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Climate Change and Reversed Intergenerational Equity: the Problem of Costs Now, for Benefits Later

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Abstract

Climate change is often seen as an issue of intergenerational equity—consumption now creates costs for future generations. However, radical mitigation now would reverse the problem, creating immediate costs for current generations, while the benefits would be primarily for future ones. This is a policy problem, as persuading those living now to bear the cost of changes whose benefits will mostly accrue after their deaths is politically difficult. The policy challenge is then how to temporally match costs to benefits, either by deferring mitigation costs, or by speeding up climatic benefits. Geoengineering may provide some help here, as it might enable climate change to be slowed more immediately, at a lower upfront cost, and allow a greater share of the mitigation and adaptation burden to be passed on to those in the future who will benefit most.

Keywords

intergenerational equity – intergenerational justice – mitigation costs – cost-benefit analysis – geoengineering – negative-emission technologies (NETS) – solar radiation management (SRM)

1 Introduction

Climate change should be an easy problem, and for that reason it is a mysterious one. Even with current scientific knowledge it would be possible for humanity to live in a way that is both sustainable and allows for a high quality

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of life.[1] The techniques to produce energy, food, and pleasure in a sufficient and sustainable way do exist, even for the world's current population. Yet this is not happening—humanity is not yet adopting the measures needed to prevent climate change over the coming decennia from causing extreme and perhaps catastrophic harm. We are not behaving in our own best interests as a species, let alone the best interests of other life forms. The mystery is why.

It is tempting to regard this as an issue of information, will, or special interests: if only people knew the truth, if only those in power cared enough, and if only lobby groups could be combatted, then better policy would be adopted. This leads to ever fiercer attempts to persuade, expose, and confront, as if mitigating climate change is above all a question of winning an argument.

This article suggests a different frame for the question of how to optimize climate policy, and that frame is intergenerational equity. It is common to consider the intergenerational aspect of climate change, but here the usual approach is reversed.[2] I suggest that a fundamental problem for climate policy is that mitigation by emission reductions requires current generations to pay the costs for a benefit that future generations will receive: emission reductions entail sacrifices now, whereas the benefits come primarily in the future.[3]

Perhaps this intergenerational solidarity can be achieved, to some extent, by appealing to the moral sensitivities of the present generation, but any policymaker knows that trying to get one group to pay for the benefits of another is uphill work. It is far easier if the paying group can see that it gets a benefit too, and indeed if it can see that the other beneficiaries are also paying.

Central questions for climate policy are then how to achieve one or both of two things: (i) bring the benefits of climate action forward so that they are experienced now and not over fifty years; (ii) defer the costs of climate action, so that they are not borne to such a great extent by current generations, and are borne more by later ones, while still doing enough to make a reasonable long-term scenario achievable.

1 Stephen Pacala and Robert Socolow, 'Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies', 13 *Science* 968 (2004).

2 E.g. James C. Wood, 'Intergenerational Equity and Climate Change', 8 *Georgetown International Environmental Law Review* 293 (1996); Peter Lawrence, *Justice for Future Generations: Climate Change and International Law* (Cheltenham; Edward Elgar 2014); Inigo Gonzalez-Ricoy and Felipe Rey, 'Enfranchising the Future: Climate Justice and the Representation of Future Generations', 10:e598 *WIREs Climate Change* (2019); Fabian Schuppert, 'Climate Change Mitigation and Intergenerational Justice', 20(3) *Environmental Politics* 303–21 (2011).

3 If not the only fundamental problem; see Stephen M. Gardiner's three storms, in 'A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption' 15(3) *Environmental Values* 397–413 (2006).

This approach may seem counter-intuitive. However, the aim is to bring cost and benefit closer to each other, so that those who are required to give up pleasures, luxuries, or freedoms get something back in the short term—making it more likely that they accept that sacrifice.

This article expands on and explains this argument. It then shows how it casts a positive light on geoengineering as an important element of climate policy. For some of the criticisms of geoengineering—that it is not a fundamental solution but at best a short-to-medium term fix which defers fundamental changes and dumps them in the lap of future generations[4]—become virtues when seen through the lens of reversed intergenerational equity. Geoengineering might allow us to combat the apparent injustice involved in asking the middle-aged of today to make sacrifices for a world that they will barely see.

It should be noted that the above argument is a pragmatic one: it is concerned with the question of how people can be persuaded to take sufficiently effective climate action, and not with what is morally 'right'. Nevertheless, the use of the inherently normative concept of intergenerational *equity* might seem to contradict this.

