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Geoengineering & Climate Change

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From the standpoint of a higher socio-economic formation, the private property of particular individuals in the earth will appear just as absurd as the private property of one man in other men [i.e., slavery]. Even an entire society, a nation, or all simultaneously existing societies taken together, are not the owners of the earth. They are simply its possessors, its beneficiaries, and have to bequeath it in an improved state to succeeding generations as *boni patres familias* [good heads of the household] (Marx, 1976, 959)

Geoengineering can be defined as the deliberate technological intervention into our climate in order to limit and/or reverse climate change and is currently being explored by governments, scientists, universities and private think tanks as an option in humanity's fight against global warming. In this chapter, I argue against choosing geoengineering as a tactic in dealing with global warming because of: (1), substantial flaws in the assumptions that ground economic-centric studies; and (2), problems with how data has been selectively used to support its implementation. Many of these studies are erroneously based upon static conceptions of consumption rates, human behavior and basic social objectives. I also make the case that there is an alternative way to approach the study of climate change and environmental issues using Andrew Feenberg's philosophy of technology approach (Feenberg, 1995, 1991/2002, 1999).

Following a brief definition of geoengineering, I begin with a brief discussion of the now indefinitely postponed Stratospheric Particle Injection for Climate Engineering (SPICE) project, which aims to test the feasibility of one specific geoengineering technique. I use this particular case, and a considered analysis of the studies that surround it, throughout this chapter as a way into an overarching analysis of the problems of economic methodologies that are most often applied to the assessment of climate change as well as geoengineering. I begin my examination of these flaws with a brief critique of quantitative methodologies, as they relate to the study of the environment, and follow this with a critical examination of demand estimates using the cases of the airline industry as an example. Next, I discuss the problems associated with the so-called 'Energy Paradox,' which leads to host of further of difficulties such as direct and indirect rebound effects. Also reviewed in this section are the problems connected to *ceteris paribus* logic which assumes that all variables involved in economic analysis of environmental issues will remain unchanged – which they rarely do.

A second set of complications associated with economic studies of the climate change discussed in this piece emerges out of Andrew Feenberg's work on the environment in which he discusses *ceteris paribus* modes of analysis in detail. *Ceteris paribus* refers to Feenberg argues that *ceteris paribus* thinking, as it has been applied to the subject of climate in particular, fails to consider the articulation, development and implementation of new technical standards, which, if widely adopted, could alter current projections around emissions. While Feenberg's critique shares several assumptions with the economic critique also discussed, it differs in that his approach highlights how changes in technical standards related to the environment might develop over time.

In the third section, I discuss a further flaw in economic studies of climate change which center around the belief that there will be no substantive cultural and/or political constraints on future energy use. The assumption here is that the public will not consent to make changes in lifestyle and consumption patterns in order to mitigate global warming and, consequently, geoengineering will be necessary. This conclusion is not inevitable. What is required, and can develop if given the needed support and space, is a reconfiguration of value hierarchies based on a long-term view of social and environmental well-being.

In the final section of this chapter, a more detailed discussion of how the articulation of new environmental and technical standards and values can engender a transformed relationship with the environment is undertaken. Democratic rationalization, as discussed by Andrew Feenberg in his work on the philosophy of technology, is the end result of this process. Overall, I conclude that the oftentimes painful arguments over technological solutions to environmental problems, and the many possible avenues by which we might begin to deal with anthropocentric climate change, is a natural part of the process of technical evolution.

Moreover, I make the case that the traditional economic arguments which support geoengineering may well come to be widely seen as unsuitable due to the unique nature of climate change. Anthropocentric global warming, in this context, has to be thought of as a cultural issue threatening civilization, not one of economic costs and benefits.

1. Geoengineering

Geoengineering can be defined as intentional technological interventions into the world's climate in order to prevent, mitigate or reverse anthropogenic global warming (Allenby, 2010 and Long et al, 2012). Its techniques are purposeful, have far-reaching effects and rely on technology as its central driver. Geoengineering generally falls under one of two categories: first, solar radiation management (SRM) techniques, which aim to reflect sunlight away from the earth through such methods as enhancing cloud whitening, in which seawater is sprayed into the atmosphere with the aim of increasing the proportion of light reflecting cloud cover, and albedo enhancement, which involves covering regions with light reflecting white materials or pumping aerosol sulphates in the stratosphere in pursuit of the same objective.

Second, CDRs (carbon dioxide removal techniques), on the other hand, aim to remove carbon dioxide directly from the atmosphere. In one technique, called biochar, geoengineers would plant, burn, and bury large quantities of biomass. This method aims to suck in and store a large amount of atmospheric carbon dioxide during the burning phase.¹ Carbon capture and sequestration is another CDR method in which carbon is physically captured and sequestered underground. This technique is currently being tested in the private sector. As well, ocean fertilization, wherein the ocean is seeded with iron with the objective of increasing the quantity of carbon absorbing algae blooms, also falls into the category of CDR.

2. SPICE Project

Currently, a concerted effort is taking place to carefully and comprehensively test the feasibility of SRM geoengineering in the UK through intensive modeling. The project, called SPICE (Stratospheric Particle Injection for Climate Engineering) is a collaboration among Marshall Aerospace, a European company specializing in military, civilian and commercial aircraft engineering, and the Universities of Cambridge, Oxford, Bristol and Edinburgh. The project aims to initiate the first steps towards testing the feasibility of injecting light reflecting particles into the stratosphere – which will then, it is believed, lead to global temperature cooling. Those involved in the project had, in fact, originally intended to physically test aspects of this geoengineering technique. However, as a result of strong public opposition, the testing elements of the project have been put on hold indefinitely. Yet SPICE remains the most legitimized, well-known and publicly discussed geoengineering project. As such, it serves as a useful case study – particularly with respect to how it has been justified in economic terms.²

Basically, and consistent with SPICE's SRM geoengineering project, researchers hope that the effects of dispersing sulfur dioxide particulates, or other such aerosols, into the lower atmosphere will reflect sunlight back into space and initiate a cooling effect (note that this would not, however, reduce the existing levels of atmospheric greenhouse gases). Over a number of weeks, the sulfur dioxide would combine with water and oxygen to form sulfuric acid gas and then condense into aerosol droplets creating a visible haze that reflects sunlight. This method of geoengineering relies on the cooling effects experienced after volcanic eruptions.

