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Scalable Carbon Removal Solution for the Cement Industry using Algae

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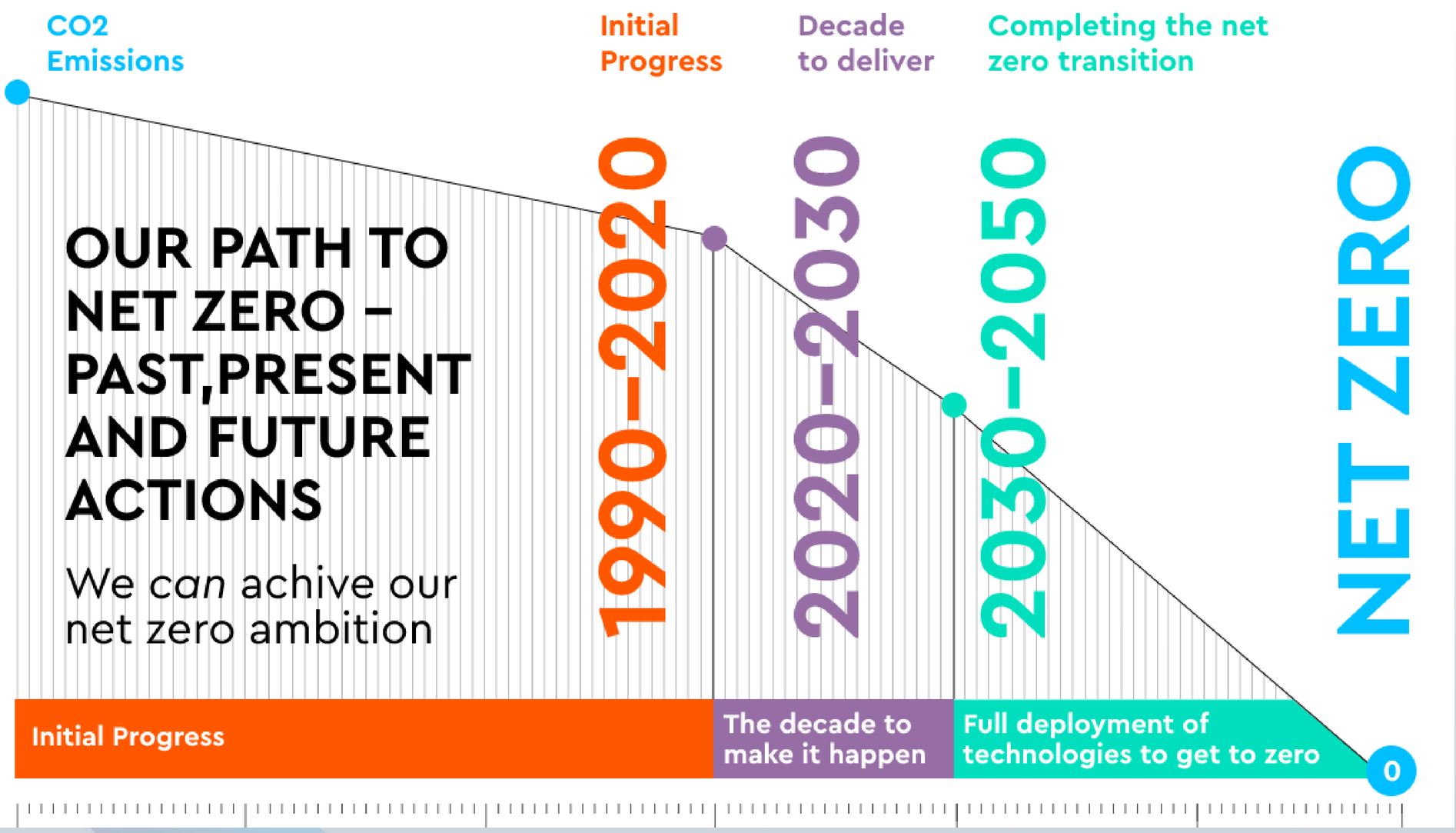

