The Importance of Sustainable Construction

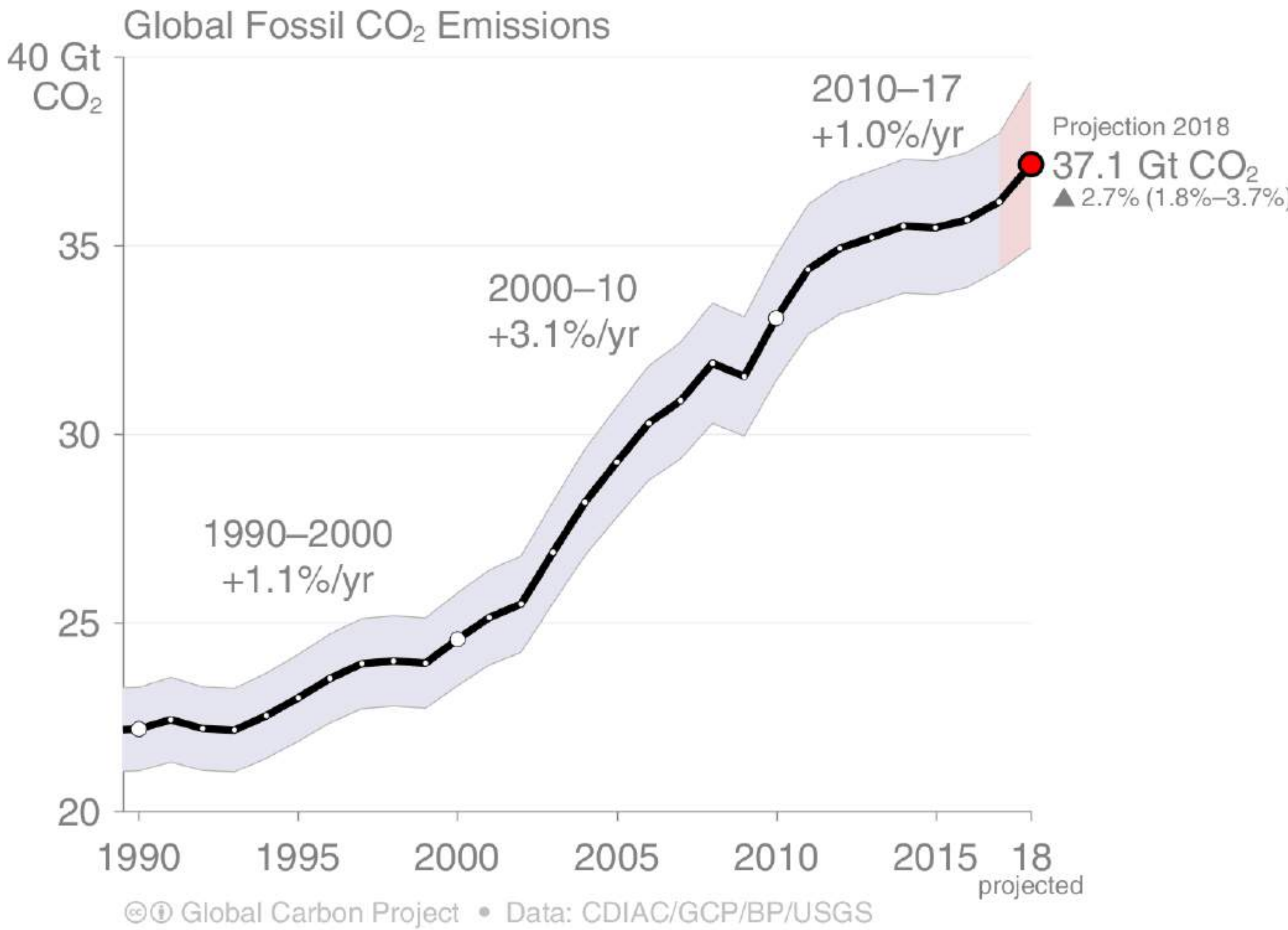
Climate change and the need for carbon sequestration

Gideon Henderson
University of Oxford

UNIVERSITY OF OXFORD

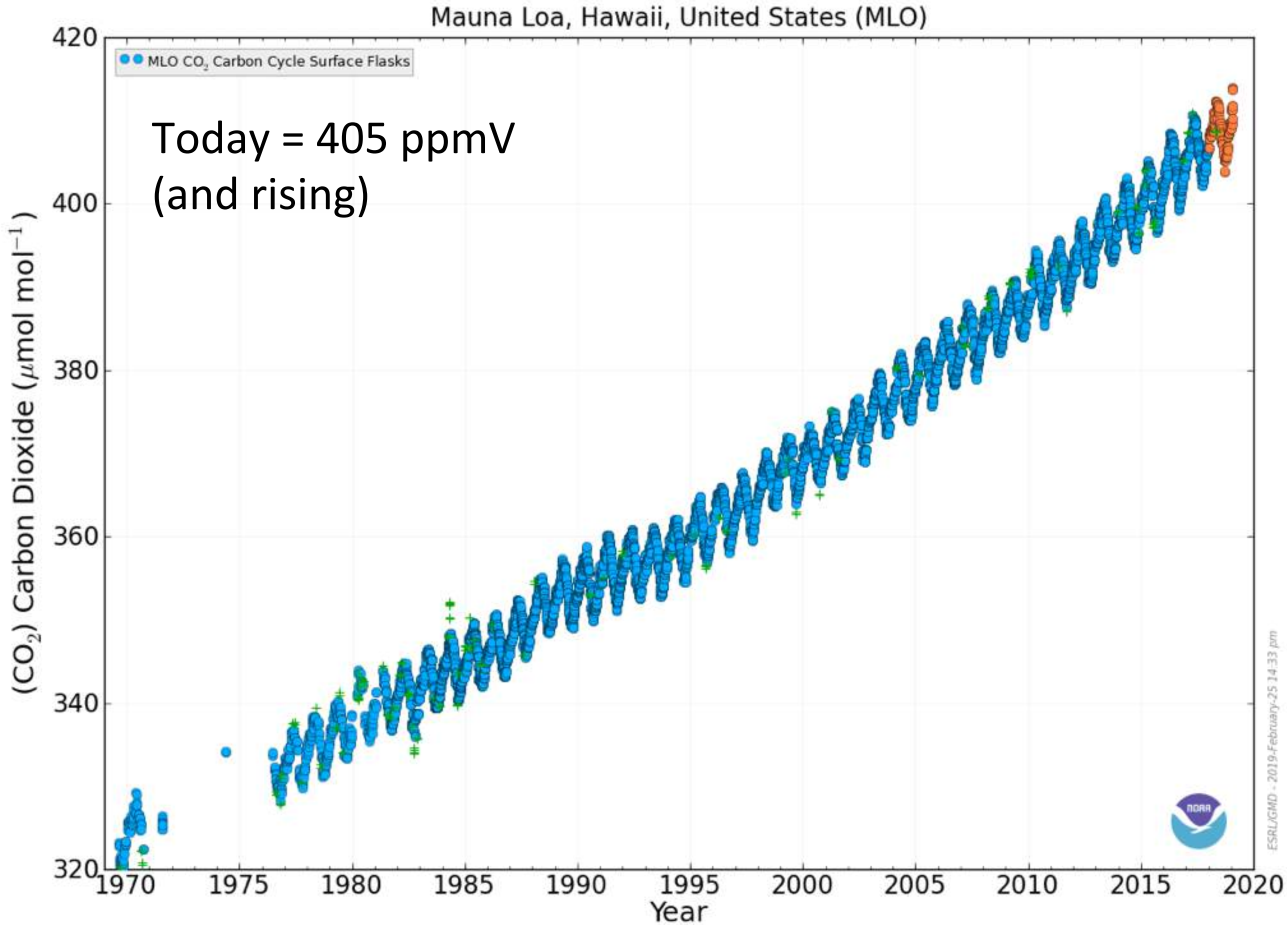
Human emissions of carbon dioxide

Emissions in billion tonnes of CO_2 (= $GtCO_2$, $PgCO_2$, 10^{15} gCO_2)



