Deriving a Canadian Greenhouse Gas reduction target in line with the Paris Agreement's 1.5°C goal and the findings of the IPCC Special Report on 1.5°C

Christian Holz, Climate Equity Reference Project, cholz@climateequityreference.org

This technical backgrounder serves to outline the methodological and normative-ethical choices taken by members of Climate Action Network Canada - Réseau action climat Canada (CAN-Rac) in deriving their current position on Canada's fair share towards a global mitigation effort consistent with limiting warming to 1.5°C, based on the findings of the IPCC Special Report on 1.5°C (IPCC SR15) [1].

These choices broadly occurred in three distinct areas and in line with CAN-Rac members' values, namely:

1. Selecting a global pathway or a range of global pathways from the IPCC SR15 scenario database;
2. Determining how to fairly share the global mitigation effort among Earth's peoples and countries; and
3. Determine how much of Canada's fair share should be implemented via domestic emissions reductions measures, and implications for international cooperation and support.

These areas will be discussed in turn. Such decision making is required since the IPCC's science assessments of mitigation pathways offer, generally speaking, summaries for global figures, rather than national. As a consequence, the question of how to distribute this global effort among the world's countries, cannot be answered by the physical science of climate change but is a question for social scientists - ethicists, political scientists, and potentially economists.

1. Select a global pathway or a range of global pathways

It's important to recall that the IPCC summarizes all relevant published science, taking an agnostic view with regards to the assumptions and implications of the underlying studies. As a result, the "top-level" figures presented in the IPCC reports, including the Summary for Policy Makers, may include studies whose underlying premises, assumptions, trade-offs and values do not necessarily align with the values of specific users of the reports. CAN-Rac members examined the pathways consistent with 1.5°C for alignment with their values, specifically with regards to the length and amount of temperature overshoot of the scenarios and with regards to the scale of carbon dioxide removal technologies (CDR, or negative emissions technologies, NETs) assumed to be employed in the scenarios. 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.” [2] Likewise, CDR carries with it substantial risks (see appendix 1 for more detail) and CAN-Rac members applied the precautionary principle in selecting an appropriate pathway from the IPCC scenario database.

Specifically, **CAN-Rac members selected as the global mitigation scenario to pursue the “Low Energy Demand” (LED) scenario** [3], highlighted as scenario P1 in the IPCC SR1.5’s Summary for Policy Makers (SPM), since it aligns best with the precautionary principle and with important justice principles like equitable energy access (see appendix 2 for a more detailed description of the pathway).

