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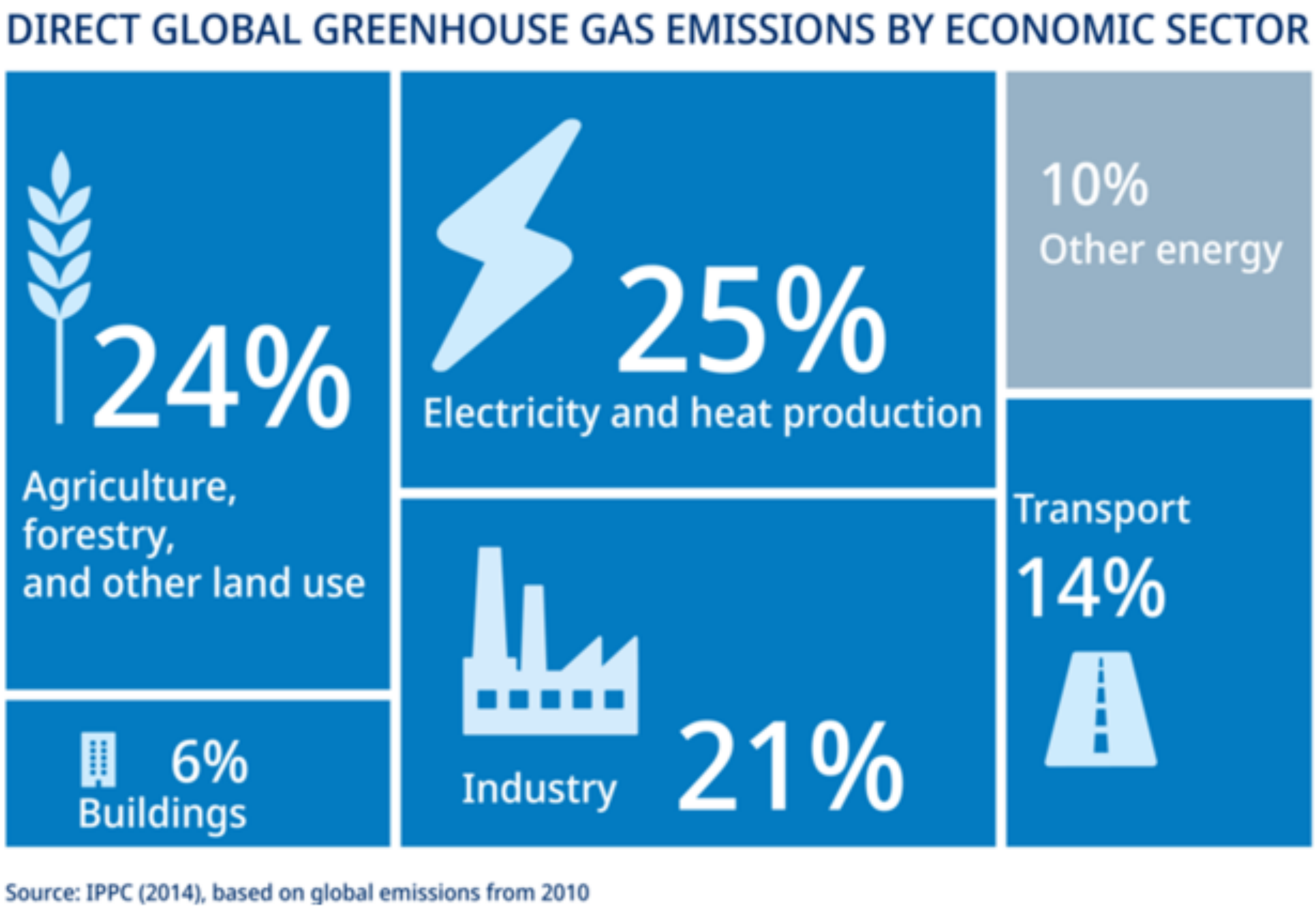
Melbourne Energy Institute

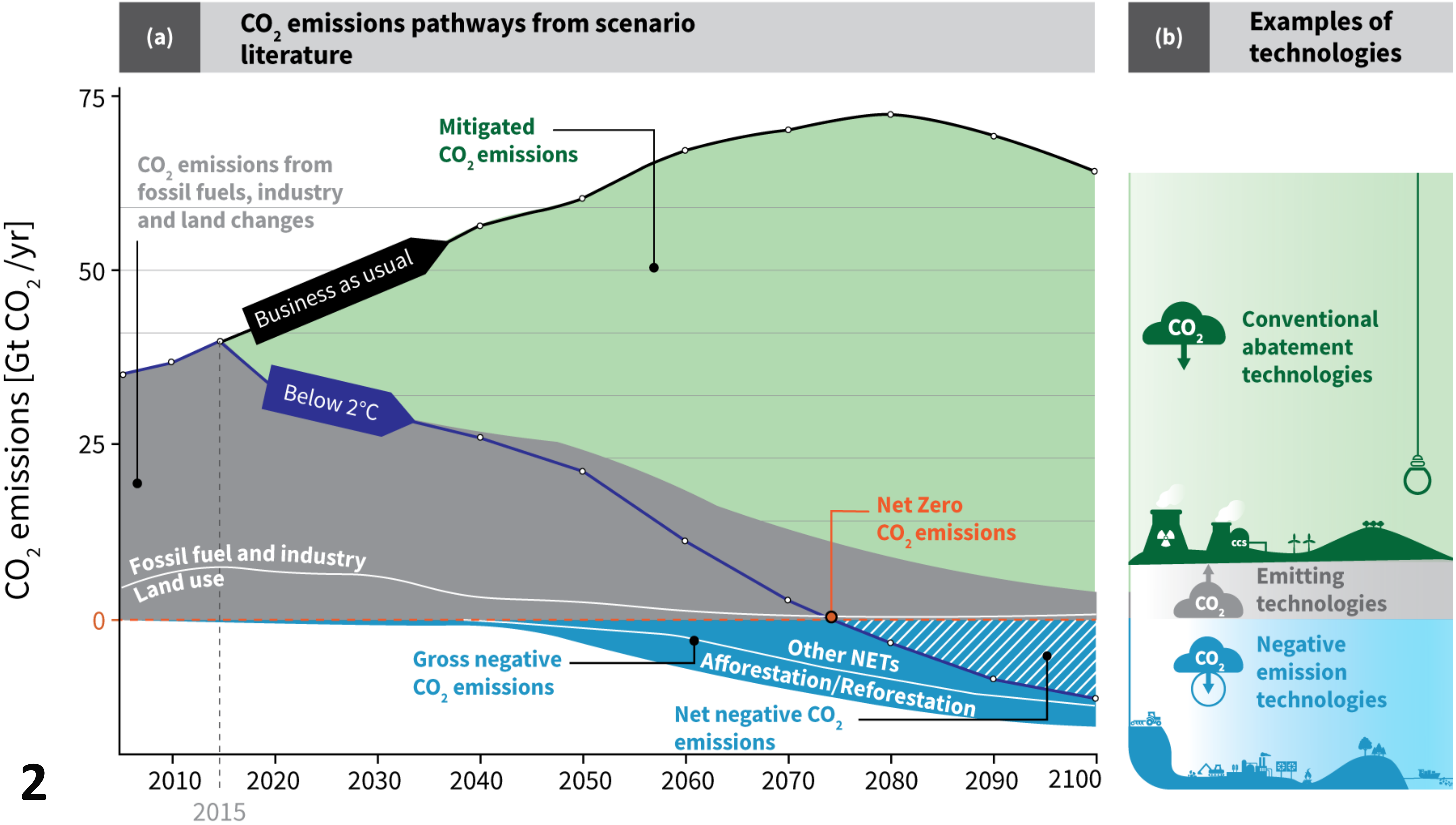
The Peter Cook Centre for CSS Research

Negative Emission Technologies in Australia

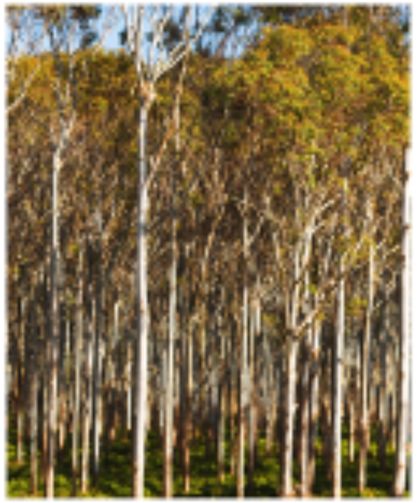
Peter Cook, Peter Cook Centre for CSS Research

Tony Wood (Chair), Grattan Institute


DIRECT GLOBAL GREENHOUSE GAS EMISSIONS BY ECONOMIC SECTOR
24%
Agriculture, forestry, and other land use
25%
Electricity and heat production
10%
Other energy
Transport
14%
6%
Buildings
Industry
21%
Source: IPPC (2014), based on global emissions from 2010

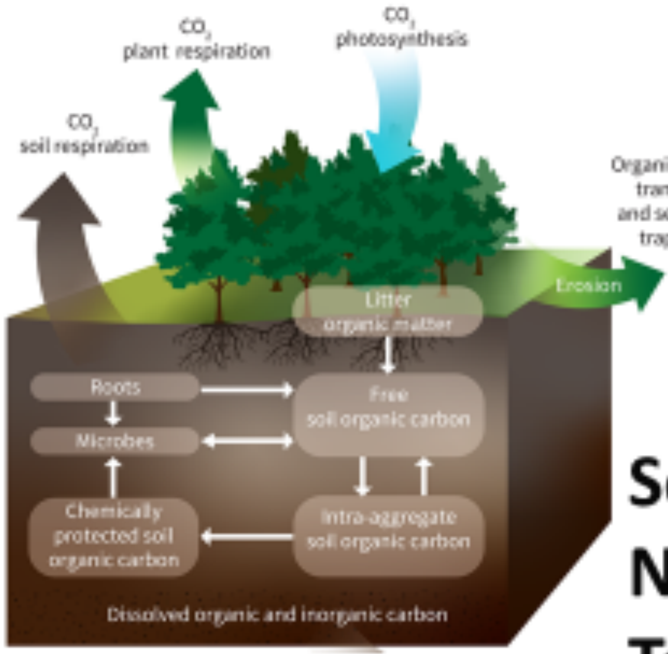

(a)
CO_2 emissions pathways from scenario literature
(b)
Examples of technologies
CO_2 emissions [Gt CO_2 /yr]
75
50
25
0
CO_2 emissions from fossil fuels, industry and land changes
Mitigated CO_2 emissions
Business as usual
Below 2°C
Net Zero CO_2 emissions
Fossil fuel and industry
Land use
Other NETs
Afforestation/Reforestation
Gross negative CO_2 emissions
Net negative CO_2 emissions
2010
2015
2020
2030
2040
2050
2060
2070
2080
2090
2100
CO_2
Conventional abatement technologies
CCS
Emitting technologies
Negative emission technologies

