**Current Situation**

Bruce Parker

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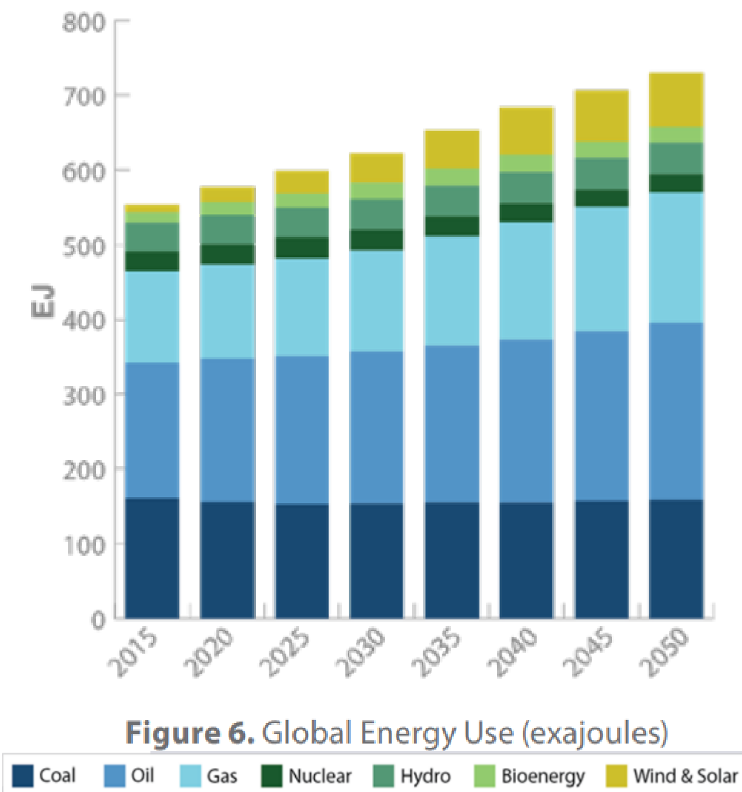
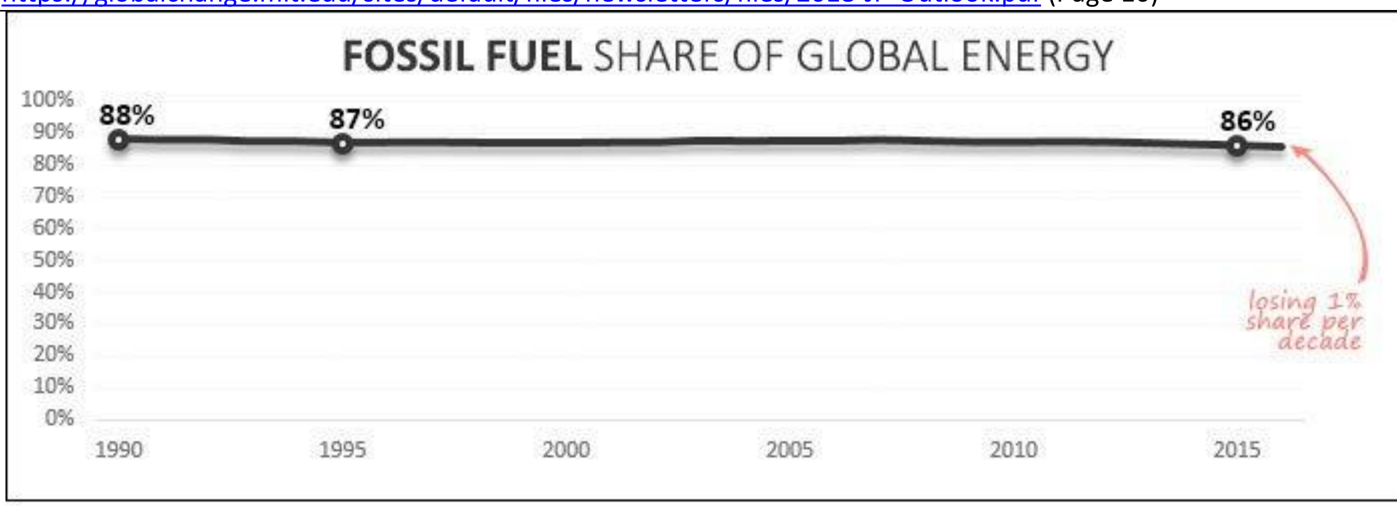
http://ccdatacenter.org/documents/CurrentSituation.pdf

