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JULY 2023

Geoheat for Horticulture
Direct Air Capture of CO2

PRESENTED BY

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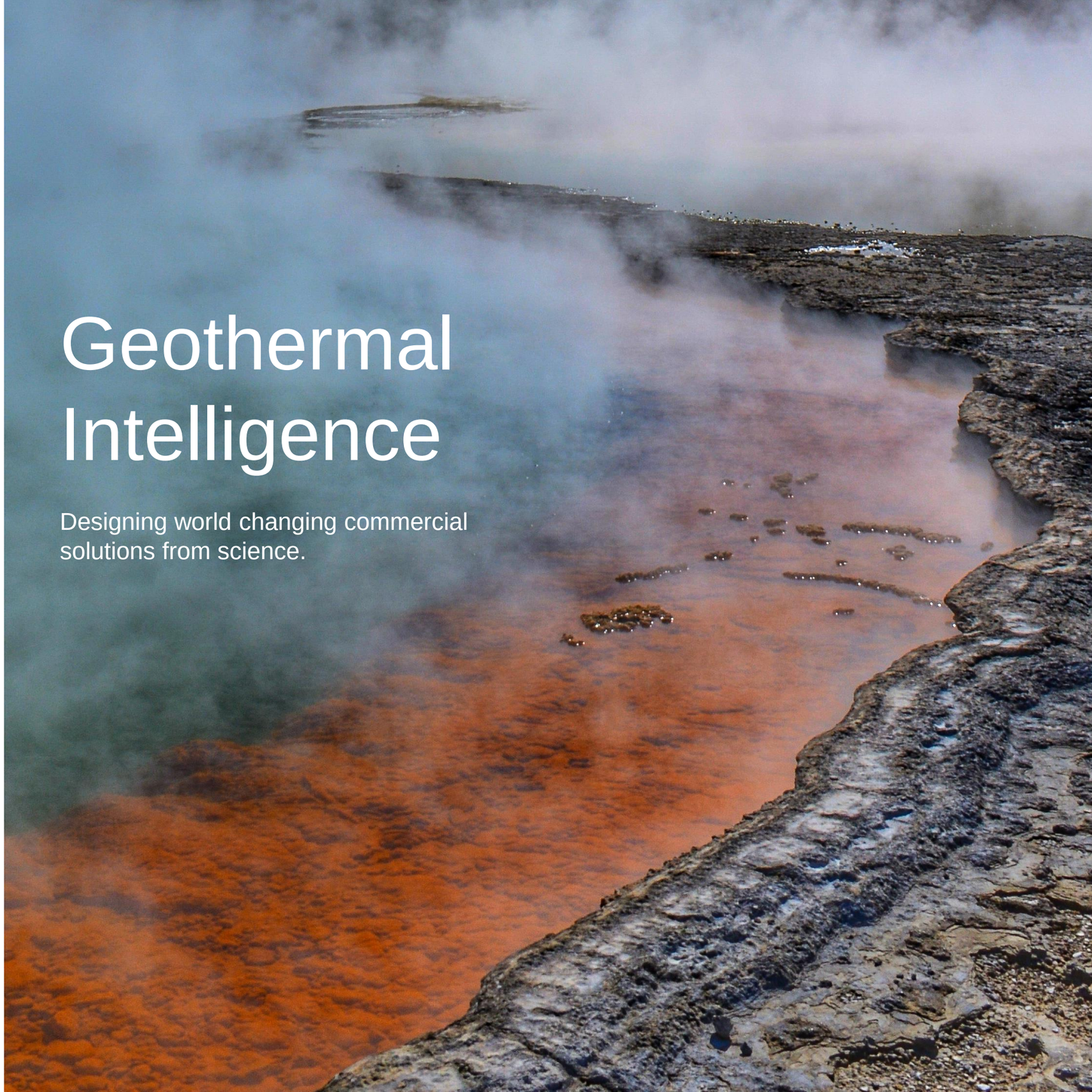
Summary

- Intro to Geothermal Food Systems Project
- What is Direct Air Capture of Carbon Dioxide
- Basic Process for Direct Air Capture
- Geothermally linked Direct Air Capture
- Economics of Direct Air Capture CO_2