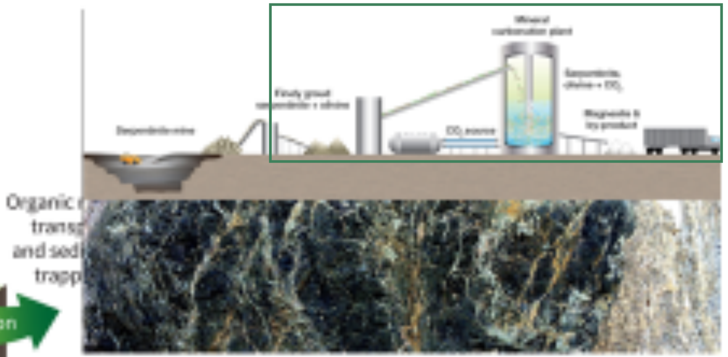
2



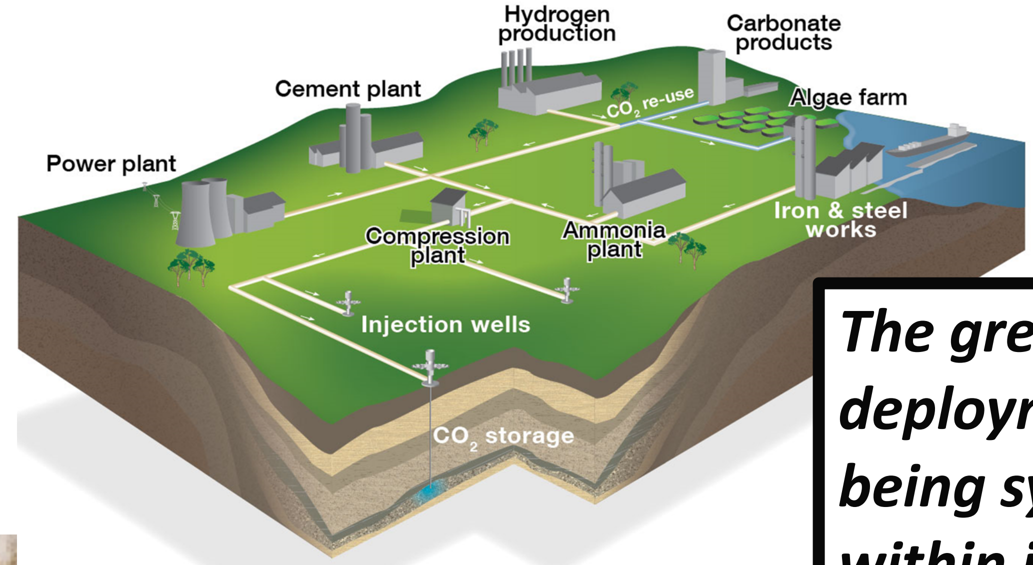
RE-AFFORESTATION

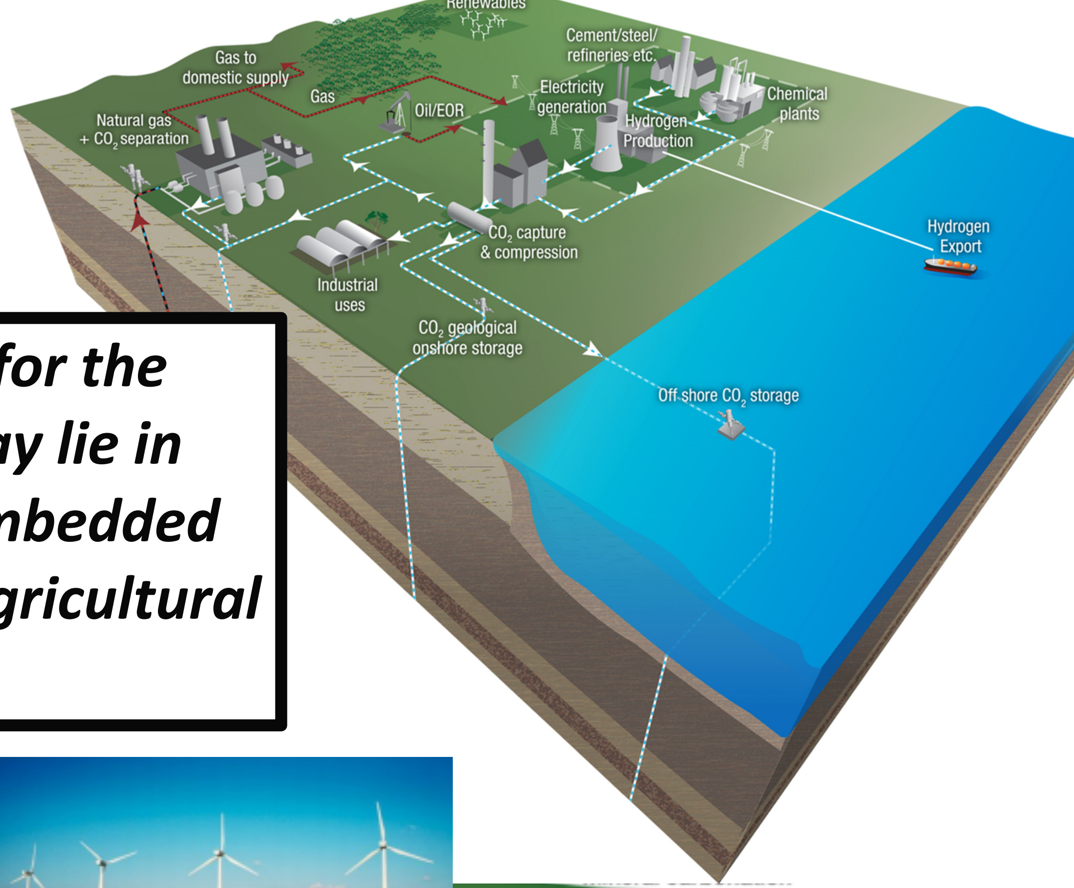
RE-AFFORESTATION



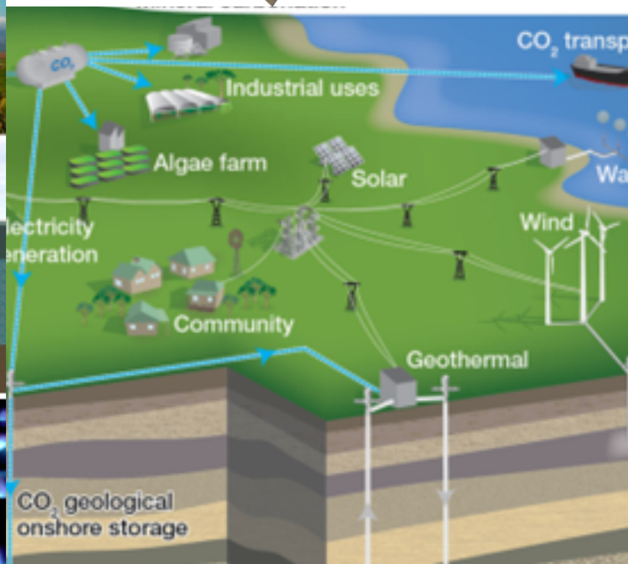


Some land-based Negative Emission Technologies





The greatest potential for the deployment of NETs may lie in being synergistically embedded within industrial and agricultural ecosystems



Co-ordinating Authors
Peter J Cook and Alfonso M Arranz
University of Melbourne

Roundtable Committee: Peter Cook (Chair), Henry Adams, Michael Brear, Rebecca Burdon, Ralf Haese, William Howard, Jeffrey McGee, Bill Stathopoulos, Anita Talberg, and Paul Webley.
Rapporteur: Alfonso M. Arranz
Facilitator: John Burgess

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[redacted]
Carbon Capture and Storage Research

NEGATIVE EMISSION TECHNOLOGIES IN AUSTRALIA

Report on 2019 Roundtable Discussions

https://petercook.unimelb.edu.au/__data/assets/file/0007/3454927/NETs-report.pdf

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Speakers

Peter Cook, Peter Cook Centre for CSS Research

Tony Wood (Chair), Grattan Institute

Andrew Lenton, CSIRO Climate Science Centre

Robin Batterham, The University of Melbourne

Nasim Pour, Jacobs' Economics

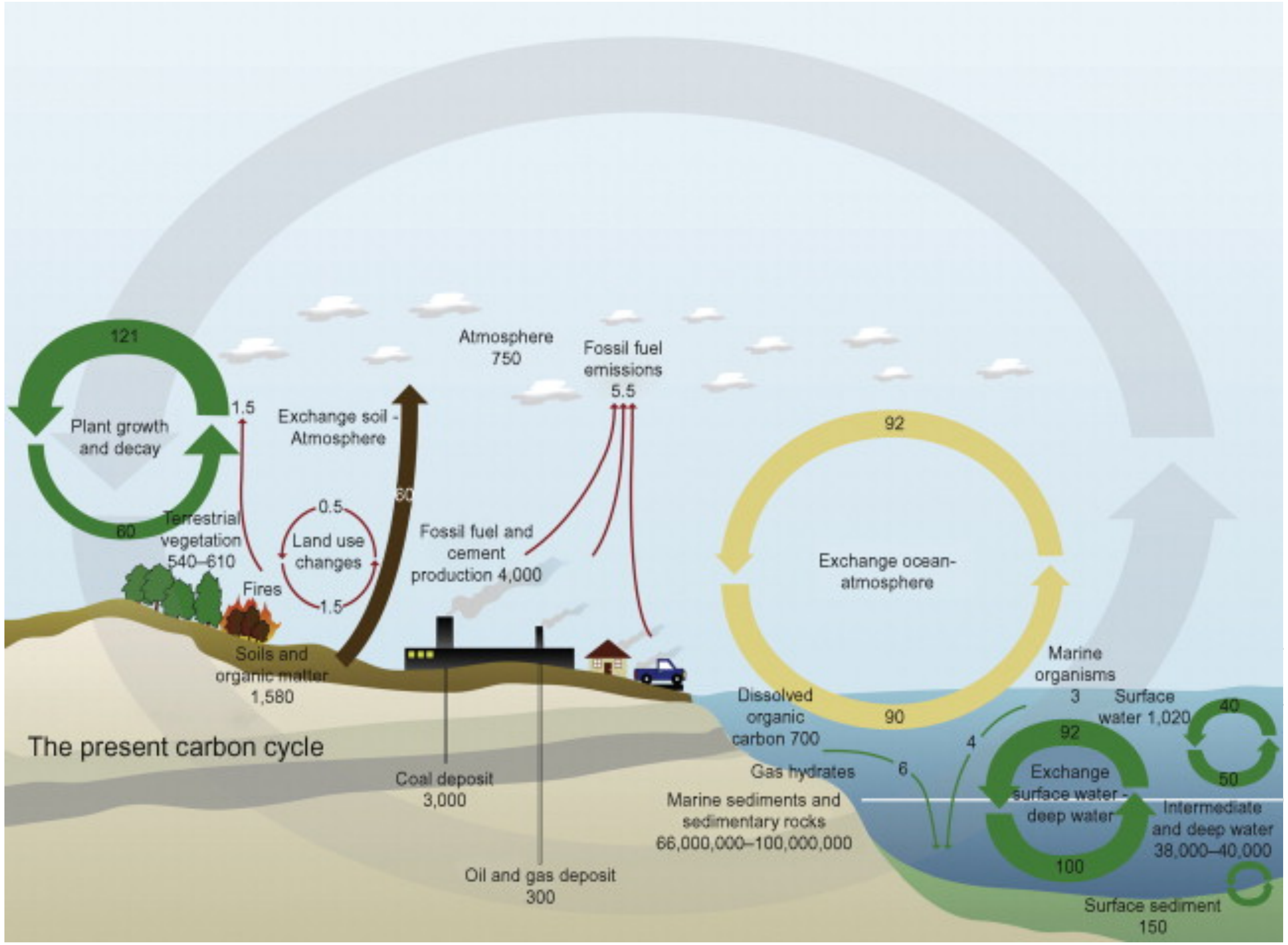
David Byers, CO2CRC

The Global Carbon Cycle and what it tells us about the need for Negative Emissions

andrew.lenton@csiro.au

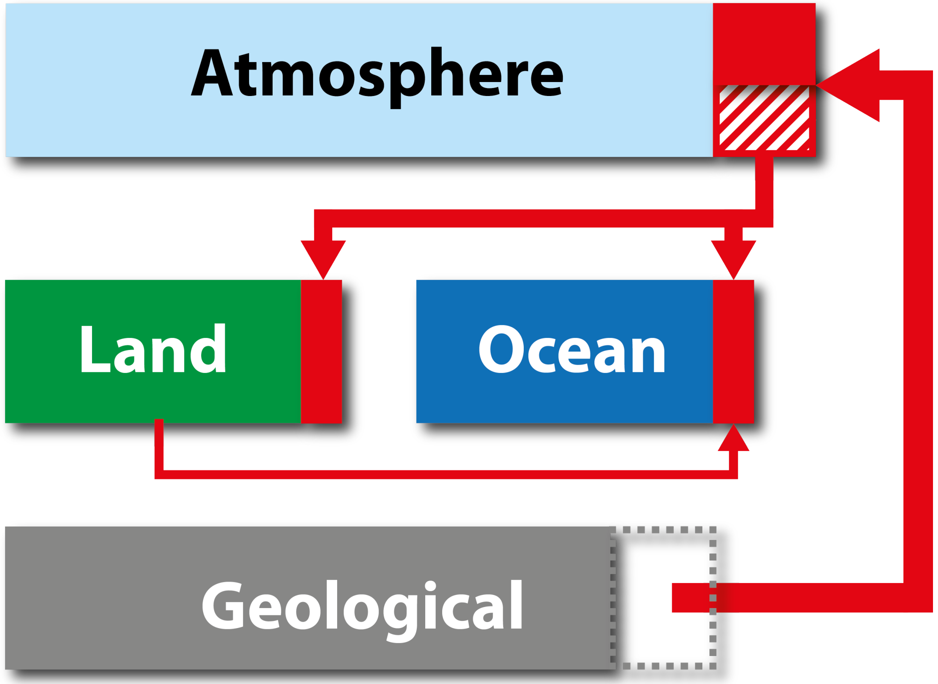
Andrew Lenton
Principal Research Scientist
CSIRO Oceans and Atmosphere

