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Modelling 1.5°C-Compliant Mitigation Scenarios Without Carbon Dioxide Removal

By Ceecee Holz

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Edited by the Heinrich Böll Foundation

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INTRODUCTION

In the Paris Agreement, the countries of the world agreed to «pursue efforts to limit temperature increase to 1.5° C above pre-industrial levels».[1] Climate scientists typically interpret this phrase to mean to limit global warming to 1.5° C or less in 2100. They can then develop greenhouse gas (GHG) emissions pathways that can lead to this outcome.[2] The majority of the 1.5° C-compatible emissions pathways in the climate modelling literature[3] rely on removing large amounts of carbon dioxide (CO_2) from the atmosphere. This Carbon Dioxide Removal (or CDR) by large-scale technological means is typically focussed in the second half of the century and is typically modelled as Bioenergy combined with Carbon Capture and Storage (BECCS). BECCS means that CO_2 is removed from the atmosphere through photosynthesis of bioenergy crops, which are then used in bioenergy power plants or converted to liquid fuels, hydrogen or methane for the transport sector, while the associated emissions are partially captured and stored underground. The 1.5° C scenarios analyzed in Rogelj et al. (2015) envision cumulative removals between 450 and 1,000 $GtCO_2$ over the course of the century, with annual removals as high as 20 $GtCO_2$.[4] Contrasting this figure with the current level of annual global emissions from fossil fuels, industry and land use change of about 31 $GtCO_2$ illustrates the scale.[5]

More recently, scholars, policy-makers and civil society have increasingly questioned the feasibility of implementing CDR, especially BECCS, at this large scale, pointing to large land requirements for bioenergy crops, and the associated risks for food and water security or biodiversity, as well as technological feasibility, social

1 UNFCCC. (2015). *Decision 1/CP.21 – Adoption of the Paris Agreement*. Paris: UNFCCC. https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

2 IPCC. (2014). *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (Edenhofer, O., et al., Eds.). Cambridge: Cambridge University Press. http://mitigation2014.org/report/final-draft; See also: Rogelj, J., et al. (2015). Energy System Transformations for Limiting End-Of-Century Warming to Below 1.5° C. *Nature Climate Change*, 5 (6), 519–527. https://doi.org/10.1038/nclimate2572

3 E.g.: IPCC, 2014, op. cit.; Rogelj, J., et al., 2015, op. cit.; Rogelj, J., et al. (2018). Scenarios Towards Limiting Global Mean Temperature Increase Below 1.5° C. *Nature Climate Change*, 8 (4), 325–332. https://doi.org/10.1038/s41558-018-0091-3

4 Rogelj, J., et al., 2015, op. cit.

5 Le Quéré, C., et al. (2018). Global Carbon Budget 2017. National Emissions v1.2. *The Global Carbon Project*. https://doi.org/10.18160/GCP-2017

and political acceptance issues, and storage permanence.[6] In addition to BECCS, other CDR technologies have been proposed, such as biochar, soil carbon management, direct air capture (DAC), or enhanced weathering (EW). Other models include afforestation, where plantations of fast-growing trees are established on land that does not naturally support forest, in order to absorb and store CO_2 in these trees and soil.

Given the risks and uncertainties surrounding CDR, scholars have suggested to follow a precautionary approach, wherein «the mitigation agenda should proceed on the premise that [CDR] will not work at scale.»[7] This is because embarking today on an emissions pathway that assumes successful large-scale deployment of CO_2 removal in the future leads to a breach of the carbon budget if this deployment fails to materialize: Reliance on CDR allows modelled scenarios to follow less stringent emissions pathways in the near term since later removal essentially increases the available net CO_2 emissions budget. In a recent study,[8] we show that restricting CDR to zero requires 2030 benchmark emissions of CO_2 to be at least one third lower than in a scenario with a full complement of CDR options (22.2 vs 32.2 $GtCO_2$). This indicates the importance of increasing mitigation ambition in the very near term if a precautionary approach to CDR is to be followed.

