Reaching the Paris Goal

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The goal

"Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels."

Whilst this is the right objective to minimise the worst effects of climate change it is very challenging to achieve.

According to the IPCC's Fifth Assessment Report (AR5), it will be hard to stand a good chance (better than 66%) of staying below 2°C, let alone limiting temperature rise to 1.5°C.

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Global carbon budget

There is a carbon budget for staying below any particular temperature rise.

As the IPCC puts it in AR5: “limiting total human-induced warming to less than 2°C with a probability of >66% would require cumulative CO_2 emissions to remain below about 2900 $GtCO_2$. About 1900 $GtCO_2$ had already been emitted by 2011.”

So there is only about one third (1,000 $GtCO_2$) of the budget left.

In fact, there is less because emissions have continued to rise since 2011. The budget is even smaller for reaching 1.5°C.

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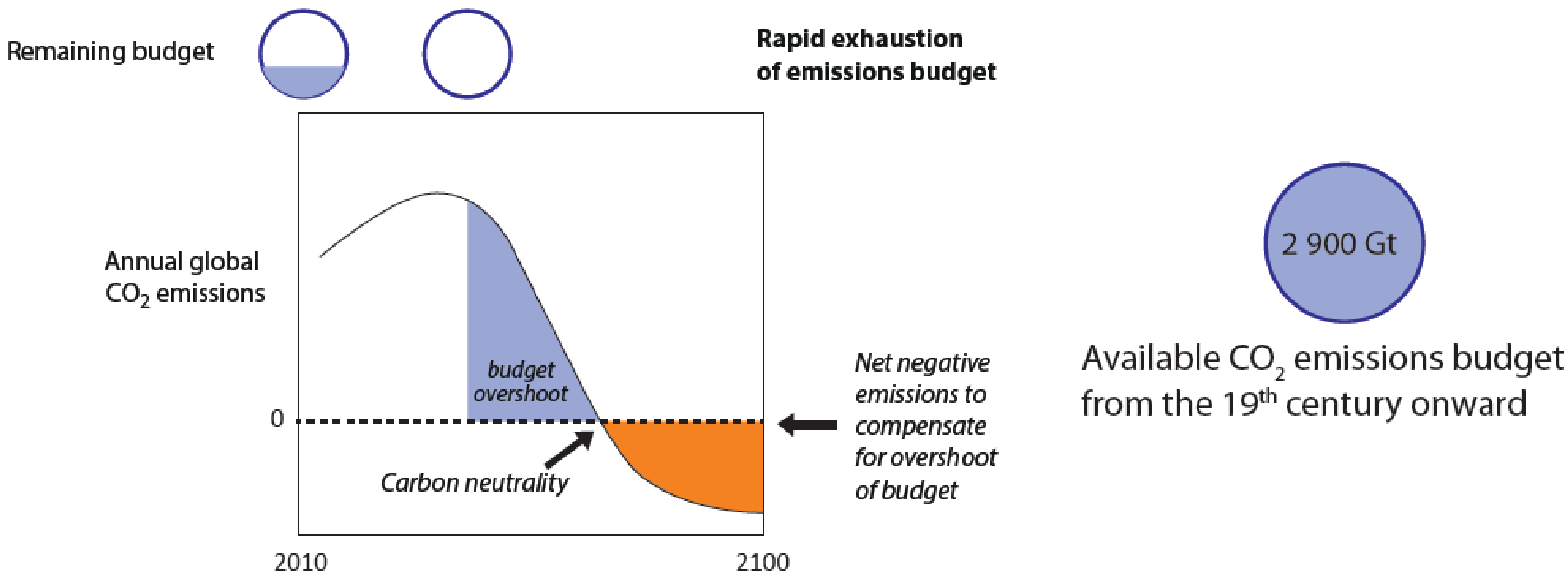
Keeping within budget

Given historical and ongoing delays in reducing global emissions it seems likely that we will exceed our budget.

Scenario modellers have therefore postulated that it will probably be necessary to remove carbon dioxide from the atmosphere so as to compensate for overspending the budget.



Going below 2°C

We are not on an emission pathway that takes us below two degrees, and certainly not to 1.5°C.

UNFCCC analysis of INDCs indicates that, “aggregate emission levels resulting from their implementation do not fall within least-cost 2°C scenarios levels”.

Other studies indicate that the INDCs will lead to a temperature rise of between 2.7 and 3.7°C.

Most AR5 scenarios do not give a good chance of staying below 2°C without overshooting the required atmospheric concentration of greenhouse gases and then falling rapidly.

About 10% of scenarios indicate that it is possible stay below 2°C but it is necessary to peak emissions by 2020 and then decline rapidly at about 3% per year.