Intro

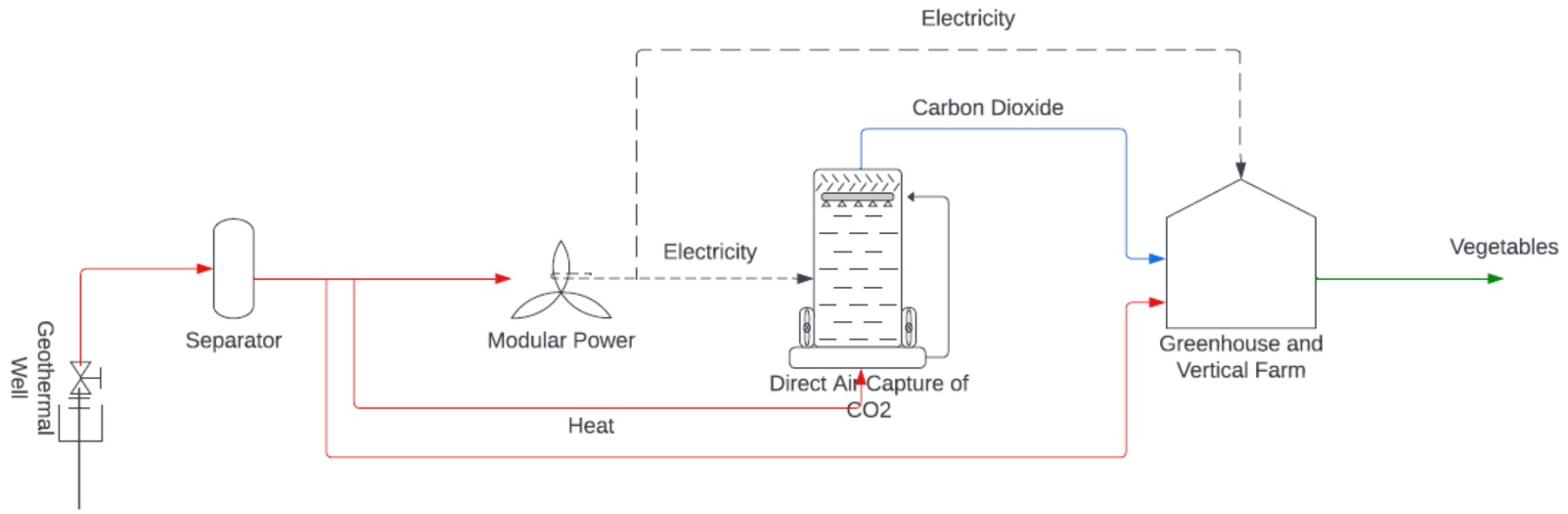
Who Am I:

- Chemical Process Engineer
- ~10 years in the geothermal power generation industry
- 4 years as a Geothermal Power Station Chemist
- 2 years as a Process Engineer – Geothermal Power Stations
- 3 years as a Project Engineer for a Geothermal Well Servicing company
- Started with Upflow ~3 months ago.



Geothermal Food Systems Project

1. Modular Power Generation
2. Direct Air Capture (DAC) of Carbon Dioxide
3. Geothermal heating
4. Greenhouse/Vertical Farm Growing Space



