OpenMinds

NextGen Project Readouts

Carbon Capture, Utilization, and Storage

December 2025

CALPINE®

Main insights and recommendations from the NextGen team

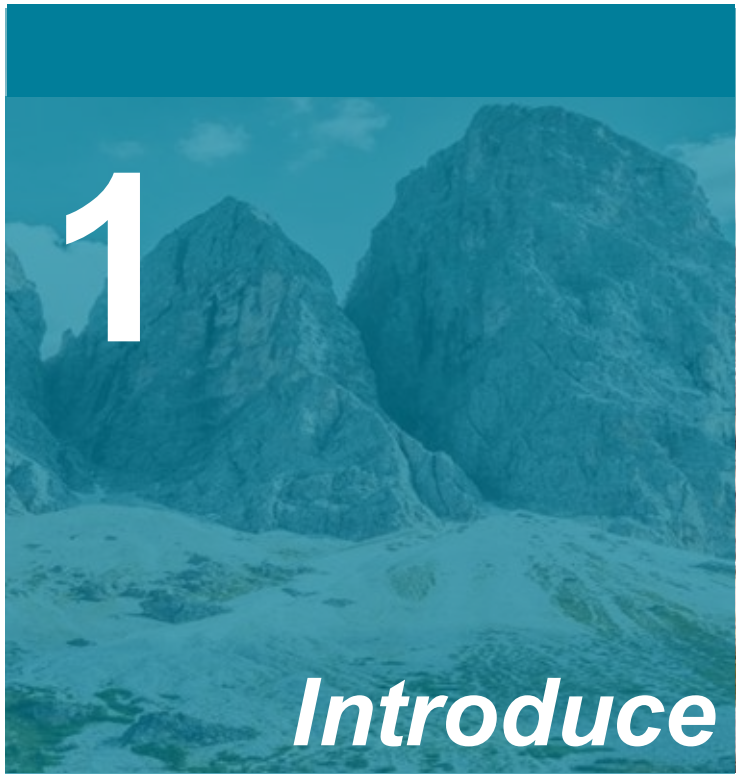
Overview	**Goal:** Identify moonshot carbon capture opportunities for NGCC ● Assessed the landscape of novel capture technologies globally, selecting a technology shortlist ● Evaluated shortlisted technologies on capture economics, commercial momentum, strength of team, and strategic partnership opportunities ● Identified potential across moonshot solutions; significant ecosystem collaboration is required

Recommended Companies for Collaboration *(alphabetical order)*		
Ardent	*The Scaler with a Hybrid Edge*	Hybrid membrane and sorbent; experienced scale-up team; promising NGCC applications; lesser cost reduction potential
KC8	*Strongest Commercial Traction, Best Bet for the Near-Term*	Potassium carbonate solvent; strong commercial traction; <$50/t$CO_2$ credible
Mantel	*The Truest 'Moonshot' for Energy-Positive Capture*	Molten borate system; heat recovery lowers energy penalty; lowest cost potential

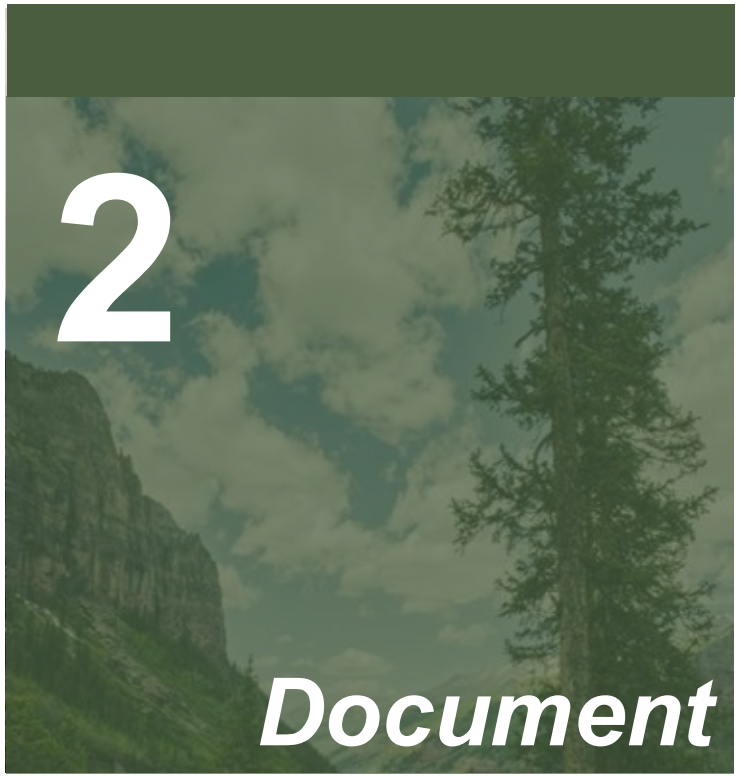
Recommended Next Steps	● Discuss technological and commercial characteristics of shortlisted companies; identify top opportunities for near- and long-term collaboration ● Engage with selected companies; discuss next steps for partnership (e.g., NDAs) ● Monitor progress on lower TRL technologies, including through Stanford STEER

