Carbon Capture Battery

Transforming CO_2 Capture into a Profitable Grid-Scale Battery

75 Remedium

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Omid Saghafifar
Moji Hashemi

What is the common factor?

Cement and Steel are killing our planet

6 billion

Cement and steel annual CO_2 emission

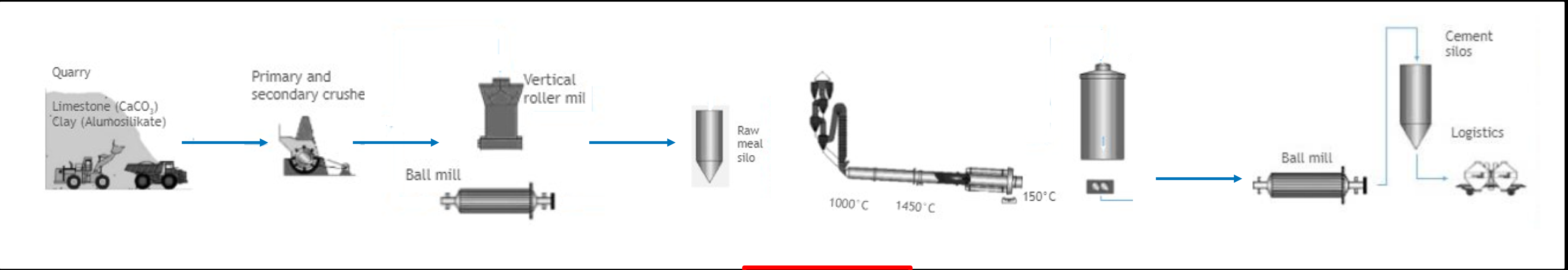
18%

Annual global CO_2 emission

Equal to transport sector CO_2 emission

Emissions along the cement value chain

1. Processing of raw materials	2. Milling	3. Burning and storing clinker	4. Cement milling and packing



Scope 1 emissions (%)	0.4%	2.6%	52% calcination process	34% fossil fuels	3%	5.3%	2.4%
Scope 2 emissions (%)	0.3%	2%	39%	26%	2.3%	4%	1.8%

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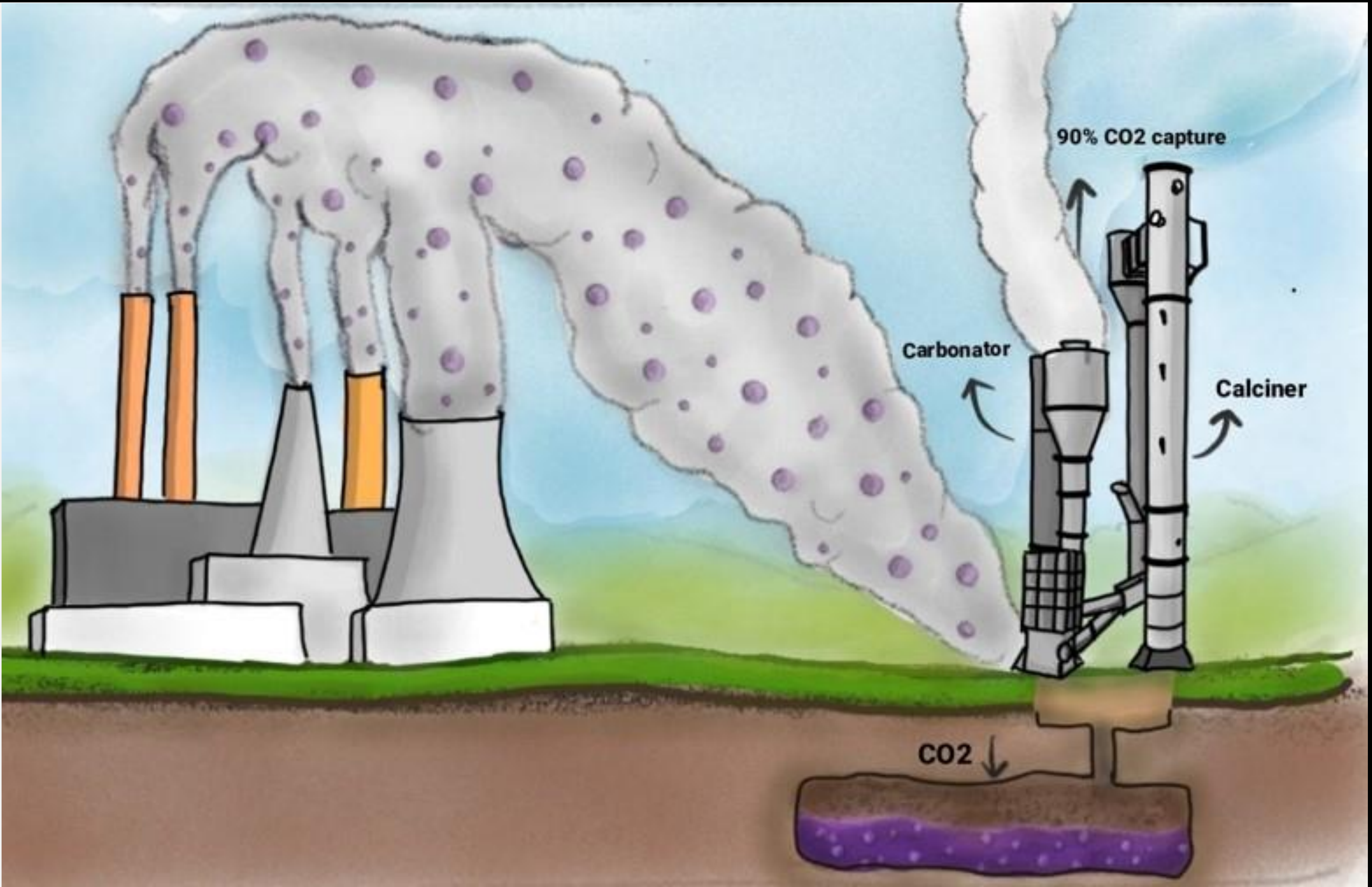
A Potential to save our planet



Carbon Capture

Carbon Capture is the most feasible CO_2 abetment pathway to decarbonise Cement and Steel

Where we are, where we need to be!

43 Mtpa

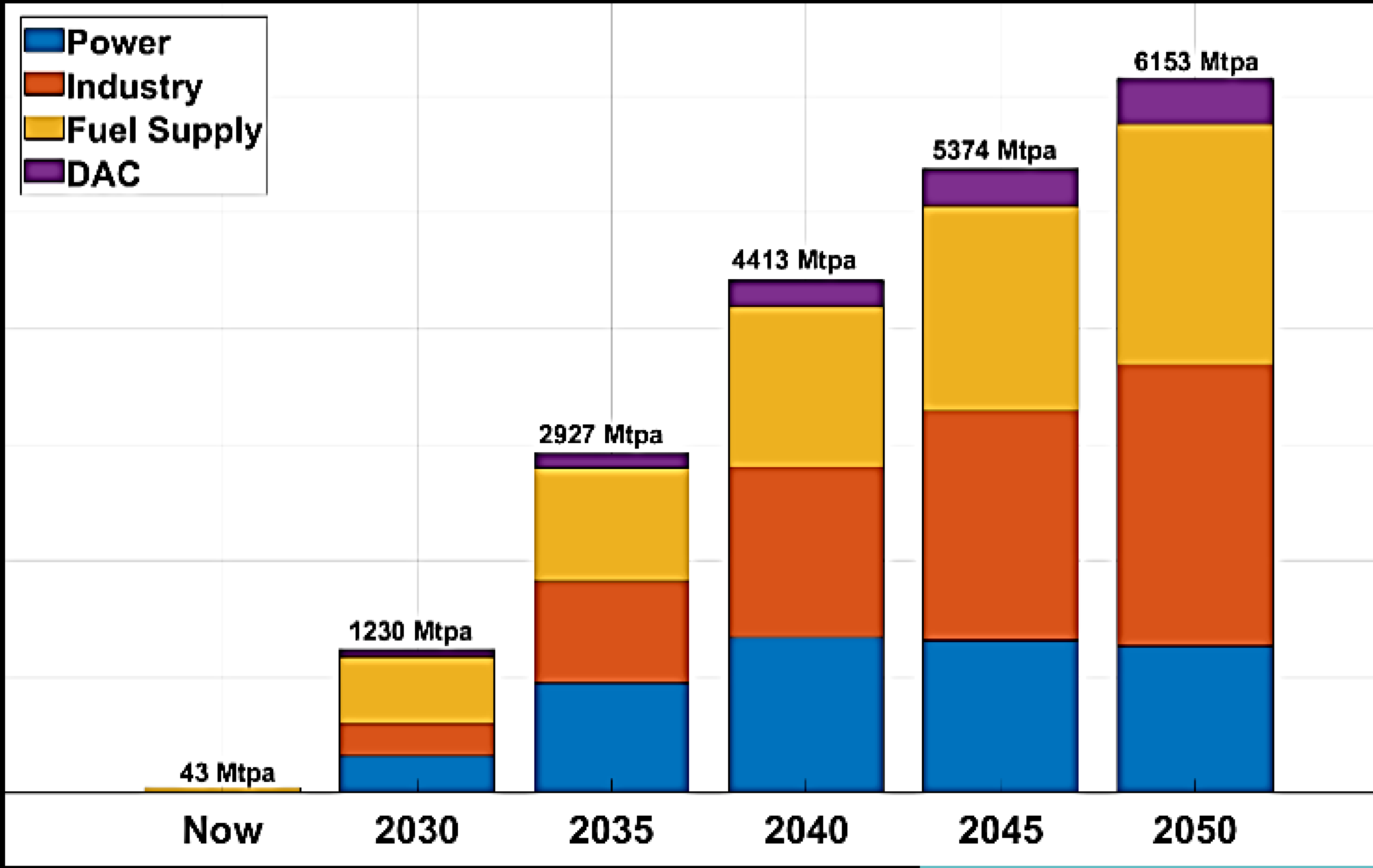
Current carbon capture capacity.

4400 Mtpa

Carbon capture capacity needed by 2040.

100x

Carbon capture capacity increase in less than 16 years.



IEA World Energy Outlook Report

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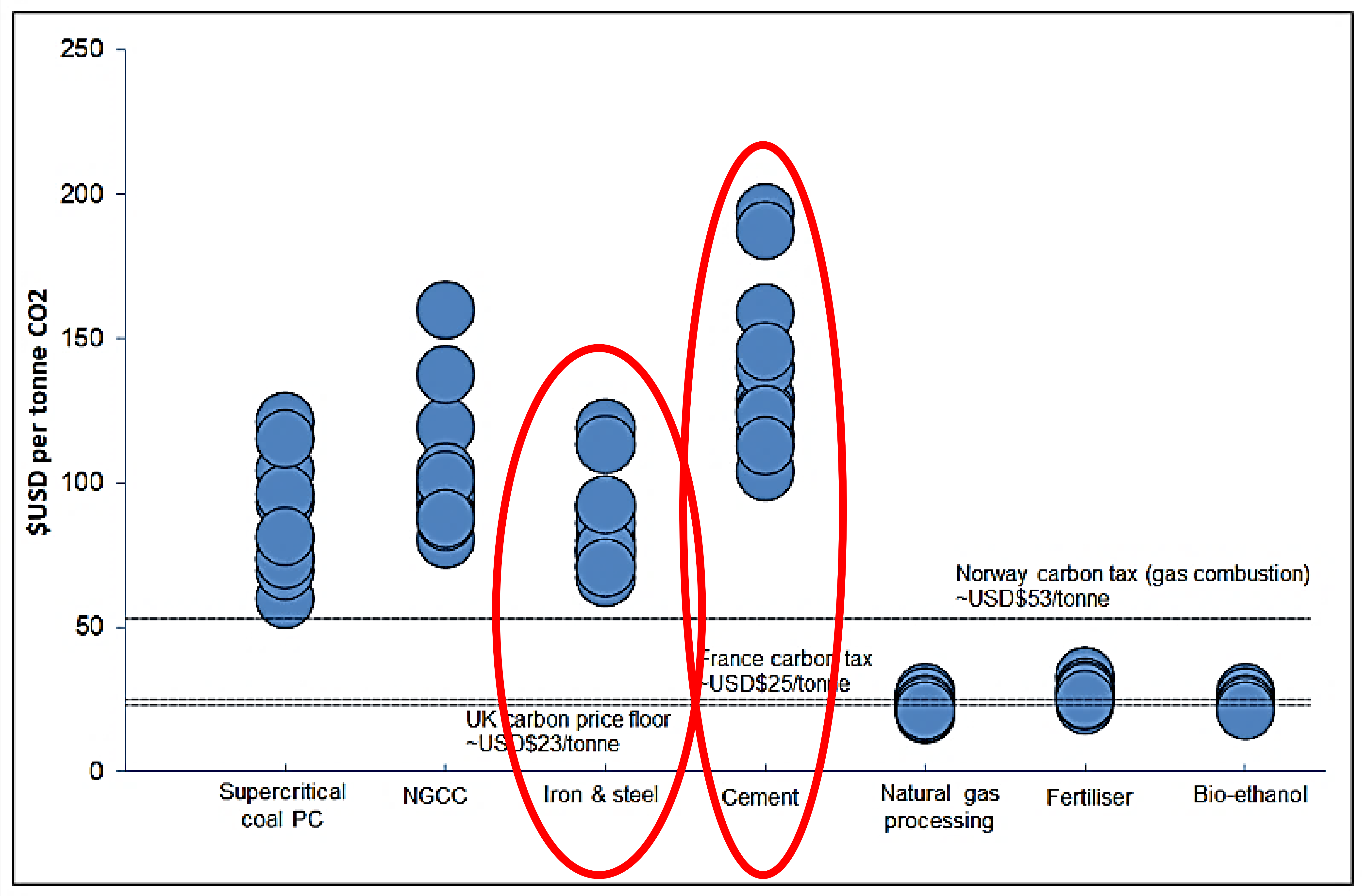
What is the main barrier?