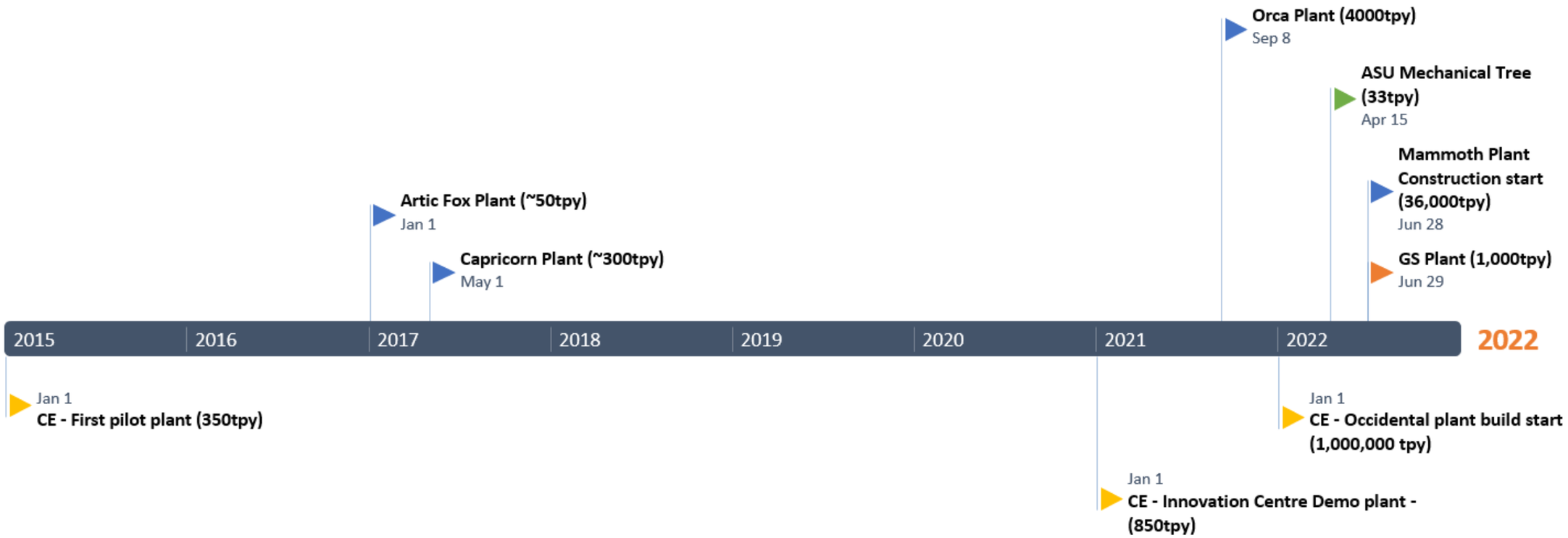
What is Direct Air Capture of CO_2

- Sequestration of carbon dioxide directly from the air
- Acid-base reaction between CO_2 and basic capture media
- Solid sorbents vs liquid solvents
- Typically require fans to get enough air flow for decent CO_2 capture rates

