Engineering Institute of Technology.

Watch Webinar Recording Here

Addressing the Challenges of Large-Scale Carbon Capture, Storage and Utilization

28 February 2024 | Technical Topic Webinar

Presented by:

Dr. Harisinh Parmar
EIT Lab Coordinator

About EIT

Engineering Institute of Technology.

We are dedicated to ensuring that you receive a world-class education and gain skills that you can immediately implement in the workforce.

World-Class Australia Accredited Education

Our vocational programs and higher education degrees are registered and accredited by the Australian Government. We have programs that are also recognized under three international engineering accords.

Engineering Specialists

EIT is one of the only institutes in the world specializing in Engineering. We deliver professional certificates, diplomas, advanced diplomas, undergraduate and graduate certificates, bachelor's and master's degrees, and a Doctorate of Engineering.

Industry Experienced Lecturers

Our lecturers are highly experienced engineers and subject specialists with applied knowledge. The technologies employed by EIT, both online and on-campus, enable us to source our lecturers from a large, global pool of expertise.

Industry Oriented Programs

Our programs are designed by industry experts, ensuring you graduate with cutting-edge skills that are valued by employers. Our program content remains current with rapidly changing technology and industry developments.

Unique Delivery Model

We deliver our programs via a unique delivery methodology that makes use of live and interactive webinars, an international pool of expert lecturers, dedicated learning support officers, and state-of-the-art such as hands-on workshops, remote laboratories, and simulation software.

Introduction - Presenter

Dr. Harisinh Parmar

Harisinh is a chemical engineer with a strong background in CFD modeling involving multiphase flow. Currently, he is working as a lab coordinator and academic staff at EIT. Along with teaching bachelor's and postgraduate students, Harisinh has recently been involved with Hydrogen Energy related teaching and modeling work. In his previous role at Curtin University, he modeled and designed a subsea settling tank using ANSYS Fluent and conducted pilot scale experiments to validate settling efficiency.

Survey

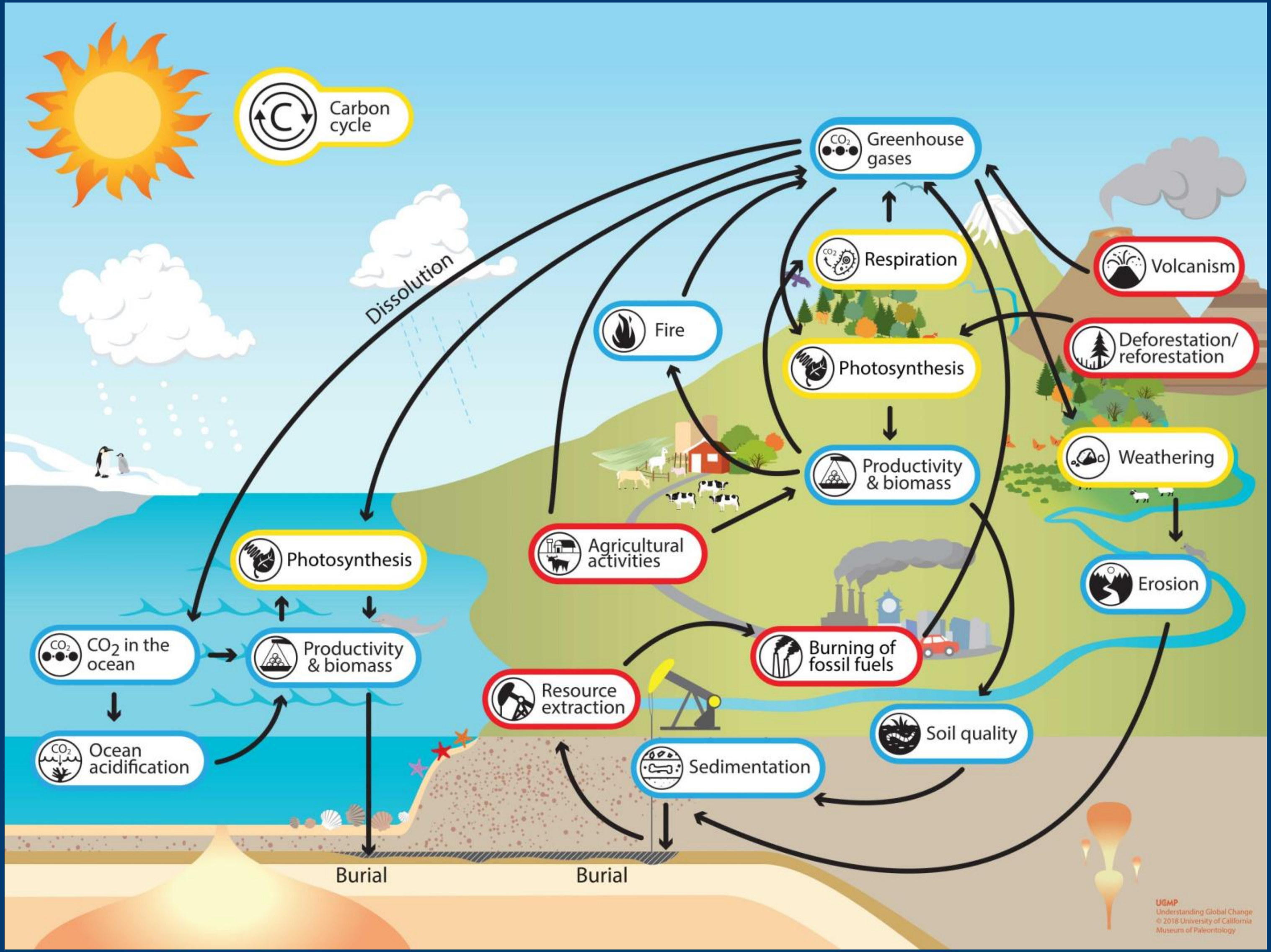
Engineering Institute of Technology.

In your view, what are the three primary global challenges?

Content

- Carbon Cycle
- Carbon Budget
- CCS Plans around the world
- Carbon capture process
- Carbon storage
- Transportation
- Course outline

Carbon Cycle and CO_2



CO_2 :

- Dominant anthropogenic, or human sourced, greenhouse gas (GHG).
- Generated by use of fossil fuels, biomass combustion, agriculture, and diffuse industrial and domestic sources.

How we reduce the Emission:

- Energy efficiency and
- Substitution of fossil fuels by renewable or nuclear energy.

- To achieve net zero emissions, any surplus emissions need to be captured and securely stored.

Carbon cycle - Understanding Global Change (berkeley.edu)

Global Carbon Budget 2022

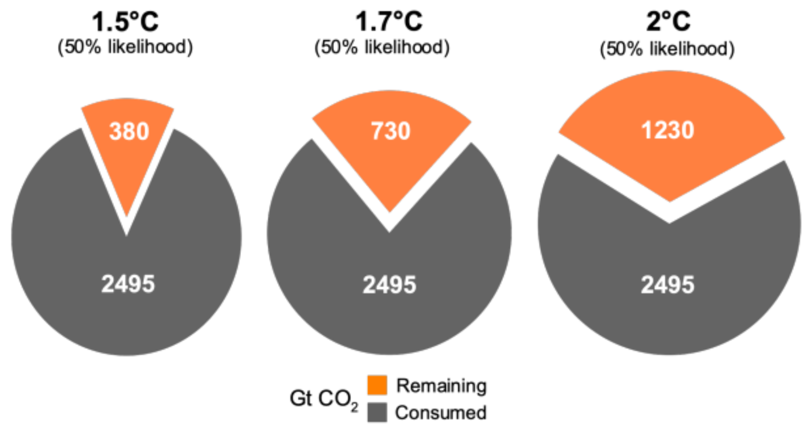
- The carbon budget is the amount of CO_2 that a human can emit while still having a chance to contain global warming within 1.5°centigrade compared with preindustrial levels, as advocated by the Paris Agreement.
- Our planet can count on certain natural **carbon sinks** such as forests and oceans, but even these sinks can no longer keep up with the rate at which greenhouse gases are pouring into the atmosphere.

Global Carbon Budget 2022

The numbers that tell the truth about climate action Global carbon emissions in 2022 remain at record levels

There is a limited cumulative CO_2 emission budget for any given climate target.

If current emissions levels persist, there is now a 50% chance that global warming of 1.5°C will be exceeded in nine years.

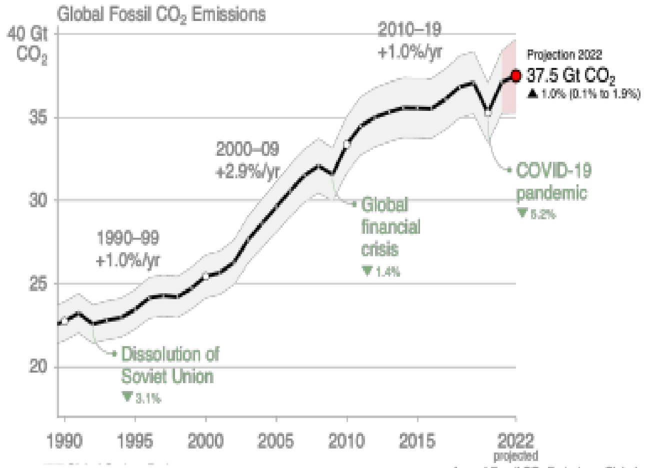


Global fossil CO_2 emissions

2020 emissions: declined 5.4% from 2019 levels to due COVID-19 measures.