AGENDA:

Presentation outline and objectives



Project foundation and team members



Project approach and technology overview

Insights, results, and recommendations

OpenMinds

CCUS NextGen project team

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PROJECT COACHES

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PROJECT SPONSOR

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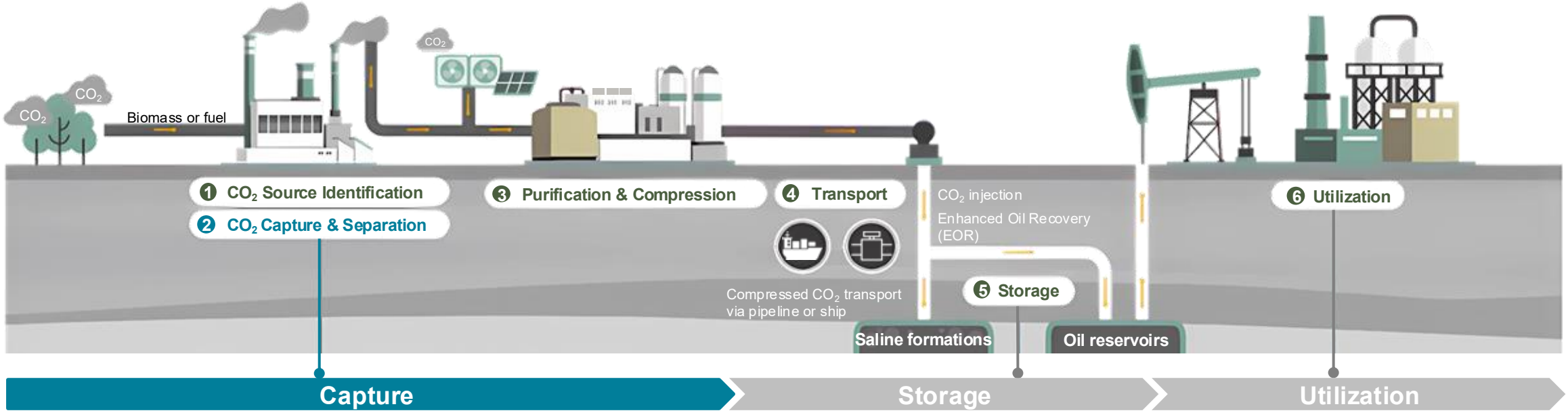
Can moonshot capture tech deliver cost reductions by 2040?

