Tightening the Net:

Climate Justice and Net Zero Emissions

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**Abstract:**

In recent years the target of Net Zero emissions by 2050 has come to the forefront of global climate politics. Net Zero would see carbon emissions matched by carbon removals, and should allow the planet to avoid dangerous climate change. But the recent prominence of this goal should not distract from the fact that there are many possible versions of Net Zero. Each of them will have different climate justice implications, and some of them could have very negative consequences for the world’s poor. This paper demonstrates the many ambiguities of Net Zero, and argues in favour of a Net Zero strategy in which those who can reasonably bear the burden of doing so act to pursue early and aggressive mitigation policies. We also argue for a Net Zero strategy in which countries place the lion’s share of their faith in known emissions reduction technologies, rather than being heavily reliant on as-yet unproven Negative Emissions Techniques. Our overarching goal is to put Net Zero in its place, by providing a clear-sighted view of what Net Zero will achieve, and where the ‘Net’ in Net Zero needs to be tightened further if the world is to achieve climate justice.

In recent years, and especially following the 2015 Paris Agreement, the target of Net Zero emissions by 2050 has come to the forefront of global climate politics. As a sign of its increasing prominence, on 31st March 2021 the International Energy Agency organised a dedicated Net Zero Summit, bringing together leaders from more than forty countries in an attempt to cement the central role of a Net Zero target in discussions within the UN Framework on Climate Change. Meeting a Net Zero target would involve any ‘residual’ carbon emissions being counter-balanced by removals achieved through Negative Emissions Techniques (NETs)[[1]](#endnote-1). As the Intergovernmental Panel on Climate Change has put it, Net Zero occurs ‘when anthropogenic CO2 emissions are balanced globally by anthropogenic CO2 removals.’[[2]](#endnote-2) The Paris Agreement called – rather more vaguely - for achieving “a balance between emissions and removals in the second half of this century,” while the IPCC subsequently specified that to restrict temperature rises to 1.5°C, Net Zero would need to be achieved by 2050. Achieving Net Zero is essential to stabilising the increase in temperatures, although the specific temperature at stabilisation depends upon the cumulative emissions until that date. With an early peak in emissions and Net Zero by 2050, there would be a reasonable chance of limiting warming to 1.5°C. Though achieving 1.5°C will be formidably difficult,[[3]](#endnote-3) the widespread embrace of national Net Zero targets should provide an important step towards climate stabilisation.

But it is also important to be clear-sighted about the role Net Zero can play in governing our climate. Net Zero is an important target in the drive towards limiting climate change to manageable levels (as represented by the 1.5°C guardrail). But it would not solve all of our climate problems. The world could meet Net Zero, for instance, and still see 80cm of sea level rise by 2100 (and significantly more after that).[[4]](#endnote-4) This suggests that Net Zero is at most a necessary, but not a sufficient, response to dangerous climate change. Achieving Net Zero by 2050 is an important interim target, but it alone does not guarantee restricting temperature rises to 1.5°C, and a subsequent period of net-negative emissions will likely be required to reverse any overshoot of temperature goals, and to ensure that temperatures can then be kept well below 2°C above pre-industrial levels. Even then, adaptation measures will remain necessary.[[5]](#endnote-5) Our goal in this paper is to put Net Zero in its place, by providing a clear-sighted view of what Net Zero will achieve, and where the ‘Net’ in Net Zero needs to be tightened further if the world is to achieve climate justice. An important first step is to recognise the many ambiguities associated with a Net Zero target.

The Ambiguities of Net Zero

Net Zero has been the subject of a remarkable political convergence in recent years. In many ways this appears to be a positive development. But experience suggests that framing matters[[6]](#endnote-6). Many previous framings of key climate goals have facilitated an excessive reliance on under-delivered promises of technological innovation.[[7]](#endnote-7) The result has been to justify procrastination and the deferral of serious mitigation efforts, especially when those efforts would challenge dominant interests and ideologies. In recent decades the framing of climate goals has shifted away from specified emissions cuts, towards atmospheric GHG concentrations and carbon budgets, and now once again towards the current Net Zero frame. But to date each formulation has enabled delay in serious mitigation action, by allowing countries to invest collective political faith in promises of so-far unrealised technological capacity.

The danger, then, is that the Net Zero target provides one more framing in which an as yet unrealised promise, in this case the promise of carbon removal technologies at a very large scale, enables further procrastination. How might Net Zero facilitate such a framing? In this section we will argue that Net Zero is a much more open-ended commitment than we might suppose. In some ways this feature is an advantage: a degree of ambiguity can mean that an idea has more ‘convening power’ in politics. But it also means that widespread agreement on the importance of Net Zero nevertheless masks important disputes about what it should mean in practice. It also masks the power relations between, and conflicting interests of, the diversity of actors involved. Climate politics remains a minefield of both deliberate disinformation and unintentional self-delusion.[[8]](#endnote-8) Ambiguous Net Zero discourses can fuel both of these problems. When they are co-opted by ‘discourses of delay’,[[9]](#endnote-9) Net Zero narratives and policies draw attention to primarily technical responses which minimise disruption to political and socio-economic relations, highlighting the apparent impossibility of rapid elimination of emissions, as well as the setbacks to various interests that would arise from any *attempt* to swiftly eliminate emissions. Such arguments are then seized on by powerful actors (such as oil and gas companies), and can sustain continued ‘moral corruption’, a phenomenon in which actors grasp at and validate policy responses which reflect their material and socio-economic privileges - even if this means imposing risks and costs on other, less privileged people.[[10]](#endnote-10)

Although its ambiguities may have helped convene attention, if Net Zero is to deliver on its promise, disagreements over its concrete meaning cannot be deferred indefinitely, but will need to be unpacked and resolved – and the sooner the better. ‘Tightening the Net’ will be difficult political work. But it will also be necessary if Net Zero is going to serve as an organizing target for the radical climate action needed to keep temperature rises well below 2°C.

In what follows, we will argue that ‘tightening the net’ is important for four reasons, each connected to key concerns of climate justice.[[11]](#endnote-11) First, ambiguous or excessively permissive versions of Net Zero may provide an excuse for further delay, and even the dilution of climate commitments – which would in turn exacerbate the unfair distribution of harms (both international and intergenerational) imposed by climate change. Second, actors must pay close attention to the pathway to Net Zero, and to the side-effects associated with the various distinct pathways that are open to them. Some pathways to Net Zero allow for greater cumulative emissions than others. But with greater cumulative emissions necessarily comes either a higher outcome temperature (which would mean greater harms for the world’s poor) or a greater need for future carbon removal (the costs of which would also likely be distributed in regressive ways if modelling exercises, which predict high reliance on Bioenergy with Carbon Capture and Storage, or BECCS, are any guide[[12]](#endnote-12)). Third, pathways to Net Zero which allowed for greater residual emissions would see a higher rather than lower level of continuing fossil economy activities. This would therefore involve more rather than less of the socio-economic burdens (including pollution and, in some cases, repression and dispossession) typically associated with the fossil economy. These burdens are again likely to be unevenly distributed. Finally, ambiguity about the distribution of mitigation efforts across time is leading to pressure on countries which have made only a modest historical contribution to climate emissions to achieve Net Zero on similar timescales to those with large climate debts. Given that the latter typically have much greater resources and capacities to address the problem, this would further compound climate injustice.

