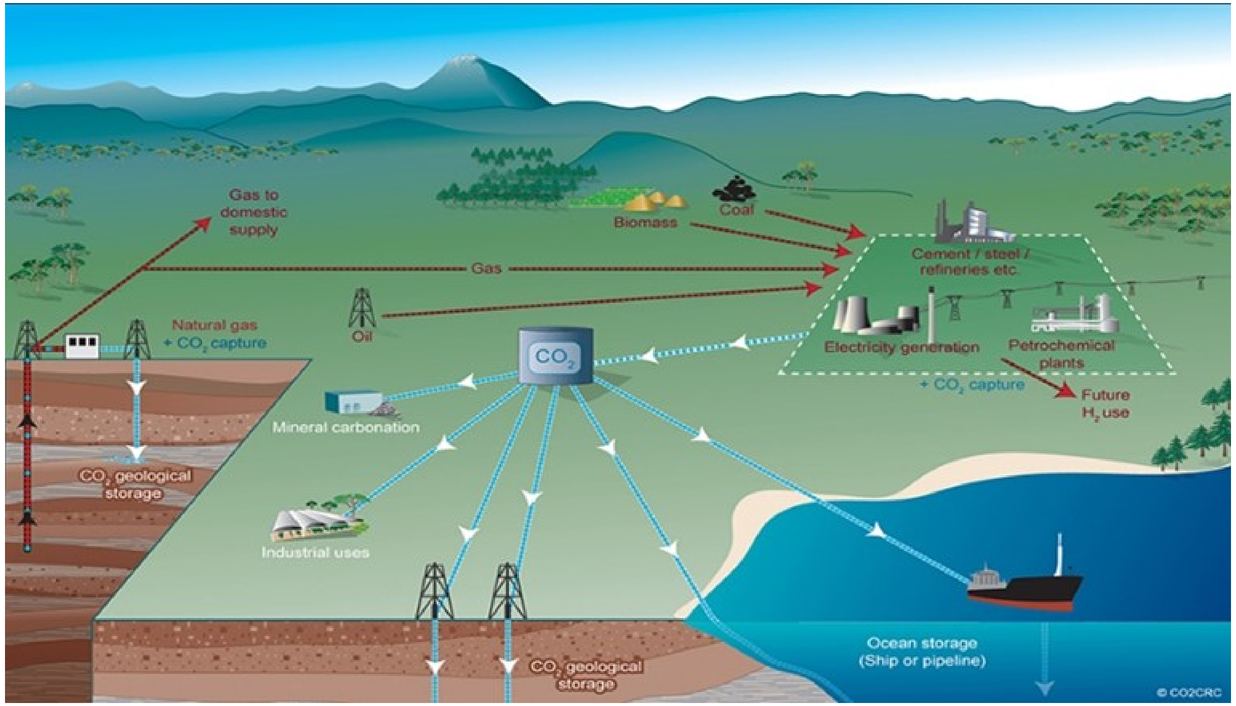


IPCC – Climate Change 2022: Mitigation

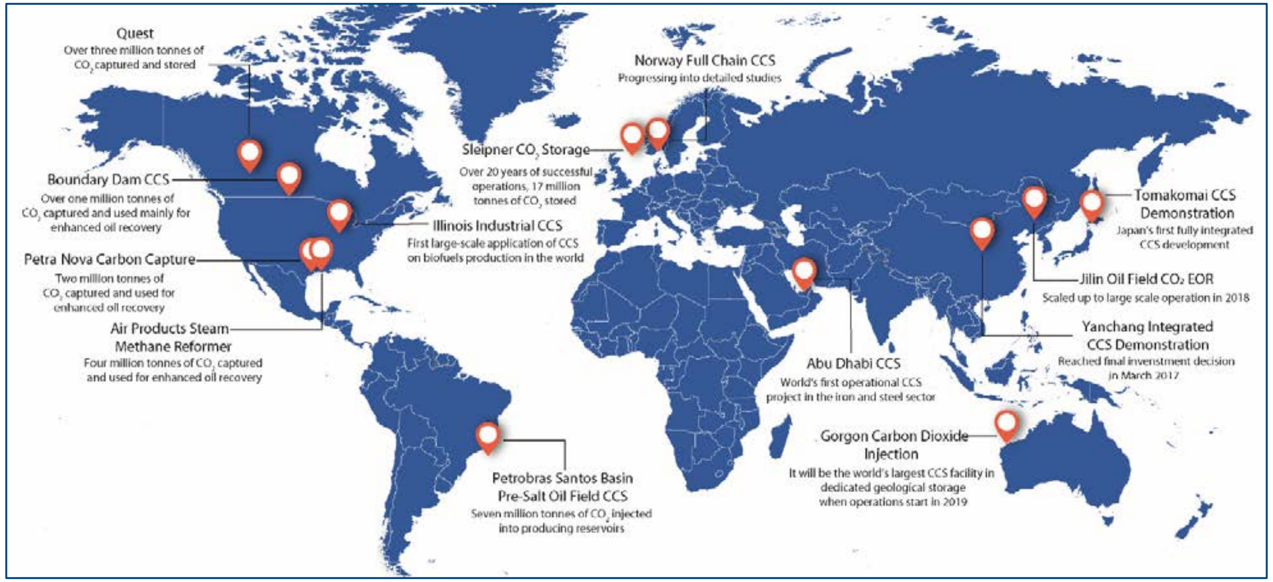
What is CC(U)S ?

CCS refers to a set of CO2 capture, transport and storage technologies that are put together to abate emissions from various stationary CO2 sources

1. **Capture a reach-CO2 gas from industrial plant(s);**
2. **Transport (pipeline or shipping);**
3. **Injection (or utilization)**