My decision to use this concept, rather than presenting the argument in the less normative language of incentives, is because intergenerational equity is already an accepted frame for thinking about climate policy. I want to show how, at least for a significant part of the population, its conclusions are less self-evident than is often assumed, and may even lead them to the opposite conclusion from the usual one. However, rather than pitting the two views of intergenerational equity against each other in a philosophical standoff—which would be misguided anyway, given the multi-faceted complexity and context-specificity of the notion of equity—my aim in this article is to lay out the factors that could lead to this 'reversed' perception and offer some thoughts on how they might be addressed. The way that this normative concept can be used is one of the elements that helps me build an argument about what might *work*.[5]

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4 Duncan McLaren and William Burns, 'It Would Be Irresponsible, Unethical, and Unlawful to Rely on NETs at Large Scale Instead of Mitigation', in *Debating Climate Law*, edited by Benoit Mayer and Alexander Zahar (Cambridge: Cambridge University Press, forthcoming 2021); Stephen M. Gardiner, 'Is "Arming the Future" with Geoengineering Really the Lesser Evil? Some Doubts about the Ethics of Intentionally Manipulating the Climate System', in *Climate Ethics*, edited by S. M. Gardiner et al. (Oxford: Oxford University Press, 2010); William Burns, 'Climate Geoengineering: Solar Radiation Management and its Implications for Intergenerational Equity', 4 *Stanford Journal of Law, Science and Policy* 39–55 (2011); Anders Arvesen, Ryan Bright, and Edgar Hertwich, 'Considering Only First-Order Effects? How Simplifications Lead to Unrealistic Technology Optimism in Climate Change Mitigation', 39 *Energy Policy* 7448 (2011).

5 Other 'pragmatic' approaches to climate include John Broome, *Climate Matters* (New York: Norton, 2012); Eric Posner and David Weisbach, 'International Paretianism: A Defence', 13 *Chicago Journal of International Law* 347 (2013).

Accordingly, I first explain why climate change action can be seen as a problem of (reversed) intergenerational equity, and then why this implies support for geoengineering techniques.

2 Climate Change and Intergenerational Equity

2.1 *Intergenerational Equity in Transactional Terms*

It is conventional to look at climate change through the lens of intergenerational equity. The emphasis is on the harm done by the current inhabitants of the planet, and the consequences that this will have for future ones.[6] Yet the idea of equity—or justice—is complex, and is rarely fully unpacked in these discussions.[7] Implicitly, there is assumed to be a relationship of obligation between generations. On one common view, the obligation is violated where one generation consumes more than its 'fair share'—if it leaves the world more depleted than it found it.[8] Equitable behaviour would consist in living in a way that could be continued indefinitely.

However, societies are constantly changing, socially, technologically, and environmentally, and always have been. No generation has ever left the world as it found it, and each age has different needs and ways of using the resources it finds. To construct an ideal based on the possibility of continuing without change is unrealistic and undesirable, given that change is a fundamental and unavoidable aspect of human life and society. Similarly, an ideal based on not harming the environment would be largely meaningless, since every age both degrades and improves the world, and sometimes one and the same change can be seen both ways.

There is thus something to be said for regarding equity, and sustainability, in more dynamic and relational terms.[9] Rather than asking, 'Could we carry on like this for ever?', we ask: 'What are the consequences of what we do for those who come next?'

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6 See works in note 2, supra; Edward Page, 'Intergenerational Justice and Climate Change', 47 *Political Studies* 53–66 (1999).

7 Page, ibid.

8 Brian Barry, 'The Ethics of Resource Depletion', in *Democracy, Power and Justice*, by Brian Barry, (Oxford: Clarendon, 1989), at 511–25; Brian Baxter, *Ecologism* (Edinburgh: Edinburgh University Press, 1999).

9 Alexander Zahar, 'Climate Law, Environmental Law, and the Schism Ahead' (2020), available at <https://ssrn.com/abstract=3536096>.

This approach to intergenerational equity would take account of both costs and benefits for current and future generations. It would suggest that we should not pass on costs to future generations for the benefits and pleasures that we are now enjoying—or at least that such discrepancies should be examined critically in light of their consequences.[10] But it would also suggest that where future generations receive benefits from actions taken now, they should reasonably also contribute to the costs. Instead of looking at intergenerational issues through a simple 'polluter pays' perspective, we would adopt a more nuanced one, which takes account of benefits and change, and incorporates the 'beneficiary pays principle' too—a form of intergenerational solidarity.[11] This approach (who is paying for whose benefits?) would be about intergenerational redistribution.