The Global Carbon Cycle

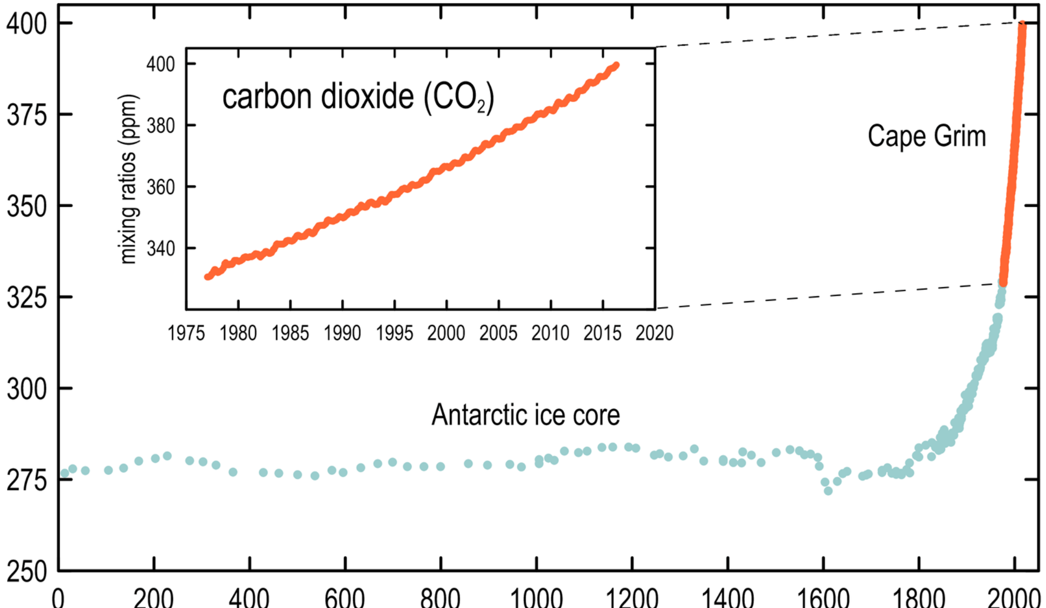


UNEP/GRID-Arendal.

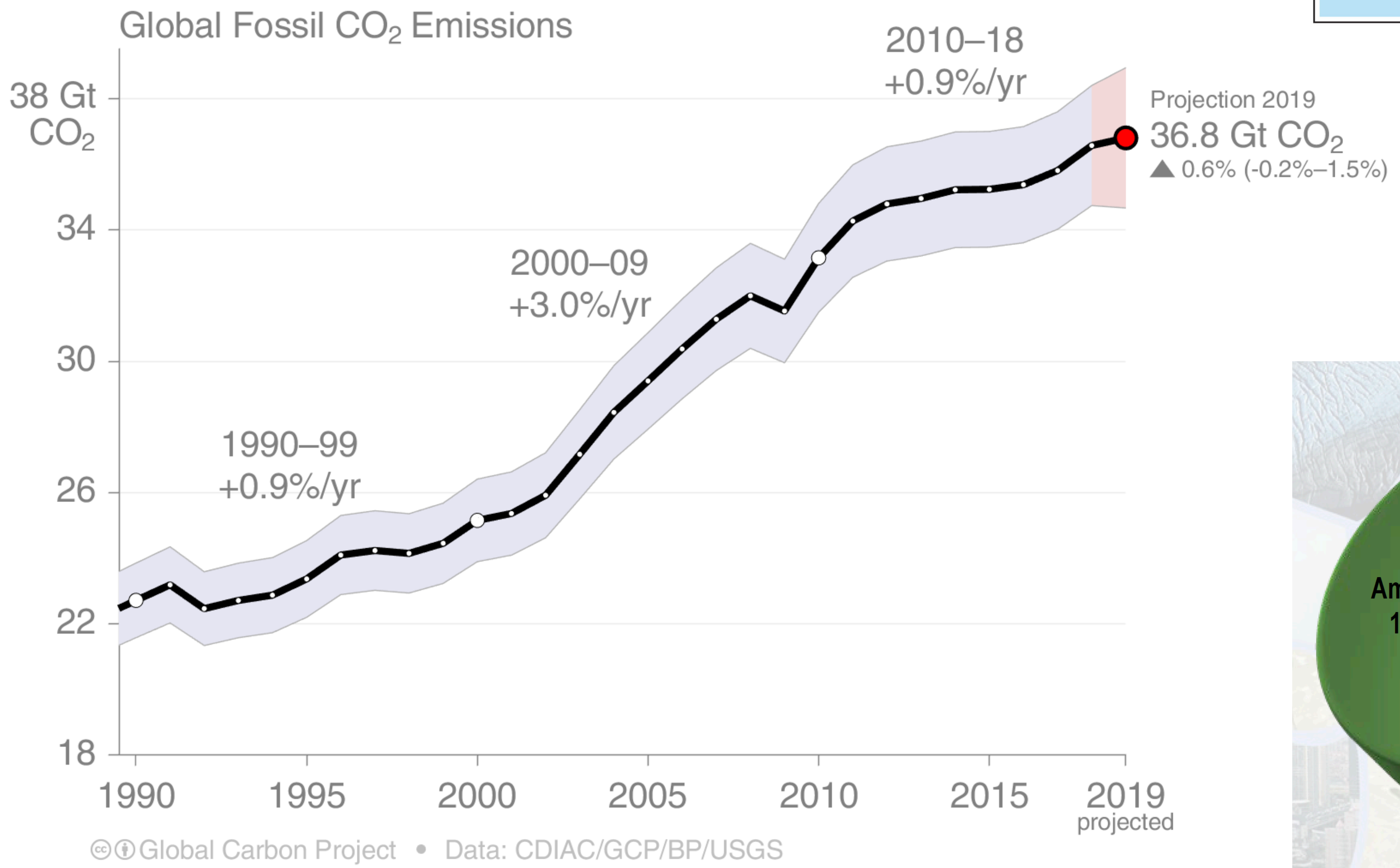
Keller Lenton et al, Current Climate Change Reports 2018

