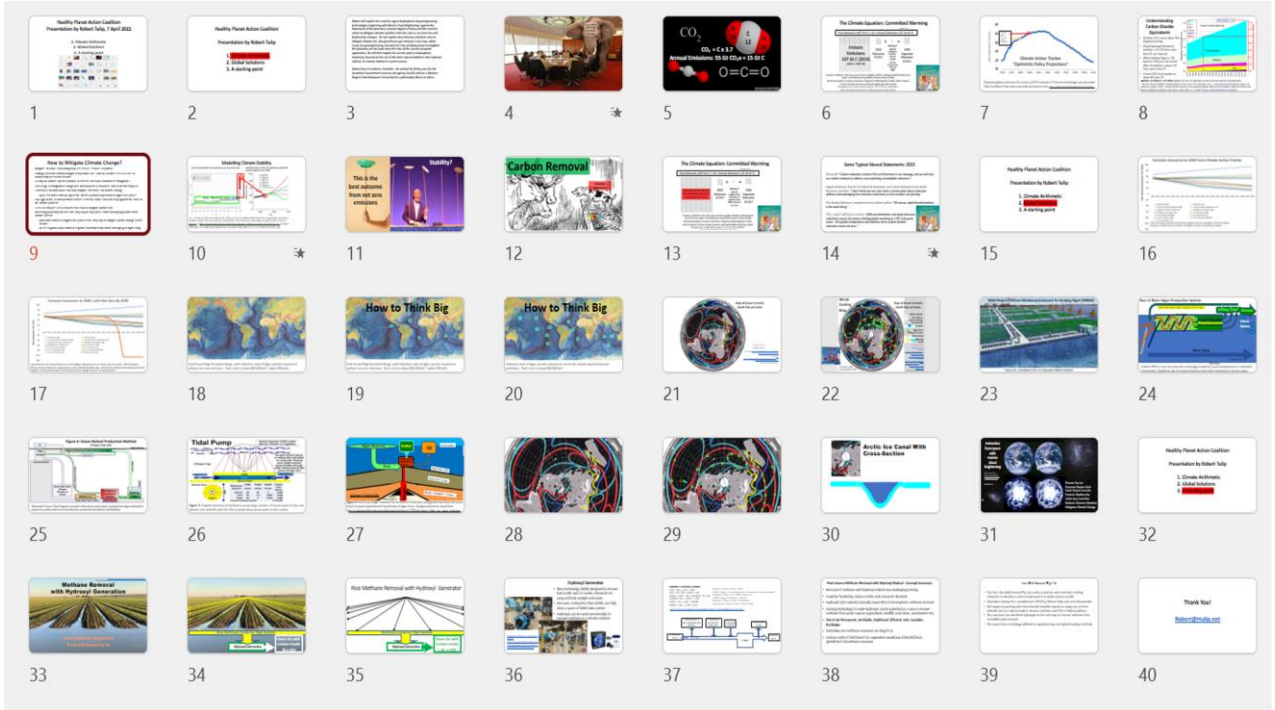
Healthy Planet Action Coalition
Presentation by Robert Tulip, 7 April 2022

1. Climate Arithmetic
2. Global Solutions
3. A starting point



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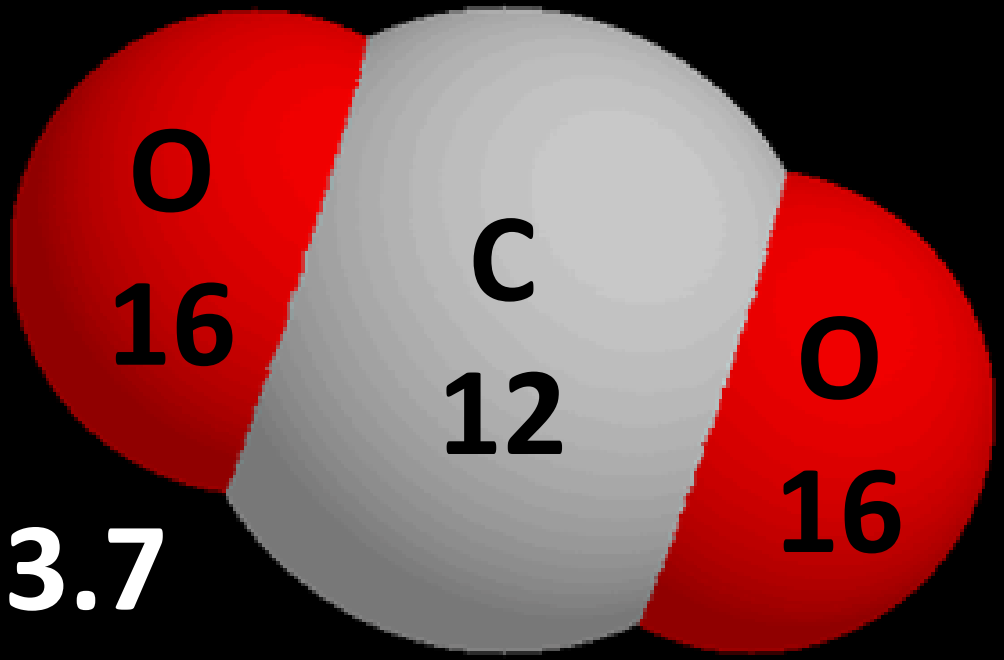
Robert will explain the need for urgent deployment of geoengineering technologies, beginning with Marine Cloud Brightening, against the framework of the planetary security impacts of delay and the need for action to mitigate extreme weather and risks such as sea level rise and biodiversity collapse. He will explain why emission reduction cannot mitigate climate risk, why greenhouse gas removal is too slow, safety issues for geoengineering, and why the risks of taking action to brighten the planet are far lower than the risks of the current accepted approaches. He will then explain his current work in atmospheric chemistry, focused on the use of the main natural methane sink, hydroxyl radicals, to remove methane in point sources.

Robert lives in Canberra, Australia. He worked for thirty years for the Australian Government overseas aid agency AusAID and has a Masters Degree from Macquarie University for a philosophy thesis on ethics.

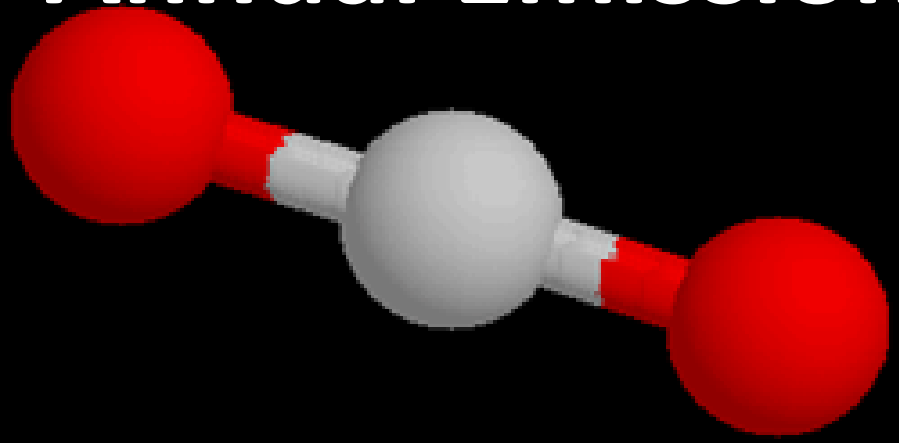

Committed Warming From Past Emissions
Decarbonisation

CO_2



CO_2 = C x 3.7

Annual Emissions: 55 Gt CO_2e = 15 Gt C



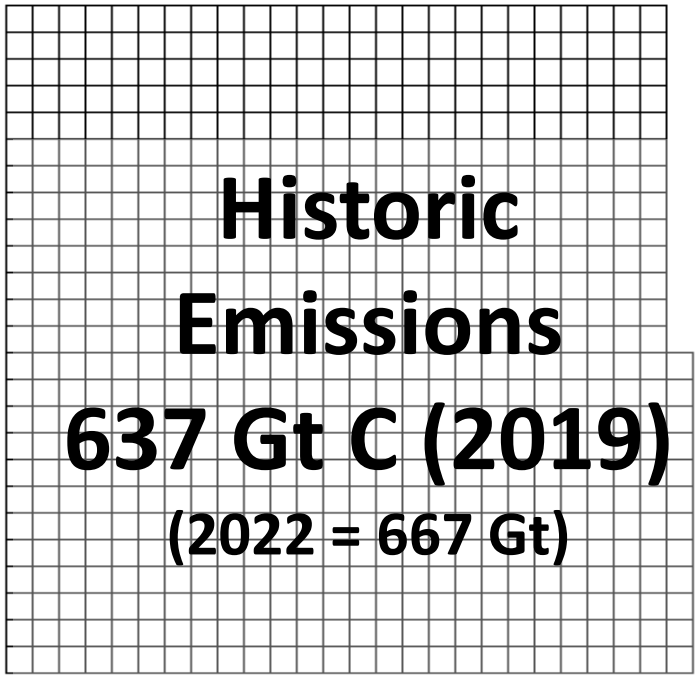
O=C=O

https://scied.ucar.edu/sites/default/files/media/images/co2_molecule_720x400.gif

The Climate Equation: Committed Warming

by Robert Tulip

Past Emissions (637 Gt C) = 42 x Annual Emissions (15-16 Gt C)



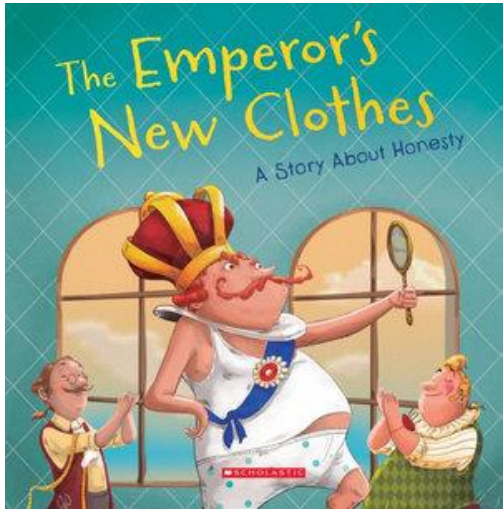
2020 Emissions 15 Gt C

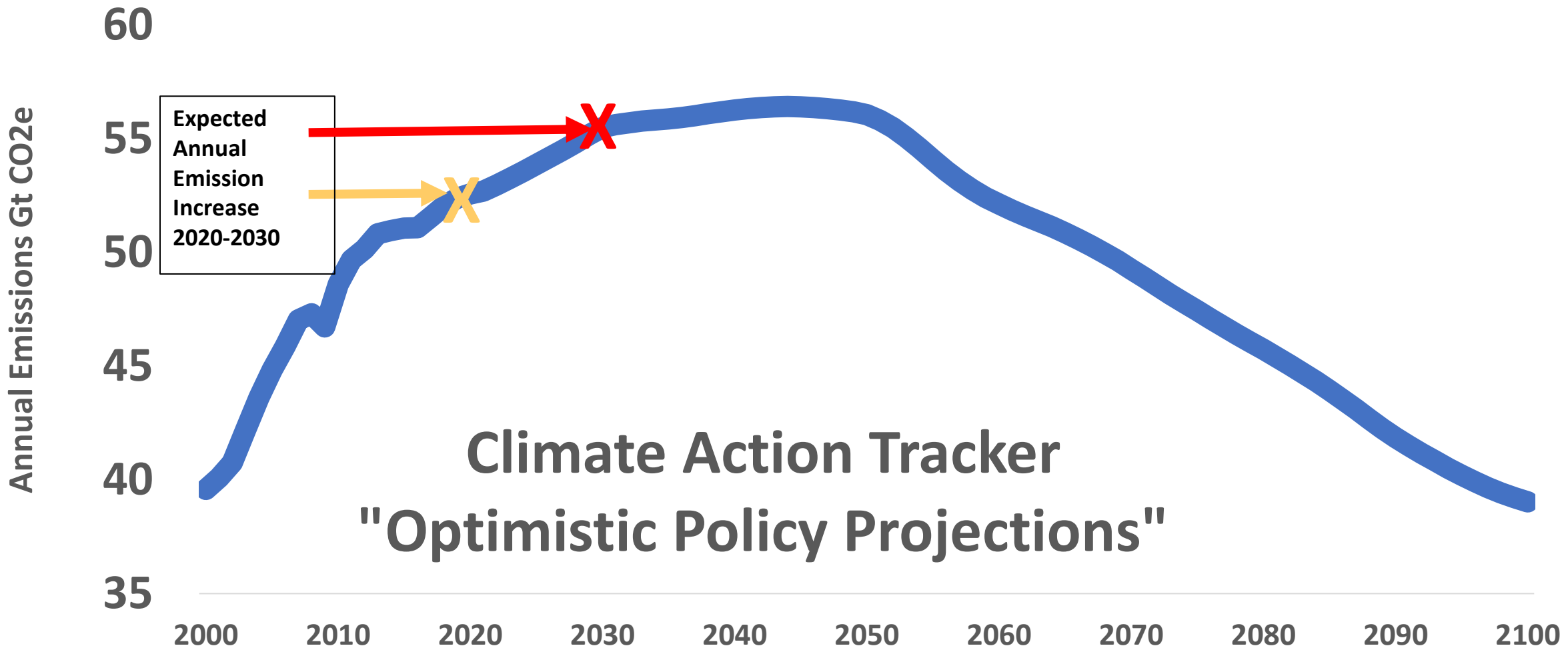
Meeting all national pledges to the Paris Accord would increase emissions by 1 Gt C by 2030

2030 Expected Emissions 16 Gt C

Emission reduction only slows new emissions (right), and does nothing about the forty times larger committed warming effects of past emissions (left).
Decarbonising the economy is therefore marginal to stabilising the climate, which requires removal of past emissions and rapid brightening of the planet.