http://www.globalcarbonproject.org/carbonbudget/

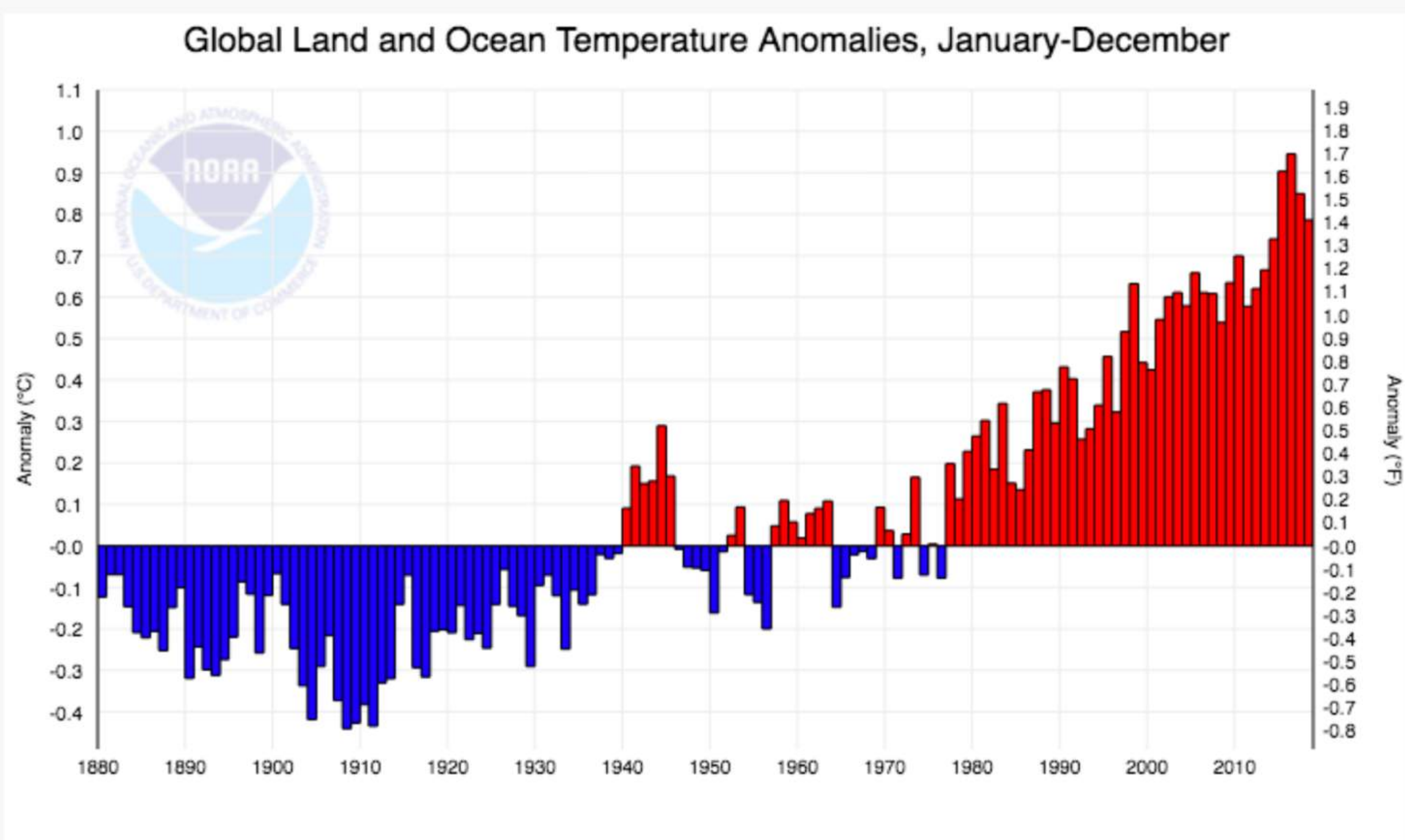
Resulting rise in atmospheric CO_2



Compares to 280 ppmV before human activity
And 200 ppmV during the last ice age

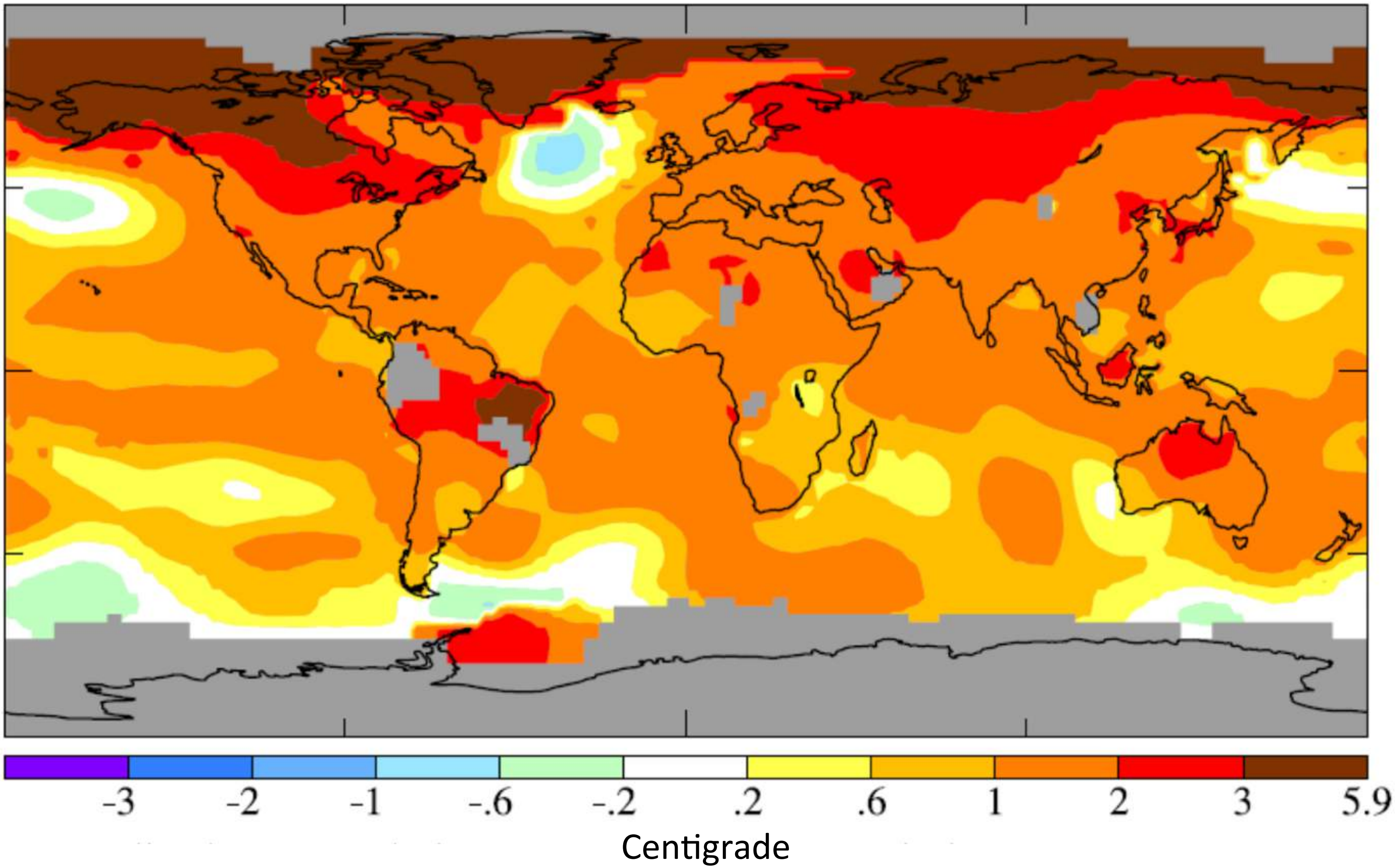
http://www.esrl.noaa.gov/gmd/dv/iadv/

Global temperature



https://www.ncdc.noaa.gov/cag/

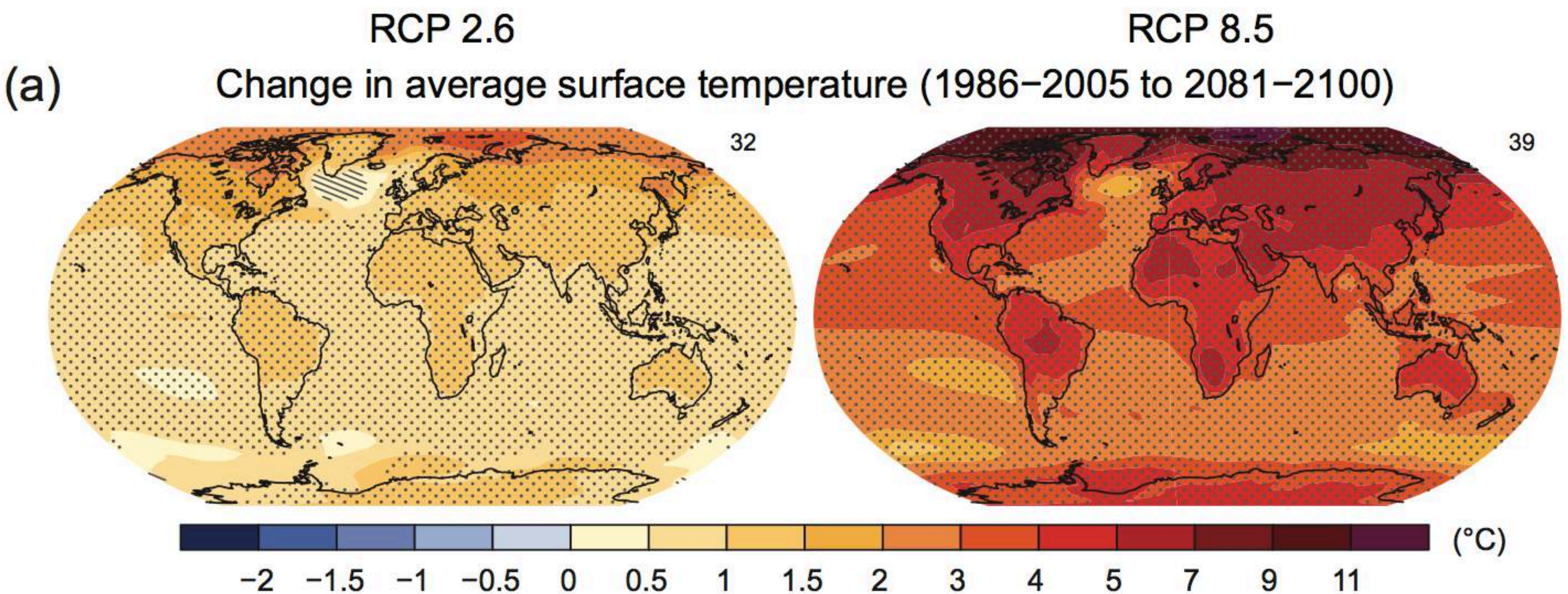
2016 Mean Annual Temperature (relative to 1880-1920)



We can choose our future temperature

Stop releasing CO_2

Carry on as we are



Average < 2°C

Average >4°C

IPCC AR5 2013

Paris COP21 agreement

Agreed to limit warming to substantially less than 2°C (1.5°C target)