One view of climate change, through this lens, would be that, on current trajectories, future generations will face high costs as a result of the careless overconsumption of those living now. Future generations will face, at worst, a catastrophic climate situation, or they will have, at best, to engage in mitigation and adaptation at such scale and with such urgency that the costs will be enormous. We are enjoying benefits while expecting the future to pay for them. That is the conventional view.

However, this transactional view of intergenerational equity can also be turned around. To call for mitigation of climate change through emission reductions now is to ask current generations to make material sacrifices when the real benefits of those sacrifices will accrue to those who come later.[12] It allows later generations to free-ride on the sacrifices of those currently living. Acting to correct one justice problem creates another one that is precisely the reverse.[13] When faced with the argument, 'You are harming the future', current generations may respond, 'But if we give up our pleasures then the future will be harming us'.

One argument does not directly rebut the other; it just leaves a policy impasse. Each choice asks one generation to suffer more so that another may

10 Page, supra note 6; Peter Lawrence and Lukas Kohler, 'Representation of Future Generations Through International Climate Litigation: A Normative Framework', 60 *German Yearbook of International Law* 639–66 (2017).

11 Schuppert, supra note 2; Zahar, supra note 9.

12 Mark Jaccard, John Nyboer, and Bryn Sadownik, *The Cost of Climate Policy* (Vancouver: UBC Press 2002), at xiv; Christopher Armstrong, 'Climate Change and Justice', in *Oxford Research Encyclopedias: Politics*, edited by W. R. Thompson (Oxford: Oxford University Press, 2017); Simon Caney, 'Climate Change, Intergenerational Equity and the Social Discount Rate' 13(4) *Politics, Philosophy and Economics* 320–42 (2014).

13 Page, supra note 6;.

suffer less. When those currently living ask, 'Why should we pay so that they can live more comfortably after we've gone?', policymakers could try to provide a normative answer, but they could also address the underlying grievance to see how the cost-benefit discrepancy could be reduced. The latter—trying to avoid the dilemma—may be more effective.

2.2 *The Cost-Benefit Discrepancy in Climate Change*

The situation above arises because mitigation brings immediate material and lifestyle costs, while its benefits for the climate come only later.[14] A serious turn away from fossil fuels, meat-eating, or flying, would have short-term economic impacts, as well as depriving those alive now of pleasures and freedoms they are accustomed to. Many would experience the reduced travel, reduced meat, and more expensive energy as diminishing their wealth and quality of life.[15] Moreover, the major costs of transitioning to a low-emission lifestyle are in the process of transition itself. Sustainable energy and food are not inherently more expensive or scarce, and a green economy will ultimately be more welfare-enhancing, but moving from current practices to new ones entails closures, unemployment, retraining, social and cultural consequences, and so on: the challenge of reduced emissions is in the change and not in the new way of life.[16]

The timing of that change determines who pays for it. This is true in two ways: those who make the change will make the sacrifices, but also, if the change is slower, it is likely to be easier. Not only are socioeconomic adaptations less disruptive when they can be made gradually,[17] but with time it is likely that technology will, to some extent, make the requirements of sustainability and low emissions easier to meet.

On the other hand, the major benefits of these actions would accrue in the future. Although climate change is alarmingly fast, for most middle-aged people the chances are good that, even on current trajectories, their climate and

14 Jaccard et al., supra note 12; Bruce Arnold, 'How Policies to Reduce Greenhouse Gas Emissions Could Affect Employment', Congressional Budget Office, Economic and Budget Issue Brief (2010); Kenneth Gillingham and James H. Stock, 'The Cost of Reducing Greenhouse Gas Emissions', 32(4) *Journal of Economic Perspectives* 53–72 (2018); Darrel Moellendorf, 'Justice and the Assignment of the Intergenerational Costs of climate Change', 40(2) *Journal of Social Philosophy* 204–24 (2009).

15 Jaccard et al., supra note 12; Moellendorf, supra note 14.

16 Samuel Fankhaeser, Friedel Sehlleier, and Nicholas Stern, 'Climate Change, Innovation and Jobs', 8(4) *Climate Policy* 421–29 (2008).