Agreeing on Net Zero by or before 2050 is therefore necessary, but not sufficient for climate justice. While agreement on Net Zero is vital,[[13]](#endnote-13) it still leaves much work to do. If it is to operate as the lodestar of global climate politics, we need to determine *which* Net Zero we are aiming at. A concern for climate justice, we will show, will often give us reason to prefer some ways of delivering on Net Zero rather than others. Throughout the rest of this paper we will demonstrate why this is the case. By examining the timing of climate action, the pathway to net zero, the allocation of residual emissions, the impact on the poor of Net Zero strategies, and the question of what happens *beyond* Net Zero, we will emphasise important – but too often neglected – climate justice implications of the commitment to Net Zero.

The Timing of Climate Action

Even if the world commits to the goal of Net Zero by 2050, important political choices will remain to be made – and made soon. One of the most crucial decisions relates to timing. In light of the urgency of the climate problem, 2050 is a very long way away. Nearly three decades takes us far beyond the regular political cycle of elections and coalition-forming. It would be relatively easy for leaders to embrace Net Zero by 2050 now, and to leave the toughest decisions for much later. The mechanism for regular review of NDCs under the Paris Agreement may create pressure for continually improved *targets*, but it has done little to drive interim *action*. And given that politicians can rarely bind the actions of their successors very tightly (goals adopted now can be abandoned later, or reconceived with more or less faithfulness to their original aims), there is a strong argument that countries should pursue ambitious mitigation actions early. Cumulative emissions matter intensely for temperature outcomes. Unless mitigation is accelerated rapidly, and urgently, to deliver substantial global emissions reductions by 2030, the world will have little chance of avoiding global temperature rise in excess of 1.5°C.[[14]](#endnote-14)

Here, though, the openness of the Net Zero target becomes apparent.[[15]](#endnote-15) Agreeing on a target of Net Zero by 2050 does not commit actors to any particular timeline for achieving it, beyond the brute goal of equilibrium between emissions and removals by that particular date. One country (or company) could agree on the necessity of Net Zero by 2050, and aim to take dramatic decarbonisation measures during the 2020s. Another might defer serious action until the 2040s. Taken by itself, the Net Zero target is neutral on which pathway is to be preferred. But the choice between these pathways will make a huge difference to total cumulative emissions, which in turn looks likely to have momentous consequences for the climate. And clearly, the longer radical emissions cuts are delayed, the more carbon removal will eventually be required if the world is to have a chance of keeping temperature rises within 1.5°C. But this is to place a level of faith in the potential of Negative Emissions Techniques that might turn out to be highly ill-advised (see below).

The possibility that actors might commit to the target of Net Zero by 2050 but nevertheless defer radical mitigation efforts opens up some worrying possibilities. For instance, actors might commit to Net Zero by 2050 *naively*, or in *bad faith*. Actors would commit naively if they assumed that cheap technical solutions will emerge closer to 2050, without a reasonably well-informed idea of what those solutions might look like, or without a clear recognition of the limitations or costs that might be associated with those solutions.[[16]](#endnote-16) Policy-makers might look at the various Integrated Assessment Models on climate change, for instance, and infer that delaying emissions cuts will be the most cost-effective response, on the assumption that subsequent technological progress will make mitigation significantly cheaper than it is now. There is evidence, however, that policy-makers wrongly assume that the assumptions made in these Models about future technology are feasible by definition. To the extent that this is a mistaken assumption, policy-makers will act naively.[[17]](#endnote-17)

Actors would act in bad faith, by contrast, if they committed to Net Zero without any clear intention to actually take decisive action, or to bear their fair share of the costs of global mitigation efforts. History provides ample reason to worry that an overt commitment to Net Zero might simply operate as cover for high-emitting industries to continue emitting much as they are today. In the past, anticipated advances in nuclear technology have been employed as a reason to defer emissions reductions, and so have ambitious projections of the potential of ‘carbon capture and storage’ (CCS) technologies applied to fossil fuel use in power generation and industry.[[18]](#endnote-18) Today, the technologies that function as the most significant distraction are probably negative emissions technologies such as Bioenergy with Carbon Capture and Storage (BECCS). If BECCS or similar mechanisms can deliver large net emissions reductions, countries will need to cut emissions less. But BECCS is unproven, and the hopes vested in it could be a dangerous – and, if its proponents understand its likely shortcomings, irresponsible - distraction.[[19]](#endnote-19) Its widespread adoption may also, as we argue below, significantly set back the interests of people in the global South.[[20]](#endnote-20) For all of these reasons, decisive early action is more attractive than reliance on unproven future technologies.

The Pathway to Net Zero

It would be easy to assume that since Net Zero is an apparently simple goal, the pathway to it must be clear. But this would be an illusion concealing important political decisions that remain to be made. We have already identified one major issue: the timing of mitigation efforts, and specifically whether to front-load or back-load actions to reduce emissions. But there are two further issues that anyone committed to Net Zero must confront. Political decisions on each of them will have important implications for people’s opportunities and livelihoods across the world.

First, it is important to recognise that stabilisation at +1.5°C will require Net Zero at the global level, but not at the level of each of the world’s countries. Net Zero by 2050 is an *aggregate* goal, which is compatible with rich countries reaching Net Zero before 2050, and poor countries reaching it later. As such, urging India to reach Net Zero by 2050[[21]](#endnote-21), for instance, would be unnecessary. It would also be unfair: India, after all, has historically made a comparatively modest contribution to the problem of dangerous climate change, and its ability to absorb the costs of the transition away from climate is far more limited than many wealthier (and high-emitting) countries. China has committed to reach Net Zero by 2060, rather than 2050, and its slightly slower path to Net Zero could enable faster progress in alleviating poverty, which is an important moral goal in its own right. Finland, by contrast, has committed to Net Zero by 2035, and Germany and Sweden by 2045.[[22]](#endnote-22) In the latter cases, the countries in question have the resources to attempt an accelerated path towards Net Zero, rendering the aggregate goal of global Net Zero possible even if poor countries delay radical climate action. These different pathways are compatible with the idea of ‘common but differentiated responsibilities and respective capabilities,’ which has played a central role in international climate negotiations since the United Nations Framework Convention on Climate Change of 1992 and which was given pride of place in the 1997 Kyoto Protocol. Fortunately – though careful management of local transitions will be required - the developed world possesses the capacity – if not always the will - to meet the costs of rapid decarbonisation without forcing anyone into poverty. But the same cannot be said in many countries of the global South. A slower transition for such countries is morally acceptable if it is vital to their continued efforts to help people escape from poverty.[[23]](#endnote-23)

The second issue is how to balance the focus on emissions reductions with the focus on developing Negative Emissions Techniques. As we discuss below, any Net Zero future is likely to see some continuing carbon emissions. Those ‘residual’ emissions would need to be balanced by removals using Negative Emissions Techniques. But the statement that emissions and NETs must come into balance is too vague, because we can imagine quite different balances between emissions and NETs. On what we might call *narrow convergence*, emissions are cut to a very low level, and are balanced by a modest deployment of NETs. On what we might call *broad convergence*, emissions remain much higher, and are balanced by a much more widespread and large-scale deployment of NETs. Each strategy delivers on the goal of Net Zero. The two pathways, however, could have very different effects on human well-being and on the natural environment. There are, we will argue, two strong reasons for preferring what we have called narrow convergence.