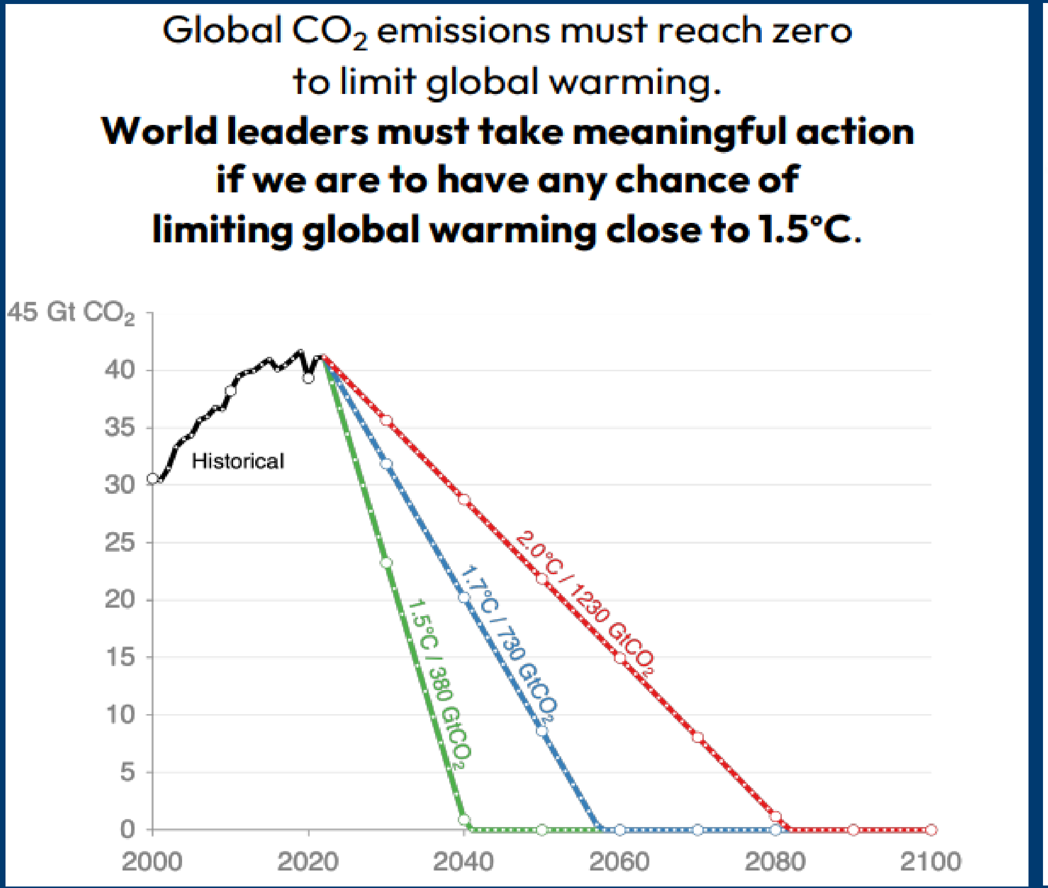
2021 emissions: rebounded 5.1% from 2020 levels.

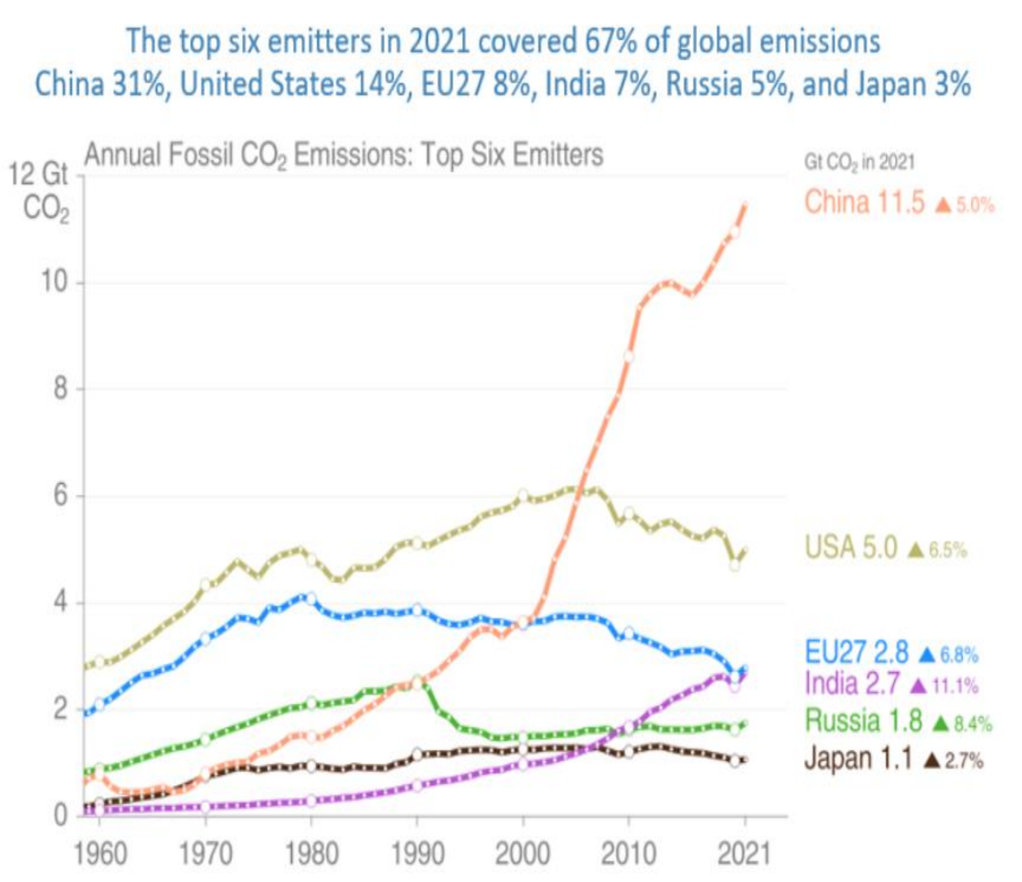
Emissions projected to rise again by 1.0% in 2022 – slightly above the pre-COVID-19 levels.



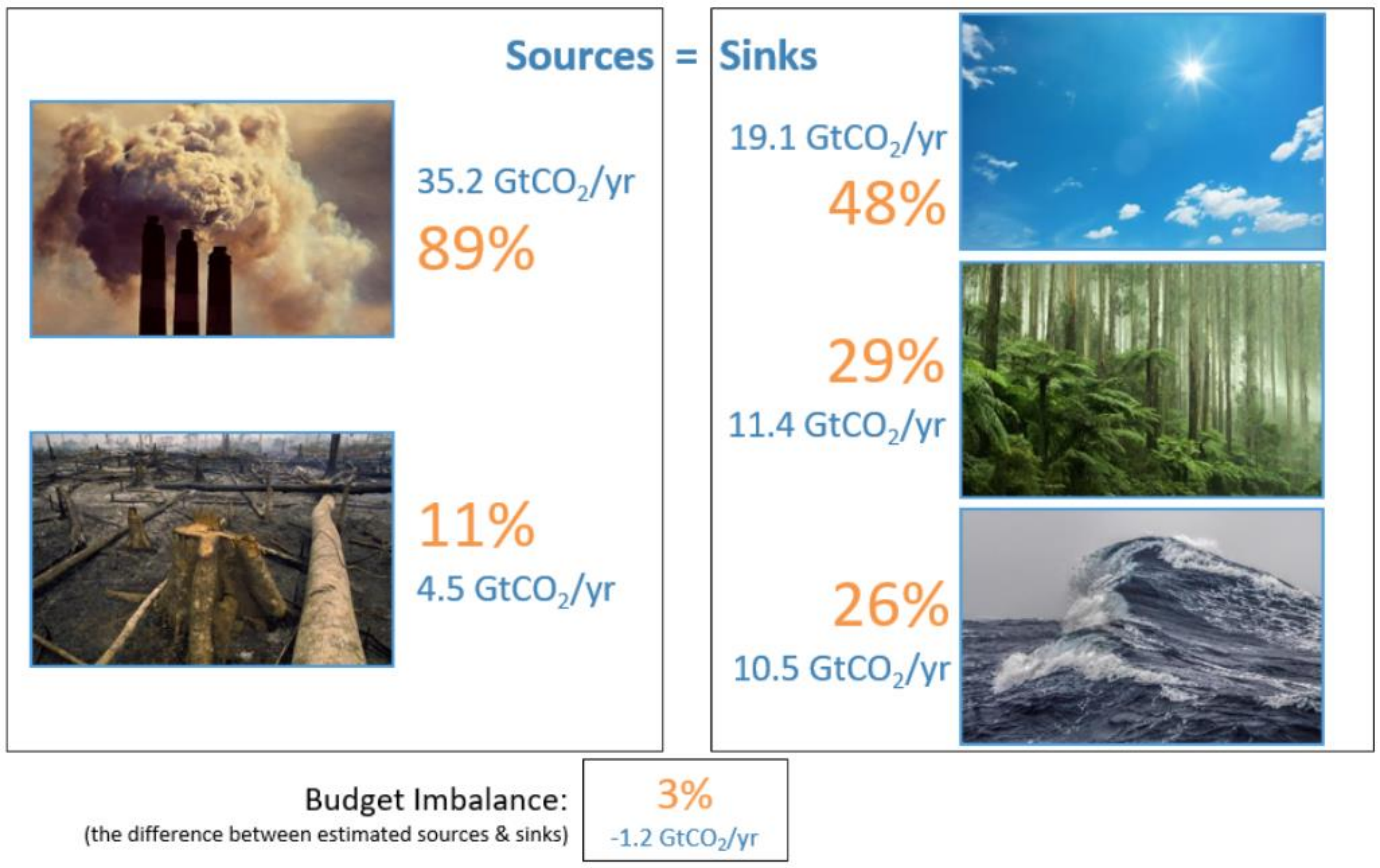
Every un-emitted gigatons CO2 matters. Every avoided tenth of degree of warming matters