17 Jan Rotmans and Rene Kemp, 'Managing Societal Transitions: Dilemmas and Uncertainties: The Dutch Energy Case-Study', OECD Workshop on the Benefits of Climate Policy: Improving Information for Policy Makers, ENV/EPOC/GSP(2003)15/FINAL (2003).

environment will remain broadly recognizable for the remainder of their life. The more nightmarish scenarios of dramatic temperature increase or weather change, ecosystem collapse, and so on, are usually projected to occur in the second half of the twenty-first century.[18] The Paris Agreement builds its policy construct with reference to the year 2050, after which it implicitly imagines—in line with the IPCC—negative emissions as being necessary in order to prevent the planet from moving into a new and catastrophic phase.[19]

2.3 *The Problem of Slow Effects*

The underlying problem is that the effects of emissions are cumulative and long-lasting. This means that the effects of both emissions and mitigation are slow, but gradually increase: a structural net reduction or increase has a limited effect in the short term, but corresponds to an ever-greater climate difference as the years go by. To put it another way, the best-case and worst-case scenarios diverge over time.[20]

Hence truly significant emission reductions in the short term—such as are not being made, but are advised—would have a limited effect in the coming twenty to thirty years, but ever greater ones in the longer term, as the worst-case scenario is avoided. The benefits, in short, would be primarily some time away, while the major costs, which occur when the transition to a new kind of society is made, would be more immediate.

This time disparity, between mitigation now and significant benefits over thirty, fifty, or seventy years may not seem so huge. However, for those who need to be persuaded of the need to take action, it is beyond their horizon. They are, above all, those with wealth and power in the richer countries of the world, the people who may be expected to take the lead and assume the greatest proportion of the costs. In these countries, the median age is around forty (the average is not much different), and the age of the median voter is of course much higher.[21] Moreover, power and money are disproportionately concentrated among the older-than-average. In order to achieve significant change

18 IPCC, *Climate Change 2014: Synthesis Report: Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by R. K. Pachauri and L. A. Meyer (Geneva: IPCC, 2014), 151.

19 Alastair Neil Craik and William Burns, 'Climate Engineering under the Paris Agreement', 43 *Environmental Law Reporter* 11113 (2019); Duncan McLaren, David Tyfield, Rebecca Willis, Bronislaw Szerszynski, and Nils Markusson, 'Beyond 'Net-Zero': A Case For Separate Targets For Emissions Reduction and Negative Emissions', 1 *Frontiers in Climate* 4 (2019).

20 IPCC, supra note 18.

21 Hannah Ritchie, 'Age Structure', published online at OurWorldInData.org (2019), <https://ourworldindata.org/age-structure>.

in climate policy, those who need to be persuaded are primarily between forty and seventy years old. In the developing world median (and average) ages are lower, but leaders are even more influential, and, once again, power is concentrated in the above-middle-aged.

That is not to deny the intragenerational diversity of the world, or the moral claims, or the environmental and material needs, of the world's young and poor. These create global policy tensions and questions of intragenerational justice that exist alongside the challenges discussed here. However, the power to change climate policy lies overwhelmingly with the world's wealthy middle-aged and elderly. They are among those most benefitting from the status quo and least likely to be harmed by climate change in the next few decades.

All this means that to call for dramatic action on climate now is to appeal to a group of power-holders who will not see the major benefits of their actions. Many of them may see the year 2050, but, when they do, the future will be less prominent to them than the past, and the moment at which climate change is likely to become an existential threat to humankind will not be part of their lives. Radical mitigation now, a fundamental change in the amount of global warming that we cause, is asking these people to give up what they have become used to, the foundations of their lifestyle, in order to prevent events that they will never see. They must pay, so that others will benefit in the future.

2.4 *Policy Implications*

There are, of course, a number of arguments why this demographic group should, and despite everything may, take meaningful climate action. Moral arguments of various forms have been made, and have considerable persuasive force.[22] People may be influenced by the opinions of their children and grandchildren. It is certainly the case that many individuals, for various reasons, do care about what happens in the world after their death. Others find that the community, identity, and practices of an ecological lifestyle bring them more satisfaction than a high-consumption one does. They, in a sense, gain in quality-of-life from the material sacrifices they make. A major plank of any intelligent climate policy should be to try to grow the membership of this group—demonstrating and spreading the low-carbon ways to pleasure.