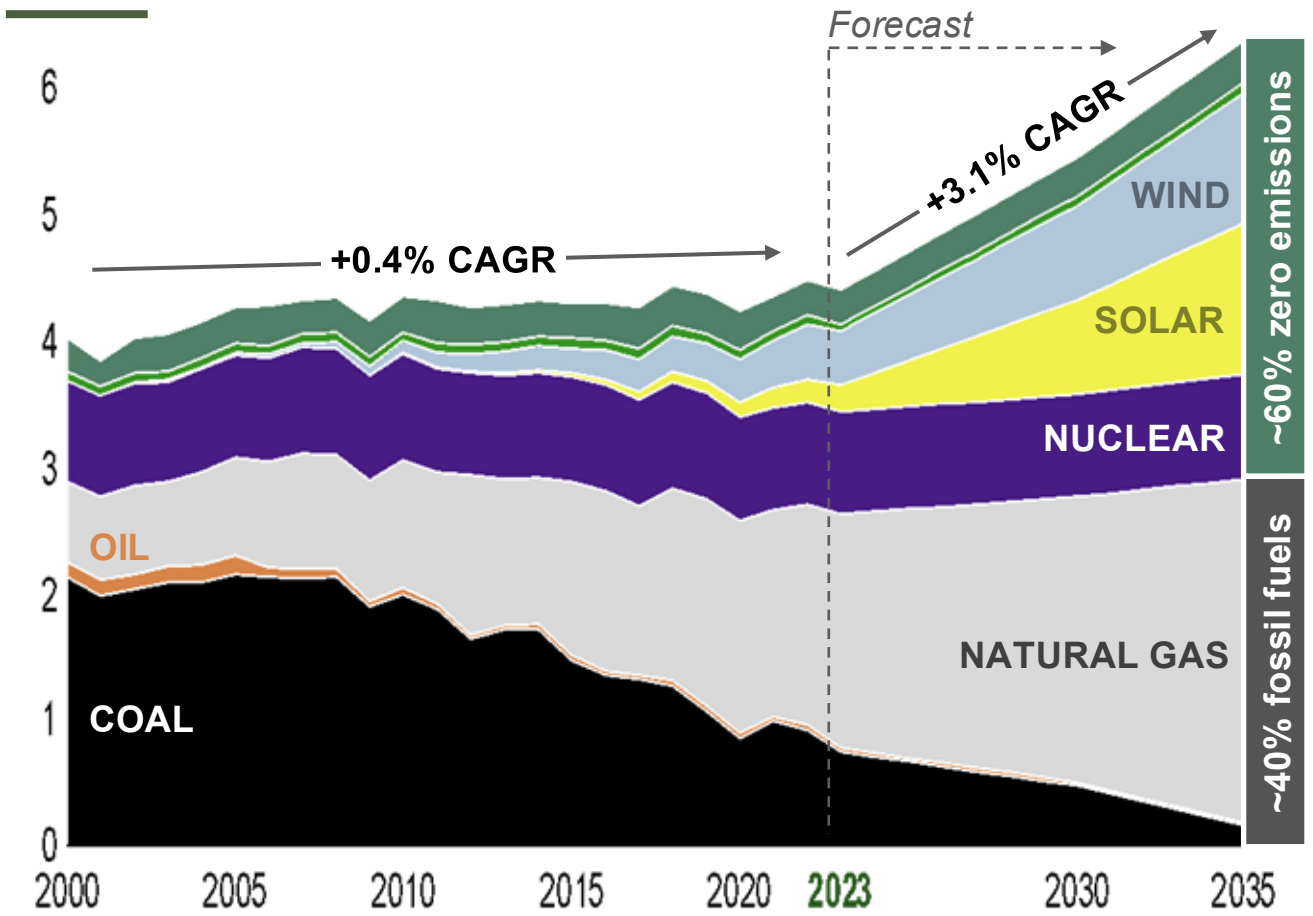
Project:	Assess emerging CO_2 capture technology as a source of moonshot cost reductions for implementation on natural gas power plant carbon capture and storage (NGCC CCS).

Project scope (NGCC CCS capture technology) mapped against the CCUS value-chain:



NGCC CCS is challenging for two main reasons: **CONCENTRATION** (typical flue gas stream is ~4% CO_2) and **ACHIEVING VOLUME** (>1Mt CO_2 /year)

Natural gas is expected to be ~40% of US power gen by 2035



CCS technology enables natural gas plants to deliver **stable, continuous power** while significantly reducing emissions by **capturing 95% of CO_2**.

Calpine operates a large natural gas power generation fleet, with a capacity of **~27 GW across 79 facilities**.