Source: Climeworks website 2023

Source: Global Thermostat website 2023

Deployment of Direct Air Capture around the world



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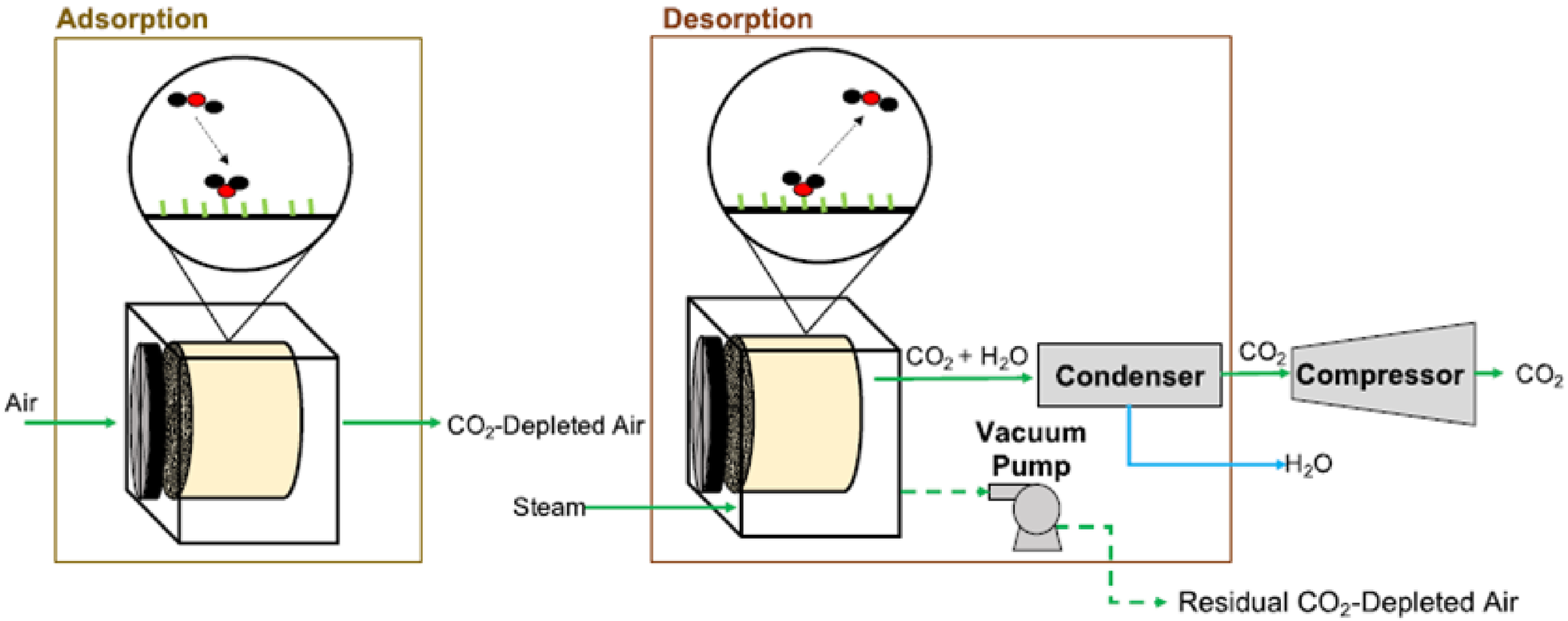
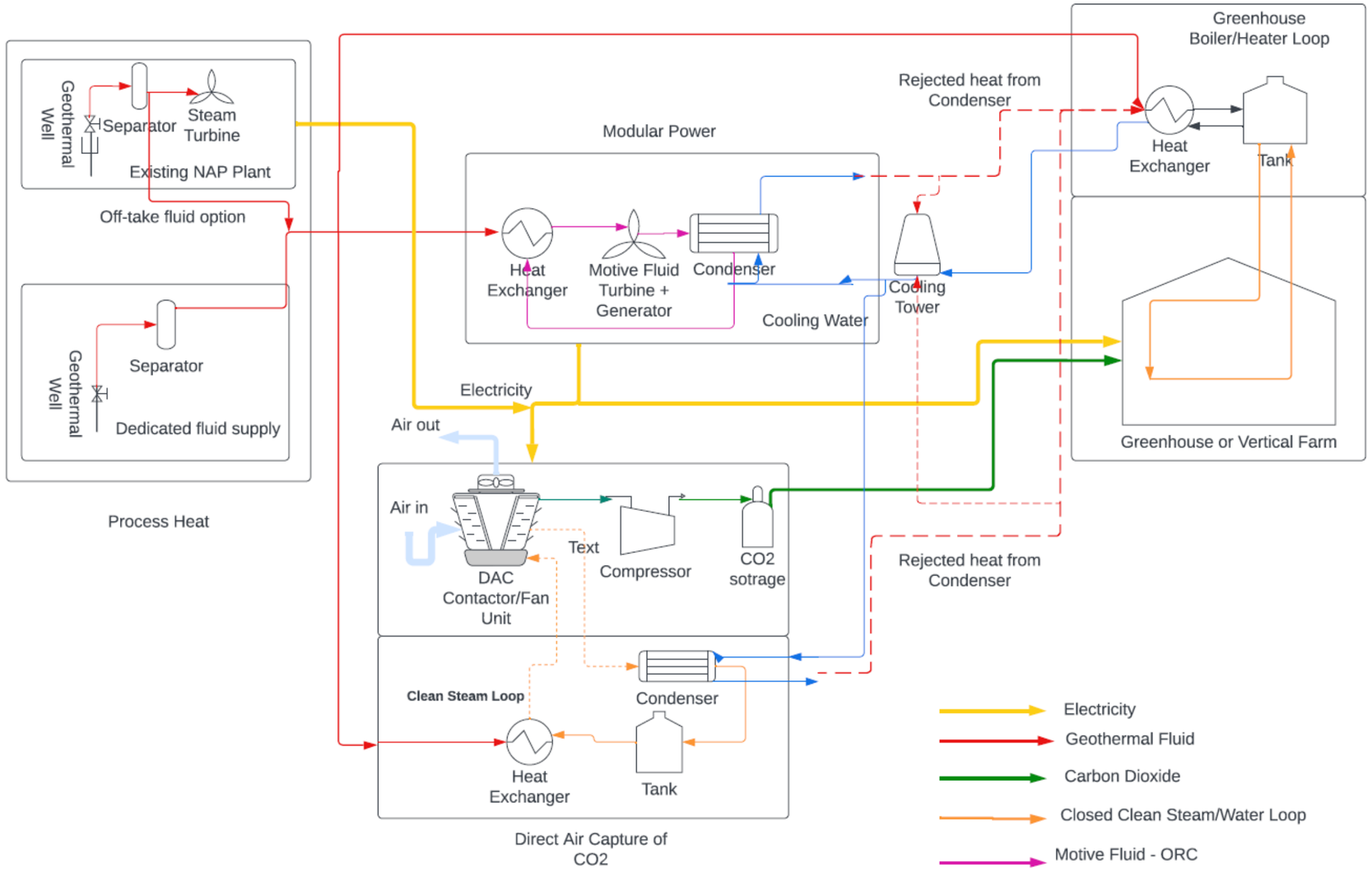
Basic Process for Direct Air Capture of CO2