Global Carbon Budget 2022



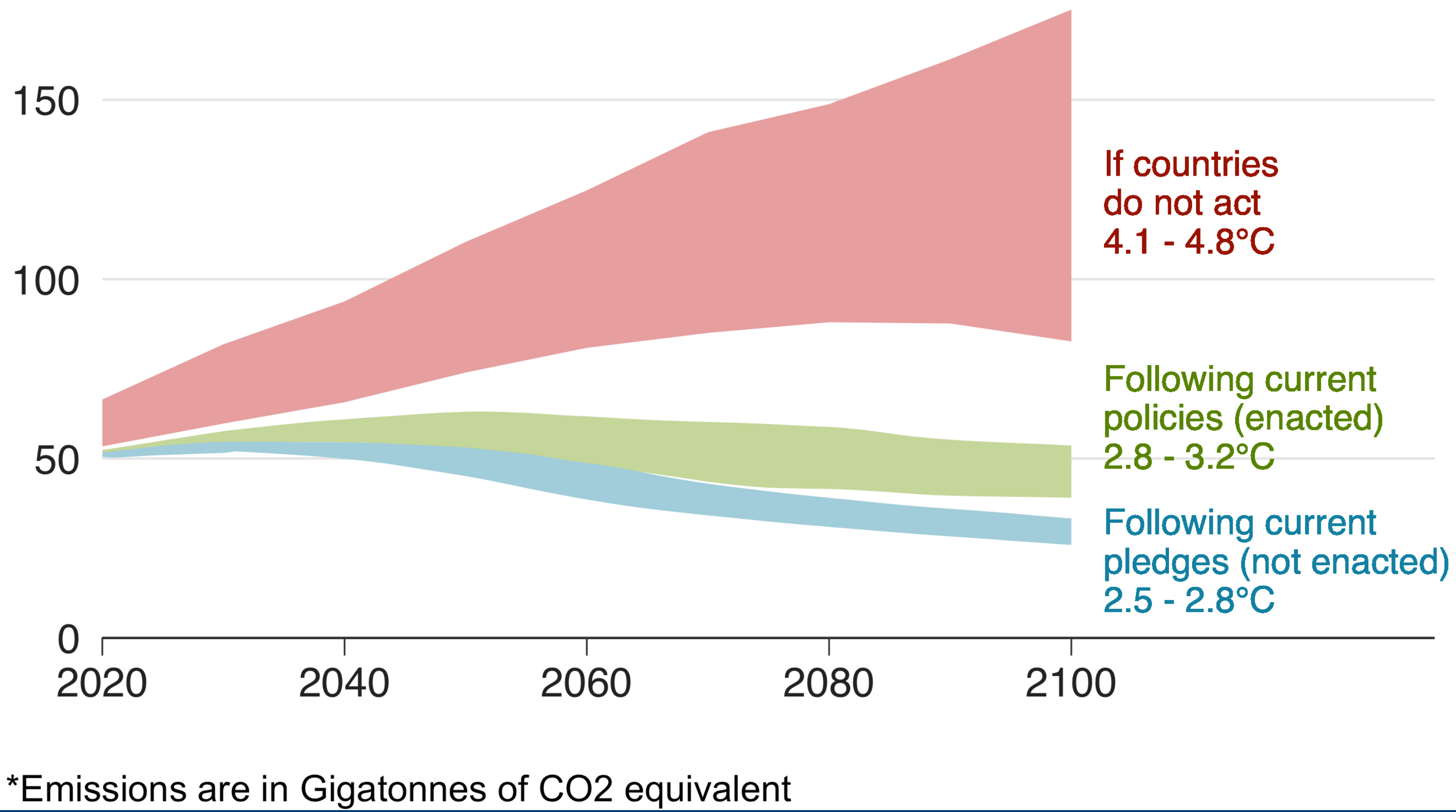


Global Carbon Budget 2022



How much worse will the problem get?

Engineering Institute of Technology.

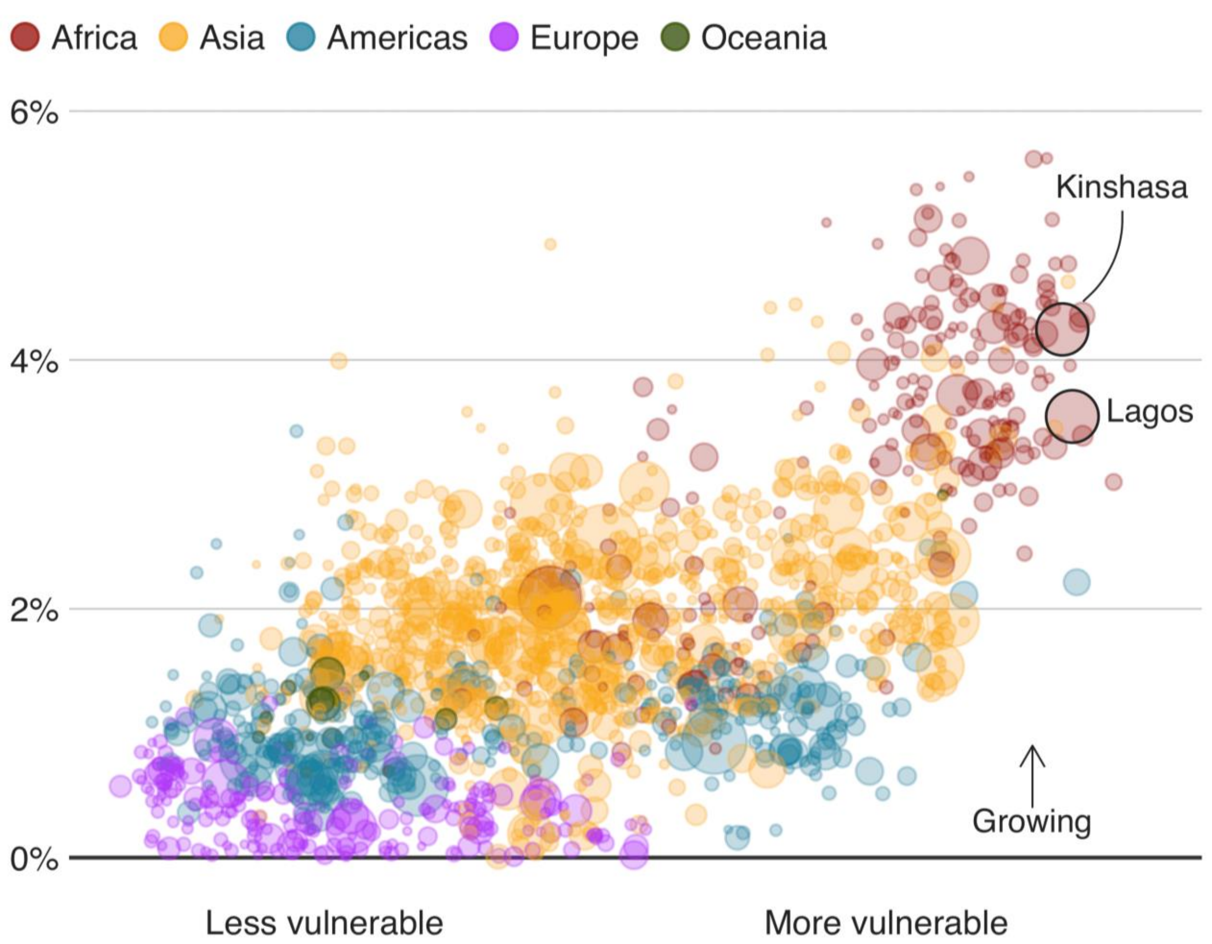


If we add up all the promises to cut emissions made by countries that are party to the Paris climate agreement, the world would still warm by more than 3C by the end of this century

Fast-growing cities-worse climate risks

Engineering Institute of Technology.

Population growth 2018-2035 over climate change vulnerability



- 95% of cities facing extreme climate risks are in Africa or Asia,
- Lagos in Nigeria and Kinshasa in the Democratic Republic of Congo.
- 84 of the world's 100 fastest-growing cities face "extreme" risks from rising temperatures and extreme weather brought on by climate change.

