Commentary in Response to the Interim Report of the "Deep Decarbonization Pathways Project" (DDPP)

The full report is available at: www.deepdecarbonization.org
It can also be downloaded from:
http://unsdsn.org/wp-content/uploads/2014/07/DDPP_interim_2014_report.pdf

This responsive commentary is grounded in the recently published presentation "Sensitivity and the Carbon Budget"(1) which is the culmination of nine years of intensive systems dynamics analysis carried out under the aegis of the Apollo-Gaia Project.(2) That publication brings together two streams of work. The first is the analysis of "Sensitivity, Non-Linearity and Self-Amplification in the Global Climate System"(3) presented to the Club of Rome as the conference keynote address at their annual gathering in September 2013. The second is the "Basis for a Carbon Budget? A Critical Evaluation of the Summary for Policymakers of the IPCC AR5 WG1"(4) released in February 2014. The Commentary and its underlying analyses are offered to the UNSDSN as a strategic resource ahead of the Global Leaders meeting convened this coming September in New York under the aegis of the United Nations. The new analysis has profound and potentially transformative implications for the whole strategic process of our international commitment to avoid dangerous climate change.

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Preface

1. The Deep Decarbonization Pathways Project (DDPP) is a collaborative initiative to understand and show how individual countries can transition to a low-carbon economy and how the world can meet the internationally agreed target of limiting the increase in global mean surface temperature to less than 2 degrees Celsius (°C). Achieving the 2°C limit will require that global net emissions of greenhouse gases (GHG) approach zero by the second half of the century. This will require a profound transformation of energy systems by mid-century through steep declines in carbon intensity in all sectors of the economy, a transition we call "deep decarbonization." *(p vi)*

> **DW:** The Preface sets the goal of the Report. It is about the "how" of achieving the target of keeping the increase in average surface temperature of the planet below the internationally agreed ceiling of 2°C. However, restricting the methodology to reduction in GHG **emissions** alone, rests on unexplored assumptions that determine the envelope of necessary and sufficient criteria for effective goal achievement.

Executive Summary

2. **Avoiding dangerous climate change and achieving sustainable development are inextricably linked.** There is no prospect of winning the fight against climate change if countries fail on poverty eradication or if countries do not succeed in raising the living standards of their people. Addressing climate change requires deep emission reductions of all greenhouse gases (GHGs), including the deep decarbonization of energy systems. To be successful, this transition must ensure that socio-economic development needs are met within the constraints of very low emissions. *(p xi)*

DW: The "inextricable linkage" is an ideological imposition that has no roots in the dynamics of human systems. The "wealth/poverty bifurcation" is embedded in the power dynamics of resource transactions. At their core lie processes (and their underlying drivers) of energy transfer across boundaries both within the human group and between that and its holding environment. Until the last couple of centuries, humanity has evolved within the constraints of the annual harvest of sustainable solar energy, essentially via photosynthesis supplemented by wind and the hydrological cycle. The addition of vast (and escalating) amounts of energy, derived from fossil deposits of stored solar power, did not transform the "wealth/poverty bifurcation". The termination of this energy source (whether driven by resource depletion or dictated by the unanticipated collateral damage to the holding environment) will reduce the overall standard of living unless alternative energy sources can be smoothly mobilised during the transition. It will do nothing to the underlying "wealth/poverty bifurcation". If anything the bifurcation becomes more intense in conditions of perceived shortfall in resource availability which are likely to accompany the transition.

Maintenance of political stability and social cohesion during the transition is altogether another matter. Populations experiencing reduction in living standards or forced into impoverishment may erupt in anarchic behaviour particularly if the rationale is not collectively accepted, or if those in power are seen to be profiting at the expense of those affected.

The logic of the Report becomes perverse at this point. The unconditional imperative lies not in the meeting of the "socio-economic development needs", but in the re-stabilising of the climate system, whatever that takes. The coat will then have to be cut within the constraints of the cloth. It might be worth reflecting on the sense of well-being of the returning astronauts aboard the damaged capsule of Apollo-13.