The basic problem, as I see it, is that, based on likely anthropogenic GHG emissions and climate feedbacks, we are almost certainly headed towards a "hothouse Earth" unless many gigatons of carbon are removed annually from the atmosphere. But although we can likely afford the necessary costs there is very little likelihood that politicians will actually allocate the necessary funds for the needed carbon dioxide removal. There is no detailed plan under discussion that will remotely come close to both reducing emissions fast enough and paying for massive carbon dioxide removal. About all that has been proposed is a carbon tax (which, politically, cannot not be high enough to really be effective), the "free market" with minor government incentives, and sequestering carbon in the biosphere (which lacks the needed capacity). Also, the models that were used to develop the carbon budgets are very conservative, not fully taking into account albedo changes in the Arctic, emissions from natural feedbacks, etc. So the situation is much more dire than the recent IPCC 1.5°C report indicated and the general public is totally unaware of the sacrifices that would need to be made to prevent catastrophic climate change.

To keep the Earth's average temperature from rising more than 1.5°C, the IPCC assessment is that net-zero global emissions will be required in just a few decades. But emissions are likely to increase between now and 2050[1,2] as world GDP increases[3] (and there has been a very strong (logarithmic) correlation between GDP and atmospheric CO2 for several hundred years[4]), which will likely result in a temperature increase of around 2°C between 2050 and 2060[5]. Given reasonable expectations for climate feedbacks, non-CO2 radiative forcing, and climate sensitivity, there is, for all practical purposes, no carbon budget left[6]. If CO2 emissions could be reduced by 2%/year after 2030 (and this is not likely) and if average carbon dioxide removal costs between now and 2050 can be reduced to about $250/ton C then cumulative global CDR costs would likely be over $175 trillion ($25 trillion for the U.S.) by 2100 if the Paris temperature target is to be met[7].

A global average warming of 1–2 °C with strong polar amplification has, in the past, been accompanied by significant shifts in climate zones and the spatial distribution of land and ocean ecosystems. Sustained warming at this level has also led to substantial reductions of the Greenland and Antarctic ice sheets, with sea-level increases of at least several meters on millennial timescales. Comparison of palaeo observations with climate model results suggests that, due to the lack of certain feedback processes, model-based climate projections may underestimate long-term warming in response to future radiative forcing by as much as a factor of two, and thus may also underestimate centennial-to-millennial-scale sea-level rise. (https://m.phys.org/news/2018-07-global-climate.html#jCp)

Given that it is unlikely that our society will pay enough to limit the temperature increase to 2.0°C this century, the most important questions become: (1) How quickly will the temperature increase this century? (2) What effects will we see for various temperature increases? and (3) What is the best way to prepare for the expected temperature increase?

| | |
|---|---|
| 1 | <br><br>**Figure 6.** Global Energy Use (exajoules)<br>https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf (Page 10) |
| 2 | <br><br>GLOBAL FOSSIL FUEL CONSUMPTION, 1990 - 2016. Percent of total energy consumption. SOURCE: Sum of Oil, Gas and Coal consumption vs total energy in BP Statistical Review of World Energy June 2017. CHART by Barry Saxifrage at VisualCarbon.org, June 2017<br>https://twitter.com/kencaldeira/status/948093886508892160<br>MIT Outlook 2018 has fossil fuel share of global energy decreasing from 84% (93 exajoules) in 2015 to 78% (114 exajoules) in 2050<br>https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf (Page 10) |

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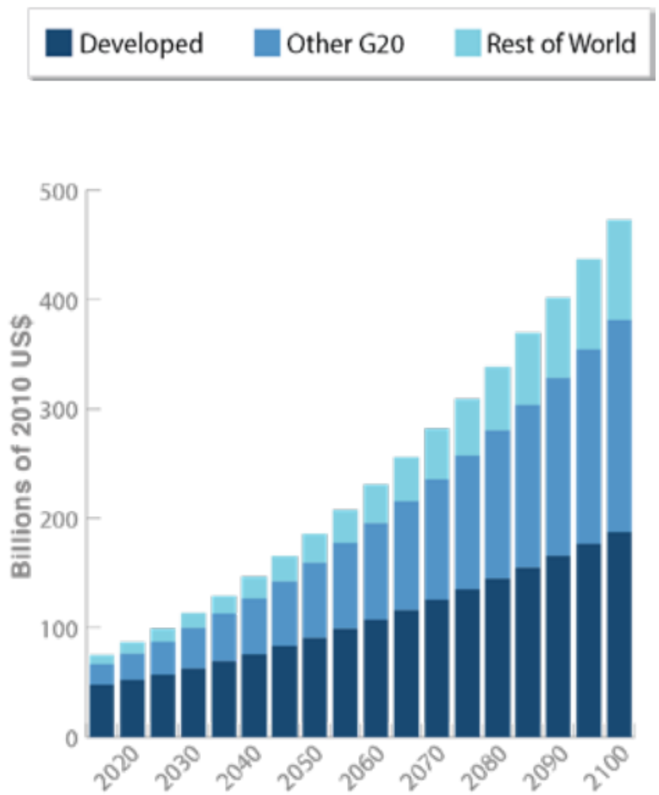