Nevertheless, any policymaker knows that trying to persuade one group to pay for benefits received by another is an uphill struggle, even with plausible arguments for virtue on one's side. It is far easier if the paying group can see a more concrete self-interest in their payments than mere warm feelings. That is

22 Gardiner, supra note 3; John Barry, Arthur P. J. Mol, and Anthony R. Zito, 'Climate Change Ethics, Rights, and Policies: An Introduction', 22(3) *Environmental Politics* 361–76 (2013).

not to say that self-interest is the only driver of action, but that on almost any model it is an important one.[23]

From a pragmatic, rather than a normative, perspective, then, for any significant improvement in climate policy, it will help if the costs and benefits of mitigation are better aligned. This has two aspects: (i) how could the benefits be made more immediate so that those who pay the initial costs of mitigation see more return on their investment; and (ii) how could the short-term costs be reduced, or deferred, so that those who receive most of the benefits, and who would otherwise live in an age of catastrophe, pay more of the costs, while those living now, who have to be persuaded to act, pay less?

This approach does not imply doing nothing. A failure to take any climate action now would reduce current costs, but it would leave future generations in a catastrophic situation that they would be unable to remedy, at least not at the speed that will be required. My aim, rather, is to consider policy approaches that are compatible with long-term positive climate outcomes but that distribute the costs of climate action more equitably between generations and do not place the entire cost burden on the generation living now. Future generations will enjoy the benefits of the world's ongoing industrialization—the wealth, knowledge, infrastructure, and freedoms that it brings them—which were developed by the generations before them. It is reasonable that they bear some of its costs, in particular the environmental ones, which are significant. The challenge, therefore, is to distribute those costs across time, without delaying action to the point when excessive irreversible climate harm is done.[24]

3 Aligning Costs and Benefits: Using Geoengineering

3.1 *Aligning Costs and Benefits*

There may be different ways of aligning the costs and benefits of climate action. The simplest aspect is reducing the short-term costs. For example, more-efficient renewable energy sources, or better ways of reducing consumption, would help. It is hard to see any objection to these. Nevertheless, increasing efficiency in this way tends to be incremental, and the associated reduction in

23 See e.g. Dennis Chong, Jack Citrin, and Patricia Conley, 'When Self-Interest Matters', 22(3) *Political Psychology* 541 (2001); Adam Levine and Reuben Kline, 'When Does Self-Interest Motivate Political Engagement? The Case of Climate Change' (12 March 2017), available at <https://ssrn.com/abstract=2931842>.

24 See further Edward A. Page, 'Intergenerational Justice of What: Welfare, Resources or Capabilities?' 16(3) *Environmental Politics* 453–69 (2007).

transition costs therefore slow and limited. Deferring costs—one of the planks of the argument here—is somewhat harder, although perhaps financial instruments could play a role. Hardest of all is speeding up benefits: even zero emissions tomorrow would only take full effect gradually.

Geoengineering, the artificial manipulation of the climate, might change this picture. Below I will focus on its two major forms—negative-emission technologies (NETs), which remove greenhouse gases from the atmosphere, and solar radiation management (SRM), which shields the world from sunlight or increases its albedo, thus cooling it—and how they could potentially reduce the cost-benefit discrepancy.[25] While contested and unperfected, these techniques, if they could be made to work, have two characteristics of interest: (i) they may potentially allow a faster stabilization of the climate; i.e. more benefits now; and (ii) some forms of geoengineering are potentially cheaper than emission reductions. Although often considered, at best, as a way to delay, rather than stop, climate change, these techniques could be combined with more structural and expensive mitigation that could then—thanks to the time bought by geoengineering—be achieved more slowly; i.e. quick, cheap measures now, expensive ones later. Costs could thus be deferred.

Conceivably, therefore, geoengineering could rebalance the cost-benefit discrepancy from both sides, reducing immediate costs and accelerating benefits.

3.2 *Negative-Emission Technologies*

Clearly, greater cuts in emissions will bring greater short-term effects. However, greater cuts also bring greater costs, so that the problem of cost-benefit discrepancy is not solved. Moreover, there is a limit to how much short-term effect can be achieved with emission reduction. Even a reduction of emissions to zero would leave atmospheric greenhouse gas levels at historic highs. The climatic difference between business-as-usual and zero emissions would not be significant for at least a couple of decades.[26]

NETs offer one way of influencing climate change faster, by removing greenhouse gases from the atmosphere.[27] Were NETs available and useable at a sufficient scale and for a low-enough cost, they would potentially allow for a greater short-term effect on the climate, undoing some of the changes already experienced.

25 Royal Society, *Geoengineering the Climate: Science, Governance and Uncertainty*, Report 10/09, RS1636, September 2009.