The most studied and cited example of such an eruption is that of Mount Pinatubo in 1991 (a major study of the Mount Pinatubo eruption in the Philippines was undertaken by NASA's Goddard Institute for Space Studies). It was concluded by NASA that the net effect of this volcanic eruption was that the released sulfur dioxide, over one year, led to a cooling effect over the Northern Hemisphere of 0.5 to 0.6 degrees (Celsius). However,

¹ Biochar is produced when various forms of plant matter are heated in a low oxygen environment. When the remaining matter (biochar) is placed in soil, it removes carbon from the atmosphere and stores it, thus acting as form of sequestration

² SPICE studies have also formed the basis of David Keith and James Anderson's (both Harvard engineers) current plan to conduct a similar field experiment in New Mexico.

it should also be noted that similar studies show that this was followed by unusually rapid ozone depletion rates in the Southern Hemisphere (Pinatubo Volcano Observatory Team, 1991).

The SPICE project, as stated, marks the preliminary steps towards testing whether the cooling experienced after Mount Pinatubo can be replicated through human intervention – i.e., by injecting sulfur dioxide, or other such particulates, into the atmosphere directly (although this test would have used water). The SPICE test, which was to have taken place in Norfolk, UK, was to have attached a helium filled balloon to a one kilometer long piece of hosepipe that is firmly tethered to the ground. Water would then be pumped from the ground to the top of the hosepipe and sprayed into the surrounding area. According to the lead researcher of the project, Dr. Matt Watson of Bristol University, SPICE, that it

will eventually be the first UK project aimed at providing some much-needed, evidence based, knowledge about geoengineering technologies. The project itself is not carrying out geoengineering, just investigating the feasibility of doing so. We hope that by carrying out this research we will start to shed light on some of the uncertainties surrounding this controversial subject, and encourage mature and wide-ranging debate that will help inform any future research and decision making (NERC, 2011).

Moreover, this test, according to the principle investigators – who still hope to get permission to go ahead in the near future – aims to further two specific strands of inquiry: first, to test the particle candidates – that is, to consider “what would be an 'ideal' particle to inject into the stratosphere.” In doing so, the researchers “aim to identify a particle with excellent solar radiation scattering properties, and consider what potential impacts might be on climate, weather, ecosystems and human health” (NERC, 2011). Additionally, the scientists involved hope to examine the tethered balloon transportation/delivery system and build new modeling criteria based on the conclusions reached.

As such, the SPICE project marks the first step towards more focused, small-scale, legitimate geoengineering testing. The next phase anticipates using a 20 kilometer long piece of hosepipe, although that particular test is thought to be years away. I return to the SPICE project and methods that have been developed to assess the test's outcomes further on in this piece.

In the next section, a general critique of quantitative research methods is given as they relate to the environment as well as a more intensive and critical assessment of economic-focused, cost benefit modes of analysis – particularly with respect to how they inform environmental issues and geoengineering..

3. Critique of Economic Approach: Quantitative Methods

More often than not, when studying environmental issues, research methods that are not exclusively quantitative are dismissed as irrelevant because they are perceived as subjective, unscientific, non-cumulative and non-generalizable. Quantitative ‘scientific’ and empirical data, in contrast, is seen as “unproblematically available to observation free from any prior theoretical commitments” (Demeritt, 2006, 455). I, however, am in good company in arguing that there is much more to the study of social, natural and environmental phenomena than a simple number and discrete sets of data (Van den Bergh, Jeroen, 2004; Creswell, Lark, 2007). More qualitative modes of analysis must be incorporated into studies of climate change and environmental degradation. The IPCC has taken steps to do so through the incorporation of socio-economic issues – for example in their 2014 report, which studies issues of food security, poverty, risks and sustainable development.

Qualitative methods, on the other hand, tend to focus more intently on experiences, cultures, understandings and interactions. As Berg argues, “Quality refers to the what, how, when, and where of a thing – its essence and ambience. Qualitative research thus refers to the meanings, concepts, definitions, characteristics, metaphors, symbols, and descriptions of things” (Berg, 2007, 3). An over-reliance on quantitative methods is problematic in that they are underpinned by a realist, positivist epistemology which assumes that there exist objective facts in the world that can be known through specific kinds of scientifically derived and experiment-based research. Overall, using the scientific method (and attendant techniques of observation and deduction) to study the natural and social world is supposed to remove the uncertain and often muddled factors of values, ideology and politics.

Those skeptical of this perspective, many of whom fall into the category of social constructivists, contend that this is not the case and assert that knowledge about the world is actively constructed. Of particular importance to the subject of geoengineering and climate change, is the predictive bias of most quantitative methodologies, which draw on statistical analysis in ways that tend to endow the analyses with an aura of certainty. Quantitative methods also assume a certain predictive and controlling faculty that is far from certain when it comes to the unpredictable side-effects of geoengineering, which can range from acid rain to flooding and even drought.

4. Critique of Economic Studies of Environmental Issues: A General Assessment

Moving from this general critique of quantitative methods to the more specific critique of the kinds of economic analysis associated with environmental impact assessments, it is critical to begin by unpacking the assumptions and biases that permeate analyses of this sort. First, it is often the case that traditional environmental economics, as they relate to subjects like sustainability and risk, tend to ignore non-market values such as the “individual’s willingness to pay for preserving a particular resource for future use, [and]...the individuals’ willingness to pay for preserving a particular resource for the sake of its existence” (Venkatachalam, 2004, 90; see Straton, 2006 & Boyd, 2007).

