Why wealthy countries must not drop nuclear energy: coal power, climate change and the fate of the global poor

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The reactor meltdowns at Fukushima in 2011 vividly demonstrated once more the risks associated with using nuclear fission as a source of energy. In the wake of this catastrophic accident, public support for nuclear power plummeted in many developed nations.[1] Across the world, citizens increasingly have come to question whether the economic benefits of atomic energy outweigh the dangers of radioactive contamination. In the eyes of many, nuclear energy has indeed turned out to be 'the dream that failed'.[2] One developed country, Germany, quickly decided to phase out all operating reactors within a decade. Japan itself temporarily shut down 52 of its 54 reactors to have them inspected for safety. While the current Abe administration is committed to recommencing nuclear power generation, a solid majority of Japanese voters oppose such a step.[3] Further accidents and major malfunctions would certainly arouse yet more opposition in wealthy societies. Confronted with a sudden surge in public anxiety, elites even in less worried nations, such as Britain, France or the United States, might face enormous pressures to reconsider their commitment to nuclear power.

But is giving up nuclear energy an option for developed countries in the age of global warming? Recent data show that the world's greenhouse gas (GHG) emissions continue to rise at an alarming pace.[4] Consequently, many experts and governments still deem nuclear energy indispensable. The Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) have emphasized the advantages of nuclear fission as a climate-friendly alternative to carbon-fuelled power plants.[5] Even some prominent environmentalists, such as Patrick Moore, George Monbiot and James Lovelock, have come to question mainstream 'green' views by identifying atomic energy as the lesser evil. Just like the IPCC, they advocate building additional reactors rather than shutting down

* The author would like to thank the anonymous reviewers for their helpful comments.

1 Younghwan Kim, Minki Kim and Wonjoon Kim, 'Effect of the Fukushima nuclear disaster on global public acceptance of nuclear energy', *Energy Policy*, vol. 61, Oct. 2013, pp. 822–8.

2 Oliver Morton, 'Nuclear energy: the dream that failed', *The Economist,* 10 March 2012.

3 Mari Iwata, 'Abe's party stands firm on nuclear energy in Japan', *Wall Street Journal*, 19 July 2013.

4 Intergovernmental Panel on Climate Change (IPCC), *Climate change 2014: mitigation of climate change. Summary for policymakers* (Geneva, 2014), p. 5; World Meteorological Organization, *Greenhouse gas bulletin*, no. 10, 9 Sept. 2014.

5 International Energy Agency (IEA), *World energy outlook 2011* (Paris: OECD, 2011), p. 44; IPCC, *Climate change 2007: impacts, adaptation and vulnerability* (Cambridge: Cambridge University Press, 2007), pp. 66–7.

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existing plants. The current American and British governments also favour this option. Are they justified in putting the health of their citizens at risk in order to maintain energy consumption levels? Or are they just following a moral imperative by sticking with a climate-friendly technology?

This article will analyse whether developed nations are permitted to shut down nuclear plants that have not yet, in technical terms, reached the end of their lifetime. It will not say much about the bigger and more technical question of whether new reactors may or should be constructed to increase the production of nuclear energy. Addressing that issue would require, among other things, detailed studies of the prospects, costs and benefits of many different energy options. In particular, it would need to compare the relative risks and merits of nuclear power and different types of renewable energies. Instead, this article takes the envisioned surge in renewable energies as its starting point and focuses on the question of *how this additional electricity may be used in the near future*: can it be used to replace still operating nuclear reactors which have not reached the end of their possible operating time? Or does a moral perspective demand that renewables (or advances in energy efficiency) should first be used to replace the vast number of coal-fired power plants that are still operating in most industrialized countries?[6]

I will argue that global responsibility requires that existing nuclear plants continue to operate until renewable energies have at least replaced all coal-fired plants. The article contends that nations—developed ones in particular—must not follow the German example and drop atomic energy while their fossil fuel-burning plants continue to emit huge amounts of carbon dioxide. To do so would violate the wealthy countries' obligation to mitigate the harm climate change is already causing in developing countries (which, notoriously, bear the brunt of global warming). Being the chief originators of climate change, developed countries must simply put up with the local risks their energy consumption entails. They cannot unilaterally transfer such risks to societies which (a) benefit hardly at all from the developed nations' energy consumption and (b) are far less able to cope with a rise in global temperatures, let alone with catastrophic climate change. Faced with a choice between operating coal-fired power plants and operating nuclear reactors, governments must always opt for the latter. Coal power must be phased out as soon as possible, even when this necessitates a prolonged use of nuclear energy.