26 See IPCC, supra note 18.

27 Duncan McLaren, 'A Comparative Global Assessment of Potential Negative Emissions Technologies', 90(6) *Process Safety and Environmental Protection* 489 (2012); National

Unfortunately, there are no NETs falling into this category at the moment.[28] While it is a fast-developing field of research, with methods often seeing their status fluctuate from 'great hope for the planet' to 'hopeless', and back again, in very little time, it remains the case that all methods currently on the table face critical unsolved problems, whether technological, social, or environmental. NETs that are ready to use are only workable at a small scale, and the ones which might be useable at a climate-impacting scale still require technical advances, cost reductions, or political adjustments, for which no realistic pathway has yet been mapped.[29] Even in combination with radical mitigation, and even if society were prepared to bear considerable costs in order to restore the climate to its past state, there is no currently available way of doing so in the short-to-medium term with NETs.

Nevertheless, to simply assume that what cannot be done now cannot be done in the future, even the relatively near future, is unscientific and ahistorical. At a very general level it is clear that the planet is capable, in different ways, of absorbing CO_2 at a scale that would reduce atmospheric levels: anthropogenic emissions of CO_2 are only a small fraction of the global carbon cycle.[30] Humanity's influence on carbon is at the margins, although no less effective for that. The obstacles to implementing a practical climate-influencing NET scheme are thus not ones of fundamental scientific principle, but of technique, and of politics.[31] That does not mean that these obstacles can be dismissed, or that we can assume that they can be overcome. However, it is the case that technology and politics can proceed in leaps, and what is impossible one year can become possible the next. As is often said in the context of

Academies of Sciences, Engineering, and Medicine, *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda* (Washington, DC: The National Academies Press, 2019) <doi: https://doi.org/10.17226/25259>; Guy Lomax, Mark Workman, Timothy Lenton, and Nilay Shah, 'Reframing the Policy Approach to Greenhouse Gas Removal Technologies', 78 *Energy Policy* 125–36 (2015).

28 Sabine Fuss, Josep Canadell, Glen Peters, et al., 'Betting on Negative Emissions', 4 *Nature Climate Change* 850 (2014); *Negative Emission Technologies: What Role in Meeting Paris Agreement Targets?*, European Academies' Science Advisory Council (EASAC) Policy Report 35, February 2018; cf. Stuart Haszeldine, Stephanie Flude, Gareth Johnson, and Vivian Scott, 'Negative Emissions Technologies and Carbon Capture and Storage to Achieve the Paris Agreement Commitments', 376 *Philosophical Transactions of the Royal Society A*: 20160447 (2018), <http://dx.doi.org/10.1098/rsta.2016.0447>.

29 Ibid.; Holly Jean Buck, 'Rapid Scale-Up of Negative Emissions Technologies: Social Barriers and Social Implications', 139 *Climatic Change* 155–67 (2016).

30 Carly Green and Kenneth A. Byrne, 'Biomass: Impact on Carbon Cycle and Greenhouse Gas Emissions', in *Encyclopedia of Energy*, edited by Cutler J. Cleveland (Elsevier, 2004), 223–36.

31 Buck, supra note 30.

computer technology, people tend to overestimate what can be done in two years, and underestimate what can be done in ten.[32]

Thus, while it would be irresponsible to assume that in ten or even twenty years NETS will be able to stop or reverse climate change, it would be unscientific and arbitrary to assume they will not. The only rational perspective is to treat the potential impact of NETS as an ongoing unknown, falling within a range that is considerable. That means that no policy can be built around assumptions of their success. On the other hand, no policy can ignore that they could be game-changing. Given that the costs of research are trivial by comparison with the costs of climate change, adaptation, or mitigation, the only rational approach, if we want to see faster, greater, climate effects, would be to invest hugely in NET research.

Hardly anyone is against NETS in principle—if they can be made to work. One might think that an effective way of removing greenhouse gases from the atmosphere needs no argument. However, the fact that large-scale NETS are still somewhat speculative, and the fact that the effect of most of them is limited—one can plant only so many forests—is for many a reason to play down their role in climate action and focus instead on permanent, structural, solutions which we know can work.[33]

My argument casts NETS in a different light. The fact that they will reach a peak of effectiveness and then run out of force is less of a problem: it is the speed of their effects, not its duration, that counts. By potentially increasing the degree to which climate change can be stopped or reversed within current middle-aged lifetimes, they deliver a quicker return, making it more attractive to engage in emission reductions as well. Although reductions may be costly, if they are part of a package that visibly stabilizes the climate, it is a more immediately balanced transaction. If NETS can be made to work at scale, they make immediate engagement attractive, and that justifies prioritizing their research and their use.