One gigatonne of carbon (GtC) equals 3.7 Gt of CO_2 and equivalents.
Data from Oxford University and Climate Action Tracker (2019).

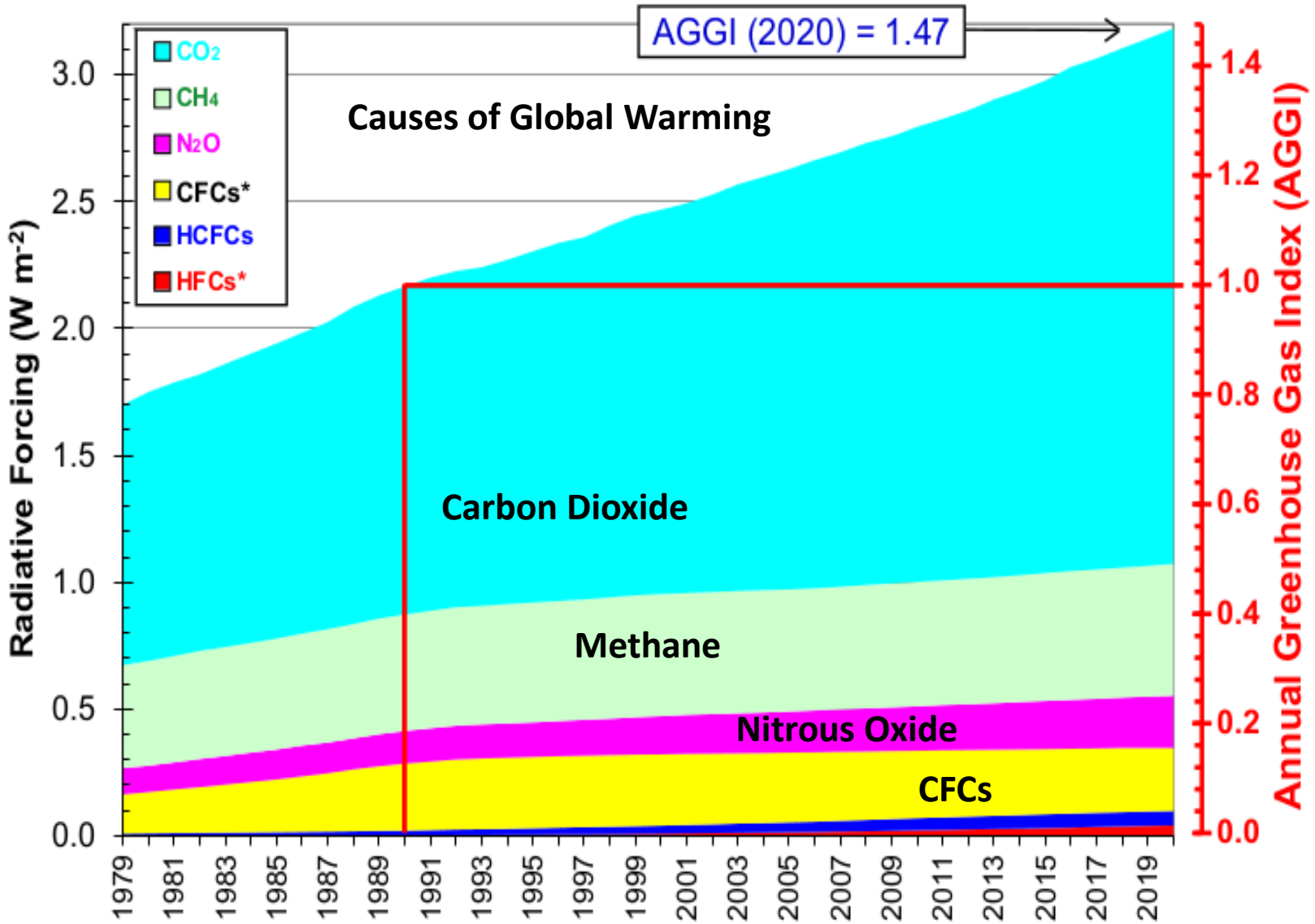




Projected global emissions this century (2019 estimates) if Paris Accord pledges are exceeded.
Chart by Robert Tulip, data used with permission from https://climateactiontracker.org/data-portal/

Understanding Carbon Dioxide Equivalents

- Methane (CH_4) causes about 20% of global warming
- Global Warming Potential of methane is 20-120 times more than CO_2 per molecule
- official methane figure is 25x based on 100 years, but annual effect of methane is about 120 times worse than CO_2
- Current CO2e level equates to about 462 ppm CO_2



Annual Greenhouse Gas Index (2020) from the US National Oceanic and Atmospheric Administration. Left axis shows radiative forcing relative to the year 1750 (280 ppm CO_2), of all long-lived greenhouse gases, in watts per square metre. Carbon dioxide has the most warming impact followed by methane. Right axis shows the NOAA Annual Greenhouse Gas Index (year 1990 = 1). Credit: NOAA/ Global Monitoring Laboratory

How to Mitigate Climate Change?

- **Mitigate: “to make (something bad) less severe, serious, or painful”**
- **Cutting emissions cannot mitigate temperature rise, extreme weather, sea level rise or biodiversity loss in this decade.**
- **So why do climate experts continue to refer to emission reduction as “mitigation”?**
- **This usage of mitigation is dangerous and incorrect. It should be called out and stopped.**
- **Emission Reduction Alone can only mitigate emissions, not climate change.**
  - **And even that is dubious given the intense political opposition to higher fuel prices**
- **“All eggs in the Decarbonisation Basket” is far too small, slow and risky against the scale of the climate problem.**
- **Even Greenhouse Gas Removal is too slow to mitigate climate risk.**
- **Increasing planetary albedo is the only way to stop phase shifts and tipping points in the climate system.**
  - **Immediate action to brighten the planet is the only way to mitigate climate change in this decade.**
  - **We need global cooperation to regulate planetary temperature through geoengineering**

Modelling Climate Stability

(a) Carbon Dioxide Concentrations over the Holocene

(b) Atmospheric CO2 concentrations with IPCC model trajectories to 2100.

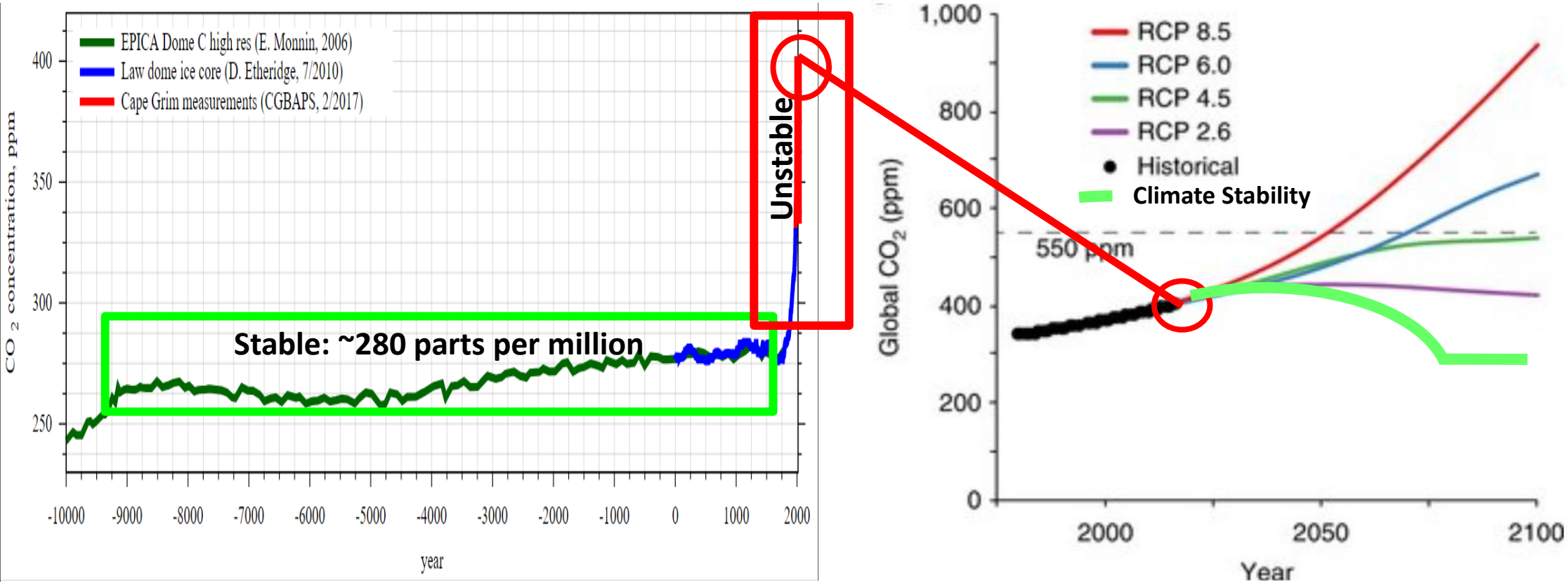
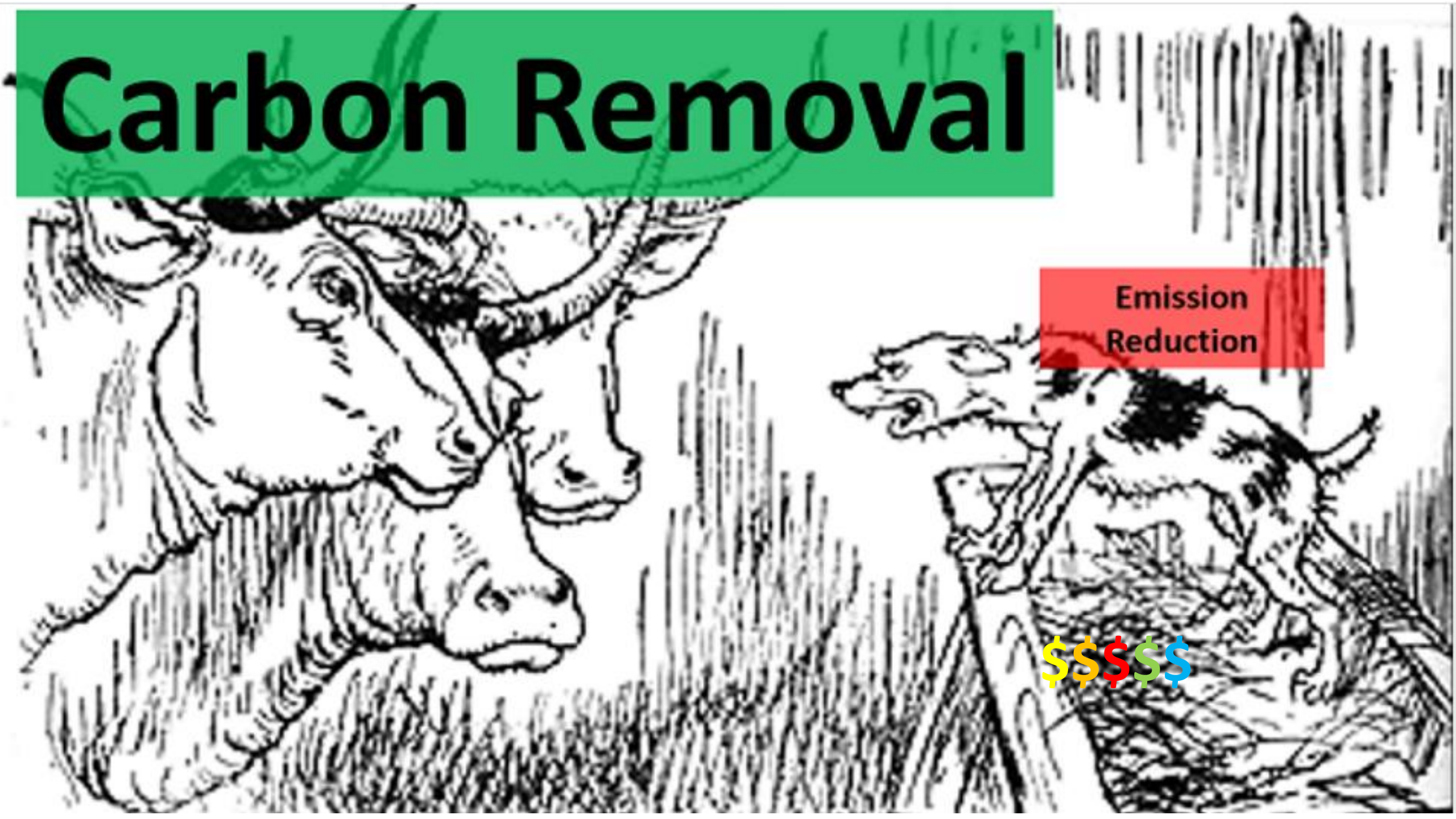


Fig 1 sets the well-known 'hockey-stick' of the geologically sudden shift to high CO_2 (a) against the observation (b) that a return to Holocene stability would need to remove far more carbon than envisaged in IPCC scenarios
Sources: (a) https://upload.wikimedia.org/wikipedia/commons/1/1d/Ghgs-epcia-holocene-CO2-en.svg, (b) Myers and Smith, 2018. Stable and Unstable bars in (a) and Climate Stability line in (b) added by Robert Tulip.