Peak in global emissions asap, rapid reductions thereafter

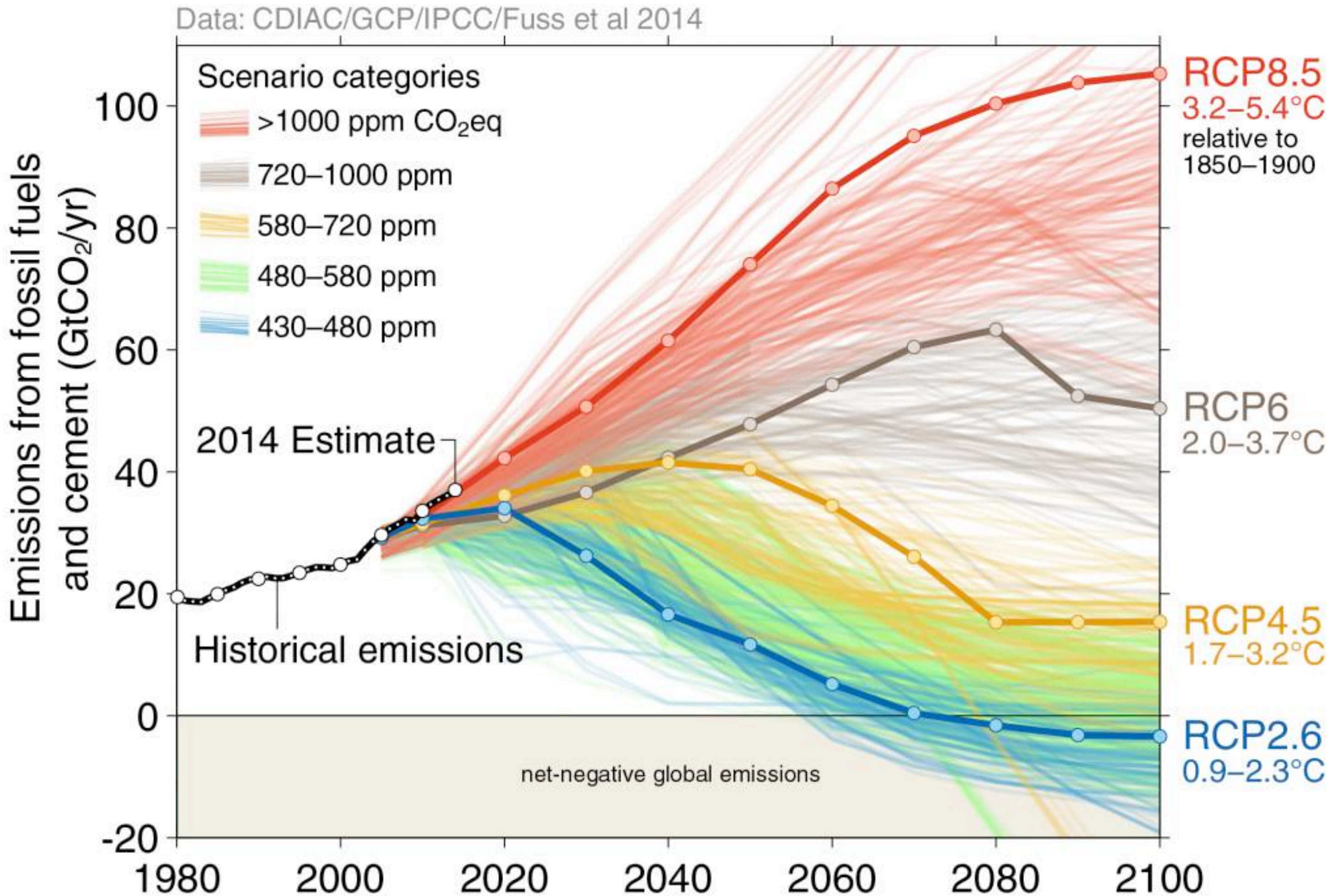
Net zero emissions in 2nd half of this century

Countries submitted national climate action plans

Meet every 5 years to and set more ambitious targets

PARIS2015
CONFÉRENCE DES NATIONS UNIES
SUR LES CHANGEMENTS CLIMATIQUES
COP21·CMP11

Integrated Assessment Models: Future emission scenarios



IPCC AR5 and at the time of Paris Agreement

87% of 2°C scenarios and 100% of 1.5°C scenarios use some greenhouse gas removal (GGR)

$GtCO_2$ per year levels of GGR required by 2030s

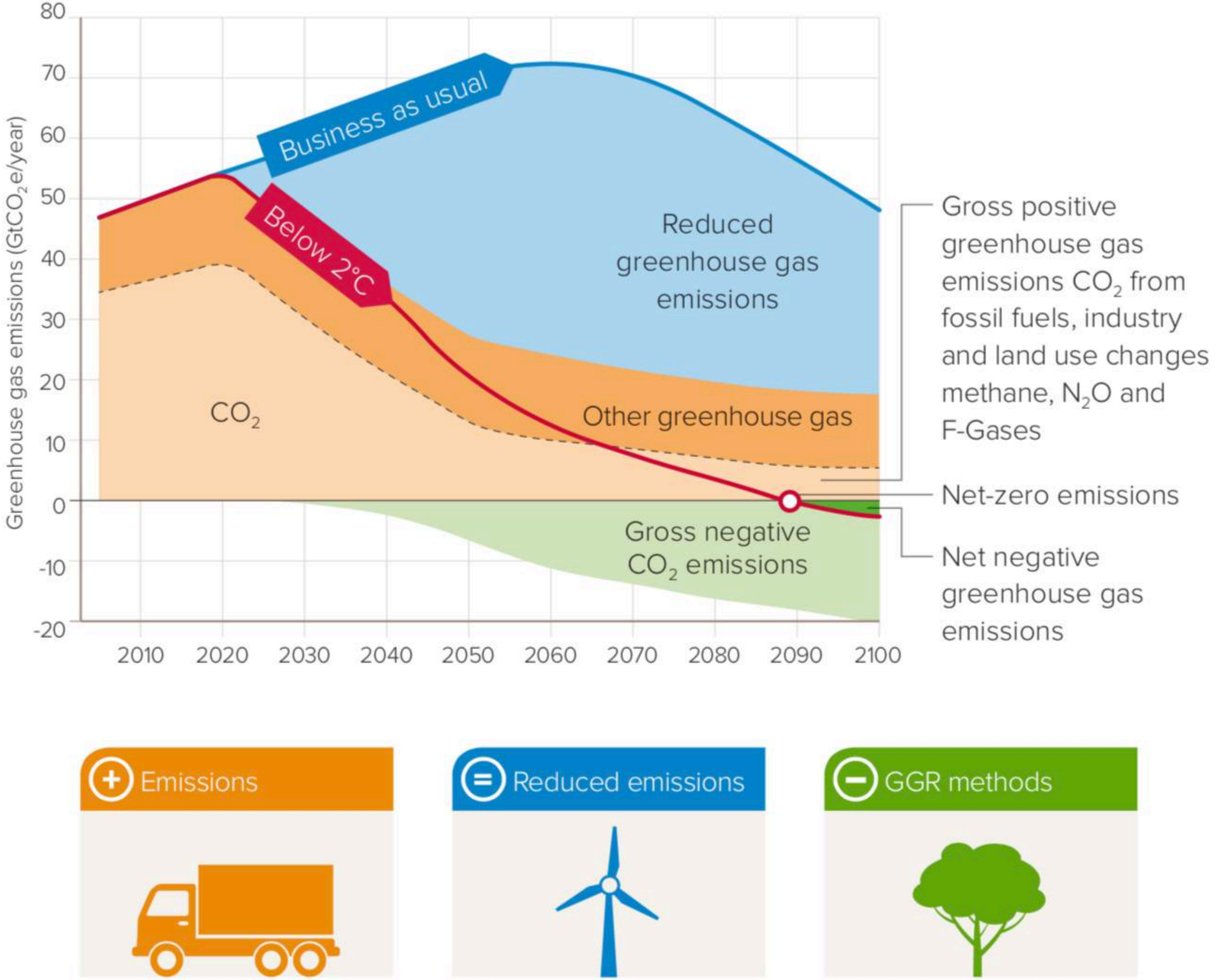
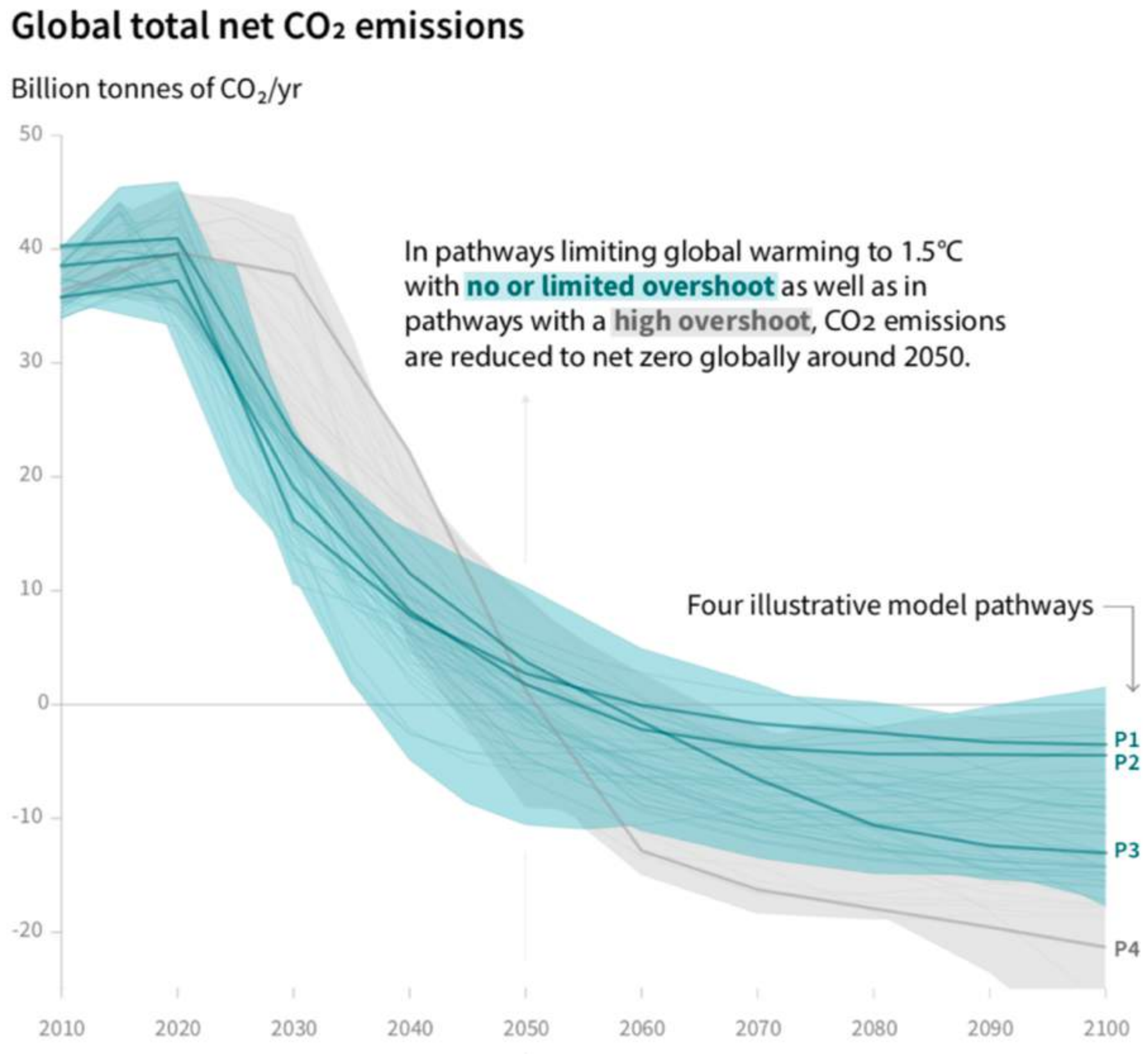