3.3 *Solar Radiation Management*

The other way of getting quick results is to use SRM. Various SRM techniques have been proposed, all of which are controversial because of the risk of side-effects and because of governance problems.[34] It is hard to calculate how weather will be influenced by a global sun-shield of one form or another, and it is also

32 'We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten'. Attributed to Bill Gates; see Nancy Weil, *IDG News Service*, 'The Quotable Bill Gates', <https://abcnews.go.com/Technology/PCWorld/story?id=5214635>.

33 Mclaren and Burns, supra note 4.

34 Royal Society, supra note 25; Burns, supra note 4; Sikina Jinnah and Simon Nicholson, 'Introduction to the Symposium on "Geoengineering: Governing Solar Radiation

hard to see how decisions on the 'global thermostat' could be taken without some degree of political conflict.[35] On the other hand, variations on these fears could be applied to global warming itself.[36] It too creates risks of dramatic weather effects, above and beyond increasing average temperatures as such. It too demands global consensus of a kind that is hard to achieve, and creates global tensions. The problems of SRM are serious, but not of a type that justify dismissing it out of hand. Any climate policy comes with risks and challenges.

There are three characteristics of SRM that make it interesting from the perspective of intergenerational equity. One is that it is potentially fast—there is something approaching a scientific consensus that it would be possible, if necessary, to cool Earth quite quickly and effectively, using sulphur aerosols in the upper atmosphere.[37] One reason for this is that volcanic eruptions have done it in the past—nature has provided some useful experiments. Other techniques, such as cloud enhancement, might also work, but are less developed. That is not to say that sulphur SRM is ready to use, but merely that there is agreement that it is in principle achievable and that the technical challenges of implementation could probably be overcome.

The other characteristic of SRM is that it is cheap. Estimates vary, but suggest that, for tens or hundreds of billions of dollars, anthropogenic temperature increases could be reversed.[38] By comparison with the short-term costs of mitigation, these are small sums. SRM avoids high costs now.

However, the third characteristic of SRM is the most interesting: it is only a temporary 'solution'.[39] It does not solve the problem of ocean acidification

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Management'", 28(3) *Environmental Politics* 385–96 (2019); Stephen H. Schneider, 'Geoengineering: Could—Or Should—We Do It?', 33 *Climatic Change* 291–302 (1996); John Virgoe, 'International Governance of a Possible Geoengineering Intervention to Combat Climate Change', 95 *Climatic Change* 103–19 (2009); Gareth Davies, 'Framing the Social, Political and Environmental Risks and Benefits of Geoengineering: Balancing the Hard-to-Imagine Against the Hard-to-Measure', 46(2) *Tulsa Law Review* 261 (2010).

35 Alan Robock, Alison Marquardt, Ben Kravitz, and Georgiy Stenchikov, 'Benefits, Risks, and Costs of Stratospheric Geoengineering', 36 *Geophysical Research Letters* L19703 (2009); Virgoe, supra note 34; Schneider, supra note 34; Wilfried Rickels, Martin F. Quaas, Kate Ricke, Johannes Quaas, Juan Moreno-Cruz, and Sjak Smulders, *Turning the Global Thermostat: Who, When, and How Much?* (Kiel Institute for the World Economy Working Paper 2110, 2018).

36 Davies, supra note 36.

37 Royal Society, supra note 25; Robock et al., supra note 37.

38 Royal Society, supra note 25; Robock et al., supra note 37; Anthony Harding and Juan Moreno-Cruz, 'Solar Geoengineering Economics: From Incredible to Inevitable and Half-Way Back', 4 *Earth's Future* 569–77 (2016).

39 Royal Society, supra note 25; Robock et al., supra note 37; Andy Parker and Peter Irvine, 'The Risk of Termination Shock From Solar Geoengineering', 6 *Earth's Future* 456–67 (2018).

resulting from increased CO_2 absorption. A pure SRM approach would thus ultimately lead to the death of the seas. Also, it can probably not be expanded indefinitely. If greenhouse gas levels continue to rise, at some point the amount of shielding required to maintain temperature stability would either be impossible to achieve, or would bring excessive side-effects of other kinds. SRM is thus a transitional measure at best, a way of stabilizing temperature while other measures are adopted to reduce atmospheric CO_2.[40] These measures become, if anything, more essential than they would be without SRM, because if SRM is wound back too fast, or fails, and CO_2 levels have risen, then the planet would suddenly be exposed to the full effects of the higher CO_2 levels, and there would be—albeit there is some dispute about this—a rapid temperature increase that would be more apocalyptic than a gradual one.[41]