2050 Net Zero Roadmap

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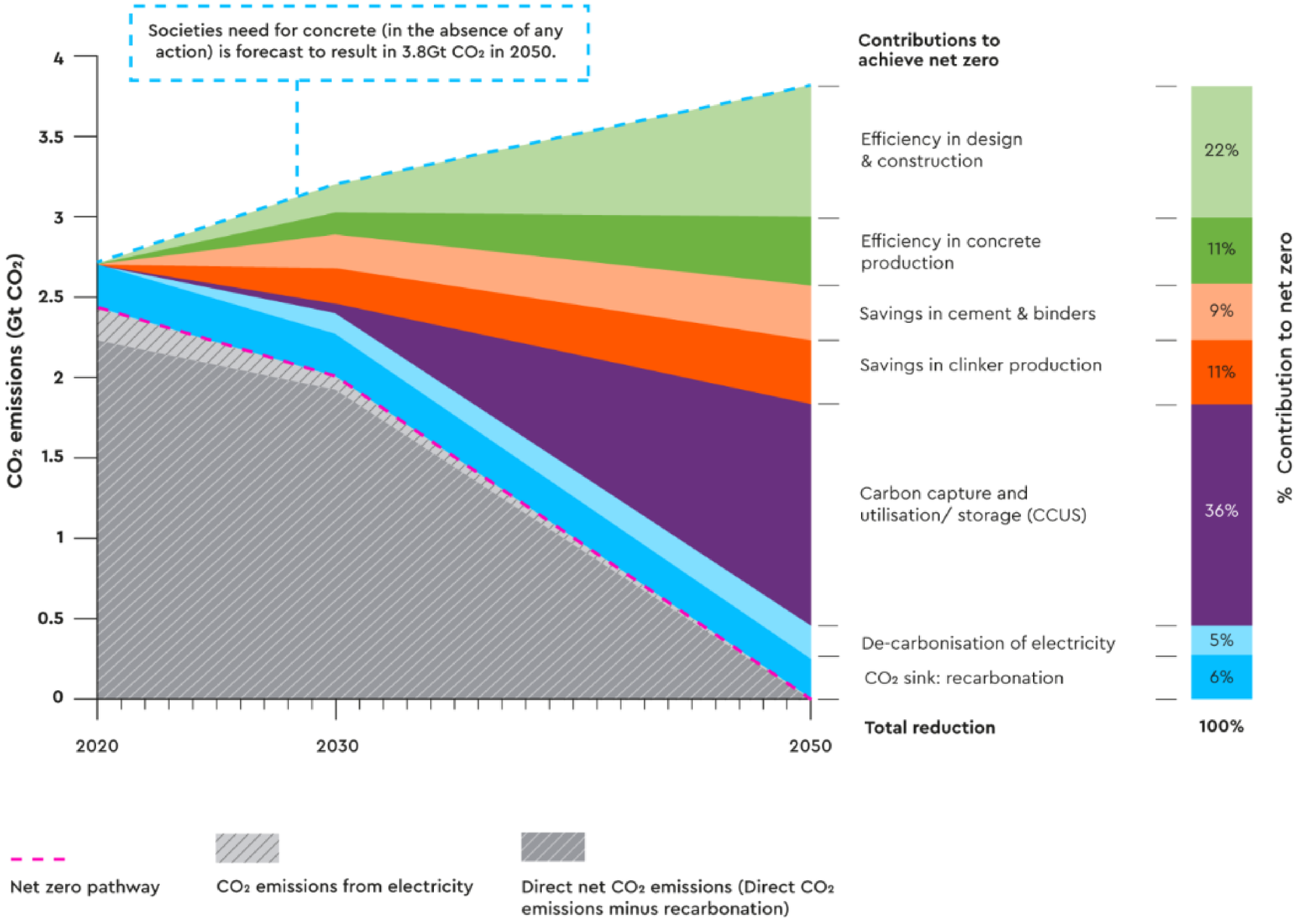

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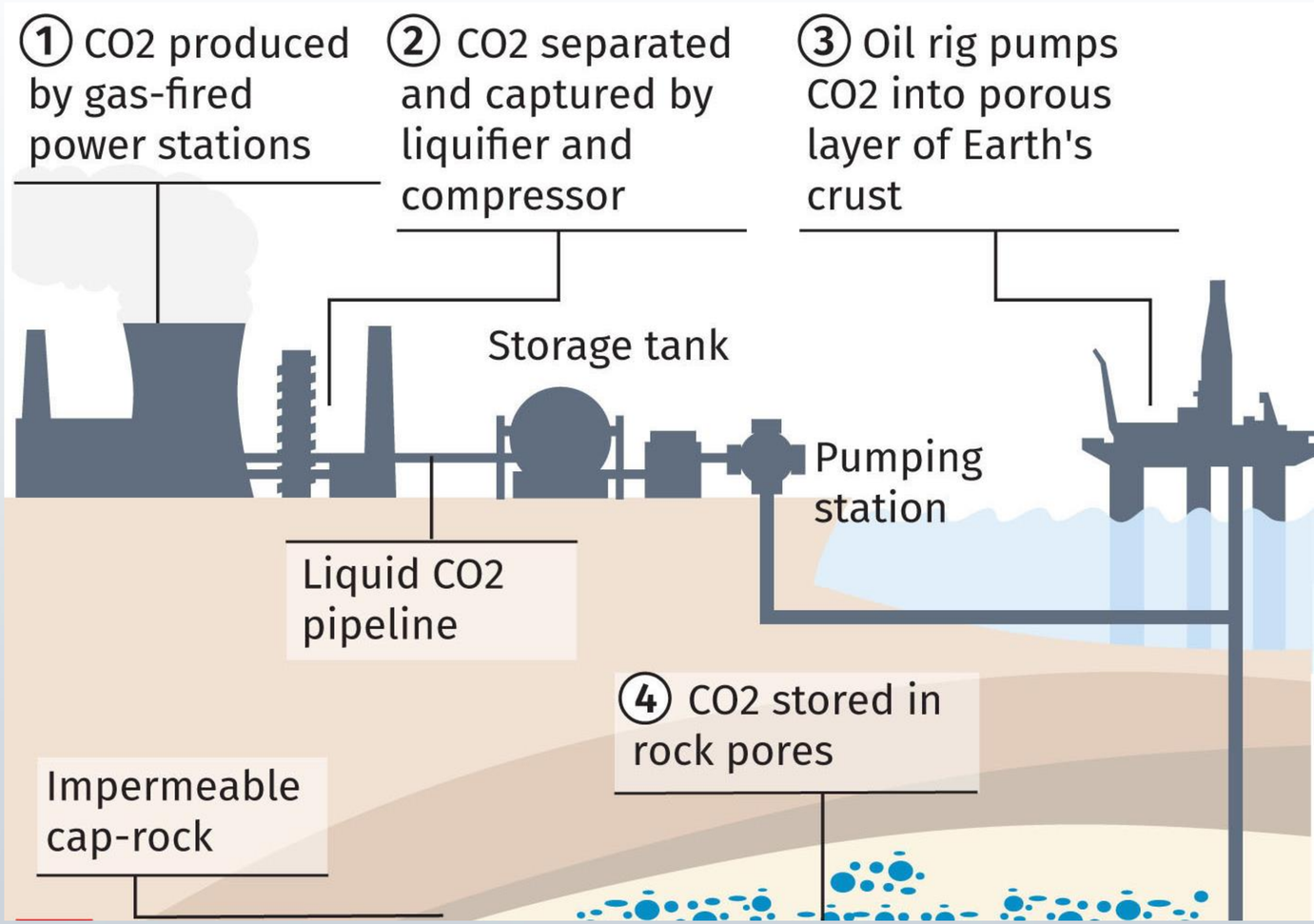
Carbon Capture, Utilization and Storage (CCUS)