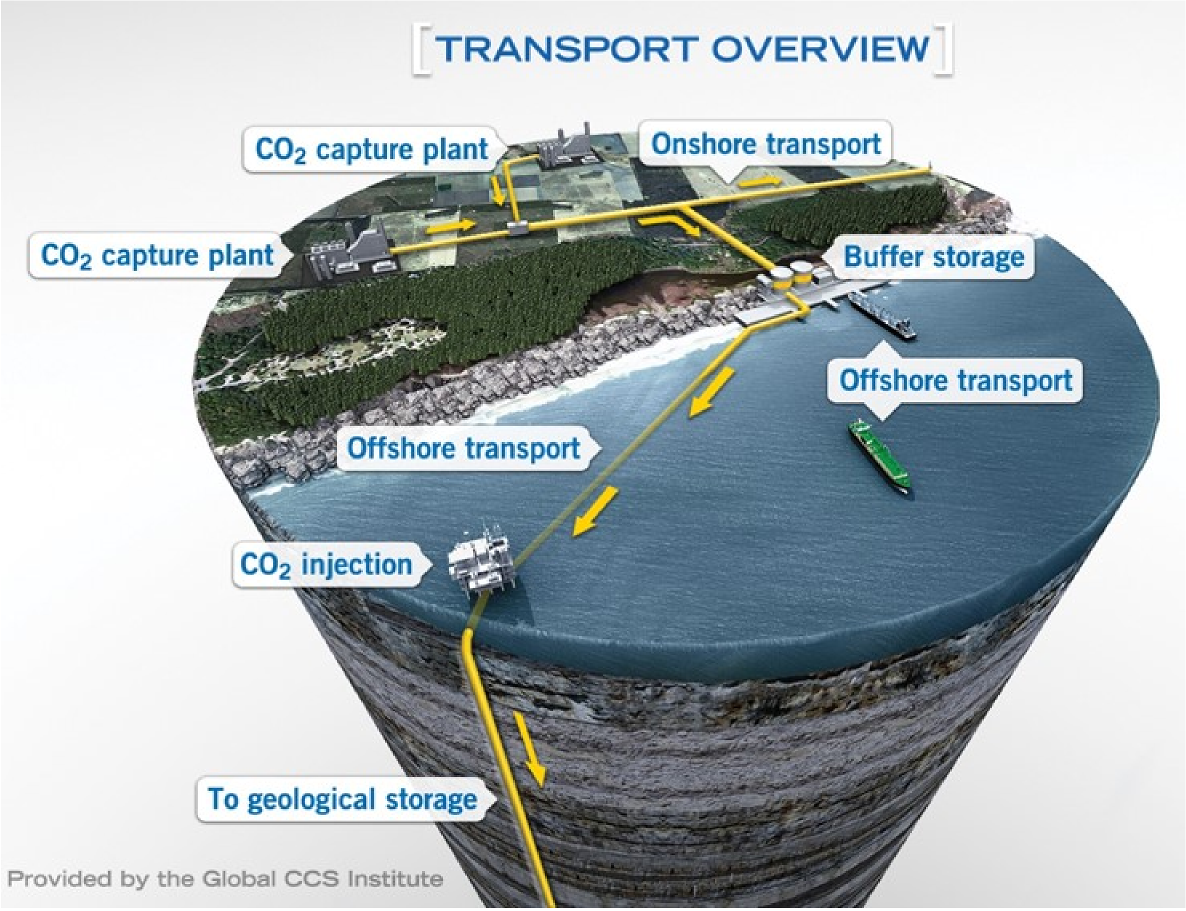


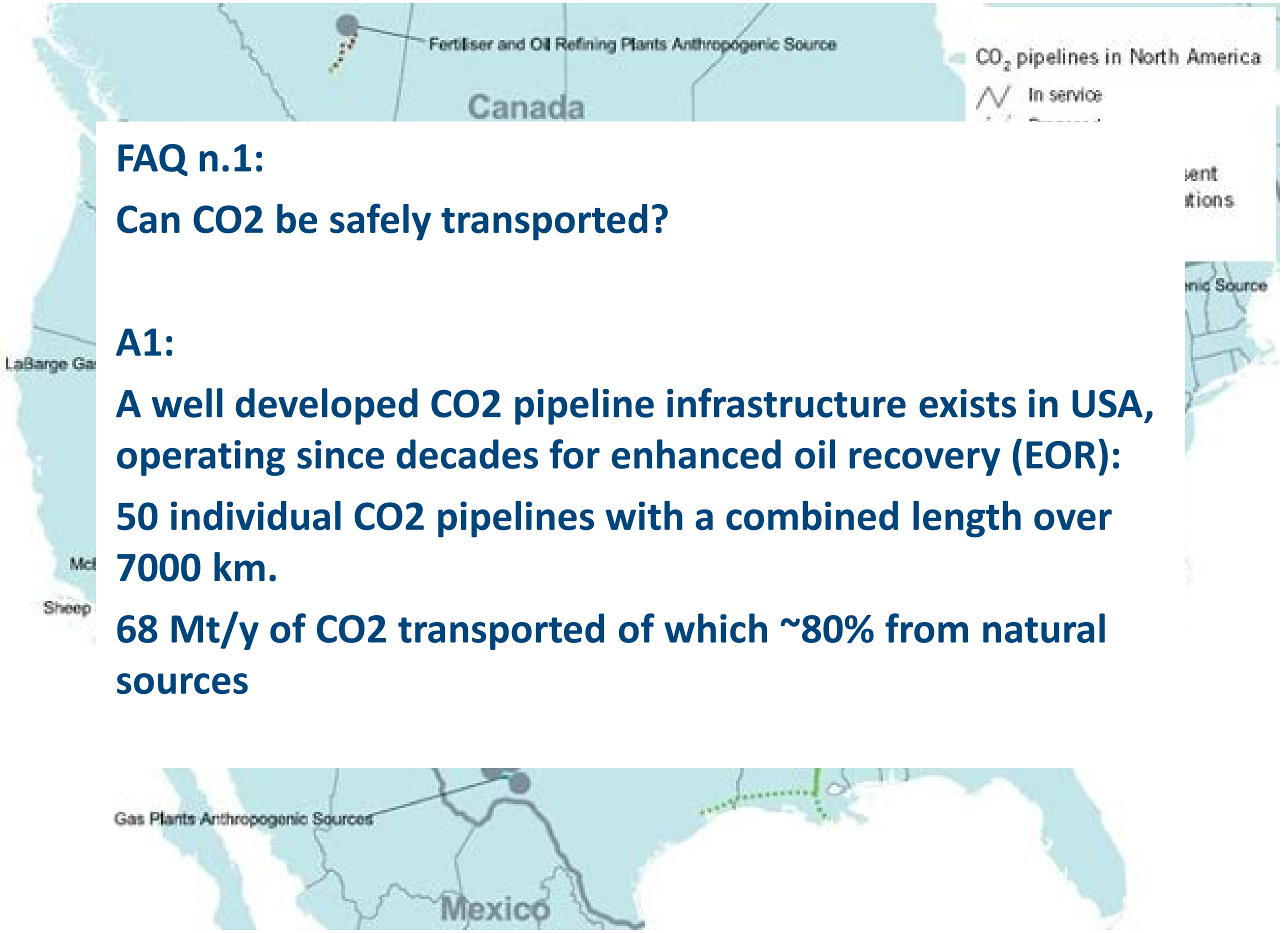
__CCS PROJECTS__



__Global CCS Institute__, The global status of CCS, 2018.

CO_2 Transport





FAQ n.1:

Can CO2 be safely transported?