50-200 $/t CO_2

Cost of carbon capture in cement and steel industry.



Global costs of carbon capture and storage

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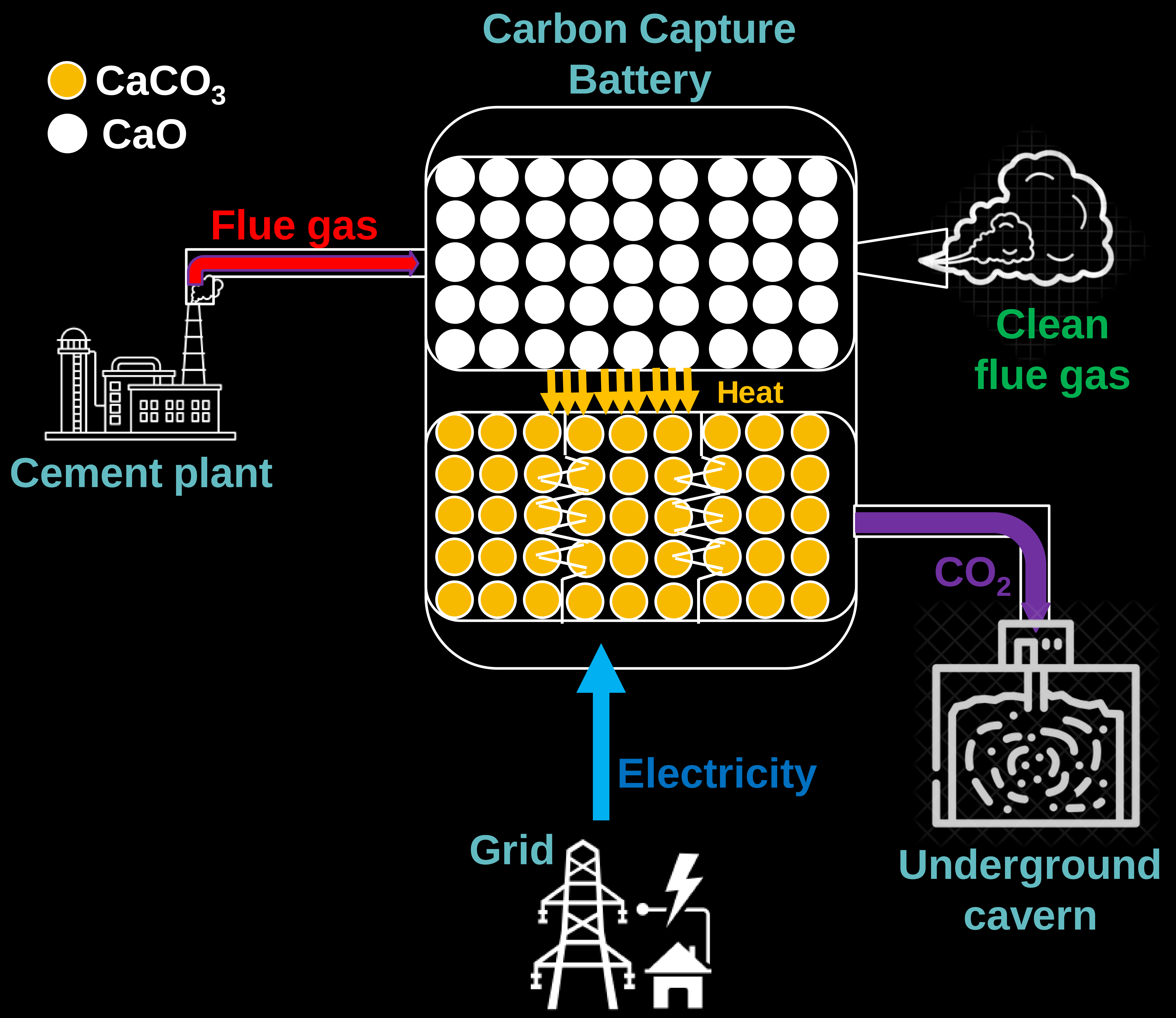
Capture CO_2 and electricity storage



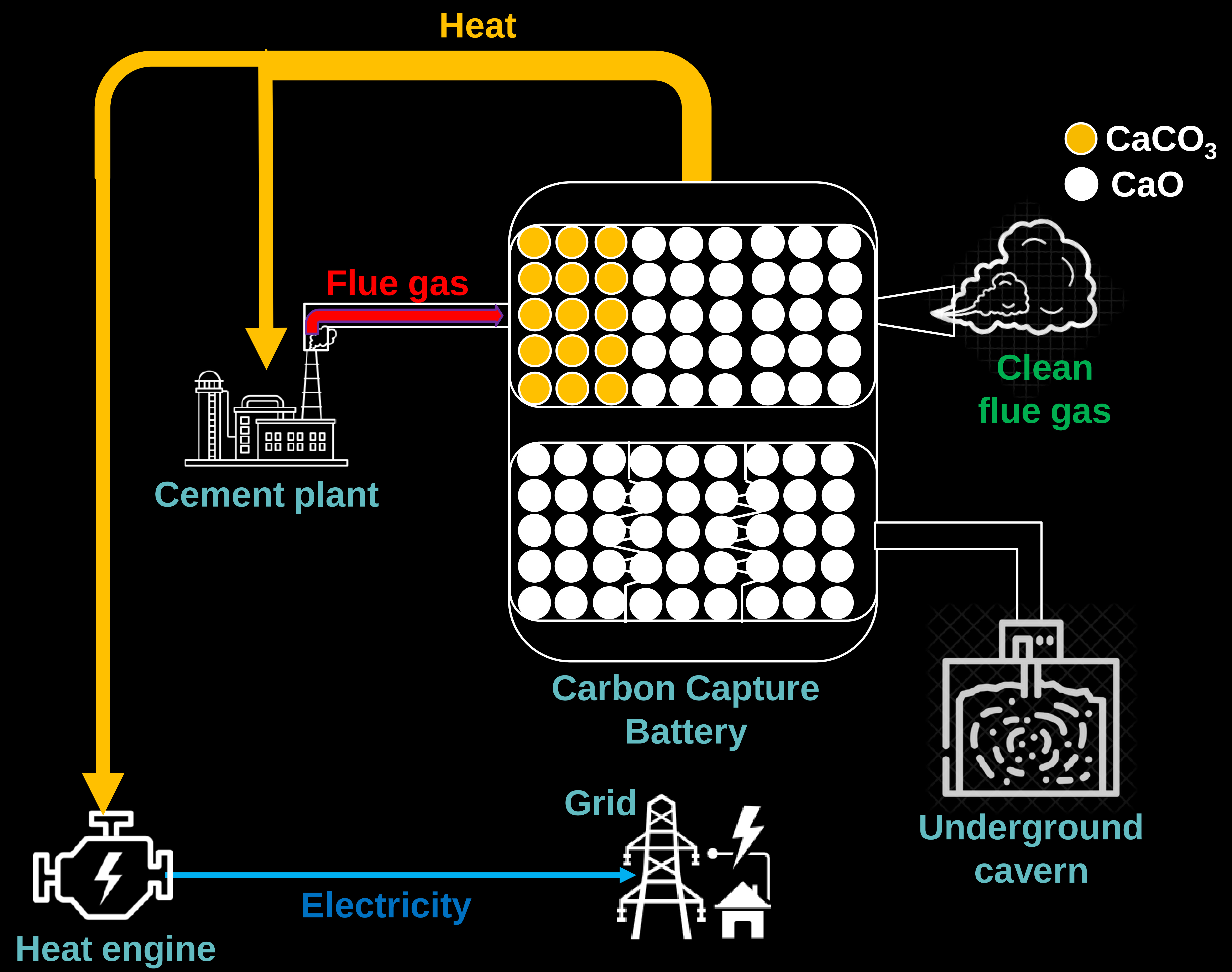
CO_2 capture rate

>90%

Store electricity

300 kWh/m³

Capture CO_2 and electricity discharge



CO_2 capture rate

>90%

Round-trip efficiency (heat)

60%

Round-trip efficiency (electricity)

40%

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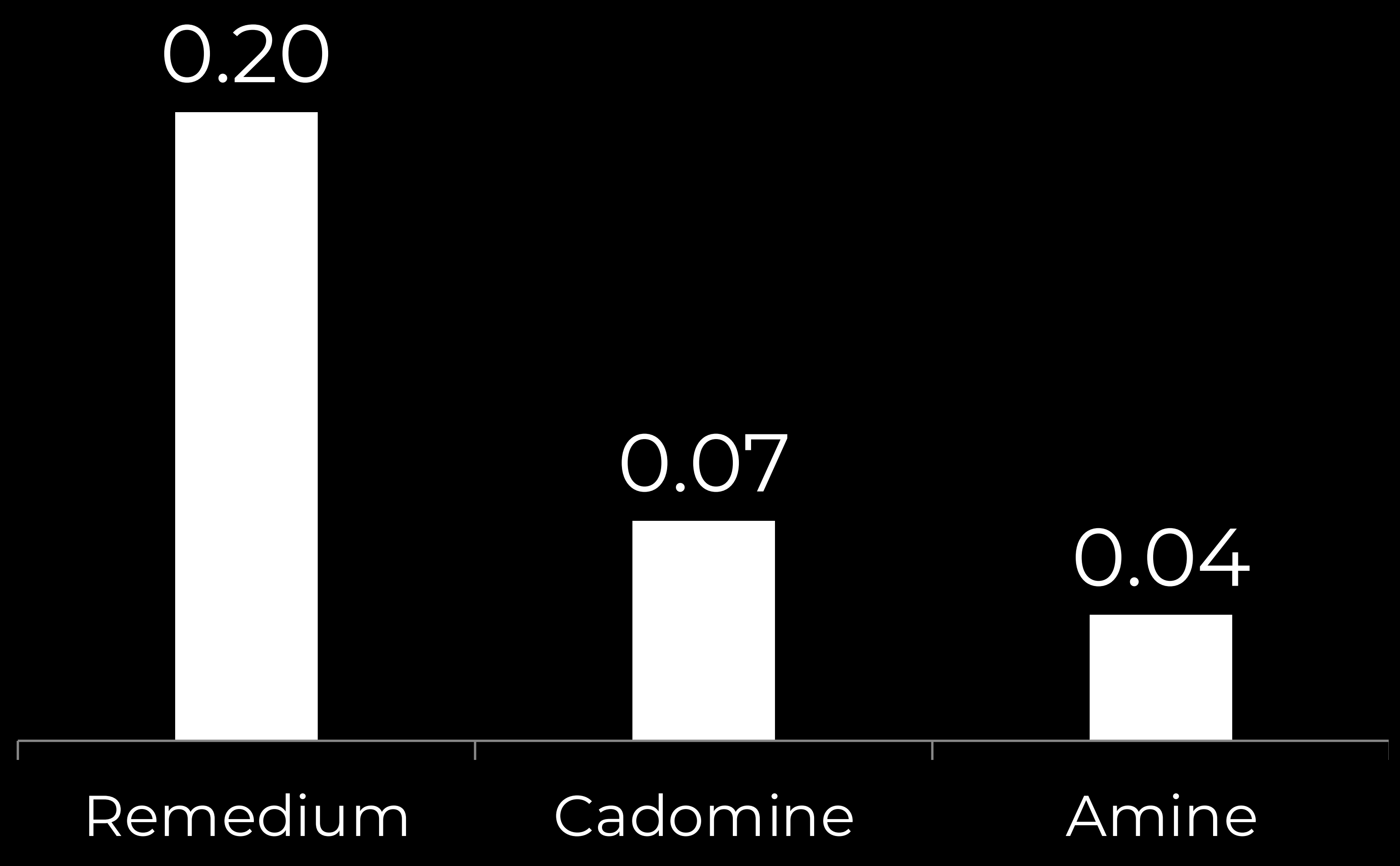
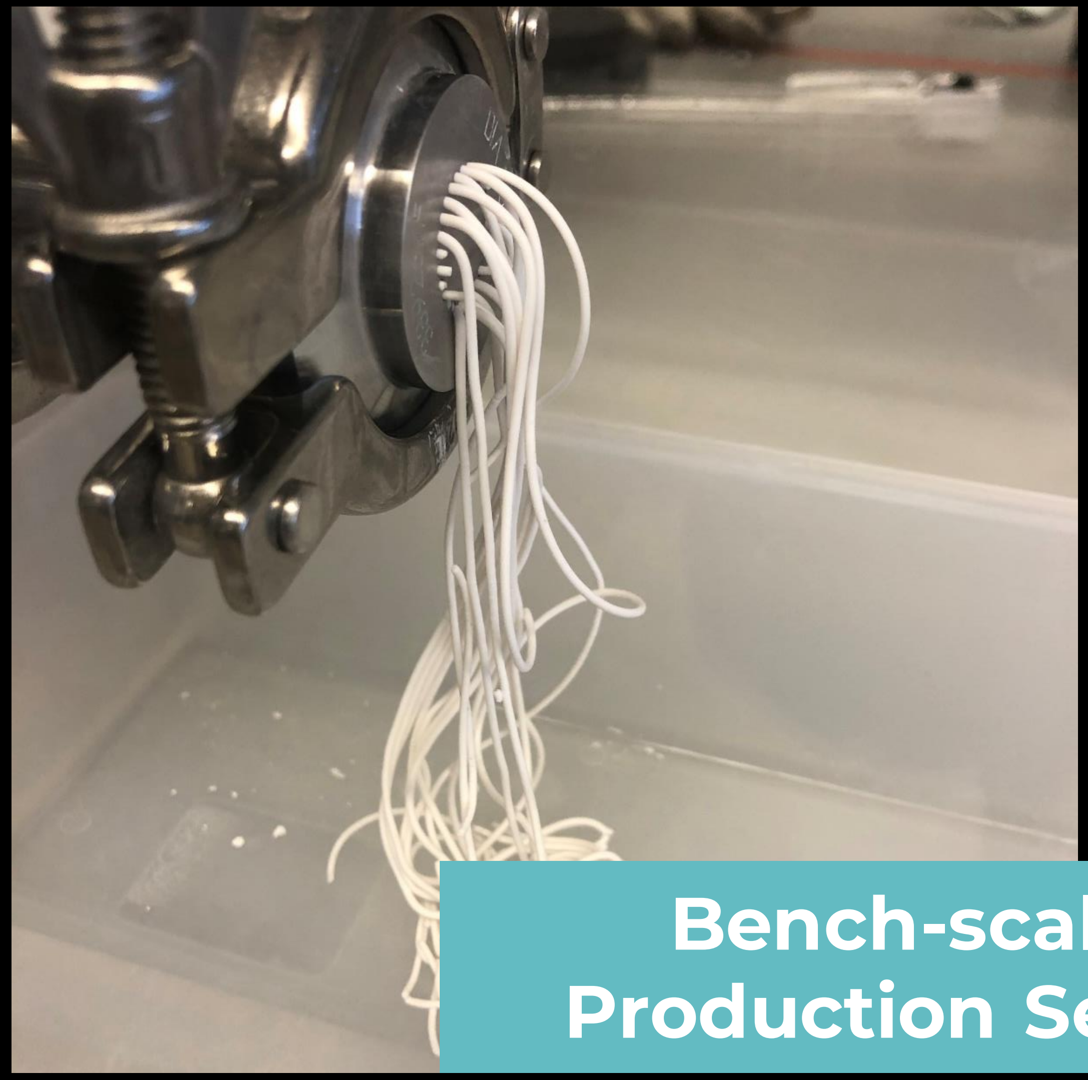
A cheap and abundant sorbent

