

Formulas for Estimating CDR Requirements

An analysis based on a subset of the 408 model runs from the IPCC's 2018 1.5°C Report were used to develop formulas to calculate

1. The net cumulative CO2 emissions that are correlated to an increase in in temperature in a given year (for three different “probabilities” – 50%, 66%, and 90% for the “MAGICC” model) (i.e., given a specific temperature increase an estimate of the cumulative net CO2 emissions that causes that increase can be calculated)
2. The expected atmospheric CO2 PPM in a given year based on net cumulative CO2 emissions
3. A “temperature adjustment” based on percentage reduction of CH4 (methane) annual emissions from 2020 to 2060

The variables that were used to develop the formulas are shown in Table 1. In order for the model to base the calculations based on values after the year 2020, values for both temperature and CO2 PPM were adjusted for the years 2020 to 2060 based on the difference between the reported data and the 2020 values indicated in Table 1.

#	Variable	2020 value
1	Emissions CO2	
2	AR5 climate diagnostics Temperature Global Mean MAGICC6 MED	1.25
3	AR5 climate diagnostics Temperature Global Mean MAGICC6 P66	1.25
4	AR5 climate diagnostics Temperature Global Mean MAGICC6 P90	1.25
5	AR5 climate diagnostics Concentration CO2 MAGICC6 MED	412.5
6	Emissions CH4	

Table 1

Model Step 1

The CDR model first computes the cumulative net CO2 emissions by year from 2020 to 2060

1. The cumulative net CO2 emissions in 2020 are set to zero
2. Cumulative net CO2 emissions for the years 2021-2060 are set to the previous year's cumulative + previous year's gross CO2 emissions + CO2 emissions from natural feedbacks in the previous year - CO2 captured by CCS in the previous year

Model Step 2

If a “PPM Goal” was specified, the model calculates the corresponding “Temperature Goal”. The “Temperature Goal” is adjusted if the 2020 methane emissions are reduced by a percentage other than 60%. The model then uses the “Temperature Goal” and net CO2 emissions for 2060 (or whatever “Ending Year” was specified) to estimate what quantity of CO2 emissions would cause that temperature increase, and that amount is subtracted from the pathway's net emissions to determine how much CO2

must be removed from the atmosphere to meet the temperature target (for an example, see Table 2 #1 - #6).

Model Step 3

Based on (1) Year “Direct Air Capture” starts, (2) Year “Direct Air Capture” gets to maximum value, and (3) Amount of CO2 that needs to be removed, the model calculates the “Annual CO2 sequestered by ‘Direct Air Capture’ in the “Year “Direct Air Capture” gets to maximum value” (for an example, see Table 2 #7 - #9 and Figure 1)

#	Value	Item
1	1.75°C	Target temperature increase for 2060
2	66%	Probability of making the target
3	583	Cumulative CO2 to meet that temperature increase target
3	Optimistic	Climate Action Tracker scenario (does not include any CCS, BECCS, etc.)
5	1004	Cumulative CO2 for the Optimistic scenario
6	421	Amount of CO2 that needs to be removed to meet the temperature increase goal
7	2030	Year “Direct Air Capture” starts (and increases linearly)
8	2040	Year “Direct Air Capture” gets to maximum value
9	17	Annual CO2 sequestered by “Direct Air Capture”

Model Step 4

The Model then calculates the expected temperature increase and CO2 PPM for 2020 to the 2060 (See Figure 1 and Table 3). Figure 4 compares one of the IPCC scenario values (for AIM/CGE2.0 – Advance 2020 1.5C 2100) to the values calculated by the model.

