Anthropogenic CO2 Emissions Expectations

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http://ccdatacenter.org/documents/AnthropogenicCO2EmissionsExpectations.pdf

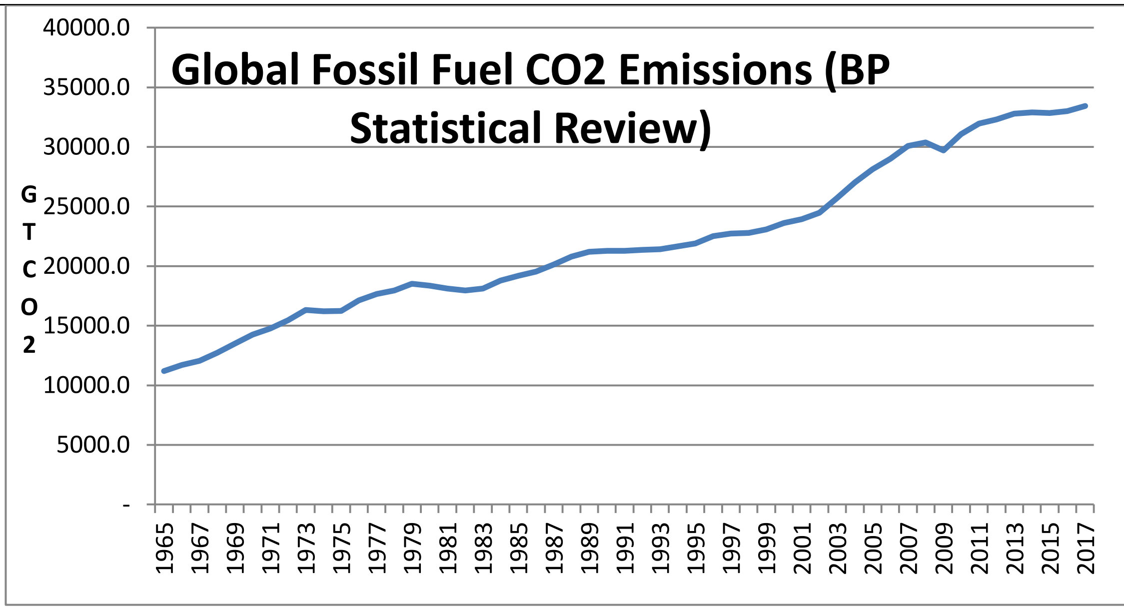
Anthropogenic CO2 emissions are likely to continue to increase through at least 2030 and possibly through 2050:

- Greenhouse gas emissions will increase about 1% per year through 2030 under current policies (latest UN "Emissions Gap Report")
- Entrenched interests (fossil fuels, etc.) are interested in maintaining the status quo
- Our society has not taken any really serious steps to reduce greenhouse gas emissions

Background Information

- CO2 emissions from fossil fuels have been increasing about 1.3%/year for the last 10 years and were about 9.124 GTC in 2015[1]
- CO2 emissions from cement in 2016 were 0.4 GTC[2]
- CO2 emissions from land use change in 2015 were about 1.32 GTC[3]
- Deforestation is likely to increase into the 2020's[4,5], but cumulative land use changes are hard to predict[6]
- Current emissions pledges ("NDCs") do not come close to meeting the objectives of the Paris agreement[7] *(note that the emissions ranges for 1.5 and 2.0° C include natural emission, so anthropogenic emissions would need to be a lot less, making the gap even wider)*
- Global CO2 emissions from fossil fuels will likely remain the same through 2050 at about 10 GTC/year[8] and atmospheric CO2 could reach 480 PPM by 2050[8]
- If CO2 fossil fuel emissions increase 1%/year between now and 2030 and then decline by 2%/year through 2100, total CO2 emissions through 2100 would about 625 GTC[9], about triple the estimates for 2.0° C carbon budgets
- Global energy consumption has almost quadrupled since 1965[10]
- For every trillion dollars of global GDP we add, the concentration of CO2 increases by 1.7 ppmv[11]
- World GDP is likely to increase by a factor of around 7 by 2100[12]
- Fossil fuel use will likely increase through at least 2050[13,14,15]
- The atmospheric concentration of greenhouse gases is approaching 500 PPM CO2e[16]

Footnotes

<table>
<tr><td>1</td><td>


2017 CO_2 emissions from fossil fuels were about 33,444 MTCO2 (9.124 GTC) in 2017, an increase of 1.6% from 2016 (the 10-year average growth through 2017 was rate of 1.3%). (2015 fossil fuel emissions were 8.966 GTC)

Since the Kyoto Protocol was signed global carbon dioxide emissions have increased by 19%.

https://www.forbes.com/sites/rrapier/2018/06/29/global-carbon-dioxide-emissions-set-new-record/#18c1feab43a9
</td></tr>
<tr><td>2</td><td>
Global CO2 emissions from cement production

We show that global process emissions in 2016 were 1.45 ± 0.20 GtCO2 [0.40 GTC], equivalent to about 4 % of emissions from fossil fuels. Cumulative emissions from 1928 to 2016 were 39.3 ± 2.4 GtCO2, 66 % of which have occurred since 1990. Emissions in 2015 were 30 % lower than those recently reported by the Global Carbon Project. The data associated with this article can be found at https://doi.org/10.5281/zenodo.831455.

https://www.earth-syst-sci-data.net/10/195/2018/essd-10-195-2018.pdf
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<tr><td>3</td><td>
Global_Carbon_Budget_2016_v1.0.xlxs (from http://cdiac.ornl.gov/GCP/) has fossil fuel +cement CO2 emissions at 9.90 GTC and land use change emissions at 1.32 GTC (for a total of 11.22 GTC) in 2015
</td></tr>
</table>