3x

More efficient CO_2 capture

CO_2 Uptake (kg CO_2/kg sorbent)





Bench-scale Production Setup

Conventional amine	Remedium
Up to 2 kg of waste amine per tonne CO_2	Cheap precursors → Efficient sorbents → Reused in cement

Waste Free

Is this a shift? No, a revolution

	Remedium	Svante	Delta CLEANTECH	climeworks
Income per tonne CO2 capture	$+10	$-50	$-60	>-$100
Versatility	Post-comb Pre-combustion	Post-comb	Post-comb	DAC
Additional functionality	Electricity storage	None	None	None
Sorbent regeneration	Electricity	Fossil fuel	Fossil fuel	Electricity
Process waste	Minimal	Minimal	2 kg per tonne CO_2	Minimal

Market size: Annual revenue

TAM

Global annual market for Carbon Capture in 2050
CAGR 8.4% 2030-2050

$307.6Bn

SAM

Cement & steel carbon capture market in 2050

$84.4Bn

SOM

30% of Cement
10% of Steel
NA/EU/UK

$1.2Bn

Here is a billion-dollar enterprise

T&S Scheme

Emitter → Capture → Transport → Storage

Joint Venture

Emitter → Capture → Transport → Storage

Emission off-take

Emitter → Capture → Transport → Storage

Route 1: 2024-2034

CCS Plant Design & Licensing

Remedium acts as the IP holder and know how expert.

By partnership with EPC companies, we design and build CCS plans for joint venture users and emitters in T&S scheme

Total Revenue

$158 million

Route 2: 2034-2044

Emission off-take service

Remedium charge a fix fee per tonne Co_2 capture from emitters.

Total Annual Revenue

$80 million-$1.2 billion

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Team

CO-founder - CEO

Omid Saghafifar

- PhD in Engineering, University of Cambridge
- Post-doc associate, University of Cambridge
- Thesis in CCUS and Electricity Storage
- Former R&D Engineer, NanoSUN

Co-founder - CTO

Moji Hashemi

- PhD in Chemical Engineering, University of Calgary
- Energy and climate consultant, BCG
- Thesis in CCUS
- Former Post-doc at University of Calgary
- Process Engineer Experience in Canadian Oil Sands Industry

Engineering Director

Ahmad Saghafifar

- BSc in Mechanical Engineering, University of Shiraz
- +30 Years of Experience in EPC companies
- Former Lead Piping Engineer, Wood & Petrofac

Our Milestones

2022
Start

2022 – Sorbent Development

- Carried out sorbent bench-scale testing
- Reached TRL of 5
- Demonstrated carbon capture potential of sorbent over 100 cycles
- Published results in scientific journal papers
- Filed a patent on sorbent manufacturing procedure

2023 - Business development

- Incorporated Remedium Energy
- Participated in entrepreneurship and training programs:
  - ✓ CarbonNext (Foresight Canada)
  - ✓ EnterpriseTech (student)
  - ✓ Impulse at Maxwell Centre
  - ✓ EnterpriseTech (Inventor)
  - ✓ EnterpriseTech Star

2024
Going On

2023 – Electricity storage scheme

- Carried out detailed techno-economic analysis
- Reached TRL of 3
- Published results in scientific journal papers
- Filed a patent on electricity storage scheme
- Build a single reactor (5g reactor) showcasing the concept
- Reached TRL of 4

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Awards and Competitions

2022
Start

Nov 2022
Prototype for Humanity

Corporate solution winner amongst 100 finalist and more than 1000 entries

Prize: $25k

Jun 2023
Falling Wall lab

Was selected amongst finalist in Cambridge University

Aug 2023
Chris Abell Competition

Was selected amongst 12 semi-finalists in University of Cambridge

Mar 2024
21toWatch list

Was selected to be on 21towatch list Amongst 7 companies in 2024 in East of England with high potential

Prize: included services worth £20k

2024
Going On

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Traction and Customer Discovery

Pan United (Singapore's largest cement producer)

We held multiple meetings with representatives from Pan united and discussed our solution for decarbonising their industry. They showed vast interest in Remedium's carbon capture technology and its synergy with cement industry.

Canadian Natural

We held a meeting with a member of Technology & Innovation team at Canadian Natural. Our discussion with CNRL has been encouraging and we have been invited to present our solution their GHG emissions team.

CCUS Consortium in Singapore

Remedium participated in a Foresight ESG event presenting our company to Singapore Enterprise and CCUS Consortium in Singapore. CCUS Consortium in Singapore has shown massive interest in Remedium's solution and we had a follow up meeting with them discussing the technical and economic aspects of our solution.

Arcelormittal (2nd largest steel producer)

We held a call with a former member of acquisition of Arcelormittal venture arm, and he showed massive interest in our solution and recommended details of how such a solution can be integrated with s a steel plant. He believes that such a solution can play an important role in decarbonising steel.

Building our pilot plant by 2028

Pre-Seed round:
£1 – 1.5 M

2024

1. Carbon Capture Battery lab demonstration
2. Reach TRL 5
3. Build MVP

2025

1. Pilot plant design Initiation
2. Pilot scale sorbent production line
3. Material live flue gas test (TRL 7)

Seed round:
£5-7 M

2026

1. Sorbent production expansion (50 kg/day)
2. Pilot plant design complete
3. Pilot plant build commencement by partnership with EPC companies

2027

1. Continuation of pilot Plant build
2. Carbon capture battery pilot scale demonstration (TRL 7)

Series A round:
£20-40 M

2028

Pilot plant build complete

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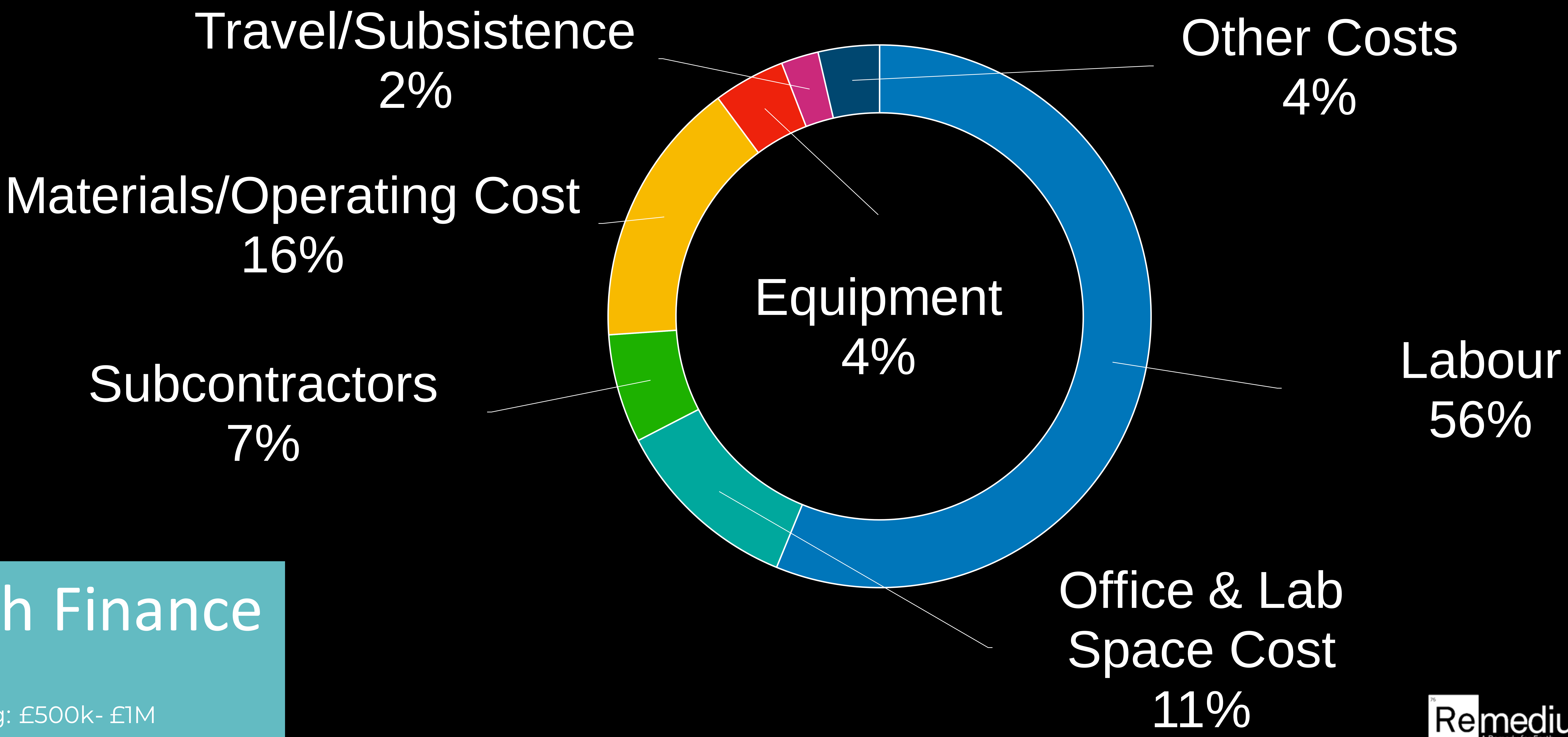
Cost Breakdown