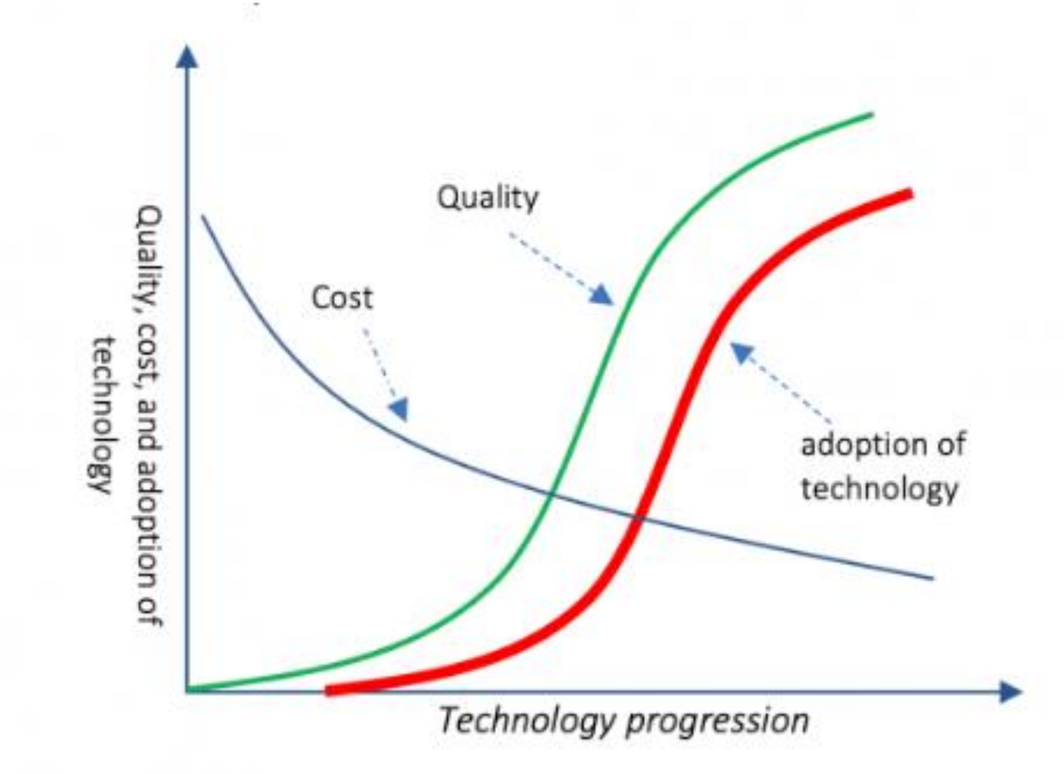


Source: McQueen et al, 2021, “A review of direct air capture (DAC): Scaling up commercial technologies and innovating for the future