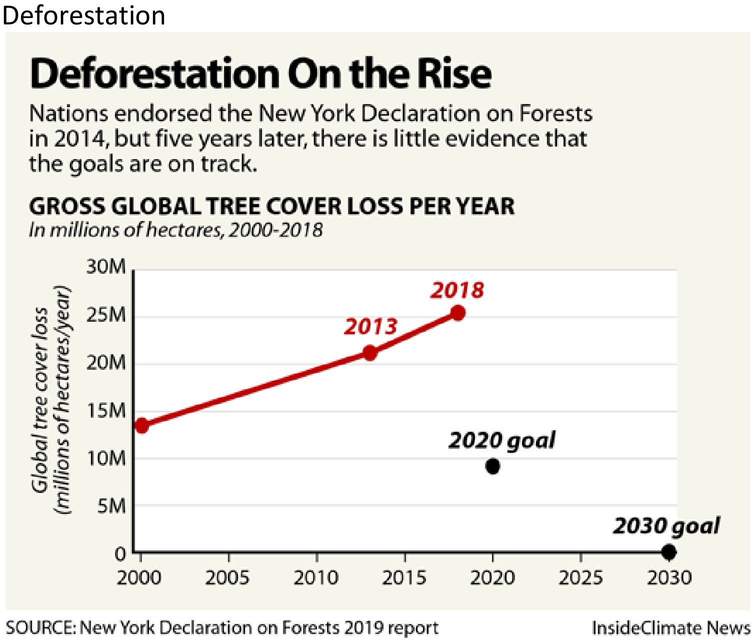
4 **Terrifying Trends Collide as Surging Deforestation 'Making World a Hotter, Drier Place'** , June 2018

New data shows climate goals and biodiversity threatened as tropics continue to lose "alarming" number of trees

Last year alone, tropical forests lost 39 million acres of trees—which could cover an area roughly the size of Bangladesh—according to new findings that have conservationists concerned about failing efforts to protect trees and the vital role forests play in battling anthropogenic global warming.

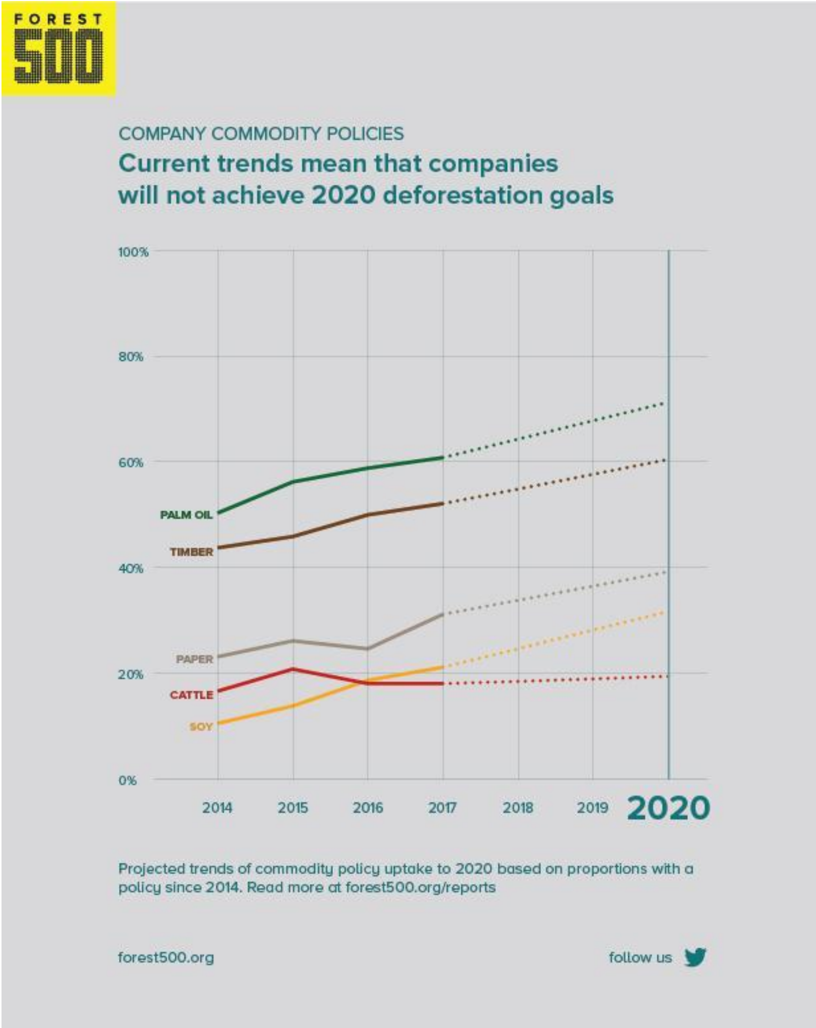
https://www.commondreams.org/news/2018/06/27/terrifying-trends-collide-surging-deforestation-making-world-hotter-drier-place

4A Deforestation



https://insideclimatenews.org/news/13092019/forest-loss-rate-global-deforestation-amazon-fires-corporate-agribusiness-international-declaration

5	**Companies still falling short on deforestation: more action needed** December 2017