Even aspects like the public's willingness to accept environmental risk, which is factored into some more recent cost-benefit studies of environmental policy and technology, reflect a bias towards retaining the environmental status quo when it comes to measures that might upset our current way of life. As such, with respect to the subject of geoengineering, it is often assumed that preserving our current economic and socio-political system is of the greatest importance to individuals. Supporters of geoengineering who rely on this assumption often hold an implicit, or even explicit, conservative bias in that they assume *a priori* resistance to fundamental change. An example of this can be found in the work of Gregory Benford, who, in an essay written for the conservative Reason Foundation in 1997, argues that

Instead of draconian cutbacks in greenhouse-gas emissions, there may very well be fairly simple ways—even easy ones—to fix our dilemma. ...take seriously the concept of “geoengineering,” of consciously altering atmospheric chemistry and conditions, of mitigating the effects of greenhouse gases rather than simply calling for their reduction or outright prohibition (Benford, 1997).

This ethos persists today and is reiterated by groups like the American Enterprise Institute (AEI) as well as governments and individual scientists like Kerry Emanuel of MIT and David Keith, formerly at the University of Calgary and now at Harvard.³

Second, it should be noted that much of the disparity between econometric analyses of environmental goods and more socially resonant ones comes down to the way questions about environmental measures are articulated and framed:

Take for instance, a proposed change in an environmental policy that would result in an improved air quality in a particular locality. *Ceteris paribus* (such as property rights, etc.), an individual in the locality can either be asked to state her maximum willingness to pay (compensating variation) for ensuring the change in the policy that aims at say, improving the air quality in the region or she can be asked to state minimum willingness to accept compensation (equivalent variation) required to compensate the expected utility foregone due to nonimplementation of the proposed policy. (Venkatachalam, 2004, 92)

With respect to geoengineering, much of the concern around risk, using economic analysis, has centered on how the calculation of the public's willingness to accept compensation is made and how much compensation they would require to accept the possible fallout. This comes to replace more important questions like the public's willingness to make concrete changes to their lives in order to address the root causes of climate change – rather than relying on a technological quick-fix that may backfire. It also, as Charlesworth and Okereke (2010) argue, undermines the ability for people to make decisions about risk – particularly when they are not given the information needed

³ Note that Keith is more reluctant than AEI or Emanuel in his support of geoengineering, preferring to pose it as a unfortunate but necessary alternative that must be studied.

to do so.

5. Critique of Specific Economic Methods

In the following sections, I give three further reasons why economic analyses, when applied to the study of the environment and geoengineering, have serious limitations. Such concerns center on problematic demand estimates, the so-called ‘Energy Paradox,’ as well as an over-reliance on flawed *ceteris paribus* logic. The conclusion reached through an examination of these methods not only points to and supports opponents of geoengineering, but also describes the limits of focusing solely on technological solutions to climate change – even with respect to *specific* energy efficient technologies (even though they are desperately needed) – since these do not address the central problems of an overconsumptive and resource-based economic system.

5.1 Demand Estimates

First, with respect to demand estimates, it is the case that many of the projections used to support the need for geoengineering rely on estimations of energy demands that do not consider possible changes in lifestyle and consumption patterns, or even technological changes made with public input, that might put us on a more sustainable path. These estimates draw on equations that assume the present patterns of emissions, consumption and demand will continue to rise. It is important to note, however, that statistics related to future energy use are based upon past consumption patterns and are therefore considered by most economists to be probabilities that can be interpreted in a variety of ways. However, I argue that proponents of geoengineering have politicized and transformed these probabilities into projections to support geoengineering.

For example, according to the International Energy Agency’s (IEA) research in this area, at present, the following statistics most accurately captures expectations related to future energy use:

Transport accounts for about one quarter of global energy use and energy-related CO₂ emissions. In absence of new policies, transport energy use and related CO₂ emissions are projected to increase by nearly 50% by 2030 and by more than 80% by 2050. Nearly 70% of electricity is generated from fossil fuels: coal (42% of generated power globally in 2007); gas (21%); hydro (16%); nuclear (14%); oil (6%); and non-hydro-renewables (2%). As a result, electricity accounts for 40% of global energy-related CO₂ emissions; these emissions will grow by 58% globally by 2030 unless new policy measures are introduced. Industry accounts for approximately one-third of global final energy use and almost 40% of total energy-related CO₂ emissions. Over recent decades, industrial energy efficiency has improved and CO₂ intensity declined in many sectors, but this progress has been offset by growing industrial production worldwide. Projections of future energy use and emissions show that without decisive action, these trends will continue (IEA, 2011).

What is striking about these statistics is not how dire they are, but rather, that because they rely entirely on the assumption that consumption patterns will inevitably increase, their assessment of demand estimates has opened the door for some groups to seize on this sense of futility in order to push for drastic forms of technological mitigation like geoengineering.

Some evidence, for example data collected by the global energy intelligence firm Enerdata, suggests world energy demand is actually decreasing for the first time in thirty years (Enerdata, 2010). Note that while the assumption of increasing energy demand and its consequences are not false or faulty, as these figures are often used to support the call for sustainability as well, what is problematic is that proponents of geoengineering have taken to using them to support their case for immediate technological intervention.⁴ By (1) assuming that demand, use, and supply will remain stable (*ceteris paribus*), (2) failing to define the role and drawbacks of extrapolations, which tend to use aggregate data and assume that past trends will predict the future, and (3) by conflating extrapolations with projections, the latter of which assume that certain future conditions will hold based on a set of assumptions about the present, this data then feeds into a kind of groupthink on the inevitable need for geoengineering that does little justice to its complexity or tenuousness.