3. **In 2010, all governments operationalized the objective of the UNFCCC to "prevent dangerous anthropogenic interference with the climate system" by adopting the target of keeping the global rise in mean surface temperature below 2°C compared with the pre-industrial average.** They did this in recognition of the extreme risks to future human wellbeing resulting from a rise in temperature above 2°C. The latest scientific research analyzed by the IPCC Fifth Assessment Report (AR5) Working Group 2 (WG2) concludes that even an increase in global temperatures of 2°C constitutes a serious threat to human wellbeing. Keeping below 2°C of global warming is indispensable to maintain climate change within the boundaries of manageable risks and to our ability to adapt to climate change. *(p xii)*

DW: The original UNFCCC goal was stated in terms of limitation of the stock of atmospheric CO_2 ("stabilising the concentration of GHG in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system"). There were two fundamental problems with the "operationalization" of that goal.

The first problem concerned the translation of dangerous risk into a limit of temperature increase. That was done on the best understanding of risk at the time, but has proved inadequate. Operationalization of the UNFCCC goal now requires that limit to be halved to 1°C, and even that involves significant and dangerous anthropogenic interference with the climate system.

The second problem was the correlation of the 2°C limit with a concentration of c. 440 ppm of CO_{2e}. That depended totally on the sensitivity of the planetary temperature to changes in CO_2 concentration. The value of sensitivity employed was based on computer models that grossly underestimated the feedback dynamics of the climate system. Today's best (and most robust) value for the earth system sensitivity has increased the original estimate by a factor of more than 2.5. *[See "Sensitivity and the*

Carbon Budget"[(1)] *pp 14f]* That lowers the original 2°C target to an equivalent concentration of c.330 ppm CO_{2e} and operationalizes the current UNFCCC goal of not more than 1°C above pre-industrial levels at c.310 ppm CO_{2e}. The implications for the budgetary approach to deep decarbonization cannot be overstated.

Keeping below 2°C of global warming is indeed "indispensable to maintain climate change within the boundaries of manageable risks and to our ability to adapt to climate change". Necessary it may be, but it is absolutely not sufficient to meet those goals.

4. **Limiting the increase in global mean temperature to less than 2°C imposes a tough constraint on cumulative GHG emissions, including CO2 emissions, which are the largest single source (76%) of GHG emissions.** To have a likely chance—defined as a probability higher than two-thirds—of staying within this limit, the level of cumulative CO2 emissions from land use, fossil fuels, and industry must be in the range of 550-1300 billion tons (Gigatons or Gt) by mid-century. If one excludes a significant contribution from net negative emissions, the CO2 budget to 2050 is 825 Gt. Staying within this CO2 budget requires very near-term peaking and a sharp reduction in CO2 emissions thereafter, especially in energy-related CO2 emissions. The scenarios reviewed by the IPCC that give a likely chance of staying within the 2°C limit project CO2 emissions from the burning of fossil fuels and industrial processes ("CO2-energy emissions") close to 11 Gt in 2050 on average (down from 34 Gt in 2011). The IEA Energy Technology Perspective (ETP) 2°C scenario (2DS), which gives only a 50% chance of staying within the 2°C limit, reaches 15 Gt CO2-energy in 2050. Assuming a world population of 9.5 billion people by 2050—in line with the medium fertility forecast of the UN Population Division—this means that countries would need to converge close to a global average of CO2-energy emissions per capita of 1.6 tons in 2050, which is a sharp decrease compared to today's global average of 5.2 tons, especially for developed countries with current emissions per capita much higher than today's global average. *(p xii)*