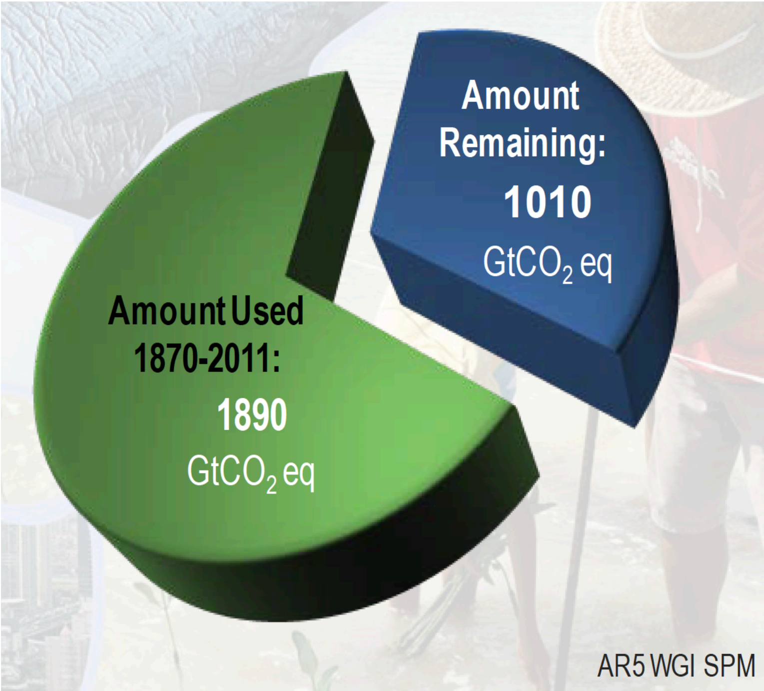


Paul Krummel

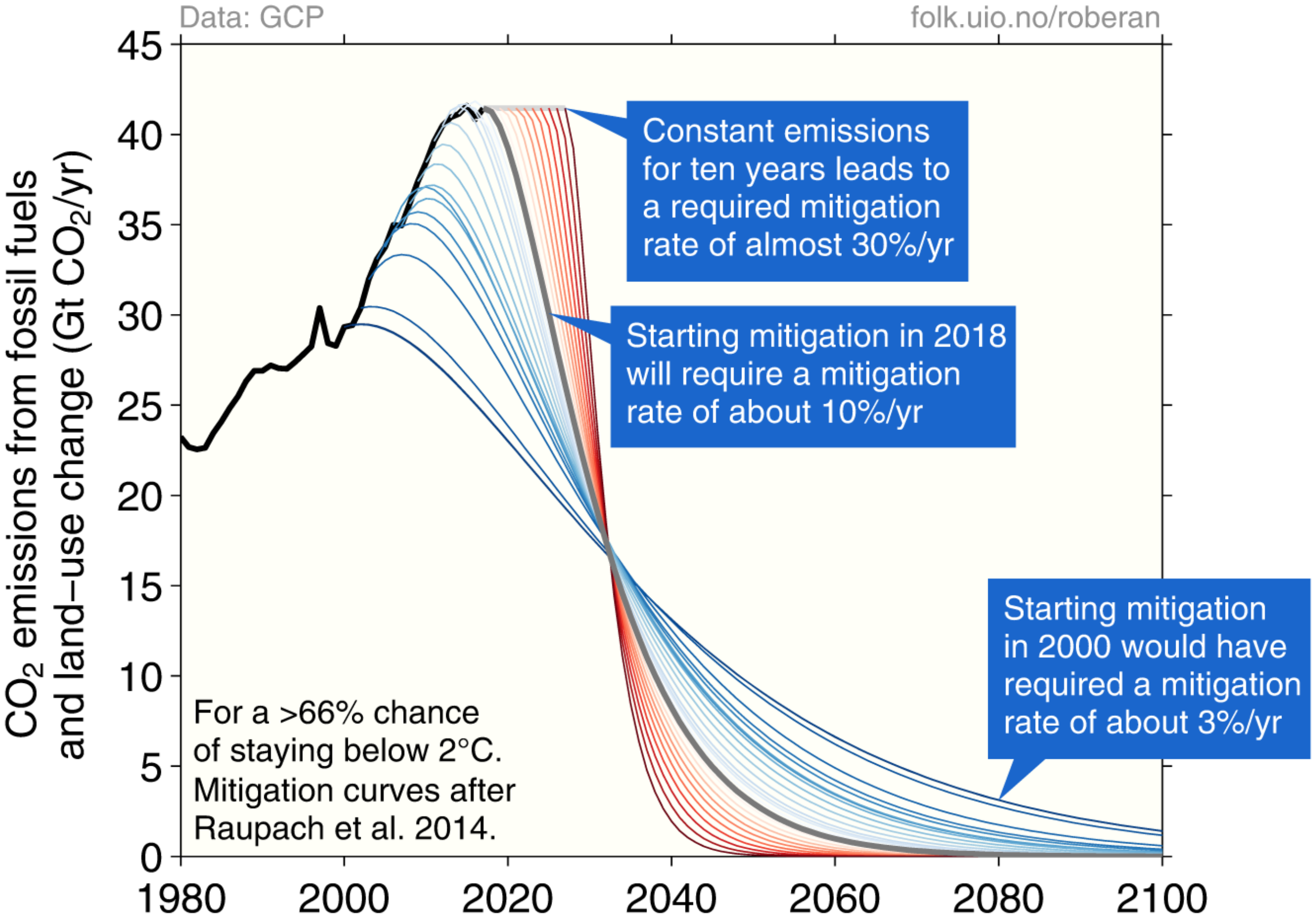


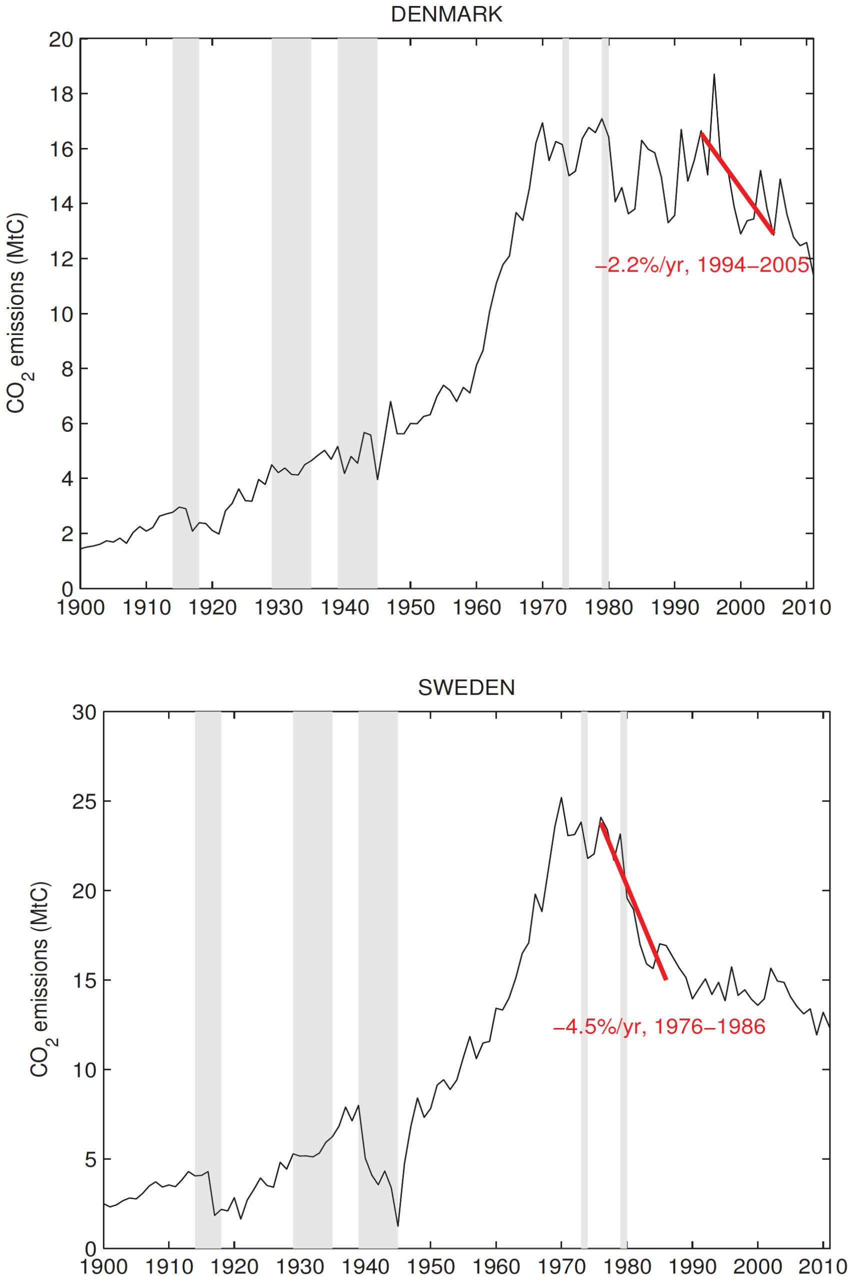
Current Emissions & Paris





Can’t we just Decarbonise?





Global Carbon Project 2017; Mitigation curves after Raupach et al. 2014, NatureCC

Peters et al. 2013, NatureCC; Global Carbon Budget 2016

Not all sectors can be easily decarbonised

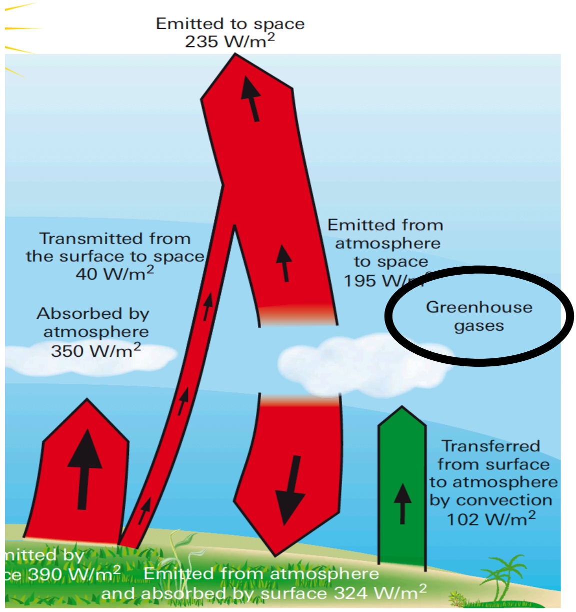
(> 1/3 total GHGs)

CO_2 Emissions

CO_2 Emissions

Non-CO_2 Emissions

Negative Emissions



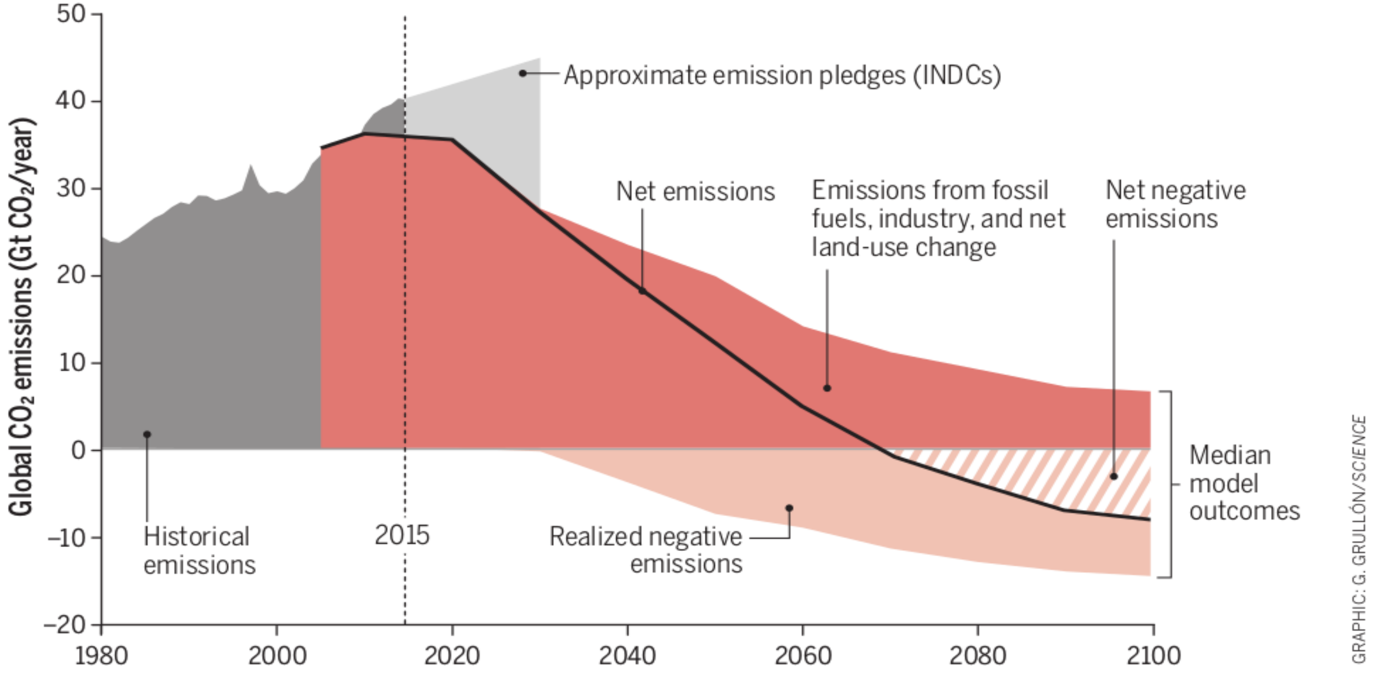
Carbon Dioxide Removal or Negative Emissions

Reduces impacts through reducing atmospheric GHG concentrations

Neg Emissions have long been part of the low emissions pathways (IPCC)

Increasingly difficult to get to Paris without CDR.

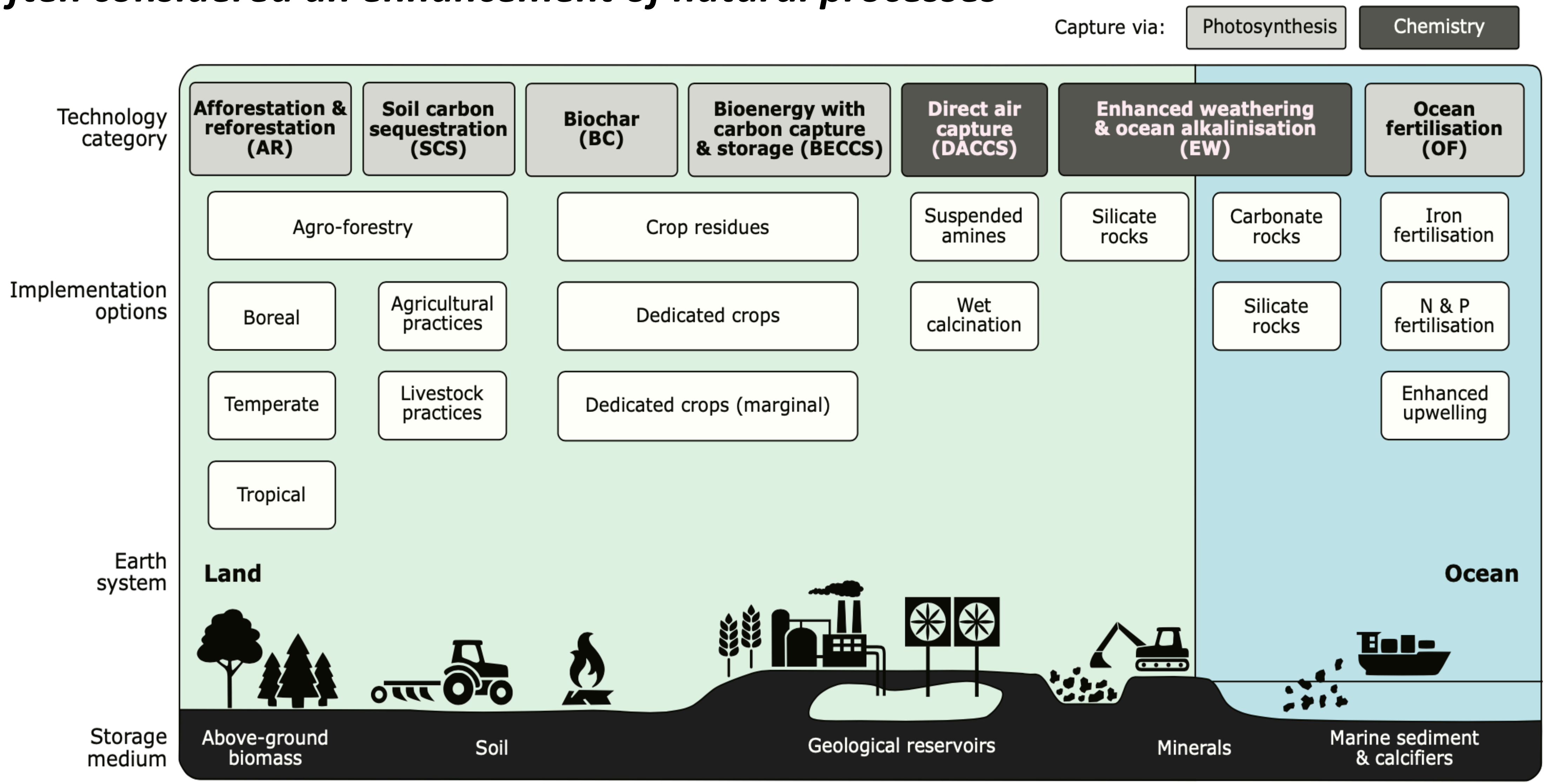
UNITED NATIONS PARIS CLIMATE AGREEMENT SIGNING CEREMONY 22 APRIL 2016



Anderson & Peters, 2016

Negative Emissions Technologies (NETs)