The first reason is that emissions cuts provide a more secure contribution to climate stabilisation, compared to reliance on NETs. When countries reduce their emissions of carbon or other greenhouse gases, they reduce the radiative forcing of the earth’s atmosphere, in ways that we can measure and predict with some certainty. The contribution made by NETs, by contrast, is much less certain in various ways.[[24]](#endnote-24) One problem, which we have already noted, is that some NETs remain on the drawing board, in the sense that we do not yet know if – or how well, or how economically - they will work. Furthermore, even if they were initially successful, many NETs could turn out to be ‘leaky’ in the longer term. Even if they initially remove carbon from the atmosphere, in other words, their full effect may not endure for long. Biological NETs (such as forests and soils) can be quickly turned from carbon stores into sources of carbon emissions, as a result of changes in either climate or land management. Even high-tech NETs such as direct air capture (DAC) can ‘leak’ if the captured carbon is diverted for use in enhanced oil recovery, or in the production of synthetic fuels or fizzy drinks.[[25]](#endnote-25) This suggests that it may be facile to consider emissions reductions and NETs as simple functional equivalents.[[26]](#endnote-26) Reductions in carbon emissions will have a long-lasting effect, on which we can rely well into the future. In the case of NETs we have much less grounds for confidence. This provides good reason, other things being equal, to favour the former over the latter as means of approaching Net Zero.

The second reason for favouring narrow convergence lies with the implications for the world’s poor of a heavy reliance on mooted carbon removal technologies. For BECCS to make a major contribution to climate stabilisation, for instance, might require the repurposing of between a quarter and four-fifths of all land currently under cultivation.[[27]](#endnote-27) Where will that land come from? It is clear that high-emitting developed countries simply do not have enough re-purposable land within their own borders to bring them close to Net Zero.[[28]](#endnote-28) If they were to lean heavily on BECCS as a means of approaching Net Zero, they would therefore have to rely on countries in the global South to make land available for replanting, and compensate them through some kind of carbon trading mechanism. Such an arrangement, however, could have dramatic implications for food security in the global South. By creating massive new demand for land, it can be expected to drive up food prices for the global poor; and the real-world phenomenon of ‘fortress conservation’ gives grounds for worrying that it might see people being driven from their land.[[29]](#endnote-29) Reliance on such techniques in the global South could also see the poor being outcompeted for scarce water supplies. A similar worry applies to domestic energy. Direct Air Capture, another mooted carbon removal technology, would, if used at sufficient scale, require up to nine times the energy consumed by the whole of India.[[30]](#endnote-30) Even if the energy used was renewable, there is a high likelihood that the large-scale adoption of this technology would push up energy prices, exacerbating energy poverty. The danger that some emissions reductions technologies would worsen existing global inequalities, and even reinforce severe poverty and dispossession, must be fully considered when selecting the policies or technologies that bring the world closer to Net Zero.

Both reasons – the challenges of delivering NETs, and their potential impacts on the poor - suggest that in the longer term a system in broad convergence would be more stressed and less sustainable than one in narrow convergence.

Residual Emissions

As we have seen, Net Zero would not mean no emissions at all. Some emissions may simply be impractical to eliminate, such as methane emissions from rice-paddies. A good case can be made that some such emissions should be allowed to continue, given that the activities that cause them have clear social value. Activities such as the manufacture of vaccines, or the rescue of migrants at sea, might be difficult or impossible without some small carbon footprint. If so, the resulting emissions should be treated as ‘residual’: we should assume, at least given current technology, that they would continue even in a climate-just future. As such, they would have to be balanced by carbon removal techniques. This is why we have defended an approach of narrow convergence, rather than total convergence: we can assume that some carbon emissions will be with us long into the future. But how do we define *which* emissions are to be treated as residual, and which should be earmarked for eradication? If the ‘residual’ pie is of limited size, who should get to consume it?

This is a hugely significant normative question, and the answer that is eventually settled on will have important socio-economic ramifications in the wider transition away from carbon. In contemporary climate politics, many actors have already established plans which assume they have a good claim to a slice of the residual pie. But whether those claims are good ones is sometimes far from obvious. In the rich world, for instance, aviation is often treated as a likely source of residual emissions. Likewise, significant industrial sectors such as steel or concrete also currently lack a clear pathway to absolute zero emissions. On the assumption that countries’ reliance on removals using NETs will, and should, be limited, those activities and sectors that are angling for residual emission status are staking competing claims to what is a limited resource. What is at stake is the right to be among *the* activities chosen to be offset by those limited removals. Oil and gas companies which suggest that continued emissions arising from their sale of fossil fuels will be offset by large afforestation or forest protection projects – as Shell has, for instance[[31]](#endnote-31) - are not only gambling on the uncertain permanence of such removals techniques. They are also effectively claiming some of the residual pie. But since the size of that pie is limited, arguments that offsetting (luxury) emissions from driving or flying is permissible may not be compatible with *also* accepting emissions from subsistence food production, or from meeting other basic needs. In practice, many corporations have committed to the Net Zero target. But on closer inspection, most such plans turn out to assume that substantial proportions of their carbon emissions are going to be offset by carbon removals, rather than avoided in the first place. They are claiming, that is, a large slice of the pie of residual emissions – a slice that will as a result not be available to less privileged actors.