Scientists like Nobel Prize Winner Paul Crutzen and Ken Caldeira of Carnegie Mellon and MIT's David Battisti have all formulated public justifications of geoengineering based on the view that significant reductions in greenhouse gas emissions will not occur and that technologies that will substantively reduce climate change will likely not be conceived of or produced in the near future. In fact, these numbers have functioned as compelling arguments to justify projects like SPICE. Specifically, it has been argued that the SPICE experiment is necessary because of the rapid rate of anthropogenic climate change and a firm belief that consumption patterns will continue to rise unabated. According to the SPICE project's initial grant proposal to the Engineering and Physical Sciences Research Council (EPSRC), it claimed that:

Future projections by climate models indicate substantial changes in future decades, much of which is on a regional scale that will severely impact regions of the world that are already under stress. There has been much improved understanding of the serious nature of the global warming problem both by politicians and the general public in recent years. However, there is great concern that efforts to mitigate future change by reduced greenhouse gas (GHG) emissions, including the outcome of the international meeting in Copenhagen 2009, are proceeding too slowly to avoid the risk of dangerous climate change and the possibility of certain 'tipping points' (such as the collapse of the Indian Monsoon or melting of the Arctic ice sheet) being reached. This has prompted

⁴ Nor, in this context, does it matter whether these projections are true or false. What matters is how these estimates are taken up without proper explanation and contextualization.

consideration of intervention by alternative means. (Watson, 2010)

Ironically, several private and politically conservative think tanks also hold this view. For instance, in the concluding statement from the Climate Institute's Asilomar on Climate Intervention Technologies, in which many noted scientists took part, it was asserted that: "Despite ongoing efforts to reduce emissions and adapt to the changing climate, global greenhouse gas emissions are far above what is required to reverse the increasing changes in atmospheric composition" (Climate Institute, 2, 2010). Again, while this conclusion is based on sound science, its basic assumption is that nothing behavioral, or even technological (in terms of energy efficient technologies), will occur to change these figures.

In what follows, I apply the critique of demand estimates to the study of the fuel efficiency in the airline industry. This case offers a concrete illustration of the problems with the conclusions reached using demand estimates based solely on past behavior. Similar conclusions can be extrapolated and applied to the case of geoengineering.

5.2 The Airline Industry

An example of an industry in which problematic demand estimates have been relied upon is that of fuel efficiencies related to the airline industry. When evaluated in light of geoengineering, what becomes clear is that (1) energy efficient technologies need to be assessed and studied using more flexible criteria; and (2) even with the wide implementation of energy saving technology and regulation (as they exist now), climate warming will likely continue.

With respect to the airline industry, in its 2011 Intergovernmental Panel on Climate Change (IPCC) report, the IPCC makes it clear that the current methods used to assess the environmental concerns of the aviation industry (which are then used to guide public policy on efficiency targets and emissions limits) are highly problematic. The report criticizes the overuse of cost-benefit analysis which tends to conclude that demand for airline travel will inevitably fall as a result of efficiency targets due to higher costs – which are passed on to consumers – thereby harming the airline sector in particular and the global economy in general. This thesis, however, fails to consider the fact that "airlines operate in a highly competitive environment, and in the short term many may absorb fare increases at a cost to profitability rather than pass them on to passengers" (IPCCa, 2011). The neglect of factors such as this is rife in economic-focused studies of technologies like geoengineering as well.

These estimates also, the IPCC maintains, do not explain the fact that: (1) a good deal of the data in sectors like the airline industry is protected by industry/commercial confidentiality and therefore are not factored into current studies; (2) forecasts require a long appraisal period to adequately calculate the benefits of emissions reductions; (3) scientific uncertainties regarding the impact of emissions leads to the use of estimated pollution reductions as the only measure of benefits; and (4) uncertainties about future

trends in technology, which may be much more efficient and safe, are rarely considered (IPCCa, 2011).

As stated, many of the pitfalls of economic analysis discussed with respect to the airline industry apply to geoengineering studies as well. Some of these problems can be seen in to the SPICE project's public consultation process. While its final report, titled 'Public Engagement on Geoengineering Research: Preliminary Report on the SPICE Deliberative Workshops,' offers a nuanced and open discussion of the SPICE project's objectives, methods, consequences, and the public's concerns, its basic assumptions ignore the possibility that new, more democratic technologies might be developed or that consumption patterns might fundamentally change. It assumes, as such, that environmental conditions will remain as they are. These shortcomings persist despite the fact that this particular consultative process drew on a qualitative research process, namely the focus group.

Philosopher Andrew Feenberg terms this kind of logic consistent with *ceteris paribus* reasoning, which assumes that all factors considered in these kinds of analysis will remain constant – including demand. While *ceteris paribus* assumptions simplify complex economic data, they also constrain and leave out a large number of important variables and, in doing so, often lead to projections that are divorced from reality. An example of this is the Law of Demand, which asserts that “quantity demanded depends negatively on price *ceteris paribus*.” However, while it is widely acknowledged that this is a “very useful and convenient theory,” it only works as long as the “*ceteris paribus* assumption is not ignored.” We also have to also consider, as Bierens and Swanson argue, “that complements as well as substitutes exist for most traded goods” (Bierens and Swanson, 1998, 4). A wider account and critique of *ceteris paribus* logic is given below.

5.3 The “Energy Paradox”

A second misuse of economic logic based on these assumptions leads to what is called the “Energy Paradox” which is comprised of two interconnected theses. First, is the misperception that it is the consumers themselves who apply unreasonable hurdles to impede investment in energy saving technologies. This part of the paradox claims that it is the consumer's inflated monetary expectations, and their frustration when these expectations do not materialize, that leads to objections when the next generation of efficient technologies are made available.

This assumption, however, fails to account for the consumer factoring in the high future monetary and social costs of increased energy consumption, which are often not made clear or concrete. For this to be rectified, what would be required is that: one, clear information be made available to consumers about potential costs and savings in the long term; two, that nonrational behavioral factors and choices be considered (such resource and time constraints as well as the tendency to be “biased toward the status quo,” overall risk aversion, and an increased willingness to “take risks to avoid losses than to achieve

gains in making economic decisions”) (Pew Center, 2011); and three, that carbon emissions themselves be priced so that decisions about energy use and efficiency are placed in a social, rather than just a personal or individual, context.