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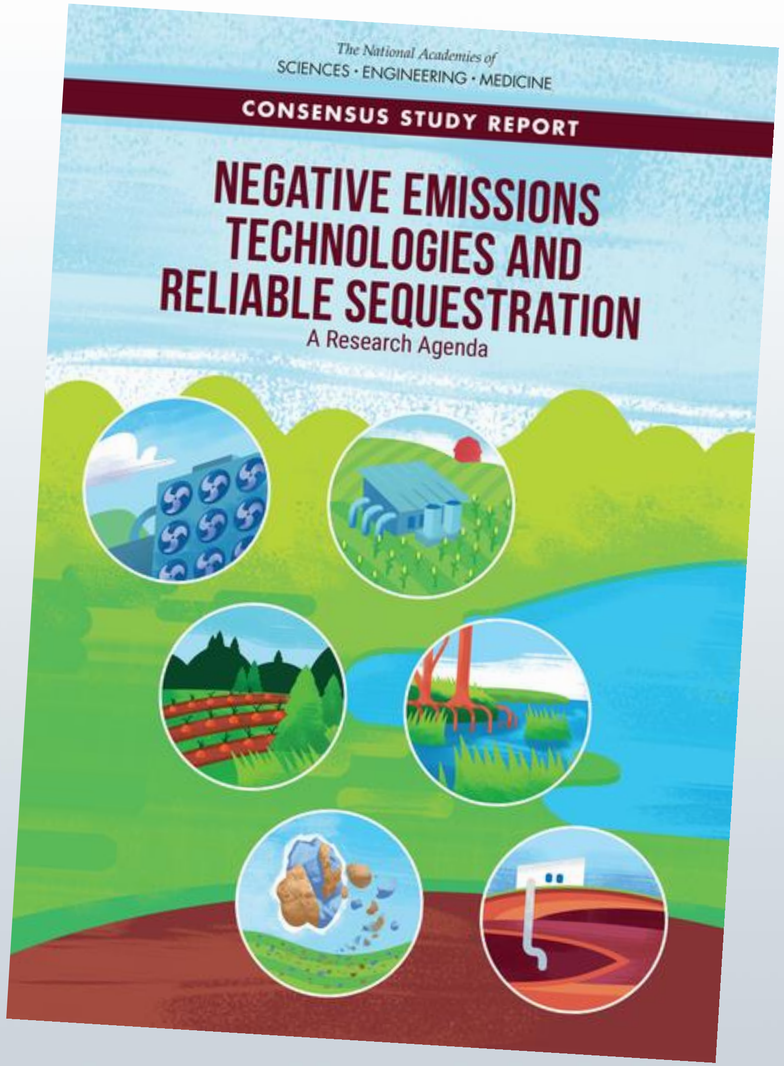
Negative Emissions Technologies (NETs) and Reliable Sequestration: A Research Agenda (2019)