24-month Finance

Pre-seed: £1 - £1.5M

Grants and Funding: £500k- £1M

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Moji Hashemi, CTO
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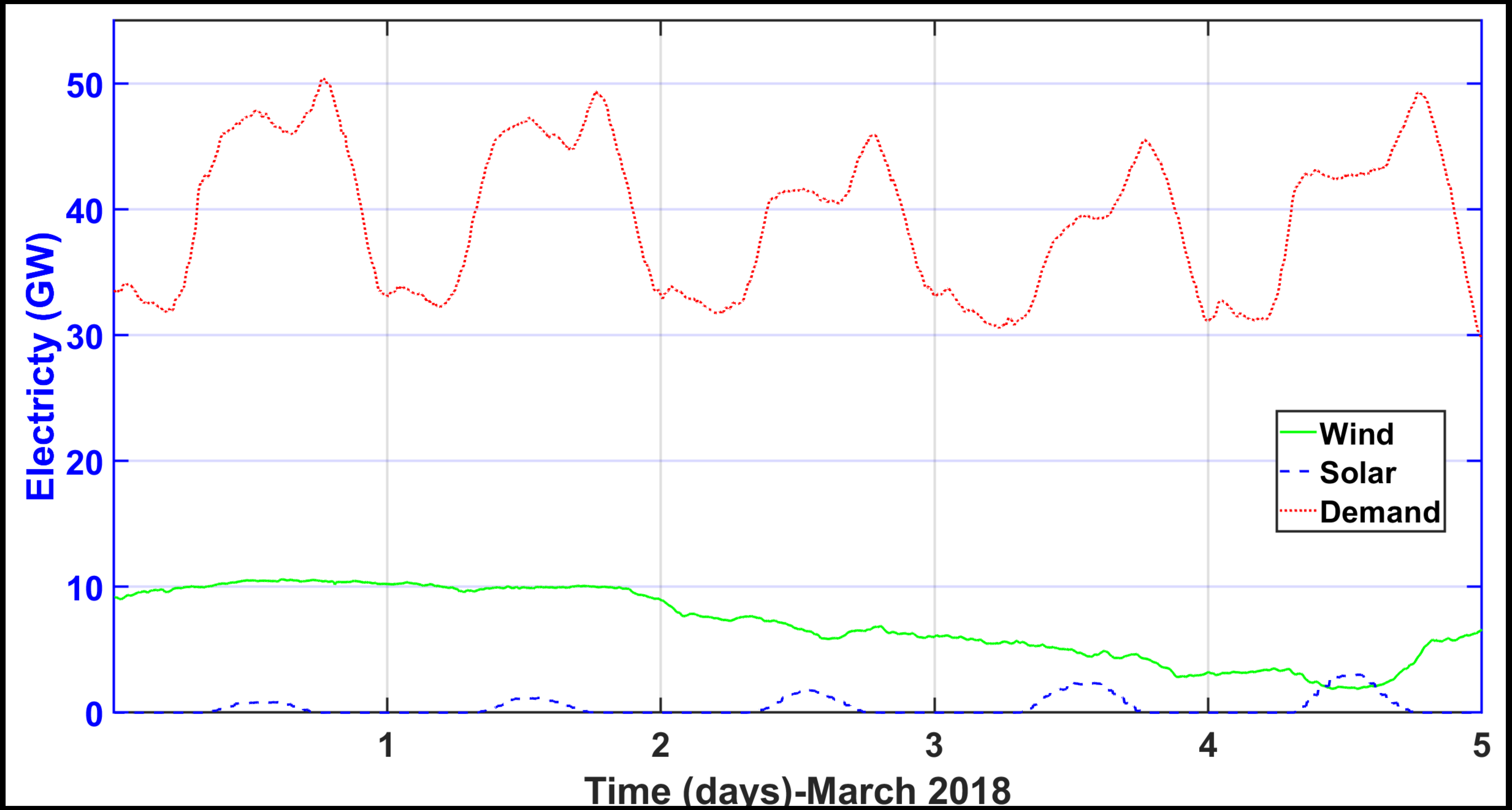
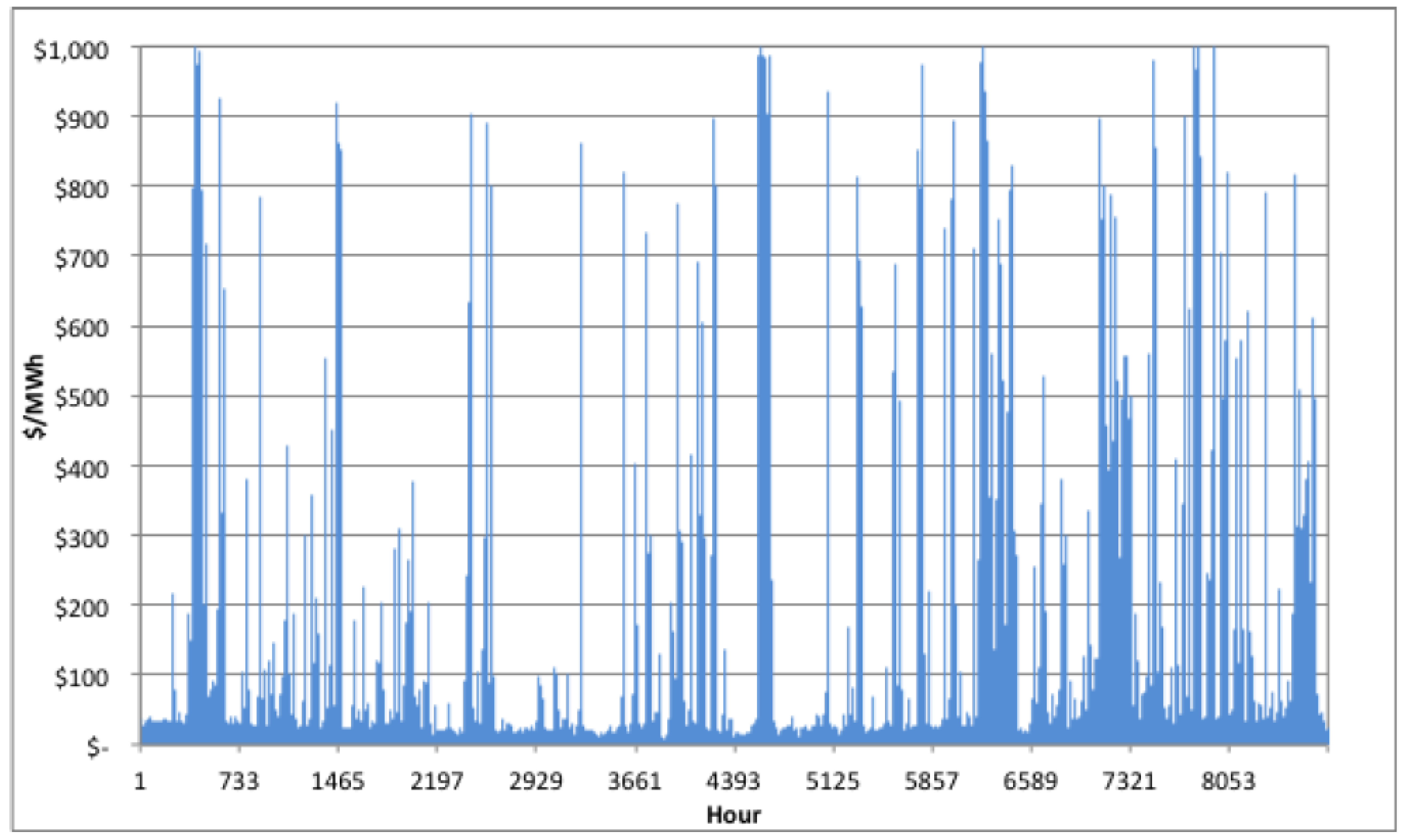
Q&A

Supplementary 1: UK Grid Data



UK grid data

Supplementary 2: UK Grid Data



Electricity Price-Alberta 2012

Hourly price of electricity is very volatile

- **50% of the time: below $25/MWh**
- **Average of the remaining: $110/MWh**
- **Price volatility increases with increase in the share of renewable energy**

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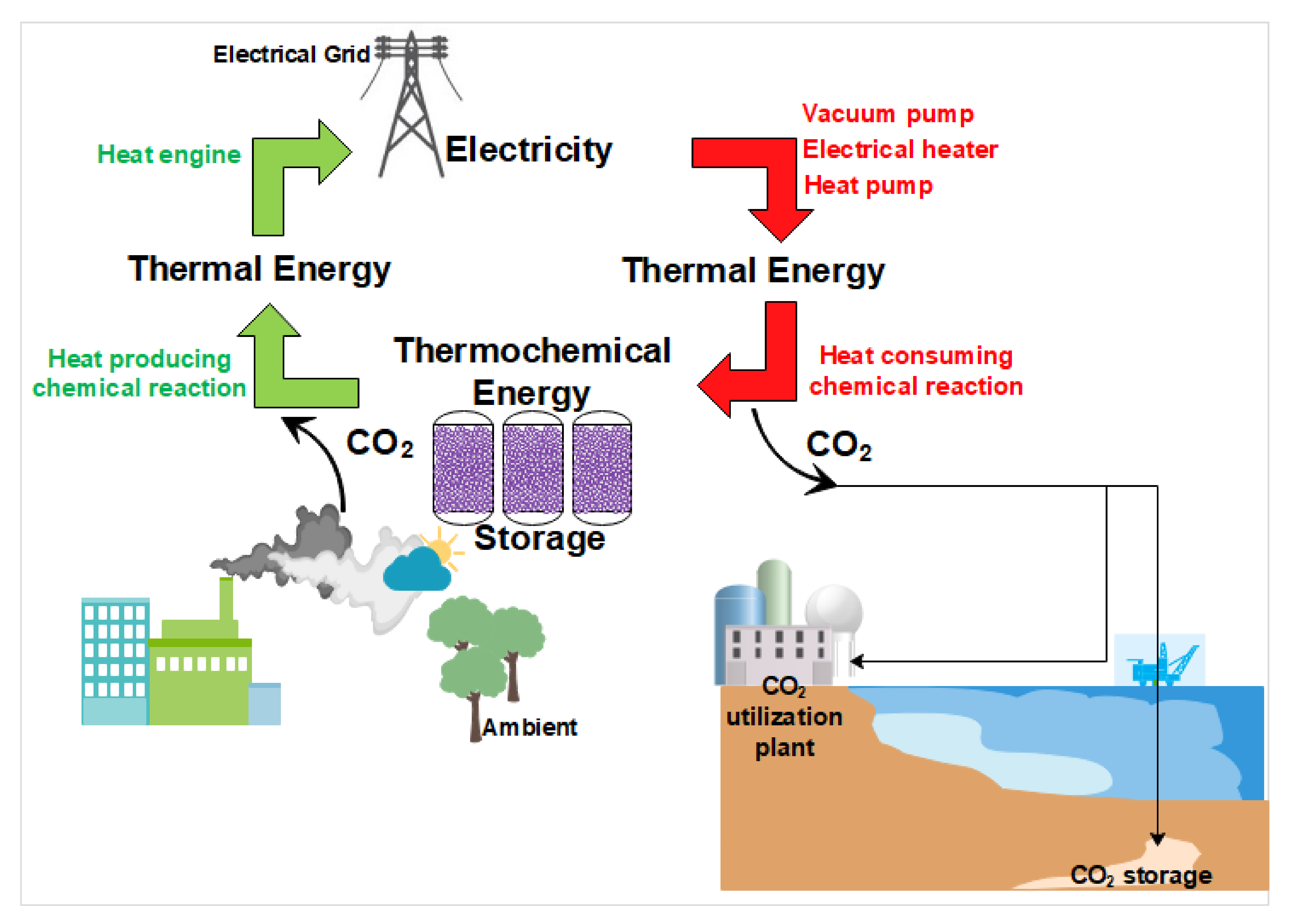
Supplementary 2: UK Grid Data