Affordable, reliable energy for all, with less emissions – fast.

Note: (*) Variable renewable energy - includes percentage share of wind and solar combined; Other renewables include 'Hydropower'; IRA – Inflation Reduction Act
Source: Intersect$_{SM}$ Carbon & Energy Transition CGE Model; IEA

The historical industry-scale standard: amine-based capture

Example: Petra Nova carbon capture project

the largest post-combustion CO2 capture project in the world[1]

Energy intensive:
temperature swing regeneration results in high energy penalty and opex

Large capital requirements:
challenges project economics and keeps the cost of capture high

Highly bespoke design:
integration into existing NGCC makes it challenges to iterate and standardize

Specialized equipment:
strains the supply chain and results limited movement down the cost-curve

Cost goals for NGCC CCS:

amine-based systems remain costly[2]

NGCC CCS costs

CO2 capture subsidy per 45Q/45Z:

$85/tCO$_2$e

vs.

Estimated cost of NGCC amine CCS:

~$150/tCO$_2$e

Resulting in a substantial green premium

Capture only

Current capture component cost:

~$100/tCO$_2$e

a moonshot reduction of 50%

Moonshot goal for capture cost of NGCC:

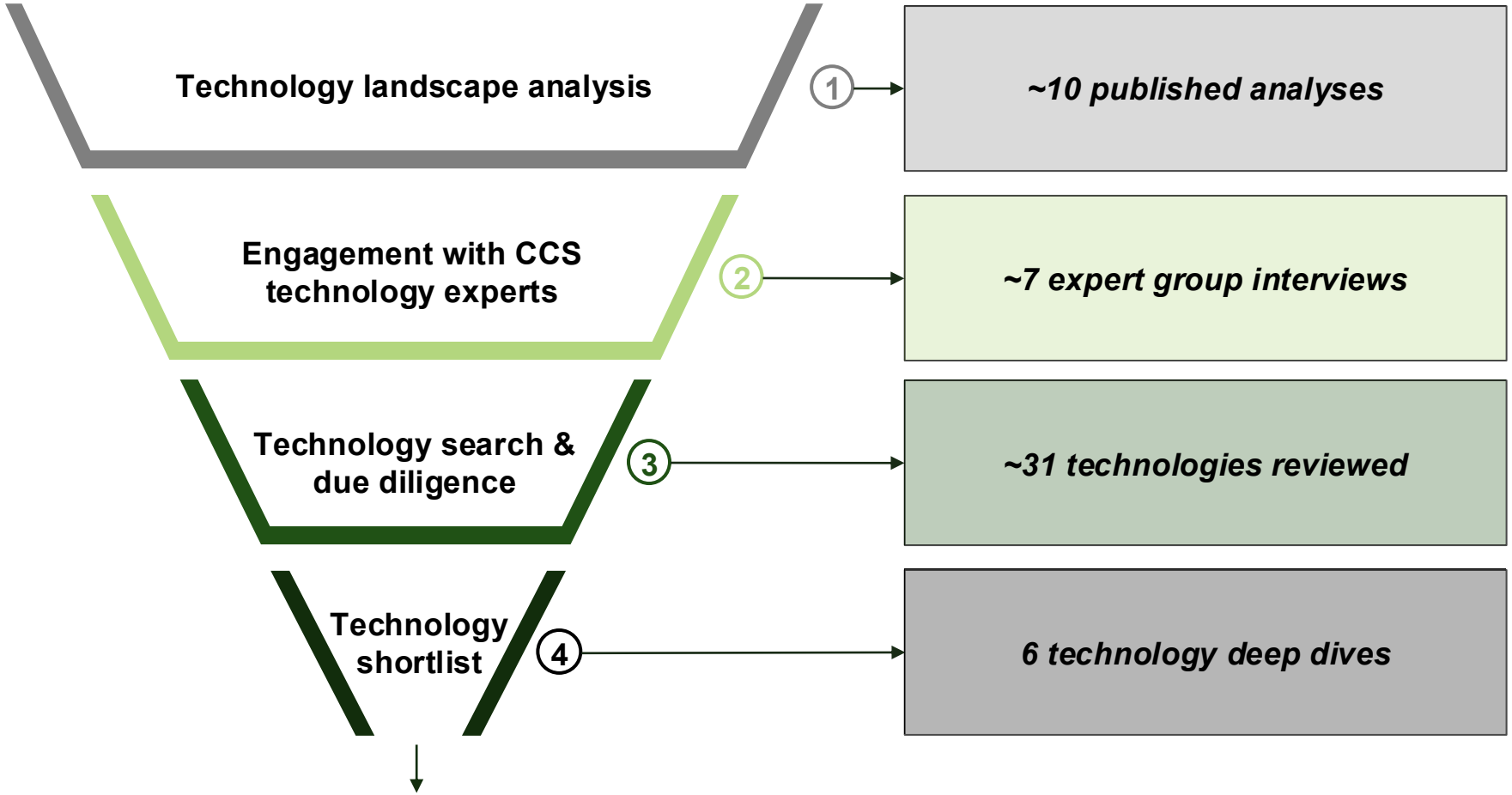
~$50/tCO$_2$e

to bring cost on parity to current tax credit