**Figure 3.** World GDP

https://globalchange.mit.edu/sites/default/files/newsletters/files/2018-JP-Outlook.pdf (Page 7)

4

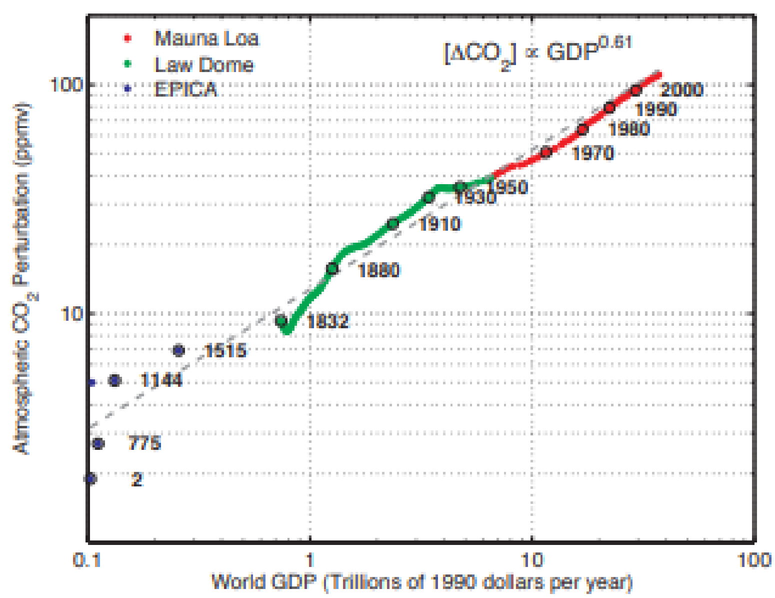


**Fig. C1.** Measured perturbations in atmospheric $CO_2$ concentrations from a baseline of 275 ppmv, compared with historical estimates of global GDP in inflation adjusted 1990 dollars, with associated year markers, and a linear fit to the data.

https://www.earth-syst-dynam.net/3/1/2012/esd-3-1-2012.pdf

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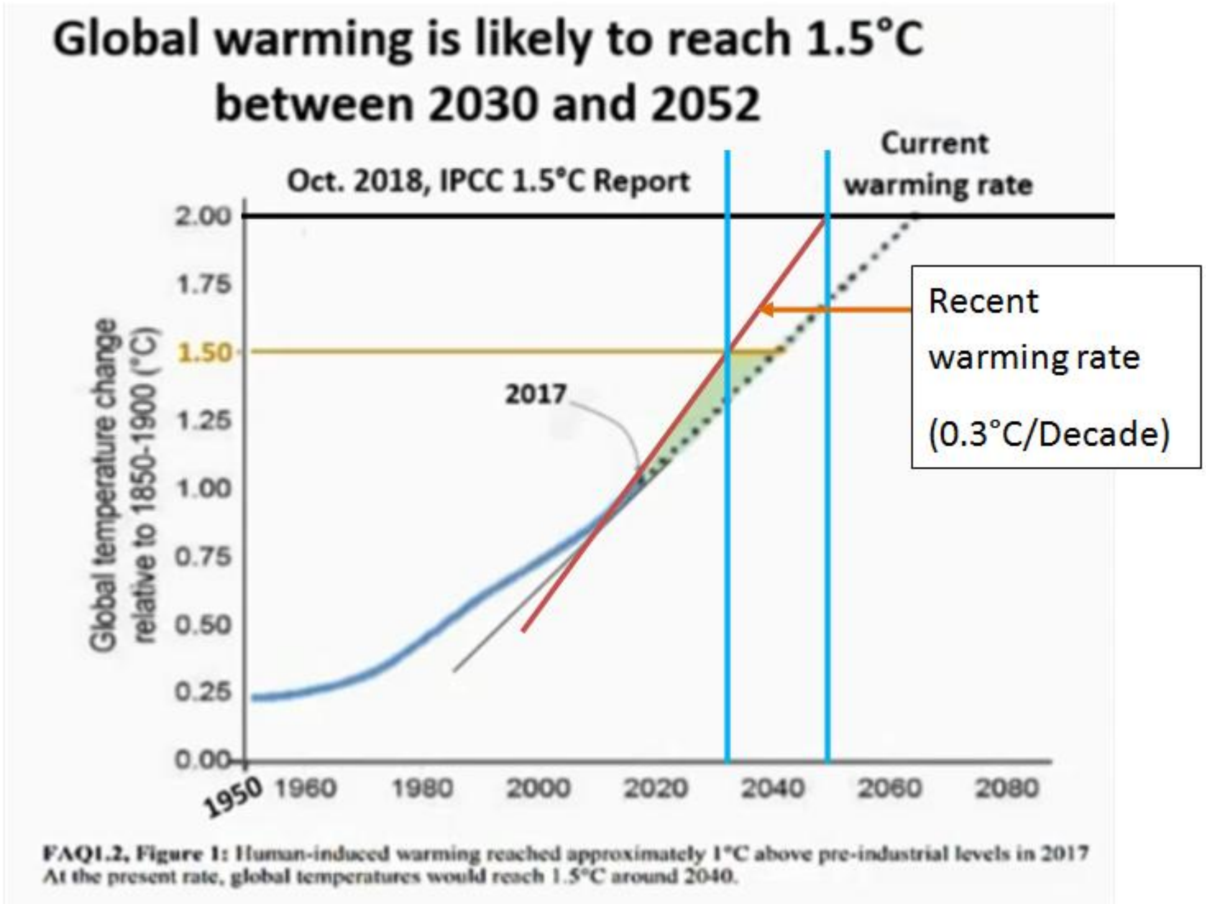