To make its point, this article will take as its normative basis the harm principle. Unlike most discussions of climate justice, it will sidestep the issue of quantitative pollution rights. As the enormous and still growing literature on climate ethics demonstrates, even moral philosophers (to say nothing of politicians) cannot agree on the normative criteria for a fair distribution of emission rights.[7]

[6] Coal-fired plants continue to dominate electricity production in OECD countries. In 2007, they generated more than 37% (4,022 terawatt-hours [TWh] of a total of 10,978 TWh), while renewables contributed just over 15% (1,697 TWh). See IEA, *World energy outlook 2011*, p. 328, table 9.4. As a result of anticipated progress in renewables, OECD use of coal power is expected to fall by one-quarter between 2013 and 2035, while overall electricity consumption is projected to rise within the OECD area. See IEA, *World energy outlook factsheet* (Paris: OECD, 2013), pp. 1, 4.

[7] Simon Caney, 'Just emissions', *Philosophy and Public Affairs* 40: 4, Fall 2012, pp. 255–300; Stephen M. Gardiner, *A perfect moral storm: the ethical tragedy of climate change*, 'Environmental ethics and science policy' series (New

Because concepts of distributive justice rest on specific cultural perspectives they will always be disputed across the lines of ethical communities. By contrast, the obligation not to inflict serious physical harm on others is commonly accepted as a *prima facie* duty. Moral agents must not inflict avoidable harm of any kind on others without proper justification, particularly when the physical safety of those others is at issue. This claim is a fundamental principle of every moral doctrine which takes humans as ends in themselves. In that sense the avoidance of physical harm is a minimum requirement which takes precedence over norms of distributional justice, especially when a society cannot agree on the proper contents of those norms.[8] Hence I will argue that developed nations must offer strong reasons for delaying achievable emission reductions.

The argument will proceed as follows. In the first section I will outline why the harm principle applies to climate change and what duties it entails for the developed polluters. Next, I shall discuss the relative risks and damages nuclear reactors and fossil fuel plants entail for developed and developing countries, respectively. This is followed by an evaluation of options for combining an early exit from nuclear energy with some compensatory measures, such as an acceleration of emission cuts at some later stage, a transfer of emission abatement duties to other (developed) countries, or increased financial transfers for climate change adaptation in developing countries. In the conclusion I summarize my argument that an early exit from nuclear energy amounts to an immoral policy that ignores northern countries' obligations towards the weakest members of international society.

The obligation not to harm developing countries

Contrary to widespread perceptions, climate change is not a problem of coming decades. Rather, it is a disaster that is already with us—or, to be more precise, with *some* of us. The rise in temperature that historical GHG emissions have caused over the past decades has already impaired the health of millions of people. Desertification, growing water shortages and falling crop yields have threatened food security for many communities. Weather-related disasters, such as storms and floods, have sharply increased in number, a trend which has endangered both the communities and the very survival of people living in exposed coastal regions. Warmer climates have exacerbated the spread of diseases such as malaria and dengue fever and infections causing diarrhoea.[9]

York: Oxford University Press, 2011); Stephen M. Gardiner, Simon Caney and Dale Jamieson, eds, *Climate ethics: essential readings* (Oxford and New York: Oxford University Press, 2010); James Garvey, *The ethics of climate change: right and wrong in a warming world* (London: Continuum, 2008); Steve Vanderheiden, *Atmospheric justice: a political theory of climate change* (Oxford and New York: Oxford University Press, 2008); Eric A. Posner and David A. Weisbach, *Climate change justice* (Princeton, NJ: Princeton University Press, 2010).

[8] Richard Shapcott, 'Anti-cosmopolitanism, pluralism and the cosmopolitan harm principle', *Review of International Studies* 34: 2, April 2008, pp. 185–205; Henry Shue, 'Exporting hazards', *Ethics* 91: 4, July 1981, pp. 579–606; Henry Shue, *Climate justice: vulnerability and protection* (Oxford: Oxford University Press, 2014), pp. 154–6, 309; Andrew Linklater, 'The harm principle and global ethics', *Global Society* 20: 3, July 2006, pp. 329–43; Thom Brooks, 'Climate change and negative duties', *Politics* 32: 1, Feb. 2012, pp. 1–9; Lorraine Elliott, 'Cosmopolitan environmental harm conventions', *Global Society* 20: 3, July 2006, pp. 345–63.