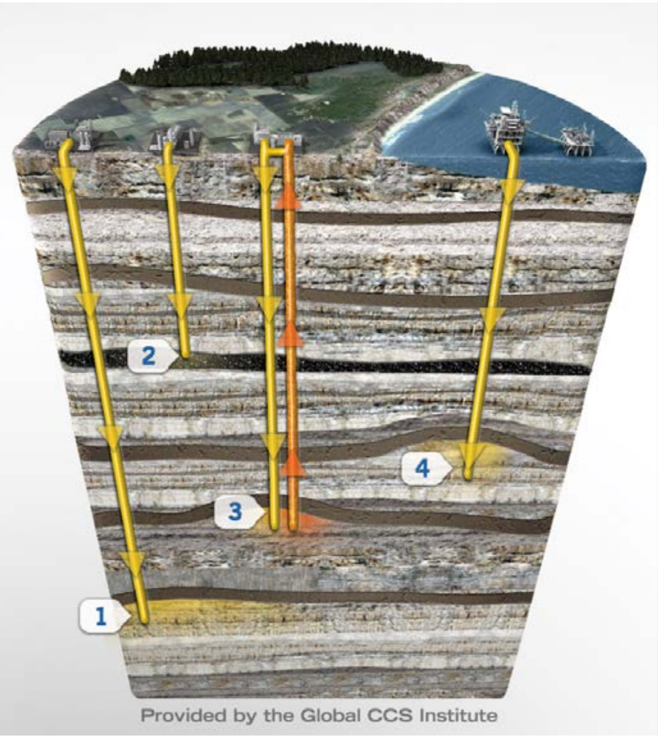
A1:

A well developed CO2 pipeline infrastructure exists in USA, operating since decades for enhanced oil recovery (EOR):

50 individual CO2 pipelines with a combined length over 7000 km.

68 Mt/y of CO2 transported of which ~80% from natural sources

CO_2 Storage (or utilization)



1 – Saline formation
2 – Deep unmineable coal seams
3 - EOR
4 – Depleted oil and gas reservoirs

FAQ n.2:

Will CO_2 remain stored for sufficiently long (i.e. several thousand years)?