(Figure is a slight modification of a screenshot from Peter Carter's "Global Warming Acceleration" YouTube video)

6

CO2 Budget 2016-2100 = (278 * e((5.35 * Ln(1 + ET / CS) - NonCO2RF) /5.35) - 342.87)/ 0.2586

CO2 Budget 2019-2100 = CO2 Budget 2016-2100 - 35

| | | Temp Increase: 1.5 °C | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Climate Sensititivity | | | | | | | | | | | | | | | |
| | | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 |
| Non-CO2 RF (W/m-2) | 0.0 | 520 | 447 | 386 | 334 | 290 | 252 | 218 | 188 | 162 | 138 | 117 | 98 | 81 | 65 | 50 | 37 |
| | 0.1 | 485 | 414 | 354 | 303 | 259 | 222 | 189 | 160 | 134 | 111 | 90 | 71 | 54 | 38 | 24 | 11 |
| | 0.2 | 451 | 381 | 322 | 272 | 229 | 192 | 160 | 132 | 106 | 83 | 63 | 45 | 28 | 12 | -2 | -15 |
| | 0.3 | 418 | 348 | 291 | 242 | 200 | 164 | 132 | 104 | 79 | 57 | 37 | 18 | 2 | -13 | -27 | -40 |
| | 0.4 | 385 | 317 | 260 | 212 | 171 | 135 | 104 | 77 | 52 | 30 | 11 | -7 | -23 | -38 | -52 | -64 |
| | 0.5 | 352 | 286 | 230 | 183 | 143 | 108 | 77 | 50 | 26 | 5 | -15 | -32 | -48 | -63 | -76 | -88 |
| | 0.6 | 321 | 255 | 201 | 154 | 115 | 81 | 51 | 24 | 0 | -21 | -40 | -57 | -72 | -87 | -100 | -112 |
| | 0.7 | 290 | 225 | 172 | 126 | 88 | 54 | 24 | -2 | -25 | -45 | -64 | -81 | -96 | -110 | -123 | -135 |
| | 0.8 | 259 | 196 | 143 | 99 | 61 | 28 | -1 | -27 | -49 | -70 | -88 | -105 | -120 | -133 | -146 | -157 |
| | 0.9 | 229 | 167 | 116 | 72 | 34 | 2 | -26 | -51 | -74 | -94 | -112 | -128 | -143 | -156 | -168 | -180 |
| | 1.0 | 200 | 139 | 88 | 45 | 9 | -23 | -51 | -76 | -98 | -117 | -135 | -151 | -165 | -178 | -190 | -202 |
| | 1.1 | 171 | 111 | 61 | 19 | -17 | -48 | -75 | -100 | -121 | -140 | -157 | -173 | -187 | -200 | -212 | -223 |
| | 1.2 | 142 | 84 | 35 | -6 | -42 | -72 | -99 | -123 | -144 | -163 | -180 | -195 | -209 | -222 | -233 | -244 |
| | 1.3 | 115 | 57 | 9 | -31 | -66 | -96 | -123 | -146 | -166 | -185 | -202 | -217 | -230 | -243 | -254 | -265 |
| | 1.4 | 87 | 31 | -16 | -56 | -90 | -120 | -145 | -168 | -189 | -207 | -223 | -238 | -251 | -264 | -275 | -285 |
| | | CO2 Budget 2019-2100 (Emissions - GTC) | | | | | | | | | | | | | | | |