This is the best outcome from net zero emissions

Carbon Removal



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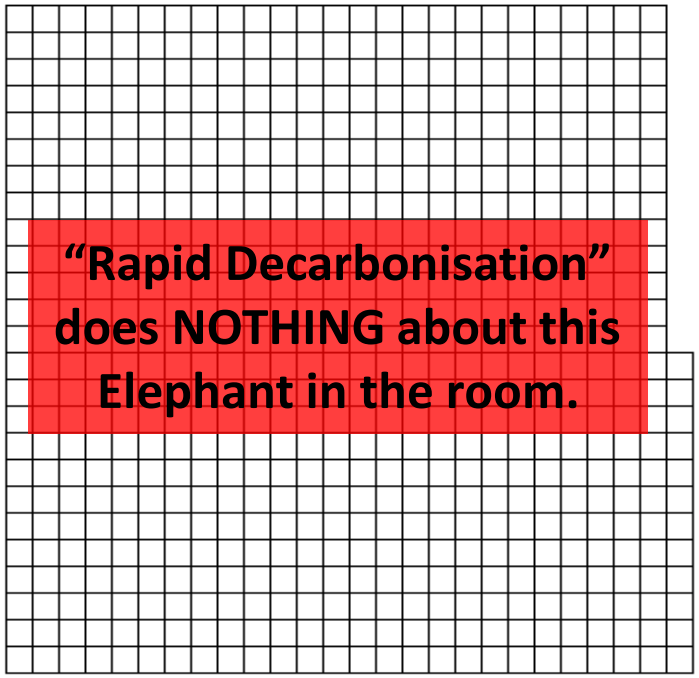

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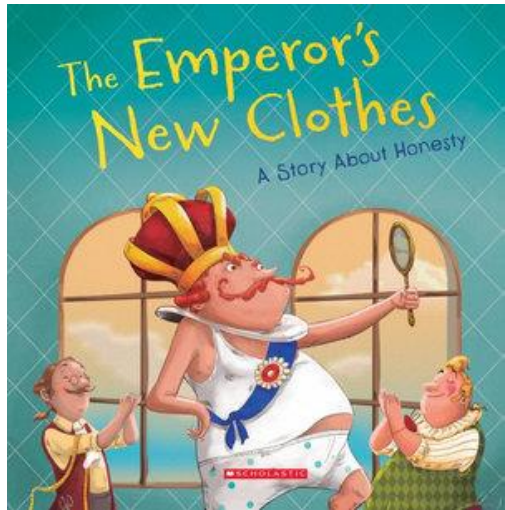


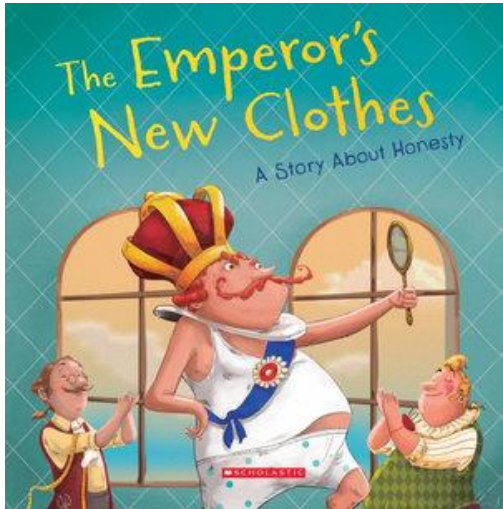
Some Typical Absurd Statements: 2022

Microsoft: **“Carbon reduction remains first and foremost in our strategy, and we will only use carbon removal to address any remaining unavoidable emissions.”**

Angela Anderson, Director of Industrial Innovation and Carbon Removal at the World Resources Institute: “**I don't think we can even start a conversation about removals without acknowledging that emission reductions are the number one priority.** ”

Kim Stanley Robinson, renowned science fiction author: **“Of course, rapid decarbonization is the main thing.”**

IPCC, 4 April, WG3 press release: **“Without immediate and deep emissions reductions across all sectors, limiting global warming to 1.5°C is beyond reach… The global temperature will stabilise when carbon dioxide emissions reach net zero. ”**



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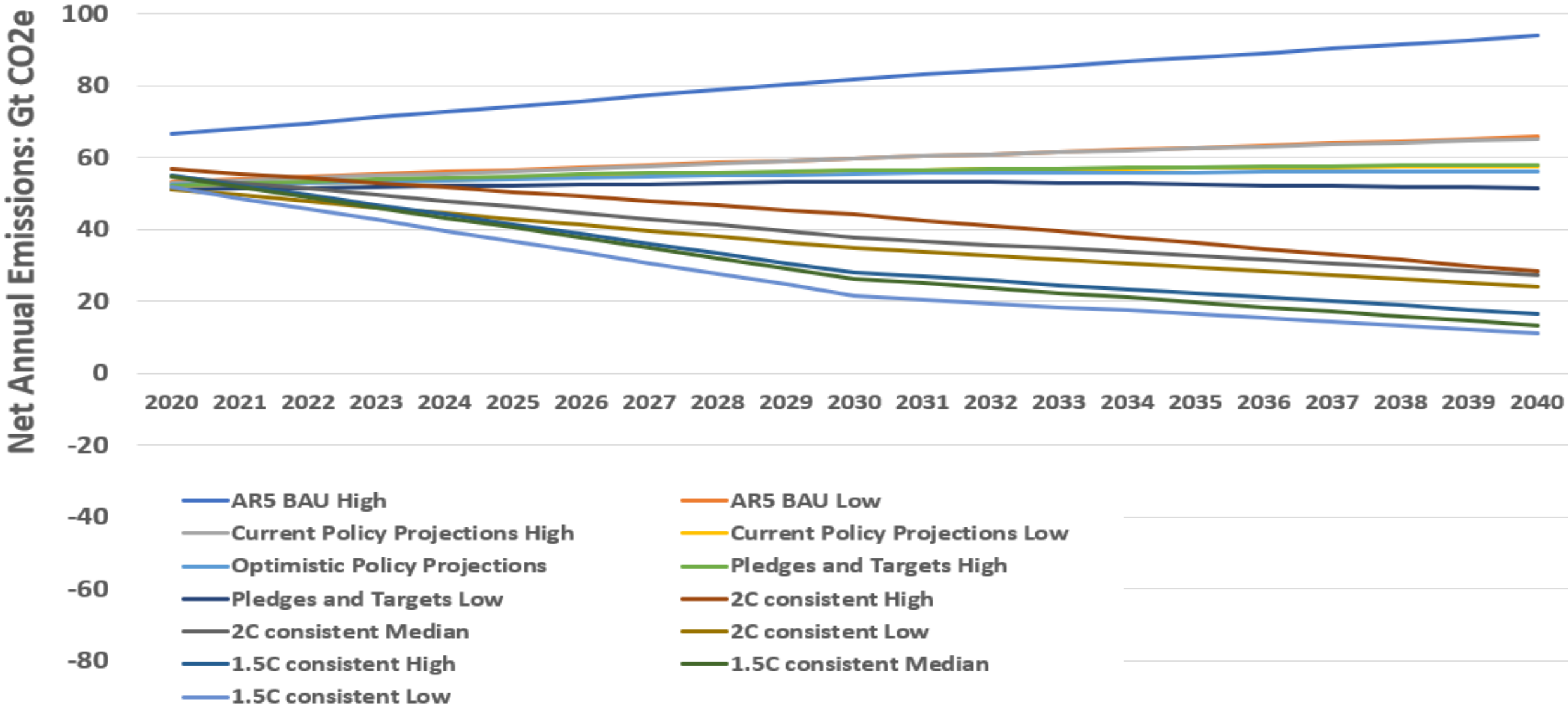
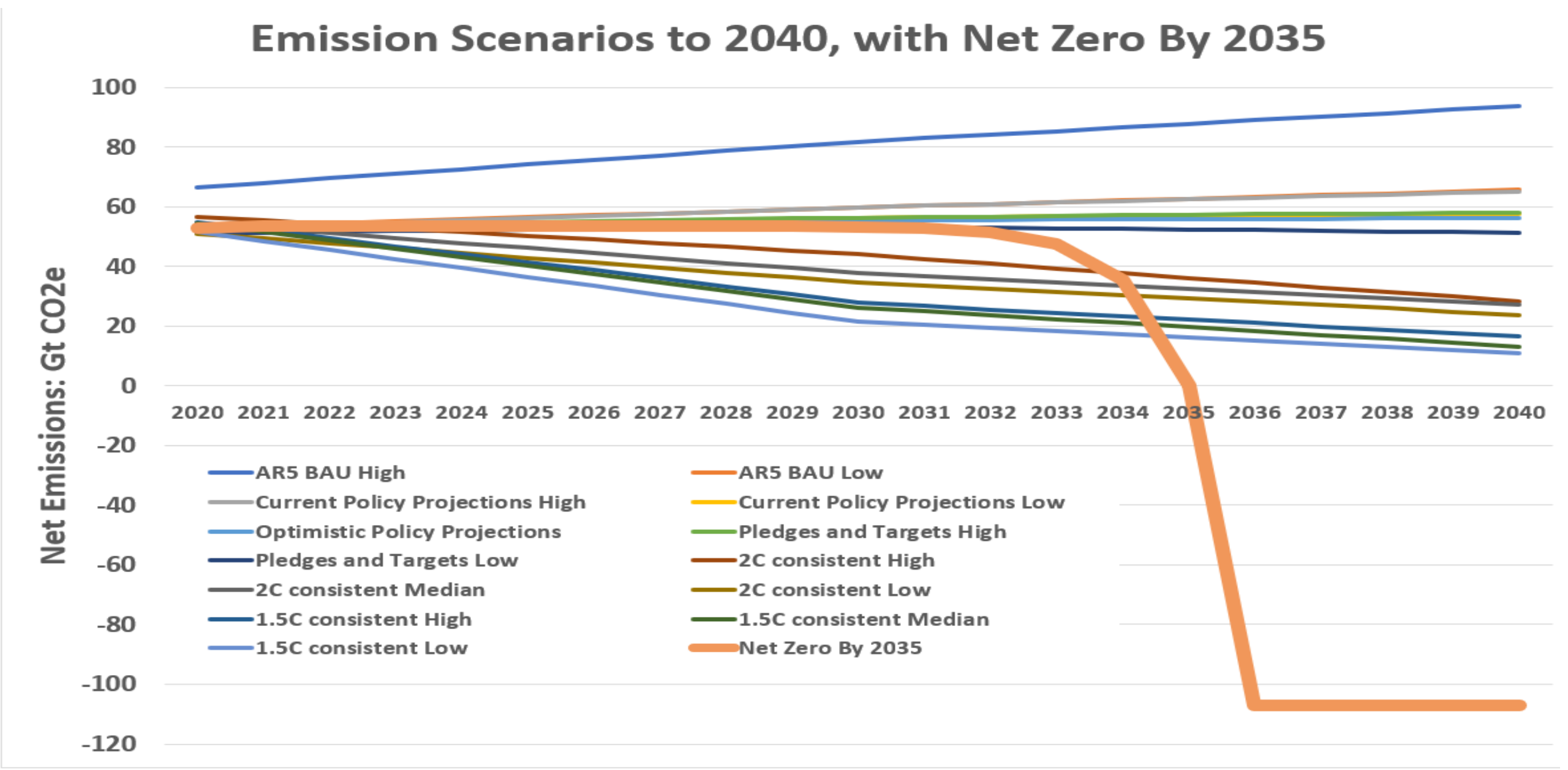
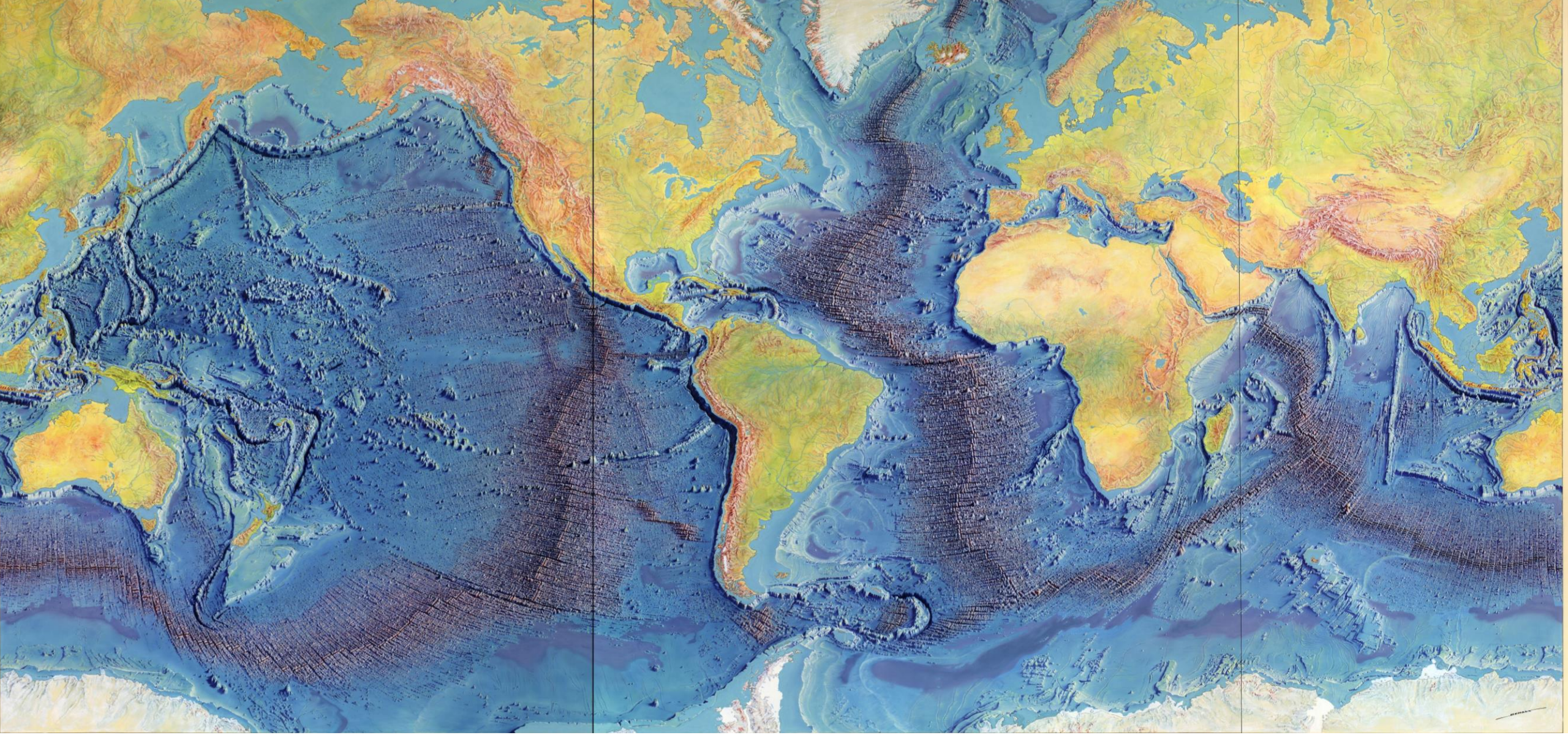
Emission Scenarios to 2040 from Climate Action Tracker





