IEAGHG Information Paper 2016-IP41: 1.5 Degrees – Meeting the Challenges of the Paris Agreement

The climate agreement reached at COP21 in Paris last year commits us to limit global warming to well below 2°C. In this regard, the UNFCCC asked the IPCC to provide a "special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways" (in short: SR1.5) until the end of 2018. The IPCC accepted the invitation and decided to provide a special report on this topic in the context of strengthening the global response to the threat of climate change, sustainable development and efforts to eradicate poverty. Other special report will focus on oceans and land use.

As a project from Concordia University shows[1], we might reach 1.5°C as early as 2032. A similar exercise from University of Oxford, which displays the global warming index in real-time and historically, confirms we have already reached 1°C this summer (see Figure 1). The urgency following from these numbers is reflected in the timeline of the forthcoming SR1.5, which is tight throughout. The call for author nominations will open 31 October this year and close on 27 November[2]. Thus, any new research that the authors should consider during their assessment has to be submitted to and accepted by peer reviewed scientific journals very soon.

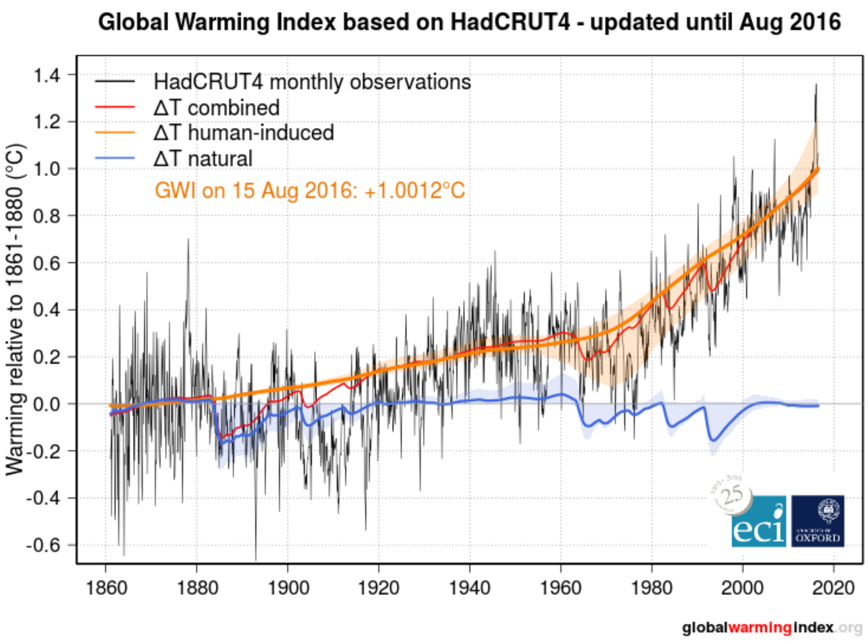


Figure 1 Observed global warming index from 1860 to 2016[3], broken down in natural and human-induced contributions.

As 1.5°C represents a significantly greater mitigation challenge than 2°C, the University of Oxford organised a conference to understand how the 1.5°C goal is to be interpreted, to explore the options

[1] http://www.countdown2degrees.com/ is provided by Human Impact Lab and Concordia University
[2] More information about the timeline and scope of SR1.5 is available here: http://www.ipcc.ch/report/sr15/
[3] http://globalwarmingindex.org/ is provided by the Oxford University Environmental Change Institute (with data from IPCC 2013)

for how a 1.5°C target could be achieved and thus to contribute to the evidence base for SR1.5. As the interest in this conference was very high and spaces limited, attendance was by application only.

I attended on behalf of IEAGHG and also took the opportunity to present a poster summarising our recent studies on Bio-CCS and unburnable carbon, two highly relevant topics for the deep decarbonisation required for such an ambitious target as the 1.5°C.

The conference started with a public lecture the evening before in Oxford Town Hall. Speakers were Janos Pasztor (Senior Advisor to the UN Secretary-General on Climate Change, United Nations), Laurence Tubiana (French Ambassador for the Climate Change Negotiations) and Nebojsa Nakicenovic (Deputy Director General, International Institute for Applied Systems Analysis (IIASA)), who all shared their views on how and why the 1.5 °C target came about. Pilita Clarke (Environmental Correspondent, Financial Times) moderated the session and the subsequent panel discussion. The talks provided an excellent preface for the conference and my take away messages were the following:

- There is a need to link the temperature target to balancing of source and sinks.
- Why did Paris work? → It created space for each constituency, intense bilateral and diplomatic discussions with key countries took place, and governments were in solution-seeking mode.
- Achieving 1.5°C will need major transformation in every sector that on top have to be aligned with sustainable development goals.
- As the technologies to achieve such a deep atmospheric GHG reduction are not up and running at the necessary scale yet, lifestyle changes will be inevitable. The demand-side can provide the push for mitigation options.
- The coal industry will likely face a harder time than oil & gas.
- Still an open question that needs to be addressed: How to ensure justice related to climate change?