[9] U. Confalonieri, B. Menne, R. Akhtar, K. L. Ebi, M. Hauengue, B. Kovats, B. Revich and A. Woodward,

While it is hard to specify the number of humans harmed by such effects, current estimates indicate that even the 'moderate' rise in temperatures thus far effected by anthropogenic climate change (roughly 0.8 degrees centigrade since pre-industrial times) has already had truly catastrophic consequences. The World Health Organization (WHO) calculates that in the year 2004 alone, climate change-related diseases brought about the premature death of some 141,000 people.[10] A climate study commissioned by the Global Humanitarian Forum (GHF), a Geneva-based NGO headed by Kofi Annan, puts the total death toll (which also includes victims of weather disasters and environmental degradation) for the year 2009 at 315,000.[11] According to the same report, to date global warming has also forced 10 million people into extreme poverty and made 45 million people go hungry. And this is only the beginning: over the next two decades, most of these climate impacts are expected to double in magnitude, thus thwarting many projects to reduce global poverty.[12] By the point, some time around mid-century, when global temperatures will have risen by 2 or 3 degrees from pre-industrial times, these catastrophic numbers may well have doubled again; and, given the various feedback mechanisms at work between these negative effects, the global climate system could pass crucial tipping points, rendering the global condition far more dangerous.[13]

The vast majority of current and prospective victims of climate change live in the developing and least developed nations of Africa and South-East Asia; that is, in countries already burdened by higher (natural) temperatures.[14] More importantly, most of these societies lack the resources to cope with anthropogenic temperature increases.[15] The WHO estimated that in 2004, 115,000 climate change-related deaths occurred in Africa and South-East Asia, while only 1,000 people died in Europe as a consequence of higher temperatures.[16] Similarly, the GHF calculates that 99 per cent of current weather-related diseases occur in developing countries, and that 98 per cent of people seriously affected by global warming live in those states.[17]

On the other hand, the main originators of climate change live in the wealthy countries of the northern hemisphere. Almost 60 per cent of the anthropogenic carbon dioxide emitted since 1890 has been set free by member states of the OECD. Thus, for many decades, this small number of developed countries has emitted

'Human health', in Martin L. Parry, ed., *Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007), pp. 391–431; A. J. MacMichael, D. H. Campbell-Lendrum, C.F. Corvalán, K. L. Ebi, A. K. Githeko, J. D. Scheraga, A. Woodward, *Climate change and human health: risks and responses* (Geneva: World Health Organization, 2003), ch. 6; Samuel S. Myers and Jonathan A. Patz, 'Emerging threats to human health from global environmental change', *Annual Review of Environment and Resources* 34: 1, 2009, pp. 223–52; WHO, *Global health risks: mortality and burden of disease attributable to selected major risks* (Geneva, 2009), p. 24; World Bank, *Turn down the heat: climate extremes, regional impacts, and the case for resilience* (Washington DC, 2013).

[10] WHO, *Global health risks*, p. 50; also MacMichael et al., *Climate change*, p. 276.

[11] GHF, *Human impact report: climate change. The anatomy of a silent crisis* (Geneva, 2009), p. 11.

[12] GHF, *Human impact report*, p. 24; World Bank, *Turn down the heat*, pp. xxv.

[13] World Bank, *Turn down the heat*, pp. xxiv.

[14] WHO, *Global health risks*, pp. 50–51.

[15] World Bank, *Turn down the heat: why a 4°C warmer world must be avoided* (Washington DC, 2012), executive summary.

[16] WHO, *Global health risks*, pp. 50–51.

[17] GHF, *Human impact report*, p. 3.

more CO_2 than the rest of the world together.[18] Moreover, a large proportion of the emissions caused by people living in OECD countries has been aptly termed 'luxury emissions', since they go way beyond the basic energy requirements needed for subsistence.[19] On a per capita basis the OECD countries still produce far more carbon dioxide than the developing world: in 2009 the average person in the OECD set free 9.83 tonnes, whereas the average Asian or African emitted just 1.43 or 0.92 tonnes respectively.[20] Most strikingly, the poorest (and thus least resilient) nations contribute hardly at all to the climate problem: in 2004, 'the 50 Least Developed Countries emitted less than 1 per cent of total emissions'.[21] Hence it is hard to criticize Uganda's President Museveni for calling climate change 'an act of aggression by the rich against the poor'.[22] Moreover, within these disadvantaged countries it is precisely the poorest citizens who suffer most, since they have the lowest capacity to adapt.[23]