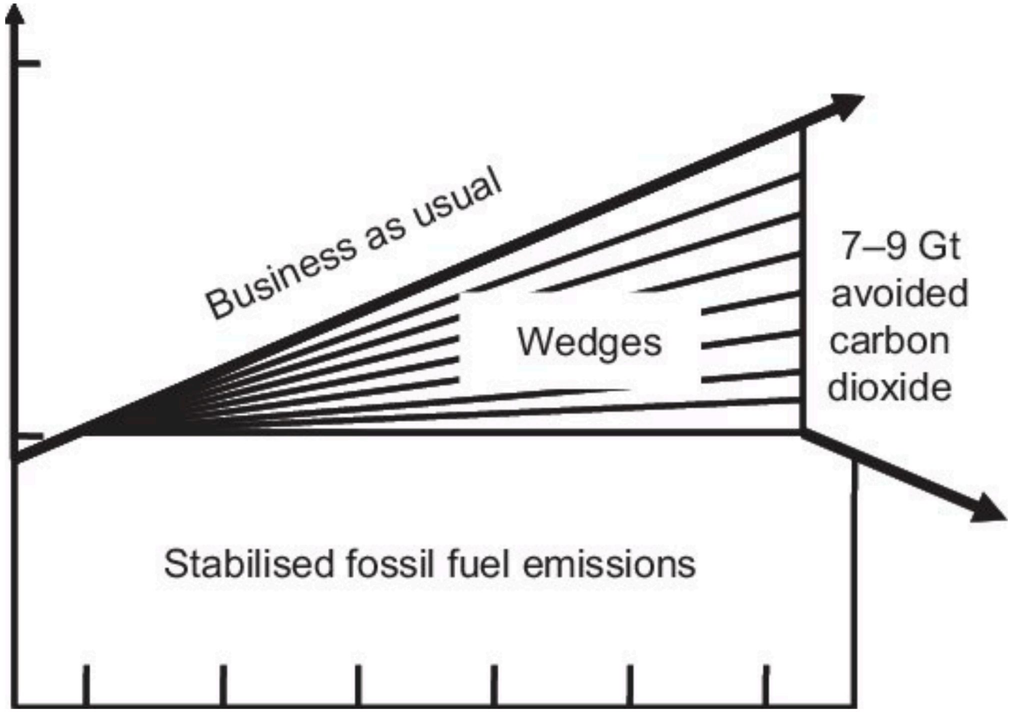
"Often considered an enhancement of natural processes"



Minx et al, 2018

Implementation & Integration

Not likely to be one simple global solution, but a **patchwork** of different forms of GE applied which will interact with each other over space and time

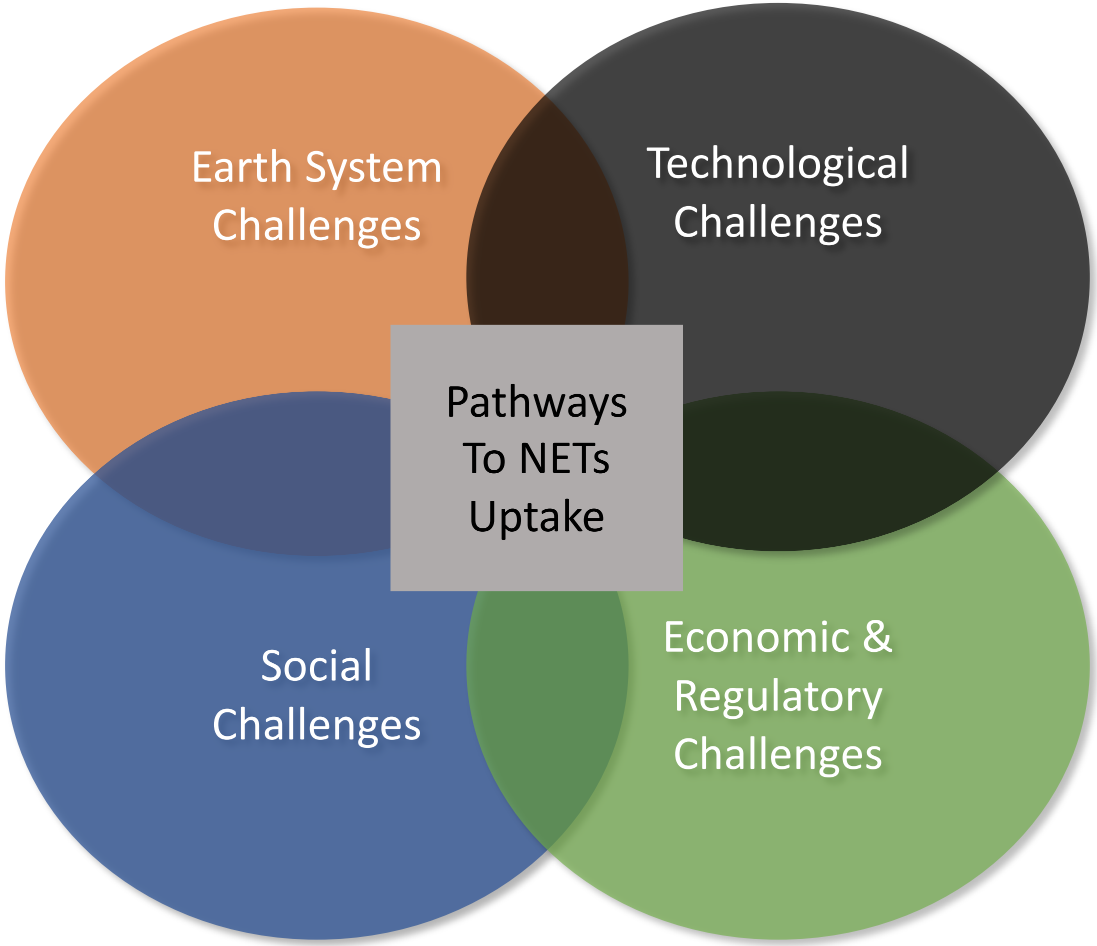


Fink (2013) after Pacala and Socolow (2004)

TOPICAL REVIEW

Negative emissions—Part 3: Innovation and upscaling

Gregory F Nemet[1,8], Max W Callaghan[2], Felix Creutzig[2,3], Sabine Fuss[2], Jens Hartman
Hilaire[2,6], William F Lamb[2], Jan C Minx[2,4], Sophia Rogers[1] and Pete Smith[7]



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Negative emission technologies in Australia

Panel discussion

4 August 2020

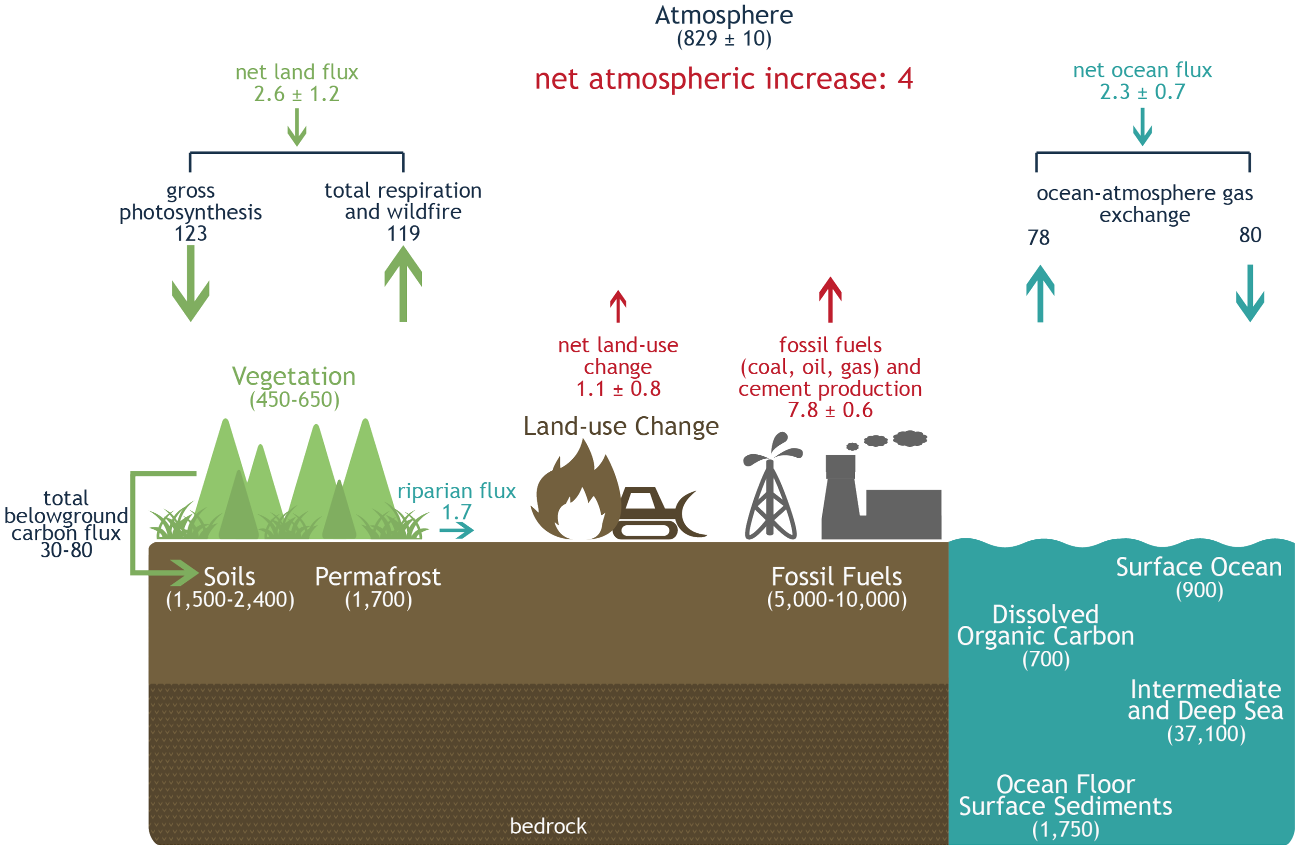
Professor Robin J Batterham AO, FAA, FTSE, FNAE. FCAE, FREng, FSATW, FINAE
Kernot Professor, School of Engineering

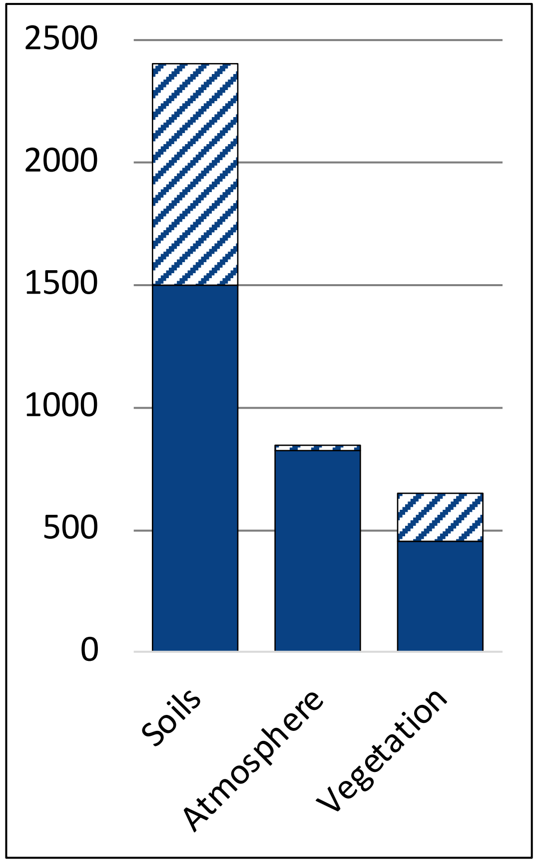
- **Soil carbon – a reminder on the numbers**

- How much could we sequester?