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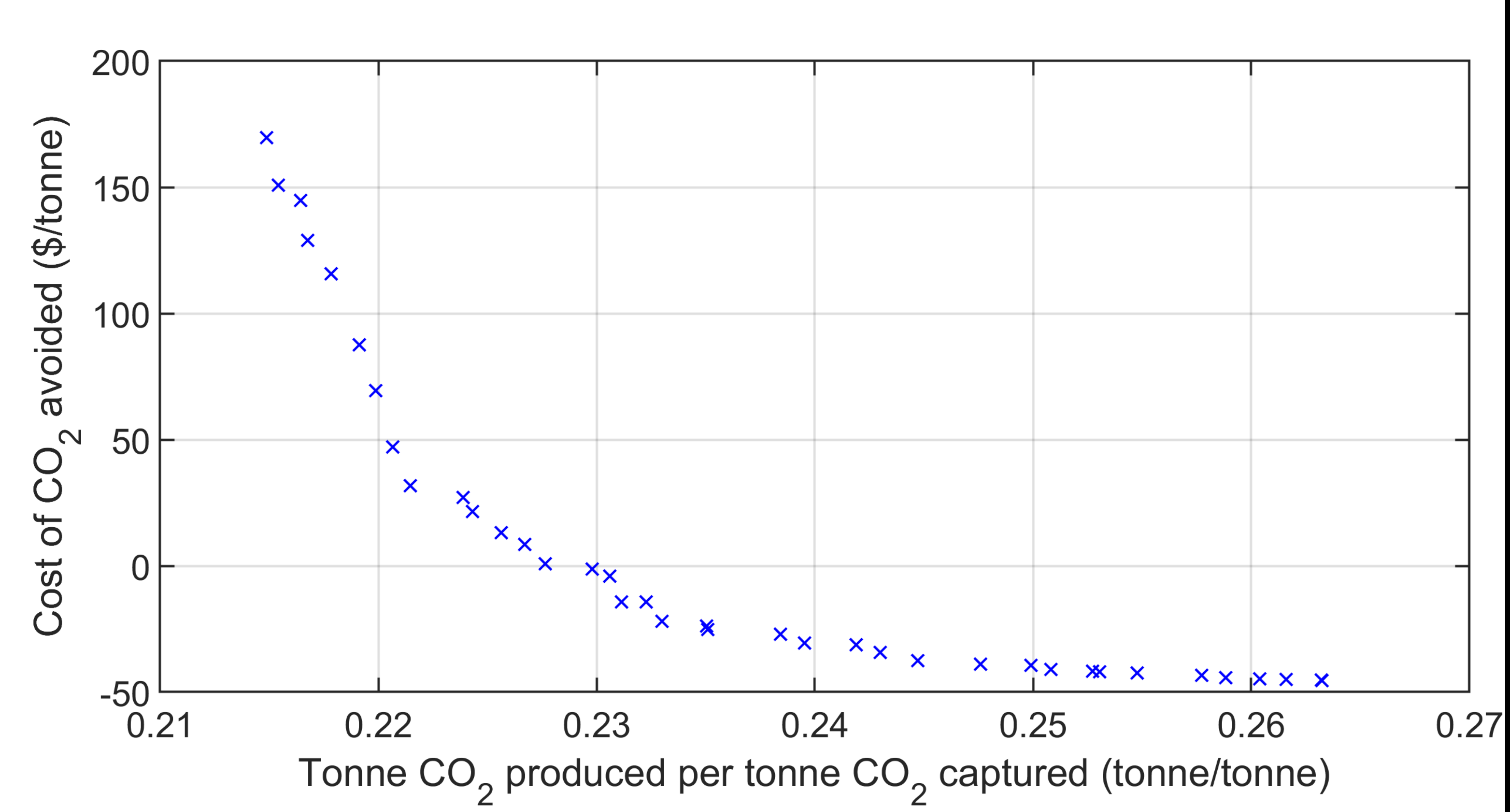
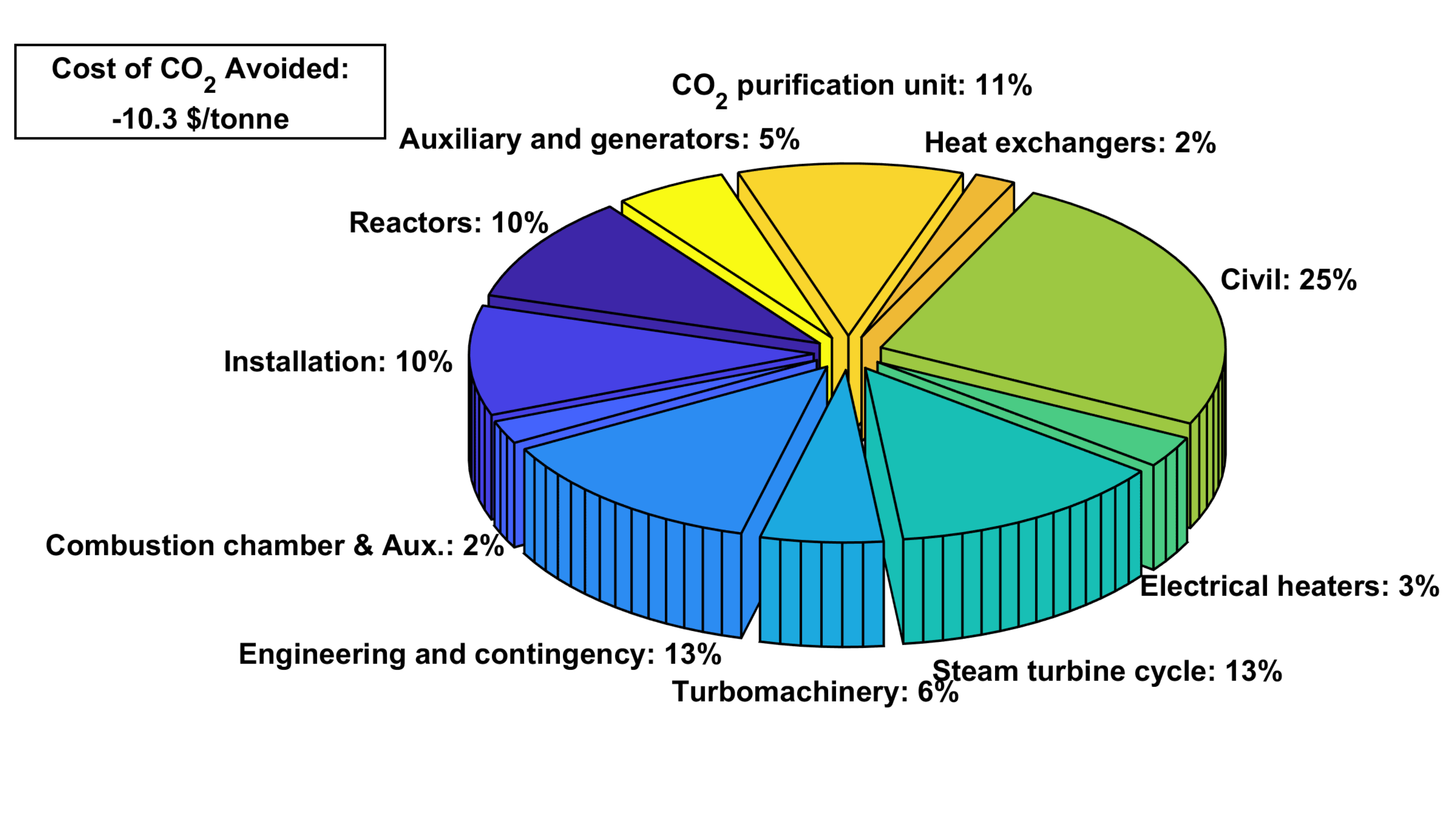
Supplementary 4: Carbon Capture Battery potential



Additional investment needed to make the carbon capture battery as compared with the conventional calcium looping process only account for about **10% total initial investment**.



Negative Cost of CO_2 Capture

For the first time a technology was shown to achieved negative cost of CO_2 capture, i.e. **making the process of capturing CO_2 profitable**

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Supplementary 5: Grid Scale electricity storage comparison

Technology	Round-trip efficiency (%)	Capacity (kWh/m³)	Cost (US$/MWh)
Pumped Hydro	65-80	0.5-1.5	10-15
Compressed air	70-80	5-10	15-20
Carbon capture battery	35-45	150-300	20-25
Hydrogen	25-40	600	25-30