DW: Fundamental to the budgetary approach of this whole section is the unacknowledged dependence on a low value for climate sensitivity of c. 3°C in response to a doubling of the atmospheric concentration of CO_2. Dependence of the budgetary approach on climate sensitivity is acknowledged in the main body of the IPCC AR5 WG1, but elided from the Summary for Policymakers. Once the full value of the earth system sensitivity is applied (of at least 7.8°C in equilibrium response to a doubling of the atmospheric concentration of CO_2) it becomes totally clear that the available budget of CO_2 emissions collapses to zero. Additionally, since the 2°C ceiling was broken when atmospheric concentrations passed the 330ppm level, human civilization is already in massive "overshoot" of CO_2 emissions to the tune of c 1340 Gt CO_2. That amount would have to be drawn down from the current atmospheric stock if we are to have a reasonable chance of limiting global warming to an eventual 2°C above the pre-industrial benchmark. The required drawn-down would have to increase to take account of the effects of GHGs other than CO_2. It would also have to be increased to compensate for all further emissions during the transition to a zero-carbon economy. Still further increase in the draw-down total would be required to arrive at the operational goal of limiting global warming to at most 1°C above the pre-industrial benchmark. Humanity is living with the delusion of available credit at the bank while in reality adding to a massive overdraft. We are trading while bankrupt, except that in this situation there are no available arrangements for going into liquidation. The full debt will have to be repaid.

5. The IPCC AR5 Working Group 3 (WG3) calculates that in the absence of additional commitments to reduce GHG emissions, the world is on a trajectory to an increase in global

mean temperature of 3.7°C to 4.8°C compared to pre-industrial levels. When accounting for full climate uncertainty, this range extends from 2.5°C to 7.8°C by the end of the century. *(p xii)*

> **DW:** The set of emission reduction commitments currently on the table is a significant improvement on the present "business as usual" output. However, without significant further improvement in the reduction commitments, this set is still expected to lead to a total cumulative carbon emission of some 2000 GtC by the end of the century. That would give an atmospheric concentration of CO_2 at c.694ppm. If that level of GHG concentration were then stabilized the predicted eventual temperature change from the pre-industrial benchmark would only be around 4°C if the predictions limited their calculations to exclude all but the most basic "fast feedbacks" of the climate system. If the full earth system sensitivity is taken into account the equilibrium temperature response to this level of forcing is just over 10°C, with a far smaller uncertainty spread than that produced by the CMIP5 computing ensemble that underlies the IPCC AR5 predictions. *[See "Basis for a Carbon Budget?"[(4)] pp. 9-17]* The Decarbonization report then switches to "end of century" spread which is of course lower that the full equilibrium level. This shorter term or "transient" temperature response is also dependent on gross underestimate of the climate sensitivity. Applying the full earth system sensitivity, the end of century change in average surface temperature with current emission reduction commitments would hit around 8°C with a much lower range of "climate uncertainty" than that generated by the computer ensemble.

6. **The consequences of such a temperature rise would be catastrophic**. A recent report prepared by the Potsdam Institute for Climate Impact Research (PIK) for the World Bank [*Schellnhuber, HJ, et al. Turn down the heat: climate extremes, regional impacts, and the case for resilience - Washington DC; World Bank. June 2013*[(5)]] describes a dramatic picture of a 4°C warmer world, where climate and weather extremes would cause devastation and intense human suffering. It would have severe repercussions on human and physical systems and potentially unleash positive feedback mechanisms that further amplify the human drivers. The IPCC AR5 and a large number of other international and national assessments validate this finding. It is therefore vital that the world become much more serious about the implications of staying within the 2°C limit. Governments, businesses, and civil society must understand and operationalize the profound transformations required to reach this target. *(p xiii)*

> **DW:** If the consequences of a 4°C rise are deemed to be "catastrophic" how much more devastating is the prospect of an increase heading towards 10°C. That figure does not take into account the forcing from non CO_2 GHGs. Nor does it recognise the difficulties current being experienced in the implementation of the set of emission-reduction commitments already tabled. The situation is also exacerbated by expected increase in climatic response to GHG forcing due to anthropogenic sink degrade and the effects of rapid change and far-from equilibrium behaviour that characterise the Anthropocene.