Because SRM does no more than buy a little time, it is often treated as a policy irrelevance, a distraction from the ultimately necessary work of reducing emissions. However, its temporary nature is precisely what makes it attractive. For, during the few decades of SRM, the world would have time to prepare, intellectually, socially, and economically, and to begin, a transition to zero emissions and to NETs on an enormous scale. The costs of the later-occurring transition would be borne by the generation that would benefit most, the generation which might have faced apocalypse, but which would instead continue to live in an industrialized and climate-stable society.

Moreover, that future generation would be almost compelled to take the mitigation measures required, whatever their cost, because the alternative would be a disastrous swing-back in temperature. That generation would essentially be blackmailed into adopting a negative greenhouse gas society. SRM, precisely because it is such an imperfect solution, may well be an effective way to ensure long-term climate stability. As with the metaphor of the frog and the boiling water, the cultivation of a sense of crisis can be a way of stimulating self-preservation.[42] Less-than-sufficient mitigation begins a long, slow, step-by-step descent into environmental disaster. SRMs may create short-term stability only to face future generations with the choice between immediate catastrophe or planet-saving reorganization. That increases the chances of the latter.

40 Paul J. Crutzen, 'Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?', 77 *Climatic Change* 211 (2006).

41 H. D. Matthews and Keith Caldeira, 'Transient Climate-Carbon Simulations of Planetary Geoengineering', 104(24) *Proceedings of the National Academy of Sciences USA* 9949–54 (2007). But see also Parker and Irvine, supra note 41; Jesse L. Reynolds, Andy Parker, and Peter Irvine, 'Five Solar Geoengineering Tropes That Have Outstayed Their Welcome', 4 *Earth's Future* 562–68 (2016).

42 Davies, supra note 36.

Nevertheless, it is not my intention to imply that SRM offers a solution that can begin tomorrow. While SRM is probably easier to apply at a planetary scale than NETs, or closer to that stage, no technique is so advanced that it is off-the-shelf. Further research or experimentation might reveal that SRM fails, or is less effective than hoped.

The point here is to think about the shape of a policy that deals with intergenerational costs and benefits. SRM, if it could be made to work as the more optimistic scenarios suggest it could, could be a part of that. This is a reason, as with NETs, to research hugely and research fast. The outcome of that research is unknown, but if humanity sees a tool that could, if it works, help fix climate policy, then surely it should do everything possible to make that tool work.

4 Conclusion

The mystery of climate change is this: if we know what needs to be done, why are we not doing it? This article suggests an answer based on self-interest. It is hard to persuade people to make difficult changes to their lives if the harm to be prevented is not one that they will otherwise experience. People are reluctant to accept costs where the benefits will accrue to others. The climate-policy problem can thus be seen in intergenerational terms: how do we persuade the present generation to pay to help future ones?

While appeals to moral arguments can be part of an answer—and I am in no sense rejecting them—a purely pragmatic policy approach would suggest that we look for ways to align costs and benefits, so that the current generation pays less and sees more return, while future generations, who are the primary beneficiaries of an effective climate policy, pay more.

Geoengineering by SRM, as a potentially quick, cheap, short-term policy, is well suited to this goal. It allows significant climate stability to be achieved quickly at a relatively low cost, but leaves future generations with the burden of transitioning out from geoengineering once it reaches its peak effect. Intuitively that may seem an unfair, even abhorrent approach, but those generations will have sufficient interest in taking the steps necessary, because the alternative for them would be disastrous. The costs we dump on them will at least bring them an immediate benefit. Geoengineering allows an incentive structure to be created whereby self-interest and saving the planet coincide. This may be less attractive in some ways than sustainable behaviour based on altruism, compassion, or deep ecological sensibilities. However, while the question of our moral obligations to the future is certainly important, so surely is the question of what works.

Nevertheless, SRM is not ready for use. The policy prescription this article leads to is that there should be an unprecedented scale of investment in SRM and NET research, with an urgency akin to, but greater than, what we have seen in the Covid-19 pandemic. Perhaps that research will fail. But if it does not, the results could help combat the intergenerational inequity that is one of the greatest obstacles to long-term positive climate outcomes and to effective climate action now.