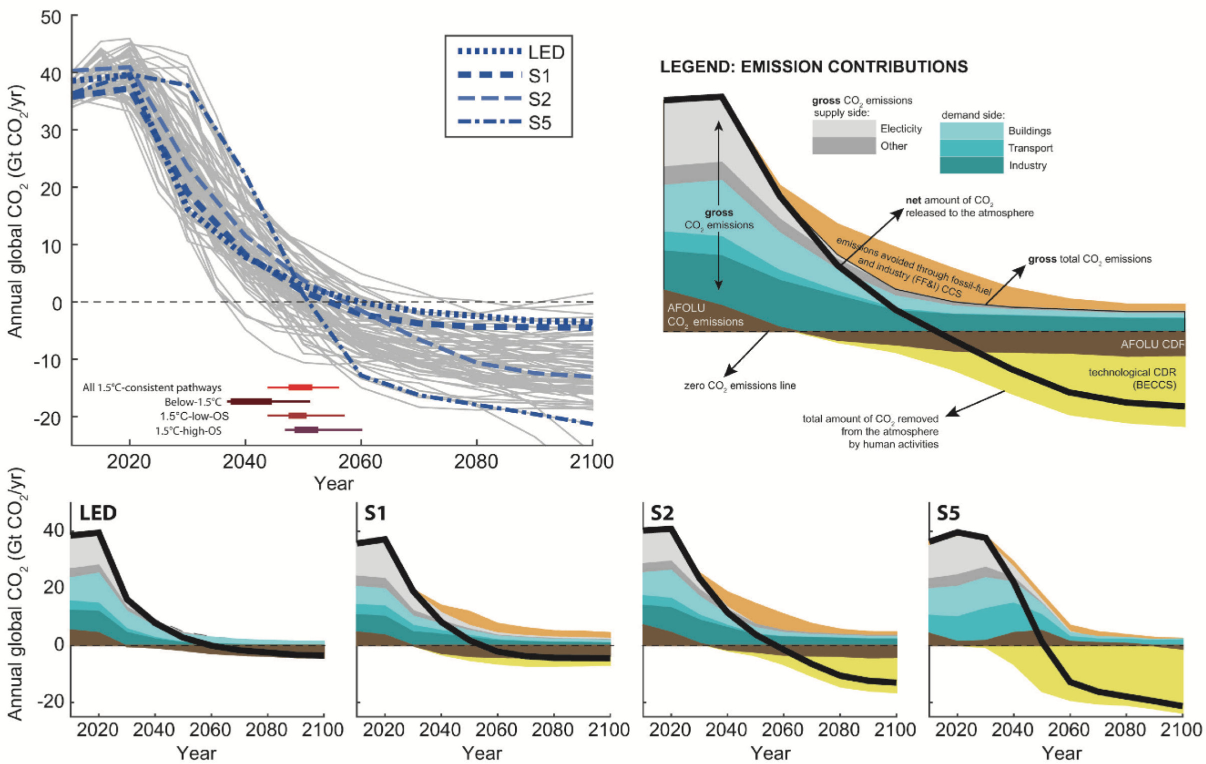

Figure 1: Taxonomy of 1.5°C pathways. Source: Fig 2.5 of IPCC SR1.5, Chapter 2 (the corresponding pathway labels in the IPCC SR1.5 Summary for Policy Makers are: P1=LED, P2=S1, P3=S2, P4=S5) The yellow area reflects the scale of carbon dioxide removal technology.

Due to the precautionary principle applied to both temperature overshoot and carbon dioxide removal technologies, emissions in the LED scenario decline faster compared to the group of model pathways with no or low overshoot of 1.5°C as a whole, as summarized in the IPCC SR1.5 SPM: Anthropogenic CO2 emissions in 2030 in the LED scenario are 52% lower than in 2010, while CO2 emissions in the median no or low overshoot scenarios are 45% below 2010 levels in 2030. Relative to a no-effort baseline projection as calculated by the climate equity reference calculator [4], [5], emissions are 25.2 Gt CO_2eq lower in 2030 – this is the global effort required in 2030 to achieve the LED pathway's emissions.

2. Determining how to fairly share the global mitigation effort among Earth's peoples and countries

Having determined a global effort, as per the LED pathway, aligned with CAN-Rac members' values with regards to risks and the precautionary principle, the question emerges how to distribute this effort fairly among the world's countries. The Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC) acknowledge the importance of equity in implementing a global response to the climate crisis. Specifically, both treaties highlight the equity principle of "Common But Differentiated Responsibilities and Respective Capabilities," which acknowledges that addressing climate change is a shared ("common responsibilities") responsibility of all countries, while they bear different degrees of responsibility for causing the problem and thus for contributing to the solution ("differentiated responsibilities"), while also acknowledging that countries' different levels of economic development and financial wherewithal constitute different levels of capacity to contribute to addressing the climate crisis ("respective capabilities"). Furthermore, the Paris Agreement explicitly acknowledges (in Article 4.1 [6]) that peaking of emissions will occur later in developing countries, which implies that developing countries' emissions would reduce at a relative rate slower than the global figures with developed countries having to achieve deeper reductions.

The Climate Equity Reference framework (CERf) is an equity modelling framework that allows to quantitatively reflect these equity principles in a quantitative way to derive "national fair shares" of a specified global efforts (e.g. that implied by the LED scenario pathway) under a variety of specific ethical-normative interpretations of the equity principles of the UNFCCC and the Paris Agreement. The CERf methodology is peer-reviewed [7], is highlighted in the IPCC's Fifth Assessment Report [8] as one of the frameworks implementing the "responsibility — capability — need" approach to equitable effort sharing, and has since 2015 been utilized by a large, diverse and global coalition of organizations and movements as a basis for a series of equity assessments of the climate pledges of countries [9]–[12].