Chapter I. Taking the 2°C Limit Seriously

7. Our moment of truth has arrived. Twenty-two years ago at the Rio Earth Summit, the world's governments recognized that humanity was changing the climate system profoundly, posing risks for human wellbeing and sustainable development prospects. They adopted the United Nations Framework Convention on Climate Change (UNFCCC) two years later, and resolved to protect the planet and promote sustainable development by stabilizing "GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

DW: Note that the UNFCCC deals with the issue of stabilizing the **stock** of GHG at a safe level.

8. Yet, more than two decades later, GHG emissions are still far from stabilizing. In 1994, at the first Conference of the Parties (COP1) of the UNFCCC, CO2 emissions from the burning of fossil fuels and direct CO2 emissions from industrial processes were 23 billion tons (gigatons or Gt), and the CO2 concentration stood at 358.8 parts per million (ppm). By 2013, at COP19, global CO2 emissions had soared to 36 billion tons, and CO2 concentrations stood at 396.5 ppm.

DW: However, in the very next section, the DDPP report reflects the **displacement from stock to flow**. It speaks of the stabilization of emissions. Note that the stabilization of emissions produces a constant rate of change in the stock of atmospheric GHGs. It does not stabilize the stock or level of concentration!

9. At the 16th COP held in Cancun in 2010, the world's governments committed to a new and clear target: to keep the global rise in mean surface temperature below 2°C compared with the pre-industrial average. The COP added a proviso that the 2°C limit may be revised downward to 1.5°C in light of available science. The 2°C limit is the world's most explicit, and many climate scientists would say last-ditch, effort to operationalize the goal of avoiding dangerous anthropogenic interference with the climate system. *(p 1)*

DW: The next level of displacement removes strategic attention even further away from the UNFCCC target. The substitution of a ceiling temperature target opens two compounding layers of error. The first equates a given temperature projection with a GHG stock or concentration level of some 440ppm. That is flawed by use of the major underestimate of the sensitivity of temperature to change in CO_2 concentration. (See notes on sections 2 and 3 above) The second layer of error concerns the sensitivity of the climate system to changes in average surface temperature. This also was subject to gross underestimation as noted above.

10. The business-as-usual (BAU) course is so deeply entrenched that one study after another blithely assumes that the world will overshoot the 2°C limit. One can review any authoritative report on energy trends—by the International Energy Agency (IEA), the US Energy Information Association (EIA), or industry groups such as BP or Shell—and the result is the same: all reports present a "baseline" or BAU trajectory of roughly 4°C. This outcome is somehow received as normal, despite the global commitment stating otherwise. Clearly, our global politics and our energy practices are out of line, though they are implicitly accepted as normal. Yet this is anything but normal. Humanity faces catastrophic risks on our current path. *(p 2)*

DW: Every single one of these reports depends on the application of the "fast feedback sensitivity" now known to be underestimating the temperature outcome of increase in GHG stock by a factor exceeding 2.5. So for 2°C we should read 5°C. For 4°C we should read 10°C. In addition, the energy use forecasts used by the vested-interest groups take no account of the constraints imposed by the collateral damage from continued use of fossil energy. Their forecasts are driven by projected rise in energy demand from a growing population. They represent a commitment to protect the economics of the global energy business. The DDPP report pays insufficient attention to the power of this sector to block any effective strategic attempt to prevent dangerous climate change.

11. The risks of unabated climate change are enormous. They threaten every prospect of achieving sustainable development and humanity's fervent hopes to end poverty and achieve a decent life for all on this planet. The current trajectory is not just risky; it is potentially catastrophic. Runaway climate change would threaten the life-support systems of the planet: food production, human health and productivity, and safety from extreme storms and other climate disruptions. Rising sea levels would overtake many of the world's largest urban agglomerations and low-lying countries, such as Bangladesh and small island states. Many threatened regions in today's poor world, particularly the tropics, drylands, forests, and alpine regions, may become uninhabitable, leading to mass migration and suffering. *(p 2)*