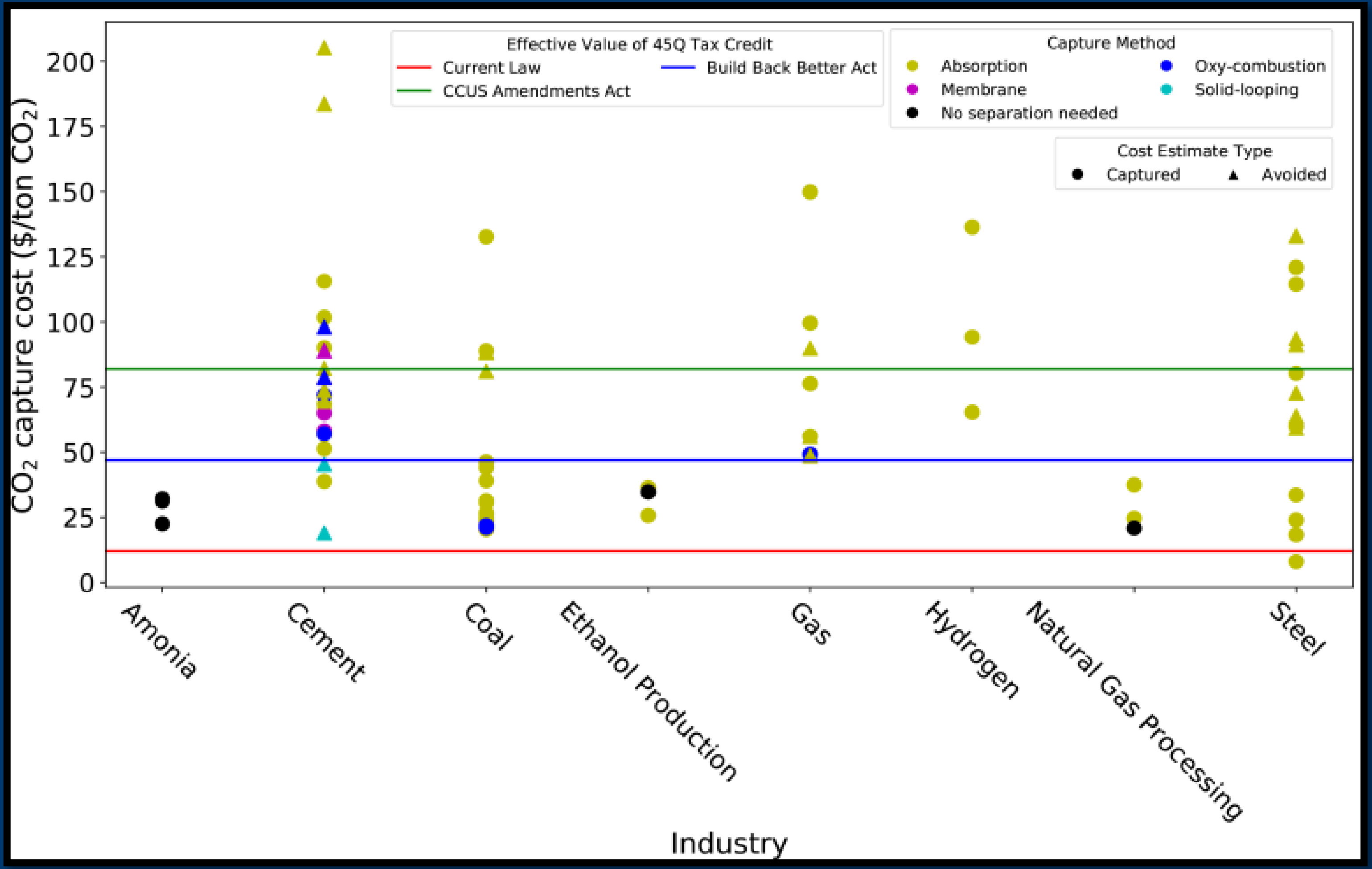
Survey

Engineering Institute of Technology.

What steps do we take as a matter of priority to reduce the carbon intensity?

Carbon Capture and its cost

Estimates of carbon capture costs by industry and category of capture technology, presented in 2021 U.S. dollars.



Carbon Capture: Key Challenges

Engineering Institute of Technology.

Technical Issues

- Capture Technology
  - Existing Plants
  - New Plants
- Cost of CCS
- Sufficient Storage Capacity
- Best practices
  - Storage site characterization
  - Monitoring / Verification
  - Site Closure

Legal/Social Issues

- Regulatory Framework
  - Permitting
  - Treatment of CO_2
- Policy incentives
- Infrastructure
- Human capital
- Legal Framework
  - Liability
  - Ownership
    - Pore Space\
    - CO_2
- Public Acceptance

Carbon Capture: Pros Vs Cons

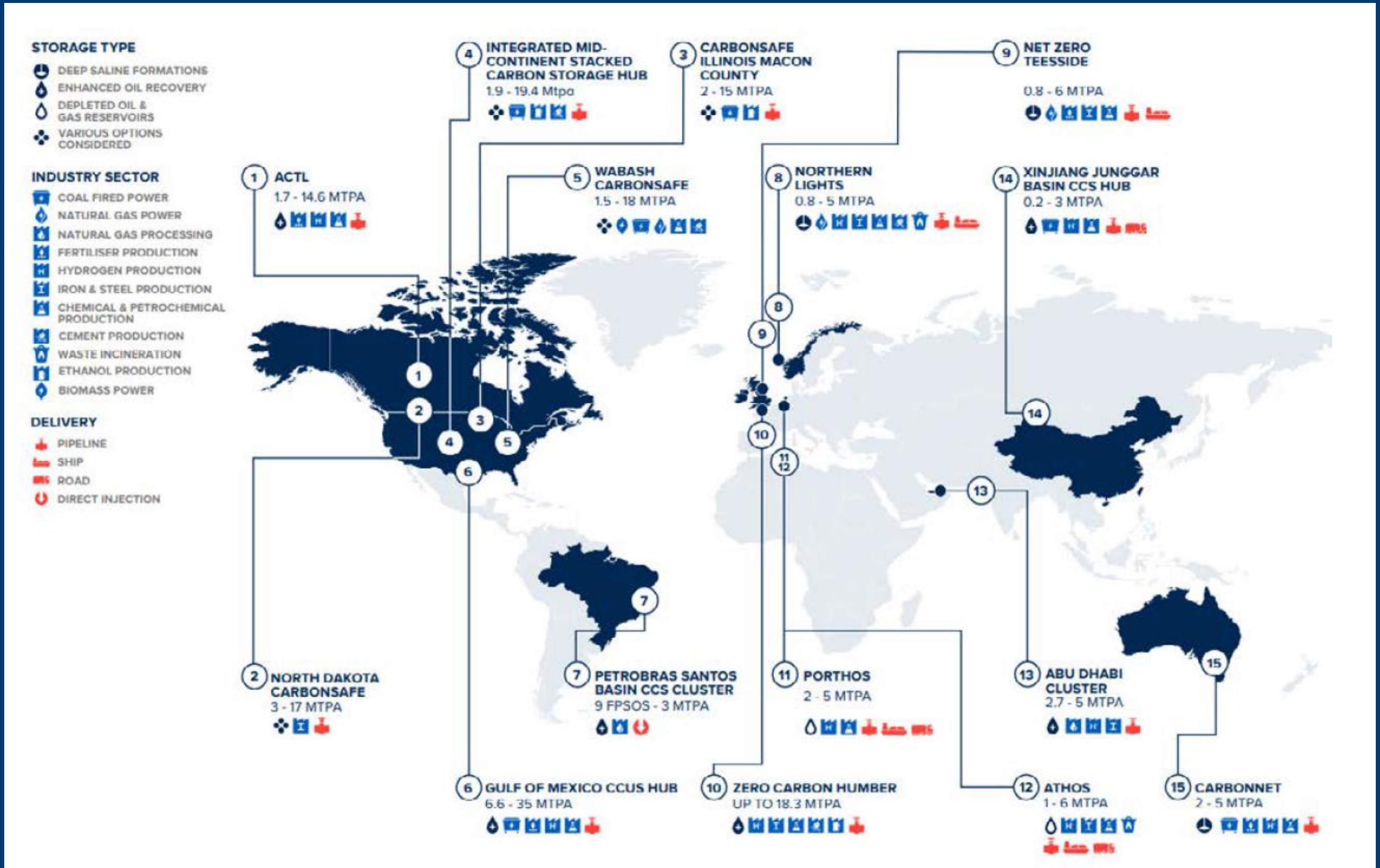
PROS

- It can reduce emissions at source
  - Capable to remove 20% of total CO_2 emissions from industrial and energy production facilities
  - Capable of removing 90% of CO_2 from power plants
- Faster removing CO_2 than planting trees
  - A typical tree: capture around 21 kilograms (kg) of CO2 per year - after 20 years
  - Over the first 20 years of a tree's life, it only actually absorbs 39kg of carbon dioxide
  - Carbon capture, on the other hand, can reduce large amounts of CO2 emissions at the source

CONS

- Expensive
  - It currently costs an average of $600 (£440) per tons of CO2 absorbed, which isn't ideal, given humans emit 36 billion tons of CO2 a year. Treatment of CO_2
  - Expert are working to make more affordable
- Energy Intensive
  - more amount of thermal energy required
  - Compress CO_2 for storage
- Increase emission
- Significant risk involved
  - it can be harmful to human health.
  - Water bodies damage risk

CCS Plants operating/development



Global capture and storage capacity is now around 40MtCO_2/yr.

CCS Plants operating/development

- Natural gas processing uses well-established CO_2 separation technologies. Operations in Shute Creek (7MtCO_2/yr) and Century Plant (5MtCO_2/yr) in the USA as well as Gorgon (4MtCO_2/yr) in Australia

- Coal-fired power with CCS using amine solvent for post-combustion capture of CO_2 used for EOR has performed safely and effectively at two power stations. The Boundary Dam plant in Saskatchewan (Canada) since 2014 and Petra Nova in Texas, since 2017.

- Gas-fired power with CCS has not yet been undertaken at scale, although small-scale CO_2 capture without permanent storage has been used commercially at a natural gas combined cycle plant in the USA 'clean gas' project at Teesside, North-East England, is now proposed, while two similar gas-power-CCS projects are being planned in the Humber region.