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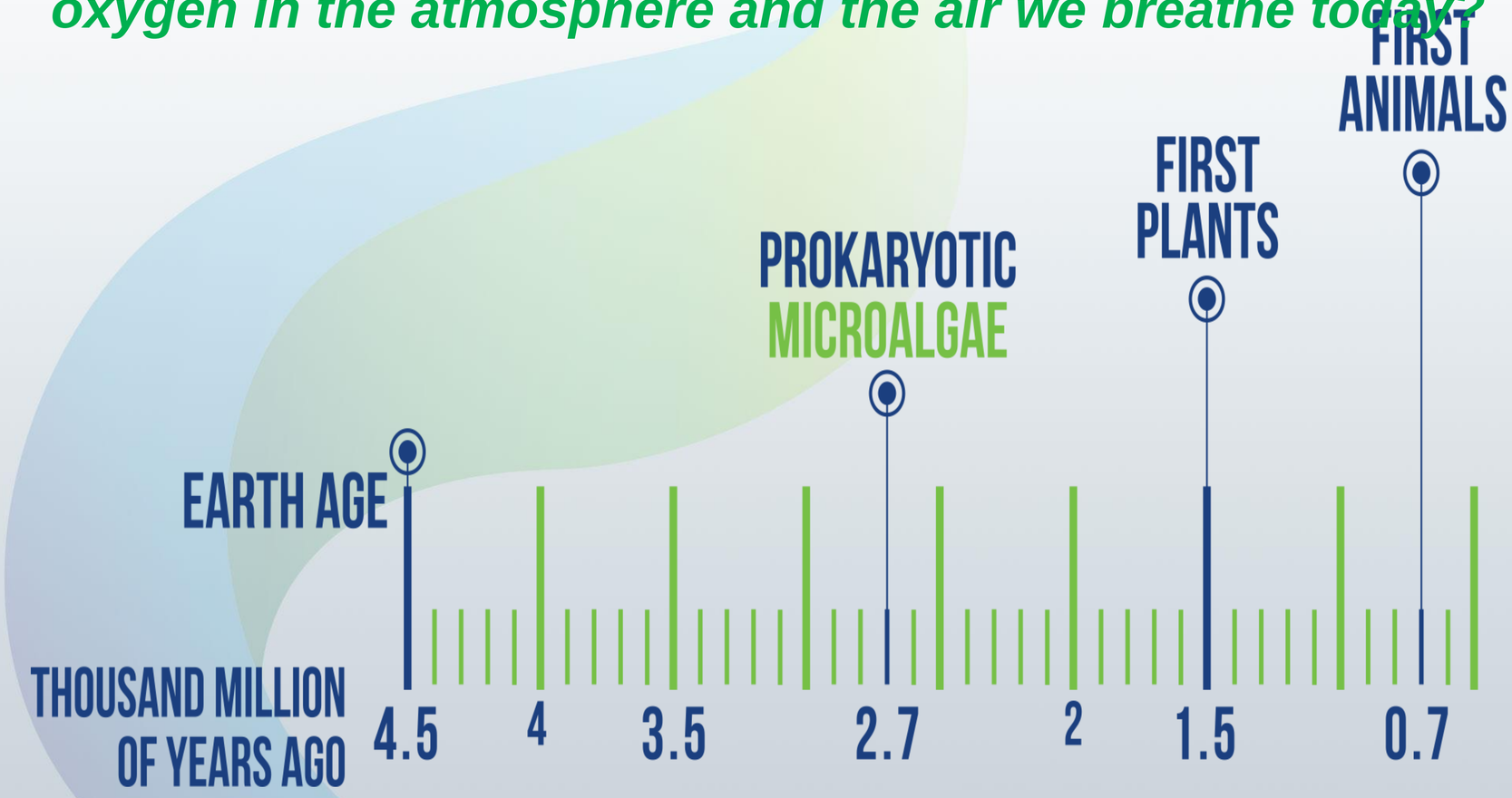
Microalgae, first microorganism to carry out oxygenic photosynthesis, and are responsible for most of the oxygen in the atmosphere and the air we breathe today?