> **DW:** The inflated language of high-level risk used at this point in the report leaves little room for the added domain when full sensitivity values are applied. If low-level sensitivity values combined with a BAU trajectory are "not just risky, but potentially catastrophic" then we would have to postulate an escalation from "catastrophic" to "cataclysmic" when the appropriate sensitivity values are taken into account.
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> The undisciplined use of the term "runaway" is inappropriate. Runaway climate change (technically a state of self-amplification in the climate system) can only occur if the forcing added by the feedback system for a given change in temperature is greater than the reduction in forcing due to the "radiative damping coefficient" (the major negative feedback) over the same change in temperature. *[See "Sensitivity and the Carbon Budget"(1) pp.25f]* It is fundamentally a characteristic of the feedback system and does not depend on the GHG concentration or the actual change in temperature. The threats identified in the report are realistic in response to "unabated climate change" without recourse to a postulated episode of runaway behaviour.

12. Recent scientific evidence suggests that even a temperature increase of only 2°C may generate very severe, pervasive and irreversible risks. Some leading climate scientists are in fact advising to limit global warming to 1°C instead. They cite the grave long-term consequences that a 2°C increase could have on the earth, society, and future generations. Professor Hansen, formerly the top climate scientist at NASA, points out that Earth's paleoclimate history projects that a 2°C global warming is likely to result in eventual sea-level rise of six meters (20 feet). He and others also emphasize that warming of 2°C could induce "slow amplifying feedbacks." For example, the Amazon rainforest could eventually die as a result of repeated drought, releasing massive amounts of CO2 into the atmosphere. Similarly, methane and CO2 buried in the permafrost in the tundra could be released into the air as the tundra melts. By pushing the climate beyond the experience of the human era of the past 100,000 years, the world risks inducing conditions that are inhospitable for the human species and millions of others, especially when humanity now comprises more than 7 billion inhabitants on a crowded planet. ….. a rise in temperature of 2°C or more threatens many positive feedback loops that could push the global climate system into runaway and irreversible disruptions. *(p 3)*

> **DW:** In the light of the current experience of dangerous climate change already felt as a consequence of a rise of only 0.85°C, even a 1°C ceiling will fall foul of the UNFCCC goal. However, in this section there are several myths about the effects of a 2°C rise which must be challenged and laid to rest:
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> **Firstly**, the issue of the rate of sea-level rise. Professor Hansen shows from paleo records, that temperatures of c.2°C above the pre-industrial benchmark correlate with a sea-level some 6 meters above the present. However, the rate of change in the paleo-record is very slow (hence the "eventual" tag). It corresponds to the slow (astronomical) rates of change in the shape of the earth's orbit around the sun, together

with shifts in tilt and wobble of the planet's rotation about its axis. Todays' rate of change is not governed by these astronomically slow functions, but by the extremely rapid change in GHG concentration driven by human activity. There are no historical examples on which to base prediction of the rate of sea-level rise. Current rates of change are running at some 3mm per year. Projecting that rate as a constant gives a rise of around 30cm by the end of the century. However, Professor Hansen also points out that initial observations indicate that the change is not linear but exponential with a doubling rate of 10 years or less. That would give a rise of 6 meters by the end of the century. It is highly probable that the doubling rate is itself subject to decay, in which case the 6 meter rise would be achieved even earlier.

The second myth concerns the onset of "slow amplifying feedbacks". Almost all the amplifying feedbacks in the climate system are driven by change in temperature and are activated as soon as temperature starts to increase. 2°C does not constitute a "triggering threshold" beyond which positive feedback starts to happen. No conditionality is involved ("could induce"). The complex feedback system is already active. Some processes build up faster than others. Some processes are stronger than others. The overall pace of temperature change depends on the massive thermal inertia of the planet as a whole. Certain mechanisms may be pushed into rapid change at particular thresholds in this process ("tipping points"), but again the word "eventually" is misleading. The cascade collapse of the Amazon rain forest could occur within a decade if a three-year drought were to be experienced. The recent two-year drought shifted the Amazon from a net sink to a significant source of atmospheric CO_2. Again there is no "could be" about the release of CO_2 and methane from melting permafrost whether terrestrial or submarine. Those mechanisms are already under way.