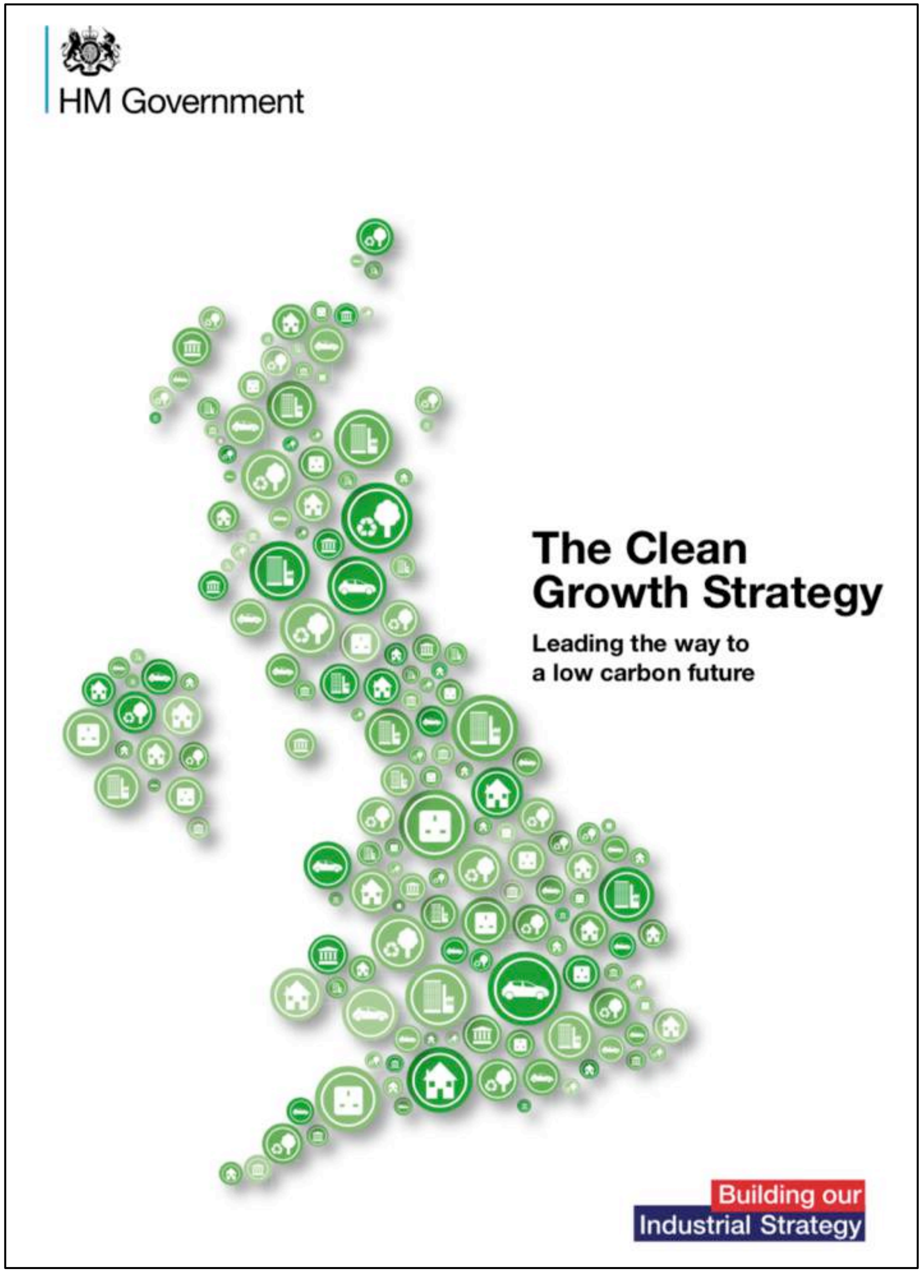
Figure from RS/RAEng GGR report, 2018

Emissions Scenarios in IPCC 2018 1.5°C Report



From Summary for Policy Makers:

All pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 $GtCO_2$ over the 21st century

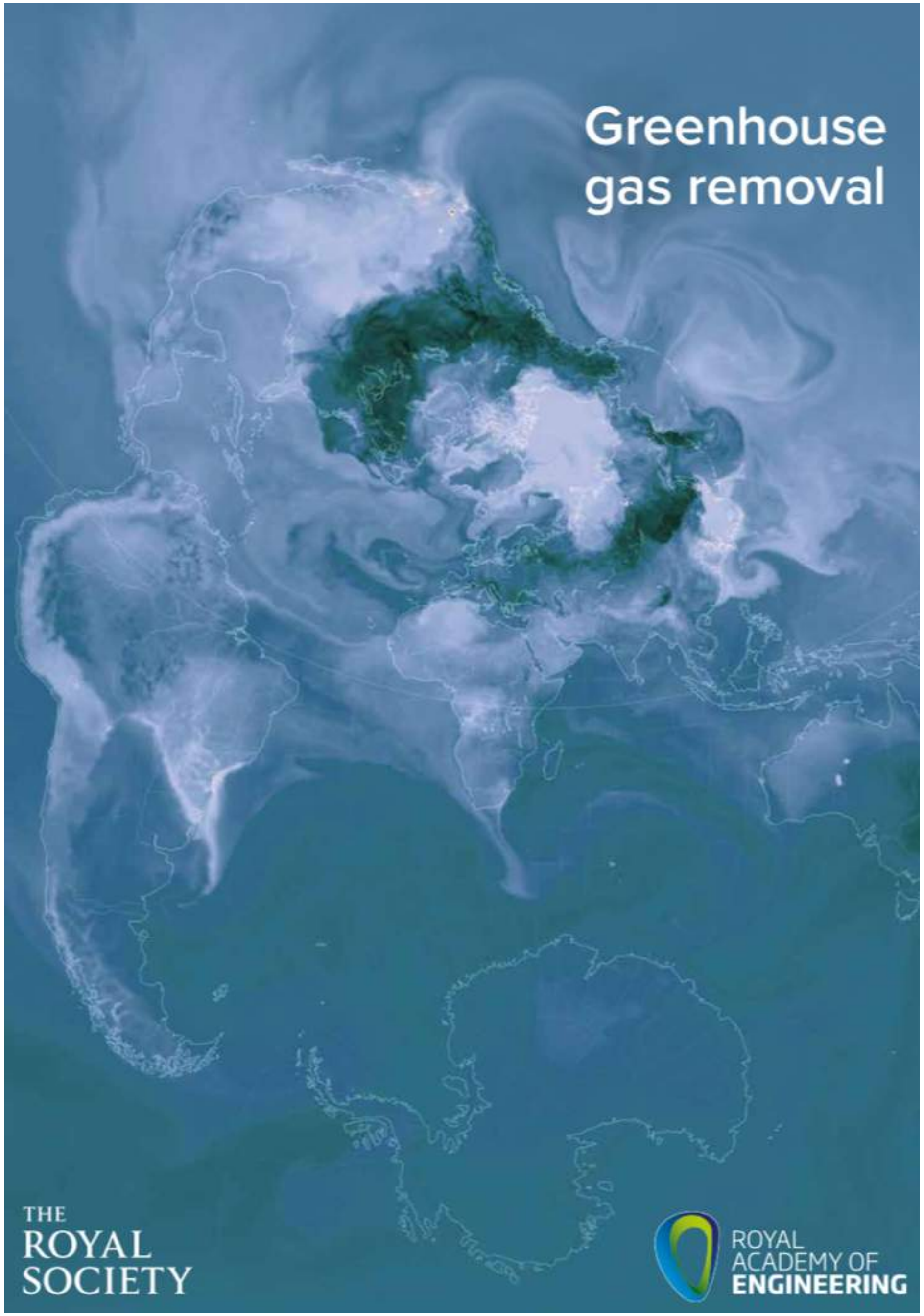


A UK perspective in 3 reports

i. UK Clean Growth Strategy Autumn 2017

From key policies and proposals

"Develop our strategic approach to greenhouse gas removal technologies…. addressing the barriers to their long term deployment."