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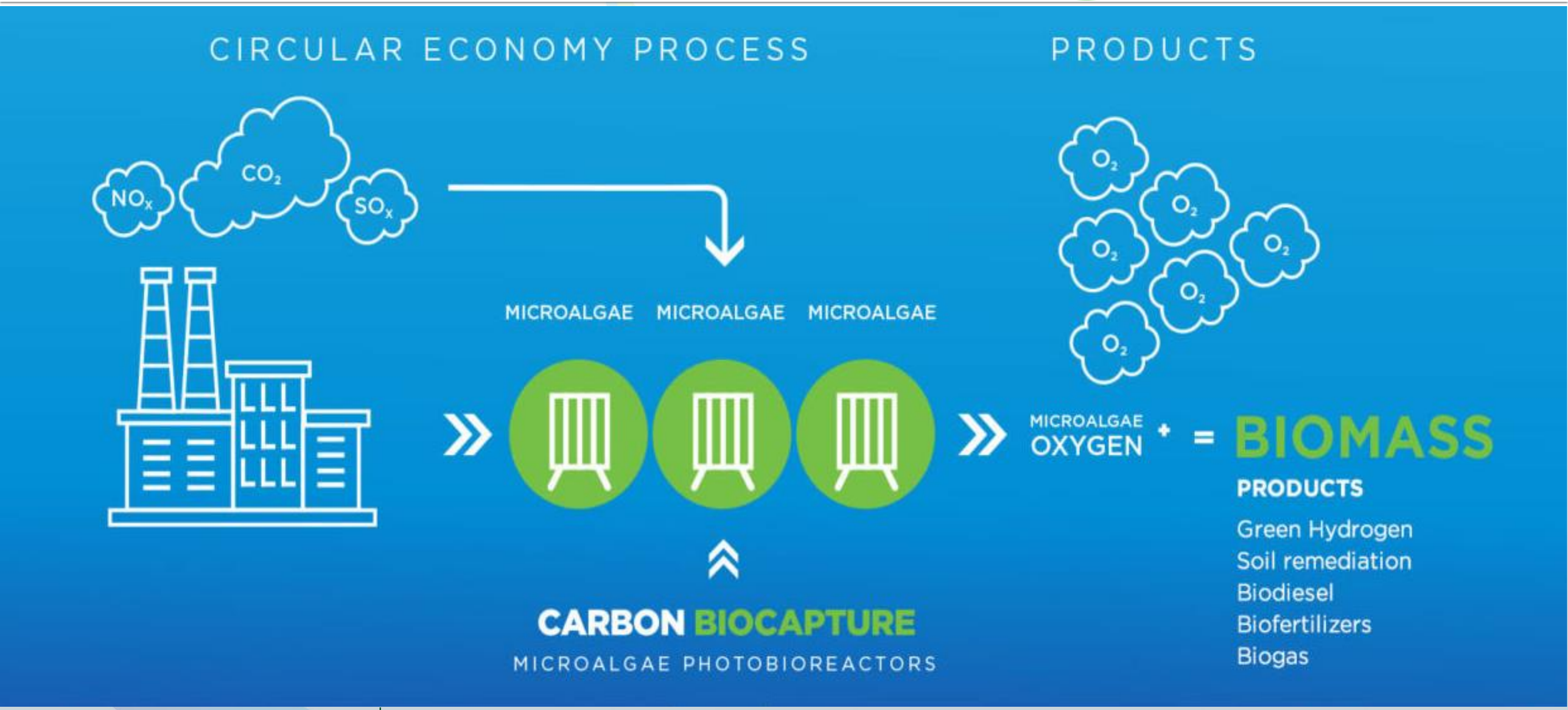

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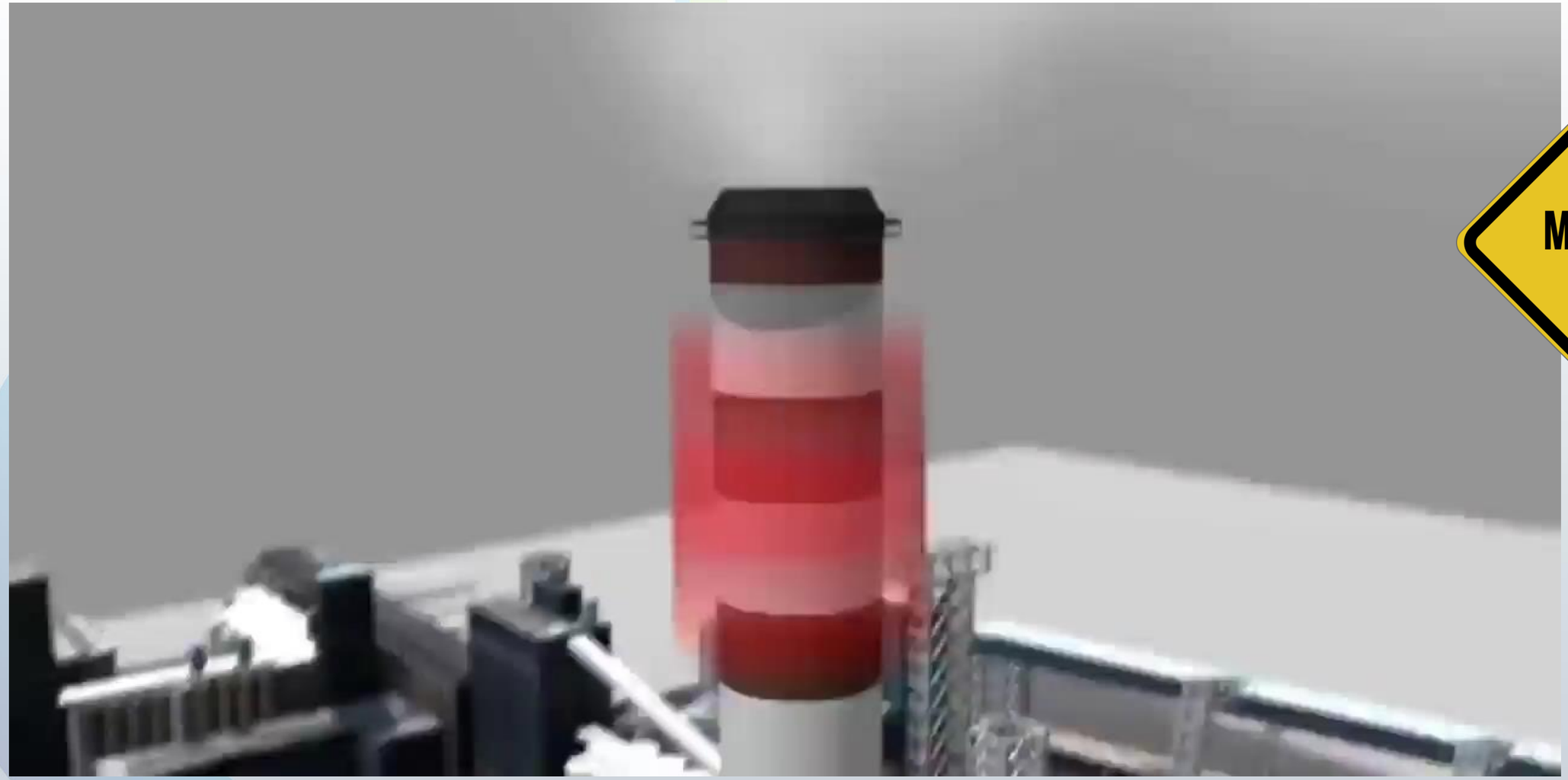