- Blue' hydrogen production in the QUEST project in Alberta, Canada, uses amine solvent to capture 1MtCO_2/yr with 99.5% purity. The Port Arthur refinery in Texas, uses pressure swing adsorption to separate CO_2, leaving 99% pure hydrogen

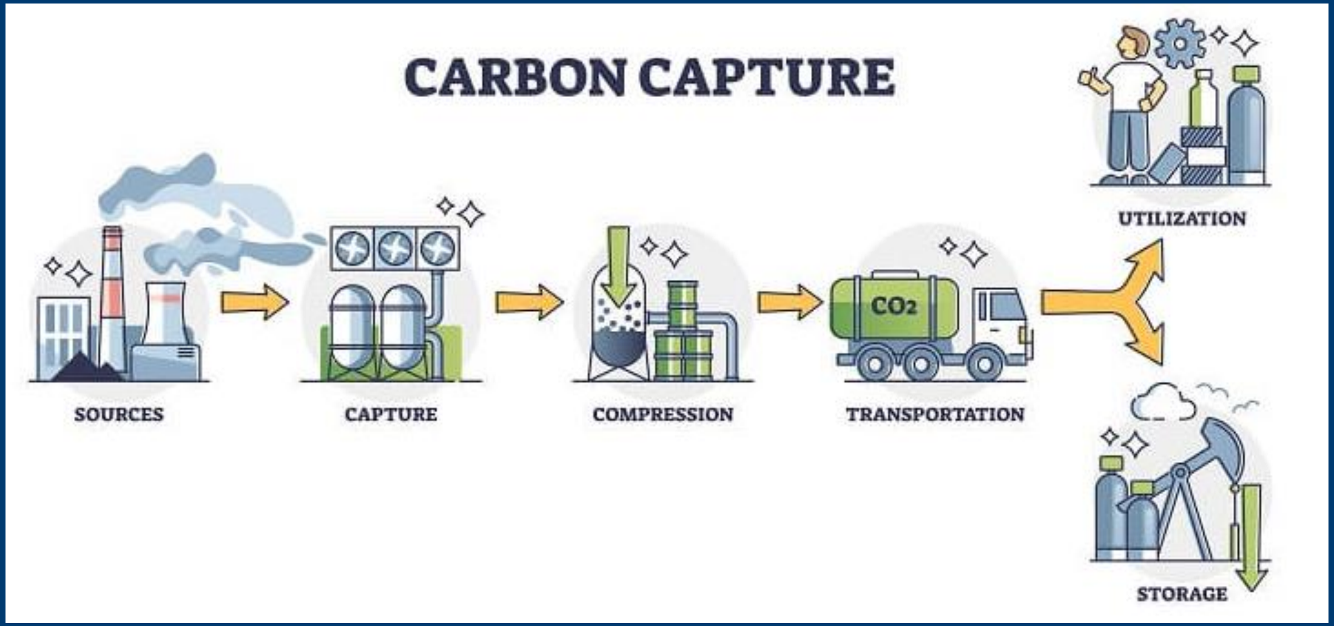
CCS Plants operating/development

- Cement production decarbonization, which accounts for 8% of the world's CO_2 emissions, the EU Low Emissions Intensity Lime and Cement industry-research collaboration (LEILAC) has run a demonstration plant at Lixhe, Belgium, and is designing a scaled-up plant at Hannover, Germany.

- Norway's Longship CCS programmed includes capture of CO_2 from the Brevik cement plant and a waste-to-energy facility in the Oslofjord region, shipping it in liquid form to an onshore terminal on the coast, from where it will be piped to storage under the North Sea by the Northern Lights project

- Emirates Steel Industries in Abu Dhabi, has developed the first iron and steel plant with CCS, using methane reformed to a hydrogen / carbon monoxide syngas for direct reduction of iron ore

Carbon Capture Process



- Carbon Capture and Storage (CCS) is a way of reducing carbon emissions, that helps to tackle with global warming.
- CCS involves the capture of carbon dioxide (CO_2) emissions from industrial processes (steel and cement production) or burning of fossil fuels in power generation.
- This carbon is then transported from where it was produced, through shipping or in a pipeline and can be stored deep underground in geological formations.

Carbon Capture Process

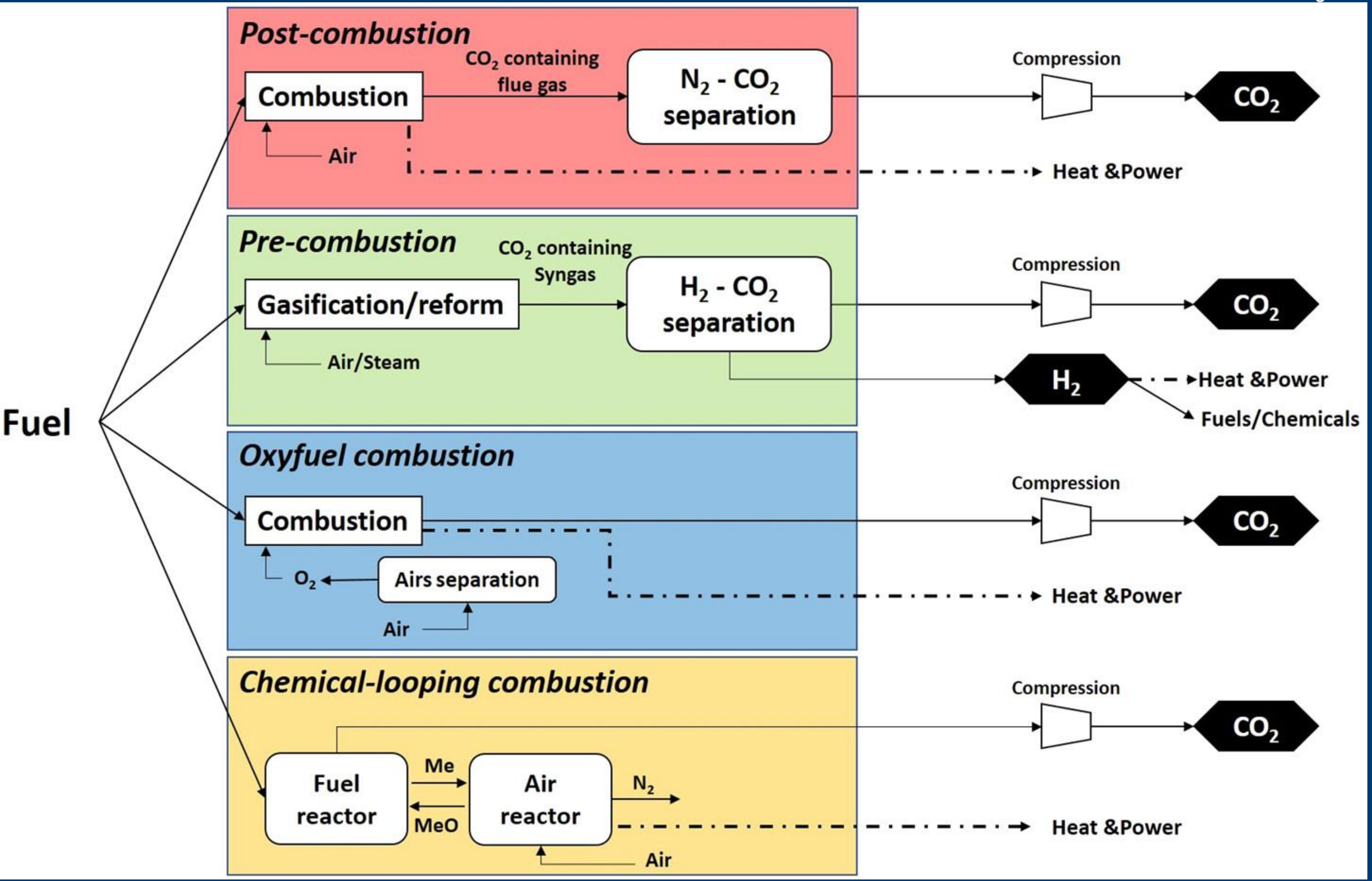
1. **Capturing carbon dioxide** – CO_2 is separated from other gases that are produced in industrial processes. There are three basic types of CO_2 capture: pre-combustion, post-combustion, and oxyfuel post-combustion:

   - **Pre-combustion** – Converts fuel into a gaseous mixture of hydrogen and CO_2. The hydrogen is separated and can be burnt without producing any CO_2, and the CO_2 can be compressed and stored
   - **Post-combustion –** Separates CO_2 from combustion-exhaust gases. The CO_2 is captured using a liquid solvent or other separation methods. Once absorbed by the solvent, CO_2 is then released and forms a "high-purity CO_2 stream"
   - **Oxyfuel combustion** – Uses oxygen rather than air for the combustion of fuel. This produces exhaust gas that is mainly water vapor and CO_2, which can be easily separated to produce high-purity CO_2