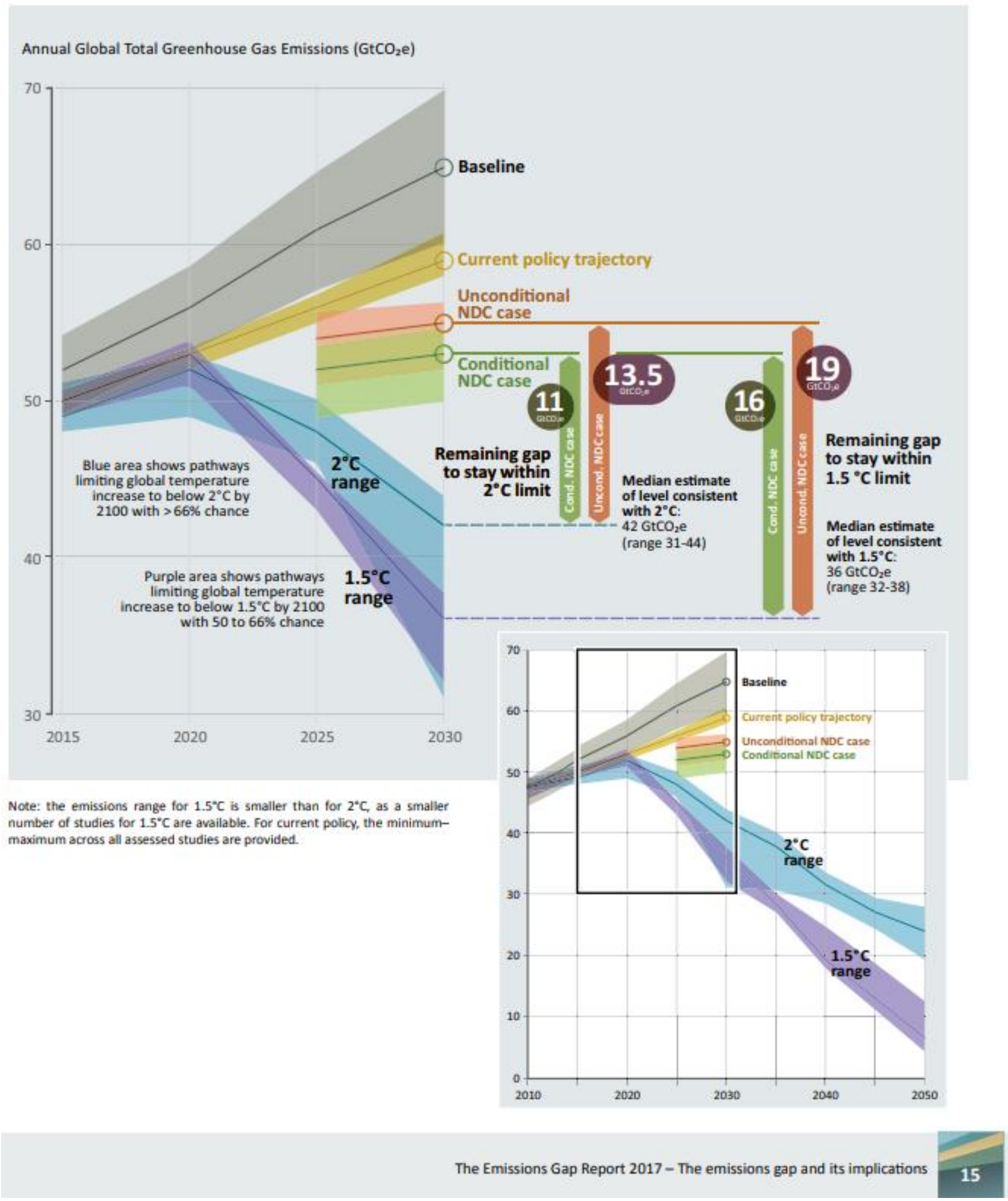
Our 2017 analysis of company commitments shows that at current rates of policy uptake, the 2020 goals to eliminate commodity driven deforestation will not be met. At current rates, the 250 most influential companies will not have introduced, let alone implemented, policies covering the key forest risk commodities by 2020.
https://forest500.org/analysis/insights/companies-still-falling-short-deforestation-more-action-needed

6 **Anthropogenic CO2 emissions from agriculture, forestry, land use for IPCC RCP scenarios**

	Anthropogenic CO2 emissions from agriculture, forestry, land use (AFOLU) (PgC yr–1)			
Year	RCP2.6	RCP4.5	RCP6.0	RCP8.5
2010	1.09	0.94	0.93	1.08
2020	0.97	0.41	0.38	0.91
2030	0.79	0.23	-0.43	0.74
2040	0.51	0.21	-0.67	0.65
2050	0.29	0.23	-0.48	0.58
2060	0.55	0.19	-0.27	0.50
2070	0.55	0.11	-0.04	0.42
2080	0.55	0.02	0.20	0.31
2090	0.59	0.03	0.24	0.20
2100	0.50	0.04	0.18	0.09
Total 2016-2100	50.73	17.85	-6.46	46.96

7

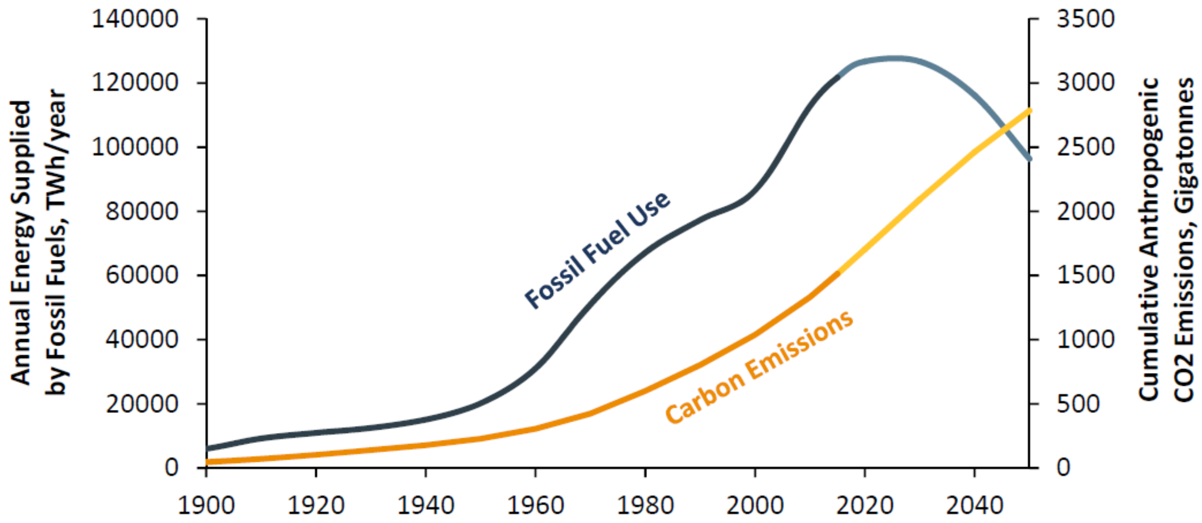
Figure 3.1: Global greenhouse gas emissions under different scenarios and the emissions gap in 2030 (median estimate and 10th to 90th percentile range).