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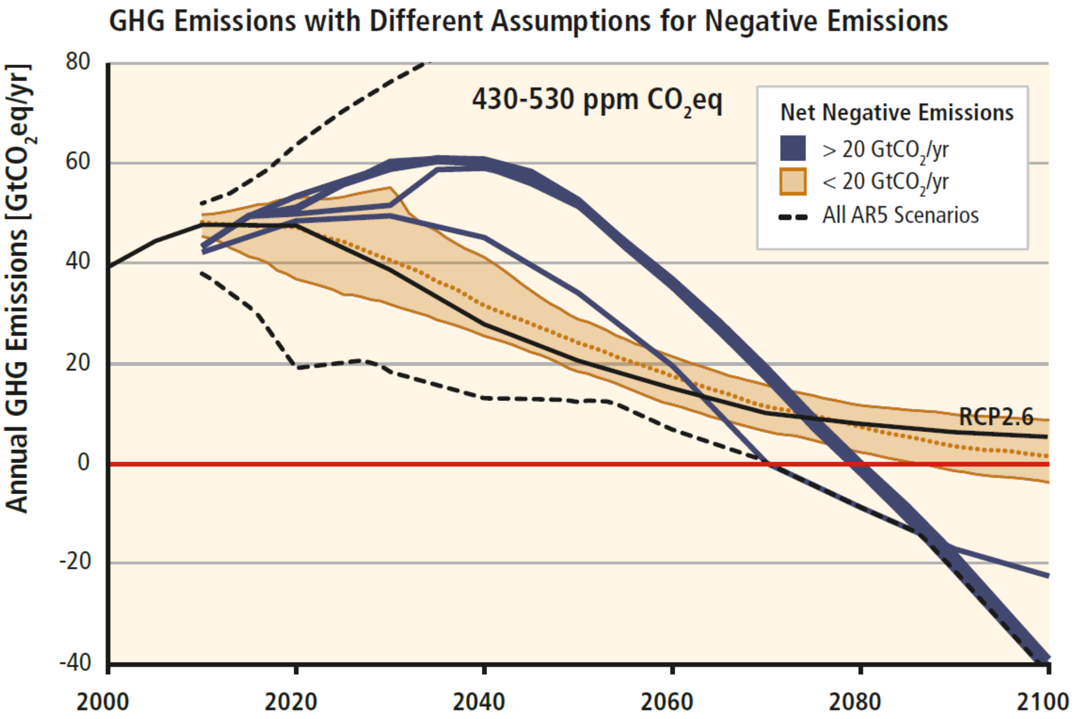
Carbon dioxide removal (CDR)

IPCC AR5: "The vast majority of scenarios with overshoot of greater than 35-50ppm CO2eq deploy carbon dioxide removal (CDR) technologies to an extent that net global CO_2 emissions become negative". Below are pathways for peaking earlier without large scale CDR (amber) or peaking later with large scale CDR (blue).



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What about 1.5°C

None of the scenarios cited in the IPCC's Fifth Assessment Report give a better than fifty-fifty chance of reaching 1.5°C and most give a much lower probability.

There are no scenarios in the literature that have a high probability of staying below 1.5°C during the entire 21st century. Nearly all scenarios first exceed 1.5°C by a fraction of a degree before returning to that temperature by 2100.

1.5°C scenarios typically show that even faster emission reductions are required than for 2°C.

They conclude that a larger amount of carbon dioxide removal will required earlier too. CDR offsets a larger share (60-85%) of fossil fuel emissions than the 2°C scenarios, which typically offset less than 50%.

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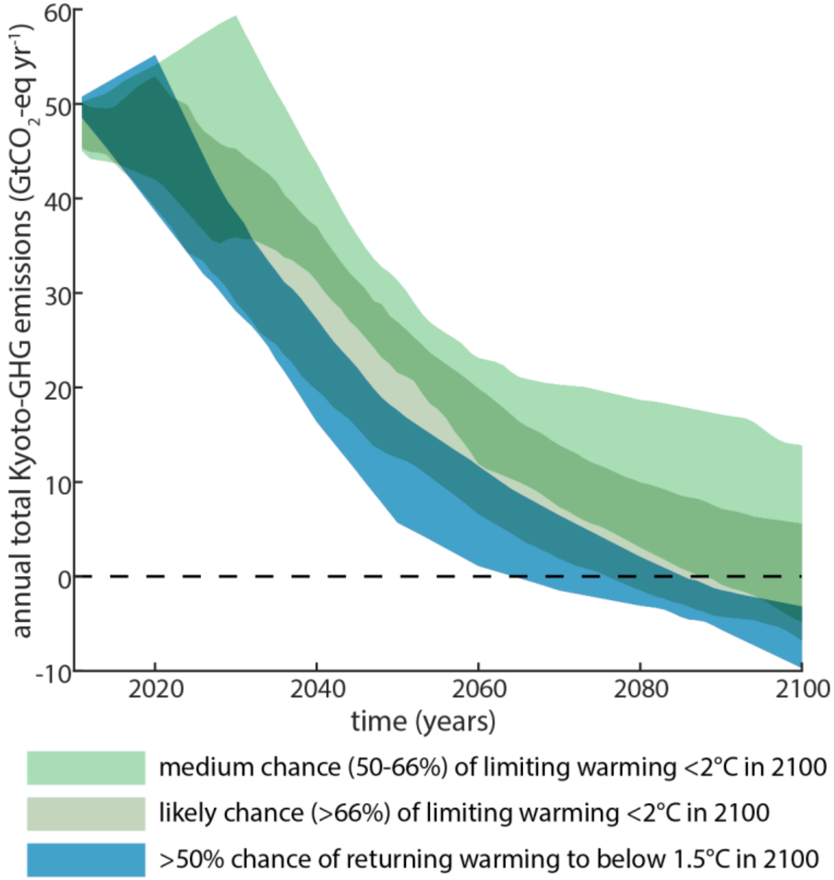
Going to 1.5°C