The second and most intractable part of this so-called Energy Paradox asserts that energy efficient technologies often create a rebound effect whereby moves towards energy efficiency, like in the case of improved housing insulation as well as energy efficient cars, appliances, and planes, do not lead to a decrease in consumption but an *increase* due to a decline in the cost of operating the utility (i.e., heating) or appliance. This is known as a direct rebound effect and can also include cases in which companies take their profits from investment in energy efficient technologies and use it to expand the company in ways that not only increase output, but also emissions.

Indirect rebound effects, on the other hand, include cases in which, for example, families who save money on energy efficient appliances then use the saved money to engage in activities that leave a significant carbon footprint (like take a vacation which involves plane travel). It should be noted, however, that this can also occur in circumstances apart from choices made about purchasing energy efficient technologies when, for example, individuals who save money by buying solar panels uses the saved money to purchase something that is emissions intensive and produces waste, like a newer TV.

Yet, as in most cases in which economic-based analyses are chosen to evaluate complex human behavior, there exists a further often overlooked set of problems related to rebound effects. To begin with, there is competing data on the precise levels of rebound effects, which suggests that they are limits to its applicability to such things as water use, larger appliances, and heating (Greening, Green and Difiglio, 2000). Even the less than progressive Breakthrough Institute, a think tank which recently compiled a comprehensive literature review of data on rebound effects, argues that the highest levels of rebound occurs "not at the consumer level but in the productive sectors of the economy (industry and commerce). Improving the efficiency of a steel plant may result in lower cost of steel, greater demand for steel, and also create greater economic growth – all of which will drive significant rebound in energy use following efficiency improvements” (The Breakthrough Institute, 2011).⁵

The UK Energy Research Centre (UKERC) reached similar findings in a 2007 report titled, ‘The Rebound Effect: An Assessment of the Evidence for Economy-Wide Energy Savings from Improved Energy Efficiency.’ In it, the authors provide a comprehensive assessment of statistics related to perceived rebound effects by comparing a future scenario in which the International Energy Agency’s (IEA) efficiency

⁵ Many scientists (Evan Mills at Berkeley’s Lawrence Berkeley National Laboratory and Jim Sweeney of Stanford) have come out against the Breakthrough Institute’s assertions with respect to the rebound effects of corporations, which they argue, are based on faulty research.

recommendations were adopted with one in which they were not.⁶ One of the report's most significant conclusions is that when applied to the household energy use, investment in energy efficient technologies can in fact save a significant amount of energy – particularly when coupled with taxation and regulation. The Research Centre report also finds that direct rebound effects are likely to “decline in the future as demand saturates. Improvements in energy efficiency should therefore achieve 70% or more of the reduction in energy consumption using engineering principles” (UKERC, vi).⁷ Factors such as the short time span of studies and the lack of consideration of developing nations' energy use in this context pose similar limitations.

Applied to the case of geoengineering, the rebound effect argument has been taken to support the thesis that because increased energy efficiency will not significantly alter levels of greenhouse gas emissions, geoengineering will become necessary. As such, any evidence that suggests that consumption will increase, despite competing data that indicates this is does not have to be the case, has been used to support further testing and research. Physicist David Keith, in a recent interview with *Scientific America*, makes this very argument. He states that because the “The Arctic is melting faster than people expected,” and since not much has been done to counteract this, that geoengineering will have to be adopted (Biello, 2011).

However, it is equally important to acknowledge that evidence supporting the thesis that energy efficient technologies will not solve the climate problem can be interpreted in another way: i.e. to suggest that *existing* energy efficient technologies can only do so much, that more open and publically initiated discussion of new technologies is required, and that fundamental political and economic change is necessary. Accompanying this line of thought, a case can also be made for the argument that an overreliance on technological solutions like geoengineering will likely fail to solve the underlying problem: our extractive and consumption-based economic system.

5.4 Ceteris Paribus

The third and final economic argument that has been used to undermine less invasive technological solutions to climate change is an overreliance on ceteris paribus logic. It is significant, with respect to the ceteris paribus projections and the supportive conclusions derived thereof, that this mode of reasoning has been consistently drawn on to support both SRM and CDR geoengineering. This is particularly evident with respect to discussions taking place at the levels of governance and public policy such at the Royal Society (2009) and the US House Committee on Science and Technology (2010). Both of these bodies have reached conclusions that support the *possible* need for geoengineering based on statistics relating to future energy use and have agreed to work together on

⁶ The Research Councils UK, which have a rich history of funding research, funds the UKERC through public monies and block grants (the councils also fund other research groups inside and outside the scientific, technological and environmental domain).

⁷ This does not, however, account for indirect rebound effects, which might limit this reduction.

geoengineering issues.

Since 2009, both bodies have undertaken research on international decision-making, governance of geoengineering research and deployment, as well as on the science, price and environmental impacts of these technologies. While research in this area continues, even when based upon the most lukewarm support for further study, it is most often based upon the assumption that everything will remain *ceteris paribus*. Geoengineering's advocates have then taken this up not as evidence of the need for immediate changes to rates of energy consumption and economic formations, as many in the scientific community contend, but to support geoengineering as a viable alternative to more traditional mitigation strategies. It recently came to light that Russia asked the IPCC to include a discussion of geoengineering in its 2013 report – particularly in light of the dire *ceteris paribus* based projections coming out of the IPCC. Russia has also publicly acknowledged that it is conducting its own geoengineering research.

The 2013 IPCC report itself, in a box marked TS.7, provides an overview of geoengineering and highlights the unknowns of both SRM and CDR methods. While both critical and skeptical of both approaches, the report also suggests that, *ceteris paribus*, “Modelling indicates that SRM methods, if realizable, have the potential to substantially offset global temperature rise...” (IPCCb, 21). Critics have highlighted that the inclusion of TS.7 serves to legitimate geoengineering and this tepid statement, which is followed by several caveats, gives backing to its proponents.