- And in Australia?

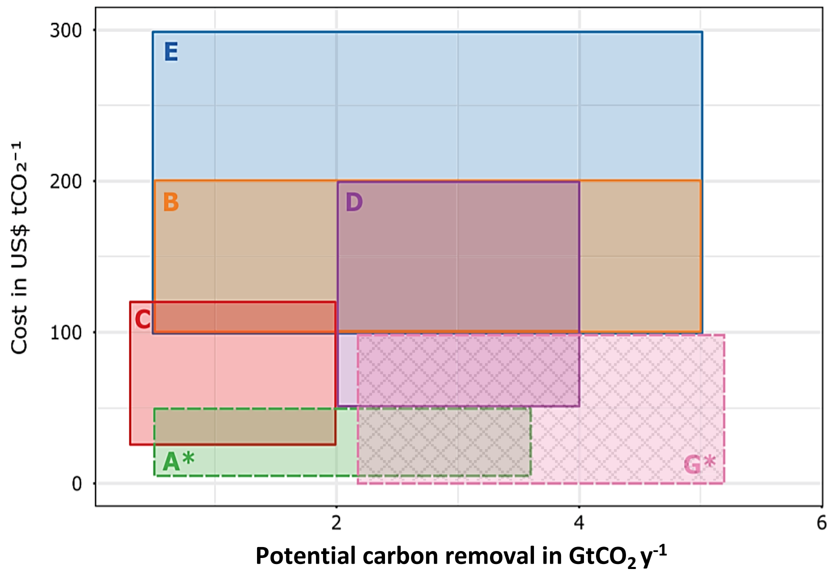
Soil carbon – a reminder on the numbers





Source: https://www.fs.usda.gov/ccrc/topics/global-carbon

How much could we sequester?



A Afforestation and reafforestation
B Bioenergy carbon capture and storage
C Biochar
D Enhanced weathering
E Direct air capture
F Ocean fertilisation
G Soil carbon sequestration

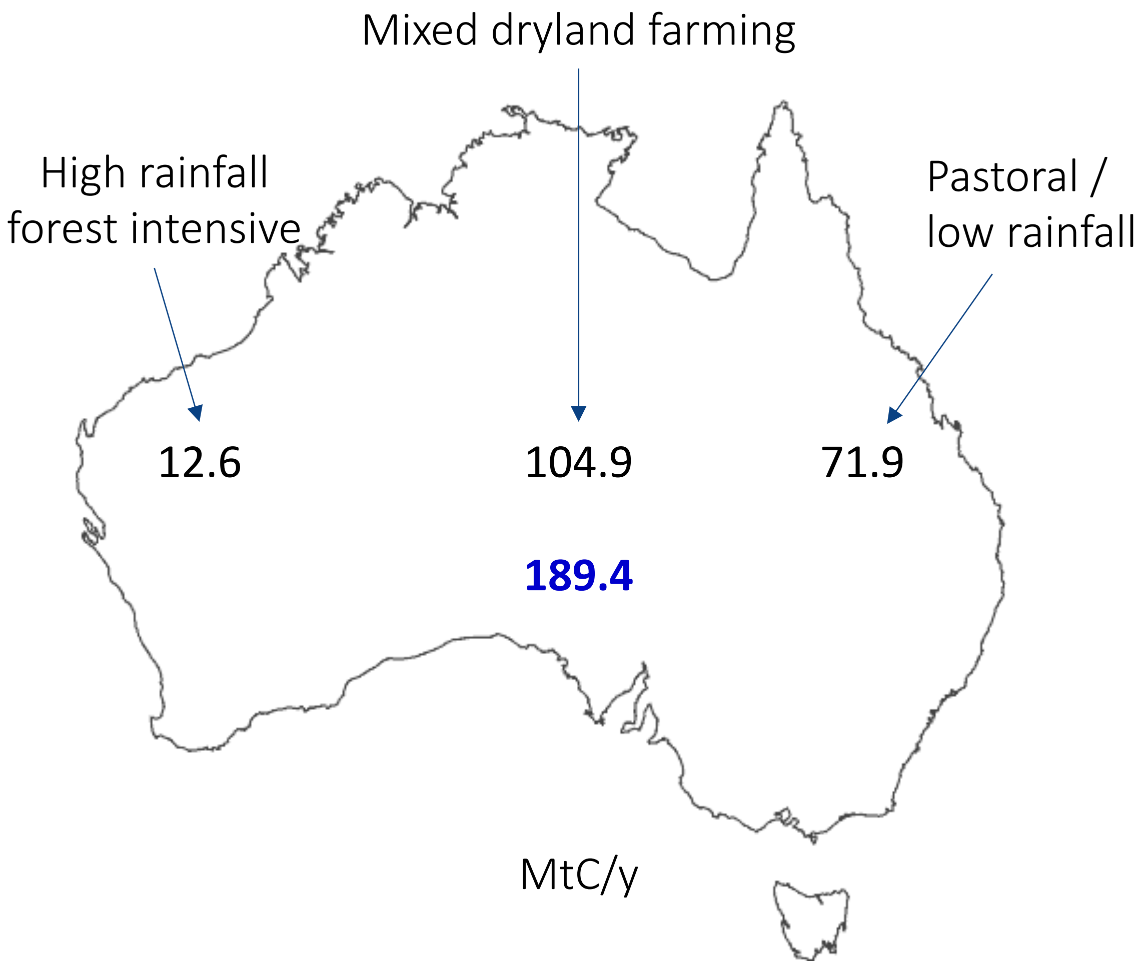
USA currently 0.7 Gt CO_2/y falling to 0.35 in 2050

Can target maintaining 0.85 Gt CO_2/y, negative emissions of 0.15 Gt CO_2/y

Source: Sabine Fuss et al 2018 Environ. Res. Lett. 13 063002.

Private communication, Princeton University –Net -Zero America Project.

And in Australia



Conservative estimate for 0.15% soil C increase to a depth of 15 cm for 50% of dryland and irrigated crop land: 42 Mt C/y

Source: Totals from Carbon working group of the Restore Australia Technical Advisory Board.

Conservative estimate from report by Adrian Lawrie.

Jacobs Challenging today. Reinventing tomorrow.

Bioenergy with CCS – Potential & Challenges

Negative Emissions Technologies (Melbourne Energy Institute)

August 2020

Nasim Pour

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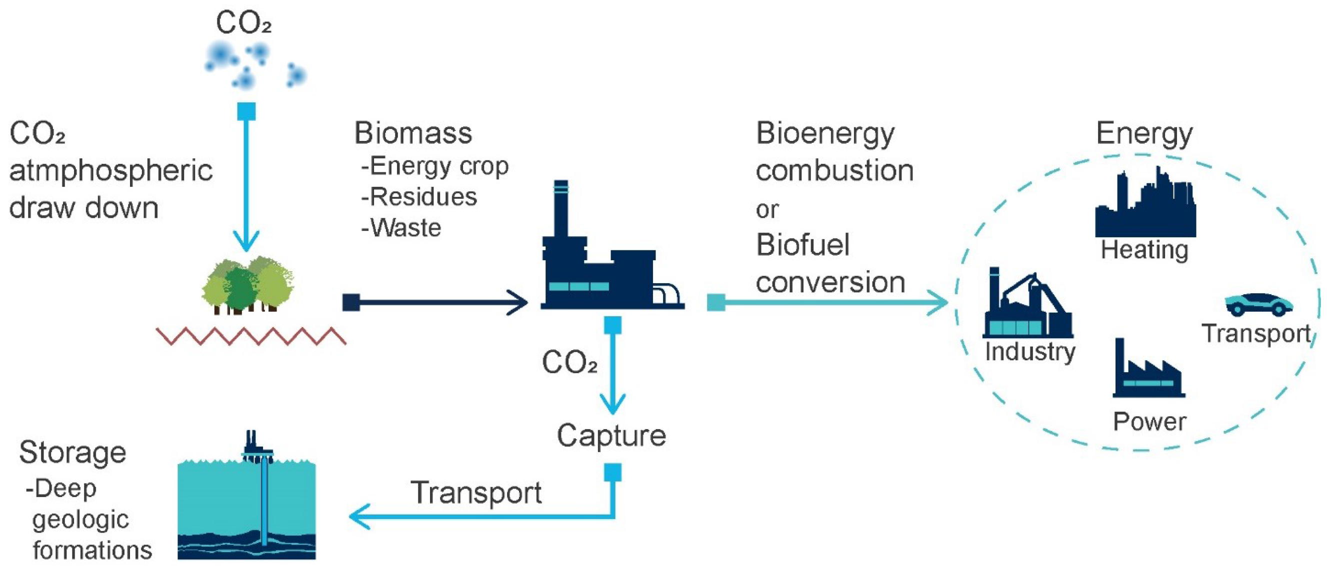
Bioenergy with CCS (BECCS)



Source: Bioenergy and Carbon Capture and Storage- Global CCS Institute, 2019 Perspective

- Currently five BECCS projects are operating, capturing CO_2 from ethanol production plants with a total capacity range of 0.1–1Mt CO_2/year negative emission.
- So far, the only large-scale deployment of BECCS is the Illinois Industrial CCS Project (IICCSP) with the CO_2 injection rate up to 1 Mt CO_2/year.

The negative emission potential of BECCS in the literature up to 20 Gt CO_2/year

Bioenergy potential up to 1000 EJ/ year

Intensification of *energy crops production* could result in:

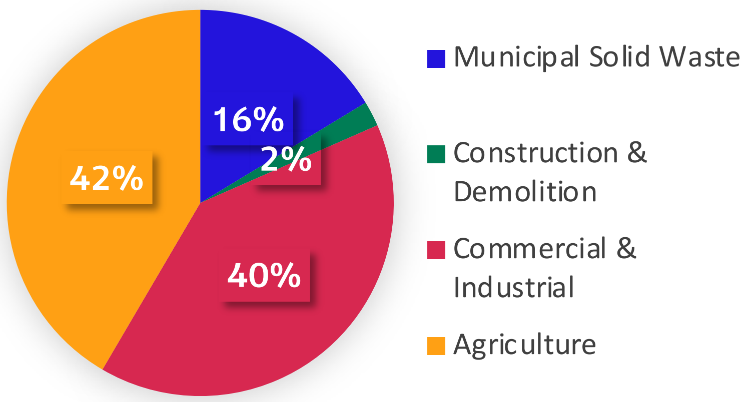
- **Severe competition between food, feed, and energy**

→ Leading to controversial economic, ethical, and environmental issues

- **Future bioenergy potential should be restricted to:**
  - **No land-use expansion**
  - **No increase in water consumption**

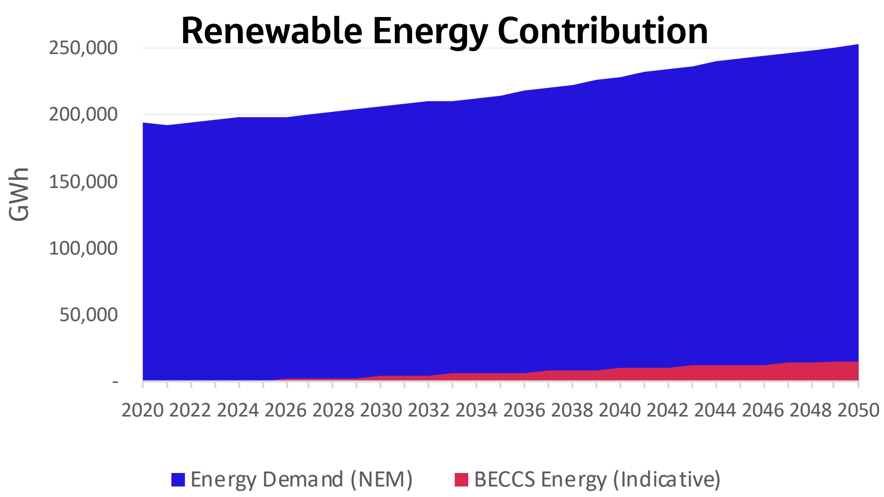
Near Term BECCS in Australia: Waste to Energy

In 2016–2017 around 30 Mt of organic waste and residues was generated in Australia[1].