Exponential path to Net Zero By 2035, based on annual tripling of algae production and storage of produced carbon. With Net Negative Emissions of 110 Gt CO2e/year in subsequent years, author calculation by Robert Tulip. Data from https://climateactiontracker.org/data-portal/

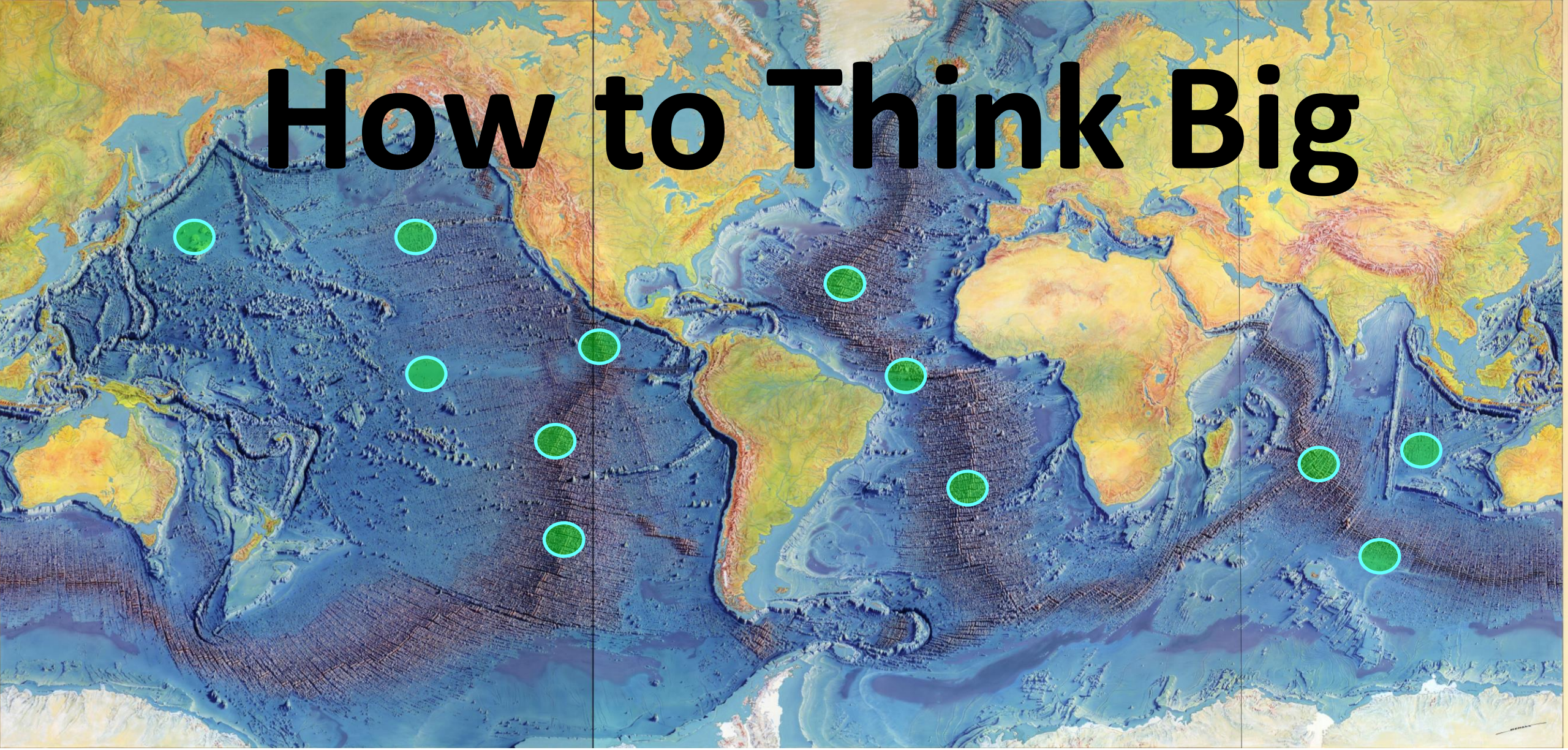


Mid Ocean Ridge Mountain Range, with indicative scale of algae systems required to achieve net zero emissions. Each circle is about 800,000 km^2 (radius 500 km).

How to Think Big

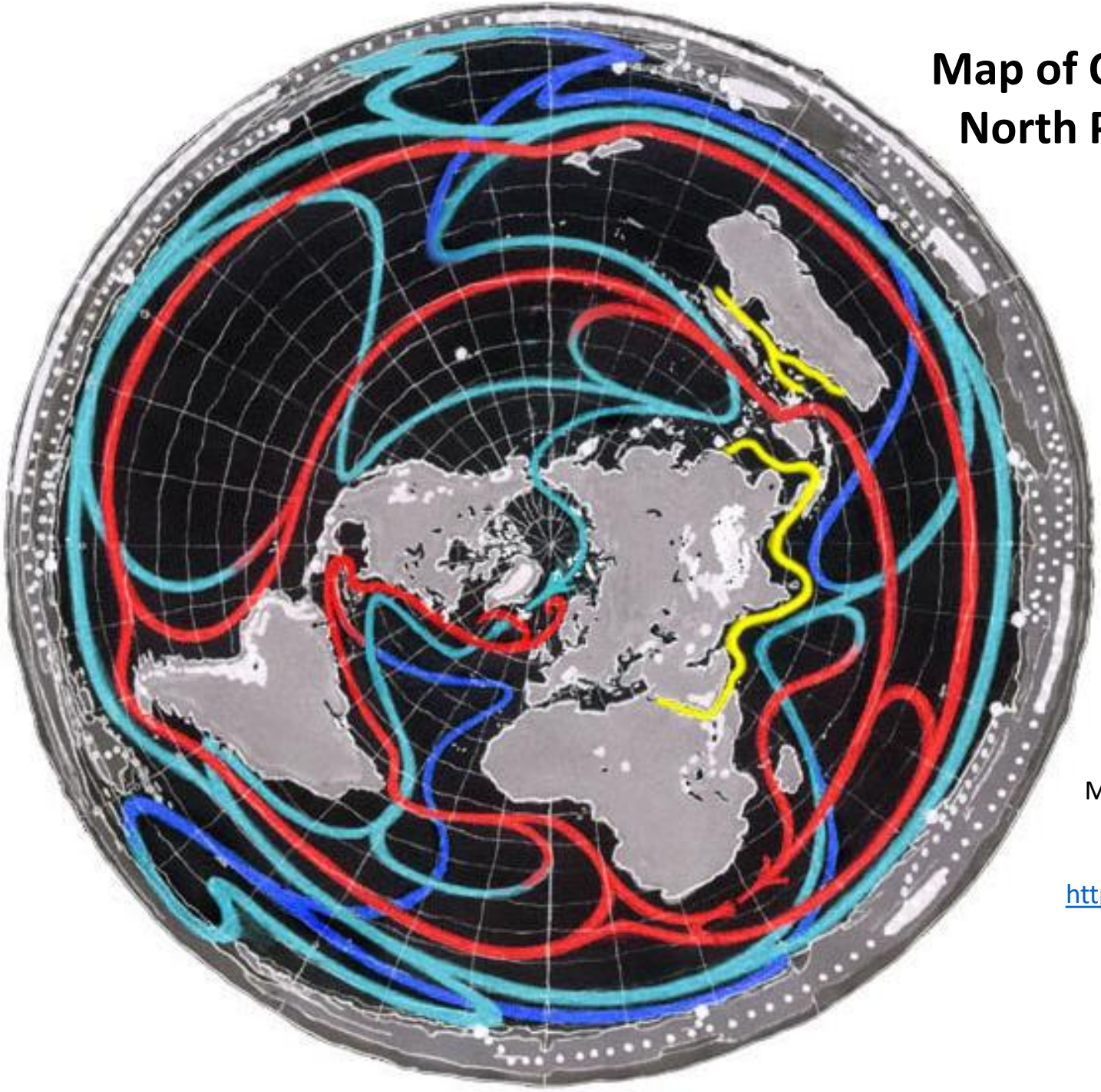
Mid Ocean Ridge Mountain Range, with indicative scale of algae systems required to achieve net zero emissions. Each circle is about 800,000 km^2 (radius 500 km).

How to Think Big



Indicative scale of algae systems required to return the climate toward Holocene conditions. Each circle is about 800,000 km^2.