Specifically, the CERf considers the equity principle of responsibility by calculating the share of any country of the cumulative global emissions (of individuals above the development threshold, ses below) since a given start year. Capacity is taken into account by considering each country's total income of individuals above a certain "development threshold," below which incomes are not considered to be available to address climate change. This reflects the normative position that for the poorest individuals in every country the fulfilment of their immediate basic needs ought to take precedent over contributing to addressing the climate crisis. This is equivalent to progressive taxation which is very common in income tax regimes around the world, in Canada for example, reflected by the "basic amount" of tax-free income. Capacity calculations can also include a second threshold, making the calculations equivalent to "more progressive" taxation regime, with the rate at which incomes are considered to be available to address climate change gradually rising between the development threshold and this second threshold - this reflects income taxation regimes with multiple tax brackets with progressively higher marginal tax rates.

The CERf calculates how much of the global capacity and global responsibility (each calculated as described above) can be attributed to each country and then apportions the global effort, here: the global effort to implement mitigation in line with the LED pathway, to each country.

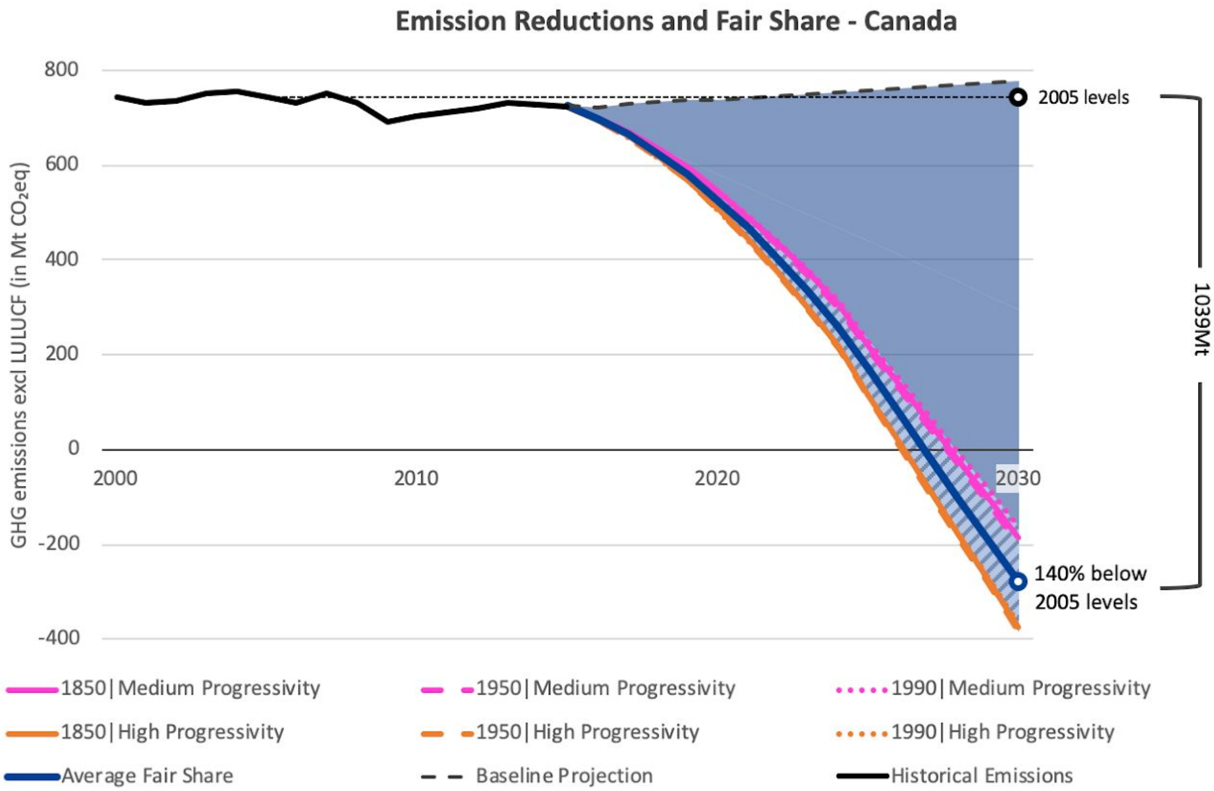

Figure 2: Canada's Fair Shares of the global mitigation effort implied by the LED global pathway. The pink lines reflect fair shares calculations using "medium progressivity" ($7500 development threshold), the brown lines "high progressivity" ($7500 development and $50,000 second threshold); pink and brown lines are solid, dashed or dotted for historical responsibility start dates of 1850, 1950, and 1990, respectively. The striped area shows the additional fair shares mitigation of the most stringent of these fair shares calculations relative to the least stringent ones. The solid blue line reflects the rounded average of the six fair shares calculations. Own calculations using the Climate Equity Reference Calculator [4], [5]