The next two days of the conference dived deeper into mitigation options, sensitivity of natural systems, human impacts, implications for adaption, financing and societal issues.

The starting question was: how do we measure that we have reached 1.5°C? Currently, the favoured way of measuring the human influence on global warming is via determining the growth rate of radiative forcing. The RCP4.5 scenario roughly corresponds to a 2°C warming and RCP2.6 is about equivalent to 1.5°C. However, only a few scenarios of RCP2.6 used in integrated assessment models (IAMs) can lead to 1.5°C, thus there is a need for new scenarios. Those scenarios might have to be more stringent, as even under RCP2.6, up to 50% of all glaciers could be at risk. Another option might be to reassess and improve the IAMs rather than producing a wealth of new scenarios. In addition, it is not only about the magnitude of change we will face but also about or even more about the rate of change, and this will be especially true for impacts on biodiversity. For example, in the Palaeocene-Eocene Thermal Maximum (PETM), the warming took place over 10,000s of years, whereas we are now causing a similar process in 100s of years. Many communities are already experiencing impacts of climate change, so it is not something that will start suddenly when global warming reaches exactly 1.5°C or 2°C. Even if we now get on a path to 1.5°C, there is still the risk that we will miss the target it to some degree (maybe by 1°C or more). On top, a reality check shows current intended nationally determined contributions (INDCs) under the Paris agreement put us on a track to 2.7°C. Thus, both level and speed of commitment have to increase to change course to 1.5°C. The question, what effect the decrease in temperature after an overshoot will have, is still open. It could be easier to adapt to in increasing temperature and then stay on that level, rather than having to adapt to decreasing temperature, or the other way round. We also need to consider we might cross some tipping points irreversibly, especially when allowing for an overshoot.

A second fact check reveals we have achieved no decarbonisation of the electricity sector at all because the growth in energy demand completely outweighed the increase in renewables. Thus, technologies that allow further decarbonisation of heat and power are necessary. As carbon capture and storage (CCS) technologies prevent or reduce the emission of CO_2 to the atmosphere, they can enable the continued use of fossil fuels in carbon constrained scenarios (this is often referred to as the “unburnable carbon” concept). For example, CCS could enable emissions of 6°C in a 4°C world. Several demonstration projects around the world (e.g. Sleipner, Snøhvit, Boundary Dam) have shown CCS works and is safe. The technology is more or less ready since the 1990s but market inertia and political inaction prevented a timely roll out.

For 1.5°C, zero-carbon systems will not be sufficient. Therefore, negative emission technologies (NETs) like bioenergy with CCS (Bio-CCS or BECCS) are very likely required, whether we like it or not. So it would be better to get on with them and test them on large-scale and under real world conditions. Bio-CCS is currently proven at industrial scale (e.g. Illinois-Basin-Decatur-Project). At best, Bio-CCS could drive sustainability of biomass through incentives and certification systems. As with standard CCS, the business model is the challenge, not the technology.

One issue closely related to Bio-CCS is land availability and land use change impacts. In general, it is important to note that land use will be affected by mitigation but also by climate change, i.e. no mitigation. Therefore, benefits of 1.5°C scenarios need to be contrasted with negative impacts. Besides, agriculture, forestry and land use (AFOLU) emissions account for around 24% of total GHG emissions, with livestock dominating agricultural emissions. Sustainable intensification will not suffice to mitigate these, we need to shift to products with lower GHG footprints, as the potential for reductions is highest on the demand side (e.g. through dietary changes, waste reduction). Most models show only a small average impact of 1.5°C and 2°C on crop and livestock productivity but there are still lots of uncertainties and little understanding of vulnerability, resilience and adaptation in the models. In addition, lots of uncertainty exists in food price predictions, whether with or without climate change. Some studies that considered climate change only reported a minor impact (max. 20% increase in worst-case scenario). Regarding food systems, consumption patterns clearly drive production and its impacts. Under 2°C, if all other sectors would reduce their GHG emissions to zero, food would still account for 100% of the carbon budget. This means, under 1.5°C and the same assumption of full decarbonisation in all other sectors, emissions from food sector will blow the carbon budget.