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Microalgae Photobioreactors (PBR)

Innovation in microalgal harvesting technologies:

- No use of genetically modified algae strains.
- Use and selection of natural local strains
- Local strains are then adapted to maximize capture of CO2, SOX, and NOX from flue-gases
- System can also be used to capture atmosphere

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- AES Chile: coal-fired thermoelectric plant in Ventanas, Chile
- Algae Strain: Chlamydomona and Chlorella
- Operates 24/7 for over a decade
- Variable temperatures during the year
- First microalgal biorefinery directly and permanently connected to a coal-fired power plant.
- CO2 NOx SOx capture from raw flue gas.
- Generates biofuels and biofertilizers.

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AES Chile pilot plant

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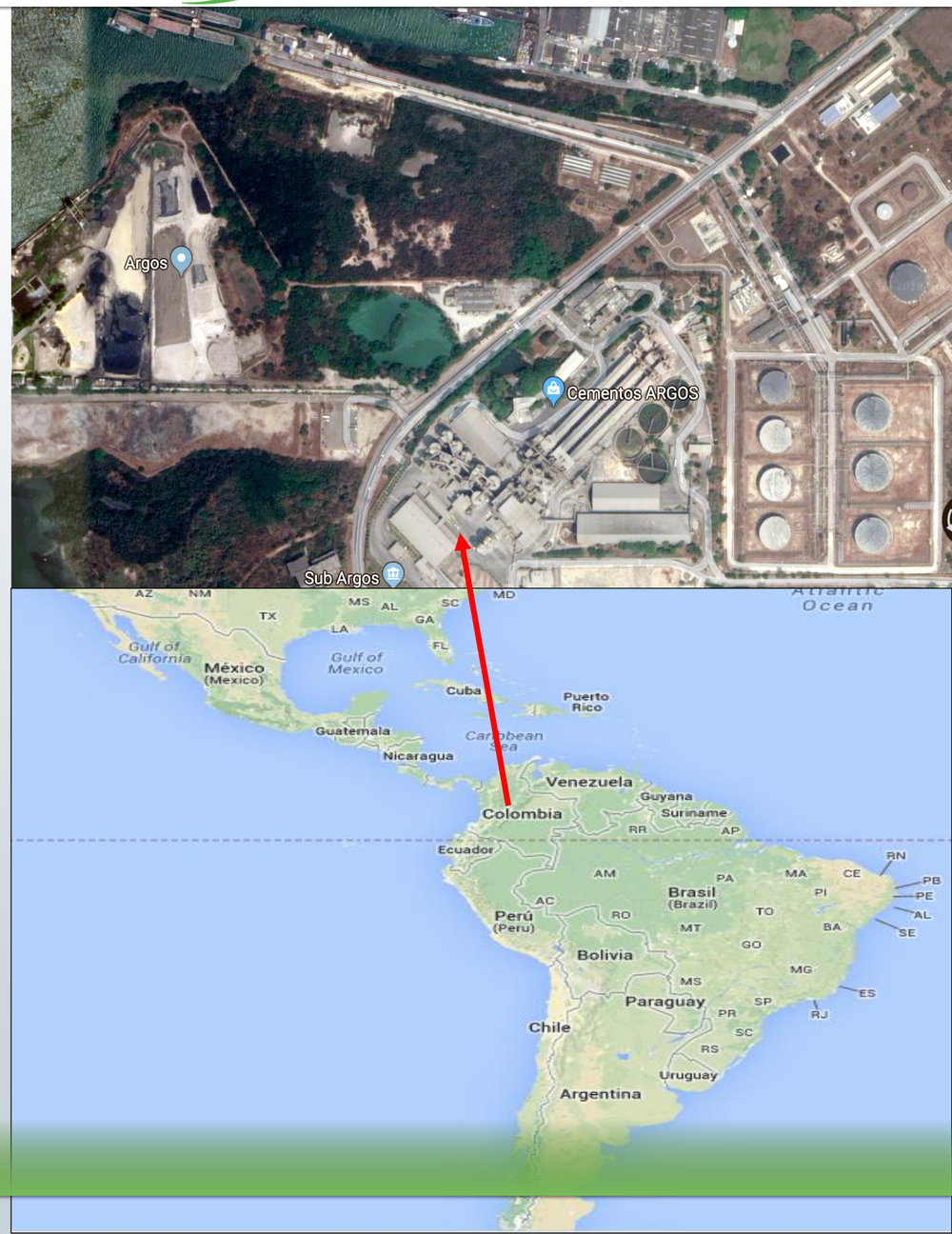
- Cementos Argos: cement plant in Cartagena, Colombia
- First microalgae biorefinery connected directly and permanently to a cement kiln.
- Capture CO2, NOx, SOx from raw flue gas.
- Biomass transformation in biodiesel.
- Strain consortium: Scenedesmus and Desmodesmus
- Operates 24/7 for over 5 years
- High temperature: 50°C approx. all the year