Thus, despite the global dimension of climate change, it is fair to say that it has somewhat regional causes and strongly regional health impacts. Up to now at least, it is a catastrophe affecting chiefly developing countries that has been caused chiefly by developed countries. Roughly speaking, the countries most affected are the ones least responsible for this predicament: 'The top 20 countries most vulnerable to climate change in 2004, 15 of which are in Africa, collectively emitted less than 0.7 per cent of total carbon emissions.'[24] This highly asymmetric distribution of causes and consequences must have normative implications for the major GHG emitters. Clearly they are morally obliged to lighten the burden of those who are harmed by their past and current emissions.[25]

The foremost and most obvious duty global warming imposes on developed countries is to limit further harm. Unfortunately, for many decades, it will be very difficult to *reduce* the annual total of climate change victims. Even if humankind were eventually to succeed in cutting back its annual carbon dioxide emissions, the number of people stricken by death, malnutrition and diseases would probably continue to go up for some time. Once emitted, carbon dioxide molecules stay in the atmosphere for centuries, if not millennia; so global temperature will inevitably rise as long as humans continue to emit significant amounts of them.[26]

[18] This has changed only recently with the economic rise of China and India. In 2009 the OECD member states were responsible for 41.5% of the world's CO_2 emissions, compared to a Chinese share of 23.7%. Back in 1973, the OECD share was 66.1%. See IEA, *World energy outlook 2009* (Paris: OECD, 2009), p. 180; IEA, *Key world energy statistics* (Paris: OECD, 2011), p. 45.

[19] Henry Shue, 'Subsistence emissions and luxury emissions', *Law and Policy* 15: 1, Jan. 1993, pp. 39–60.

[20] IEA, *Key world energy statistics*, p. 49. There are notable exceptions. The country with by far the highest per capita GHG emissions is in fact a developing country (Belize). See Posner and Weisbach, *Climate change justice*, p. 124.

[21] GHF, *Human impact report*, p. 63.

[22] Dale Jamieson, 'Climate change, responsibility, and justice', *Science and Engineering Ethics* 16: 3, Sept. 2010, pp. 431–45 at p. 438.

[23] IPCC, *Climate change 2014: impacts, adaptation, and vulnerability. Summary for policymakers* (Geneva, 2014), pp. 7–8.

[24] GHF, *Human impact report*, p. 64.

[25] Darrel Moellendorf, *The moral challenge of dangerous climate change: values, poverty, and policy* (Cambridge: Cambridge University Press, 2014), chs 1 and 5.

[26] Archer gives an average lifetime of 300 years as a rule of thumb. See David Archer, 'Fate of fossil fuel CO_2 in geologic time', *Journal of Geophysical Research* 110: C9, 2005, pp. 1–6 at p. 5. See also IPCC, *Climate change 2013: the physical science basis. Working group I contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change. Summary for policymakers* (Geneva, 2013), p. 27.

Owing to the thermal inertia of the oceans, stabilization of atmospheric temperature will begin only centuries *after* the total amount of atmospheric carbon has started to decline. In the light of this recognition, the duty to prevent further damage requires that developed countries do their utmost to avoid unnecessary deaths and hardships, by *at least slowing down the rate of increase* of the harm caused by their accumulating GHG emissions. To this end, they are obliged to lower this output as fast as appears reasonable given their duties towards their own citizens.[27]

Given the high stakes involved, any avoidable delays in potential GHG reduction efforts require explicit justification. Such arguments would have to explain why, in the case at hand, the interests of a given developed society should enjoy priority over the interests of potential climate change victims. In particular, such justifications would need to take into account that GHG emissions endanger the basic rights of millions of people, such as the right to life, the right to health and the right to subsistence. Some moral philosophers and international lawyers have even claimed that climate change is to be seen as an illegal infringement of human rights.[28] So what could make inflicting such harm excusable? How might wealthy GHG emitters make a case that further compromising these rights does not constitute a moral wrong?