Map of Ocean Currents
North Pole at Centre



Surface Current
Mid level Current
Abyssal Current

Map from https://rightbasicbuilding.com/earth-ocean-currents-polar-views/
direct link
https://rightbasicbuilding.files.wordpress.com/2009/03/south-edged-equal-azimuth.jpg
Additions by Robert Tulip

World Cooling Map

Map of Ocean Currents North Pole at Centre

Refrozen North Pole with ice canal connecting east and west

Ice Canal

Algae Farm floating on current

Marine Cloud Brightening Vessel

Surface Current
Mid level Current
Abyssal Current

Map from https://rightbasicbuilding.com/earth-ocean-currents-polar-views/
direct link https://rightbasicbuilding.files.wordpress.com/2009/03/south-edged-equal-azimuth.jpg
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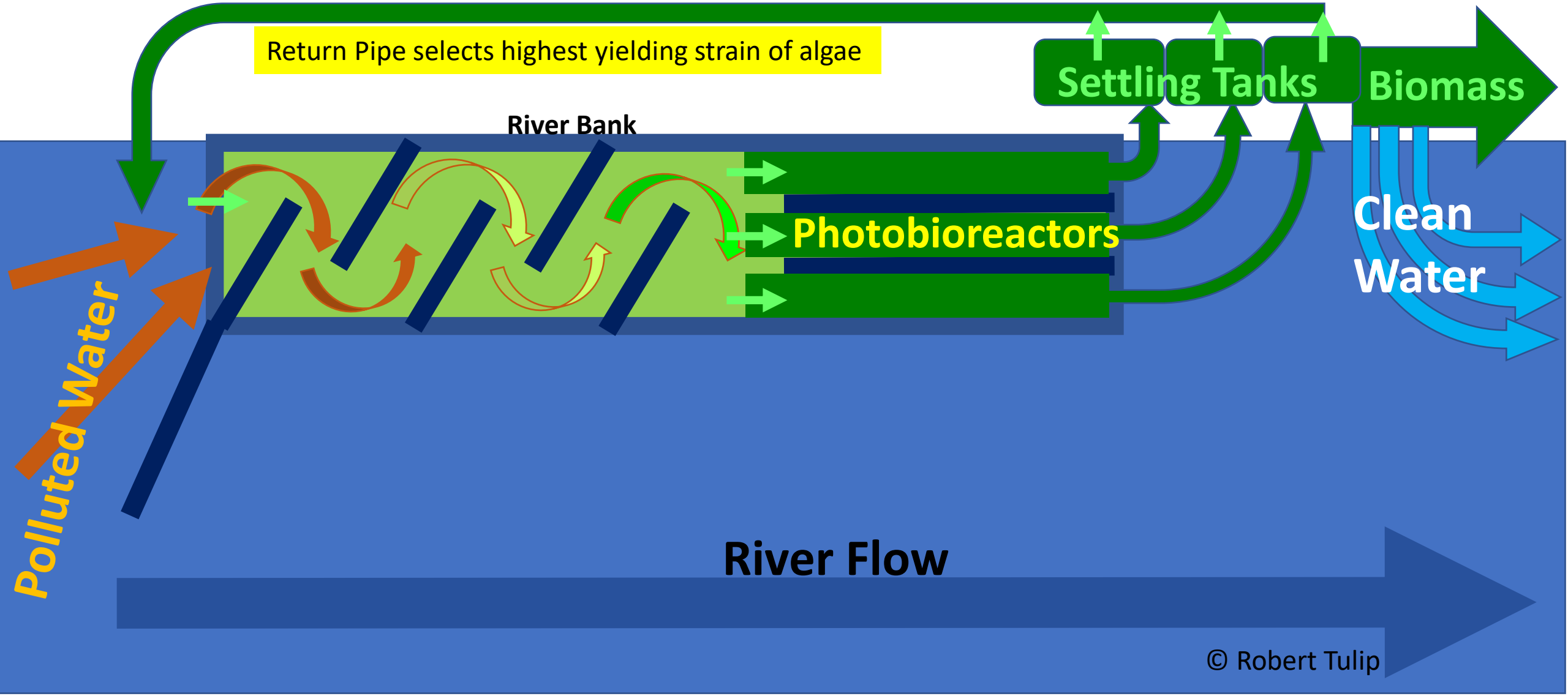
17 November 2021

NASA Project: Offshore Membrane Enclosures for Growing Algae (OMEGA)

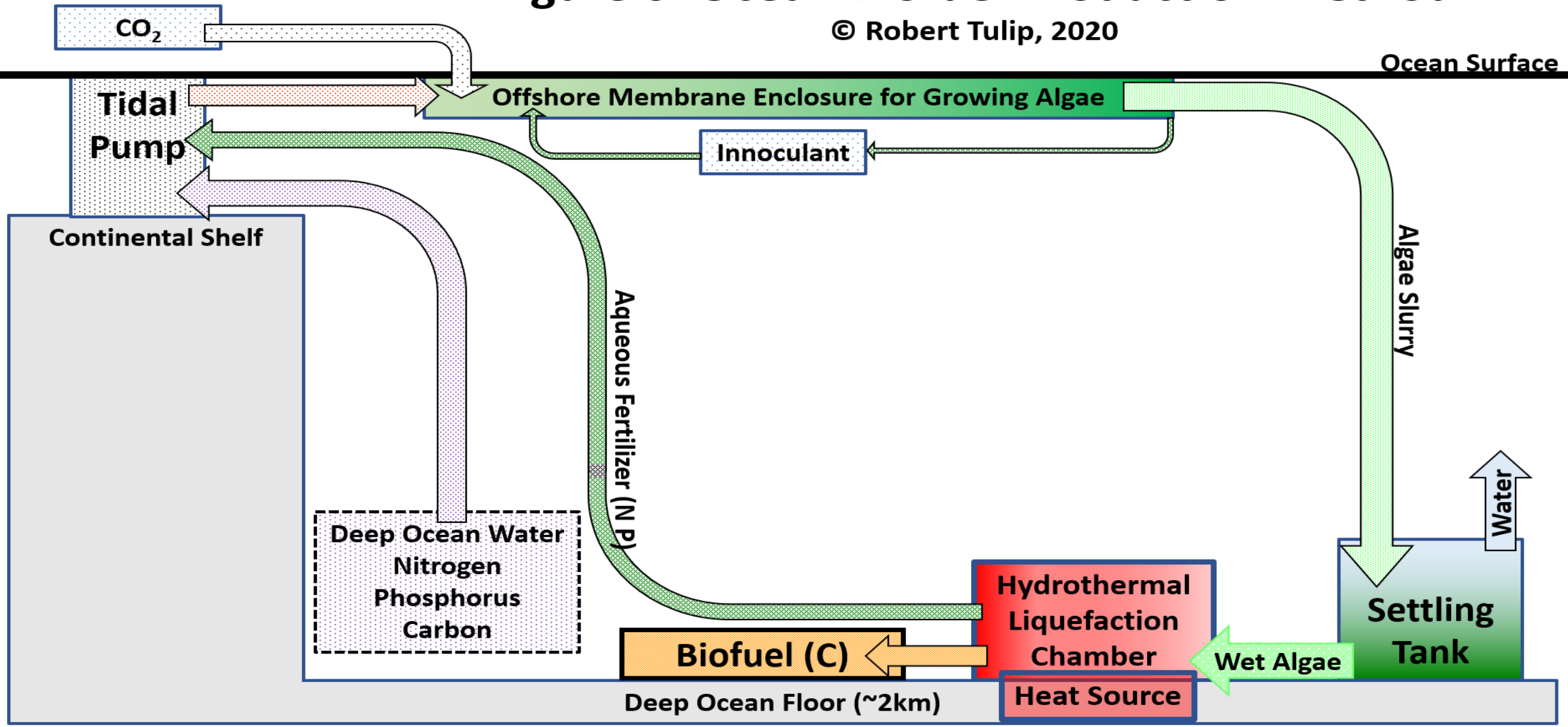
Figure 39: Conceptual View of Integrated OMEGA System

Run of River Algae Production System

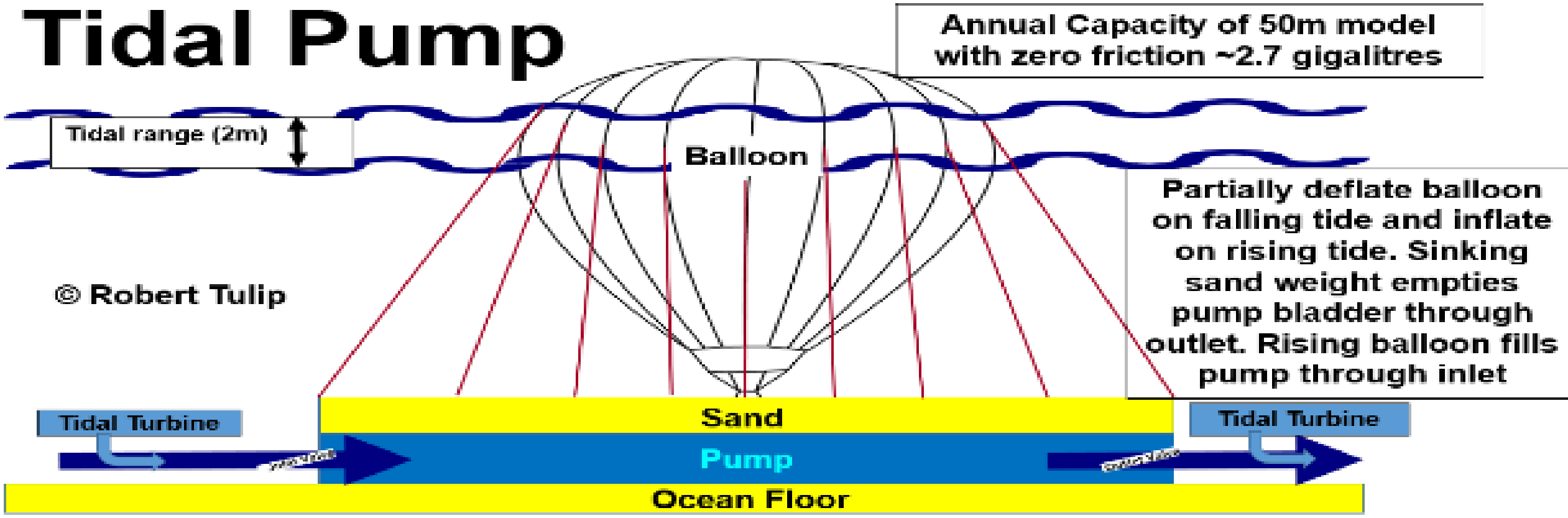


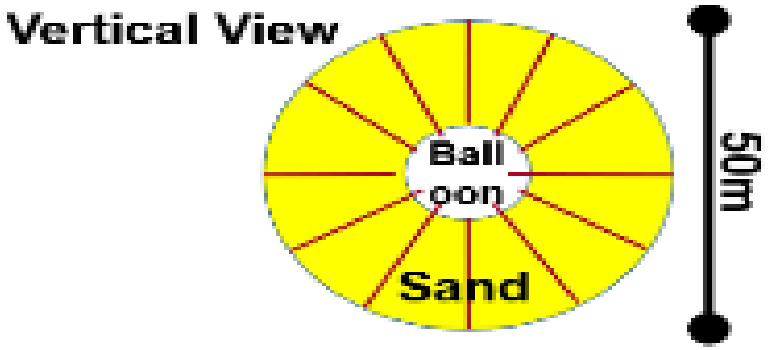
A fabric PBR in a river can prove the technology needed for ocean deployment in a controlled environment, funded by sale of produced biomass and public investment in cleaner water.

Figure 6: Ocean Biofuel Production Method



Schematic Process Flow Diagram: nutrients from deep ocean water pumped into algae production system on surface then to ocean floor for conversion into biofuel and fertilizer.





Dimensions (Approx)	Width metres	Height metres	Weight tonnes	Volume cubic metres
Balloon	20	20	8	3,800
Sand	50	1.3	4,000	2,600
Pump	50	2	4,000	4,000
Annual Pumping Capacity				2,775,900

Figure 7: Original invention of method to pump large volumes of ocean water at low cost. System rises and falls with the tide to pump deep ocean water to the surface.