In the following sections, I will first consider in more detail the drawbacks of the different CDR proposals, then discuss recent studies that explore how a 1.5° C-compliant mitigation approach could be structured to follow a somewhat precautionary approach to scenario creation in which BECCS and other technological CDR is not deployed (but other forest-based natural sequestration is occurring). This discussion will outline the conditions under which it is still possible, at least theoretically, to achieve the 1.5° C temperature limitation objective without relying on speculative

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6 Anderson, K., & Peters, G. (2016). The Trouble with Negative Emissions. *Science, 354* (6309), 182. https://doi.org/10.1126/science.aah4567; Fuss, S., et al. (2014). Betting on Negative Emissions. *Nature Climate Change*, 4, 850. https://doi.org/10.1038/nclimate2392; Fuss, S., et al. (2016). Research Priorities for Negative Emissions. *Environmental Research Letters*, 11 (11), 115007. https://doi.org/10.1088/1748-9326/11/11/115007; Heck, V., et al. (2018). Biomass-Based Negative Emissions Difficult to Reconcile with Planetary Boundaries. *Nature Climate Change*, 8 (2), 151. https://doi.org/10.1038/s41558-017-0064-y; Kreidenweis, U., et al. (2016). Afforestation to Mitigate Climate Change: Impacts on Food Prices Under Consideration of Albedo Effects. *Environmental Research Letters*, 11 (8), 085001. https://doi.org/10.1088/1748-9326/11/8/085001; Mander, S., et al. (2017). The Role of Bio-Energy with Carbon Capture and Storage in Meeting the Climate Mitigation Challenge: A Whole System Perspective. *Energy Procedia*, 114, 6036–6043. https://doi.org/10.1016/j.egypro.2017.03.1739; Schulze, E.-D., et al. (2012). Large-Scale Bioenergy from Additional Harvest of Forest Biomass Is Neither Sustainable nor Greenhouse Gas Neutral. *GCB Bioenergy*, 4 (6), 611–616. https://doi.org/10.1111/j.1757-1707.2012.01169.x; Smith, L. J., & Torn, M. S. (2013). Ecological Limits to Terrestrial Biological Carbon Dioxide Removal. *Climatic Change*, 118 (1), 89–103. https://doi.org/10.1007/s10584-012-0682-3; Smith, P., et al. (2015). Biophysical and Economic Limits to Negative CO_2 Emissions. *Nature Climate Change*, 6 (1), 42–50. https://doi.org/10.1038/nclimate2870

7 Anderson & Peters, 2016, op. cit., p. 183

8 Holz, C., Siegel, L., et al (2018). Ratcheting Ambition to Limit Warming to 1.5° C – Trade-Offs between Emission Reductions and Carbon Dioxide Removal. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/aac0c1 and potentially deleterious technology, while also aiming to safeguard the aspirations of people everywhere, including in the Global South, to a decent standard of living. Importantly, the discussion will also touch on potential additional emissions reductions options that have not been addressed in the studies.

Carbon Dioxide Removal and Natural Sequestration

BECCS' large demand for land has been pegged at about 30–160 million hectares (Mha) per $GtCO_2$, depending on the type of bioenergy feedstock used.[9] This means that land in the order of 600–3,200 Mha would be required to achieve the 20 $GtCO_2$ magnitude at the upper end of the range of annual sequestration found in the models. In contrast, current global cropland is approximately 1,500 Mha,[10] suggesting that massive-scale BECCS deployment would be in strong land-use competition with land currently used for food production, thus undermining efforts to increase food security and end hunger, or with land that is currently forest or other natural land, thus undermining protection of biodiversity and efforts to stop deforestation, itself a major contributor to climate change. Further concerns relate to the amount of water, fertilizer and energy that would be required to implement BECCS at large scales: Researchers at the Potsdam Institute for Climate Impact Research have recently investigated whether large-scale BECSS deployment can be accomplished while taking a precautionary approach to important «planetary boundaries» (freshwater use, forest loss, biodiversity, and biogeochemical flows, e.g. fertilizer) and found that only about 0.2 $GtCO_2$ per year can be achieved this way, several orders of magnitude below what is typically assumed in models.[11] Exceeding this amount would push at least one of these planetary boundaries (further) into the uncertainty or high-risk range.