Won't CO_2 escape back to the atmosphere?

A1:

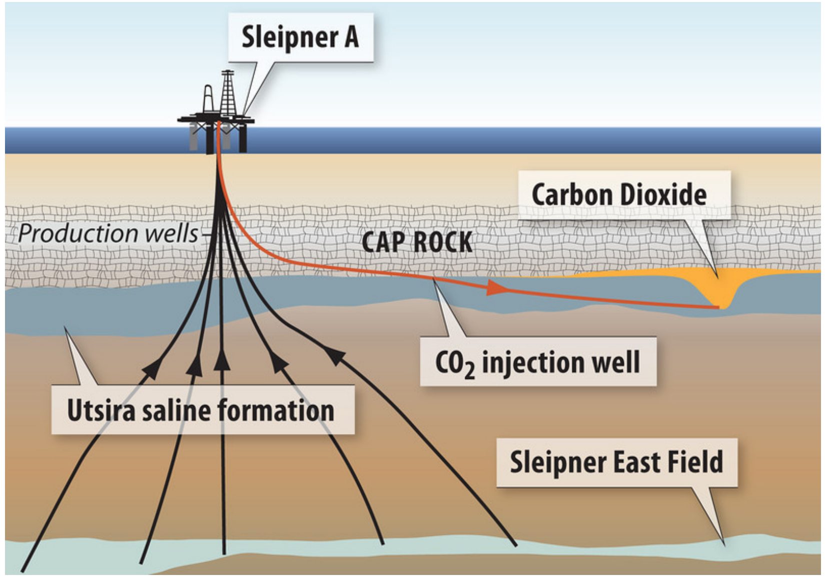
There is a huge number of natural CO_2 fields naturally storing CO_2 and other gases on geologic time scales

FAQ n.3:

Is there enough CO2 storage capacity in the world?

A2:

Yes: 100-200 GtCO2 should be stored in the next 50 years and the worldwide geologic storage capacity is much larger than this.



Sleipner plant:
0.85 Mt/year of CO2 (1996).

22

The strategic role of CC(U)S

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CC(U)S is strategic for two reasons:

1) give us the time we need to convert the activities which can be decarbonized to "low-carbon" or even "zero carbon" operation, e.g. production of electricity
2) reduce to very low levels the CO2 emissions from activities which are hard (or impossible) to decarbonize, e.g. cement and steel production

The rationale of 1) is that the dependence of our economy from fossil fuels is so massive and pervasive that the time needed for its conversion to a "low-carbon mode" cannot match the urgency of Climate Change mitigation

The extent to which 2) is needed will depend on how much and how fast shall we achieve decarbonization where decarbonization is physically / technologically possible.

No matter how much and when we'll succeed in decarbonizing, the sooner the better

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The *hard-to-abate* industry

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Distinctive features of the *hard-to-abate* industry

1) Cement, steel and petrochemical industry are the largest industrial contributors to CO_2 emissions:
2) A significant fraction of these CO_2 emissions are intrinsically associated to the industrial process, rather than to the generation of energy
3) Unlike power production, where fossil fuels and thus CO_2 emissions can be reduced / eliminated by substitution with renewable sources, the emission of CO_2 from process has no alternative (unless the production process is changed)
4) High CO_2 concentration in flue gases
5) The variety of sources and processes tends to require a CO_2 capture process and plant configuration tailored to the specific application
6) The usual classification in post-combustion / pre-combustion / oxy-fuel technology may not apply

Although more "difficult", CO_2 capture in these sectors is more compelling → the *hard-to-abate* industry is a very good candidate for the initial penetration of CC(U)S

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Non-Power: Cement - CLEANKER project

The ultimate objective of CLEANKER is <u>advancing the integrated Calcium-looping process for CO_2 capture in cement plants</u>.