According to current scenarios, returning temperature rise to 1.5°C will be impossible without significant net removals from the atmosphere.



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What is CDR?

Many ways have been mooted of removing carbon dioxide from the atmosphere.

Some involve the conservation and enhancement of the natural systems which have always removed carbon dioxide from the atmosphere, mainly forests and oceans.

Some are entirely artificial, for example direct capture of carbon dioxide from the air by engineered chemical reaction (known as direct air capture or DAC).

Some are artificial but build upon natural systems, such as afforestation (usually monoculture plantations of alien species), bioenergy with carbon capture and storage (BECCS), biochar and enhanced weathering (EW) of minerals.

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What is wrong with CDR?

If negative emission technologies (NETs) are used to remove significant amounts of carbon dioxide from the atmosphere then they need to be deployed on a large scale.

They thus need large amounts of land, or water, or energy, or nutrients, or money or combinations of these.

In some cases they can affects albedo (the reflectance of the Earth's surface) which in turn affects global heat balance and hence warming or cooling.

An extreme example is one AR5 scenario for BECCS takes more than 6 Billion Ha – about half the land area of Earth.

Some impacts of NETs

Table 1: Global impacts of NETs for the average needed global C removals per year in 2100 in 2 °C-consistent scenarios (430–480 ppm scenario category; Supplementary Table 3).

NET	Global C removal (Gt Ceq yr^{-1} in 2100)	Mean (max.) land requirement (Mha in 2100)	Estimated energy requirement (EJ yr^{-1} in 2100)	Mean (max.) water requirement (km^3 yr^{-1} in 2100)	Nutrient impact (kt N yr^{-1} in 2100)	Albedo impact in 2100	Investment needs (BECCS for electricity/biofuel; US$ yr^{-1} in 2050)
BECCS	3.3	380–700	−170	720	Variable	Variable	138 billion /123 billion
DAC	3.3	Very low (unless solar PV is used for energy)	156	10–300	None	None	≫BECCS
EW*	0.2 (1.0)	2 (10)	46	0.3 (1.5)	None	None	>BECCS
AR*	1.1 (3.3)	320 (970)	Very low	370 (1,040)	2.2 (16.8)	Negative, or reduced GHG benefit where not negative	≪BECCS

Smith et al, Nature Climate Change, Vol 6, No 1, pp 42-50 (2015).

An EJ is 10^{18} Joules (USA energy use per year is about 94 EJ.)

Note that this is for 2^{o}C consistent scenarios.

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Some remarks on CDR/NETs

Most NETS, especially those taking large areas of land would be conducted in poorer countries because scenarios are usually least cost.

Almost all NETs are untried at scale.

The authors of the NETs table conclude:

"... there is no negative emission technology (or combination of NETs) currently available that could be implemented to meet the less than 2°C target without significant impact on either land, energy, water, nutrient, albedo or cost and so 'plan A' must be to immediately and aggressively reduce GHG emissions."

But for 1.5°C ...

"Large scale application of BECCS or alternative CDR technologies in the second half of the twenty-first century *seems* indispensible for 1.5°C scenarios ..." Rogelj *et al* envisage negative emissions in the range 450-1000 $GtCO_2$ until 2100 their 1.5°C scenarios.

However, ecosystem restoration could remove between about 3 and 10 $GtCO_2$ per year and a further 3 or more $GtCO_2$ per year could be removed by reforestation.

Over a forty or fifty year period of growth or regrowth this would yield negative emissions well into the 450 to 1000 $GtCO_2$ range mentioned by Rogelj *et al.*

More work needed but there could be good CDR.

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