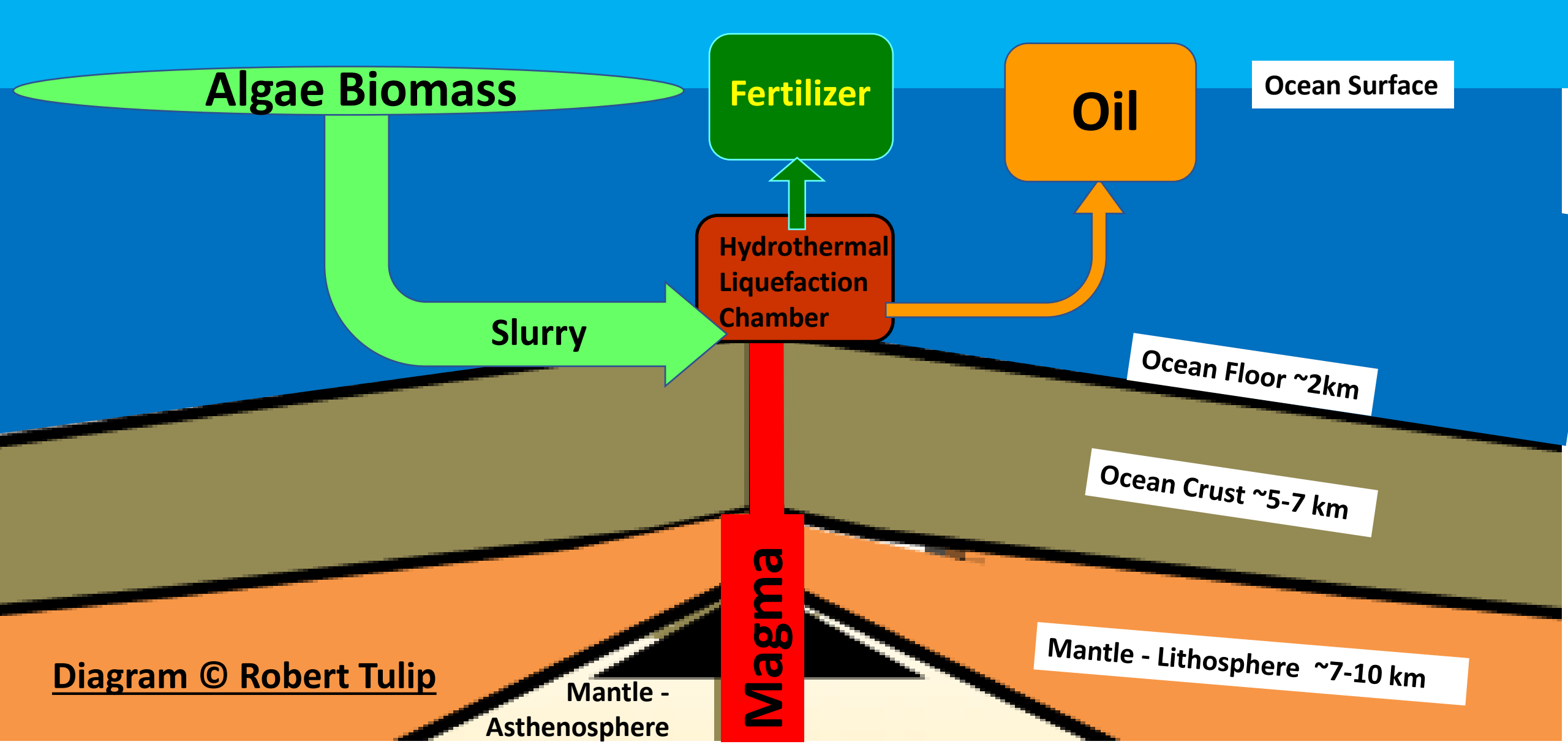
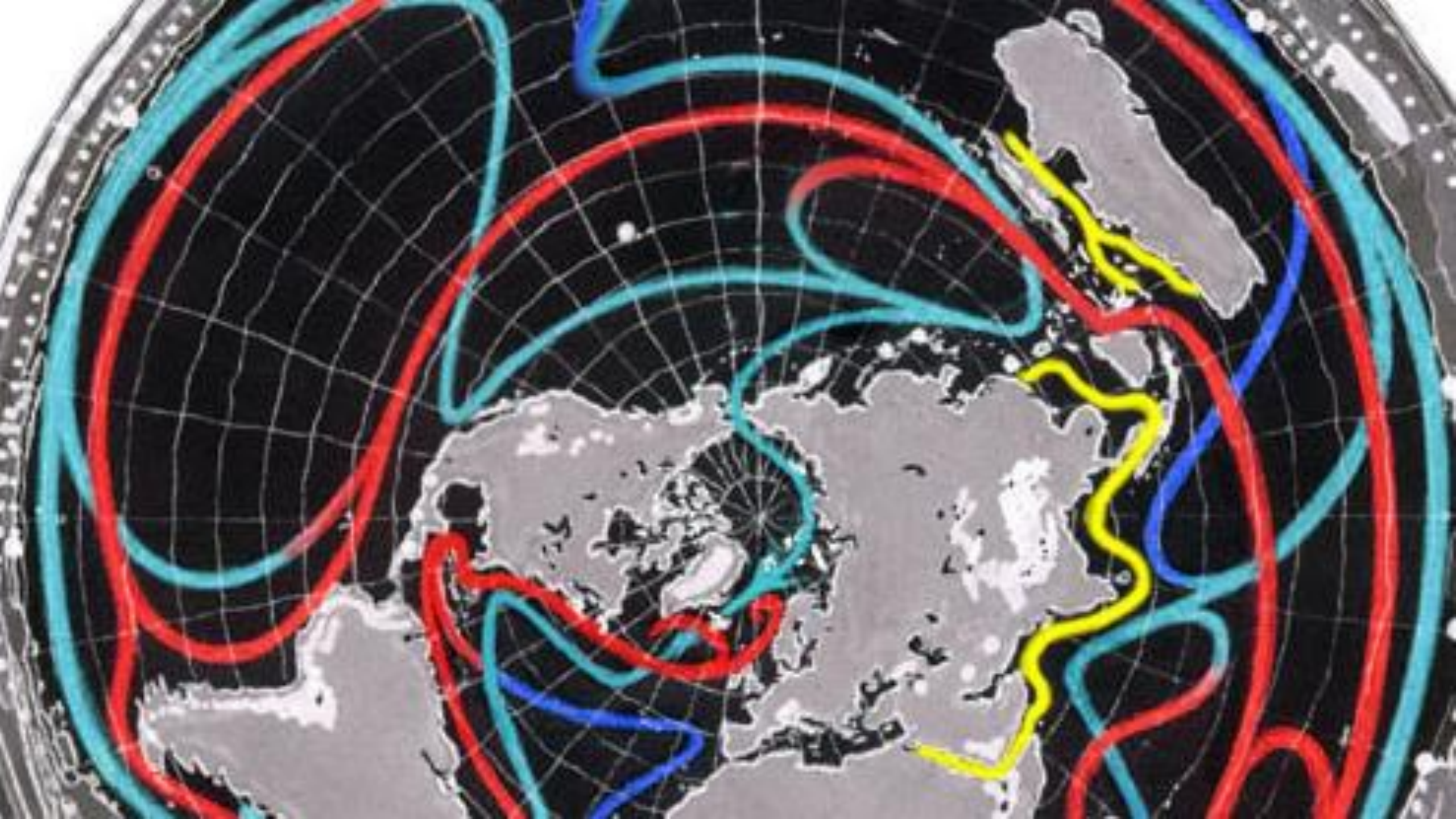
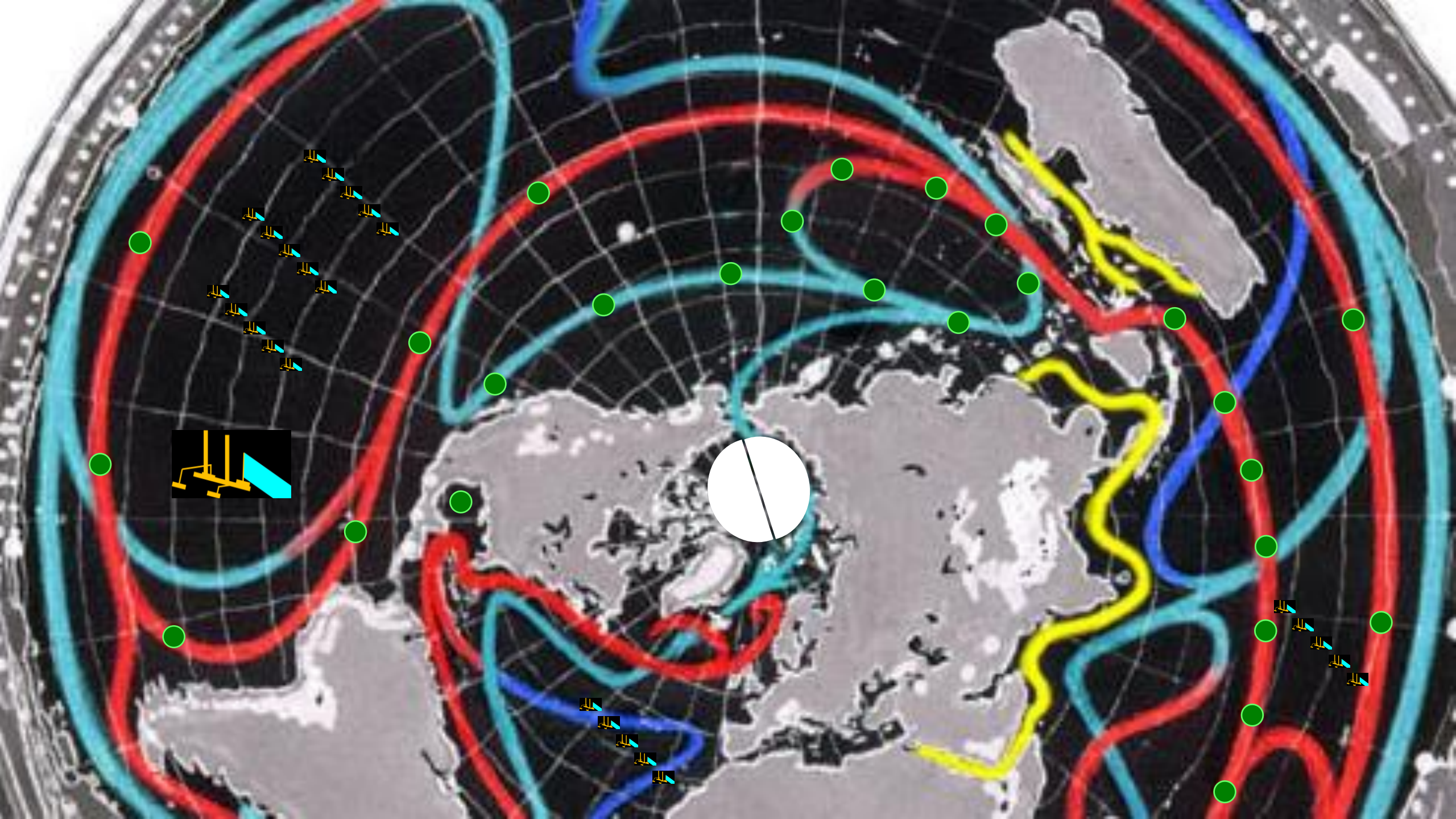
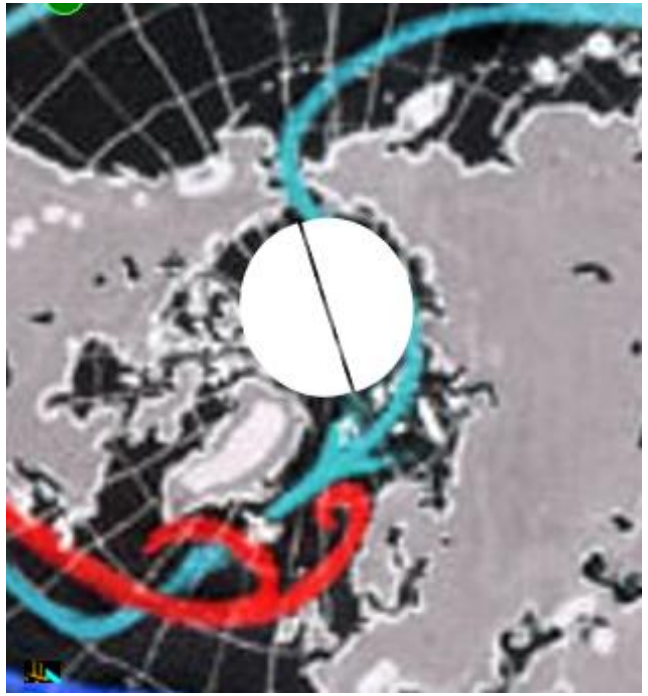