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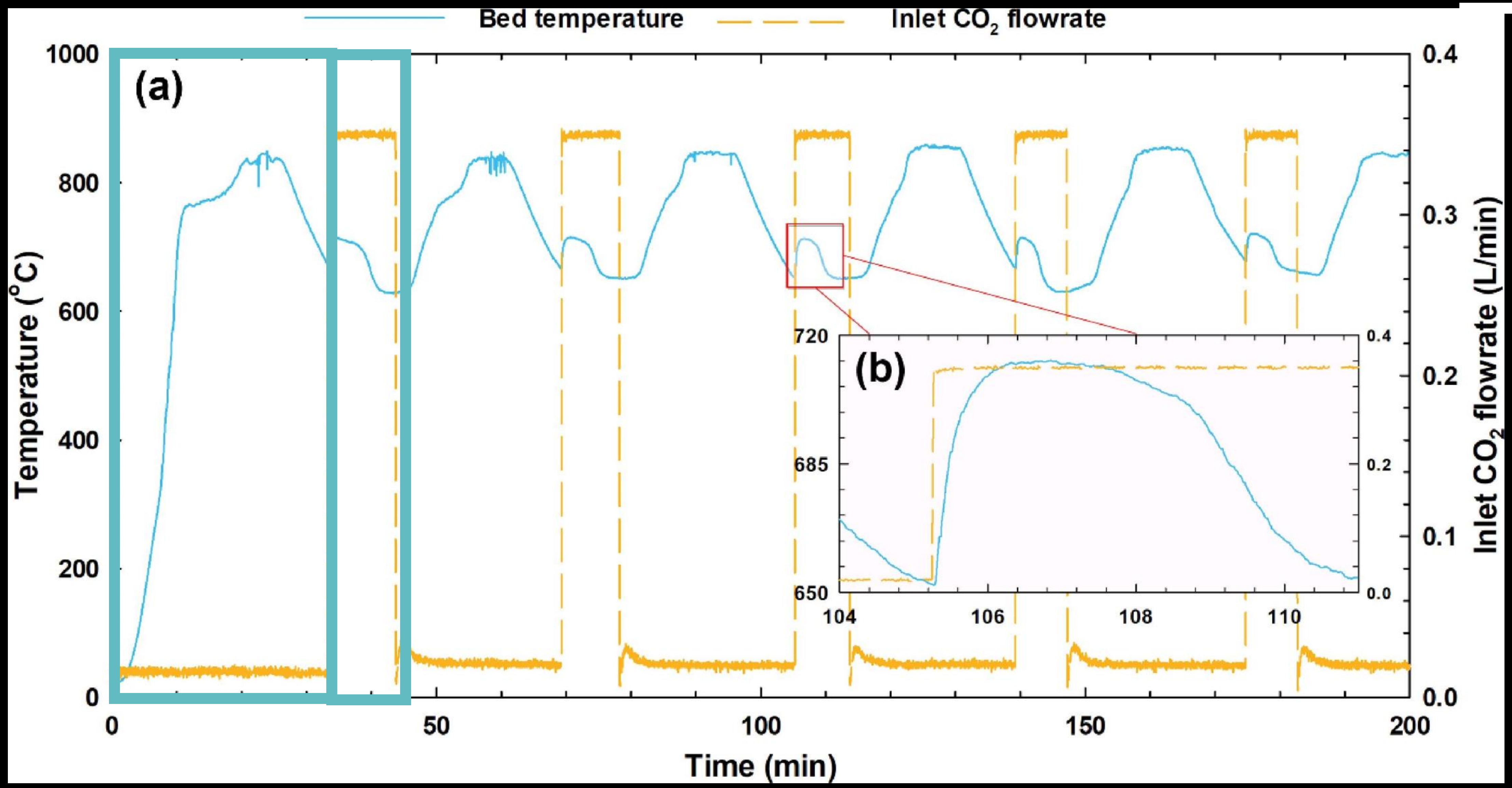
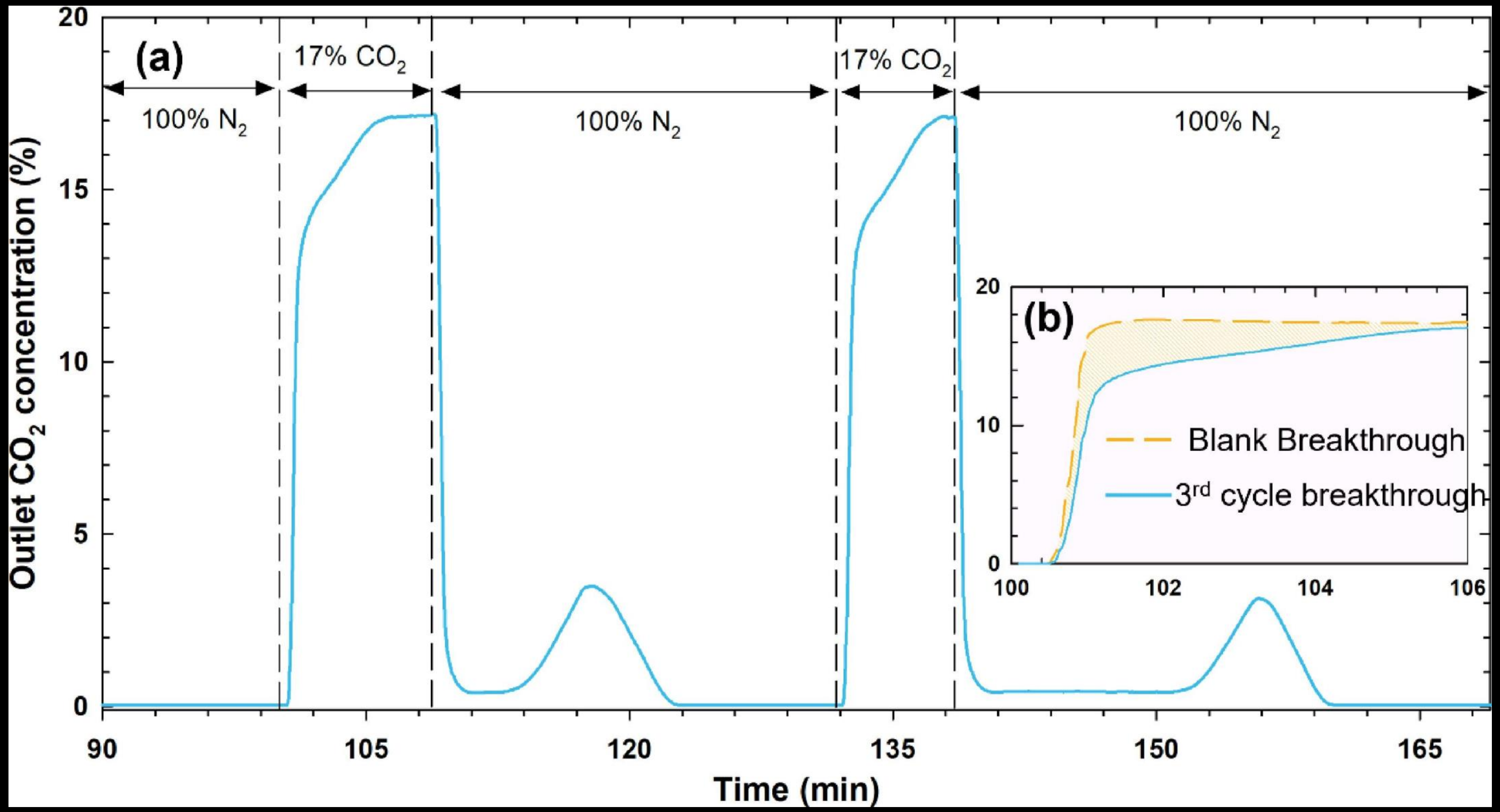
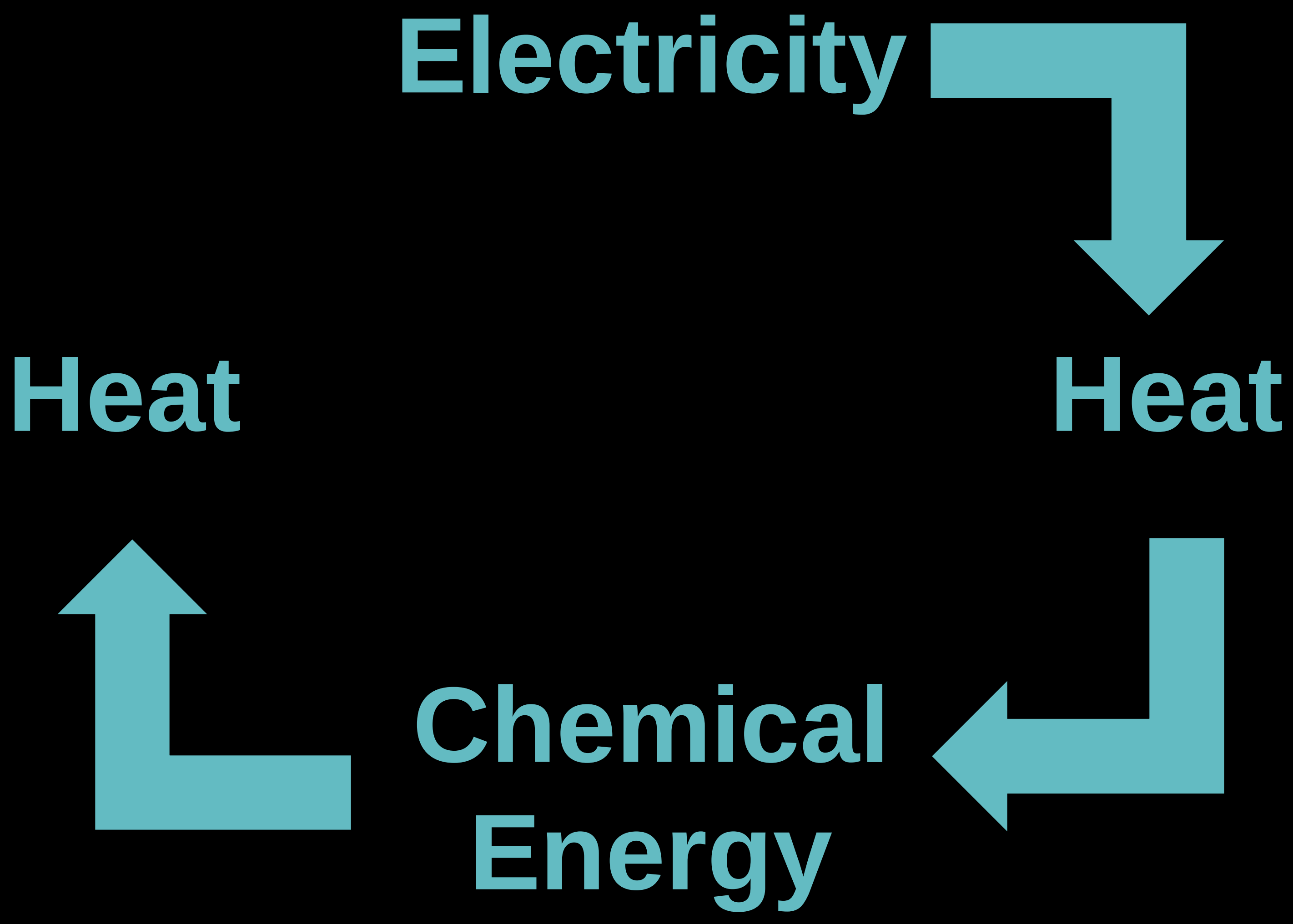
Supplementary 6: Proof of Concept Single Reactor