Other proposed CDR technologies share similar concerns. For example, DAC requires large amounts of energy to enable the chemical reactions that remove the CO_2 from the atmosphere plus energy to liquify, transport and store the CO_2 once captured. EW is an approach where rock, for example olivine, is mined, ground and then spread out over large areas to facilitate its weathering which binds CO_2. These steps require large amount of energy, similar in scale to the energy requirement of DAC. The energy required for these approaches is estimated to be as much as 12.5 GJ per ton of CO_2.[12] Considering that generating 12.5 GJ of electricity with coal would emit about 3.5 tons of CO_2 (or 2.9 or 1.6 tons of CO_2 with oil and natural gas,

9 Smith et al., 2015, op. cit.

10 Dooley, K., Christoff, P., & Nicholas, K. A. (2018). Co-Producing Climate Policy and Negative Emissions: Trade-Offs for Sustainable Land-Use. *Global Sustainability*, 1 (e3), 1–10. https://doi.org/10.1017/sus.2018.6

11 Heck et al., 2018, op. cit.

12 Smith et al., 2015, op. cit.

respectively)[13] highlights that these approaches are not a plausible alternative to fossil fuel phase-out. Furthermore, these CDR technologies are very costly with estimates for DAC and EW exceeding US $ 500 per ton of net negative CO_2.[14]

Models also often include sequestration of CO_2 from forests. It is important to distinguish this sequestration from the CDR approaches outlined above, even though models, or literature discussing model results, often do not make this distinction. Broadly speaking, forest-based sequestration can occur through afforestation or through natural sequestration by forests. Because it involves establishment of tree plantations on land that would not otherwise carry forest, afforestation shares many of the issues of the CO_2 removal approaches discussed above: to sequester large amounts to CO_2, it requires large amounts of land (thus competing with food and other land uses), nutrients, and water.

In contrast, where deforestation and forest degradation are halted, forest can be restored or re-established. In that context, natural sequestration of CO_2 by these forest would occur, potentially in the magnitude of several hundred $GtCO_2$ over the course of the 21st century.[15] However, since the carbon thus stored in the biosphere is at risk of being re-emitted to the atmosphere, for example, if pests, forest fires, or human activity were to destroy these forests, it remains risky and thus a violation of the precautionary principle to rely on these processes to occur when articulating near-term mitigation ambition. This is especially true where scenarios delay the rapid phase-out of fossil fuel use, given that existing fossil fuel deposits represent a stable way of storing carbon unlike potentially volatile storage in the biosphere.

Reliance on large-scale CDR allows modelled scenarios to follow less stringent emissions pathways in the near term since later removal essentially increases the available net CO_2 emissions budget – in such pathways, less ambitious near-term climate action bets on removing CO_2 from the atmosphere in the future. In a recent study,[16] we show that restricting CDR to zero requires 2030 benchmark emissions of CO_2 to be at least one third lower than in a scenario with a full complement of CDR options (22.2 vs 32.2 $GtCO_2$). This shows how important it is to increase mitigation ambition in the very near term to allow for a prudent precautionary approach in relation to CDR deployment. In the following sections, I will discuss recent studies that explore how a 1.5° C-compliant mitigation approach could be structured to follow such a precautionary approach where carbon sequestration levels can be met with limited forestry-based approaches alone.

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13 Using median values of the survey of life cycle analyses of emissions of different fuel types conducted by the IPCC: 1001 gCO_2/kWh for coal, 840 gCO_2/kWh for oil, and 469 gCO_2/kWh for natural gas (IPCC, 2011).