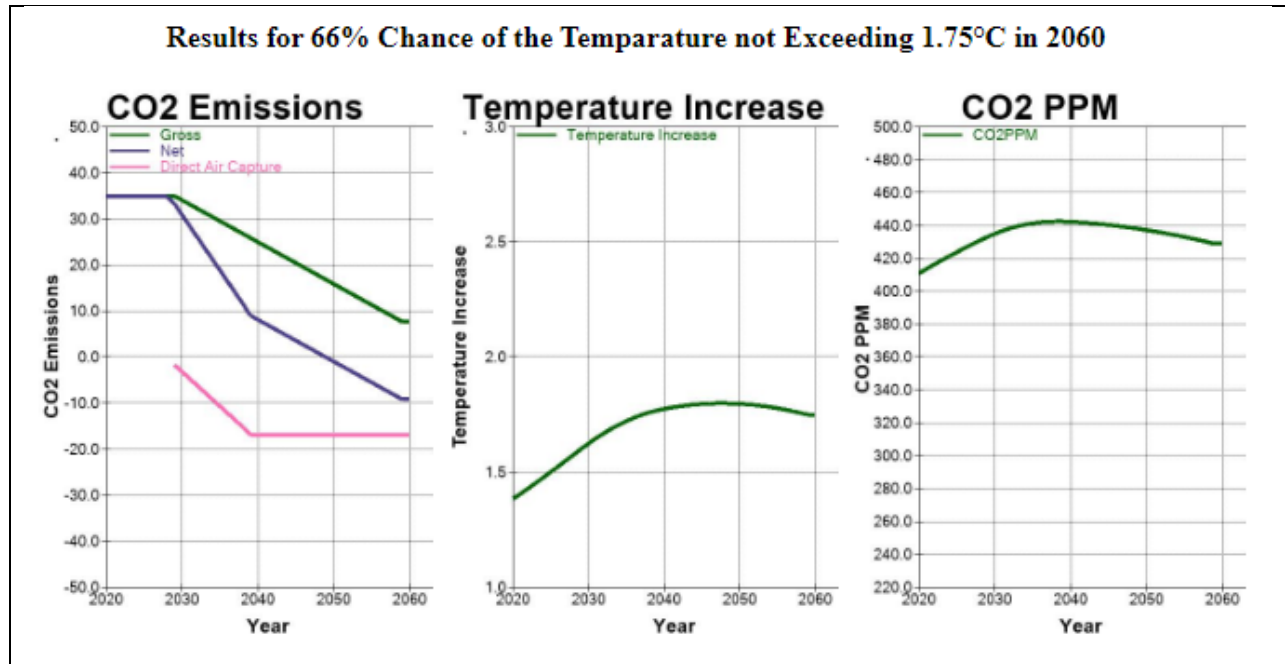
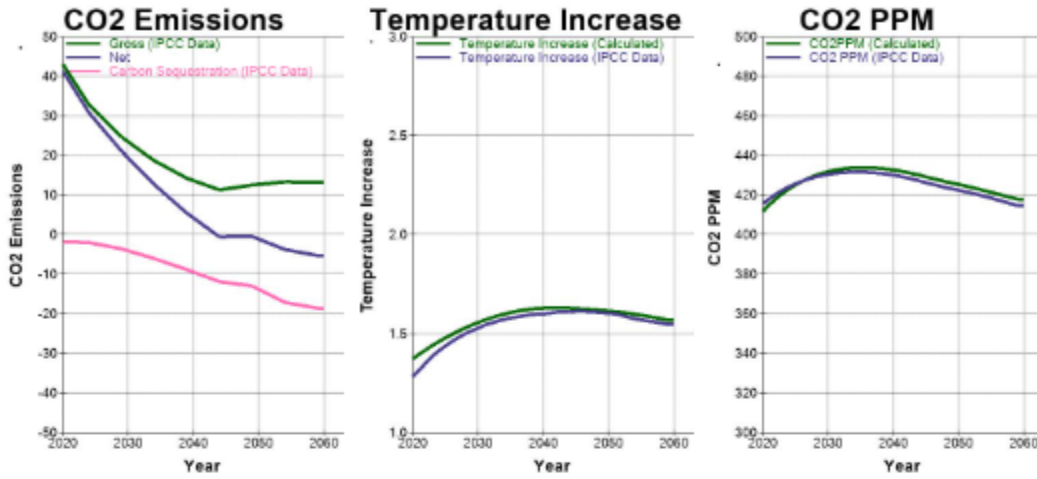


Figure 1

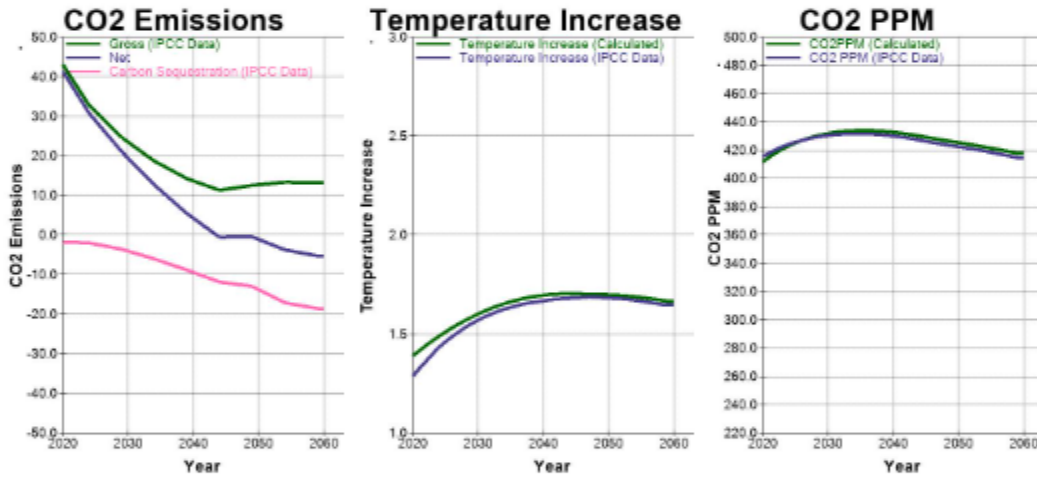
	2020	2025	2030	2035	2040	2045	2050	2055	2060
CO2 Emissions	35.00	35.00	35.00	30.45	25.90	21.35	16.80	12.25	7.70
Cum CO2 Emissions	0.00	175.00	350.00	515.90	659.04	779.45	877.10	951.99	1004.15
Results for 66% Chance of the Temperature not Exceeding 1.75°C in 2060									
Direct Air Capture (DAC)	0.00	0.00	1.68	9.17	16.85	16.85	16.85	16.85	16.85
Net CO2 Emissions	35.00	35.00	33.31	21.27	9.04	4.49	-0.05	-4.60	-9.15
Cumulative CDR	0.00	0.00	0.00	23.40	84.25	168.51	252.77	337.02	421.28
Cumulative Net Emissions	0.00	175.00	350.00	492.49	574.79	610.93	624.32	614.97	582.86
CO2 PPM	408.06	421.38	433.01	440.57	442.51	440.86	437.96	433.98	428.91
Temperature Increase	1.36	1.47	1.60	1.70	1.76	1.79	1.79	1.78	1.75

Table 3

Results: The temperature increase in 2060 is less than that for a 50% Chance of the Temperature not Exceeding 1.56°C in 2060



Results: The temperature increase in 2060 is less than that for a 66% Chance of the Temperature not Exceeding 1.66°C in 2060



Results: The temperature increase in 2060 is less than that for a 90% Chance of the Temperature not Exceeding 1.90°C in 2060