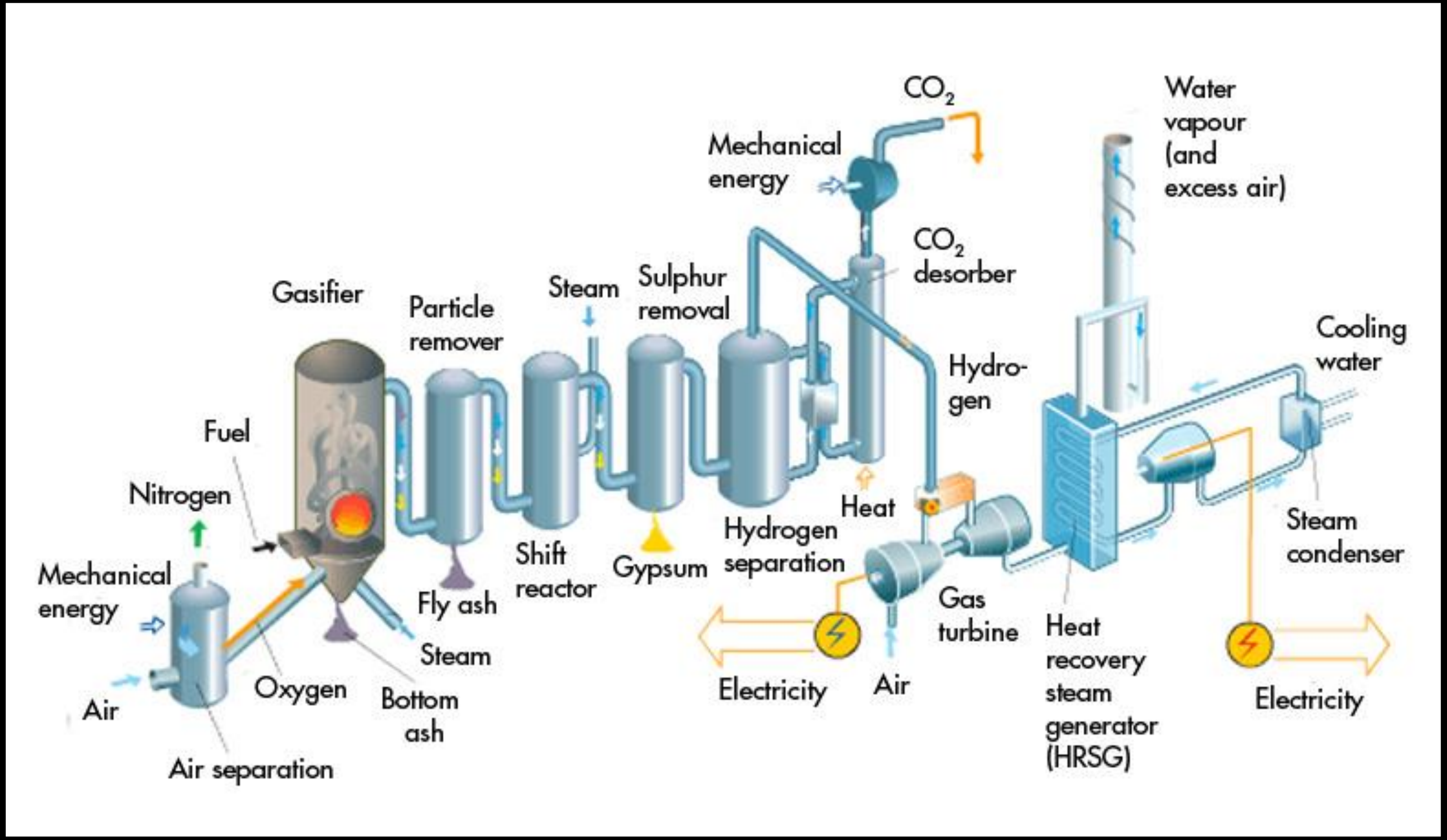
2. **Transport** – The CO_2 is then compressed and transported by road transport, ships, or through underground pipelines to a storage site

3. **Storage** – Once it reaches the storage site, the CO_2 is injected into rock formations underground, which typically run 1km deep. These storage sites are usually located at saline aquifers (geological formations) or depleted oil and gas reservoirs.