14 Smith et al., 2015, op. cit.

15 Dooley, K., & Kartha, S. (2018). Land-Based Negative Emissions: Risks for Climate Mitigation, and Impacts on Sustainable Development. *International Environmental Agreements: Politics, Law and Economics*, 18 (Special Issue: Achieving 1.5° C and Climate Justice), 79–98. https://doi.org/10.1007/s10784-017-9382-9

16 Holz, Siegel, et al., 2018, op. cit.

Near-term Ratcheting Success

In the aforementioned study,[17] we investigated different assumptions about CDR availability and by how much, under each of these assumptions, near-term mitigation ambition would have to increase to keep the 1.5°C objective within reach. Notably, even when assuming that a very large amount of CDR, through a variety of approaches, might eventually be forthcoming (net CDR in our «allCDR» scenario totals 883 $GtCO_2$ between 2016 and 2100), the level of ambition expressed in countries' current climate action pledges, or Nationally Determined Contributions (NDCs), is not consistent with the 1.5°C objective. At a minimum, developed countries need to increase their ambition by moving their current NDCs' target date up from 2030 to 2025, even if major CDR is assumed.

Disallowing BECCS and technological CDR approaches and only allowing limited, forestry-only sequestration, necessitates all countries (not just the developed ones) to shift from a trajectory consistent with their NDC to a more ambitious one by 2025 and very stringent reductions afterwards: 5.5% annual reduction for developed and 4.5% for developing countries. In another scenario, where CDR is disallowed completely, this has to increase to 9% and 8.5%, respectively. Note that while the former reduction rates have historical precedents, typically associated with economic crises and turmoil, annual reduction rates of 8.5–9% are historically unprecedented, indicating that a focussed, globally-coordinated effort would have to be undertaken to achieve this trajectory and that mitigation options that have hitherto been neglected would have to receive more attention.

The majority of 1.5°C scenarios in the literature are so-called overshoot scenarios: they result in warming of more than 1.5°C during some years of the 21st century, to return to the 1.5°C level by 2100 the latest. Temperature overshoot carries substantial potential risks and uncertainties, for example, with regard to the irreversible crossing of tipping points, or the permanence of warming impacts: «Impacts that could be wholly or partially irreversible include species extinction, coral reef death, [permafrost melt], and loss of sea or land ice, some of which themselves lead to positive feedbacks or tipping points that current carbon cycle models do not currently take into account.»[18] Due to their assumed ability to remove CO_2 from the atmosphere, and thus bring temperatures back down, scenarios using large amounts of CDR often display longer overshoot periods with higher peak warming than scenarios with less (or no) CDR. In our study, even the «noCDR» scenario led to an overshoot, due to the rapid reduction in air pollution and the associated reduction

17 Holz, Siegel, et al., 2018, op. cit.

18 Dooley & Kartha, 2018, op. cit., p. 82

in cooling.[19] Generating a «noCDR» scenario without overshoot required increasing the stringency of reductions to 12 % and 11 % annual reductions, respectively, and starting with this very ambitious trajectory as early as 2023. If allowing forestry-based sequestration of CO_2, the 8.5–9 % reduction rates mentioned earlier were sufficient (if commencing in 2023) to avoid an overshoot.

19 Air pollutants such as the aerosols sulphur dioxide or nitrogen oxides are often associated with the use of fossil fuels (e.g. co-emitted with CO_2 from coal-fired power plants, vehicle exhausts etc.). Aerosols have a cooling effect, thus offsetting some of the warming caused by the greenhouse gases. When greenhouse gases are mitigated aggressively, aerosol co-emission is also drastically reduced, leading to correspondingly less aerosol cooling (and thus, more warming).

Low Energy Demand and Decent Living

The modelling team Grübler et al.[20] built a global scenario of Low Energy Demand (LED) which explicitly takes the attainment of a decent living standard by all as a modelling criteria. For example, metrics such as floor space with thermal comfort, food demand, mobility, and access to consumer goods converge between Global North and Global South and exceed the decent living standard (DLS) recently put forward as material prerequisites for human wellbeing beyond merely addressing extreme poverty.[21] For example, in the LED scenario, «thermal comfort» converges to 30 m^2 per capita of adequately heated or cooled space, while the DLS suggests 10 m^2 per capita. Grübler et al. also assess the LED scenario in comparison to other 1.5° C scenarios[22] with regard to its benefits in terms of progress toward several of the SDGs, and find significant co-benefits.