CAN-Rac members elected to not select a single value for the start year of calculating historical responsibility or to choose a single approach to reflect progressivity in the calculation of capacity. Instead they decided to calculate Canada's fair share under historical responsibility start dates of 1850, 1950 and 1990, each combined with one progressivity approach that applies a development threshold of $7,500 annual per capita income and a second progressivity approach that additionally applies a second threshold of $50,000 per capita annual income. The (rounded) average of these six fair shares calculations was then taken as Canada's fair share of the global emissions reductions effort implied by the LED pathway scenario (figure 2 below shows the results of these six different calculations as well as the average). **Specifically, this fair share calculation implies that Canada's emissions in 2030 should be no higher than -297 Mt CO_2eq, or 140% below 2005 levels.**

It is important to note that this calculation is exclusively based upon the ethical principles of the UNFCCC and the Paris agreement as explained above and given the specific views of CAN-Rac members as to how capacity and responsibility ought to be understood. It is not based upon any techno-economic or policy analysis as to how such a target could be achieved.

3. Determine how much of Canada's fair share should be implemented via domestic emissions reductions measures, and implications for international cooperation and support.

Recall from the previous section, that the fair shares reduction target (140% below 2005 levels by 2030) as derived from ethical principles is in excess of 100%. This is a typical result for principle-based fair shares calculations for wealthy countries with a large share of the historical emissions like Canada (which is the 10th wealthiest countries in the world and top 9 emitter of greenhouse gases, despite being the home of only 0.5% of the world's population).

Obviously, it is *physically* impossible to implement this fair shares reduction, for all of which Canada is *morally* responsible, within Canada. This is because this fair share obligation exceeds any plausible interpretation of the total mitigation potential within Canada. However, the reverse is the case for most developing countries: those countries' mitigation potential exceeds, often very substantially, the amount of mitigation that can be fairly expected to be implemented by those countries. Nonetheless (and this is one of the fundamental, yet unavoidable, injustices of the climate crisis), most of the mitigation potential of those countries needs to be implemented in order to avoid exceeding the 1.5°C warming limitation objective. Since it would not be fair to expect those countries to implement that potential with their own, limited, resources, it is appropriate for wealthy countries like Canada to engage in international mitigation cooperation and support, e.g. via financing, capacity building or transfer of technologies, to ensure the availability of resources required to implement that fraction of the mitigation potential of developing countries that exceeds those countries' own fair share obligation. It is through this international support that Canada and other wealthy countries can discharge that fraction of their total fair shares contribution that exceeds their own domestic mitigation potential.

In order to be able to determine which fraction of the total fair shares reduction target, as derived from ethical principles, should be implemented through domestic mitigation and which fraction through international cooperation and support, an estimate of the domestic mitigation potential is required. CAN-Rac and several of its members carried out a separate analysis of potential mitigation policies and measures that should be implemented in Canada and of the potential emissions reductions impact of these measures. This analysis [13] concluded that sufficient mitigation potential exists to reduce emissions in Canada by at least 60% below 2005 levels while ensuring meaningful engagement of Indigenous People, promoting just transitions for workers and communities hitherto dependent on the fossil fuel industry or other carbon-intensive activities, and enhancing transparency and accountability for the overall mitigation programme carried out.

Embracing the results of this previous study, **CAN-Rac members decided to adopt "at least 60% below 2005 levels" as the domestic mitigation fraction of Canada's overall fair share**

obligation. Consequently, in order to discharge its entire fair share obligation (140% below 2005 levels), Canada would have to engage in international support resulting in mitigation in developing countries equivalent to another 80% of Canadian 2005 emissions (figure 3). Ensuring that this international portion is implemented, Canada will have to engage in international cooperation on mitigation at an unprecedented scale. This will have to include a contribution of Canada of $4bn USD per year in climate finance, which is Canada's fair share of the $100bn USD annual climate finance that developed countries collectively committed to.[1] However, it is likely that additional cooperation beyond this $4bn USD contribution would be required for Canada to ensure a mitigation impact in 2030 in developing countries equivalent to 80% of its 2005 emissions.