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Cementos Argos pilot plant

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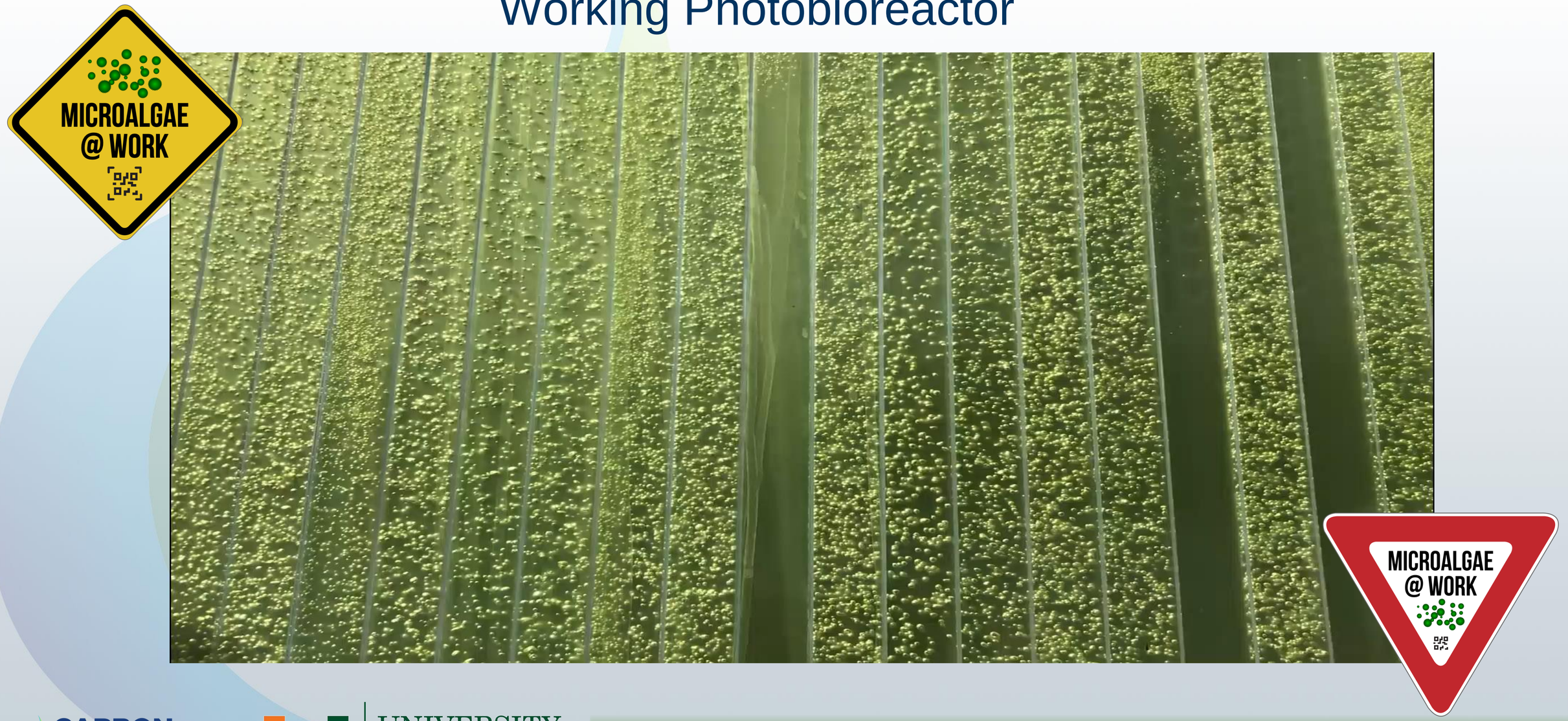
Working Photobioreactor