Source: [1]Mitsubishi Heavy Industries (MHI) Group, [2]Bain CCUS POV Study for OpenMinds

Our approach to finding moonshot capture technology

Project approach for moonshot technology identification:



Goal: Identify **2-4 capture technologies** that have real potential at delivering moonshot cost reductions on a 2040 timeframe

Broad landscape of capture technologies being explored

NON-EXHAUSTIVE

Types of capture technologies considered

Solvent technology

Amines

Amino Acids

Ammonia

Non-aqueous

Aqueous Inorganics

Physical Solvents

Sorbent technology

Functionalized Supports

Metal Oxides

MOFs

Zeolites

Others

Membrane technology

Other capture technology

Cryogenic

Oxy- / Gasification

Biological

Source: Mantel Capture, Inc

Expert interviews conducted with leading developers, consultants, and investors

First-hand experiences and insights

Amine Tech Still Dominant

- Liquid amines remain baseline for NGCC (3–6% CO_2).
- Path to <$85/t requires advances in solvent chemistry + system integration, not just scale.

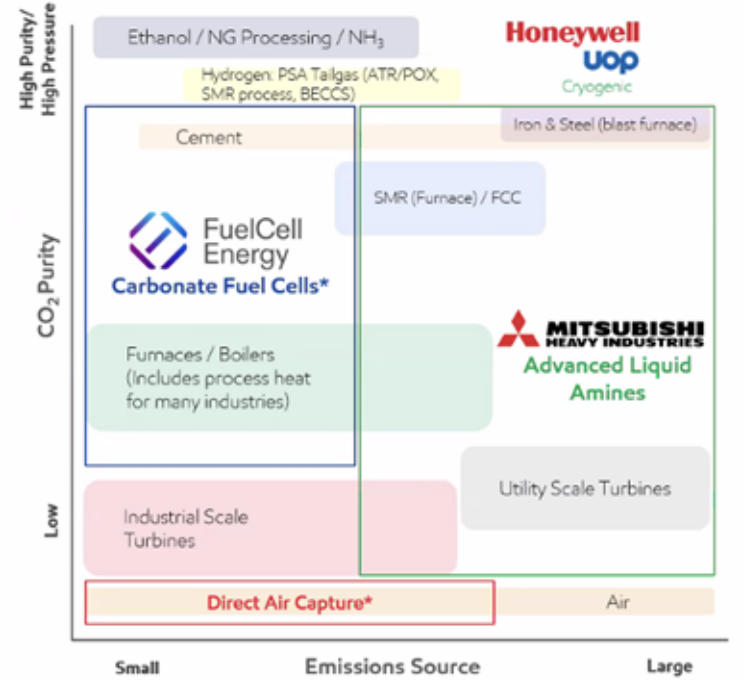
Cost Curve Reality Check

- Absorber/stripper towers are mature; unlikely to see big step-change cost drops.
- Innovation levers: advanced solvents (MHI KS21, Carbon Clean), compact contactors (Baker Hughes).
- Policy & credit markets (45Q, EOR) remain critical to economics.