http://pure.iiasa.ac.at/id/eprint/14921/1/EGR_2017_ch_3.pdf

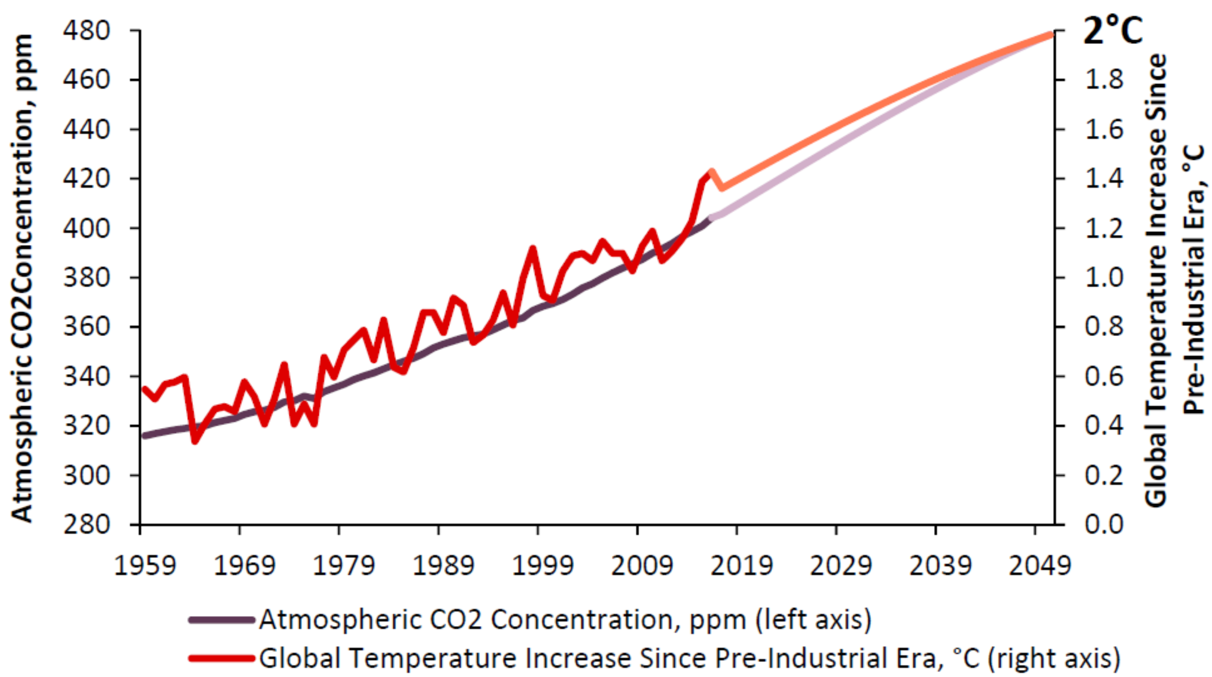
8	**The Race of Our Lives Revisited**

Exhibit 14: Annual Energy Supplied by Fossil Fuels, and Cumulative CO2 Emissions



As of 9/30/17
Source: OurWorldinData.org, Vaclav Smil, Carbon Dioxide Information Analysis Centre, GMO
Data from 2015-2050 is estimated or forecast.

Exhibit 15: Atmospheric CO2 and Temperature Increase since Pre-Industrial Era



As of 9/30/17
Source: National Oceanic and Atmospheric Administration, GMO
Data from 2016-2050 is estimated or forecast.

https://www.advisorperspectives.com/commentaries/2018/08/09/the-race-of-our-lives-revisited

(Note: the rate of CO2 emissions is about 37 GTCO2 (10 GTC) per year from 2015 through 2050)

9 The following tables show cumulative CO2 emissions from 2016-2100 for fossil fuel , cement, and land use changes for various combinations of emission reductions (without BECCS, CCS, or CDR) based on the following values:

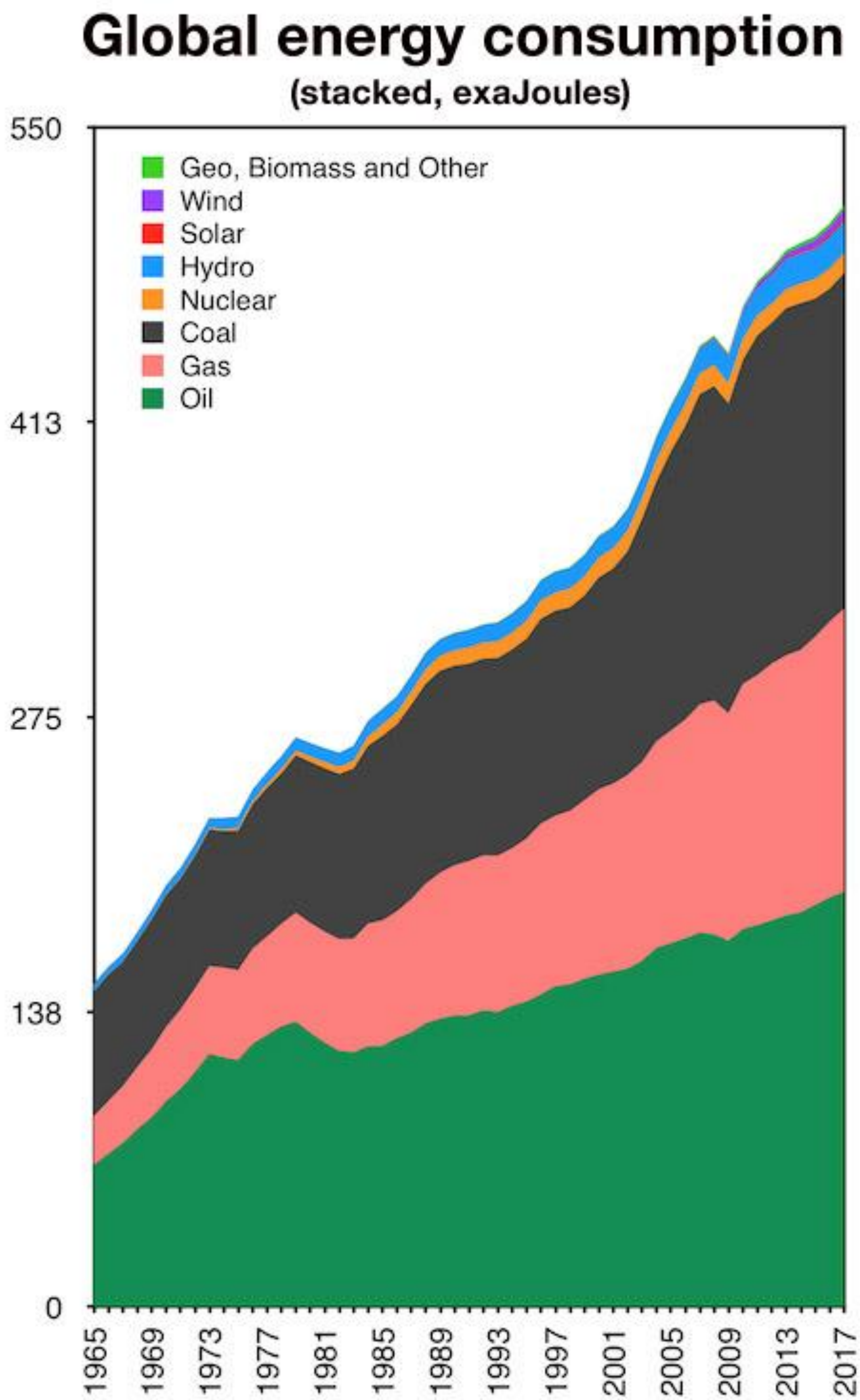
9.86	**2015 Fossil Fuel Emissions (GTC)**
1.6	**2015 land use emissions (GTC)**
2070	**Year when land use emissions reach zero**
0.029	**Land use decline/year (GTC**
43.00	**Land use emissions 2016-2070 (GTC)**

	Peak Yr:	2020			2025			2030		
	Pct Chg to Peak Yr:	0	1	2	0	1	2	0	1	2
Annual Percent Change After Peak Yr	0	881	923	966	881	964	1055	881	1005	1146
	-1	632	661	691	659	718	783	684	776	881
	-2	480	501	523	519	564	613	557	628	709
	-3	383	400	417	428	464	502	472	530	595
	-4	320	333	347	367	397	428	414	462	517
		Emissions 2016-2100			Emissions 2016-2100			Emissions 2016-2100		

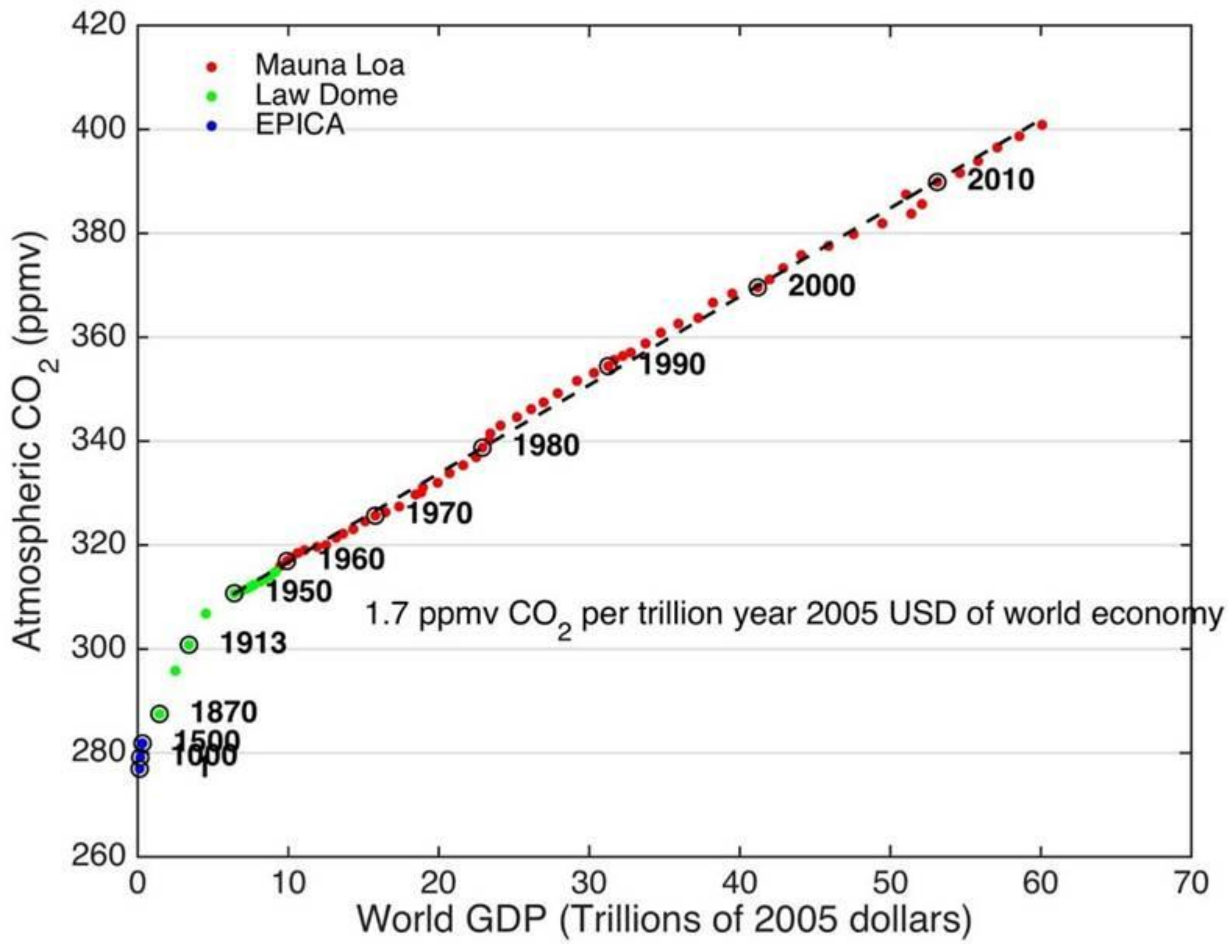
	Peak Yr:	2020			2025			2030		
	Pct Chg to Peak Yr:	0	1	2	0	1	2	0	1	2
Annual Percent Change of Peak Yr After Peak Yr	0	868	910	953	868	951	1041	868	991	1133
	-1	548	574	600	587	655	731	623	734	862
	-2	321	334	349	370	415	466	419	500	601
	-3	238	248	258	288	319	355	337	395	467
	-4	197	205	213	247	272	300	296	342	399
		Emissions 2016-2100			Emissions 2016-2100			Emissions 2016-2100		