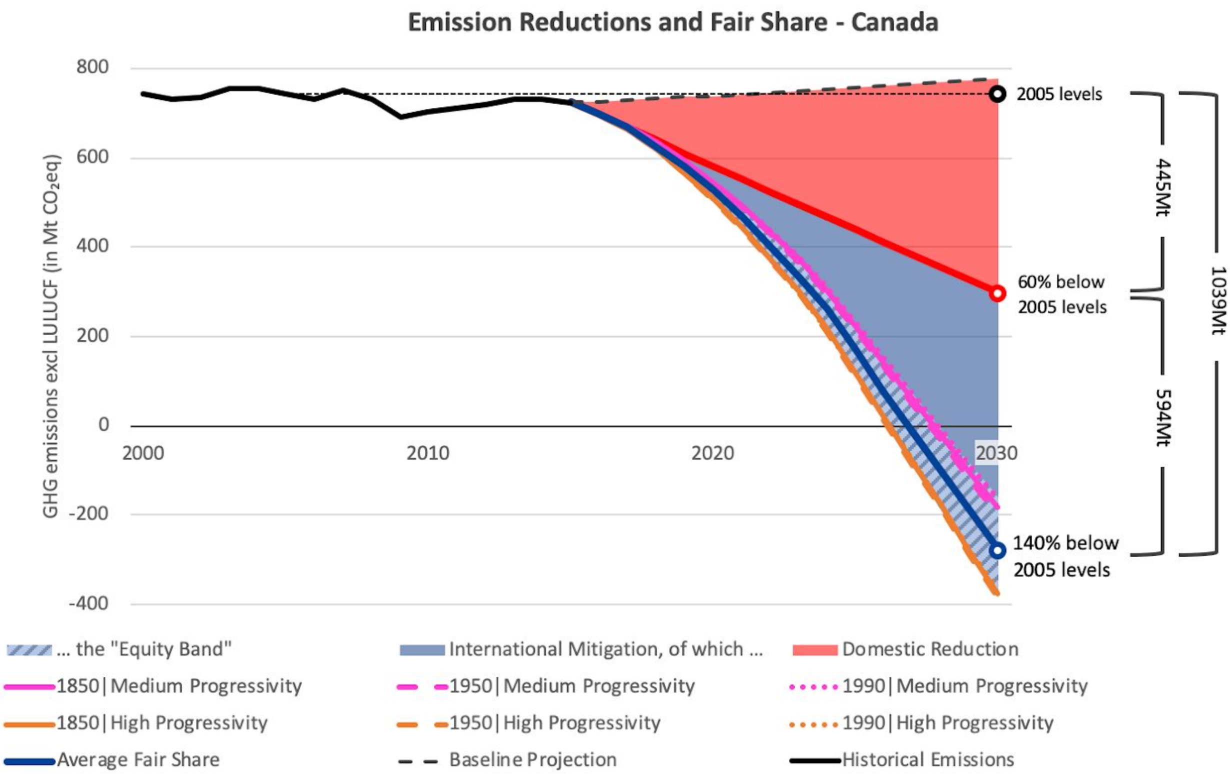

Figure 3: Canada's Fair Shares of the global mitigation effort implied by the LED global pathway, differentiated in a domestic mitigation component (red area/line) and an international support component (blue area), together constituting Canada's total fair share (blue line), based on ethical principles of capacity, responsibility and need. Pink and brown lines lines reflect underlying fair shares calculations, and the striped area the equity band - see Figure 2.

[1] This fair share estimate of the collective $100bn USD commitment is supported by a number of different approaches coming all to a similar result (see [14]). Our own calculations using the Climate Equity Reference Calculator and the range of six fair shares benchmarks described above, suggests a 4.3% fair share for Canada of the $100bn USD commitment (derived by calculating Canada's share of the combined capacity and responsibility of the OECD90+EU group of countries and averaged across the six benchmarks).