The modelling approach follows major trends in energy demand development already observable today (e.g. regarding urbanization, device convergence, the sharing economy etc). As a result of these trends and other substantial increases in energy efficiency across all sectors, the scenario projects very low energy demand in the future, substantially lower than current and reference levels (2050 global energy demand is 41 % lower than in the 2020 reference case), despite population growth and increase in «activity» of end use services, e.g. thermally comfortable floor space, the amount of food consumed per person, or the number of person-kilometers travelled. The energy efficiency increases are achieved by moving beyond a narrow focus on technological efficiency improvements to take into account broader shifts and changes that improve the efficiency of the entire system of energy service delivery. This includes shifts in service provision through granular, decentralised energy systems, shifts to new business models (e.g. to use-based rather than ownership-based business models, or the sharing economy), as well as shifts towards digitalisation (e.g. smart appliances, homes and grids) and economies of scope (e.g. through device convergence, where single devices such as smart phones fulfill the functions of numerous previous-generation devices).[23]

20 Grübler, A., et al. (2018). A Low Energy Demand Scenario for Meeting the 1.5° C Target and Sustainable Development Goals Without Negative Emission Technologies. *Nature Energy*, 3, 515–527. https://doi.org/10.1038/s41560-018-0172-6

21 Rao, N. D., & Min, J. (2017). Decent Living Standards: Material Prerequisites for Human Wellbeing. *Social Indicators Research*, 1–20. https://doi.org/10.1007/s11205-017-1650-0

22 Rogelj et al., 2018, op. cit.

23 Grübler et al., 2018, op. cit.

Having generated this very low energy demand scenario, the authors model the upstream structural changes arguing that «changes in energy end-use [...] drive supply-side transformation, as has been the case historically,»[24] with the overall shrinking of the global energy system due to lower demand providing the necessary «breathing room» for this supply-side decarbonization. Specifically, fossil fuels and traditional biomass phase down as primary energy sources quickly, BECCS or fossil CCS are not deployed since the low energy demand can comfortably be met without these sources. Notably, the low energy demand also reduces the demand for land for bioenergy crops relative to similar scenarios, which combined with a reduction in pasture land leads to an increase in global forest cover, which in turn results in the natural sequestration of a cumulative 168 Gt CO_2 from the atmosphere through forests during the 21st century.

Certain life-style changes have not been modelled, for example reduction in overall meat consumption, which is assumed to converge globally at levels roughly equivalent to current figures in the Global North, or reduction in aviation, where activity is assumed to roughly double between 2020 and 2050. These examples point toward additional mitigation potential in the scenario that could be unlocked by addressing these drivers.

Overall, the scenario leads to a very ambitious global emissions pathway that achieves the 1.5°C objective without the need for controversial negative emissions technologies and without a temporary overshoot.

24 Grübler et al., 2018, op. cit., p. 516

Alternative Mitigation Approaches

In a recent piece of scenario work, van Vuuren et al.[25] took as a starting point the 1.5° C scenario based on the Shared Socioeconomic Pathway 2 (SSP2)[26] as implemented by the IMAGE model of the Netherlands Environmental Assessment Agency. This implementation, the «default» 1.5° C strategy,[27] shares certain features with other 1.5° C-consistent SSP-based pathways, for example, that a large amount of carbon dioxide is removed through BECCS and other CDR approaches during the 21st century.[28] Van Vuuren et al. then model «alternative» pathways that implement mitigation strategies not typically modelled by integrated assessment models (IAM) such as IMAGE, because estimates of their future cost and performance is more speculative than those of «default» mitigation approaches, limiting their application in models that select measures based on cost optimization.