In closing this section, it is important to note that the use of quantitative methods to assess environmental issues and technologies, like climate change and geoengineering, also tends to influence ethical analyses. Most ethical examination of geoengineering draws on a consequentialist ethical framework that reduces normative considerations to how economic effects are distributed (Jameson and Elliot, 2009). In this way, even the atmosphere comes to be seen as property (i.e. a scarce resource) subject to our use. This kind of instrumental logic relies on a drive for human mastery over nature which, philosophers of technology like Andrew Feenberg argues, negates human reason and autonomy and endangers human survival.

6 Feenberg's Philosophy of Technology Approach

Feenberg's approach to environmental issues rooted in a critical philosophy of technology builds on these arguments and makes the case that calculations of efficiency and cost-benefit analysis, with respect to the adoption of technologies, fails to account for the complex social and cultural forces that guide technological change. What makes Feenberg's approach distinct from other critiques of economic-centric studies of climate and climate technologies is that it is rooted in a conception of technical rationality and founded on the need for further democratization.

Briefly, Feenberg views technology as an inherently social artifact that is replete with meanings that are not entirely “inscribed into the nature of the technology” itself (Feenberg, 2010, 15). As such, he contends that technical choices can be made which

reflect socially resonant and ecologically sensitive cultural values and meanings rather than standards of abstract control, efficiency and economic power. This was the case with the Internet which, rather than serving as a mere portal to access to information or for the purposes of emergency communication as was intended, became a nexus of social networks and interaction. In this context, democratic rationalization, Feenberg argues, can be understood as the process by which the controversies that surround technology are funneled into the production of innovative solutions that do not reflect power, money or abstract rationality but “a struggle to subvert the technical practices, procedure and designs structuring everyday life” (Feenberg, 2010, 27).

In line with this approach, Feenberg, in a piece titled ‘Incommensurable Paradigms: Values and the Environment,’ from his book *Between Reason and Experience*, draws on this critical framework to claim that we must reject measures of technical rationality that are defined in purely economic terms since these kinds of calculations hold economic boundaries to be invariant. Historically, however, it is clear that precisely what should be subject to economic assessment are the changing nature of these very boundaries. In this sense, it could be argued that the current controversy surrounding geoengineering is in fact part of the natural evolution of technical norms and boundaries which could, at some point, place environmental issues in the realm of social, rather than economic, interests. I return to this point further on.

One of Feenberg’s central arguments against the sole use of economic analyses of environmental issues lies in this conception of boundaries wherein the environment is forcibly placed within the boundary/sphere/purview of the economy where it does not necessarily fit and where solutions like geoengineering become common sense or, as Feenberg puts it, certain technical solutions “rigidifies into destiny” (Feenberg, 1999, 14). Feenberg also, in doing so, concludes is that it is impossible to “place monetary value on such things as natural beauty and good health because, but these values have been translated into monetary terms to enter the calculation. Trade-off arguments are thus often based on flimsy estimates of costs and benefits when they are not ideological expressions of hidden interests” (Feenberg, 2010, 33-34). This applies directly to the case of geoengineering as well.

Moreover, according to this constructivist approach, which incorporates a clear account of democracy and participation, environmental values can and should be “incorporated into technically disciplines and codes” such that environmentalism is accepted as “a self evident advance” (Feenberg, 2010, 43). This conception of democratic rationalization and its application to environmentalism and technology is critical in that it provides a clear standard by which to assess geoengineering and formulate new goals. Economically based models of analysis, as demonstrated, do not allow for this because the economy has a boundary and cannot account for the social values needed to think about the use of technologies like geoengineering or even issues around food safety, rainforest protection or nuclear energy. Moreover, this theory of rationalization, particularly with respect to the formulation of new objectives and knowledge – and when coupled with Feenberg’s considered rejection of cost-benefit analysis, offers a corrective to traditional way new

technologies have been studied.

Turning back to geoengineering, it is significant that the majority of studies, commentaries and justifications of its further research and potential use rely on precisely the kinds of economic assessments Feenberg criticizes. A significant example of this is the work of the Copenhagen Consensus Center (CCC) – a policy think tank funded by the Danish Ministry of Foreign Affairs – which aims at developing studies of the world's major challenges using the expertise of preeminent economists. As a result, all of the group's major studies employ traditional and rather conservative economic approaches. In their most recent study of climate change mitigation, 24 papers were commissioned from climate economists to answer the following question:

If the global community wants to spend up to, say \$250 billion per year over the next 10 years to diminish the adverse effects of climate changes, and to do most good for the world, which solutions would yield the greatest net benefits? – i.e. what are the costs and benefits of different viable climate interventions...given some reasonable assumptions about sensible policies for the rest of 21st century? (CCC, 2009).

In a widely cited and highly ranked paper submitted to the CCC for this project, under the aegis of the American Enterprise Institute, J.E. Bickel and Lee Lane make the case for geoengineering in line with the CCC's call for a purely economic, cost-benefit approach. Their conclusion is as follows:

We estimate that the benefit of a single watt of SRM is worth over \$6 trillion under an emissions control regime of optimal abatement. Furthermore, we show that a single watt of SRM has the same economic benefit as capturing and sequestering almost 65% of yearly CO₂ emissions, which, in conjunction with AC's significant costs, argues in favor of SRM in the near term (Bickel and Lane, 2009, 3).

Most of Bickel and Lane's study stresses the significance of quantitative benefits, cost estimates, transaction costs and political market failures. For example, their list of potential 'costs' of deploying climate engineering technologies include the costs of resources to develop, deploy and fund the technology, potential costs of conflict, and monitoring costs. Even their study of politics remains focused on potential transaction costs – particularly with respect to the potential for "political structures and rules...[to] sometimes block or distort the choice of the best response to a problem" (Bickel and Lane, 2009, 26). They suggest that stratospheric aerosol injections, of the SPICE project kind, have a very attractive benefit-cost ratio, which should warrant further testing. This mode of analysis, according to Feenberg's framework, poses a significant boundary problem since it ought to be the case that the logic of trade-offs, with respect to the climate, be considered irrelevant because of the unique status of the environment. Not only are decisions regarding the natural environment intrinsically connected to moral questions about the kind of world we want to live in, and thus not reducible to economic

calculations, but they also cannot be reduced to *ceteris paribus* logic.