For comparison, the average global mitigation requirement under the LED pathway in 2030 is 59.4% below 2005 levels for all greenhouse gases – which is nearly identical in terms of stringency to the 60% domestic mitigation target identified above. As mentioned earlier, the Paris Agreement explicitly acknowledges that developed countries' emissions would peak earlier and reduce faster, so Canada's domestic emissions reducing at essentially the same rate as the global average, as it does in the scenario envisioned by the analysis of CAN-Rac and its member organizations, is arguably somewhat inconsistent with this provision of the Paris Agreement, despite representing a very ambitious mitigation scenario for Canada. This further underlines the moral case for Canada to deeply engage in international mitigation cooperation to support deep mitigation in developing countries. It is important to note that engagement in such international cooperation on the part of Canada would not constitute offsetting or "buying our way out" of responsibility, because under a truly transformational emissions scenario like the LED scenario, domestic emissions reductions of wealthy countries would have to be very ambitious, so any international cooperation would not constitute a shirking of responsibility by the wealthy country, but rather being able to go beyond truly ambitious domestic measures in order to fulfill the full fair shares obligation.

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Appendices

Appendix 1. Negative Emissions Technologies

Source: Holz, C. (2018) *Modelling 1.5°C-Compliant Mitigation Scenarios Without Carbon Dioxide Removal*. Berlin: Heinrich Böll Foundation. https://www.boell.de/sites/default/files/radical_realism_for_climate_justice_volume_44_8.pdf

"The majority of the 1.5°C-compatible emissions pathways in the climate modelling literature 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 $GtCO_2$. 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.

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 and political acceptance issues, and storage permanence. 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.» 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, 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.

[...]

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. 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, 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. 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. 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, respectively) 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.

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. 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."

Appendix 2. The LED scenario

Source: CSO Equity Review (2018) *After Paris: Inequality, Fair Shares, and the Climate Emergency*, CSO Equity Review Coalition, Manila, London, Cape Town, Washington, et al., http://civilsocietyreview.org/report2018

"In order to place a fair-share discussion of national mitigation pledges firmly in the context of the climate challenge, it's necessary to have a proper 1.5°C scenario. Such a scenario must not only specify a path that keeps warming below 1.5°C, it must do so in a manner that is fair with respect to energy access, consumption, and other critical aspects of human well-being. To reflect such a future, we've chosen the Low Energy Demand scenario as our illustrative scenario. The LED scenario is the source of one of the four featured pathways (P1) in the IPCC's 1.5°C report. This scenario was developed at the International Institute for Applied Systems Analysis and is explicitly designed to be equitable in just these ways – by taking the universal attainment of a 'decent living standard' as one of its design criteria – but also to avoid the problem, endemic in mainstream mitigation scenario modelling, of excessive reliance on negative emissions technologies.

The Low Energy Demand (LED) scenario incorporates many current major trends in energy demand, trends that are already observable and expected to intensify, including urbanization, digitalization, the decentralization of the energy system, the shift from ownership-based to use-based consumption of services, and the emergence of a circular economy to limit material use and waste. These trends, together with other substantial increases in energy efficiency across all sectors, lead to very low energy demand projections (e.g. 42% below 2020 levels in 2050), despite population growth and a global increase in end-use energy services, including temperature-controlled housing, adequate and nutritious diets, and accessible transportation services. The point here is not to endorse all details of the LED scenario but rather to note that, in an energy system that's meant to satisfy this comparatively low overall future energy demand, it becomes much less daunting to rapidly retire fossil-fuel-based generation and transition to renewables.

Because of these features, the LED scenario can satisfy humanity's energy needs without, like many ostensible 1.5°C scenarios, assuming a heavy future reliance on negative emissions, for example through large-scale bioenergy with carbon capture and storage (BECCS), the feasibility and sustainability of which have not been proven at scale. It's ability to do so derives, in part, from the fact that the global forest sink can be enhanced significantly when there is reduced competition for land from bioenergy crops.

Compared to current (2016) global greenhouse gas emissions of about 50 gigatonnes of carbon dioxide equivalent ($GtCO_2eq$), the LED pathway enables very stringent reductions, eliminating half of current emissions by 2030 (these reach 25 $GtCO_2eq$), only about 10 $GtCO_2eq$ in 2050, and a mere 1.5 $GtCO_2eq$, primarily for agriculture, in 2100. It's important to note, however, that even more could be done. The LED pathway assumes that the economies of even the developed countries continue to expand, with incomes nearly tripling by the century's end. Clearly, even deeper reductions – and a less threatened climate – could be achieved if steadily accelerating growth was not assumed."