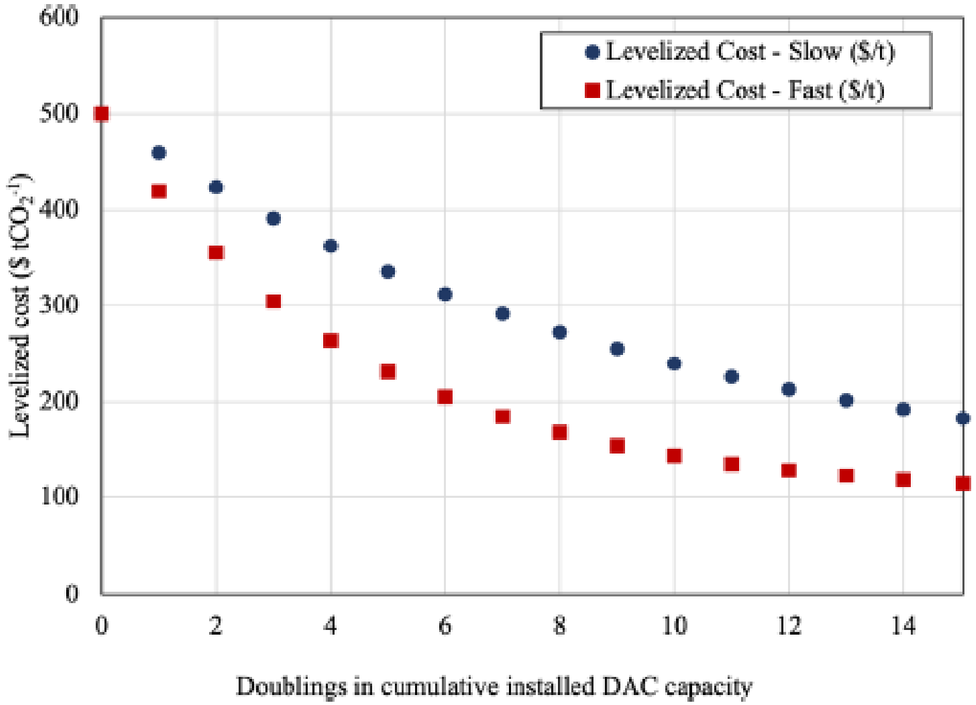
Geothermally Linked DAC plant



Economics of Direct Air Capture CO_2 Production



Source: the-waves.org, “Technology Adoption Lifecycle – from hype to reality”.



Source: McQueen et al, 2021, “A review of direct air capture (DAC): Scaling up commercial technologies and innovating for the future