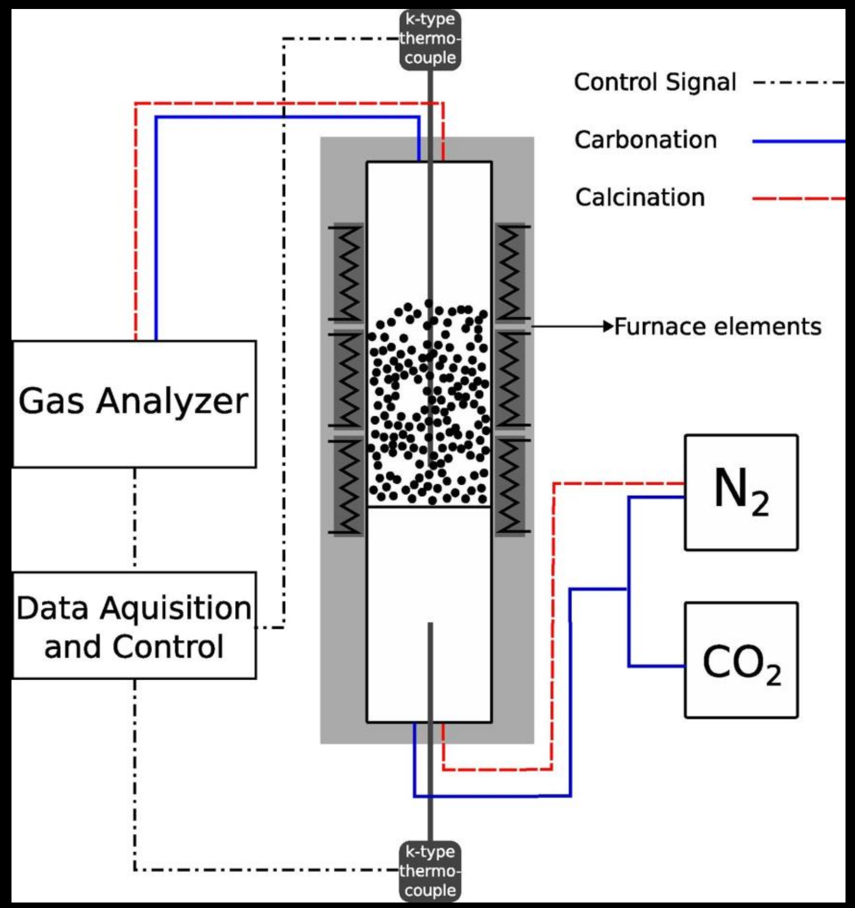




Using electricity to desorb CO_2 and regenerate heat during absorption

CO_2 absorption/desorption cycles

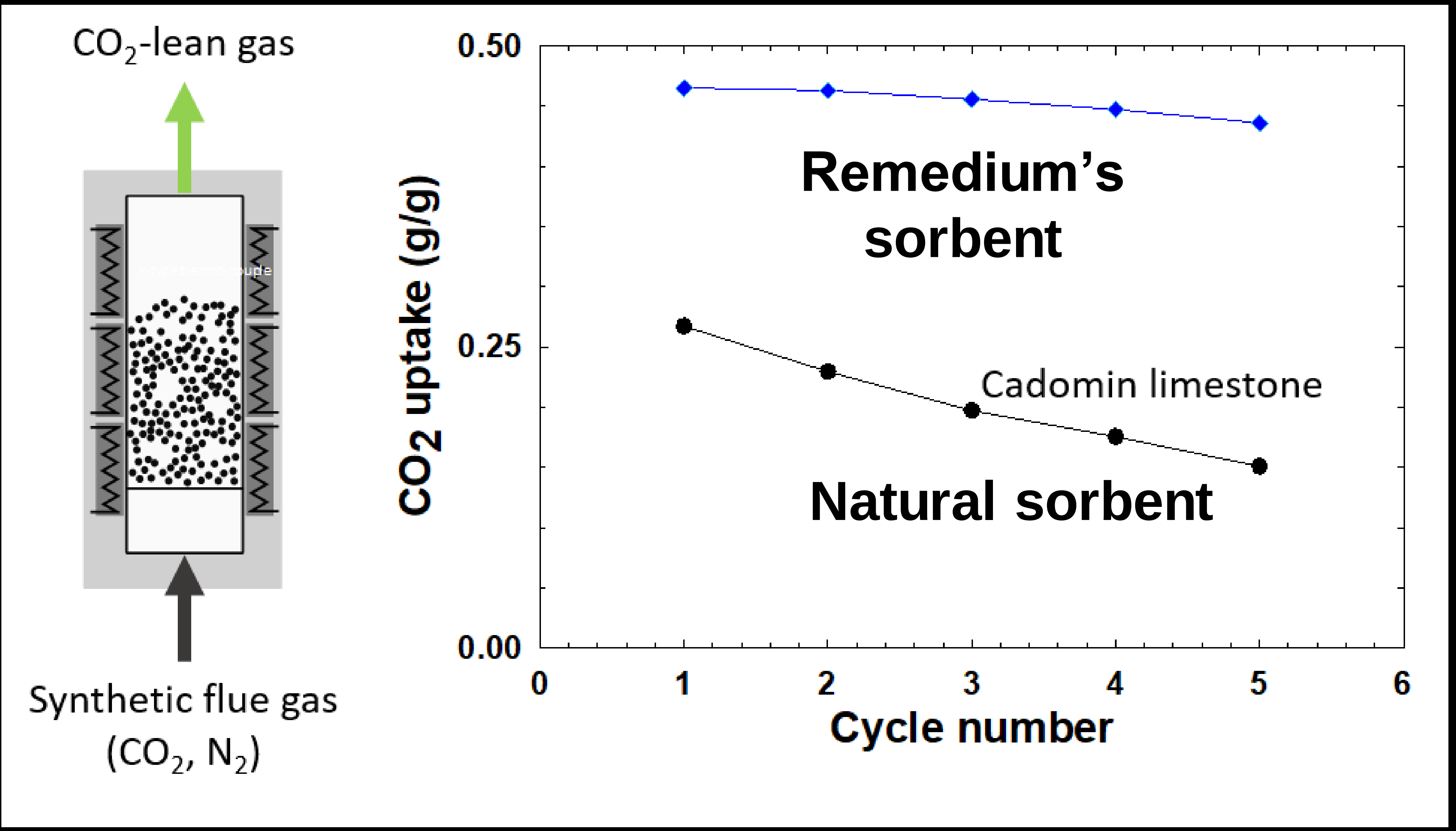




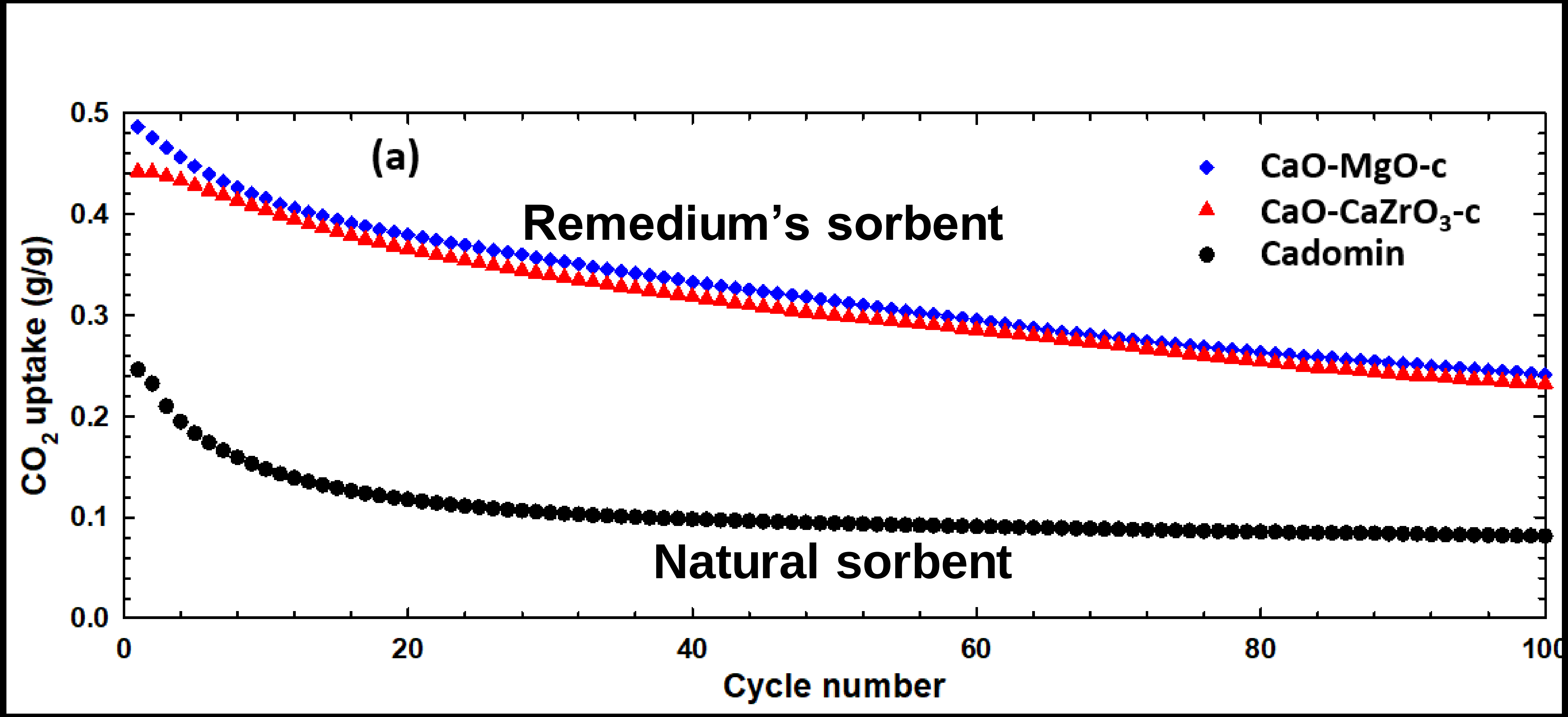
Reactor Setup

Supplementary 7: Remedium's superior sorbent

Performance in bench-scale reactor



Performance in lab-scale micro-reactor



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Supplementary 8: Competitor Analysis

	Remedium (Carbon Capture Battery)	Svante (Metallic Organic Framework)	Delta CleanTech (Amine absorption)	Climeworks (Direct Air Capture)
Benefits	- Profitable Carbon capture scheme - Applicable to wide range of flue gases - Minimal waste (used sorbents recycled in cement) - Electrical regeneration enabling renewable energy use - Providing storage capability to the grid for excess renewable energy storage - Capable of retrofitting current infrastructure - Improved performance in presence of humidity -Cheap and abundant calcium based solid sorbent	- Low heat requirement - Applicable to cases with low temperature waste heat - Applicable to a wider range of scales - Minimal waste - Capable of retrofitting current infrastructure - Pilot scale demonstration	- Commercially available - High TRL - Applicable to low temperature waste heat - Capable of retrofitting current infrastructure - Humidity does not have an effect on its performance	- Capturing CO2 from air - Can be utilized anywhere - Pilot scale demonstration - Minimal waste (used solid sorbents) - Electrical regeneration enabling renewable energy use
Cons	- High capital investment - Applicable only at large scale - Low TRL - High heat requirement (Advantageous as an energy storage scheme) - High Temperature heat needed (Advantageous as an energy storage scheme)	- Expensive sorbent (Metallic Organic Framework) - Fossil fuel fired heat input - Degraded performance in presence of humidity	- High heat requirement - Up to 2kg of waste amine per tonne of CO2 - Fossil fuel fired heat input	- Expensive cost of capture - High heat requirement
USPs over competitor	N/A	- A means of revenue generation - Grid-scale electricity storage - Electrified regeneration process - Cheap calcium based sorbent - No need for flue gas dehumidification	- A means of revenue generation -Grid-scale electricity storage - Electrified regeneration process - Minimal Waste	- A means of revenue generation -Grid-scale electricity storage - Electrified regeneration process - Minimal Waste
COST of CO_2 avoided	20£ to -10£	50£	50£	> 100£
Competitor risk rating	N/A	Low	Medium	Low

Supplementary 9: Metrics

Key Metric	Description of Key Metric	Best in Class Incumbent	Your Solution Today	Your 24-month Target	Your long-term goal
Round-Trip Efficiency	Percentage of electricity output during discharge over electricity input during charge	Pumped Hydro 65-75%	0%	20%	40%
Energy Density	Amount electricity stored per volume of storage medium	Hydrogen 600 kWh/m^3	0 kWh/m^3	50 kWh/m^3	300 kWh/m^3
Levelized cost of storage	Cost of electricity stored over the technology lifetime	Pumped Hydro 10-15 $/MWh	n.a.	>1000 $/MWh (Because of its small scale)	25-30 $/MWh
CO2 capture effectiveness	Percentage of CO_2 captured by the technology from the flue gas stream	Amine >90%	40-50% (Published results: Link)	>90%	>90%
Cost of CO2 Avoided	Change in the levelized cost of the plant product due to addition of carbon capture	Calcium Looping 30-50 $/tonne	n.a.	300-500 $/tonne (Because of its small scale and no electricity selling scheme)	-10 $/tonne
TRL	Technology Readiness Level	Amine 10	3	5	10

Supplementary 10: Carbon Intensive Industries Likely to Take a Hit

Tax credits (e.g. 45Q in the US) and carbon taxes (e.g. in Canada) are the main market drivers.

	Price/tonne (or MWh) w/o carbon tax	Carbon emitted/ tonne (or MWh)	Price/tonne (or MWh) w carbon tax	Change
Cement	$125	1 tonne	$295	+136%
Steel	$750	1.8 tonne	$1056	+41%
Ethylene	$1,000	1.3 tonne	$1221	+22%
Electricity	$66	0.4 tonne	$134	+103%

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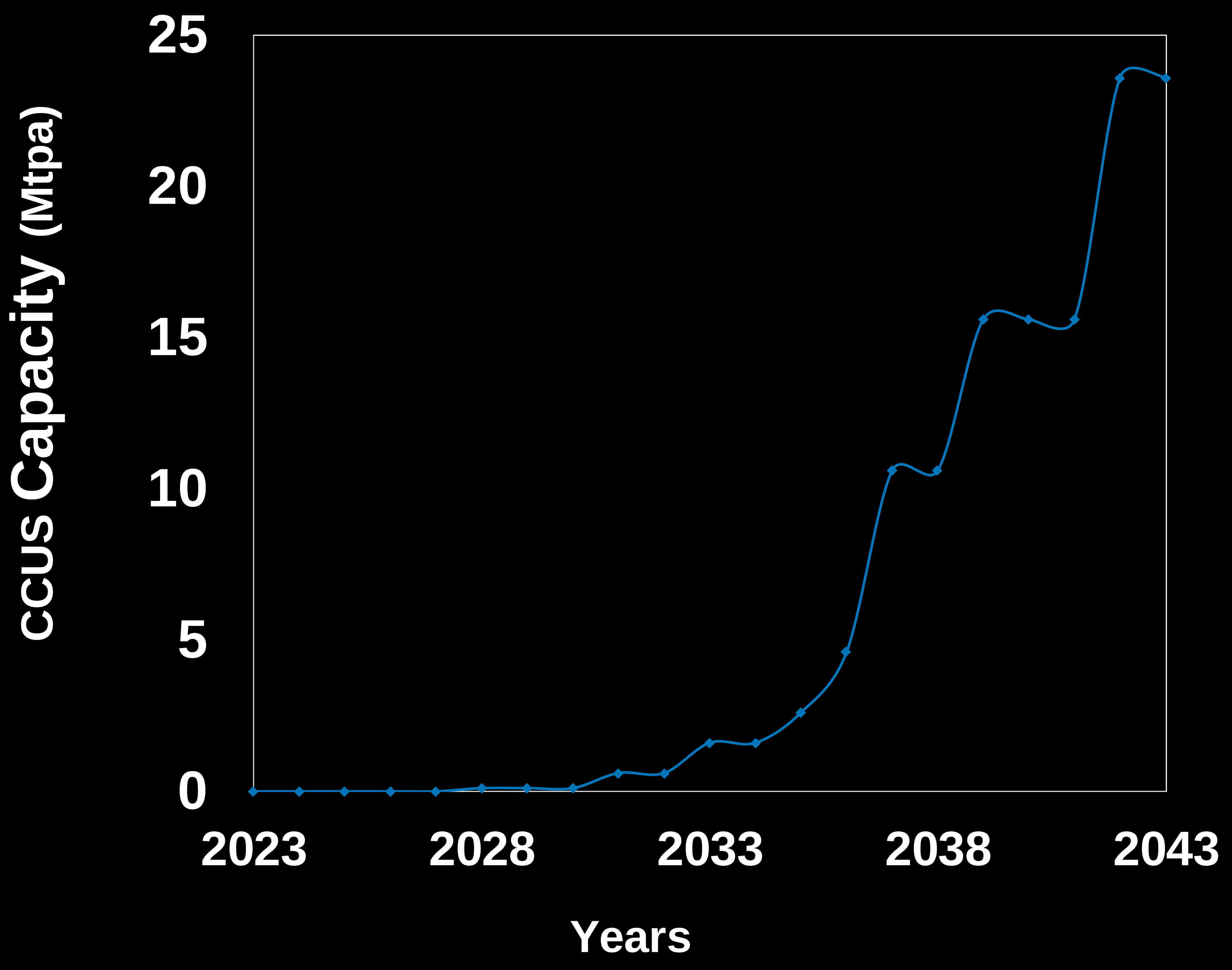
Supplementary 11: Potential customers CO_2 emission

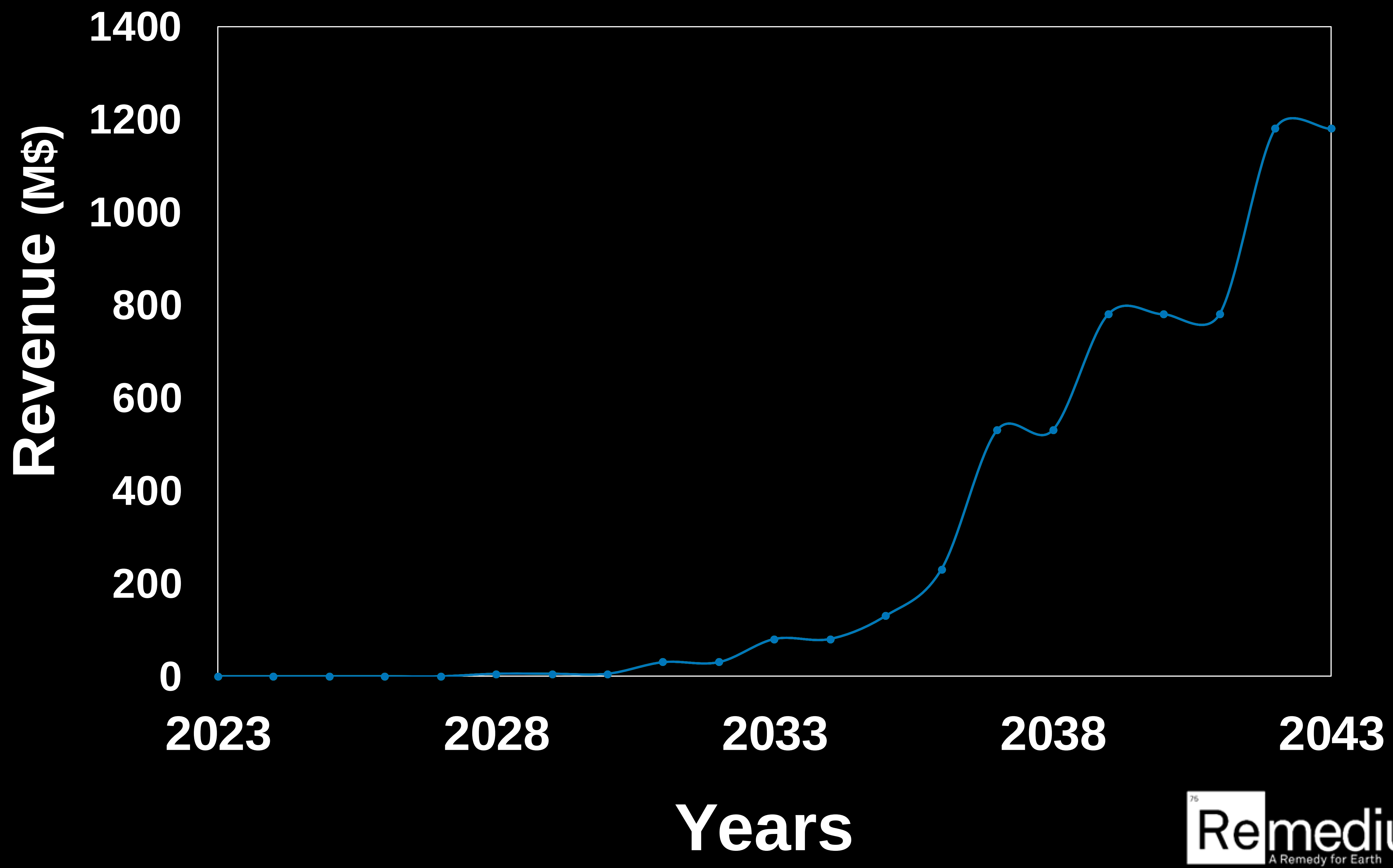
	Worldwide production (million tonne or TWh)	Worldwide CO_2 emission (million tonne)	Countries shares (million tonne or TWh)				
			USA	Germany	France	UK	Canada
Cement	4400	4400	83	31	18	8	12
Steel	1900	3400	85.8	40.1	13.9	7.2	13
Ethylene	150	200	31.4	4.9	2.4	-	-
Electricity	28000	11200	4381	584	555	309	633