A UK perspective in 3 reports

ii. Report to BEIS on GGR September 2018

UK scenario indicated that the UK could realize sufficient GGR to balance residual emissions of greenhouse gases to make the UK net zero in 2050

THE ROYAL SOCIETY

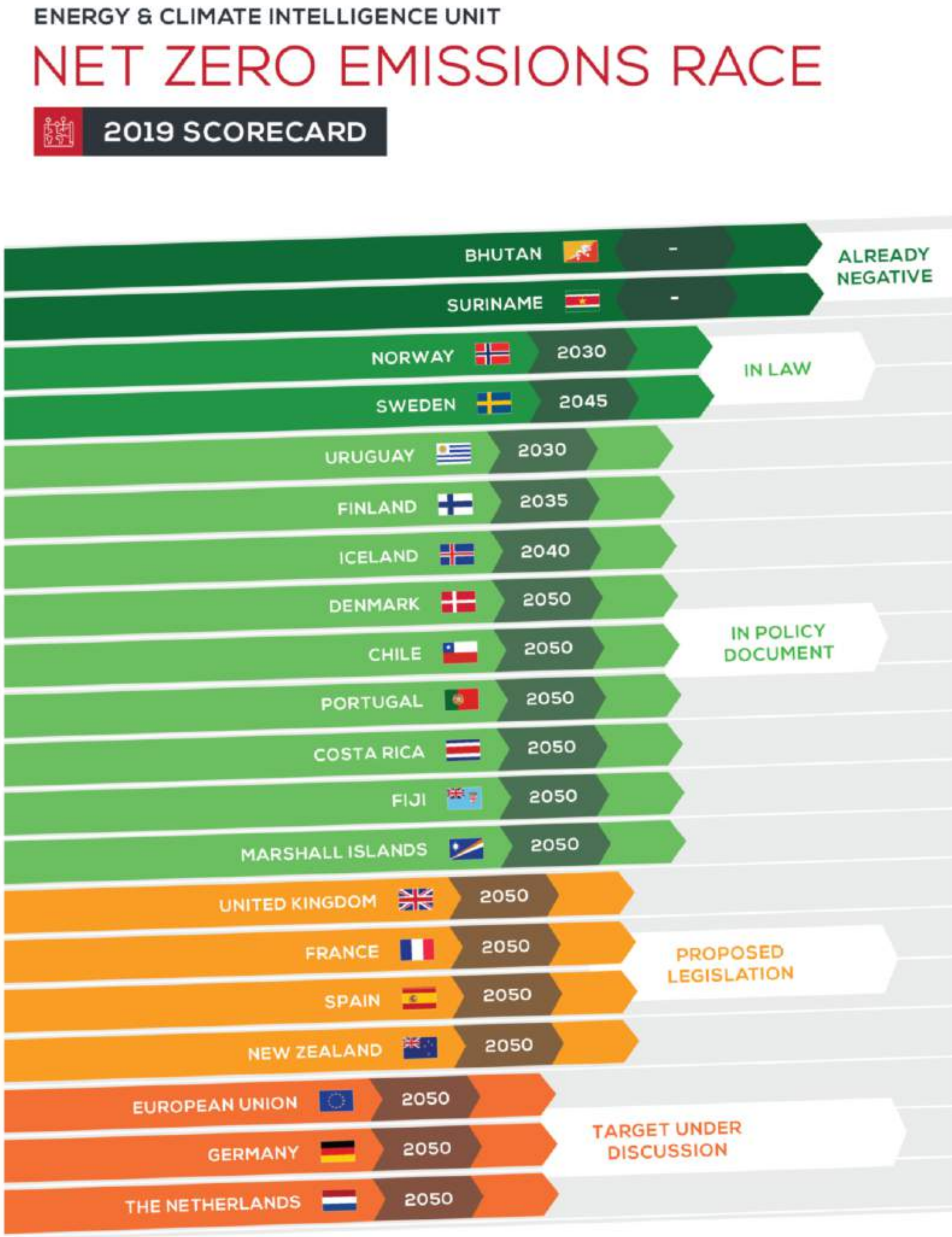
ROYAL ACADEMY OF ENGINEERING

A UK perspective in 3 reports

iii. Committee for Climate Change Net Zero Report May 2019

"The UK should set and vigorously pursue an ambitious target to reduce greenhouse gas emissions (GHGs) to 'net-zero' by 2050, ending the UK's contribution to global warming within 30 years."

Countries aiming for net zero



One week ago:

Live TV | Shows | Categories | News

NEWS | Top stories | Your area | Topics | Sport | Weather

11 June 2019 at 10:30pm

Theresa May announces plan to ... by 2050

The Telegraph | HOME | NEWS

News | Politics

Brexit | Opinion | Conservatives | Labour Party | Lib Dems | SNP | DUP | Ukip

◆ PREMIUM

News › Politics

Theresa May introduces legally-binding 'net zero' emissions target despite warnings it will cost £1trillion

INDEPENDENT

NEWS | POLITICS | VOICES | FINAL SAY

News > UK > UK Politics

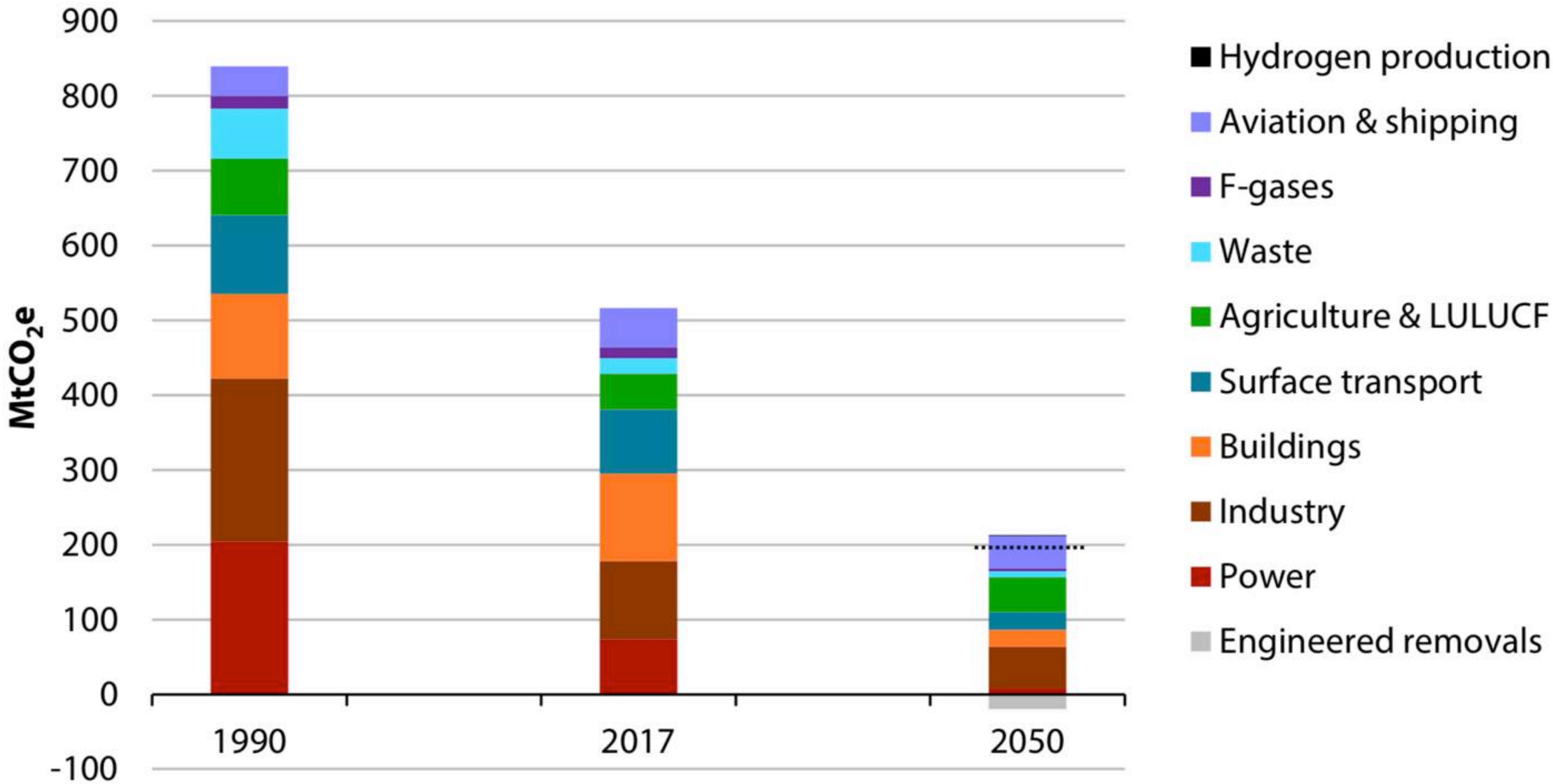
Theresa May announces legal commitment to end UK's global warming contributions by 2050

PM introduces legislation enacting target of net-zero greenhouse gas emissions by 2050