The alternative measures modelled by van Vuuren et al. individually reduce the degree to which BECCS and other non-forestry CDR are utilized, while implementing all the approaches together completely eliminates them. Notably, however, CO_2 sequestration is still assumed to occur in this case, albeit through natural sequestration where restoration of forests and reforestation takes place on land that is freed up by the reduced need for agricultural land as a result of agricultural intensification, a lower population, and low-meat diets based on cultured, as opposed to farmed, meat. Table 1 below shows the specific alternative scenarios and their descriptions and assumptions. «The rate and level with which the measures are introduced [into the model] are meant to reflect ambitious, but not unrealistic implementation.»[29]

25 van Vuuren, D. P., et al. (2018). Alternative Pathways to the 1.5° C Target Reduce the Need for Negative Emission Technologies. *Nature Climate Change*, 8 (5), 391–397. https://doi.org/10.1038/s41558-018-0119-8

26 The Shared Socio Economic Pathways (O'Neill et al., 2015) are a relatively new device in the climate modelling community that describe five different story lines (SSP1 – SSP5) of the future development of the global population, macro economy, geopolitical framework and so on, based on which modelling teams then develop specific scenarios with more or less stringent climate policies. SSP2 (Fricko et al., 2017), also known as «Middle of the Road,» involves a story line wherein global political, social and economic trends remain similar to their current situation with development uneven across the globe, relatively weak global governance institutions, medium population growth and continued inequality.

27 Cf. Rogelj et al., 2018, op. cit.

28 The cumulative amount of BECCS in recent 1.5 ° C pathways based on the SSPs ranges from 150 to 1,200 Gt CO_2, with substantial variation across models and SSPs. The range of BECCS in SSP2 scenarios (the SSP used in van Vuuren et al. [2018]) is 400–975 Gt CO_2 (Rogelj et al., 2018. op. cit.).

29 van Vuuren et al., 2018, op. cit., p. 1

Table 1: Alternative mitigation approaches modelled

Scenario	Short name	Description & key assumptions
Efficiency	Eff	Rapid application of the best available technologies for energy and material efficiency in all relevant sectors in all regions.
Renewable electricity	RenElec	Higher electrification rates in all end-use sectors, in combination with optimistic assumptions on the integration of variable renewables and on costs of transmission, distribution and storage.
Agricultural intensification	AgInt	High agricultural yields and application of intensified animal husbandry globally.
Low non-CO_2	LoNCO_2	Implementation of the best available technologies for reducing non-CO_2 emissions and full adoption of cultured meat in 2050.
Lifestyle change	LiStCh	Consumers change their habits towards a lifestyle that leads to lower GHG emissions. This includes a less meat-intensive diet (conforming to health recommendations), less CO_2-intensive transport modes (following the current modal split in Japan), less intensive use of heating and cooling (change of 1°C in heating and cooling reference levels) and a reduction in the use of several domestic appliances.
Low Population	LowPop	Scenario based on SSP1, projecting low population growth.
All	TOT	The combination of all the options described above.

Source: Van Vuuren et al. (2018).

Equity and Fair Shares

In the lead-up to the Paris climate summit in 2015, a large and diverse global coalition of civil society organizations and social movements released a report (with updates in subsequent years) contrasting countries' NDC pledges with what the groups considered their fair shares of addressing a global 1.5° C-consistent mitigation effort.[30] The analysis calculated these fair shares by taking into account countries' responsibility for contributing to the climate crisis (i.e. their historical emissions) and their capacity to act (i.e. their financial wherewithal), but did so in a way that explicitly protects the world's poor, in whichever country they may live, from an undue burden that would jeopardize their struggle for a life free of poverty.

The report found that, in aggregate, poorer countries were already pledging more than their fair share, while wealthier countries were falling far short of theirs. Importantly, the report concluded that in order to meet the global 1.5° C effort, all countries had to increase their ambition – even poorer countries that had already pledged more than their fair share had to undertake even more mitigation. However, since this additional mitigation would far exceed their fair share, these countries could not fairly be expected to undertake these efforts on their own, instead wealthier countries would have to cooperate (for example, by providing finance, capacity building or technology transfer support) to achieve this additional mitigation, for example by providing financial support to adopt cleaner energy solutions faster and at a larger scale than the country would have been able with its own resources alone.