(See worksheets EmmDecPctPeak and EmissDeclPctPrev in http://www.ccdatacenter.org/documents/FormulasAndTables.xlsx for calculations)

Note: *Based on footnotes 1 and 2, CO2 emissions from fossil fuels and cement were about 9.366 GCT (=8.966 +0.40), a bit lower than the 9.86 GTC used in this footnote)*

10	 https://www.resilience.org/stories/2018-06-18/our-energy-challenge-in-6-eye-popping-charts/
11	Another interesting fact and figure - CO_2 PPM has been correlated very strongly to global GDP since about 1950. The figure has been updated from the original in: **No way out? The double-bind in seeking global prosperity alongside mitigated climate change (2012)** **Abstract.** In a prior study (Garrett, 2011), I introduced a simple economic growth model designed to be consistent with general thermodynamic laws. Unlike traditional economic models, civilization is viewed only as a well-mixed global whole with no distinction made between individual nations, economic sectors, labor, or capital investments.

At the model core is a hypothesis that the global economy's current rate of primary energy consumption is tied through a constant to a very general representation of its historically accumulated wealth. Observations support this hypothesis, and indicate that the constant's value is $\lambda = 9.7 \pm 0.3$ milliwatts per 1990 US dollar. It is this link that allows for treatment of seemingly complex economic systems as simple physical systems. Here, this growth model is coupled to a linear formulation for the evolution of globally well-mixed atmospheric CO_2 concentrations. While very simple, the coupled model provides faithful multi-decadal hindcasts of trajectories in gross world product (GWP) and CO_2. Extending the model to the future, the model suggests that the well-known IPCC SRES scenarios substantially underestimate how much CO_2 levels will rise for a given level of future economic prosperity. For one, global CO_2 emission rates cannot be decoupled from wealth through efficiency gains. For another, like a long-term natural disaster, future greenhouse warming can be expected to act as an inflationary drag on the real growth of global wealth. For atmospheric CO_2 concentrations to remain below a "dangerous" level of 450 ppmv (Hansen et al., 2007), model forecasts suggest that there will have to be some combination of an unrealistically rapid rate of energy decarbonization and nearly immediate reductions in global civilization wealth. Effectively, it appears that civilization may be in a double-bind. If civilization does not collapse quickly this century, then CO_2 levels will likely end up exceeding 1000 ppmv; but, if CO_2 levels rise by this much, then the risk is that civilization will gradually tend towards collapse.
https://www.earth-syst-dynam.net/3/1/2012/



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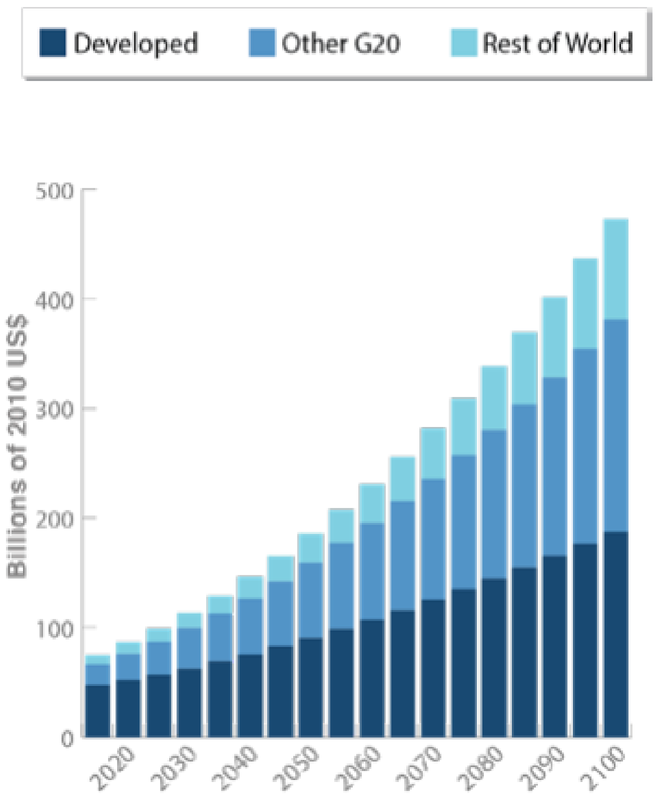