Undoubtedly, human behaviour will become more and more important in highly carbon-constrained scenarios. There are around 40 small island countries and a further 100 vulnerable countries, which are the clients of the SR1.5. Researchers from these countries often do not have access to R&D funding and would also benefit from a deeper integration into the global climate change research community. From a social science perspective, a moral discourse on mitigation options is necessary, including clarification of loss, damages and compensation issues and equity. The challenge here is that the best technology in terms of emissions reductions and cost might not necessarily be the best in terms of social impacts. In addition, solutions/pathways should acknowledge the moral obligation towards both current and future generations.

In terms of financial issues, assessments have shown that 3°C or higher scenarios have solely negative impacts on financial markets, whereas 2°C or lower has positive as well as negative impacts. When addressing impacts on financial markets and possible solutions, however, one needs to take into account that they do not work to the same standards of accuracy as science and academia. There will also be the task to distinguish the leaders from the “green washers”, as available funding for mitigation and adaptation might attract vested interests. Recommendations regarding particular solutions/technologies need to take into account the related lock-in of infrastructure these might cause, which can be up to 50 years.

One of the undesirable effects of a 1.5°C scenario might be that it is not very actionable, partly because the potentially allowed overshoot could be an entry point for constant “renegotiations”. Furthermore, there is uncertainty regarding the carbon budget of 1.5°C, and this need to be quantified and clarified as soon as possible. Although containing some uncertainty, one thing is clear: the remaining carbon budgets for 1.5°C and 2°C are very tight. First pass calculations for 1.5°C, some of them are extra-/interpolations from existing scenarios such as from IPCC’s AR5, indicate a range of about 400-1100 $GtCO_2$ until 2100. At the current rate of emissions of 40 $GtCO_2$/year, it is very likely we will exceed the budget before 2040. Bottlenecks in this regard are residual emissions that cannot be eliminated, e.g. from the steel industry.

Although carbon budgets are tight and the related challenges great, there is no evidence or certainty yet that we cannot reach 1.5°C. It will be crucial to transfer learnings from other transformational challenges in human history.

During the last panel discussions, the highest priorities for SR1.5 in terms of required R&D were pointed out:

- Integration of SDGs with adaptation and mitigation
- Consumer empowerment to drive demand side changes
- Data on real world solutions’ impact on trajectories
- Focus on human impacts
- Readability of the final report
- Better understanding of trade-offs and negative effects of 1.5°C
- Independent review and consensus of literature on geo-engineering
- Scenarios based on demand side reductions and energy efficiency

IEAGHG’s poster is attached to this IP. We will also monitor the IPCC’s SR1.5 activities very closely and will get involved, where appropriate. Personally, I would like to encourage everyone in the scientific community to submit their relevant research or to get involved otherwise in this important exercise.

A wealth of material related to the 1.5 Degrees conference is available on the website.[4]

Jasmin Kemper

10/10/2016

[4] http://www.1point5degrees.org.uk/

The role of carbon capture and storage technologies in a carbon-constrained world

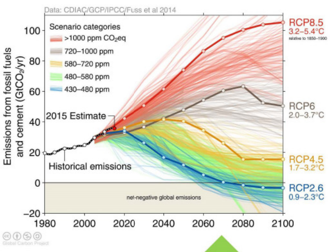
1.5 degrees
Meeting the challenges of the Paris Agreement

Jasmin Kemper[1], Tim Dixon[1], John Gale[1]

[1]IEA Greenhouse Gas R&D Programme, Pure Offices, Cheltenham Office Park, Hatherley Lane, Cheltenham, GL51 6SH, UK

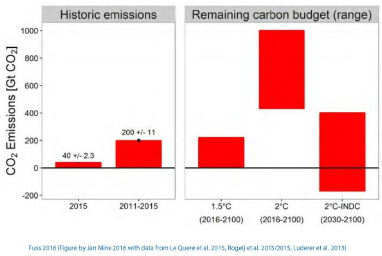
ieaghg — Evaluating technology options to mitigate greenhouse gas emissions

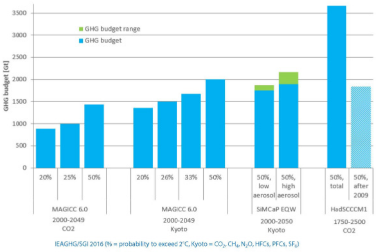
1.5°C and 2°C scenarios



➢ Net negative emissions are crucial for achieving a 1.5°C target

Carbon budget

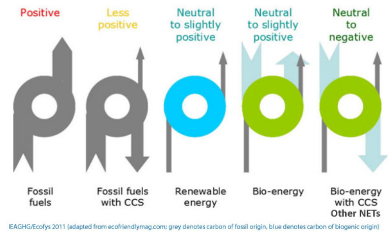




- Carbon budgets usually include fossil sources as well as land use change (LUC)
- Non-CO_2 greenhouse gases (GHGs) can contribute up to 33%
- Carbon budget 1750-2500 is ~3670 $GtCO_2$ → already used up half of this until 2009 → only 1800 $GtCO_2$ left (to have a 50% chance of meeting 2°C) (Allen et al. 2009)
- Estimation of carbon budgets contains uncertainties
- But: current emissions rate 40 $GtCO_2$/yr → quick erosion of carbon budget