Ceteris partibus logic, as Feenberg makes clear, draws on technological determinism and a neutral conception of technology that have “long since been superseded by more sophisticated approaches” (Feenberg, 2010, 34). When applied to the geoengineering debate, technological determinism, and related assumptions about the neutrality of technology, serves to minimize the socially constructed nature of these technologies whose design and development are a result of social choices which could have gone a number of ways. Also ignored is geoengineering’s tendency towards incorporating techno-centric, control-oriented and instrumental technical values at its core.

Therefore, by confining the economic measure of trade-offs when studying technology, a more sophisticated notion of historical change can emerge (i.e. one that is not static and therefore resistant to purely economic analyses). This is in addition to the realization that boundaries between what is subject to and what lies outside economic analyses shift with time and, as such, some things, like the environment, should not be subject solely to economic calculations. Yet many of the potential side effects of geoengineering still continue to be quantified primarily in economic terms by scientific bodies, think tanks and governments.

For example, in the Royal Society’s 2009 report on geoengineering, titled ‘Geoengineering the Climate: Science Governance and Uncertainty,’ the Society draws on the four primary categories of effectiveness, affordability, timeliness and safety to evaluate geoengineering technologies. Their method of reaching conclusions with respect to the possible deployment of these techniques is to assign the parameters of very high, high, low and very low to these four categories. The Society describe these respective groupings as relatively static ‘technological criteria’ that are distinct from aspects like “public attitudes, social acceptability, political feasibility and legality which may change over time” (Royal Society, 2009, 7). What the Society fails to note, however, is that technological norms and decisions are also subject to change and often these decisions have unintended consequences.

It is noteworthy that the criteria employed to evaluate geoengineering in this report, specifically with respect to so-called ‘technological’ factors, places each of these categories on a relatively equal footing. As such, even with respect to safety, which could be interpreted in relation to the social good and collective risk and thus placed above other factors, is played off against the criteria of cost and effectiveness. In this sense, if a geoengineering technique is seen to be highly effective and low in cost with medium risk to safety, its use could be justified.

This kind of reasoning is deployed in other areas of the Royal Society’s report as well. For instance, according to the study, ocean fertilization techniques are deemed to be acceptable because, while they receive a safety ranking of very low, they rank high in other categories. Yet this fertilization approach is not only unlikely to be effective in removing carbon dioxide from the atmosphere over the long term, but could also lead to

an increase in so-called oceanic ‘dead-zones,’ increased acidification of the deep ocean and conflicts over food security if the phosphorus used for such purposes rises in cost (phosphorus is required for agricultural production).

Cloud seeding is another approach that, while potentially effective in reducing carbon dioxide levels, could affect weather patterns in countries already suffering from unpredictable changes (e.g. by leading to increased precipitation in India and Bangladesh). According to the Royal Society’s own report, stratospheric seeding could negatively affect biological productivity and have adverse affects on the hydrological cycle, on the ozone and on high altitude cloud production.

Yet despite these troubling consequences, overall, the Royal Society, reaches surprising conclusions about geoengineering in general and CDR techniques in particular. In fact, they go as far as to argue that some CDR techniques are “safe, effective, sustainable and affordable” (Royal Society, 2009, xi) and should therefore be studied further. It is troubling that this monetized, trade-off approach forms the basis of most assessments of geoengineering since they fail, as much of this report does, to reflect the fact that “effects on social wealth [that are]...significant to policy...must be measured with respect to fulfillment of actual desires, not theoretical constructions” (Feenberg, 2010, 44) like affordability, timeliness, safety etc. It is also worth noting that these approaches are normative and deeply undemocratic as they seek to impose a specific kind of ethical framework not shared by those likely to be affected.

As described in the next section, and by drawing on the case of steamboat boilers and child labor, Feenberg illustrates ability of a critical philosophy of technology to reveal the absurdity of limiting our judgment of regulation and technology to static and deterministic economics, rather than environmental, cultural and political criteria.

7. New Social and Technical Criteria

During the early nineteenth century in the United States ticket sales for travel on steamboats consistently rose despite a rising death toll, which resulted from problems with dangerous boilers. According to Feenberg, if a purely cost-benefit analysis is employed to this case, there would be no need to increase regulation on boilers since it would appear that passengers have consented to take on the risk in exchange for low ticket prices – which was an argument widely held in debates over regulation at the federal level. However, in the end, the U.S. government unilaterally decided to regulate boilers and, in doing so, “prioritized the prevention of accidents” (Feenberg, 2010, 41) over economic factors like profit.

Feenberg, makes precisely this point in relation to child labor as well, the regulation of which, early on, was objected to because of its potential economic cost. That is, the case was made that the abolition of child labor would have “catastrophic economic consequences – increased poverty, unemployment, loss of international competitiveness – from the substitution of more costly adult labor” as well as from “the depreciation cycle of machinery [which would have to be replaced in order to accommodate adult

workers]...lower wages and trade problems” (Feenberg, 2010, 12).

Yet when child labor was abolished, none of these nightmare scenarios came to fruition and, as a result, child labor became seen as incompatible with the values of society. In addition, the concerns about changes to industrial machinery needed for this transformation in labor practices also came to be understood as both necessary and just. Understood in this way, it becomes clear that the social redefinition of technical values and standards, as well as of human progress and development, is possible.