Bringing this point to the surface is very important when considering the justice implications of the transition to Net Zero. The point demonstrates that we urgently need clarity about which emissions *should* be considered residual, and why – and that those who claim a slice of the pie must present an argument for *why* they should receive it instead of others. Providing a full answer to those questions would require us to turn to a wider account of climate justice. But a key distinction is likely to be that between subsistence emissions and luxury emissions. Subsistence emissions are those which are necessary to meet people’s most basic rights. They would include the emissions created by small-scale subsistence farming, or to provide essential domestic heating. Luxury emissions, by contrast, are not necessary to meet anyone’s basic rights. In an influential early intervention from the global South, Agrawal and Narain introduced this contrast between luxury and subsistence emissions by asking ‘Can we really equate the CO2 contributions of gas-guzzling automobiles in Europe and North America or, for that matter, anywhere in the Third World with the methane emissions of draught cattle and rice fields of subsistence farmers in West Bengal or Thailand? Do these people not have a right to live?’[[32]](#endnote-32) A core principle of climate justice should be that no-one is required to eradicate their subsistence emissions in order to meet a particular carbon budget, if the better-off could reduce their luxury emissions instead.[[33]](#endnote-33) To require the global poor to reduce their emissions while treating luxury emissions as ‘residual’ would fail to accord equal respect for the well-being of the poor. Similarly, what Darrel Moellendorf has called the ‘anti-poverty principle’ declares that mitigation efforts should not make it more difficult for people to escape from absolute poverty. Since we live in a world where we *could* meet the challenge of dangerous climate change without keeping people in serious poverty, it would be unjust to load the costs of transition onto the shoulders of those who can least afford to bear them.[[34]](#endnote-34) That principle too would suggest actors should foreground the interests of the global poor when determining which emissions should be considered residual. Unfortunately, many wealthy actors have not yet made the implications of their claim to a slice of the residual pie explicit. Since residual emissions caused by the wealthy must come at the expense of subsistence emissions by the world’s poor, exposing the scale and pattern of this problem is an important first step towards climate justice.

We have argued for the desirability of minimising the use of removals offsets in the delivery of net-zero, by pursuing a path of narrow rather than broad convergence. But it is also important to recognise, finally, that Net-Zero rhetoric is serving to validate the continued use of ‘avoidance offsets’ – controversial ‘emissions trading’ mechanisms whereby one actor is permitted to continue emitting by paying another to reduce their emissions by an equivalent amount. Clearly, in a net-zero state there would be no such offsets available – all possible emissions reductions would have been implemented, so no-one would have such ‘avoidance offsets’ to sell. But during the transition to Net Zero there is a danger that such offsets will continue to be a distraction, and that the resort to them could perpetuate injustice. To date the establishment of markets in avoidance offsets has generated, and been plagued by, a series of problems that have tended to prolong emissions rather than stimulate their reduction.[[35]](#endnote-35) Many offsets have merely repackaged or double-counted existing or already planned emissions reductions, rather than generating new (or ‘additional’) action. There is also a worry that mandatory emissions markets are likely to mean that rich actors can afford to pay to sustain their emissions, while the very poor cannot, even if carbon is priced lower than it ought to be on such markets. Carbon markets are thus often criticised as providing a licence to pollute for the wealthy, but more pain for the poor.[[36]](#endnote-36) The notional arguments presented in favour of such avoidance offsetting focus on economic efficiency, rather than justice, and more narrowly lean on an entirely instrumental case that such mechanisms direct funding towards desirable measures.

This latter argument has been widely adopted by advocates of NETs, as a means to direct funding to assist the development and deployment of such technologies. But tethering the development of NETs to carbon prices in emissions trading markets would be far from socially optimal, and could not guarantee either Net Zero itself, or ‘narrow convergence’. Using carbon prices alone to drive the development of NETs could be expected to channel investment to more limited, but less costly forms of removal, and would guide their deployment according to the ability to pay, rather than the underlying environmental or social need. The result of such an approach would most likely be too little investment in NETs to achieve Net Zero, but by slowing emissions reductions, could equally imply more reliance on NETs than desirable for narrow convergence. More generally, policy-makers should beware that while Net Zero incorporates a notional ‘offset’ or counter-balance between residual emissions and removals, this does not need to rely on a market mechanism of offsetting at all, and that any offsetting mechanism that permits trading of *avoidance* offsets is likely to prove counter-productive to the goal of narrow convergence Net Zero. This is a fundamental shortcoming of most current efforts to promote carbon trading, including the high-profile international Taskforce on Scaling Voluntary Carbon Markets established by Mark Carney.[[37]](#endnote-37)

A further argument in favour of narrow convergence may be that of overall cost to society. Although some NETs may be achieved at low costs, their large scale deployment is likely to be very expensive.[[38]](#endnote-38) If so, delivering narrow convergence is also normatively preferable to broad convergence on grounds of cost. Note that in assessment models and politics, the social benefits of accelerated mitigation are frequently undervalued, and the costs of future NETs discounted. As a result, the overall costs of broader convergence are made to appear lower than they really are. This point is even more pressing if the additional costs of broad convergence are likely to be disproportionately shouldered by already disadvantaged groups or by future people.

The Distribution of Side-Effects

We have seen that Net Zero could in principle (on the strategy that we have called broad convergence) involve a large quantity of residual emissions, matched by a heavy reliance on NETs. While both narrow and broad convergence deliver on Net Zero, we have already suggested several reasons for favouring the narrow strategy, maintaining a modest set of residual emissions and granting priority in their use to the global poor. Residual emissions would then be linked to subsistence-related (rather than luxury) projects. Here we propose another significant reason for favouring narrow convergence. This suggests that the social costs of both continuing emissions and NETs will be far higher if we pursue a pathway of broad convergence, and far lower if we pursue narrow convergence instead.

Let us concentrate first on emissions. Although the extraction and consumption of fossil fuels has powered development and ‘modernisation’ over the past two centuries, we have become increasingly aware of the multiple problems exacerbated by the extraction and burning of fossil fuels. The more of them people continue to burn, the more they will experience not only the political and security problems but also the massive health effects associated with their use. Particulate pollution from the use of coal and oil poses an enormous threat to physical health in many countries. Moreover it disproportionately affects the poor, both within and between countries.[[39]](#endnote-39) We can say the same of extraction, and not only use, since the negative impacts of coal-mining,[[40]](#endnote-40) oil and gas pipelines,[[41]](#endnote-41) and refineries,[[42]](#endnote-42) as well as traffic pollution[[43]](#endnote-43) and aircraft noise,[[44]](#endnote-44) have all been demonstrated to fall more heavily on disadvantaged communities, including the domestic poor and / or disadvantaged ethnic groups. Meanwhile in many countries dependence on fossil fuel extraction and export has been associated with a lack of political inclusion and even repression.[[45]](#endnote-45) In other words not only the climate impacts, but also the wider socio-economic burdens of fossil fuel extraction, distribution, processing and use all contribute to environmental and political injustice. The tighter the convergence involved in net-zero policies, the more these injustices can be reduced.