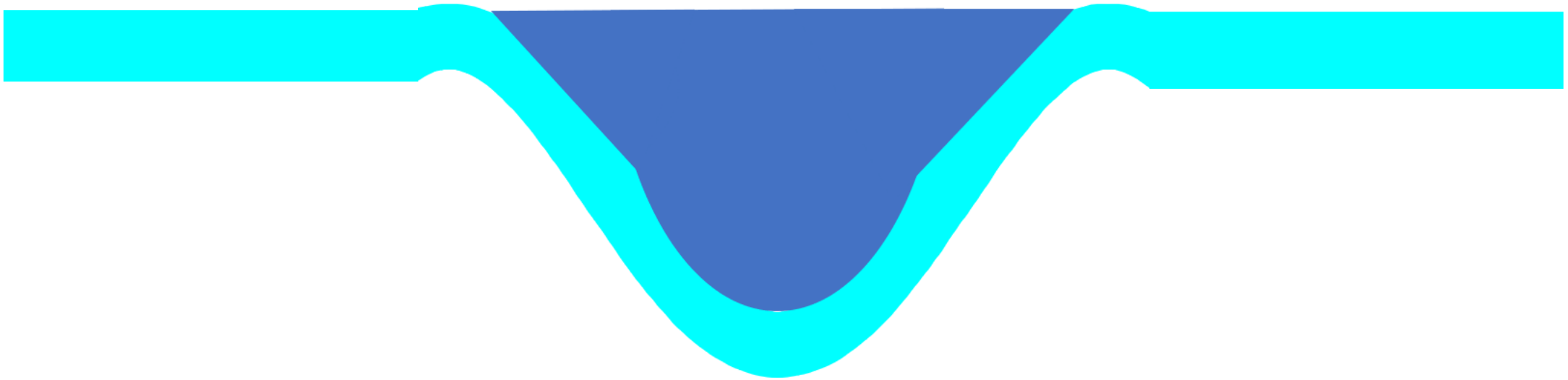
Figure 9: Mid Ocean Ridge: Potential Site for Biofuel Production using geothermal heat and ocean depth to power hydrothermal liquefaction of algae slurry. Background picture detail from https://upload.wikimedia.org/wikipedia/commons/1/15/Mid-ocean_ridge_cut_away_view.png



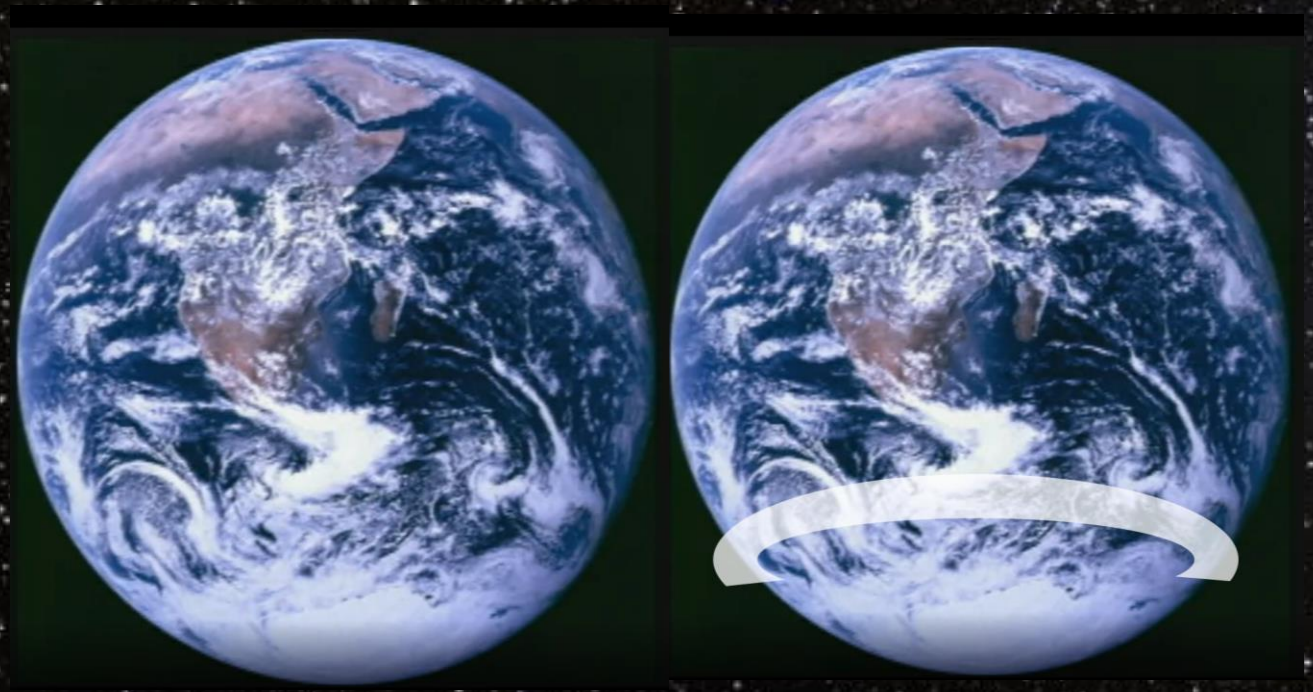


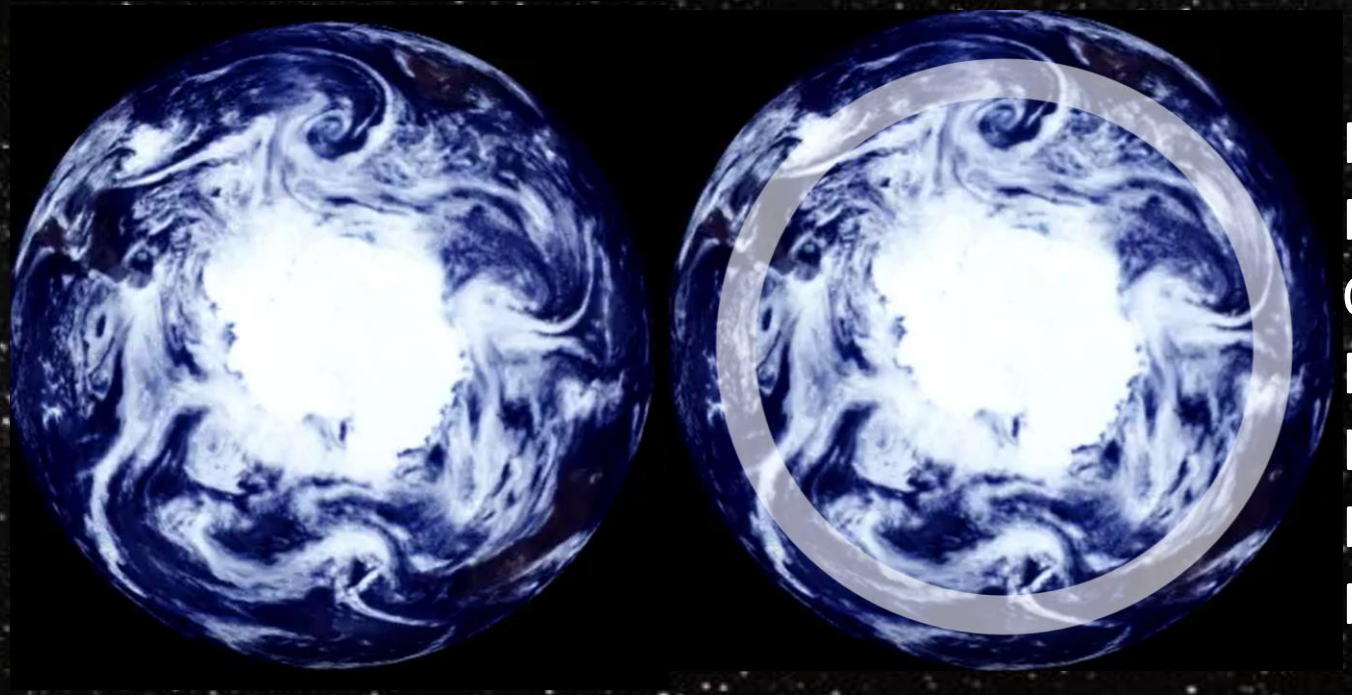


Arctic Ice Canal With Cross-Section



Antarctica from space with marine cloud brightening





Photos of Earth by NASA.
Photo of Magellanic Clouds by ESO/S. Brunier - ESO, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=7668531

Freezes Sea Ice
Prevents Glacier Melt
Cools Ocean Currents
Protects Biodiversity
Limits Sea Level Rise
Reduces Extreme Weather
Mitigates Climate Change

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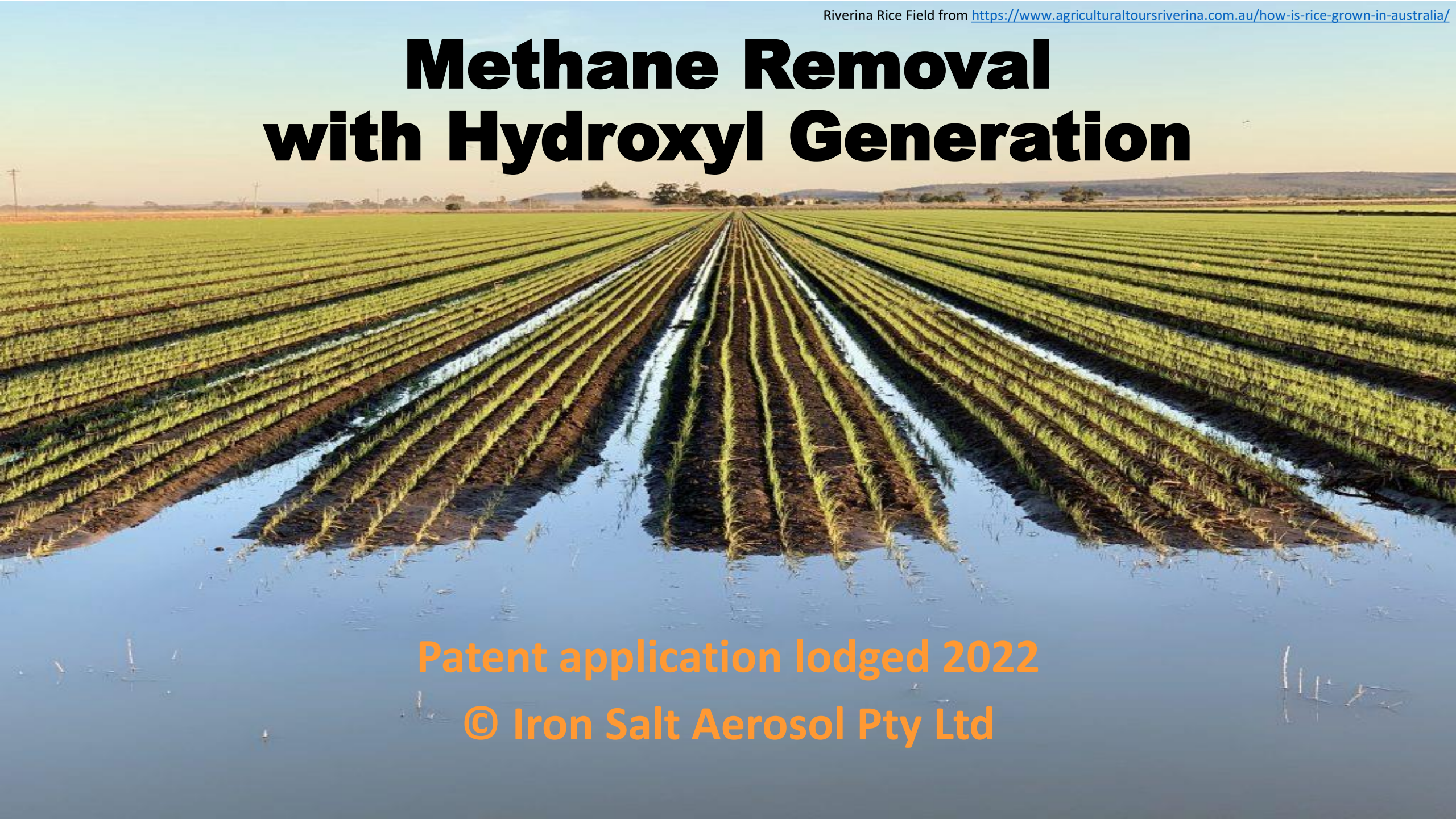
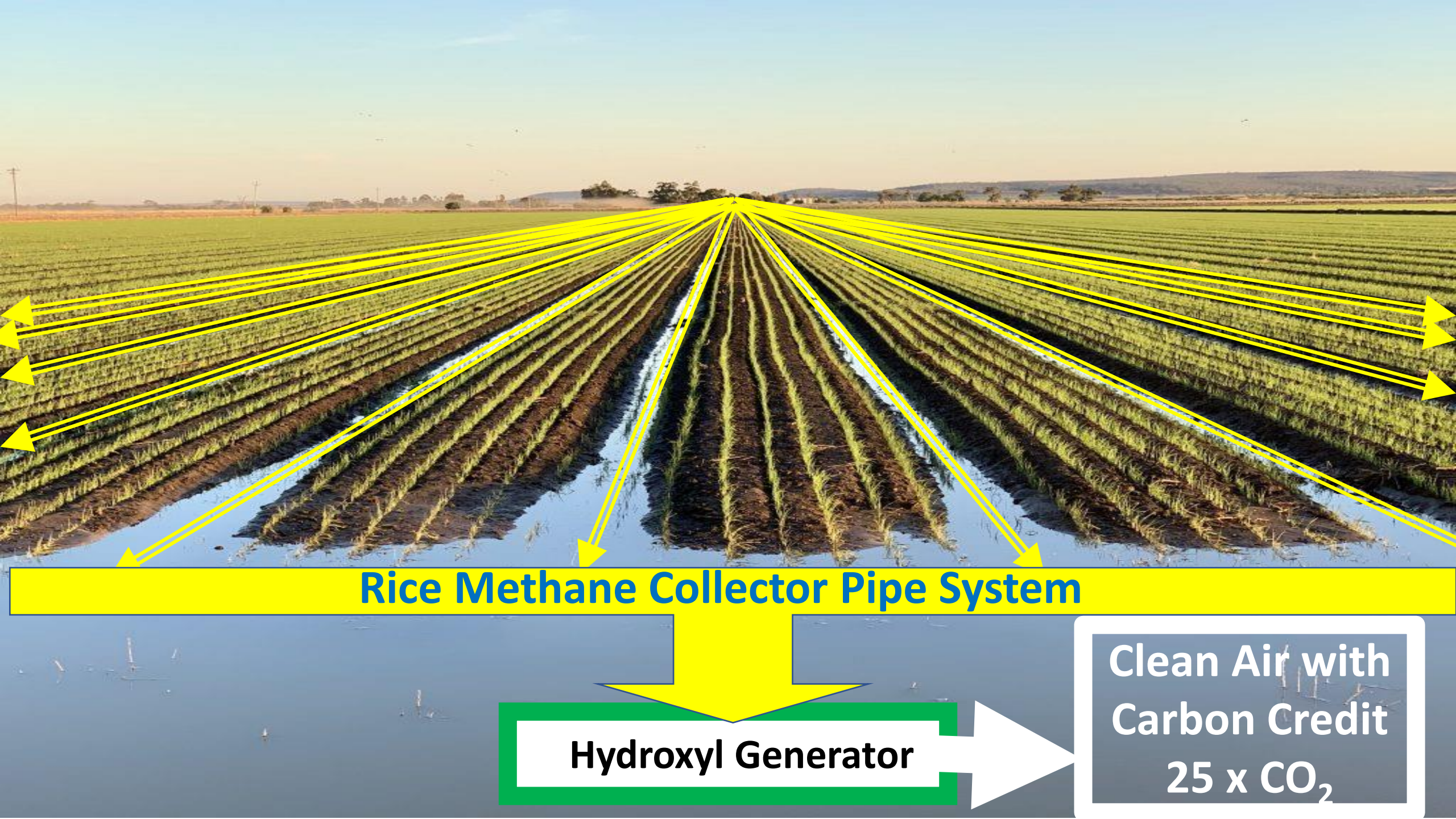
Riverina Rice Field from https://www.agriculturaltoursriverina.com.au/how-is-rice-grown-in-australia/