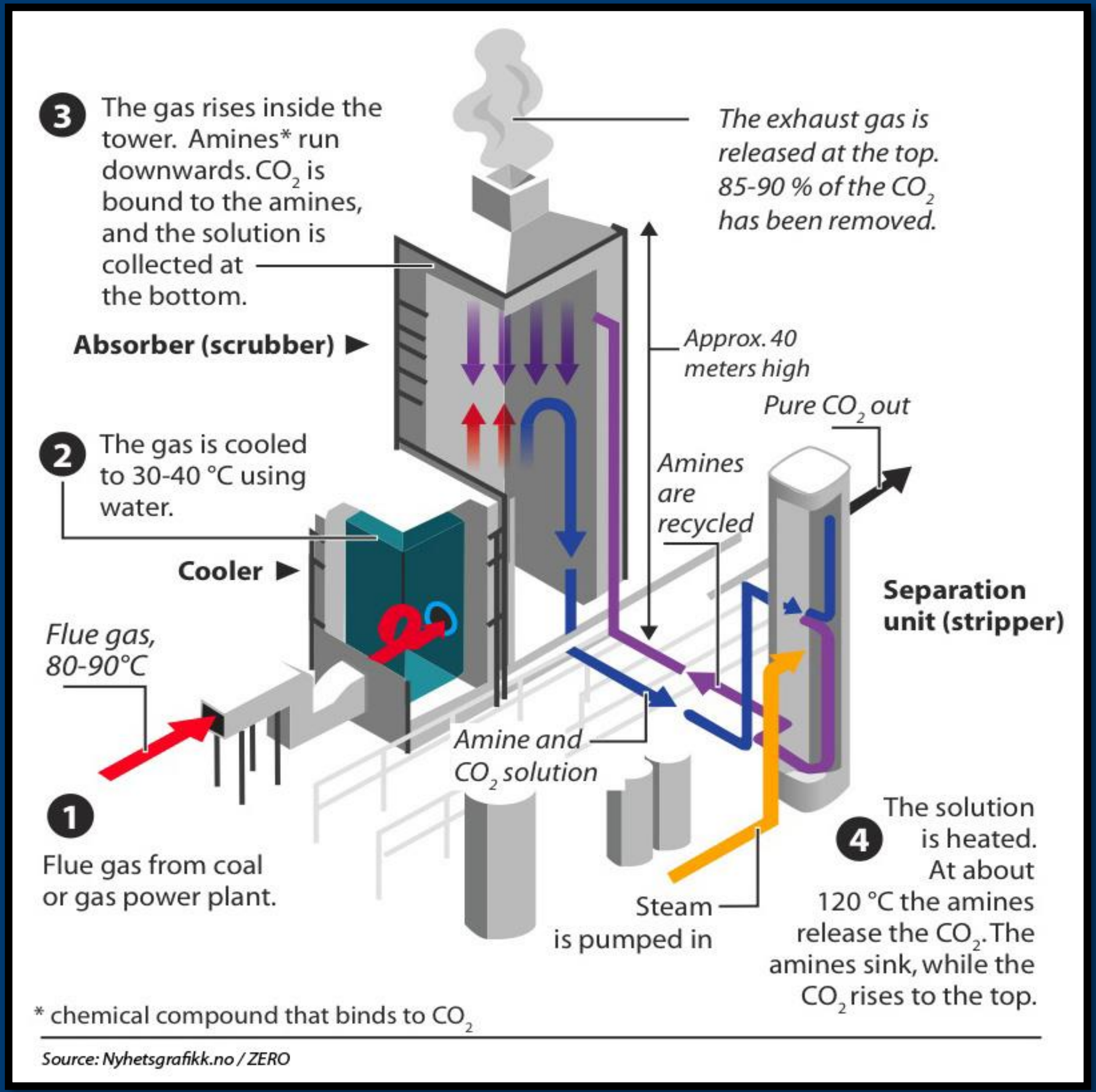
Carbon capture Process



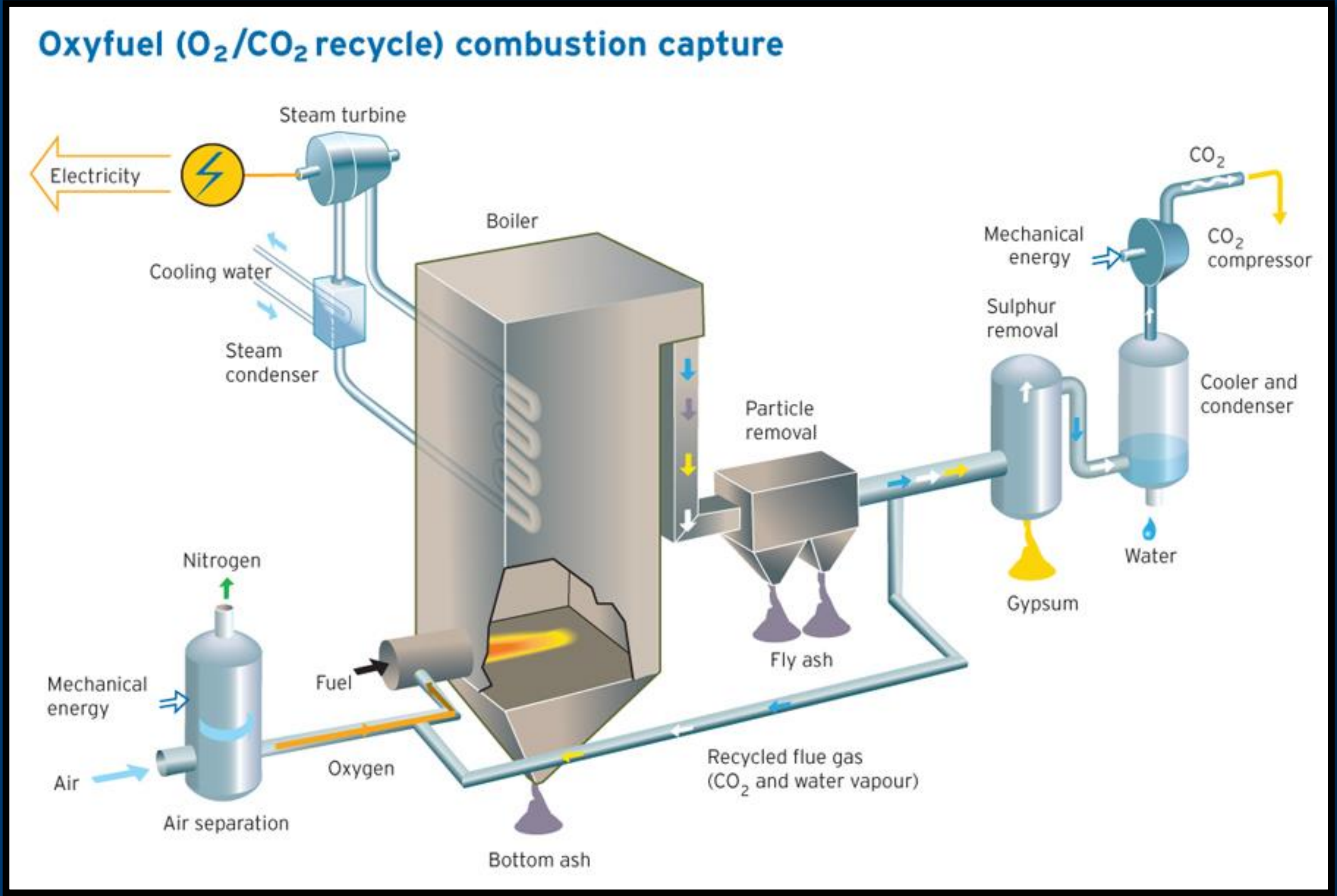
Pre combustion capture



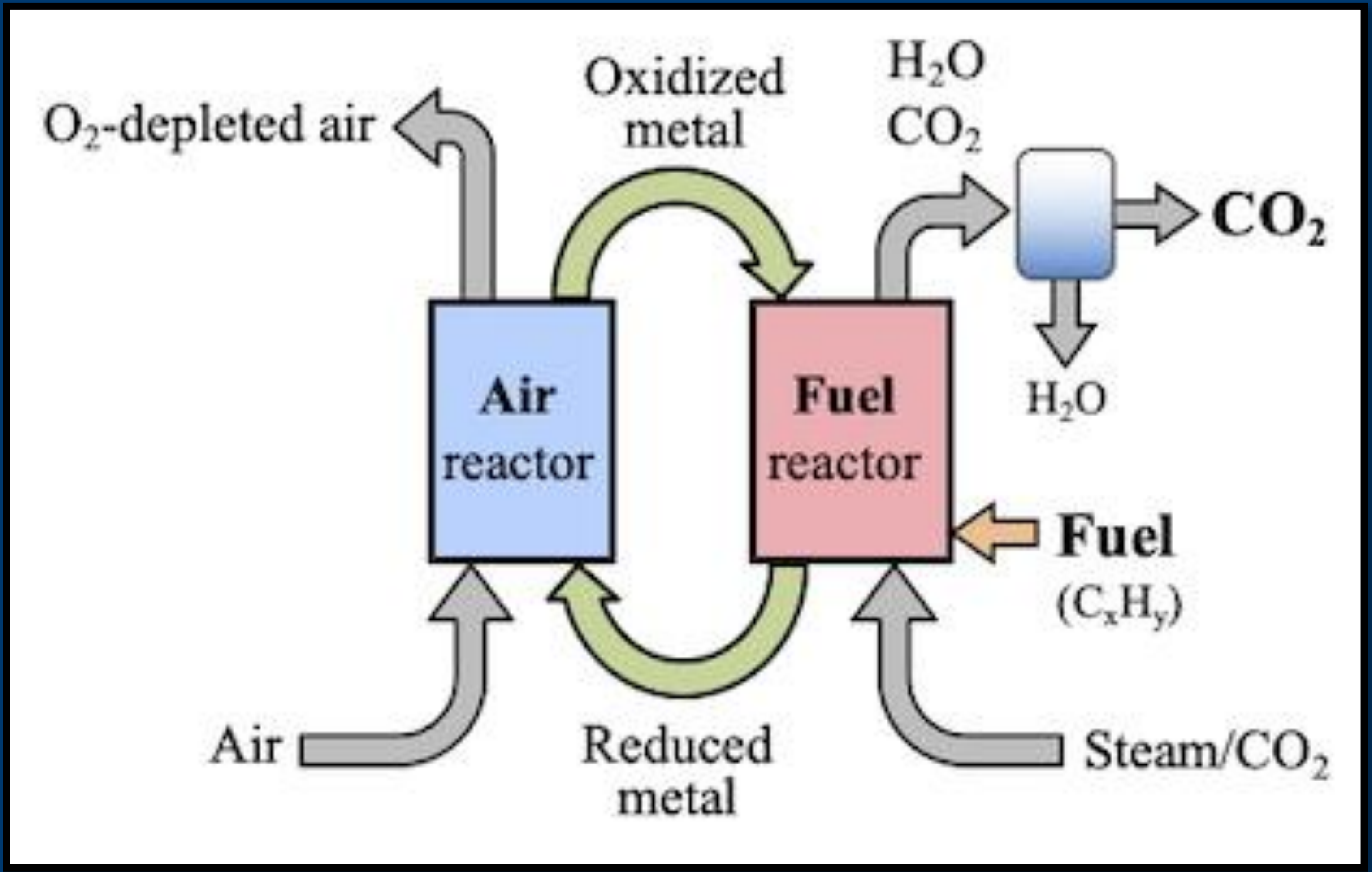
Post combustion capture



Oxy-fuel combustion capture



Chemical looping capture



Novel capture Technologies

- Molten carbonate fuel cells (MCFC) use hydrogen from a fuel source such as natural gas along with CO_2 from flue gas to produce electricity, heat, and water. The captured CO_2 exits the fuel cell at a high concentration and can easily be separated.

- Advanced cycles for combustion: Techniques such as calcium and chemical looping – where an oxygen carrying substance is circulated through two reactors – work to improve the basic efficiency of the CO_2 capture process through better integration with the power supply process.

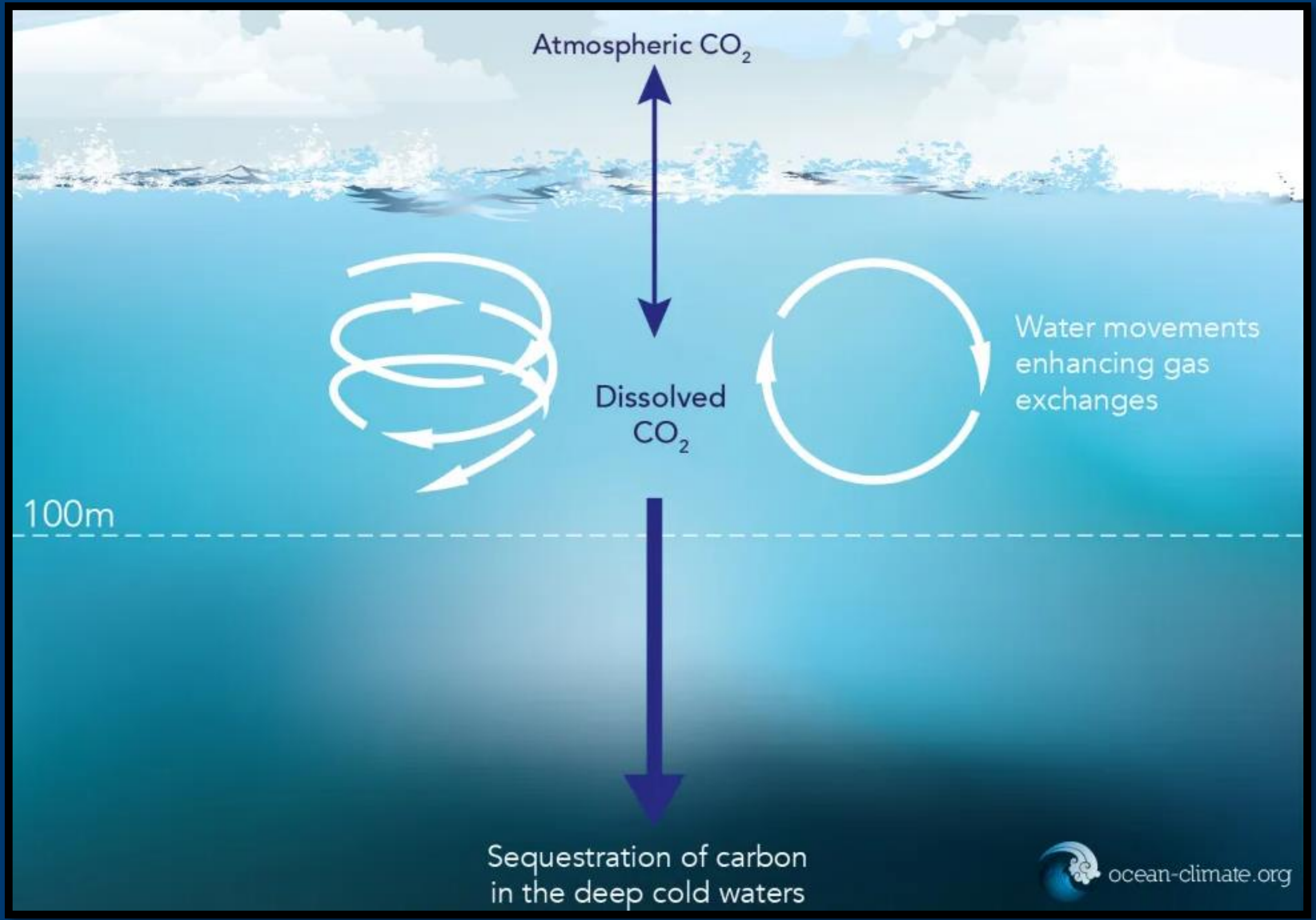
- Novel supercritical CO_2 (sCO_2) techniques use CO_2 at or above its critical temperature and pressure, offering potential benefits such as higher efficiency, lower capital costs and higher CO_2 capture rates. One emerging sCO_2 process attracting significant interest is the Allam-Fetvedt Cycle which creates a new type of power station. Rather than fitting a CCS unit onto a current combined cycle gas turbine (CCGT) plant, the turbine burns gas in a single operation with oxygen, with pure CO_2 becoming the working internal fluid, before capture or recycling. An Allam-Fetvedt Cycle demonstrator in Texas has reported a net efficiency of 59%, similar to a conventional gas-fired plant38