A parallel point can be made on the NET side of the equation. The technologies in question have generally yet to be widely deployed, and so the relevant notes of caution are necessarily more speculative in this case. Nonetheless we can identify or anticipate many similar concerns associated with the resource flows involved. Some carbon removal interventions, to be sure, appear likely to have limited undesirable side-effects, albeit these options are typically either limited in scale (as in the case of peat-bog or salt-marsh restoration) or raise concerns about verification and the permanence of removals (as in the case of soil carbon sequestration). But the problems associated with more scalable and verifiable techniques are manifold. Carbon forestry, for instance, has long raised justice concerns regarding the impacts of forest management on indigenous and subsistence users of forests,[[46]](#endnote-46) while the production of biomass for energy use and biofuels has been associated with problems of land-use change, land-grabbing, and food insecurity,[[47]](#endnote-47) with particularly severe impacts on women. The land requirements associated with broad convergence Net Zero strategies – especially those heavily reliant on BECCS - are orders of magnitude larger than those that generated concern over the impacts of biofuels on food security during the 2000s. Alternative technologies also raise concerns. Direct Air Capture would require significant energy inputs, and in some configurations could also generate significant water demands in water-scarce environments.[[48]](#endnote-48) Enhanced weathering – through the spreading of basic or ultrabasic rock dust – could be done at a small scale using existing waste materials, but at a larger scale would impose demands for additional mining and energy requirements for grinding.[[49]](#endnote-49) BECCS and DAC both also imply a need for pipelines for CO2 transmission to storage[[50]](#endnote-50), which might be expected to generate similar patterns of impact and public concern as oil and gas pipelines. The overall consensus is that no individual NET could meet likely demands alone, and that each has problems/impacts that would grow with scale.[[51]](#endnote-51) A portfolio of different technologies is likely to be preferable, as well as more feasible, but in light of these socio-economic impacts, the smaller the overall requirement for NETs the better.

To put things more positively, by contrast, even though low-carbon energy technologies are not immune from distributed environmental and social impacts, reducing emissions could be expected to generate multiple net co-benefits, including health and other benefits which have historically been poorly considered in climate policy and modelling.[[52]](#endnote-52) More active transport options (such as walking and cycling, where feasible) can be a stimulant to greater health and well-being, in which the benefits of increased physical activity can be expected to far outweigh the risks of accidents.[[53]](#endnote-53) Better home insulation can reduce energy poverty, excess winter deaths, and respiratory problems.[[54]](#endnote-54) Globally, the fine particulates generated by fossil fuel combustion result in over 10 million deaths per year, mainly in China and India[[55]](#endnote-55), and are a major – though often unaccounted - social cost associated with fossil fuel use. The transition away from fossil fuels, if managed properly, offers the potential to offer many skilled jobs: wind, wave and solar could sustain many more jobs, for instance, than are currently sustained by the fossil fuel industry.[[56]](#endnote-56) As mentioned above, it could also reduce some of the political maladies associated with fossil fuel extraction in many parts of the global South. Renewable energy sources are less associated with conflict within and between states, not least insofar as they are less geographically concentrated than oil and gas reserves.[[57]](#endnote-57) Subject to adequate just transition policies, new green jobs could offer citizens greater opportunities for economic autonomy and political voice. None of this is to suggest that poorly designed emissions reduction programs could not also have negative social or distributional consequences. But these could be managed with good policy design, and would likely pale in comparison to the impacts of the large-scale continued fossil fuel use that is licensed by the broad convergence strategy.

After Net Zero

Assume that the world does get to global Net Zero, eventually. We all breathe an enormous sigh of relief. All being well, the climate has been stabilized. Global temperatures can now be expected to remain relatively stable or even decline slowly for centuries to come. Is the project of achieving climate justice complete, or would major issues remain to be resolved? We want to sound one final note of caution, by pointing out that major decisions about climate justice would remain even in a Net Zero world. In that sense, Net Zero is a major intermediate goal of climate justice, but by no means the only goal. We would still face major questions, for instance, about temperature targets. Having achieved Net Zero and stabilised temperatures, what should our long-term goal be? Returning to and keeping within +1.5°C in perpetuity? Or should we try to get back to 0°C, the pre-industrial baseline? +1.5°C, after all, represents a ceiling if we want to avoid major negative environmental impacts consequent on climate change; but it should be possible in principle to go further.

Whether we chose to do so would presumably depend on complex calculations about the costs (and benefits) of remaining at +1.5, compared to the costs (and benefits) of reducing warming still further. Plausibly, ethical analysis here would involve a reckoning of the relevant interests not only of human beings, including future people, but also of members of other species (and perhaps of the existence value of vibrant and resilient ecosystems). And regardless of the choices made, there would remain significant issues of adaptation justice, which would demand reflection on the distribution of moral and legal liabilities for the costs of adapting to an already changed climate. There would also be questions of compensation to resolve, since climate impacts on human well-being are already with us, and given, moreover, that even the threat of climate change can be seen as a form of harm itself, undermining people’s commitment to and faith in the projects that matter to them.

If the world has followed a pathway of rapid emissions reductions and narrow convergence, temperatures may even remain within +1.5°C. But it is likely that some degree of climate repair or restoration would nevertheless be seen as desirable, even if this meant lowering global temperatures further. In this case, we would stress that the better the efforts to achieve a narrow convergence, the greater would be the remaining capacity for negative emissions to be directed to such a goal without unacceptable environmental or justice implications.

In considering such futures, as well as conventional issues of harm and reparation (Who is responsible? Who should pay?), we might also be driven to consider wider questions of repair and restoration to the earth’s ecosystems – and deeper questions of what exactly repair might mean in this context. Repair can be understood narrowly and instrumentally as an intervention to restore the functioning of an object or system. From the perspective of climate science broadly construed, such restoration might be achieved by returning atmospheric greenhouse gases to pre-industrial levels. But experiences in other arenas of repair indicate that practitioners also frequently understand repair in relational and non-instrumental ways, as an activity that centrally involves care for and attachment to the subject of repair. That understanding would preclude treating the object(s) of repair purely in such an objective and instrumental manner. In the context of the climate, reflection on the meaning of repair might even mean a deeper questioning of whether the entity in need of repair is indeed the ‘climate system’, or the relationship between humans and the Earth, understood in the context of the interwoven histories of colonialism, industrialisation and climate change.[[58]](#endnote-58) If so, an especially valuable side-effect of the achievement of Net Zero might be the beginning of a wider conversation about humanity’s place within earth’s ecosystems.

Conclusion

In this paper we have given a cautious welcome to the growing consensus on the importance of committing to Net Zero. Net Zero, as we have shown, is a precise goal in some ways (insofar as it calls for emissions and removals to be clearly matched, for example), but vague or ambiguous in others. Since Net Zero is a *balance* between emissions and removals, the target of Net Zero emissions by 2050 does not place any strict limit on cumulative emissions prior to that date; and it does not place any strict limit on residual emissions or on the extent of removal offsets. It also does not involve commitment to any specific temporal distribution of mitigation efforts, or indeed to any specific distribution of mitigation efforts between different actors.[[59]](#endnote-59) Those will be hugely important political questions in the years to come, with powerful interests served better by some answers compared to others. All of this amounts to saying that there are many different conceivable Net Zeros, and that apparent convergence around the Net Zero goal should not distract us from the fact that many of the most important political decisions still remain to be made, and that many of the most important distributive and social impacts still remain to be determined.