Carbon balance of energy systems

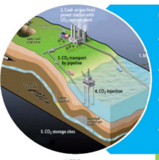
Net carbon balance



IEAGHG/Ecofys 2011 (adapted from ecofriendlymag.com; grey denotes carbon of fossil origin, blue denotes carbon of biogenic origin)

- Past/current energy systems based on the far left (fossil fuels)
- Now efforts underway transitioning to the mid three technologies (Fossil-CCS, RE, bioenergy)
- Should we stop at Fossil-CCS/RE/bioenergy?
- ➢ Need help from the far right (NETs) to make up for "damage done" in the past

What are CCS, NETs and Bio-CCS/BECCS?



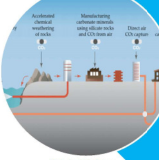
NERC

CCS (carbon capture and storage)

- Process of capturing, transporting and permanently storing CO_2 emission from anthropogenic large-point sources
- Capture
  - Pre-combustion, post-combustion, oxyfuel-combustion
- Transport
  - Pipeline, ship
- Storage
  - Enhanced oil recovery (EOR), depleted oil/gas fields, deep saline aquifers

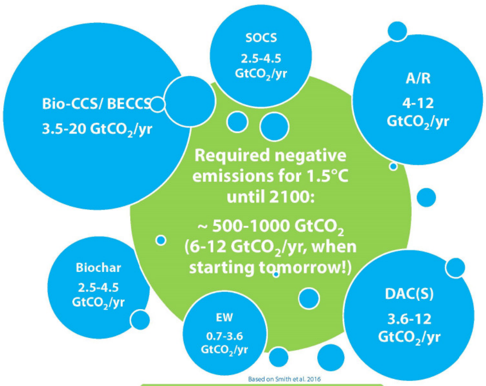
- ➢ All parts of CCS chain technically feasible, issues remain with costs and public perception
- ➢ 15 large-scale projects with 29 $MtCO_2$/yr in operation, 7 with additional 11 $MtCO_2$/yr under construction (GCCSI 2016)

NETs (negative emission technologies)



Virgin Earth Challenge

- Bio-CCS/BECCS (bioenergy with CCS) – using biomass that has previously taken up CO_2 during growth to produce power/heat/fuels, then capturing and storing the emitted CO_2
- A/R (afforestation/reforestation) – planting trees where previously (a) there were none or (b) they have been cut down
- DAC(S) (direct air CCS) – capturing CO_2 directly from air
- EW/MC (enhanced weathering/mineral carbonation) – spreading pulverised rock on land/water to take up CO_2 and form bicarbonate
- SOCS (soil organic carbon sequestration) – storing CO_2 in soil through advanced farming methods, restoration and land creation
- Biochar – adding burnt/torrefied biomass to soil for long term storage
- Ocean fertilisation – adding Fe or N to accelerate CO_2 uptake by microorganisms for photosynthesis
- Cloud/ocean treatment – (a) using alkalis to wash CO_2 out of the atmosphere, (b) using lime to absorb CO_2 from the oceans

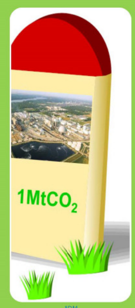


Based on Smith et al. 2016

Most important NET trade-offs

Impact on soil	Energy demand
Impact on albedo	Water demand
Costs	Land demand

Case study: Bio-CCS/BECCS



ADM

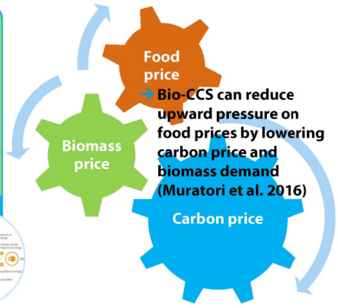
Bio-CCS/BECCS status

- Many studies conclude: Bio-CCS, incl. its CCS components, technically feasible as of today (TRL 3-7) (except microalgal biomass)
- Perceived „double benefit": heat/power + negative emissions → would be less so for fuels due to release of CO_2 during combustion
- 5 operating Bio-CCS projects: 0.1-1 $MtCO_2$/yr (all ethanol based, 3 for EOR, 4 in US, 1 rather Bio-CCU), several more underway
- GHG accounting: only 2006 IPCC GLs, CDM/JI, Ca LCFS and EU RED/FQD cover Bio-CCS
- Plenty of research on public perception of CCS but very limited and contradictory on Bio-CCS
- Bio-CCS generally has lower profile than Fossil-CCS
- Main drivers/barriers for Bio-CCS:
  - CO_2/NG price, infrastructure/clusters, sustainable feedstocks, public perception