Ashley Cowburn Political Correspondent | @ashcowburn |

4 days ago | 19 comments

Past, present and future UK emissions

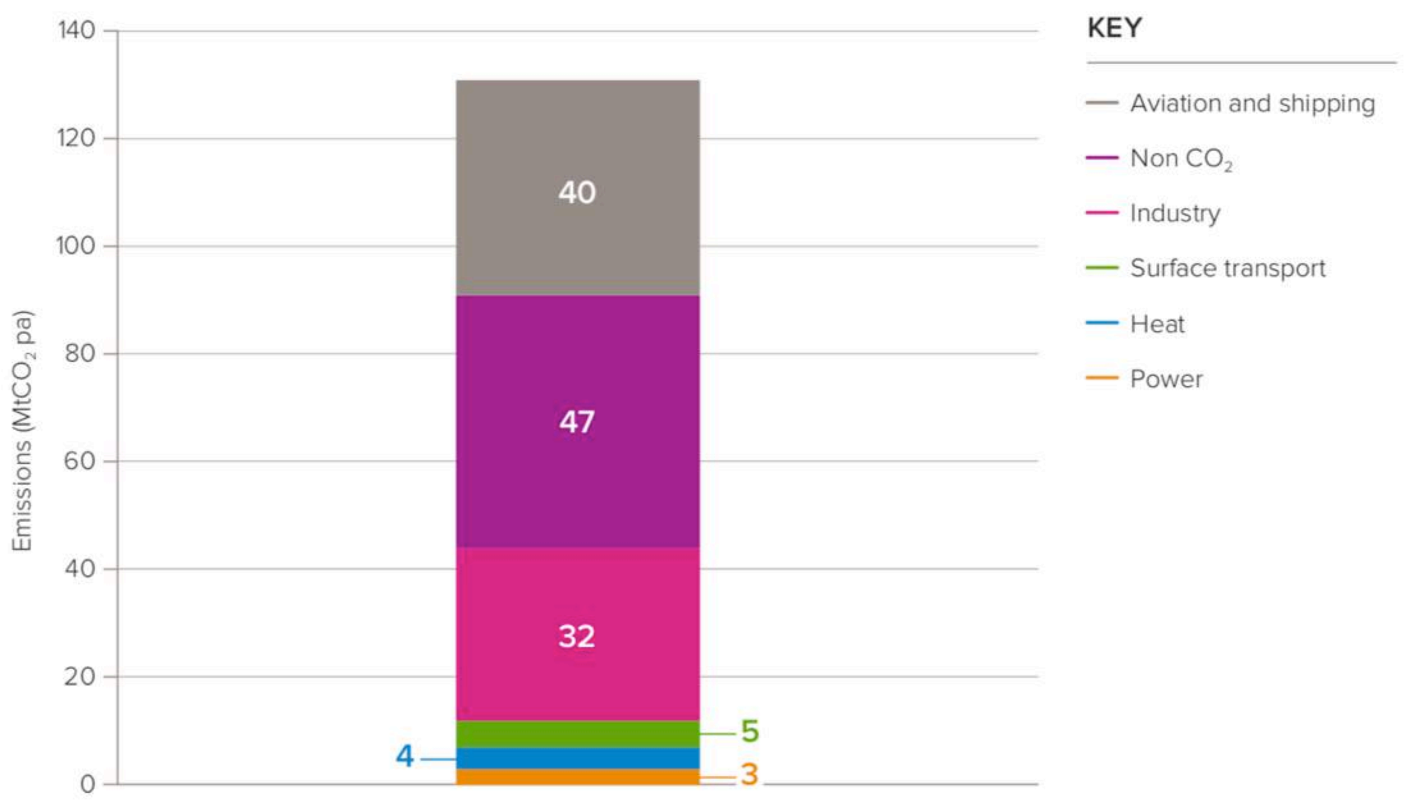


CCC 2019

Scenarios: Can the UK achieve net zero by 2050?

Present emissions 468 $MtCO_2e$ (CCC 2018)
Climate Change Act commits us to reduce to 160 $MtCO_2e$ pa
CCC (2016) considers 130 $MtCO_2e$ pa absolute minimum we could reach

Residual GGR emissions in 2050 with maximum reductions to emissions in all sectors.



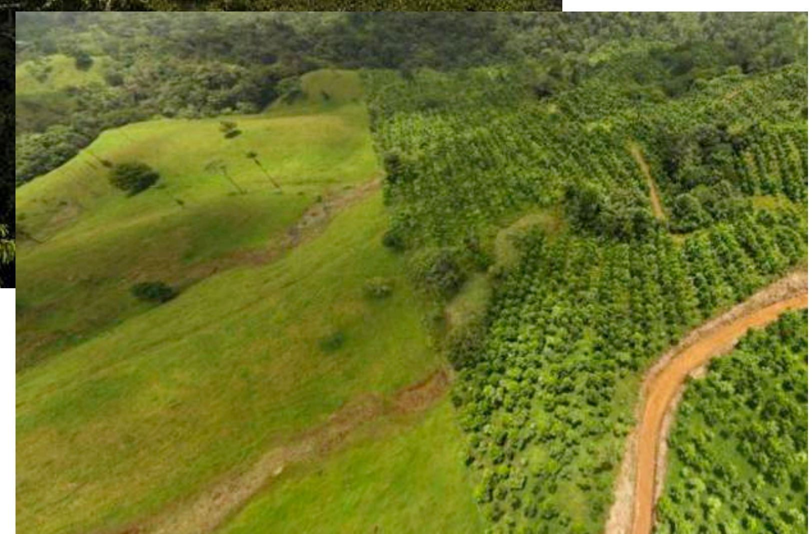
Source: Committee on Climate Change 2016 UK climate action following the Paris Agreement report.

GGR methods: Must both remove and store CO_2

Storage location		Greenhouse gas removal method		
		Increased biological uptake	Natural inorganic reactions	Engineered removal
Storage location	Land vegetation (living)	Afforestation, reforestation and forest management; Habitat restoration;		
	Soils and land vegetation (dead)	Soil carbon sequestration; Biochar	Enhanced terrestrial weathering	
	Geological	BECCS	Mineral carbonation at surface	DAC + geological storage DAC + sub-surface mineral carbonation
	Oceans	Ocean fertilisation	Ocean alkalinity	DAC + deep ocean storage
	Built environment	Building with biomass		Low-carbon concrete

Table from RS/RAEng GGR report, 2018

Reforestation

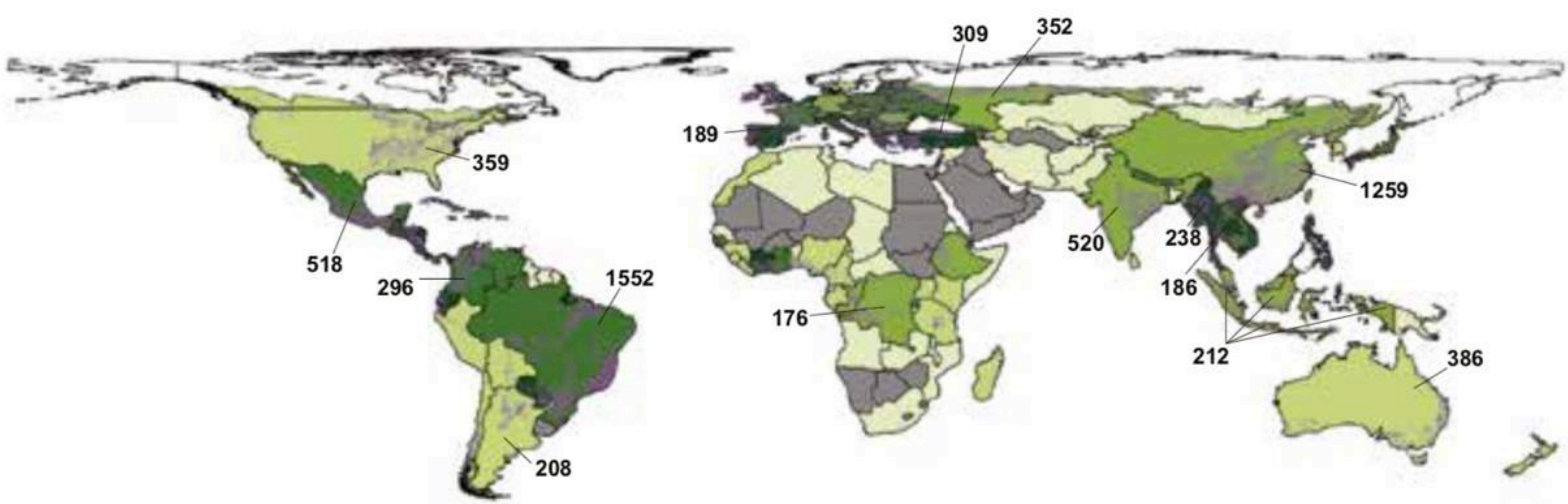


Growing forests is good but…

There is only so much space to put them
Need to be careful they don't have other negative impacts

FIGURE 4

Distribution of potential GGR by reforestation by country.



KEY

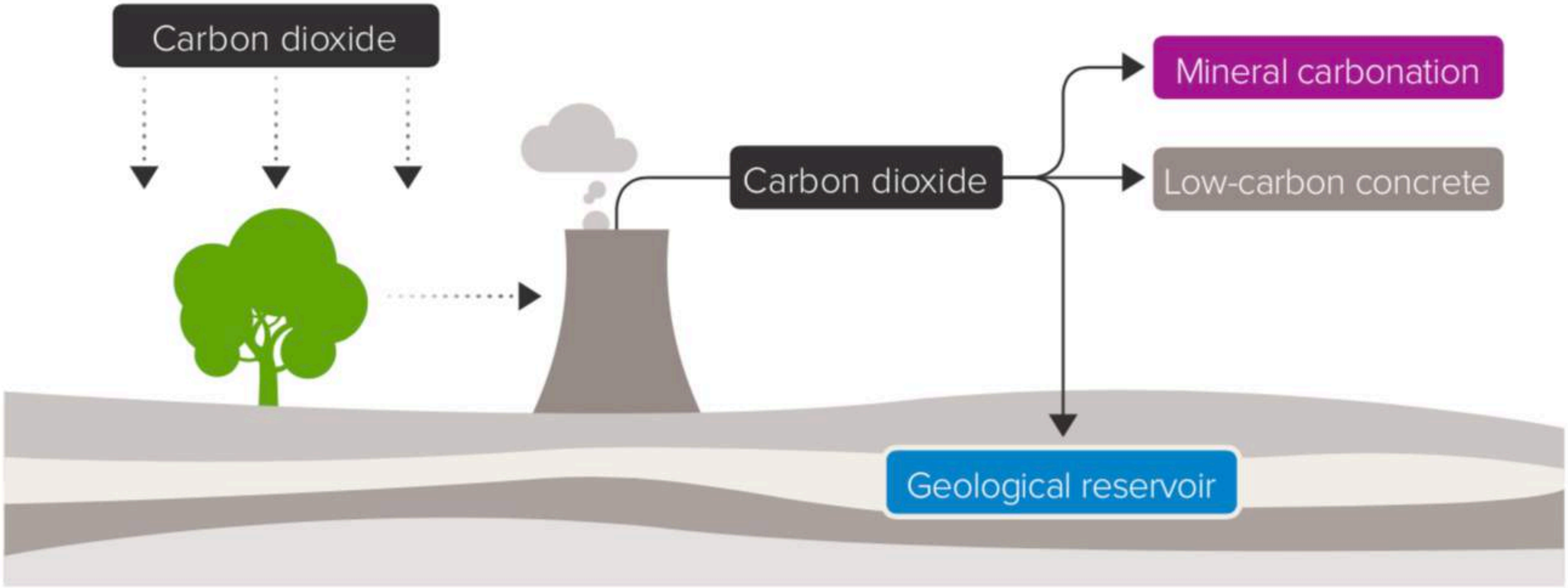
Reforestation extent $kgCO_2e\ ha^{-1}\ yr^{-1}$ | 0 | 1 – 211 | 212 – 758 | 759 –1,749 | 1,750 – 3,000 | 3,001 – 7,700 | No mitigation (Boreal zone)