Indeed we have argued that there are strong reasons of climate justice for favouring some versions of Net Zero over others. We have abundant reason to favour a Net Zero strategy in which those who can reasonably bear the burden of doing so act to pursue early and aggressive mitigation policies, rather than leaving the most important contributions to be made much later, or by others who can scarcely afford to bear the burdens of doing so. We also have reason to favour a Net Zero strategy in which we place the lion’s share of our faith in known emissions reduction techniques, rather than being heavily reliant on as-yet unproven Negative Emissions Techniques. A commitment to Net Zero is a commitment to balancing a see-saw, in which residual emissions are balanced by carbon removals, achieved via various Negative Emissions Techniques. In principle Net Zero might mean two elephants on a seesaw, or it might mean two mice. We have argued that, while some emissions should certainly be treated as residual, it is best to pursue a strategy in which residual emissions are modest, and in which they are largely earmarked for the poor and vulnerable, and in which reliance on carbon removals via Negative Emissions Techniques is also correspondingly modest – thus putting the see-saw (of our societies and polities) under minimal stress. By pursuing a pathway of what we have called narrow convergence, we will have the greatest chance of achieving climate stability without exacerbating existing socio-economic problems and North-South inequalities.

1. While we use ‘NETs’ here, the terms ‘Greenhouse Gas Removal’ or ‘Carbon Dioxide Removal’ are also sometimes used to refer to the same basic basket of techniques for capturing greenhouse gases (and particularly CO2) from the atmosphere and sequestering them for prolonged periods of time. [↑](#endnote-ref-1)
2. Intergovernmental Panel on Climate Change, *Special Report: Global Warming of 1.5°C* (2018): 24. [↑](#endnote-ref-2)
3. I. Stoddard, K. Anderson, S. Capstick, W. Carton, J. Depledge, K. Facer, et al, “Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?” *Annual Review of Environment and Resources* Vol. 46 Issue 1 (2021): 653-689. [↑](#endnote-ref-3)
4. Nauels, Alexander, Johannes Gütschow, Matthias Mengel, Malte Meinshausen, Peter U. Clark, and Carl-Friedrich Schleussner. "Attributing long-term sea-level rise to Paris Agreement emission pledges." *Proceedings of the National Academy of Sciences* 116.47 (2019): 23487-23492. [↑](#endnote-ref-4)
5. Peter Healey, Robert Scholes, Penehuro Lefale, and Pius Yanda, "Governing net zero carbon removals to avoid entrenching inequities." *Frontiers in Climate* 3 (2021): 2. [↑](#endnote-ref-5)
6. Lamb, W. F., G. Mattioli, S. Levi, J. T. Roberts, S. Capstick, F. Creutzig, J. C. Minx, F. Müller-Hansen, T. Culhane and J. K. Steinberger. "Discourses of climate delay." *Global Sustainability* 3 (2020): e17. [↑](#endnote-ref-6)
7. McLaren, D., and N. Markusson. "The co-evolution of technological promises, modelling, policies and climate change targets." *Nature Climate Change* 10.5 (2020): 392-397. [↑](#endnote-ref-7)
8. Lamb et al, "Discourses of climate delay"; Oreskes, N. and E. M. Conway. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (London, Bloomsbury Press, 2011). Norgaard, K. M., "Climate Denial and the Construction of Innocence: Reproducing Transnational Environmental Privilege in the Face of Climate Change." *Race, Gender & Class* 19.1/2 (2012): 80-103. Aklin, M. and M. Mildenberger, *Prisoners of the Wrong Dilemma.* *Global Environmental Politics* 20.4 (2020): 4-27. [↑](#endnote-ref-8)
9. Lamb et al, "Discourses of climate delay." [↑](#endnote-ref-9)
10. Gardiner, S. M., *A Perfect Moral Storm: The Ethical Tragedy of Climate Change* (Oxford, Oxford University Press, 2011). [↑](#endnote-ref-10)
11. For a discussion of fair burden-sharing within global climate justice, see [author]. [↑](#endnote-ref-11)
12. W. Burns and S. Nicholson, “Bioenergy and carbon capture with storage (BECCS): the prospects and challenges of an emerging climate policy response,” *Journal of Environmental Studies and Sciences* Vol. 7 Issue 4 (2017): 527-534. [↑](#endnote-ref-12)
13. Richard Black, Steve Smith and Thomas Hale, “Net zero: despite the greenwash, it’s vital for tackling climate change,” *The Conversation*, May 10th 2021. [↑](#endnote-ref-13)
14. Intergovernmental Panel on Climate Change, *Special Report: Global Warming of 1.5°C*; Anderson, K., J. F. Broderick and I. Stoddard, "A factor of two: how the mitigation plans of ‘climate progressive’ nations fall far short of Paris-compliant pathways." *Climate Policy* 20.10 (2020): 1290-1304. Smith, S. M., "A case for transparent net-zero carbon targets." *Communications Earth & Environment* 2.1 (2021): 24. [↑](#endnote-ref-14)
15. Note that there are other important ambiguities around measurement. Is Net Zero meant to be a target for carbon emissions, or for greenhouse gas emissions more broadly? What is the baseline against which Net Zero operates? If a country preserves a natural sink, should this count as part of its national contribution towards the overall goal of Net Zero? If existing sinks are taken as part of our baseline, their enhancement or expansion could still count as a contribution towards Net Zero, but their preservation would not. Scientific analysis tells us that Net Zero can lead to temperature stabilisation or even decline (Joeri Rogelj, Oliver Geden, Annette Cowie and A. Reisinger, "Net-zero emissions targets are vague: three ways to fix." *Nature* 591 (2021): 365-368; Matthews, H. D. and A. J. Weaver, "Committed climate warming." *Nature Geoscience* 3.3 (2010): 142-143). But this analysis assumes a continued role for natural sinks, in addition to any artificial and enhanced sinks counted in Net Zero targets. For politicians to include the preservation of natural sinks in their climate target would therefore represent a kind of ‘double-counting’ which could even shift the outcome of Net Zero from a slow temperature decline, to a continuing temperature increase. Resolving such questions is beyond our scope here, but they cannot be ignored. [↑](#endnote-ref-15)