- Competition: food vs bioenergy crops
- Shift of GHG/CO_2 emissions from one sector to another ("carbon leakage")
- Impact of large-scale biomass infrastructure, trade, and supply chains
- Impact of climate change on crop yields
- Water footprint of Bio-CCS systems
- Effects of increased fertiliser use
- Land availability and lock-in
- Land use change (LUC) impacts
- Biomass sustainability

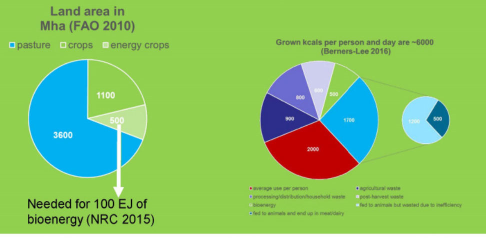
Main nexus concerns

Image: World Business Council on Sustainable Development 2014

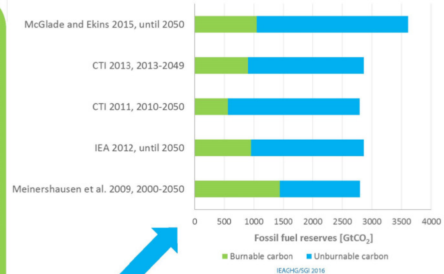


How to overcome the "lack" of land?

- ➢ Demand-side changes
- ➢ Yield increases
- ➢ Better land management



"Unburnable carbon" concept

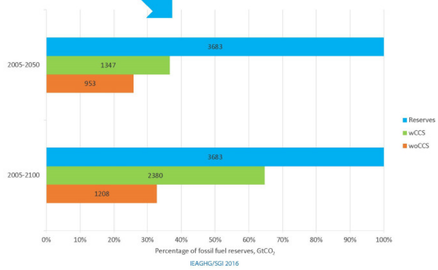


"Unburnable carbon":

- Carbon budget for emission scenarios implies → certain amount of fossil fuel reserves "unburnable", i.e. their carbon not emittable, to stay within target
- CCS prevents/reduces emission of carbon to the atmosphere
- NETs can even remove historic emissions from the atmosphere
- ➢ Both are key to enable continued use of fossil fuels

Key messages from IEAGHG/SGI study:

- Investigated effect of CCS on unburnable carbon
- Impact of CCS is material until 2050 and further increases until 2100
- 11% resp. 32% more fossil fuels can be used with CCS in a 2°C scenario
- For scenarios < 2°C higher capture rates, i.e. >> 90%, might be necessary



Conclusions

- Due to quick erosion of remaining carbon budget for a 1.5°C scenario → timely action required!
- CCS technology components are mature and CCS can enable continued access to fossil fuels under carbon-constrained scenarios
- NETs, like Bio-CCS/BECCS, could make up for historic emissions and previous inaction
- Mitigation portfolio containing various options is best bet, as each has pros and cons
- Whole systems approaches required to address the food-water-energy-climate nexus

Further work requirements

- Evaluate/quantify the role of CCS and NETs on "unburnable carbon" under a 1.5°C scenario
- Quantification of Bio-CCS/BECCS nexus → water/land/carbon/energy intensities
- Identify the sweet spots for CCS and NET implementation
- For Bio-CCS/BECCS: develop/optimise supply chains for sustainable biomass
- Develop financial mechanisms and policy frameworks to support CCS and NETs

Acknowledgements

We would like to thank the following for undertaking studies under IEAGHG:

- Sustainable Gas Institute/Imperial College London (Sara Budinis, Adam Hawkes, Samuel Krevor, Niall Mac Dowell)
- Carbon Counts (Greg Cook, Justin French-Brooks, Paul Zakkour)
- Ecofys (Chris Hendriks, Monique Hoogwijk, Klaas Koops, Joris Koornneef, Michéle Koper, Luchien Luning, Paul Noothout, Pieter van Breevoort)

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Contact:
jasmin.kemper@ieaghg.org