GGR methods: Must both remove and store CO_2

Storage location		Greenhouse gas removal method		
		Increased biological uptake	Natural inorganic reactions	Engineered removal
Storage location	Land vegetation (living)	Afforestation, reforestation and forest management; Habitat restoration;		
	Soils and land vegetation (dead)	Soil carbon sequestration; Biochar	Enhanced terrestrial weathering	
	Geological	BECCS	Mineral carbonation at surface	DAC + geological storage DAC + sub-surface mineral carbonation
	Oceans	Ocean fertilisation	Ocean alkalinity	DAC + deep ocean storage
	Built environment	Building with biomass		Low-carbon concrete

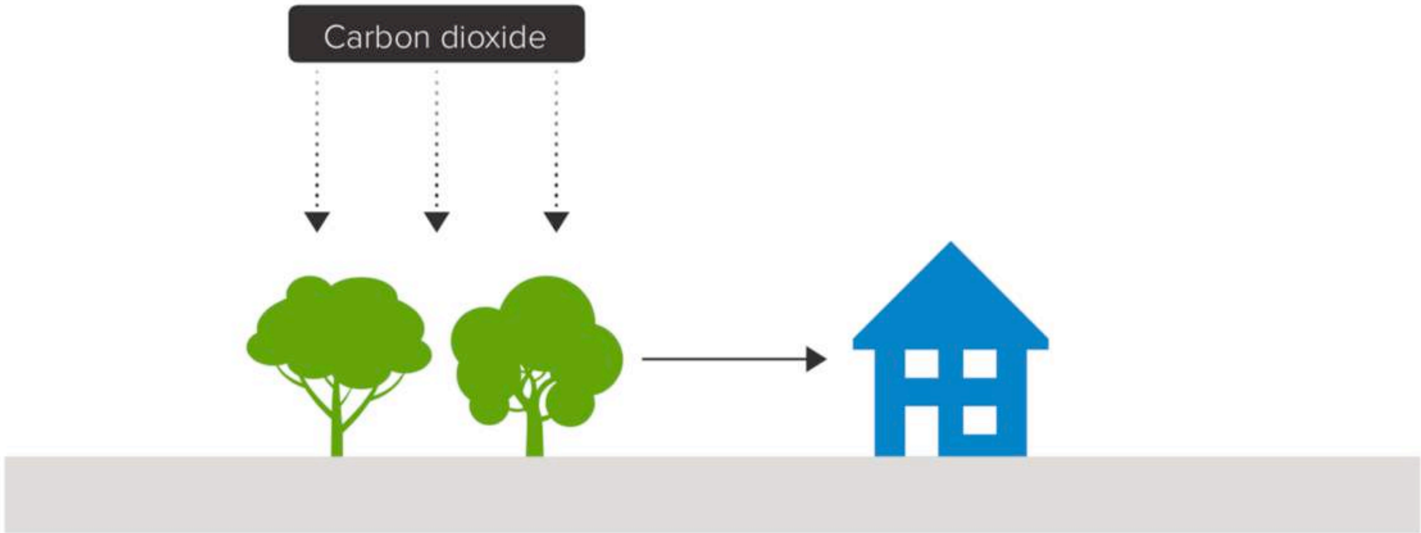
Table from RS/RAEng GGR report, 2018

Bioenergy with Carbon Capture and Storage (BECCS)



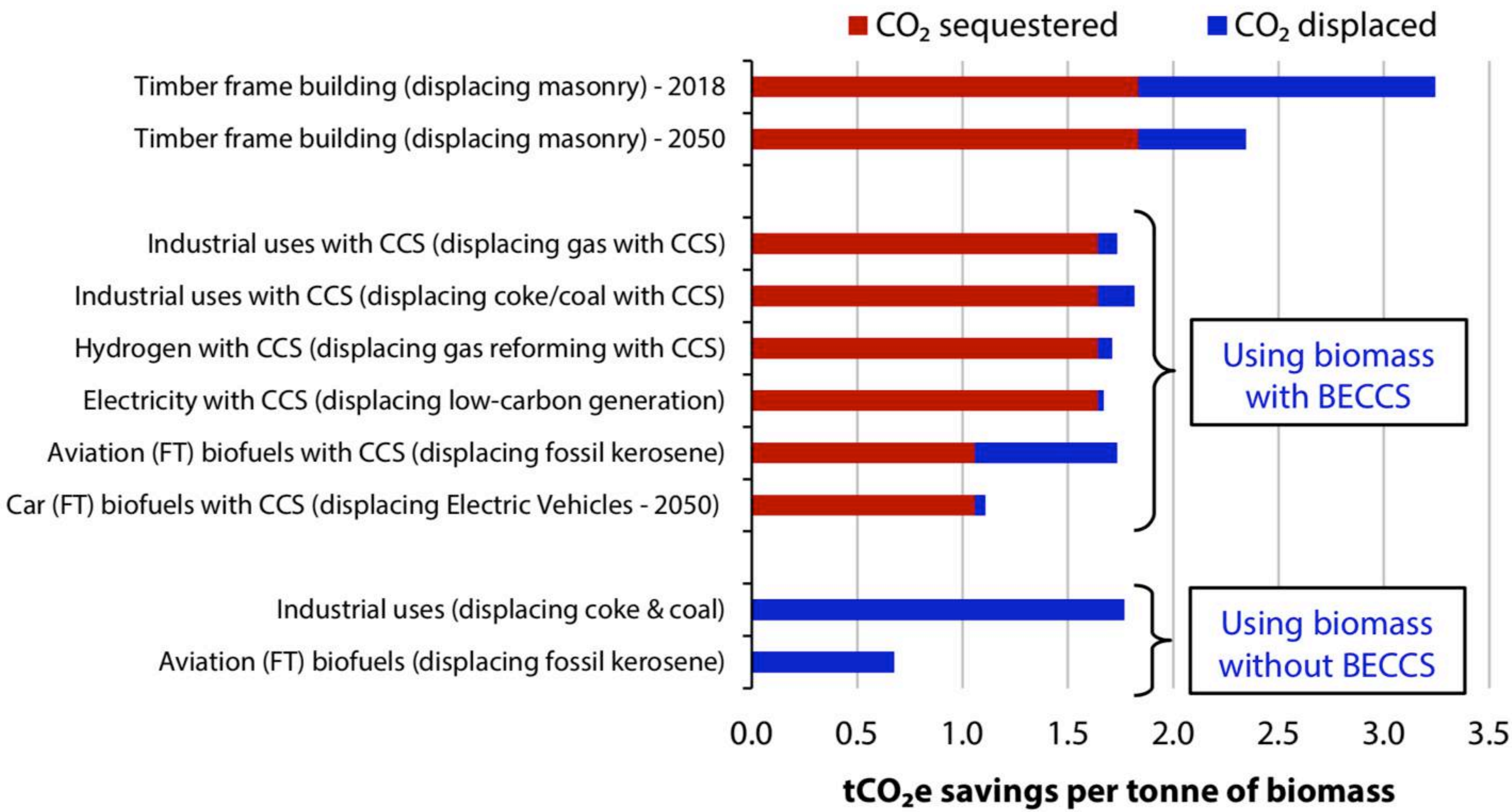
Utilising biomass for energy, capturing the CO_2 emissions and storing them to provide lifecycle GGR