Supplementary 12: CCUS Capacity & Revenue

We intend to build our pilot plant by 2028 with annual CO_2 capture capacity of 0.1 Mtpa. The next stage of our growth is to construct our first commercial plant with capacity of 0.5 Mtpa by 2031.

As we continue our growth and expansion, Remedium's CO_2 capture capacity is expected to at least increase to 24 Mtpa by 2043 which is roughly 0.5% of total global demand for CCUS in 2040.





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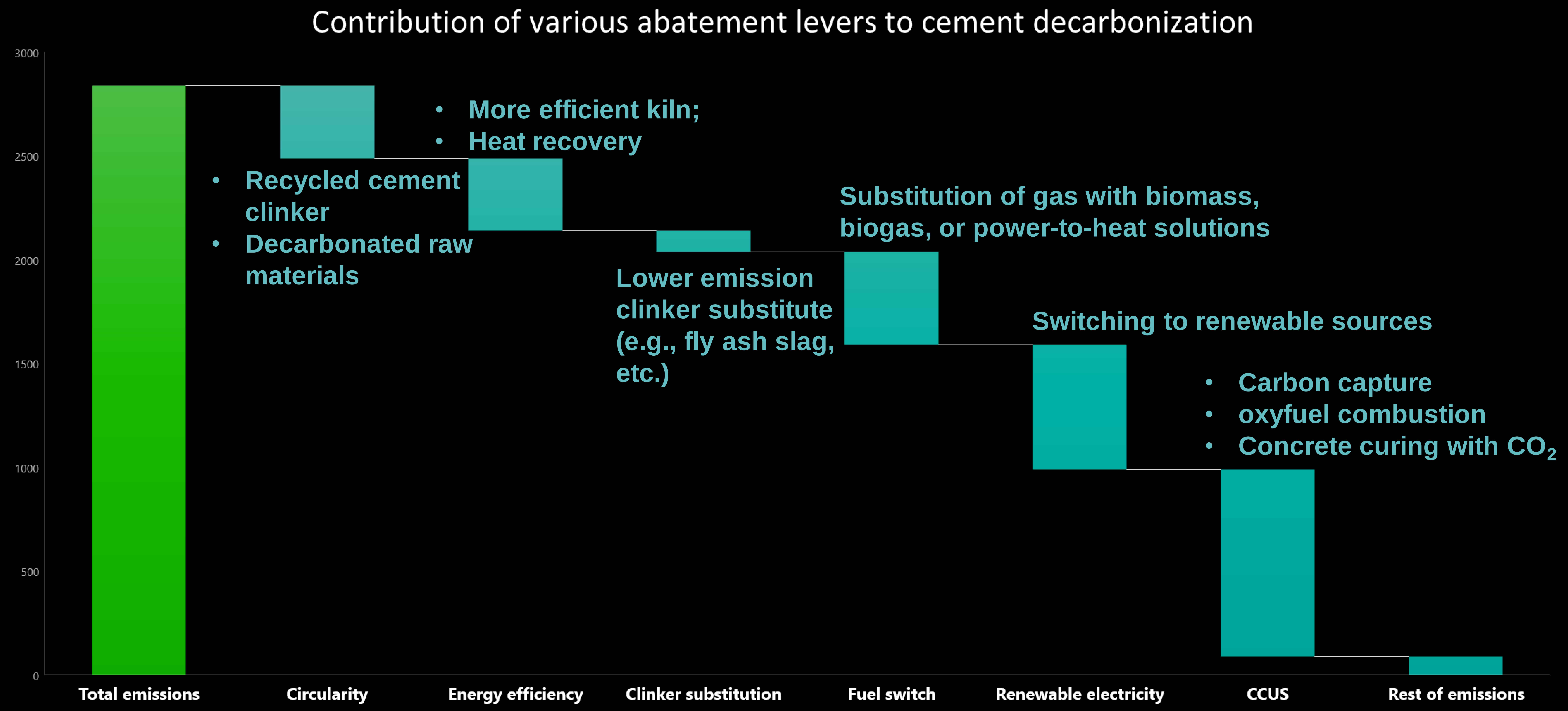
Supplementary 13: Cement emission reduction levers



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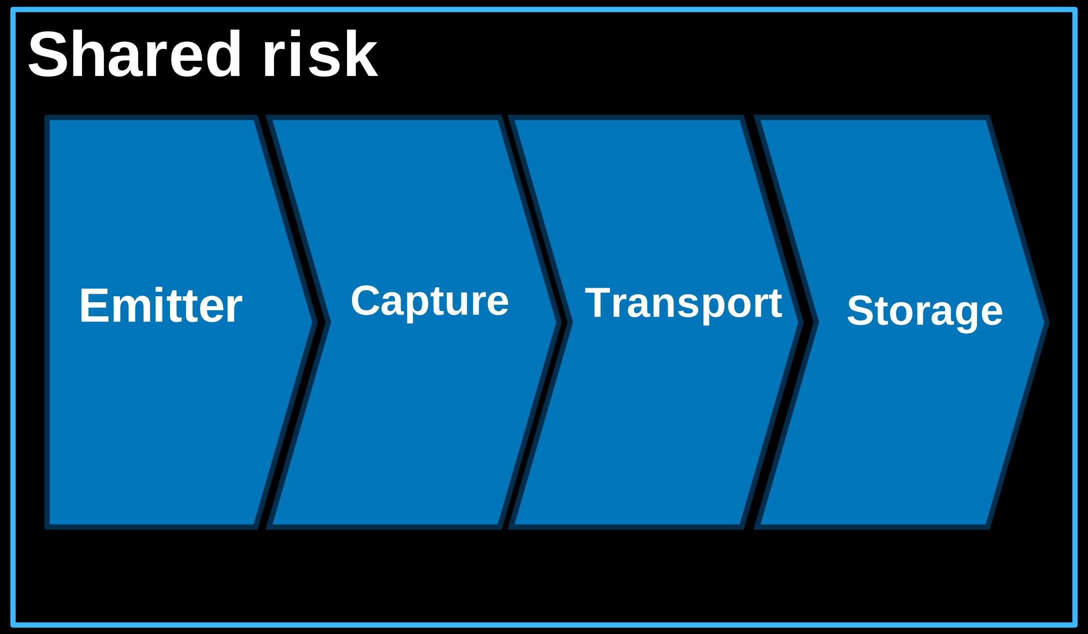
Supplementary 14: Business models

End-to-end player

Single player owns and operates capture, transport, and storage assets. Most commonly used for own-asset decarbonization.

Example: Shell Quest

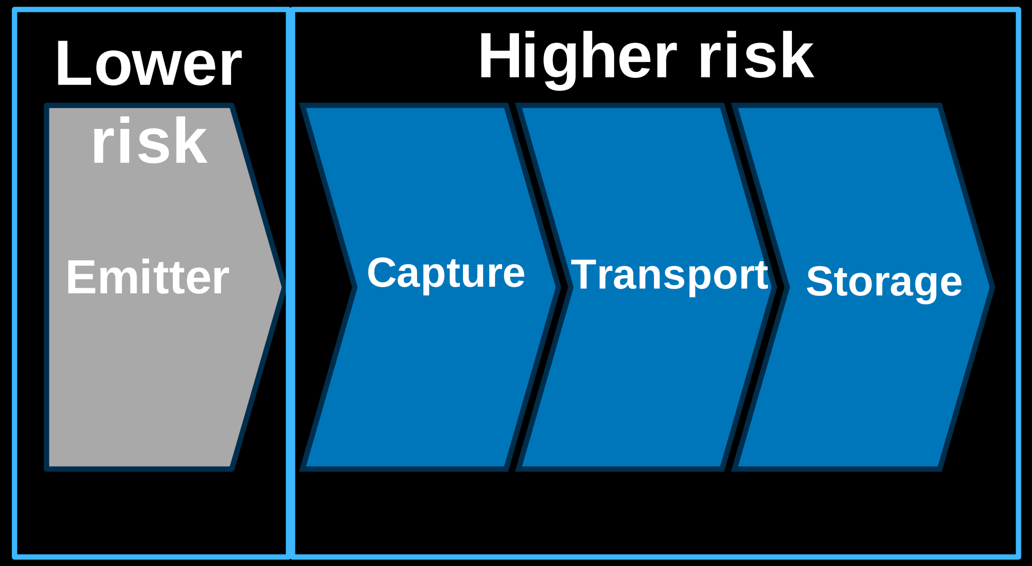


Emissions offtake

Capture service providers buy CO_2 from emitters for a fixed fee

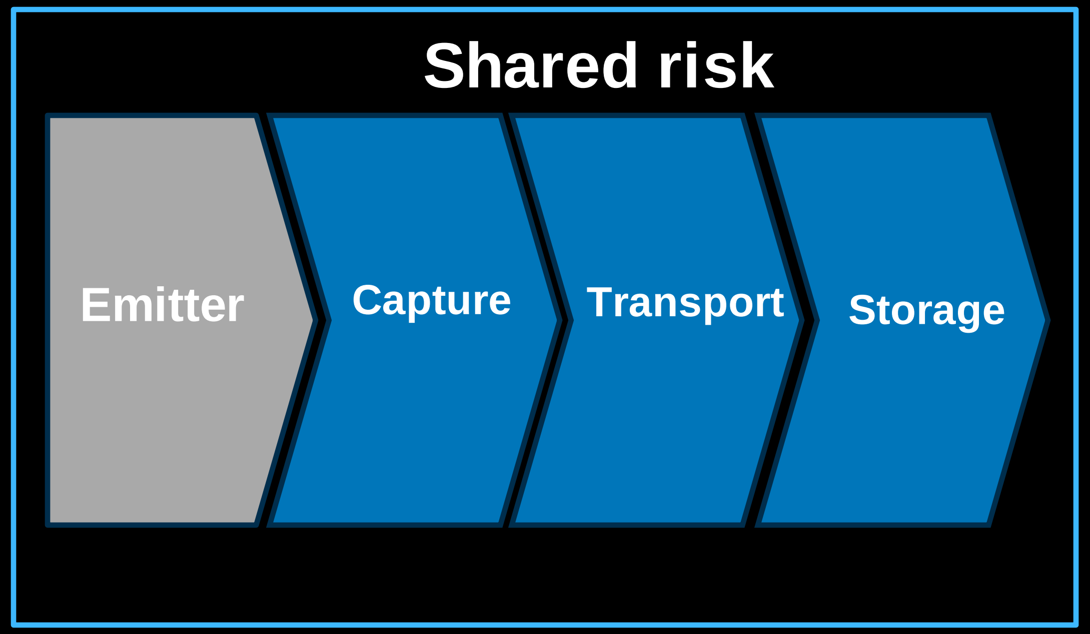
OR

Emitters pay a fixed fee to capture service providers to reduce their emissions and avoid taxes/penalties



Joint venture

Emitter pay a fixed liability cost based on the cost of carbon emissions to the JV pool; risks and rewards split between the JV parties



T&S as a service

T&S owners charge a fixed fee for their services to enable emitters to reduce their emissions and/or receive government incentives.

Example: Northern Lights, Porthos, Aramis