Key Aspects

- Up to 86% efficient CO2 capture from raw flue gas.
- Up to 92% NOx reduction and 100% SOx reduction.
- “All terrain”: adaptable to any emission source.
- Fresh water, salt water, brackish water, process water.
- Modular and scalable: up to 13,144 PBR/ha

Key Aspects

- 2 – 5 metric tons CO2 /PBR per year
- Electrical energy requirement: 500kW/ha
- High biomass production: > 15 gr/L
- Rugged PBR construction
- Real time monitoring and reports

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The composition of algae biomass makes it a promising candidate for an extensive list of applications:

- Algae can be converted into energy by biochemical or thermochemical conversion.
- Brown algae are used as a high-intensity colorant for fabrics.
- Algal fuel, algal biofuel, and algal oil offer alternatives to liquid fossil fuels and common biofuels.
- The use of algae for composting improves soil consistency and water retention in soils.

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Online Measurement

- Online emissions measurement
- Provides emission reduction certification and environmental offsets
- Set # of panels based on emissions level
- Installation of Sensors to monitor data:
  - Amount of CO2 , NOx , SOx and other gases
  - amount of emitted O2
- Data transmitted in real time via an App
- Reports generation for environmental a
  and transactions in the carbon market.

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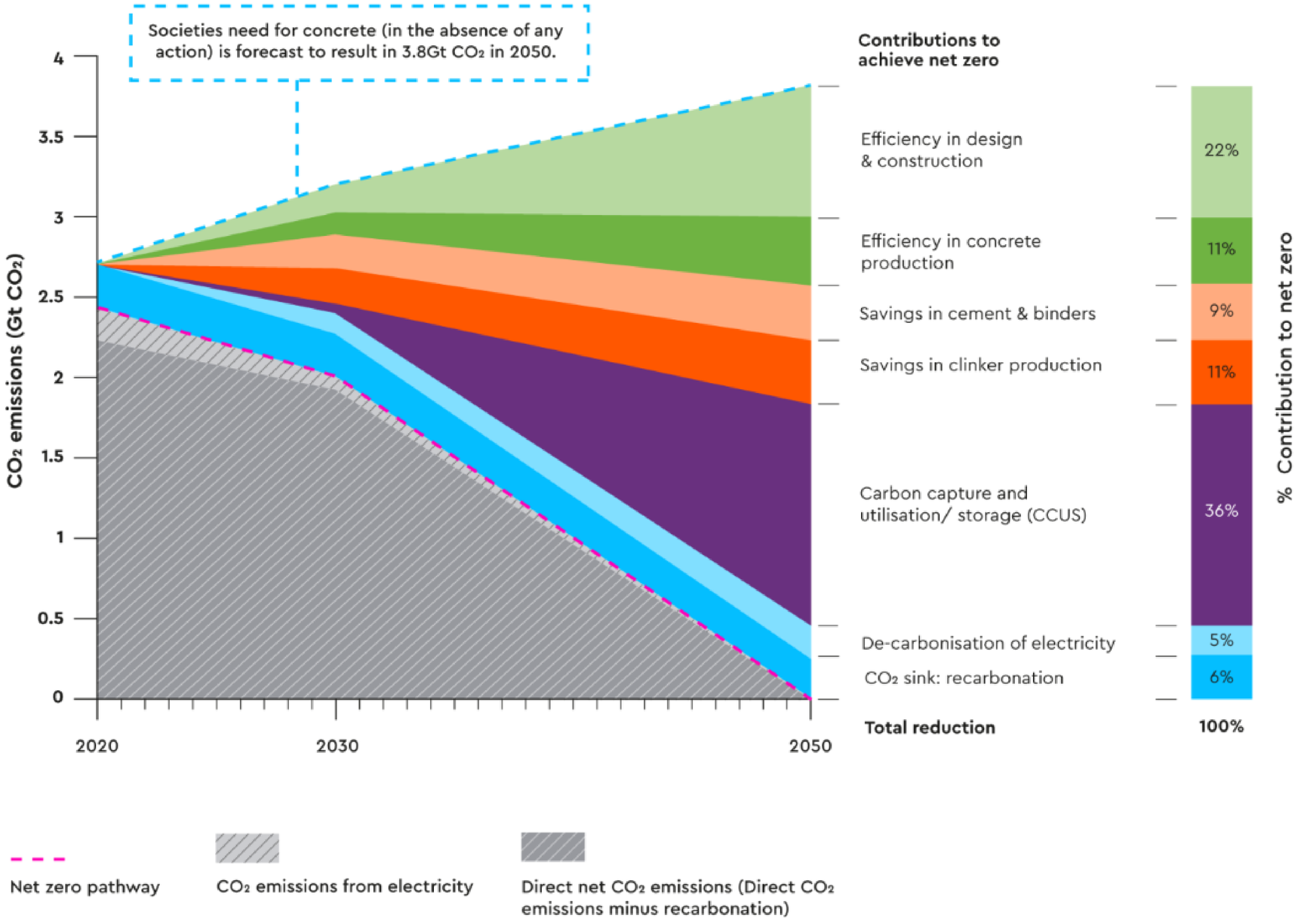

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