This highlights that in the context of sharing fairly a stringent mitigation effort, all countries have «dual obligations,» where in addition to stringent unsupported domestic reductions, countries engage in deep international mitigation cooperation, where poorer countries implement mitigation action beyond their own fair share while wealthier countries provide the support necessary to undertake those efforts. Without this large-scale international mitigation cooperation, «1.5° C-compliant mitigation will remain out of reach, impose undue suffering on the world's poorest, or both.»[31]

30 CSO Equity Review. (2015). *Fair Shares: A Civil Society Equity Review of INDCs*. Manila, London, Cape Town, Washington, et al.: CSO Equity Review Coalition. http://civilsocietyreview.org/report; CSO Equity Review. (2017). *Equity and the Ambition Ratchet: Towards a Meaningful 2018 Facilitative Dialogue*. Manila, London, Cape Town, Washington, et al.: CSO Equity Review Coalition. http://civilsocietyreview.org/report2017; Holz, C., Kartha, S., & Athanasiou, T. (2018). Fairly Sharing 1.5 – National Fair Shares of a 1.5° C-compliant Global Mitigation Effort. *International Environmental Agreements: Politics, Law and Economics*, 18 (Special Issue: Achieving 1.5° C and Climate Justice), 117–134. https://doi.org/10.1007/s10784-017-9371-z

31 Holz, Kartha, et al., 2018, op. cit., p. 117

Furthermore, pathways that rely on a large scale of CDR later in the 21st century to reach the 1.5° C objective introduce an element of intergenerational injustice: if today's societies decide to embark on pathways that feature less stringent near-term emissions reductions facilitated by assumptions of large-scale deployment of technologies that have not yet been proven to work at scale and that carry profound environmental, social and economic risks, they essentially force future generations to deploy these technologies despite those risks, or accept much higher warming.

CONCLUSION

Pathways to 1.5° C that do not rely on large-scale deployment of unproven and potentially deleterious technologies, such as BECCS or other CDR approaches, have recently become available in the literature. Such pathways share important features, namely that they require more stringent near-term emissions reductions than in 1.5° C pathways that envision removal of large amounts of CO_2 later. Figure 1 shows the scenarios discussed in this chapter in the context of the 1.5° C and 2° C scenarios from the SSP database and the level of emissions implied by the current NDCs. Compared to most other 1.5° C scenarios, the scenarios by Grübler et al. and van Vuuren et al. display much lower near-term emissions than the «default» scenarios, showing that the mitigation activities are embarked upon earlier and more stringently. Due to their research objective, the Holz, Siegel et al. scenarios were specifically designed to follow the emissions pathway implied by the NDCs as long as possible, to account for inertia of the political system, thus they are not as stringent in the period up to 2025 but then steeply reduce emissions.

Furthermore, it is notable that each of the very ambitious mitigation scenarios discussed here still leaves out additional mitigation options, for example, maintaining a high level of meat consumption, aviation, and population growth in Grübler et al.[32] None of the studies explores the impact that placing limits on GDP growth could have on the feasibility of achieving the 1.5° C temperature limitation objective, despite GDP growth having been identified as a principal driver of emissions growth.[33]

Finally, it is important to distinguish in scenarios between different types of CDR on the one hand and natural sequestration in forests and other natural ecosystems on the other. Activities like BECCS, DAW, or afforestation are only potentially attractive to societies because of their potential (under the right circumstances) to remove carbon dioxide from the atmosphere and they come with considerable risks and/or costs. In making decisions about near-term levels of ambition, societies need to be aware of the trade-offs implied with regard to CDR. Because different CDR types carry different types and levels of risks, it is important to take these into account.