16. Dyke, J., R. Watson, and W. Knorr. "Climate scientists: concept of net zero is a dangerous trap." *The Conversation* 22nd April 2021. Anderson, K. and G. Peters, "The trouble with negative emissions." *Science* 354.6309 (2016): 182; Larkin, A., J. Kuriakose, M. Sharmina and K. Anderson (2017). "What if negative emission technologies fail at scale? Implications of the Paris Agreement for big emitting nations." *Climate Policy* 18.6 (2018): 690-714. [↑](#endnote-ref-16)
17. Beck, S. and M. Mahony, "The politics of anticipation: the IPCC and the negative emissions technologies experience." *Global Sustainability* 1 (2018): e8; Van Beek, L., M. Hajer, P. Pelzer, D. van Vuuren and C. Cassen, "Anticipating futures through models: the rise of Integrated Assessment Modelling in the climate science-policy interface since 1970." *Global Environmental Change* 65 (2020): 102191. [↑](#endnote-ref-17)
18. Markusson, N., M. Dahl Gjefsen, J. C. Stephens and D. Tyfield, "The political economy of technical fixes: The (mis)alignment of clean fossil and political regimes." *Energy Research & Social Science* 23 (2017): 1-10; McLaren and Markusson. "The co-evolution of technological promises, modelling, policies and climate change targets." [↑](#endnote-ref-18)
19. Fuss, S., Canadell, J. G., Peters, G. P., Tavoni, M., Andrew, R. M., Ciais, P., & Yamagata, Y., “Betting on negative emissions.” *Nature Climate Change*, 4.10 (2014): 850-853; Low, S. and S. Schäfer, "Is bio-energy carbon capture and storage (BECCS) feasible? The contested authority of integrated assessment modeling." *Energy Research & Social Science* 60 (2020): 101326; McLaren, D. (2020). "Quantifying the Potential Scale of Mitigation Deterrence from Greenhouse Gas Removal Techniques." *Climatic Change* 162 (2020): 2411–2428; Haikola, S., J. Anshelm and A. Hansson, "Limits to climate action - Narratives of bioenergy with carbon capture and storage." *Political Geography* 88 (2021): 102416. [↑](#endnote-ref-19)
20. Biermann, F. and I. Möller, "Rich Man’s solution? Climate engineering discourses and the marginalization of the Global South." *International Environmental Agreements: Politics, Law and Economics* 19.2 (2019): 151-167; McLaren, D., & Burns, W. (2021). It Would Be Irresponsible, Unethical, and Unlawful to Rely on NETs at Large Scale Instead of Mitigation. In B. Mayer & A. Zahar (Eds.), *Debating Climate Law* (pp. 241-256). Cambridge: Cambridge University Press. doi:10.1017/9781108879064.019. [↑](#endnote-ref-20)
21. See e.g. https://india.mongabay.com/2021/05/where-are-indian-states-participating-in-net-zero-debate/# [↑](#endnote-ref-21)
22. See <https://www.climatechangenews.com/2019/06/14/countries-net-zero-climate-goal/> for current pledges, and also information on role of international offsets. [↑](#endnote-ref-22)
23. Darrel Moellendorf, *The Moral Challenge of Dangerous Climate Change* (Cambridge: Cambridge University Press, 2014), chapter 5. [↑](#endnote-ref-23)
24. McLaren, D., "A comparative global assessment of potential negative emissions technologies." *Process Safety and Environmental Protection* 90.6 (2012): 489-500; Smith, P., S.J. Davis, F. Creutzig, S. Fuss, J. Minx, B. and 35 others, "Biophysical and economic limits to negative CO2 emissions." *Nature Climate Change* 6 (2015): 42; Fuss, S., W. F. Lamb, M. W. Callaghan, J. Hilaire, F. Creutzig, T. and 13 others, "Negative emissions—Part 2: Costs, potentials and side effects." *Environmental Research Letters* 13.6 (2018): 063002; Carton, W., J. F. Lund and K. Dooley, "Undoing Equivalence: Rethinking Carbon Accounting for Just Carbon Removal." *Frontiers in Climate* 3.30 (2021). [↑](#endnote-ref-24)
25. McLaren, “Quantifying Mitigation Deterrence.” [↑](#endnote-ref-25)
26. Carton et al, "Undoing Equivalence." [↑](#endnote-ref-26)
27. Fajardy MA, Köberle AL, MacDowell NI, Fantuzzi AN., *BECCS Deployment: A Reality Check*. Grantham Institute Briefing Paper, 2019. [↑](#endnote-ref-27)
28. Healey, Scholes, Lefale and Yanda, “Governing net zero carbon removals to avoid entrenching inequities,” p. 1. [↑](#endnote-ref-28)
29. Domínguez, Lara, and Colin Luoma. "Decolonising conservation policy: how colonial land and conservation ideologies persist and perpetuate indigenous injustices at the expense of the environment." *Land* 9.3 (2020): 65. [↑](#endnote-ref-29)
30. Authors’ calculation based on Realmonte, G., L. Drouet, A. Gambhir, J. Glynn, A. Hawkes, A. C. Köberle and M. Tavoni, "An inter-model assessment of the role of direct air capture in deep mitigation pathways." *Nature Communications* 10.1 (2019): 3277. Some proponents have suggested that DAC could make multi-gigatonne contributions (eg D. Izikowitz “Carbon Purchase Agreements, Dactories, and Supply-Chain Innovation: What Will It Take to Scale-Up Modular Direct Air Capture Technology to a Gigatonne Scale” *Frontiers in Climate* 2021 Vol. 3 Issue 24. These calculations of energy costs imply that such a scale of deployment may be unlikely, and if achieved, would create serious competition for low carbon energy. [↑](#endnote-ref-30)
31. Eg https://www.carbonbrief.org/analysis-shell-says-new-brazil-sized-forest-would-be-needed-to-meet-1-5c-climate-goal [↑](#endnote-ref-31)
32. Anil Agarwal and Sunita Narain, *Global Warming In An Unequal World: A Case of Environmental Colonialism* (New Delhi: Centre for Science and Environment, 1991): 82-83. [↑](#endnote-ref-32)
33. Henry Shue, “Subsistence Emissions and Luxury Emissions,” *Law & Policy* 15.1 (1993): 39-60. [↑](#endnote-ref-33)
34. Darrel Moellendorf, *The Moral Challenge of Dangerous Climate Change* (Cambridge: Cambridge University Press, 2014), chapter 5. [↑](#endnote-ref-34)
35. Erickson, P., M. Lazarus and R. Spalding-Fecher, "Net climate change mitigation of the Clean Development Mechanism." *Energy Policy* 72 (2014): 146-154; Cames, M., R.O. Harthan, J. Füssler, M. Lazarus, C.M. Lee, P. Erickson and R. Spalding-Fecher, *How additional is the Clean Development Mechanism? Analysis of the application of current tools and proposed alternatives*. Study prepared for DG CLIMA, Oko-Institut, Berlin, 2016; Sovacool, B.K., “Four problems with global carbon markets: a critical review.” *Energy and Environment*, 22.6 (2011): 681-694; Watt, R., "The fantasy of carbon offsetting." *Environmental Politics* (2021): 1-20. [↑](#endnote-ref-35)