Building with Biomass



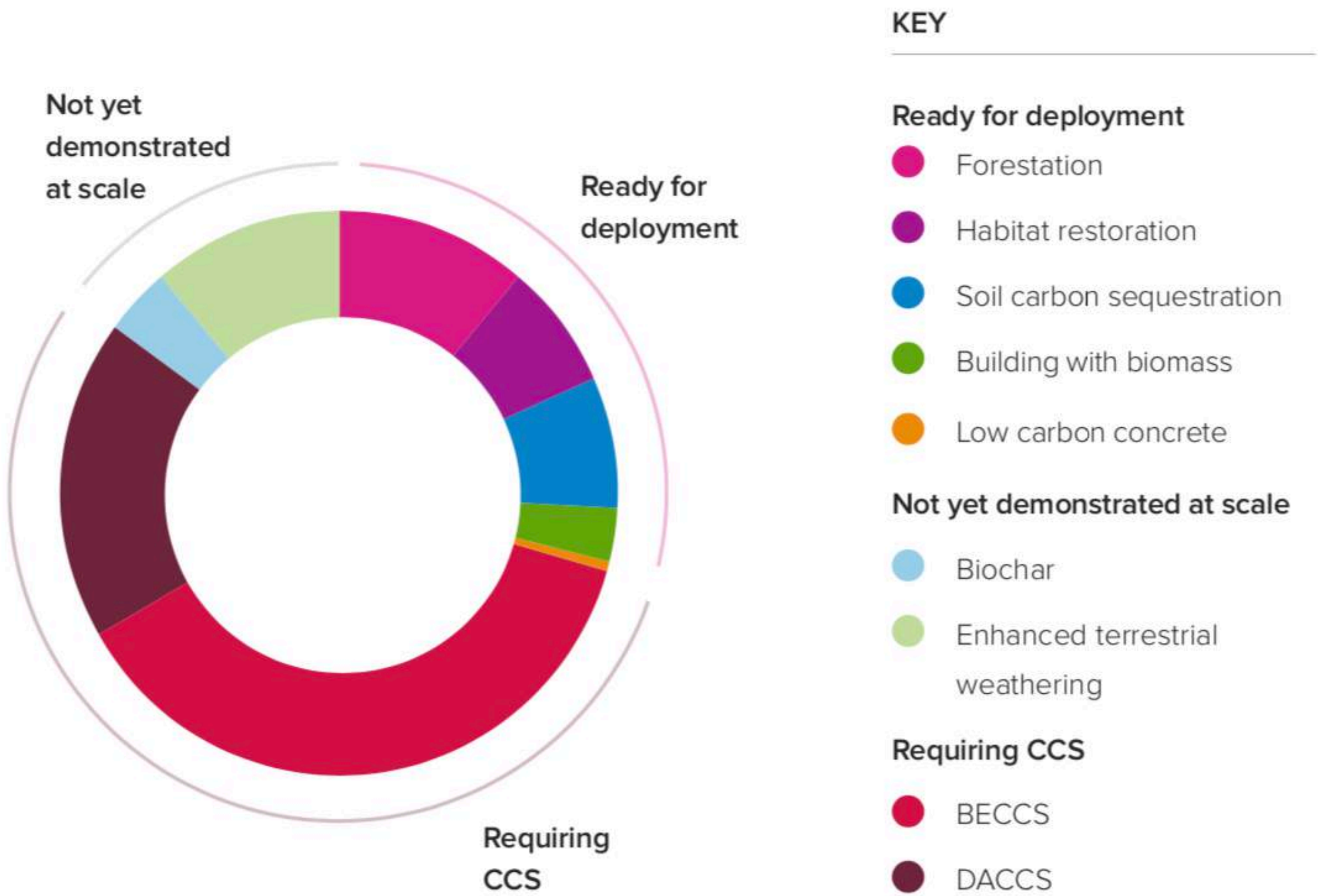
Using forestry materials in building extends the time of carbon storage of natural biomass and enables additional forestry growth

Greenhouse gas abatement for biomass use



CCC 2018

UK Scenario: A suite of GGR methods to remove 130 $MtCO_2$ pa



4 $MtCO_2$ pa from building with biomass
(equivalent to building 200,000 timber framed houses pa, compared to 220,000 new houses built across the UK pa at present)

GGR method	Global CO_2 removal potential ($GtCO_2$ pa)	Cost per tCO_2 (US$)	Technology readiness level (TRL)
Increased biological uptake			
Afforestation, reforestation and forest management[234,235,236]	Afforestation/ reforestation 3 – 20 forest management 1 – 2	3 – 30	8 – 9
Wetland, peatland and coastal habitat restoration[237]	0.4 – 20	10 – 100	5 – 6
Soil carbon sequestration[238,239]	1 – 10	10 profit – 3 cost	8 – 9
Biochar[240,241,242]	2 – 5	0 – 200	3 – 6
Bioenergy with carbon capture and storage[243,244]	10	100 – 300	Bioenergy: 7 – 9 CCS: 4 – 7
Ocean fertilisation[245,246]	1 – 3	10 – 500	1 – 5
Building with biomass[247]	0.5 – 1	0	8 – 9
Natural inorganic reactions			
Enhanced terrestrial weathering[248,249]	0.5 – 4	50 – 500	1 – 5
Mineral carbonation[250]	–	50 – 300 (*ex situ*) 20 (*in situ*)	3 – 8
Ocean alkalinity[251,252]	40	70 - 200	2 – 4
Engineered removal			
Direct air capture[253,254,255]	0.5 – 5	200 – 600 (early stage) 100 (longer term)	4 – 7
Low-carbon concrete[256,257,258]	>0.1	50 – 300 (mineral carbonation)	6 – 7

CCC Net Zero report 2019

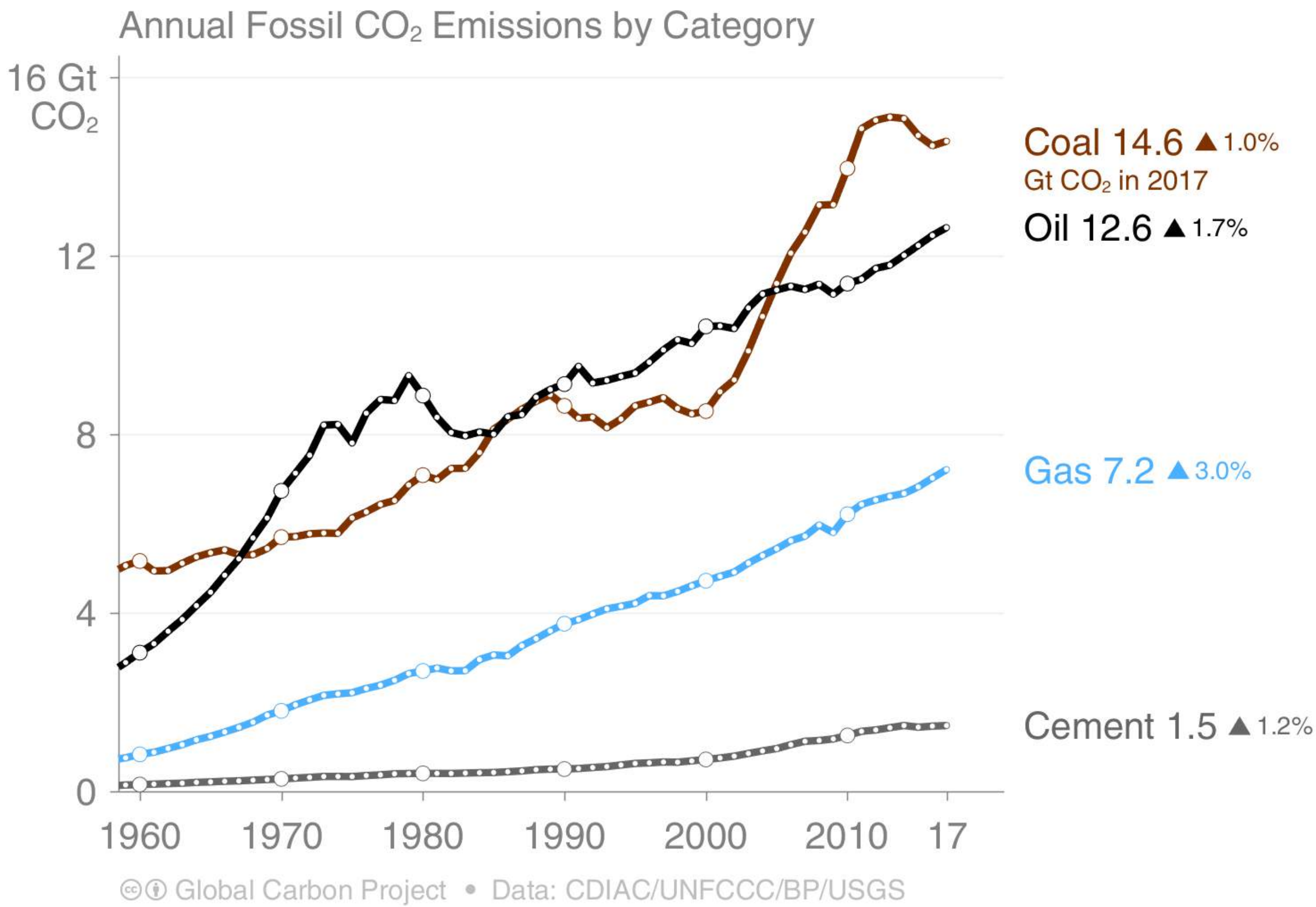
"Large increases in the percentage of houses and flats constructed with timber could enable up to 3 MtCO$_2$/yr to be stored long-term in the built environment through wood used in construction. A similar level of contribution is possible through use of engineered wood products (e.g. cross laminated timber and glulam) in non-residential buildings."

"costs of using wood as a construction material are essentially negligible"

CCC scenarios:
Core: 2 MtCO$_2$/yr
Further ambition: 2.3 MtCO$_2$/yr
Speculative: 3.2 MtCO$_2$/yr

Some Final Comments

- There is international agreement that climate change is dangerous and we should avoid it by reducing GHG emissions to zero this century
- This will require substantial reduction in emissions, via changes across all aspects of society
- It will also require pursuit of approaches to remove CO_2 from the atmosphere and store it
- Biomass provides major routes to GGR, through reforestation, BECCS, and building with wood
- In the UK, and elsewhere, there is growing recognition of the benefits for climate-change mitigation of building with wood



Annual Fossil CO2 Emissions by Category
16 Gt CO2
12
8
4
0
1960
1970
1980
1990
2000
2010
17
Coal 14.6 ▲1.0%
Gt CO2 in 2017
Oil 12.6 ▲1.7%
Gas 7.2 ▲3.0%
Cement 1.5 ▲1.2%
Global Carbon Project • Data: CDIAC/UNFCCC/BP/USGS

CCC Net Zero Report 2019:

Core: The proportion of timber-framed houses and engineered wood systems makes up the same proportion of new build as they do today (15-28%). This leads to a removal of 2.0 MtCO2e/yr in 2050, growing from a sequestration of about 1 MtCO2/yr today.

Further Ambition: The proportion of timber-framed new build houses rises to over 40% by 2050. Engineered wood systems remain a minor contributor, reaching 5% by 2050. This leads to a removal of 2.3 MtCO2e/yr in 2050.

Speculative: The proportion of timber-framed houses rises to 80%. Engineered wood systems increase at 10% per year to 2027 then 20% year from 2027 to 2050. This leads to a removal of 3.2 MtCO2e/yr in 2050.