Storage operations

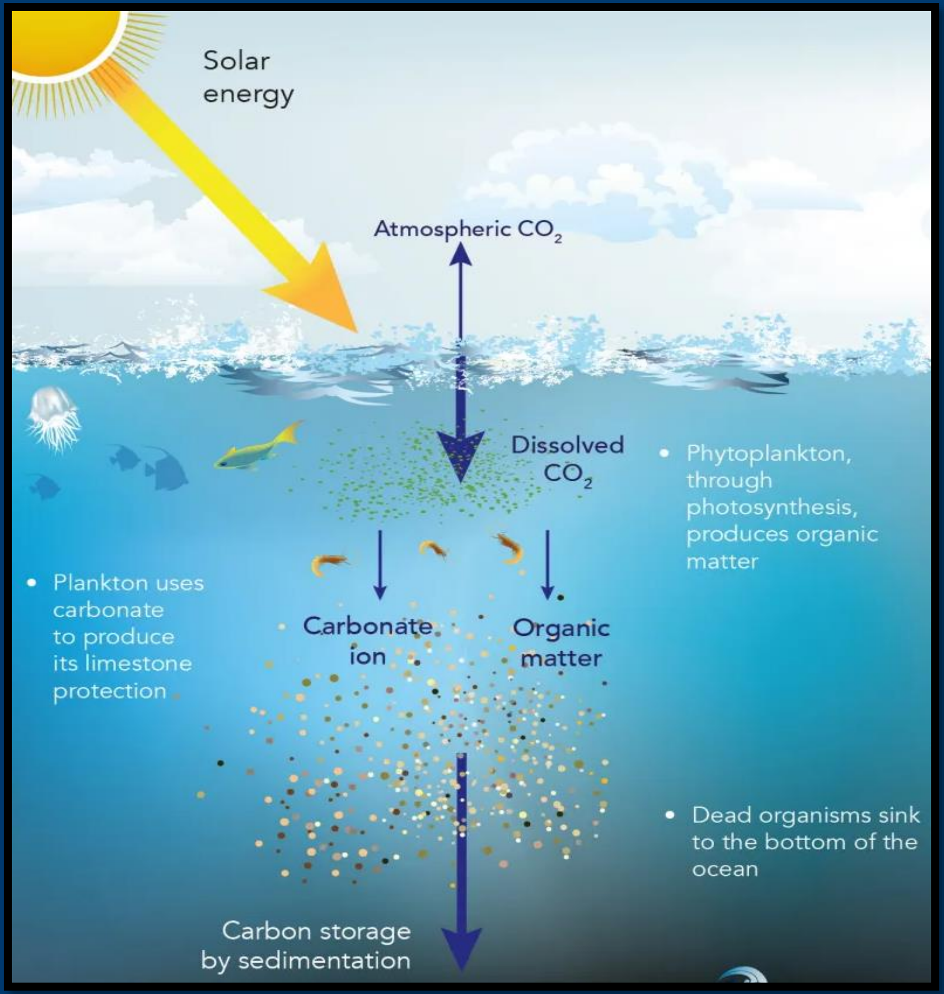
- While much captured CO_2 is currently stored by means of enhanced oil recovery (EOR), geological storage has also been carried out and monitored to meet high performance standards for climate purposes.

- For example, 1.7MtCO_2/ yr is stored in saline aquifers at the North Sea Sleipner and Snøhvit operations and 1MtCO_2/yr in an onshore aquifer from the Quest project. More than 12,000Gt of potential CO_2 storage resources have been identified worldwide and 400Gt have been evaluated as investable.

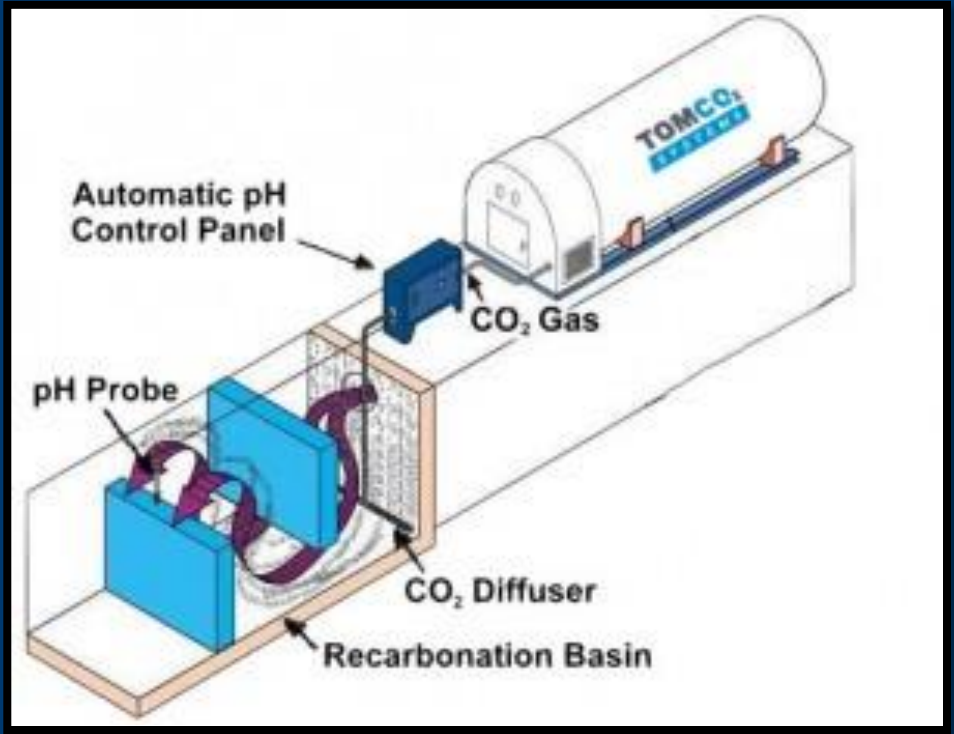
The Ocean- Carbon Sink



The Ocean- Biological Pump



Direct CO_2 injection



Sequestration: Agriculture, Wetlands

Carbon sequestration in forests

- Depending on their characteristics and local circumstances, forests plays different roles in the **carbon cycle**, from net emitters to net sinks of carbon.

- Forests sequester carbon by capturing carbon dioxide from the atmosphere and transforming it into biomass through **photosynthesis.** Sequestered carbon is then accumulated in the form of biomass, deadwood, litter and in forest soils.

- Release of carbon from forest ecosystems results from **natural processes** like respiration and oxidation as well as deliberate or unintended results of human activities.

- The contribution of forests to carbon cycles has to be evaluated taking also into account the use of **harvested wood**.

Compression & transportation of CO_2

- Carbon dioxide (CO_2) captured from coal flue gas or synthesis gas must be **compressed.**
- **Compression of CO_2** is **challenging** because it represents a potentially large auxiliary power load on the overall power plant system.
- In August 2007 study conducted for **NETL,** CO_2 compression was accomplished using a six-stage centrifugal compressor with inter-stage cooling that required an auxiliary load of approximately 7.5% of the gross power output of a subcritical pressure, coal-fired power plant.
- CO_2 can be transported via trucks or ships, but the most common and efficient method is by **pipeline**.
- In a **supercritical state**, CO_2 has the density of a liquid but the viscosity (thickness) of a gas and is, therefore, easier to transport through pipelines.
- To enable the **safe use of CO_2 pipelines**, CCS projects must ensure captured CO_2 complies with strict purity and temperature specifications, as well as making sure CO_2 is dry and free from impurities that could impact pipelines' operations.

Transportation via pipeline and marine

Carbon Capture, Utilisation & Storage

Engineering Institute of Technology.

Program Structure	
1. Introduction	7. Membrane Technology in CCS
2. CCS over the Entire Economy	8. Geological Carbon Storage
3. Capturing Carbon for Power Industry	9. Ocean Storage
4. Carbon capture from industrial operations	10. Terrestrial ecosystem storage
5. Absorption capture systems	11. Carbon Dioxide Transportation
6. Adsorption capture systems	12. Economic & Social Perspective

Thank You!

Upcoming Courses

Engineering Institute of Technology.

We have a range of courses in Renewable Energy Engineering.

Courses	Start Date
Professional Certificate of Competency in Smart Grids	12 March 2024
52910WA Graduate Certificate in Hydrogen Engineering and Management	7 May 2024
52859WA Graduate Certificate in Renewable Energy Technologies	4 June 2024
52894WA Advanced Diploma of Applied Electrical Engineering (Renewable Energy)	2 July 2024
Professional Certificate of Competency in Hydrogen Energy – Production, Delivery, Storage, and Use	9 July 2024
Professional Certificate of Competency in Battery Energy Storage and Applications	10 September 2024
Professional Certificate of Competency in Renewable Energy Systems	10 September 2024

Find MORE courses here: www.eit.edu.au/study-areas/renewable-energy/

Upcoming Webinars

Engineering Institute of Technology.

All upcoming Events & Webinars:

www.eit.edu.au/news-events/events/

Insights Into EIT's Advanced Diplomas and Other Vocational Programs
29 Feb 2024

Internet of Things (IoT) for Engineering
06 Mar 2024

Sustainable Materials and Practices in Civil Engineering
06 Mar 2024

Power Quality Challenges with High Penetration of Renewable Systems
13 Mar 2024

Hydrogen Technology Engineering and Management Towards the Net-Zero Emission
14 Mar 2024

Certificate of Attendance

EIT
Engineering Institute of Technology.

To receive your digital certificate of attendance for participating in this webinar, please fill out the form and survey here (or scan the QR Code):

https://qrco.de/beptXn

Kindly note that this form will close on Monday the 4th of March, 5:00am UTC and no further requests for certificates will be accepted after the form has closed

SCAN ME

Q&A

Engineering Institute of Technology.

Website
www.eit.edu.au

Head Office
1031 Wellington Street West Perth
Perth, WA 6005

Phone
Inside Australia: 1300 138 522
Outside Australia: +61 8 9321 1702

Email
webinars@eit.edu.au

Courses
https://www.eit.edu.au/schedule/