36. For good discussions of the ethical worries about emissions markets, see Caney, S. and C. Hepburn, "Carbon trading: unethical, unjust and ineffective?." *Royal Institute of Philosophy Supplements* 69 (2011): 201-234, and Page, Edward, "The ethics of emissions trading." *Wiley Interdisciplinary Reviews: Climate Change* 4.4 (2013): 233-243. [↑](#endnote-ref-36)
37. See: <https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf> [↑](#endnote-ref-37)
38. J. Bednar, M. Obersteiner and F. Wagner **“**On the financial viability of negative emissions” *Nature Communications* 10(1) (2019): 1783. [↑](#endnote-ref-38)
39. Vohra, K., A. Vodonos, J. Schwartz, E. A. Marais, M. P. Sulprizio and L. J. Mickley, "Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem." *Environmental Research* 195 (2021): 110754.; Tessum, C. W., D. A. Paolella, S. E. Chambliss, J. S. Apte, J. D. Hill and J. D. Marshall, "PM2.5 polluters disproportionately and systemically affect people of color in the United States." *Science Advances* 7.18 (2021): eabf4491. [↑](#endnote-ref-39)
40. Bell, S. E. and R. York, "Coal, injustice, and environmental destruction: Introduction to the special issue on coal and the environment." *Organization & Environment* 25.4 (2012): 359-367; Morrice, E. and R. Colagiuri, "Coal mining, social injustice and health: A universal conflict of power and priorities." *Health & Place* 19 (2013): 74-79. [↑](#endnote-ref-40)
41. O'Rourke, D. and S. Connolly, "Just Oil? The distribution of environmental and social impacts of oil production and consumption." *Annual Review of Environment and Resources* 28.1 (2003): 587-617; Whyte, Kyle Powys, “The Dakota Access Pipeline, Environmental Injustice, and U.S. Colonialism.” *Red Ink: An International Journal of Indigenous Literature, Arts, & Humanities*, 19.1 (2017); Braswell, T. H., "Extended Spaces of Environmental Injustice: Hydrocarbon Pipelines in the Age of Planetary Urbanization." *Social Forces* (2021). [↑](#endnote-ref-41)
42. Carpenter, A. and M. Wagner, "Environmental justice in the oil refinery industry: A panel analysis across United States counties." *Ecological Economics* 159 (2019): 101-109; Mah, A. and X. Wang, "Accumulated injuries of environmental injustice: living and working with petrochemical pollution in Nanjing, China." *Annals of the American Association of Geographers* 109.6 (2019): 1961-1977. [↑](#endnote-ref-42)
43. Clark, Lara P., Dylan B. Millet, and Julian D. Marshall. "National patterns in environmental injustice and inequality: outdoor NO2 air pollution in the United States." *PloS one* 9.4 (2014): e94431; Barnes, Joanna H., Tim J. Chatterton, and James WS Longhurst. "Emissions vs exposure: Increasing injustice from road traffic-related air pollution in the United Kingdom." *Transportation Research Part D: Transport and Environment* 73 (2019): 56-66. [↑](#endnote-ref-43)
44. Sobotta, Robin R., Heather E. Campbell, and Beverly J. Owens. "Aviation noise and environmental justice: The barrio barrier." *Journal of Regional Science* 47.1 (2007): 125-154; Collins, Timothy W., Shawna Nadybal, and Sara E. Grineski. "Sonic injustice: Disparate residential exposures to transport noise from road and aviation sources in the continental United States." *Journal of Transport Geography* 82 (2020): 102604. [↑](#endnote-ref-44)
45. Michael Ross, “What Have We Learned About the Resource Curse?” *Annual Review of Political Science* 18 (2015): 239-259. [↑](#endnote-ref-45)
46. e.g. Overbeek, W., “Resistance to REDD: Lessons from the Ground.” In Brian Tokar and Tamra Gilbertson (eds) *Climate Justice and Community Renewal* (Taylor and Francis, 2020). [↑](#endnote-ref-46)
47. e.g. Molony, T. and J. Smith, "Biofuels, food security, and Africa." *African Affairs* 109.436 (2010): 489-498. [↑](#endnote-ref-47)
48. Realmonte et al. "An inter-model assessment of the role of direct air capture…”; Smith et al. "Biophysical and economic limits to negative CO2 emissions." [↑](#endnote-ref-48)
49. Renforth, P., "The negative emission potential of alkaline materials." *Nature Communications* 10.1 (2019): 1401; Taylor, L. L., J. Quirk, R. M. Thorley, P. A. Kharecha, J. Hansen, A. Ridgwell, M. R. Lomas, S. A. Banwart and D. J. Beerling, "Enhanced weathering strategies for stabilizing climate and averting ocean acidification." *Nature Climate Change*6.4 (2016): 402-406. [↑](#endnote-ref-49)
50. McLaren, D., "A comparative global assessment of potential negative emissions technologies." [↑](#endnote-ref-50)
51. Fuss et al "Negative emissions—Part 2"; Smith et al "Biophysical and economic limits to negative CO2 emissions." [↑](#endnote-ref-51)
52. A. Workman, G. Blashki, K. J. Bowen, D. J. Karoly and J. Wiseman, “The Political Economy of Health Co-Benefits: Embedding Health in the Climate Change Agenda,” *International Journal of Environmental Research and Public Health* Vol. 15 Issue 4 (20187): 674. [↑](#endnote-ref-52)
53. Mueller, N., D. Rojas-Rueda, T. Cole-Hunter, A. de Nazelle, E. Dons, R. Gerike, T. Götschi, L. Int Panis, S. Kahlmeier and M. Nieuwenhuijsen, "Health impact assessment of active transportation: A systematic review." *Prev Med* 76 (2015): 103-114. [↑](#endnote-ref-53)
54. Ferriman, A., "Excess winter deaths linked to temperatures in cold homes." *BMJ (Clinical research ed.)* 323.7323 (2001): 1207-1207. [↑](#endnote-ref-54)
55. Vohra et al., "Global mortality from outdoor fine particle pollution…” [↑](#endnote-ref-55)
56. Jacobson, Mark Z., Mark A. Delucchi, Mary A. Cameron, Stephen J. Coughlin, Catherine A. Hay, Indu Priya Manogaran, Yanbo Shu, and Anna-Katharina von Krauland. "Impacts of green new deal energy plans on grid stability, costs, jobs, health, and climate in 143 countries." *One Earth* 1.4 (2019): 449-463. [↑](#endnote-ref-56)
57. Månsson, André. "A resource curse for renewables? Conflict and cooperation in the renewable energy sector." *Energy Research & Social Science* 10 (2015): 1-9. [↑](#endnote-ref-57)
58. McLaren, D., "In a broken world: Towards an ethics of repair in the Anthropocene." *The Anthropocene Review* 5.2 (2018): 136-154. [↑](#endnote-ref-58)
59. As we have also noted, in common usage ‘Net Zero’ often does not stipulate whether it applies to CO2 or all GHGs, nor whether the ‘net’/removals part refers to all sinks, or just anthropogenic and enhanced sinks. The answers to these questions will also have serious implications for whether Net Zero stabilises temperatures, and if so at what level). [↑](#endnote-ref-59)