In his classical treatise on the harm principle, Joel Feinberg discusses a number of circumstances that can exculpate the originators of harm:

- the harmed party has freely given its consent to the harmful activity;
- infliction of harm might be unavoidable;
- it might be necessary to protect more important interests;
- the questionable conduct imposes far smaller risks on its potential victim than its avoidance would imply for the acting party.[29]

As the first two conditions clearly do not apply in this case, any plausible justification would need to focus on the relative importance and probabilities of potential damage. Consequently, justifications for avoidable GHG emissions at the very least need to show that those emissions are necessary to protect roughly equivalent interests in developed countries. That is, developed countries can insist on their liberty to choose only if the continued use of nuclear reactors imposes greater risks on themselves than extending the operation of equivalent coal-fired plants would entail for developing societies. As always, the burden of proof for

[27] On top of this duty to reduce national emissions quickly, harm inflicted on developing countries seems to imply two additional duties which I will not address here: an obligation to compensate past and future victims for their suffering and a duty to assist in facilitating climate change adaptation in affected societies. See Moellendorf, *Moral challenge*; Marco Grasso, 'A normative ethical framework in climate change', *Climatic Change* 81: 3–4, April 2007, pp. 223–46; Henry Shue, 'Global environment and international inequality', *International Affairs* 75: 3, July 1999, pp. 531–45.

[28] Derek Bell, 'Does anthropogenic climate change violate human rights?', *Critical Review of International Social and Political Philosophy* 14: 2, March 2011, pp. 99–124; Marc Limon, 'Human rights and climate change: constructing a case for political action', *Harvard Environmental Law Review* 33: 2, 2009, pp. 439–76; Simon Caney, 'Climate change, human rights, and moral thresholds', in Gardiner et al., *Climate ethics*, pp. 163–77; John H. Knox, 'Linking human rights and climate change at the United Nations', *Harvard Environmental Law Review* 33: 2, 2009, pp. 477–98.

[29] Joel Feinberg, *The moral limits of the criminal law*, vol. 1: *Harm to others* (New York: Oxford University Press, 1984), ch. 5.

such a justification rests with those currently inflicting harm on others. It is they who are obliged to demonstrate that abandoning their harmful practice straightaway would amount to an unreasonable demand as it would impose even greater damage on themselves. As long as developed nations cannot establish that greater risks are attached to nuclear power stations, the harm principle would rule out prolonging their use of those coal-fired power plants that would be needed to compensate for an (avoidable) loss of atomic power.

Prima facie, then, the duty to reduce further climate harm reasonably fast is incompatible with national decisions that delay the exit from coal-fired power by giving up nuclear energy first. Even vocal critics of the industry accept that, per kWh of electric energy produced, nuclear reactors cause far smaller amounts of GHG emissions than coal-fired plants. According to a survey by a prominent opponent of nuclear energy, independent academic studies show that coal-fired plants set free roughly 16 times more carbon for the same energy output.[30] Extending the operation time of a coal-fired plant, rather than that of a nuclear reactor, hence entails substantial opportunity costs for the environment. Therefore, when governments (and utilities) have a choice between decommissioning a nuclear reactor and decommissioning a coal-fired plant, the correct decision should be obvious: their obligations towards the victims of climate change call for shutting down the carbon-burning plant. Accordingly, increases in renewable energy production should be used as far as possible for driving down the use of coal, rather than to enable the closing down of nuclear plants that have not yet reached the end of their lifetime.[31] Otherwise, mitigation efforts would be needlessly delayed, as one climate-friendly technology (renewables) would merely be substituted for another one (atomic energy)—with no positive effect for the victims of climate change.

[30] Kristin Shrader-Frechette, 'Data trimming, nuclear emissions, and climate change', *Science and Engineering Ethics* 15: 1, March 2009, pp. 19–23. Other independent studies arrive at far higher ratios. See M. V. Ramana, 'Nuclear power: economic, safety, health, and environmental issues of near-term technologies', *Annual Review of Environment and Resources* 34: 1, 2009, pp. 127–52 at p. 144. Technically, of course, nuclear reactors do not set free any CO_2. However, just as with renewables, a proper comparison of climate impacts must take into account emissions associated with plant construction. In addition, full lifetime analyses need to include emission effects of nuclear fuel production, plant decommissioning and radioactive waste disposal.