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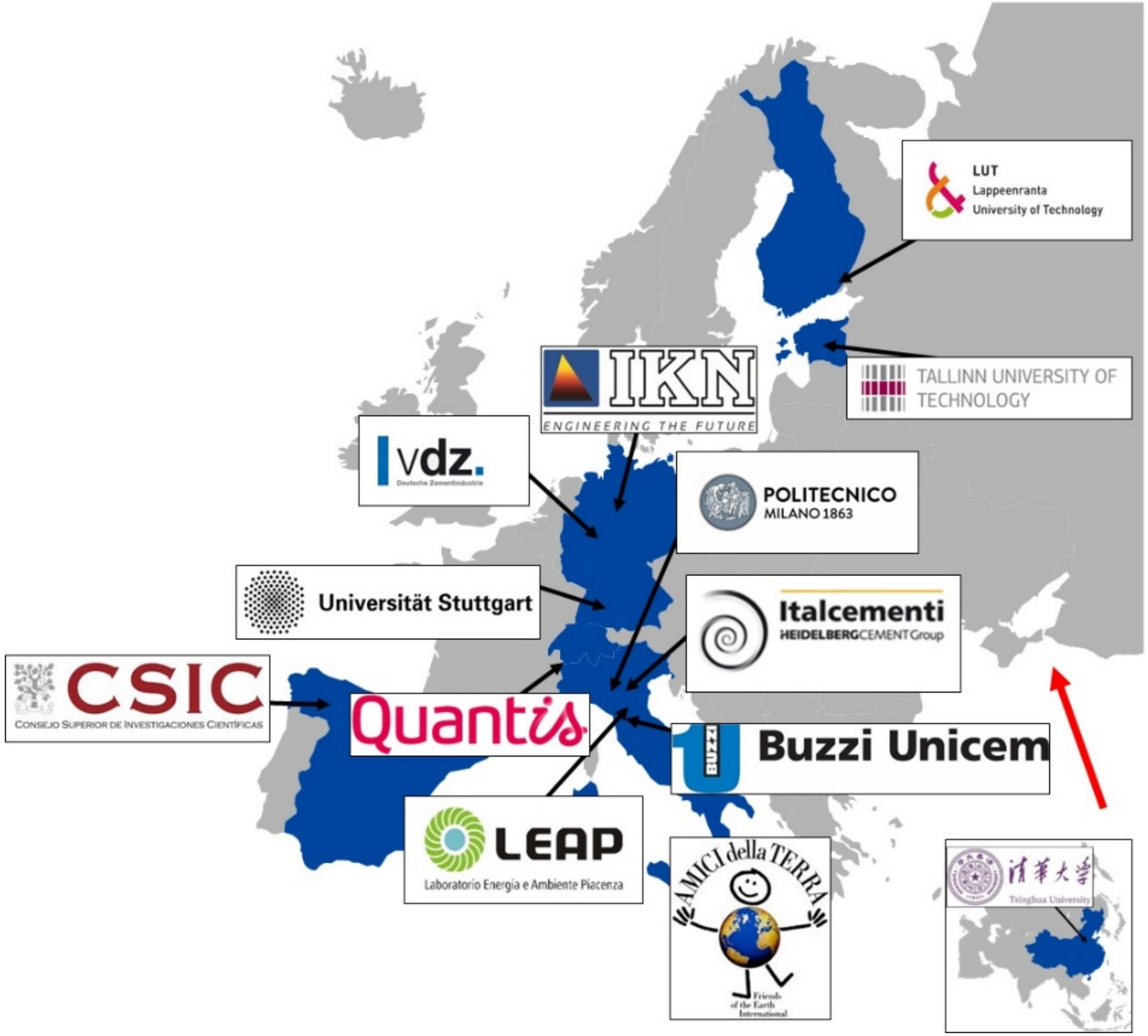
Kick-off meeting - Piacenza, 18-19 October 2017



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