Figure 3. World GDP

https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf

13

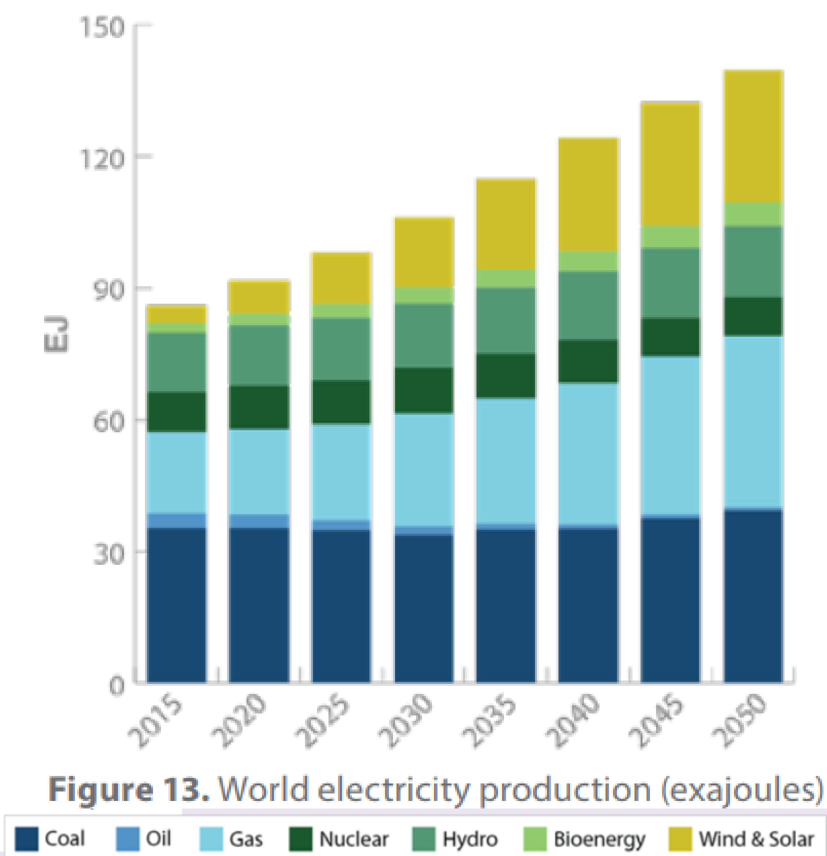


Figure 13. World electricity production (exajoules)

https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf

14

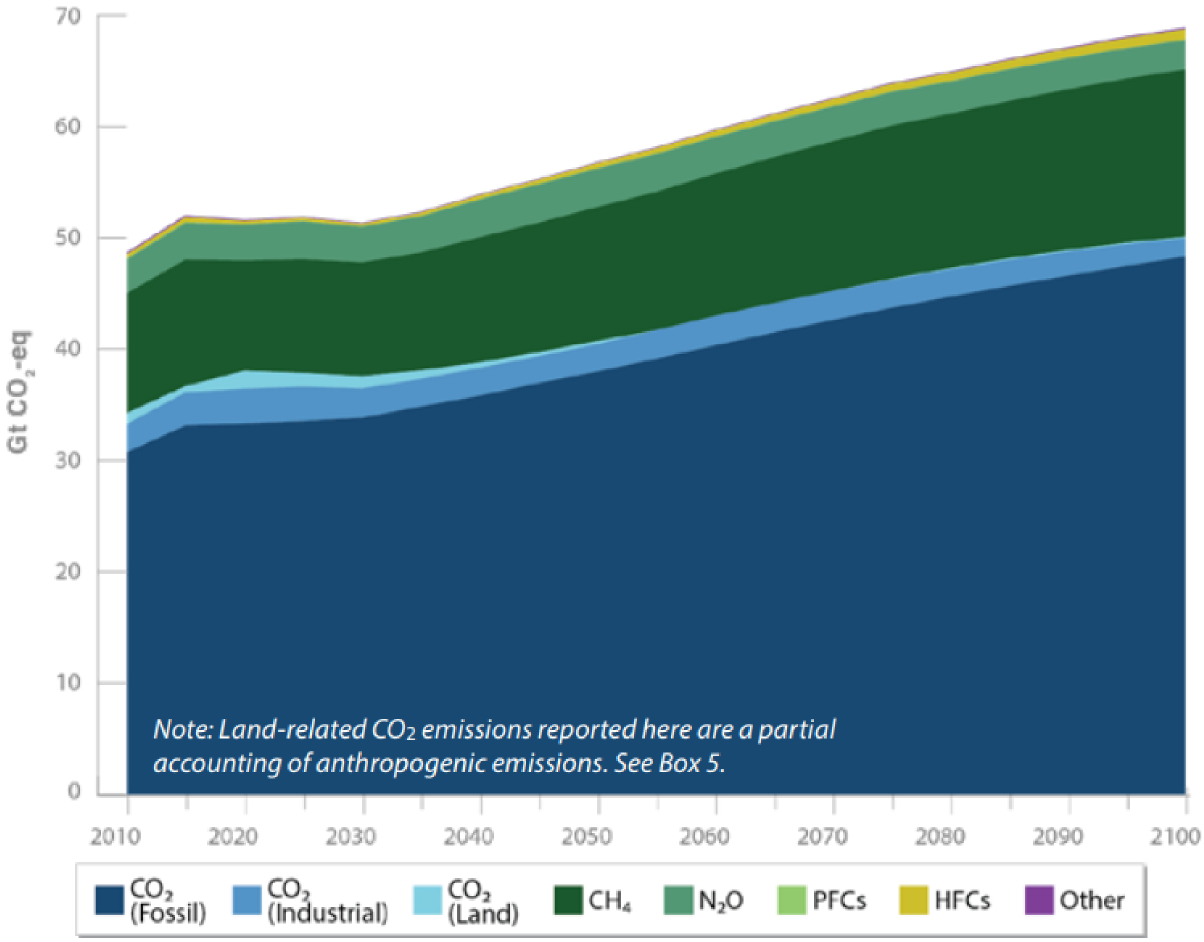
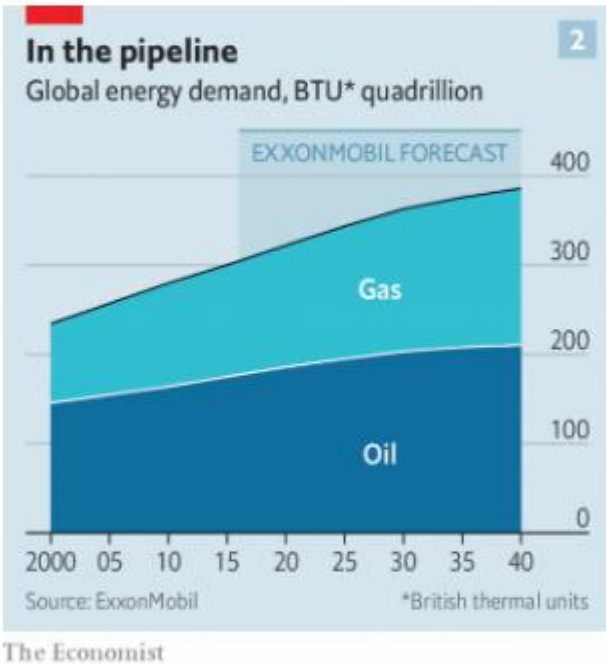