[31] The typical operating time for a nuclear plant is four decades. However, authorities in France and the United States have recently extended some permits to a total of 60 years. In fact, operating old reactors is far less risky than activating new plants. See Benjamin K. Sovacool and Christopher Cooper, 'Nuclear nonsense: why nuclear power is no answer to climate change and the world's post-Kyoto energy challenges', *William and Mary Environmental Law and Policy Review* 33: 1, Fall 2008, pp. 1–119 at n. 74. Note that I do not claim that climate-related duties necessarily require the replacement of obsolete reactors with *new* nuclear plants. (On the pros and cons of building new plants to save the climate, see *The future of nuclear power: an interdisciplinary MIT study*, Boston: MIT Press, 2003; Kristin Shrader-Frechette, *What will work: fighting climate change with renewable energy, not nuclear power*, New York: Oxford University Press, 2011; Sovacool and Cooper, 'Nuclear nonsense'.) Conceivably, any obsolete reactor might just as well be replaced by renewable energies, provided that this does not affect the overriding priority of phasing out coal-fired plants as fast as possible. Things would be different, however, if technical, legal or political bottlenecks (rather than mere financial constraints) were to delay the surge in renewables to such an extent that replacing nuclear energy only with renewables became impossible. In that eventuality, building new nuclear reactors might be a moral duty: as I will demonstrate below, *nuclear power plants must not be replaced with coal-fired ones*. Indeed, if there is an immediate imperative in the age of climate change, it is that developed countries straight away stop building coal-fired plants. See Dale Jamieson, *Reason in a dark time: why the struggle against climate change failed and why our choices still matter* (Oxford: Oxford University Press, 2014), p. 236.

Of course, national decision-makers also need to consider the harm nuclear power may inflict on their own constituents, who also understandably insist on their right to life. Conceivably, such risks do indeed outweigh any benefits atomic energy might entail in the struggle against global warming, so that wealthy societies could be justified in delaying possible emission cuts. How, then, do these drawbacks compare to the positive climate effects of currently running reactors?

Health risks and climate benefits of nuclear reactors

As this section will demonstrate, the danger a nuclear plant implies for residents in its locality hardly matches the harm an equivalent coal-fired plant inflicts on the victims of climate change. In fact, and contrary to the intuitions of many concerned citizens, the former seems to pale in comparison with the latter—and this holds true even in linear climate scenarios that do not assume a catastrophic transition to a wholly new climate system. Current estimates give no indication whatsoever that developed societies could call the demand to phase out their coal plants first unreasonable—especially if one bears in mind that the burden of proof rests with the proponents of a fast exit from nuclear power rather than with the potential victims of climate change.

As long as commercial nuclear reactors operate *as planned*, they scarcely endanger the local population at all. Natural background radiation exceeds the doses released from power plants by a factor of between 100 and 1,000.[32] Hence it is not surprising that epidemiological studies have failed to find conclusive evidence that nuclear power plants impose increased health risks on surrounding communities. There is only some preliminary (yet to be explained) evidence of an increase in leukaemia among pre-school-age children growing up very close to nuclear reactors. Other statistical surveys have found no elevated cancer rates for local residents.[33] Seen against the background of the health risks caused by global warming, such a low level of hazard can hardly justify termination of nuclear energy.

Another health risk could result from the radiation emitted by spent fuel rods. Unfortunately, finding suitable sites for the permanent disposal of nuclear waste has turned out to be far more difficult than originally expected. To be sure, this problem cannot be solved even by immediately shutting down all reactors: even were this to be done, there would still be a need for the long-term storage of fuel

[32] D. Laurier, B. Grosche, A. Auvinen, J. Clavel, C. Cobaleda, A. Dehos, S. Hornhardt, S. Jacob, P. Kaatsch, O. Kosti, C. Kuehni, T. Lightfoot, B. Spycher, A. Van Nieuwenhuyse, R. Wakeford and G. Ziegelberger, 'Childhood leukaemia risks: from unexplained findings near nuclear installations to recommendations for future research', *Journal of Radiological Protection* 34: 3, Sept. 2014, p. 58.

[33] Tyndall Centre for Climate Change Research, *A review of research relevant to new build nuclear power plants in the UK: a research briefing commissioned by Friends of the Earth England, Wales and Northern Ireland* (Manchester and Brighton, 2013), pp. 12–13; Ramana, 'Nuclear power', p. 142. A recent multinational expert workshop summarized the state of the art in the following way: 'Based on the available literature, the Workshop participants concluded that there was no elevated risk of childhood leukaemia globally near NPPs [nuclear power plants] in children less than 15 years old. The rather consistent pattern of increased leukaemia risk in the 0–4-year olds *needs to be verified in the future* and *should* not *be interpreted as a causal association*, but it may provide clues about a possible link between childhood leukaemia and living in the close proximity of a nuclear facility' (emphasis added): Laurier et al., 'Childhood leukaemia risks', p. 56.