The third myth in this section concerns the 2°C threshold as the point of onset that "threatens many positive feedback loops that could push the global climate system into runaway and irreversible disruptions". The potential for runaway behaviour is embedded in the nature of the feedback system as a whole and is not brought into play at some arbitrary temperature threshold.

Finally, there is massive confusion here between "runaway" and "irreversible" consequences. In conditions of runaway behaviour, climate change would continue to accelerate under its own dynamics even if all human contribution were to cease. Irreversible consequences are those that cannot be restored to the *status quo ante*. For example even if temperature reached a new equilibrium, ice loss from the Greenland ice cap would not be replaced (it would take another ice-age to replenish that stock). Another example is the release of methane hydrates from thawing submarine permafrost. In contrast, change in the area of floating Arctic sea-ice is reversible. It would be reconstituted if temperatures decreased.

13. Available studies show that the 2°C limit technologically feasible and that it is also likely to be economically affordable. They suggest that the global costs of reducing GHG emissions to keep the temperature increase below 2°C are modest compared to the size of the world economy. The IPCC AR5 for example calculates a 0.06 (0.04 to 0.14) percentage point reduction in the annualized consumption growth rates over the period 2010–2100 for the scenarios achieving a stabilization of GHG concentrations between 430 and 480 ppm, which give a likely chance – defined as higher than two-thirds – of keeping the global temperature increase below 2°C. *(p 4)*

DW: In this report, technological feasibility and economic affordability are based on the gross underestimates of climate sensitivity previously noted. The interventions and costs of keeping below the 2°C ceiling (let alone the preferred 1°C level) are much more stringent and challenging when projections take into account the value of the full earth system sensitivity. The DDPP report fails to address this issue at any point. The recommended Pathways may be necessary steps in the right direction; they come nowhere near being sufficient strategies for achieving stated goals.

Chapter II. CO_2-energy Budget to Stay Within the 2°C Limit

14. There is a meaningful correlation between total cumulative emissions of GHGs (measured in tons of CO2 equivalent), their long-term concentrations and radiative forcing (measured in ppm of CO2 equivalent and watts per square meter, respectively), and the resulting global average temperature response (measured in increase of global average temperatures). The overall relation between cumulative GHG emissions and global temperature increase has been determined to be approximately linear. …. The IPCC AR5 review of climate model scenarios has found that in order to have a likely chance of staying within the 2°C limit, the peak concentration of atmospheric GHGs would need to be in the range between 430 and 480 ppm of CO2 equivalent by 2100.7 That in turn implies a limit on total cumulative GHG emissions over time. *(p 6)*

DW: This fundamental section is based on the Summary for Policymakers of the IPCC AR5 WG1, and in particular on *Figure 10* of the SPM. The budgetary approach depends on the "meaningful correlation" between total cumulative emissions of GHGs, the resulting atmospheric concentration, the consequent radiative forcing and the eventual equilibrium temperature response. Two factors which have a bearing on this correlation are noted in the main body of the WG1 report but elided from the SPM:

The first (comparatively minor) factor concerns the "linear approximation". The effectiveness of CO_2 as a GHG degrades with rising concentration (the forcing stays constant for each doubling of the atmospheric concentration). Treating this logarithmic decay as "approximately constant" is reasonable for small changes in CO_2 concentration. However, the range under consideration covers two doublings (from 280 ppm to 560 ppm, and from 560 ppm to 1120 ppm). At this scale the non-linearity is significant for policymaking. *[See "Basis for a Carbon Budget?"[(4)] pp.9-12]* The use of the linear approximation significantly overestimates the available carbon budget during the first doubling, and progressively underestimates the carbon budget during the second doubling.