Figure 19. Global annual greenhouse gas emissions

https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf

15	"According to ExxonMobil, global oil and gas demand will rise by 13% by 2030. All of the majors, not just ExxonMobil, are expected to expand their output. Far from mothballing all their gasfields and gushers, the industry is investing in upstream projects from Texan shale to high-tech deep-water wells. Oil companies, directly and through trade groups, lobby against measures that would limit emissions. The trouble is that, according to an assessment by the ipcc, an intergovernmental climate-science body, oil and gas production needs to fall by about 20% by 2030 and by about 55% by 2050, in order to stop the Earth's temperature rising by more than 1.5°C above its pre-industrial level."  **https://www.economist.com/leaders/2019/02/09/the-truth-about-big-oil-and-climate-change**

16

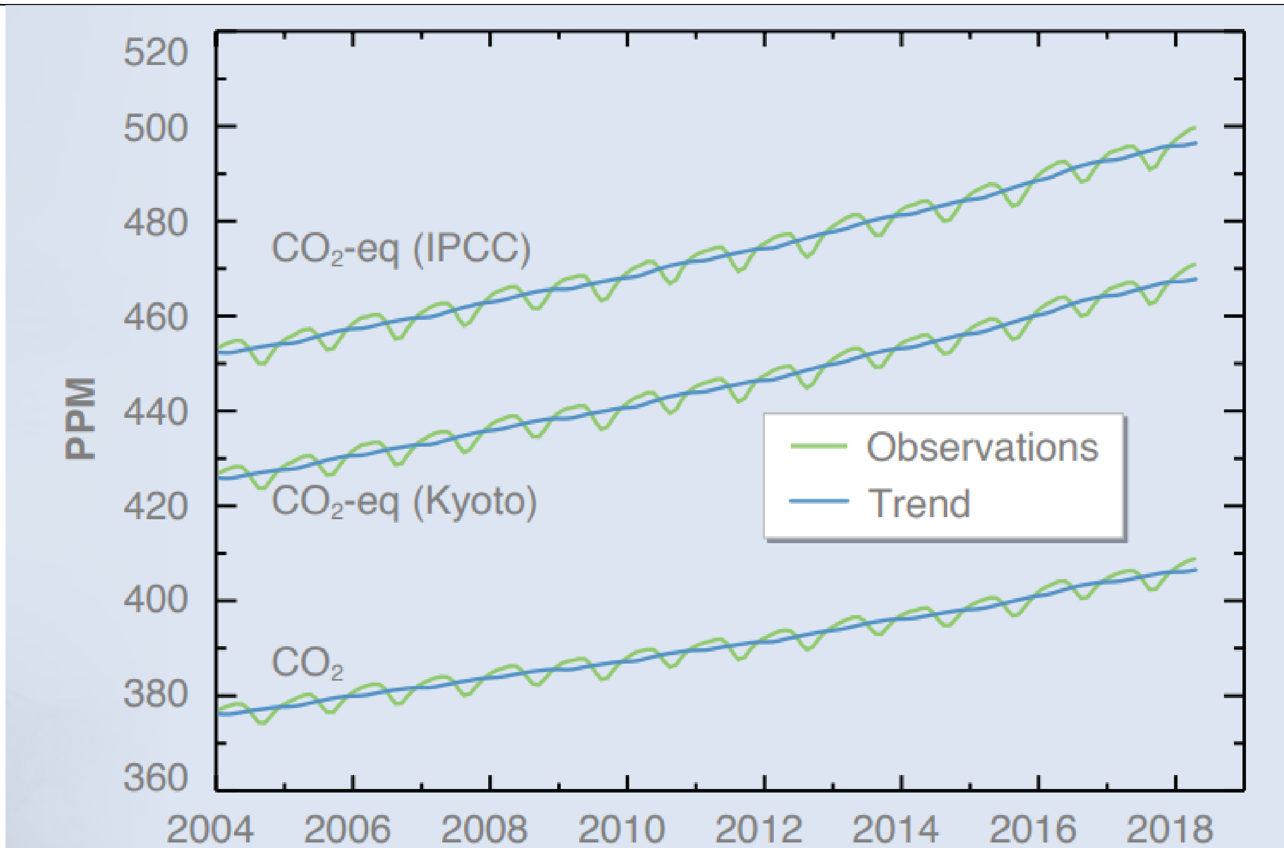


Figure 21. Current GHG concentrations

https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf

17

https://www.statista.com/statistics/263980/forecast-of-global-carbon-dioxide-emissions/

Forecast of carbon dioxide emissions worldwide from 2018 to 2050

(in billion metric tons)