that has already been used. However, an earlier exit from nuclear power would at least put a lower limit on the amount of hazardous waste and thus might make it a bit easier to find suitable geological sites. It might also constrain the damage resulting were something to go wrong in the millennia to come. Thus the continued use of nuclear energy is disadvantageous in this respect. Even so, the chief obstacles to safe disposal are political rather than technical ones.[34] Thus, an American expert commission recently came to the conclusion that 'the United States has many geological media that technically are suitable for a repository'.[35] The experiences of Sweden and Finland prove that safe sites can be found in the developed world.[36] Moreover, future problems with permanent sites may well be more susceptible to solution with future technologies. In any event, they appear far more manageable and containable than catastrophic climate risks. Leakages from disposal sites would contaminate underground water, but need not lead to any loss of life. Climate change, on the other hand, is already causing many fatalities and will increasingly restrict poor farmers' access to clean water. By 2020, between 75 million and 250 million Africans will be exposed to climate-related water stress; by 2050, more than 1 billion Asians could face shortages of fresh water.[37] Hence it is hard to argue that the long-term disposal of nuclear fuel poses a severe threat to life that overrules the right to life of those harmed by climate change—and it becomes even harder if we take into account that the 'disposal' of a ruined atmosphere would be impossible.

Finally, and most importantly of course, there is the risk of catastrophic meltdown resulting from grave malfunctions or deliberate attacks on reactors. As the Chernobyl disaster of 1986 demonstrated, accidents can indeed endanger thousands of people living in the region and perhaps even far beyond it. While the actual death toll of this event is still a matter of debate among scientists, it is widely assumed that the disaster has been responsible for thousands of additional thyroid cancers among inhabitants of the region around the plant. Moreover, the burning mixture of graphite and fuel rods inside the reactor core produced clouds of ashes which spread radioactive material over hundreds of miles. Taking into account the total amount of radioactivity released and findings concerning the long-term impacts of the two atomic bombs of 1945, a WHO expert group estimated that Chernobyl will ultimately result in up to 9,000 fatal cases of cancer.[38] Other estimates expect up to 34,000 fatalities.[39]

Compared to this, the consequences of the three reactor meltdowns at Fukushima appear rather 'moderate'. These accidents have released roughly 10 per cent of the

[34] Ramana, 'Nuclear power', pp. 142–3.
[35] Blue Ribbon Commission on America's Nuclear Future, *Disposal subcommittee: report to the full commission*, Washington DC, Jan. 2012, p. iii.
[36] IPCC, *Climate change 2014: mitigation of climate change*, p. 14.
[37] IPCC, *Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change: summary for policymakers* (Geneva, 2007), p. 13.
[38] WHO, *Health effects of the Chernobyl accident: an overview*, http://www.who.int/mediacentre/factsheets/fs303/en/index.html#, accessed 5 Jan. 2015; John P. Christodouleas, Robert D. Forrest, Christopher G. Ainsley, Zelig Tochner, Stephen M. Hahn and Eli Glatstein, 'Short-term and long-term health risks of nuclear-power-plant accidents', *New England Journal of Medicine* 364: 24, 16 June 2011, pp. 2334–41.
[39] Ramana, 'Nuclear power', p. 142.

radiation that was set free by the Chernobyl disaster.[40] Owing to the immediate evacuations and other precautions taken by the Japanese authorities (but not by the Soviet authorities after Chernobyl), public exposure to radioactivity was far lower. Medical screening revealed that few local residents received doses above 10 millisieverts[41]—roughly half the equivalent of a whole-body CT scan and two to four times an average person's yearly dose from natural background radiation.[42] It is therefore safe to assume that the ultimate death toll of Fukushima will be just a tiny fraction of that attributable to the Chernobyl disaster.[43] The most memorable cost of the Japanese meltdowns may therefore consist in the long-term evacuation of some 500 square miles around the plant.

Moreover, unlike the inevitable costs of climate change mentioned above, the damage caused by reactor meltdowns is highly exceptional rather than tragic routine. To be sure, the possibility of such catastrophes can never be completely excluded. Even with the best precautions, there are 'limits of safety'.[44] And in addition to the danger of disastrous malfunction, there is always some risk of deliberate terrorist attack, the magnitude of which is difficult to gauge.[45] Yet this does not mean that further nuclear disasters are unavoidable within the next two or three decades. Besides, meltdowns in wealthy countries would probably be more akin to the Fukushima accident than to the Chernobyl disaster, given the fact that the Soviet plant lacked a modern containment mechanism and used as moderator (inflammable) graphite rather than water. Also, it should be kept in mind that even in Chernobyl the human costs could have been far lower had the Soviet authorities rushed to take all necessary measures instead of trying to cover up the accident. Hence, it seems fair to say that the use of commercial nuclear reactors entails deadly risks for hundreds or thousands of local residents—but

[40] L. T. Dauer, P. Zanzonico, R. M. Tuttle, D. M. Quinn and H. W. Strauss , 'The Japanese tsunami and resulting nuclear emergency at the Fukushima Daiichi power facility: technical, radiologic, and response perspectives', *Journal of Nuclear Medicine* 52: 9, Sept. 2011, pp. 1423–32 at p. 1427.