| | | Temp Increase: 2.0 °C | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Climate Sensititivity | | | | | | | | | | | | | | | |
| | | 2.0 | 2.2 | 2.4 | 2.6 | 2.8 | 3.0 | 3.2 | 3.4 | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 | 4.8 | 5.0 |
| Non-CO2 RF (W/m-2) | 0.0 | 789 | 691 | 610 | 541 | 482 | 431 | 386 | 346 | 311 | 280 | 252 | 226 | 203 | 181 | 162 | 144 |
| | 0.1 | 749 | 653 | 573 | 506 | 448 | 398 | 354 | 315 | 280 | 249 | 222 | 197 | 174 | 153 | 134 | 116 |
| | 0.2 | 710 | 616 | 538 | 471 | 414 | 365 | 322 | 284 | 250 | 220 | 192 | 168 | 145 | 125 | 106 | 89 |
| | 0.3 | 672 | 579 | 502 | 437 | 381 | 333 | 291 | 253 | 220 | 190 | 164 | 139 | 117 | 97 | 79 | 62 |
| | 0.4 | 634 | 543 | 468 | 404 | 349 | 302 | 260 | 223 | 191 | 162 | 135 | 112 | 90 | 70 | 52 | 36 |
| | 0.5 | 597 | 508 | 434 | 371 | 318 | 271 | 230 | 194 | 162 | 133 | 108 | 84 | 63 | 44 | 26 | 10 |
| | 0.6 | 561 | 474 | 401 | 339 | 286 | 241 | 201 | 165 | 134 | 106 | 81 | 58 | 37 | 18 | 0 | -16 |
| | 0.7 | 525 | 440 | 368 | 308 | 256 | 211 | 172 | 137 | 106 | 79 | 54 | 31 | 11 | -8 | -25 | -40 |
| | 0.8 | 490 | 406 | 336 | 277 | 226 | 182 | 143 | 109 | 79 | 52 | 28 | 6 | -14 | -33 | -49 | -65 |
| | 0.9 | 456 | 374 | 305 | 247 | 197 | 153 | 116 | 82 | 52 | 26 | 2 | -20 | -39 | -57 | -74 | -89 |
| | 1.0 | 423 | 341 | 274 | 217 | 168 | 125 | 88 | 55 | 26 | 0 | -23 | -45 | -64 | -81 | -98 | -112 |
| | 1.1 | 390 | 310 | 244 | 188 | 139 | 98 | 61 | 29 | 1 | -25 | -48 | -69 | -88 | -105 | -121 | -136 |
| | 1.2 | 357 | 279 | 214 | 159 | 112 | 71 | 35 | 3 | -25 | -50 | -72 | -93 | -111 | -128 | -144 | -158 |
| | 1.3 | 325 | 249 | 185 | 131 | 84 | 44 | 9 | -22 | -49 | -74 | -96 | -116 | -135 | -151 | -166 | -181 |
| | 1.4 | 294 | 219 | 156 | 103 | 58 | 18 | -16 | -47 | -74 | -98 | -120 | -139 | -157 | -174 | -189 | -202 |
| | | CO2 Budget 2019-2100 (Emissions - GTC) | | | | | | | | | | | | | | | |

- Yellow cells show combinations of CS and NonCO2 RF for a post 2018 budget of around 190 GTC (roughly that put forward by the IPCC and National Academy of Science and adjusted for 2016-2019 emissions[4]).
- Orange cells show combinations of CS and NonCO2 RF for a post 2018 anthropogenic budget of around 70 GTC (assuming natural emissions of roughly 120 GTC[5])
- Green cells show the total CO2 budget for a value of climate sensitivity slightly below that which was demonstrated by the models that best capture current conditions[6,7]
- Purple cells show the CO2 budget for the non-CO2 radiative forcing for RCP 4.5[3]

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

7 http://ccdatacenter.org/documents/CDRUSCostExpectations.pdf