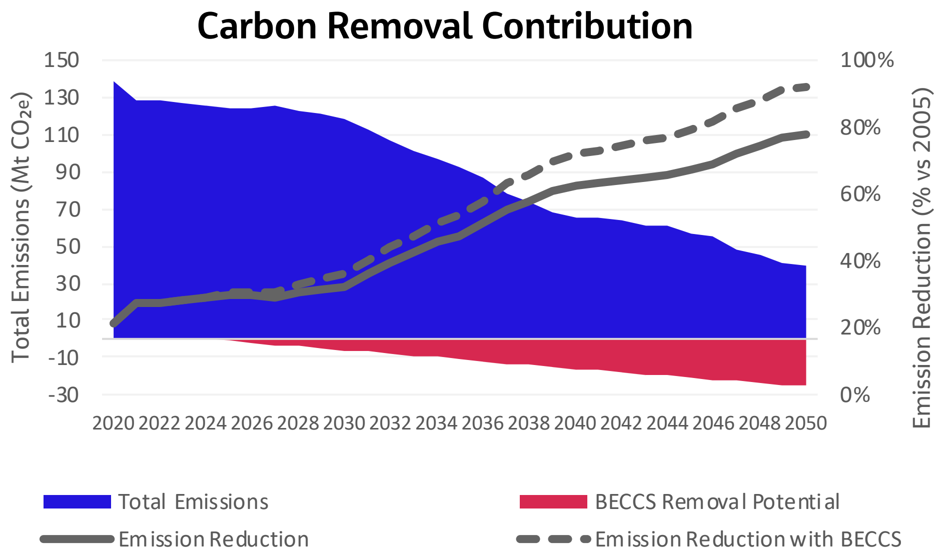


If all this organic waste/residues is utilised through BECCS, it could:

- Generate **15-35 TWh energy** per annum
- Remove **12-25 Mt CO_2** per annum



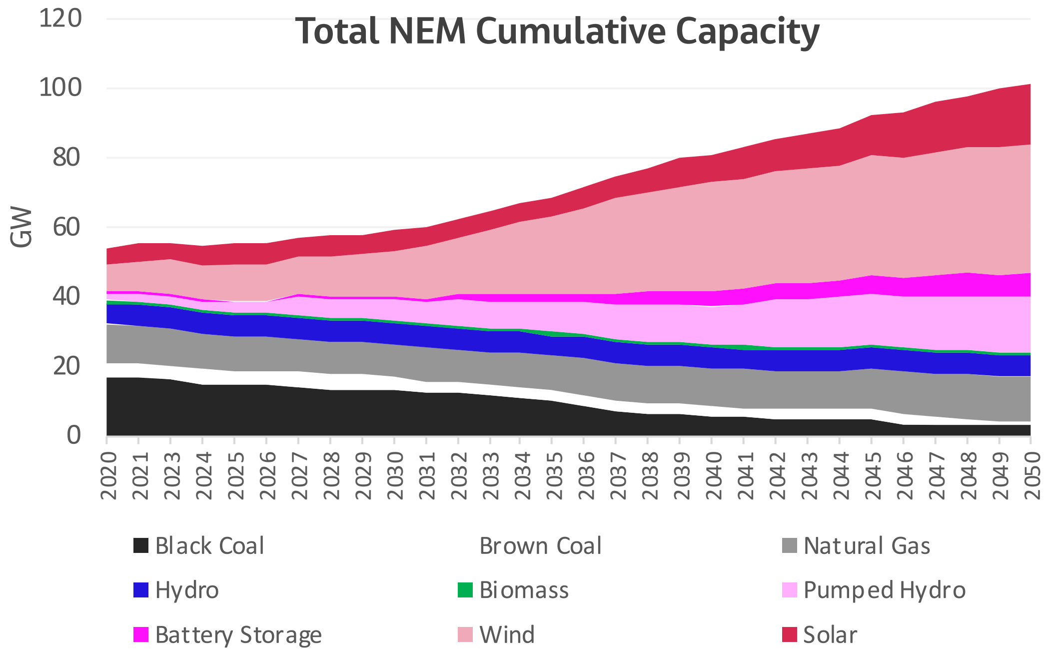
Waste-based BECCS could contribute to up to 6% of the NEM energy demand.

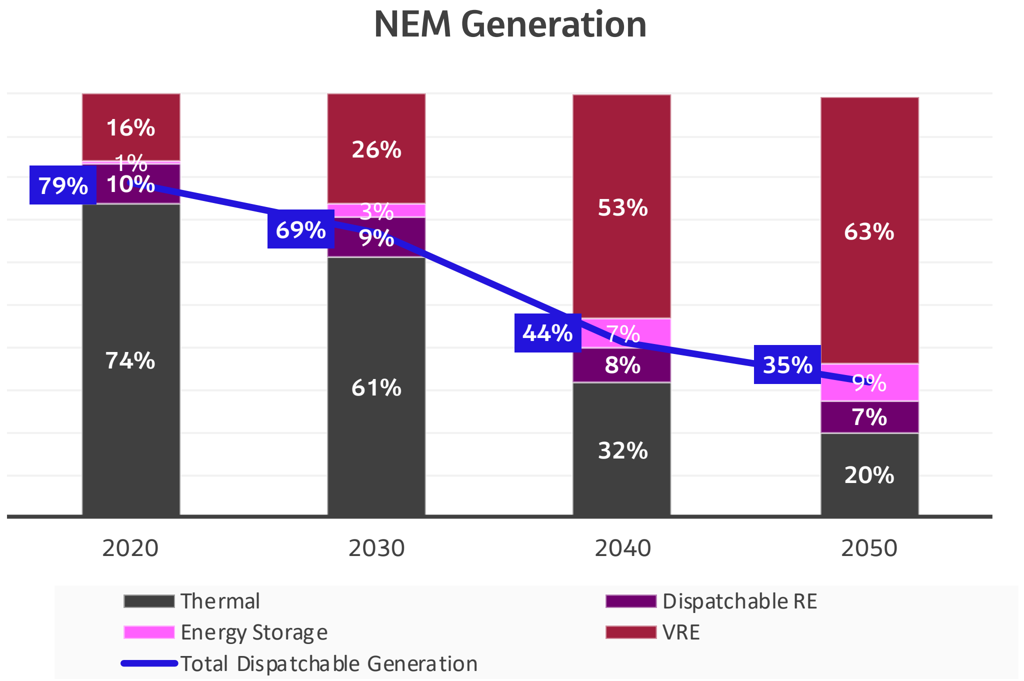


Sustainable BECCS facilitates & accelerates emission mitigation.

1. *Refer to: Australian National Waste Report 2018*

Electricity Sector- Transition and Challenges





Under a "Baseline Scenario", by 2050:

- Coal-fired power capacity retired = 17 GW
- Wind and Solar PV capacity added= 29 GW and 13 GW
- Energy Storage (BESS & PHES) capacity added= 20 GW
- Total capacity added to replace retired coal is more than 4 times of the peak demand

→ BECCS offers more (~30%) energy per MW installed than VREs

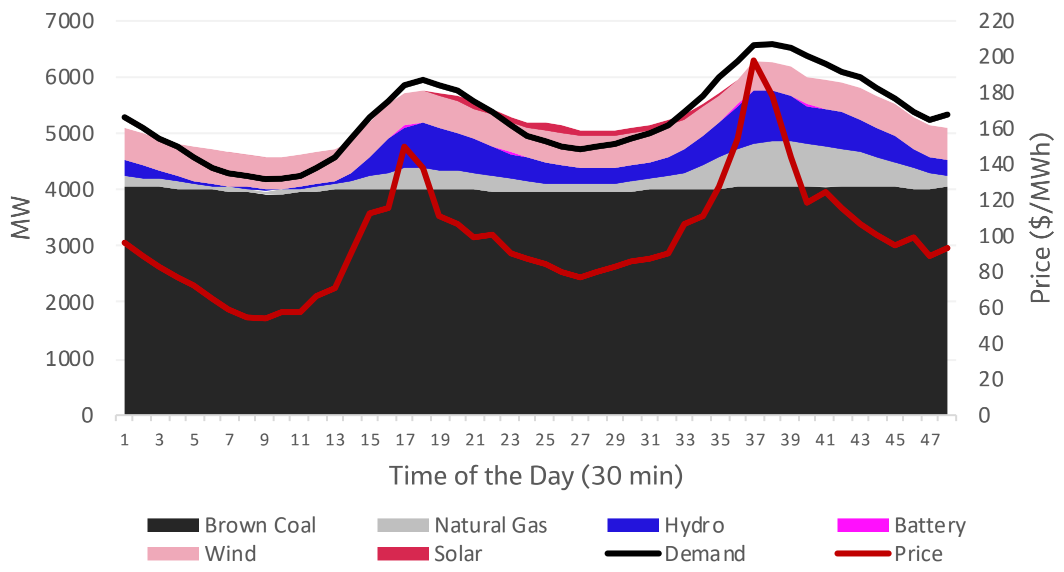
Electricity sector is transitioning towards:

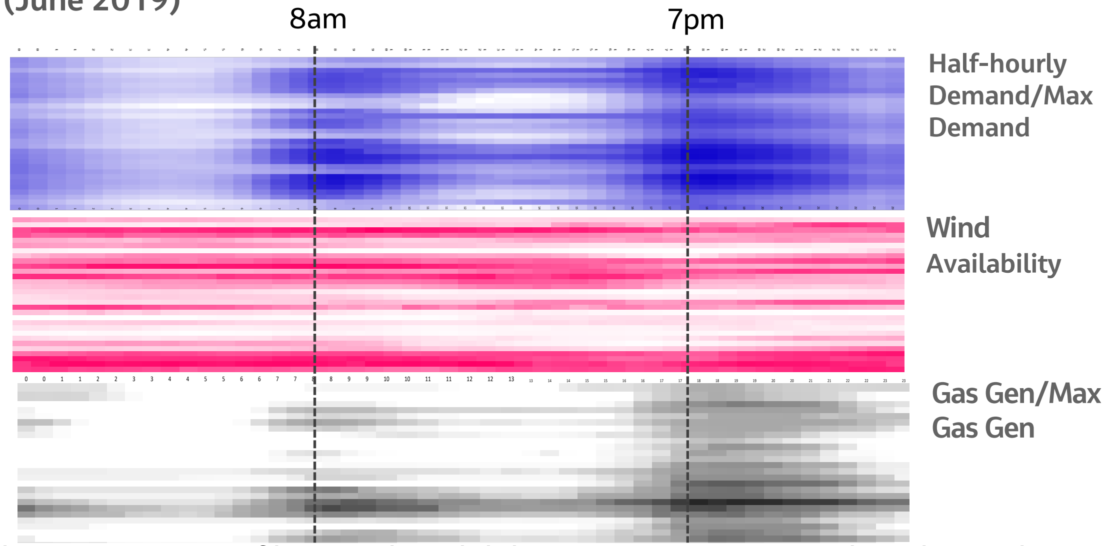
- Increasing uptake of VRE
- Lower share of dispatchable generation

→ BECCS offers dispatchable renewable capacity to improve grid stability and reliability

VRE: Variable Renewable Energy, i.e. Wind & Solar PV
Dispatchable RE: Hydro power and Bioenergy
Dispatchable Generation: energy technologies which can dispatch on demand , i.e. coal, natural gas, hydro, bioenergy and energy storage systems

Case Study- Victorian Electricity system





- Operational demand follows a "duck curve" shape, peaking at 8 am and 7 pm
- Peak demand is supplied by marginal gas generators which leads to:
  - higher wholesale electricity price
  - higher emission intensity if these plants are not operated optimally

- There is a pattern of low wind availability in June in Victoria, when demand is picking up due to winter heating load
- Solar PV generation is low (due to shorter daylight)
- Low wind energy and very low solar PV energy for consecutive days means energy storage could not fully cover the peak demand at cold winter evenings
- Going forward (beyond 2030) our modelling is showing that as we transition to higher levels of VRE, gas-fired generation is being used 16 hours per day every day of the working week

→ BECCS could reduce the need for gas-fired power to cover the peak demand in low VRE periods

BECCS could be part of a sustainable solution for three major problems

Waste Sector	By utilising (currently disposed) organic waste to generate energy, BECCS could turn a negative externality into a revenue stream
Electricity Sector	By generation dispatchable renewable energy, BECCS could enhance reliability and stability of the electricity system
Emission Reduction	BECCS offers permanent removal of CO_2 from the atmosphere

CO2CRC

BUILDING A LOW EMISSIONS FUTURE

NETS in Australia…
the foundational role of CCS

DAVID BYERS, CO2CRC LTD.