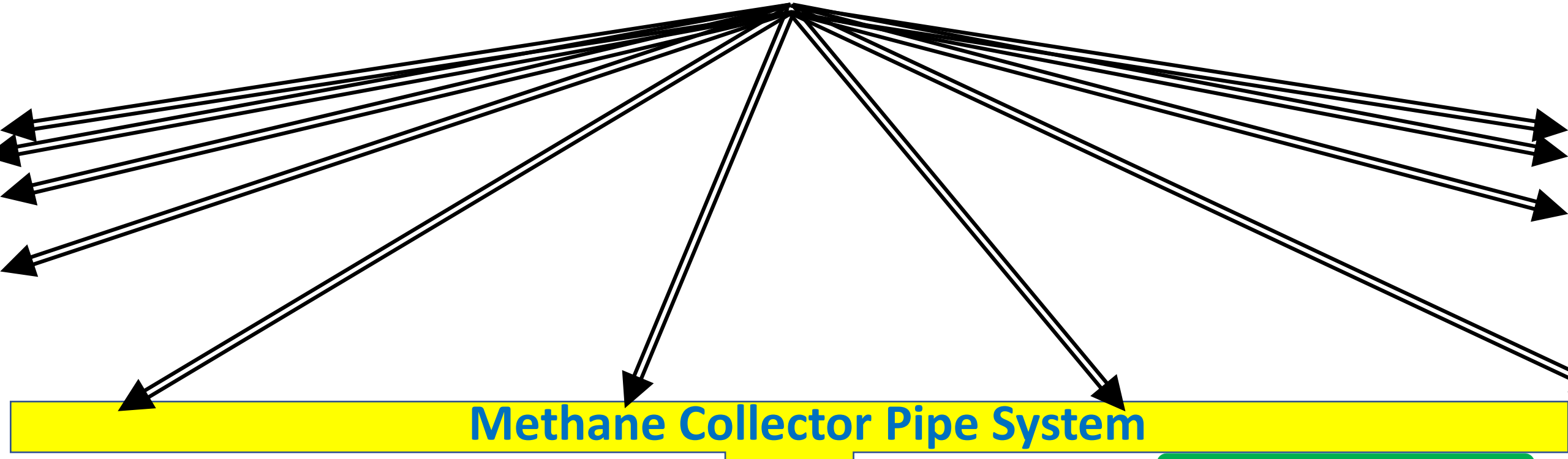
Methane Removal with Hydroxyl Generation



Patent application lodged 2022


Rice Methane Collector Pipe System
Hydroxyl Generator
Clean Air with Carbon Credit
25 x CO_2

Rice Methane Removal with Hydroxyl Generator



Methane Collector Pipe System

Hydroxyl Generator

Clean Air with Carbon Credit > 25 x CO2

Hydroxyl Generator

- New technology (2008) designed to remove bad smells such as smoke, chemicals etc using artificial sunlight and water
- One unit, costing less than $2000, can fully clean a space of 1000 cubic metres
- Hydroxyls can be used commercially to remove methane as a climate solution

[Hydroxyl Generators in operation. Source: https://www.randrmagonline.com/articles/88744-steps-to-contents-odor-removal-using-hydroxyls]

Indicative Chemical Reaction

$CH_4 + \cdot OH \rightarrow CH_3\cdot + H_2O$

$CH_3\cdot + O_2 + M \rightarrow CH_3O_2\cdot + M$

$CH_3O_2\cdot + HO_2\cdot + M \rightarrow CH_3O_2H + O_2 + M$

$CH_3O_2H + hv \rightarrow CH_3O\cdot + \cdot OH$

$CH_3O\cdot + O_2 \rightarrow HO_2\cdot + HCHO$

$HCHO + \cdot OH \rightarrow H_2O + CO_2$

Methane + ·Hydroxyl → Methyl + Water

Methyl + Oxygen + non reacting molecule → Methyldioxy + non reacting molecule

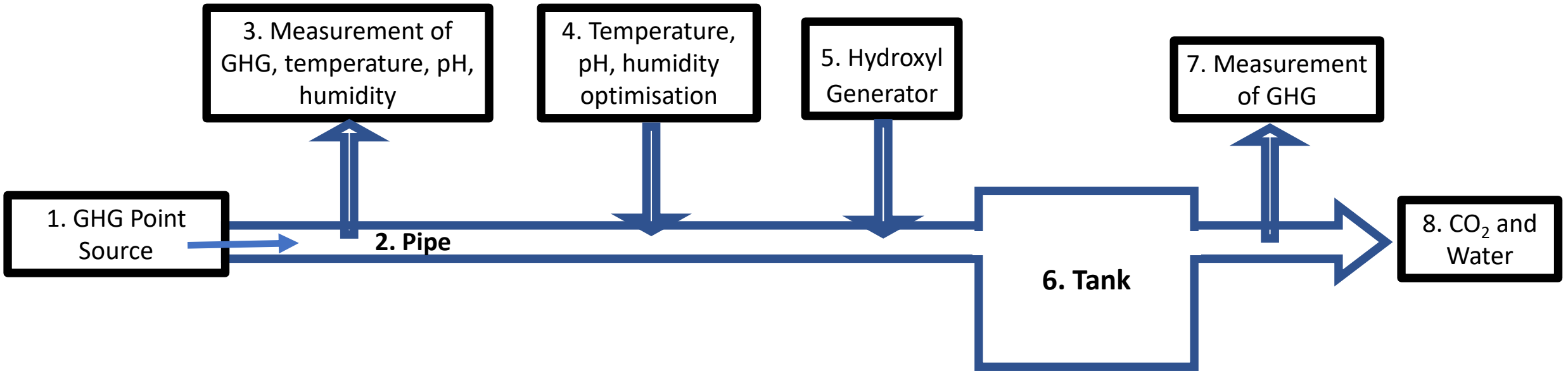
Methyldioxy + Water + M → CH_3O_2H + Oxygen + M

CH_3O_2H + energy → Methoxide· + ·Hydroxyl

Methoxide· + Oxygen → Water· + Formaldehyde

Formaldehyde + Hydroxyl → Water + Carbon Dioxide

Source: https://en.wikipedia.org/wiki/Atmospheric_methane#Removal_processes



Point Source Methane Removal with Hydroxyl Radical - Concept Summary

- Removal of methane with hydroxyl radical now undergoing testing
- Could be funded by carbon credits and consumer demand
- Hydroxyls (OH radicals) naturally cause 95% of atmospheric methane removal
- Existing technology to make hydroxyls can be patented as a way to remove methane from point sources (agriculture, landfill, coal mines, wastewater etc)
- **Aim to be Permanent, Verifiable, Additional, Efficient, Safe, Scalable, Profitable**
- Australian rice methane emissions are 30g/m^2/y
- Carbon credit of \$20/tonne CO_2 equivalent would pay \$156,000/ha/y @GWP26 if all methane removed.

Iron Salt Aerosol Pty Ltd

- Our firm, Iron Salt Aerosol Pty Ltd, seeks to partner with methane emitting industries to develop a commercial system to obtain carbon credits
- Australian startup firm, established in 2018 by Robert Tulip and John Macdonald
- We began by working with international scientific experts to study use of ferric chloride (an iron salt aerosol) to remove methane and CO_2 in field conditions
- Our research has identified hydroxyls as the best way to remove methane from controlled point sources
- We expect this technology will lead to significant low-cost global cooling methods

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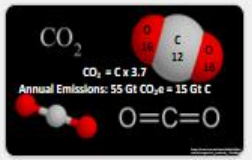

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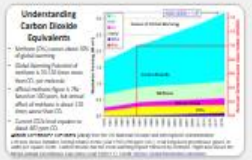

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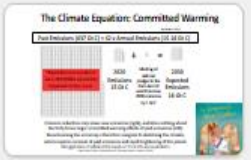

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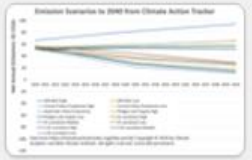

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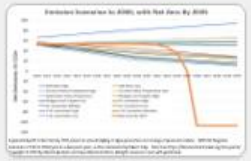

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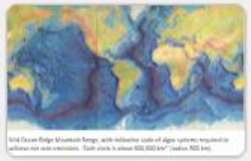

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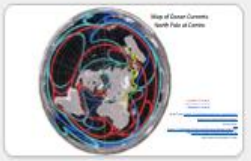

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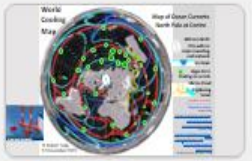

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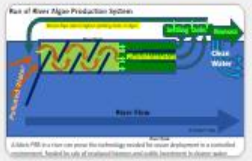

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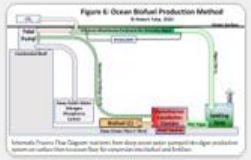

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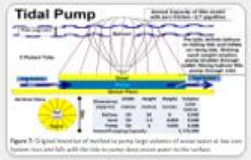

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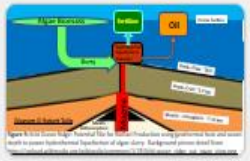

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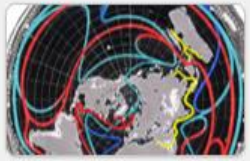

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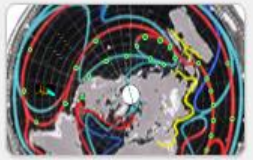

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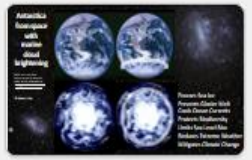

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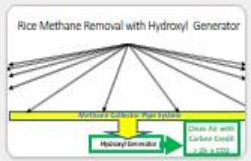

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Thank You!

Robert@rtulip.net