Alternatives Face Big Hurdles

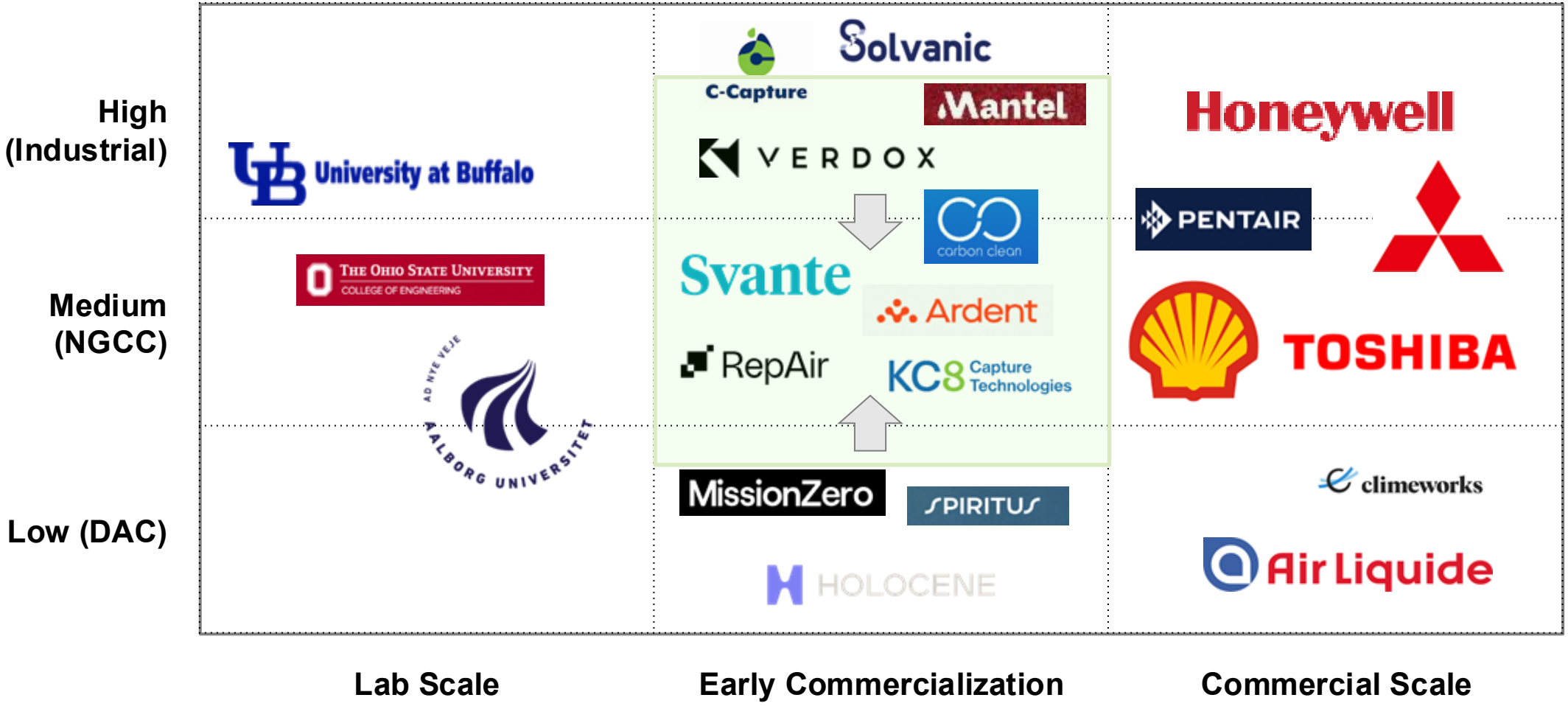
- Cryo separation at ~4% CO_2 concentration is too energy intensive
- Potassium Carbonates technology might achieve cost reduction if combined with waste heat management
- Solid sorbents technology may requires complex engineering design to maximize reaction areas, potentially increasing cost
- Electrochemical and membranes are still at early stage, need to overcome the low-CO2 concentration barrier.