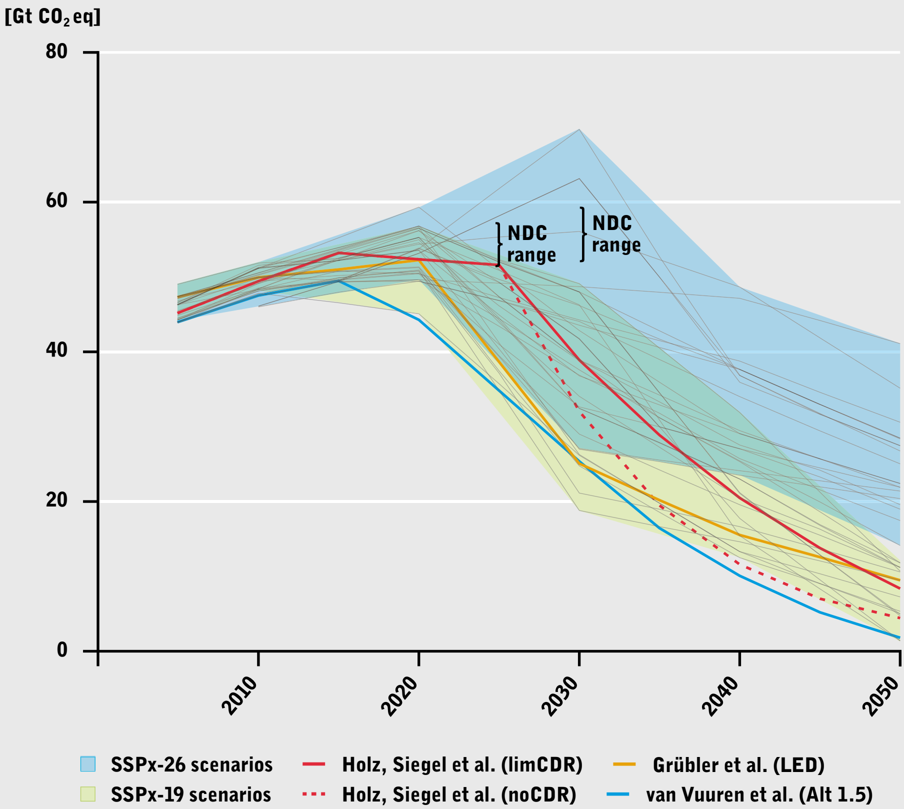
Reforestation and forest ecosystem restoration, on the other hand, can also sequester carbon dioxide, but this feature is a secondary attribute of these activities.

32 Grübler et al., 2018, op. cit.

33 Kuhnhenn, K. (2017a). Climate Mitigation Scenario – Contains Growth and Other Normative Substances. www.degrowth.info/en/2017/07/climate-mitigation-scenario-contains-growth-and-other-normative-substances; Kuhnhenn, K. (2017b). *Wachstumsrücknahme in Klimaschutzszenarien* (p. 18). Leipzig: Konzeptwerk Neue Ökonomie. www.degrowth.info/wp-content/uploads/2017/06/ModWac3.pdf

In the first instance, they are undertaken to enhance the biodiversity and resilience of the forests and to reverse the loss of forest cover and vegetation over the past 200 years. This issue is discussed in much more detail in *Re-Greening the Earth. Protecting the Climate through Ecosystem Restoration* in this publication.

Figure 1: BECCS-free scenarios in context (in Global GHG emissions [Gt CO_2 eq])



The light green, the blue and the mixed shaded areas show the range of the «default» 2°C and 1.5°C scenario implementations in the SSP database, with individual scenarios shown as grey lines.[34] The coloured lines show the BECCS-free scenarios discussed in this chapter; the right braces indicate the range of emissions that would result from the implementation of the mitigation pledges made by countries in their NDCs.[35]

Source: Grübler et al 2018, van Vuuren et al 2018 und Holz, Siegel et al 2018; SSP database, IIASA, 2016, UNFCCC, 2016; own chart.

34 IIASA. (2016). SSP Database. International Institute for Applied Systems Analysis. https://tntcat.iiasa.ac.at/SspDb

35 UNFCCC. (2016). *Aggregate Effect of the Intended Nationally Determined Contributions: An Update. Synthesis Report by the Secretariat*. Bonn: UNFCCC. http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf

An important implication of the scenarios discussed here is that the reductions pledged in countries' NDCs are not consistent with these pathways. Therefore countries have to strengthen their current pledges significantly, for example in the context of the Talanoa dialogue taking place in 2018, or in the context of the requirement to «communicate or update» NDCs by 2020.[36] Strengthening near-term mitigation ambition, including the current mitigation pledges for 2025 and 2030, is paramount to avoid locking future generations into high-risk technological pathways that might never materialize, thereby potentially committing the world to unacceptably high rates of global warming.

36 UNFCCC. 2015, op. cit., Paragraphs 23 & 24

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