DAC vs Liquid CO_2 or Natural Gas generated CO_2

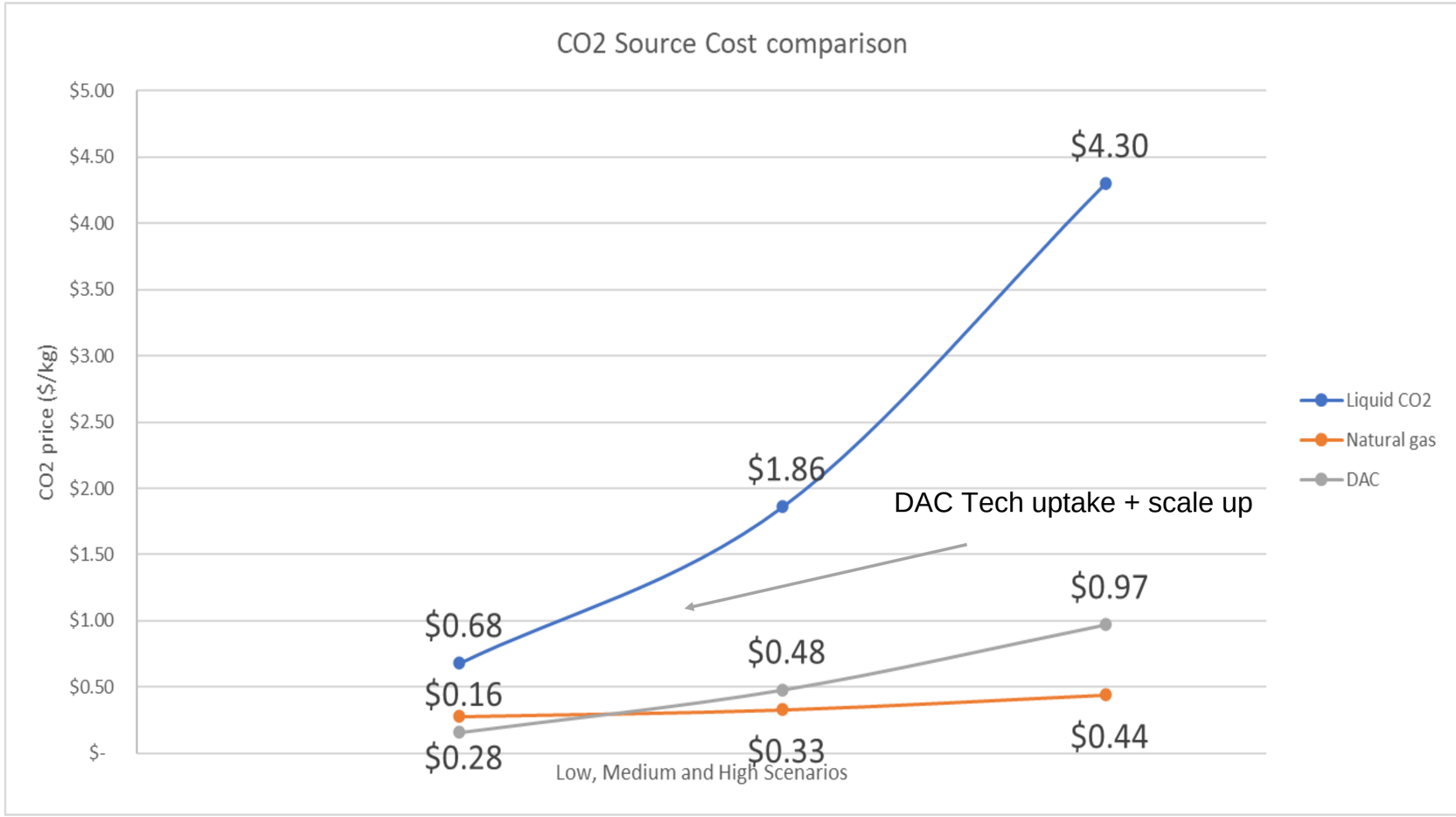
Liquid CO2 Costs

- Low = January 2022 $0.68/kg
- Med = December 2022 $1.86/kg
- High = January 2023 $4.30/kg

DAC CO2 Costs

- High (US$600/t): NZ$0.97/kg
- Med(US$300/t): NZ$0.48/kg
- Low (US$100/t): NZ$0.16/kg

(likely large-scale plants required for low)



Summary

- Direct Air Capture of CO2 is a **promising alternative** for supply to horticulture operations
- Published **costs for DAC are competitive** with the current NZ liquid CO2 market
- DAC competitiveness **depends on natural gas price** (>$0.83/m3)
- DAC will become more cost competitive as the technology is more **widely deployed**
- The cost analysis does not consider the intrinsic value of security of supply — **geothermal heat and DAC are a real contender**.

What I need help with

- Real world heating and CO_2 costs experienced by growers
- Utilization rates for CO_2
- Understanding the appetite for alternative growing environments
- What would make the geothermal food systems growing space interesting to growers:
  - growing space size
  - relationship between facility provider and grower
  - technology options
- What did I get wrong? Where am I off base?