The second (and absolutely crucial) factor concerns the effect of climate sensitivity on the temperature response. The IPCC AR5 WG1 "review of climate model scenarios" (namely the Climate Model Inter-comparison Project phase 5, or CMIP5) has a wide spread of uncertainty that is focussed around a value of c.3°C as the equilibrium temperature response to a doubling of the atmospheric concentration of CO_2. This is identical to the value of the "fast-feedback" or "Charney" sensitivity. When this inadequate (and grossly underestimating) figure is replaced by the value of the full Earth System Sensitivity (of at least 7.8°C in response to a doubling of CO_2 concentration), the correlation between total cumulative carbon emissions and resultant increase in temperature changes dramatically. *[See "Basis for a Carbon Budget?"[(4)] pp.12-17]* The level of atmospheric concentration of CO_{2e} at which the risk of exceeding the 2°C guideline becomes unacceptable is reduced from c.450ppm to c.330ppm. (Limiting the target to a rise of just 1°C lowers the concentration even further to c.310ppm). Since current CO_2 concentration already stands at 400ppm, it is immediately clear that the "available carbon budget" is not only reduced to zero, but that human civilization is already in "carbon overshoot" in an amount of around 1300 Gt CO_2. This carbon debt is currently increasing at a rate of c.40 $GtCO_2$ per year.

2.1. Total CO2 budget for the period 2011-2100

15. Defining a budget for CO2 only (the largest single source of total GHG emissions at 76%) for the 2011–2100 period requires making assumptions regarding several factors, including: the non-CO2 GHGs like methane, N2O, and F-gases, as well as contributions from climate-changing factors such as aerosols and land-use albedo; the timing of CO2 emission reductions (and therefore the time the carbon cycle has to absorb the CO2 emitted); and the sensitivity of the climate to CO2 and the other forcings. Taking into account these factors, the IPCC AR5 Working Group 3 (WG3) found that the level of cumulative CO2 emissions for the period 2011–2100 should be within the range of 630 to 1180 Gt (billion tons) of CO2, in order to achieve CO2 concentrations consistent with a likely chance of keeping within the 2°C limit. (p 6)

16. Based on the best estimates regarding non-CO2 forcings and excluding the availability of large-scale net negative emissions, the IPCC AR5 WG3 defines a CO2 budget for the 2011–2050 period of 825 Gt and of 950 Gt for the period 2011–2100. This implies 125 Gt of CO2 cumulative net emissions for the period 2051-2100. *(p 7)*

> **DW:** The complex set of assumptions and calculations in this section become profoundly irrelevant in the light of the sensitivity-driven collapse of the "available carbon budget". IPCC AR5 WG3 depended on the WG1 for its assessment of available carbon budget, and is therefore subject to the same stringent critique. The proposed emissions allowance of a further 950 $GtCO_2$ by the end of the century (equivalent to c.250 GtC) would drive the atmospheric concentration to around 450ppm. Far from giving a reasonable chance of keeping the global rise in average temperature below the currently agreed ceiling of 2°C, it would condemn the planet to an increase of c.5.4°C.
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> However deep the decarbonization pathway is driven (and it would have to achieve zero contribution to forcing from all sources), **the task of stabilizing GHG concentrations at a level that prevents dangerous anthropogenic interference with the climate can no longer be achieved by a strategy that is restricted to emissions reduction on its own. It now has to include a second strategic platform, namely the draw-down of carbon from the stock already emitted to the atmosphere, together with the draw-down of all further additions to that stock that are made during the period of transition.**
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> **That is the critical agenda that now faces world leaders, and indeed the global community as a whole, as we journey together into an uncertain future.**

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(1) http://www.apollo-gaia.org/sensitivitycarbonbudget.html
(2) http://www.apollo-gaia.org/
(3) http://www.apollo-gaia.org/ClubofRome.html
(4) http://www.apollo-gaia.org/AR5SPM.html
(5) http://documents.worldbank.org/curated/en/2013/06/17862361/turn-down-heat-climate-extremes-regional-impacts-case-resilience-full-report

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