Current technology map



Carbon Direct · ExxonMobil · National Energy Technology Laboratory · GE Vernova · Bain & Company · Google · Net Zero Technology Centre — Technology Driving Transition

We refined the landscape based on commercialization stage & CO2 concentration; some are working up/down towards 4% concentration



Shortlisted moonshot companies for technology deep dive

	Ardent	KC8 Capture Technologies (Towards a carbon neutral future)	RepAir	Mantel	Svante	carbon clean
Core Technology	**Membrane hybrid**	**Solvent**	**Electrochemical**	**Molten salt**	**Sorbent**	**Solvent**
Cost Target ($/t)	70–80	40	50	20	unknown	70
Takeaways	• Experienced team • Strong techno-economic analysis completed • Seeking partners to support NGCC scale-up	• Low capex • Flexible operation • Preparing for next commercial pilot • Exploring funding and partnership opportunities	• Low energy consumption • Applicable for 4% CO_2 • Early-stage TRL, requires scale-up validation	• ~30% lower capex vs. amine systems • Potential energy integration benefit • Engaging partners for FOAK scale-up	• Strong capitalization and commercial pilot activity • Early deployment underway	• Established solvent platform • Targeting large-scale plant (>500k t/yr) in 2029–2030
Next Steps	• Calpine & OpenMinds to engage with startups to explore potential partnership opportunities				• Execute NDA to discuss technology details • Additional meeting with potential partnerships	

Key theme: NextGen team believes partnership can greatly accelerate development and deployment.

Evaluating technologies beyond self-projected economics

Evaluation framework

including evaluation metrics beyond projects economics

Legend: Good · Fair · Limited

Capture technology	Capture economics	Learning rate differentiation	Current momentum	Proven team	Strategic value add	Supply chain resilience
Ardent	Fair	Good	Fair	Good	Good	Fair
KC8 Capture Technologies — Towards a carbon neutral future	Good/Fair	Fair	Good	Fair	Good	Good
RepAir	Good/Fair	?	Limited/Fair	Fair	Fair	Fair
Mantel	Good	Good	Fair	Fair	Good	Fair

Capture economics: how does the cost-of-capture compare to amines?

Learning rate differentiation: is a substantially different rate of learning expected compared to amines?

Current momentum: are there signs of recent progress on innovation at the scale required?

Proven team: is the team prepared to scale the technology once it has been substantially tested?

Strategic value add: can Calpine and OpenMinds accelerate innovation and deployment?

Supply chain resilience: how readily can the company secure materials and equipment at scale without major bottlenecks or dependencies?

Final insights summarizing the NextGen project analysis

Mantel, Ardent, & KC8

The NextGen team is most excited about Mantel, Ardent, and KC8 as alternative technologies with real potential at delivering moonshot cost reductions on a 2040 timeframe for NGCC CCS application.

Advanced amine solutions

The incumbent industry is moving forward with Advanced Amine Solutions with FOAK and likely early NOAK projects – though there are challenges here, you can try to incorporate learnings (Mantel) or find different solutions (Ardent).

Hybrid and system-level

The 45Q/45Z tax credit goal is a true moonshot evaluating technology plug-and-play options – with this $85/tCO$_2$ goal, hybrid combinations or system redesigns (e.g., gas recirculation, NetPower) show additional promise.

Without partnerships, moonshots will potentially fail to mature

NGCC IPP

Access to scale and NGCC CCS market

EPC & Other

Incumbent technologies and builders

Capture technology

Innovator for a cheaper and better alternative

Challenge:
Many promising alternative technologies are stuck at the **Valley of Death between demonstration and deployment**. These technologies need a pathway to scale, powered by **strategic partnerships**, if they will ever begin to mature down the cost-curve.

Equipment Manufacture

De-risk equipment integration and warranty

Partnership Builder

Unique position to help cultivate partnership

Hyperscalers

Access to willingness-to-pay for carbon free electricity

Legend

- Key Stakeholder
- Secondary Stakeholder

Solving for the
Dual Challenge.