The global Carbon Budget after the Paris Agreement

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COP21 in Paris saw the world increasing ambition on climate stabilization from a 2° target to "well below 2 °C (…) and pursuing efforts to limit the temperature increase to 1.5 °C"[i]
To make this target operational for global mitigation efforts, it must be translated into the permissible greenhouse gas emissions, the most significant part of which are CO2 emissions, in other words the global carbon budget. The latest IPCC report provides the foundation, as it contains carbon budget figures for both 2° and 1.5° targets at different probabilities.[ii] The figure for a 33% chance of staying below 1.5° is the one relevant for calculating the upper limit of the post-Paris carbon budget: 850 Gt CO2 from 2011. The next higher figure, corresponding to a 66% chance of staying below 2° is not appropriate, because a 1 in 3 chance of missing even the 2° target, which has now consensually been declared too high is not an option any longer after Paris.[iii] From 2011, the reference year of the IPCC figures to 2015, 167 Gigatons of CO2 have been emitted from fossil fuel burning.[iv] According to Anderson (2015), we must assume at least 60 Gigatons of CO2 emissions for deforestation and land use change and 150 Gigatons CO2 from cement production from 2011 over the course of the 21st century, before both of these can be phased out.[v]

473 Gigatons CO2 remain as carbon budget for fossil fuels after Paris.[vi]

1.5° and 2° are just politically negotiated proxies. What matters more for climate impacts are tipping points in the climate system[vii] and especially dynamics that lock in irreversible change. It may for example be more important to focus on a carbon budget for avoiding the melt-down of the Greenland Ice Shield, which may be triggered between 1° and 4°C warming.[viii] In 2016, we are already in this range of possibly triggering an irreversible sea-level rise of 7 meters, on top of thermal expansion and the 3 meters from the West Antarctic.[ix] 10+ meters sealevel rise may be locked in any of these years. We can not yet recognize the moment when that happens, because we do not yet precisely enough understand these tipping points. If the Paris Agreement leads us towards stopping the extraction and burning of fossil fuels within the "braking distance" to avoid some of these tipping points, it will be truly historic. The carbon budget can be understood as an approximate measure of this braking distance which is available for phasing out fossil fuel burning while transitioning to a renewable energy economy.

In terms of fossil fuel extraction, the post-Paris carbon budget represents **16% of global fossil fuel reserves**.[x] Out of these reserves, **84% or 2427 Gigatons CO2 must be kept in the ground**. Exploration for additional reserves is obsolete.

[i] Paris Agreement. http://unfccc.int/files/home/application/pdf/paris_agreement.pdf

[ii] IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf page 64, Table 2.2:

Table 2.2 | Cumulative carbon dioxide (CO_2) emission consistent with limiting warming to less than stated temperature limits at different levels of probability, based on different lines of evidence. *(WGI 12.5.4, WGIII 6)*

Cumulative CO_2 emissions from 1870 in $GtCO_2$									
Net anthropogenic warming [a]	<1.5°C			<2°C			<3°C		
Fraction of simulations meeting goal [b]	66%	50%	33%	66%	50%	33%	66%	50%	33%
Complex models, RCP scenarios only [c]	2250	2250	2550	2900	3000	3300	4200	4500	4850
Simple model, WGIII scenarios [d]	No data	2300 to 2350	2400 to 2950	2550 to 3150	2900 to 3200	2950 to 3800	n.a. [e]	4150 to 5750	5250 to 6000
Cumulative CO_2 emissions from 2011 in $GtCO_2$									
Complex models, RCP scenarios only [c]	400	550	850	1000	1300	1500	2400	2800	3250
Simple model, WGIII scenarios [d]	No data	550 to 600	600 to 1150	750 to 1400	1150 to 1400	1150 to 2050	n.a. [e]	2350 to 4000	3500 to 4250
Total fossil carbon available in 2011 [f]: 3670 to 7100 $GtCO_2$ (reserves) and 31300 to 50050 $GtCO_2$ (resources)									

[iii] In any case, modifying the budget to such a higher-risk approach would not substantially modify the budget, buying – at current rates – an extra three to four years of business-as-usual time.

[iv] 2015: 33 Gt CO2 (own estimate), 2011-2014: 134 Gt CO2 Source: Le Quéré, C, et al. (2015) Global Carbon Budget 2015 Earth System Science Data, 7, 349-396. http://www.globalcarbonproject.org/carbonbudget/15/files/Global_Carbon_Budget_2015v1.1.xlsx

[v] Anderson, Kevin (2015) Duality in climate science. Nature Geoscience 8, 898–900. http://rdcu.be/eoQY

[vi] 850 Gt CO2 in 2011, minus 167 Gt CO2 fossil fuel emissions 2011-2015 (see endnote iv),
minus 150 Gt cement emissions 2011-2100 (Anderson 2015),
minus 60 Gt land use change emissions 2011-2100 (Anderson 2015),
Post-Paris Carbon Budget for fossil fuels: 850-167-150-60=473 Gt CO2

[vii] Drijfhout, Sybren et al. (2015) Catalogue of abrupt shifts in Intergovernmental Panel on Climate Change climate models. Proceedings of the National Academy of Sciences, 112 (43) E5777-E5786. http://www.pnas.org/content/112/43/E5777.abstract

[viii] IPCC (2013) Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf page 29.

[ix] Feldmann, Johannes & Anders Levermann (2015) Collapse of the West Antarctic Ice Sheet after local destabilization of the Amundsen Basin, PNAS 112 (46) 14191-14196. http://www.pnas.org/content/112/46/14191.abstract

[x] McGlade, Christophe & Ekins, Paul (2015), The geographical distribution of fossil fuels unused when limiting global warming to 2 °C, Nature 517, 187–190. http://www.nature.com/nature/journal/v517/n7533/full/nature14016.html