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Aotearoa, New Zealand

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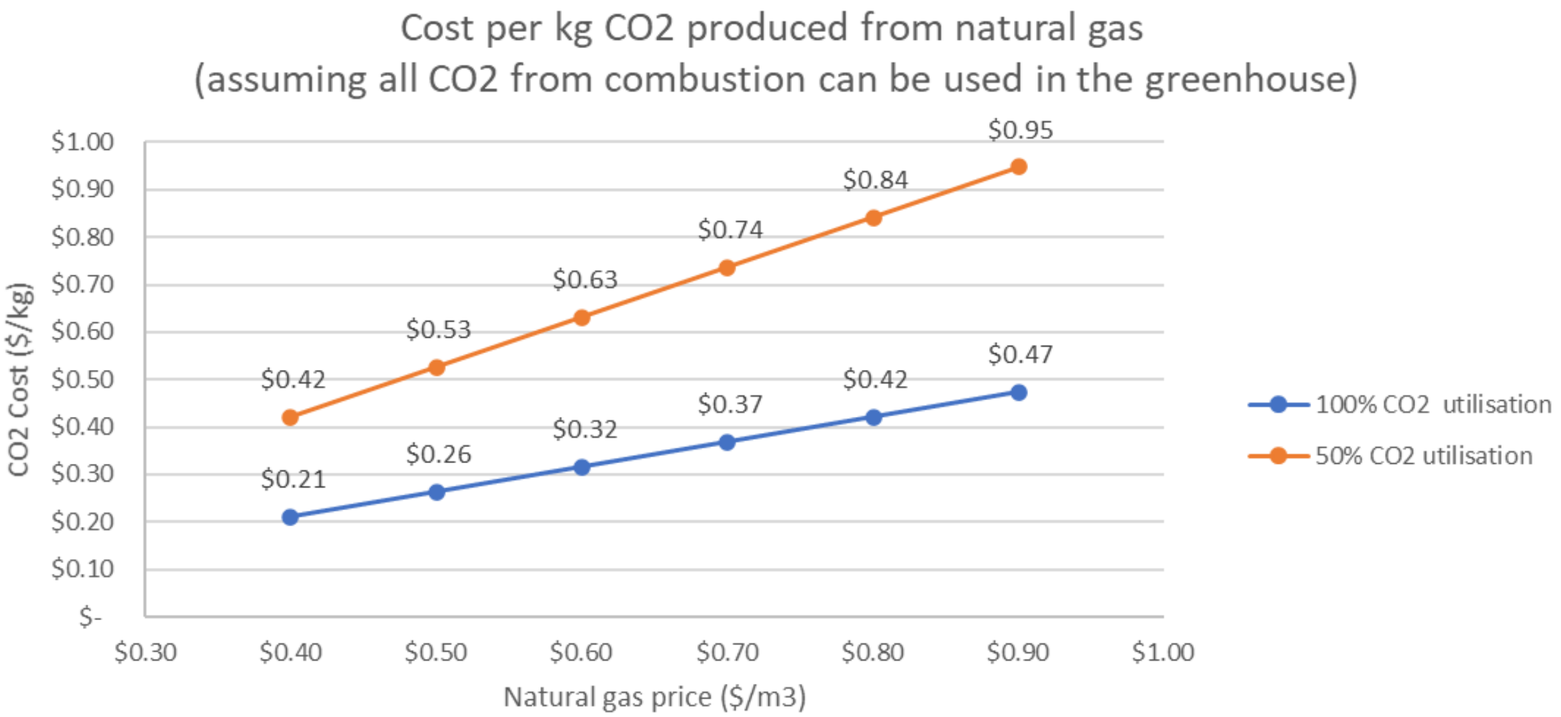
CO_2 generated from Natural Gas

Natural Gas

	Average price ($/GJ)		Average price ($/m3)	
Year	**Commerical**	**Industrial**	**Commerical**	**Industrial**
2022	23.72	11.28	0.83	0.40
2021	18.19	8.66	0.64	0.30
2020	15.32	7.13	0.54	0.25



Assumptions:

- CO_2 production rate of ~1.9kg/m3 Natural Gas
- No value of the natural gas assigned to the heat it provides – in reality – heat from this source also (a two for one deal)
- No cost for scrubbing or cleaning up the CO_2 stream

Unknowns:

- How much of the CO_2 generated can be effectively utilized in the greenhouse given the demand offset between heating and CO_2 demand

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Natural gas vs DAC Crossover Point

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