MELBOURNE ENERGY INSTITUTE

5 AUG 2020

CO_2 capture and storage fundamentals are well known…safe, reliable, permanent storage.

Capture:

Proven technology - been in commercial operation for decades (amines 1930's).

Proven capture rates of 90% of CO_2 emissions already reality; costs and energy penalties will improve with 'learning by doing'.

Development of new membranes and adsorbents.

Transport:

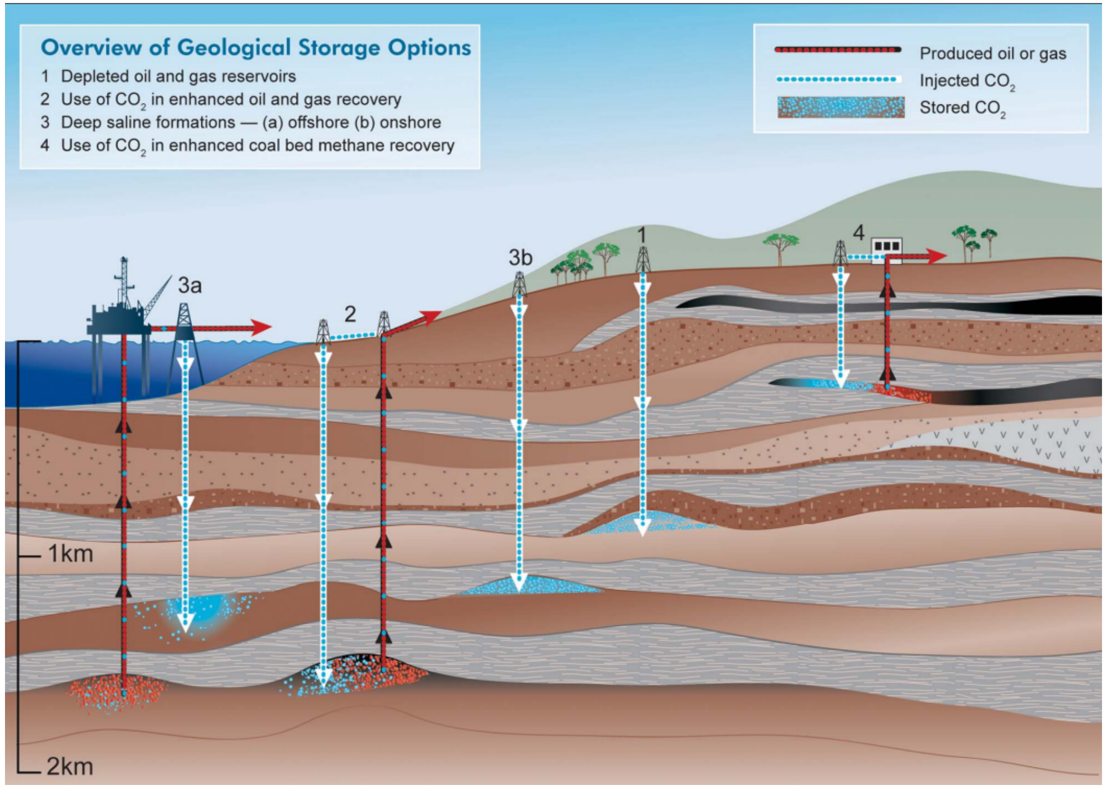
Pipelines - mature technology.

Storage

No technical barriers:
CO_2 injection is the inversion of oil and gas extraction); >700 NG storage facilities worldwide.

The target formation (oil & gas reservoir; deep saline formation) must be:

- Porous with good permeability
- Below 800m in depth (CO_2 remains in dense liquid-like state)
- Secure for storage
- Thick and continuous over larger areas (store large volumes)



Geological Storage Options

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CO2

Costs…vary with industry sector, location and project specs.

Concentrated CO_2 streams provide lowest cost near term opportunities. As technology and process design advances and experience grows, dilute streams will expand CCUS opportunity.

Dilute Streams:
Capture = primary cost (~80%) where CO_2 separation is not part of production process (power generation, steel, cement)

Concentrated Streams:
Storage = primary cost (~70%) where concentrated CO_2 streams produced as part of production process (NG, bio-ethanol plants)

Cost reductions through new technologies and process designs:

- BD3→Shand PCC $45/t$CO_2$ captured)
- CO2CRC Otway Stage 3 CO_2 75% monitoring cost reduction
- CO2CRC 2nd generation capture technology – reduce capture cost

Industry	PC super-critical	IGCC	NGCC	Iron and steel	Cement	Natural gas Processing*	Fertilizer*	Biomass to ethanol*
Cost of CCUS in US- "First of a Kind", USD/tCO_2 avoided	74-83	97	89	77	124	21.5	25.4	21.5
Cost of CCUS in Australia- USD/tCO_2 avoided	104	135	160	119	194	27	33	27

Data source. GCCSI, 2017 – Global Costs of Carbon Capture and Storage

**Figures represent the cost of CCS when applied to a highly concentrated stream of CO_2 produced as a by-product of the production process. Costs shown are not representative of CCS applied across all streams in these industrial processes.*

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BUILDING A LOW EMISSIONS FUTURE

CO2

Recognising economic value of CCS…the missing element

Project revenue or other financial benefit (policy) + continued cost reduction → builds commercial case to invest in CCS projects

Economic Value

- Can achieve major emission reductions from multiple current industry sectors (LNG, power, steel, chemicals, fertilizer, aluminium) plus future fuels (clean hydrogen)
- Key enabler for NETS (BECCS, DACS)

Project Commercial Drivers

Revenue (saleable product)

- CO_2 utilisation (EOR)

Revenue (policy)

- Carbon credits

Other financial

- Tax concessions (45Q)
- Capital grants, concessional finance

Recent Australian Developments

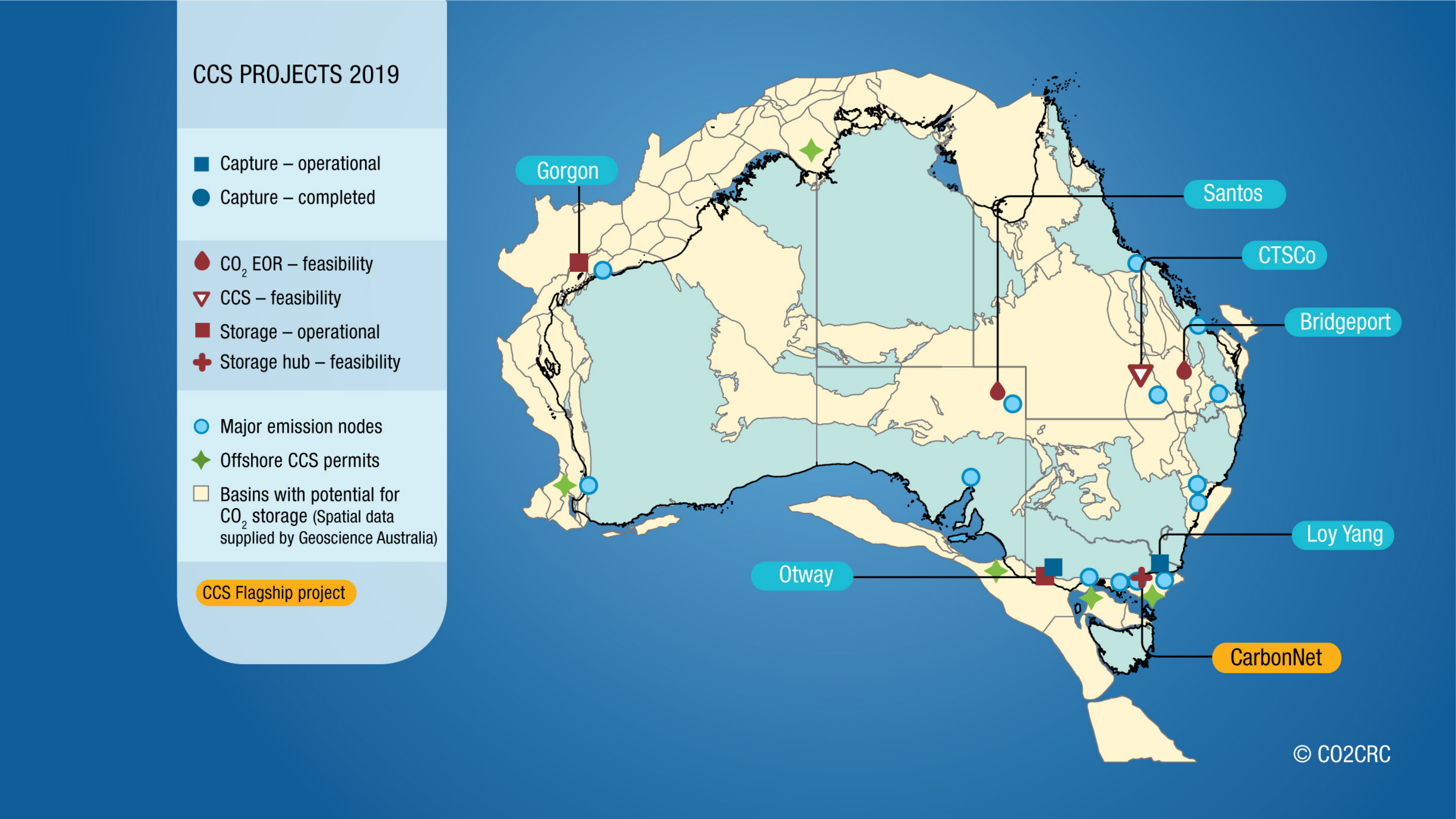
King Review

- ACCU's (Australian Carbon Credits Units)
- Finance (CEFC, ARENA)

Technology Investment Roadmap

- Early prioritization for CCUS

CO2CRC
BUILDING A LOW EMISSIONS FUTURE


CCS PROJECTS 2019
Capture – operational
Capture – completed
CO_2 EOR – feasibility
CCS – feasibility
Storage – operational
Storage hub – feasibility
Major emission nodes
Offshore CCS permits
Basins with potential for CO_2 storage (Spatial data supplied by Geoscience Australia)
CCS Flagship project
Gorgon
Santos
CTSCo
Bridgeport
Loy Yang
Otway
CarbonNet
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CO2CRC acknowledges and appreciates the strong relationships it has with industry, community, government, research organisations, and agencies in Australia and around the world