Therefore, when applied to geoengineering and climate change, as in the previous two cases, what becomes essential is need for active support of the formulation of new technical standards and human values that are not based on personal consumption, but on the welfare and health of future generations. Thus at some point, like in the case of child labor, new, more just environmental standards could be articulated, accepted, and normalized in such a way that they no are longer contested and, as a result, take on the air of commonsense – much like it now appears ridiculous and callous to suggest that arguments in support of child labor based on its economic benefit could carry any weight.

Overall, Feenberg, using his philosophy of technology perspective, draws on these examples to demonstrate how social goals are nested in competing and changing hierarchies that are open to interpretation. Following this argument, it is clear that such social goals as national unity, collective safety and the social good must be considered in decisions related to geoengineering as well. Yet it remains the case that an overwhelming number of contemporary studies on geoengineering and climate change tend to ignore this necessity. For instance, it is significant that the overriding assumption of the Royal Society’s report on geoengineering is founded on an overt rejection of the possibility that energy intensive technologies themselves could, through a concerted effort, be made redundant in the near future. While the report’s authors do emphasize the need to increase efforts aimed at reducing greenhouse gas emissions in line with the United Nations Framework Convention on Climate Change (UNFCCC) criteria (at least 50% on 1990 levels by 2050), the report is clear that present efforts at reaching this goal are failing and, therefore, because “there is no credible emissions scenario under which global mean temperature would peak and then start to decline by 2100...Unless future efforts to reduce greenhouse gas emissions are much more successful then they have been so far, additional action [geoengineering] may be required should it become necessary to cool the Earth this century” (Royal Society, 2009, ix).

What is even more perplexing is that even those opposed to geoengineering tend to use economic logic in their rejection of these radical technologies. For example, in recent meeting of the Ecological Society of America, consensus was reached amongst prominent scientists (both natural and social) that the risks of geoengineering far outweigh its benefits. Robert Jackson, key organizer of the meeting and the director of Duke University’s Center on Global Change, makes the case that there are too many unknown factors for geoengineering to be considered a viable option, particularly since “The bigger the scale of the approach, the riskier it is for the environment” (ESA Press

Release, 2009). Very little is said about the articulation of new values and, by extension, new technical codes.

These flaws with economic-centric arguments make it even easier to avoid the difficult decisions required to change our present resource-intensive and environmentally exploitative patterns of production and consumption. Feenberg asserts that much of the lack of social and institutional drive to make changes are a result of the fact that “our civilization” such that it is, “was built by people indifferent to the environment” and, therefore, “Environmental considerations were not included in earlier technical disciplines and codes” (Feenberg, 2010, 43). This indifference to environmental values, when added to the levels of comfort many of us enjoy in the West, not only explains why there is a kind of inertia in making changes that might upset this comfort, but also why, as Feenberg explains, it is so difficult to impose environmental regulations on industry. Even the Royal Society, as noted, focus their evaluation of various geoengineering techniques on the vectors of effectiveness, affordability, timeliness and safety – giving equal weight to each.

However, Feenberg also makes it clear that while, at present, environmental values are seen as extraneous to and even alien to the current norms guiding technological innovations like geoengineering, it remains possible that, like in the case of train boilers and child labor, such values as respect for nature and care for the environment could be seen “as a self-evident advance” (Feenberg, 2010, 43) in the near future. What is required, therefore, is that the new crop of energy efficient technologies be founded on technical codes that address the socially and politically grounded problems that gave rise to climate change, while also addressing the values upon which our society is organized. Which is to say that if energy efficient technologies are, one, still technocratically inclined, control-oriented (Franklin, 1992), authoritarian (Mumford, 1964) and rationalized by traditional economic analysis, very little will change. This is particularly the case since these instrumental values have solidified into technologies that are inflexible and undemocratic. While it is the case that central control is sometimes necessary, as in the case of water, sewage and energy systems, it is the ability to integrate public input into technical decision-making in a democratic way that is sorely lacking.

8. Conclusion

Overall, what is needed in our struggle against anthropogenic climate change is a firm rejection of technologies like geoengineering that perpetuate rationalizations and technical codes that are instrumentally oriented and, therefore, unable to address pressing ecological, political and socio-cultural needs. Supporting this tendency is a preponderance of contemporary economic analyses of climate change and geoengineering that rely on the politicization of demand estimates, *ceteris paribus* logic and cost-benefit analysis, which are then used to reach conclusions in support of risky technologies. These methods, I argue, must also change since they not only fail to reflect the changing nature of social life, but also supply a kind of permission to avoid making difficult choices.

In response, as Feenberg and others who subscribe to the philosophy of technology approach argue, what is needed is the articulation of new technical standards and codes based on values that will usher in a technical paradigm that reflects democratic choice. Geoengineering, because its very telos is based on technocratic and instrumental codes, does not fall into this category. This complex, yet far more difficult, tactic would require us to instigate an entire re-think of our approach to the natural environment, technological growth and development. These new democratic technical codes, according to Feenberg, will then emerge through a process of technical evolution via considered debate, discourse, protests and legal challenges that have accompanied changes to technology and policy in the past.

To conclude, it must be noted while this transformation will definitely entail the use of renewable energy and new technologies, it cannot be limited solely to this. James Lovelock makes this clear in a 2010 interview with the BBC in which he states that while renewable energy might make good business sense, it remains to be proven whether they can solve global warming. Bill McKibbin makes a similar case with respect to renewable technologies and calls for a hefty tax to be placed on carbon emissions:

One of the great side effects of moving to renewable power is that we will replace vulnerable, brittle centralized systems that are too big to fail with spread out democratic energy sources small enough to be resilient. As such, it is clear that significant social, political and behavioral changes are required to address global warming. This, when coupled with proposals like the democratization of the energy grid, which would involve decentralizing its control, could very well form the basis of a comprehensive solution to anthropogenic climate change (Battaglini et al., 2009).

[This paper is over the 4000-6000 requested word count for papers. What can you cut? We can push a little beyond 6000, but this is too far over. Is there a section that is expendable? Do you need to go into detail on the methods of geoengineering? Thanks]

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