[41] United Nations Scientific Committee on the Effects of Atomic Radiation, *UNSCEAR 2013: report to the General Assembly with scientific annexes. Scientific annex A: levels and effects of radiation exposure due to the nuclear accident after the 2011 great east-Japan earthquake and tsunami*, http://www.unscear.org/docs/reports/2013/13-85418_Report_2013_Annex_A.pdf, accessed 5 Jan. 2015, p. 9.

[42] Tyndall Centre, *Review of research*, p. 11.

[43] According to a recent WHO report there will be just two specific groups with significantly raised cancer rates over the span of their lifetimes: emergency workers and baby girls. One-year-old girls who were exposed to the highest radiation levels will have a 70% higher chance of getting thyroid cancer than other girls in Japan. Emergency workers are estimated to experience a 27% increase in the incidence of leukaemia. For all other highly exposed groups (and all other types of cancer) the increase will be below 10%. See WHO, *Health risk assessment from the nuclear accident after the 2011 great east Japan earthquake and tsunami, based on a preliminary dose estimation* (Geneva, 2013), pp. 53–66. According to UNSCEAR: 'No discernible increased incidence of radiation-related health effects are expected among exposed members of the public or their descendants.' However, up to 150 elderly people and hospitalized patients may have been brought to premature death by the stress experienced during the evacuation process. See UNSCEAR, *UNSCEAR 2013*, pp. 10, 249.

[44] Scott D. Sagan, *The limits of safety: organizations, accidents, and nuclear weapons* (Princeton, NJ: Princeton University Press, 1993); Charles Perrow, *Normal accidents: living with high-risk technologies* (New York: Basic Books, 1984).

[45] However, it must not be overlooked that terrorists themselves may see other targets as even more 'lucrative', both in terms of symbolic value (as demonstrated by the 9/11 attacks) and in terms of potential fatalities (e.g. spectators in a big sports arena). Political risks are notoriously difficult to quantify. Accordingly, my comparison can take account of neither enhanced proliferation risks entailed by a longer use of nuclear energy nor casualties potentially caused by the 'climate wars' which some experts predict. See IPCC, *Climate change 2014: synthesis report* (Geneva, 2014), p. 29.

only in worst-case scenarios where local authorities disregard their responsibilities.[46]

From the above analysis it is not yet obvious that the positive climate effects of nuclear reactors are important enough to justify the risks these plants impose on local populations. So far, the discussion has proved only that climate change has already had far worse consequences than nuclear disasters, and that it will cause even more damage in future decades and centuries. It has not yet demonstrated that the climate benefits of a typical nuclear plant outweigh its potential hazards. If operating atomic plants could save only a handful of lives in developing countries, the wealthy nations of the North might be forgiven for putting their own citizens' safety first. However, as the historical record of nuclear energy clearly demonstrates, its climate benefits are far from negligible.

In fact, the past use of nuclear power has slowed down global warming to a considerable extent. Without atomic energy, hundreds of additional coal-fired plants would have been needed with GHG emissions on a scale that would have impaired the lives of millions of people. According to Kharecha and Hansen, between 1971 and 2009 the use of nuclear energy prevented 64 gigatonnes (billion tonnes) of carbon dioxide emissions.[47] Accordingly, all the reactors operating between 1971 and 2009 helped to avoid an extra rise of total GHG emissions of about 6 per cent (considering that the total amount of anthropogenic carbon dioxide emitted up to 2009 was 800 billion tonnes and that carbon emissions contribute around 81 per cent of all GHG emissions).[48]

As a first approximation, then, we can assume that, in the year 2009 alone, nuclear power spared some 2.7 million people from going hungry (that is 6 per cent on top of the 45 million people estimated by the Global Humanitarian Forum to have gone hungry because of the *actual* total of accumulated GHG emissions) and prevented the deaths of 19,000 people (an extra 6 per cent in addition to the 315,000 gauged by the Global Humanitarian Forum for 2009). Hence the estimated number of lives spared by the use of nuclear energy during a *single year* clearly surpasses the maximum Chernobyl death toll estimated by the WHO. Roughly the same amount of harm (and possibly even more) will be avoided in each of the hundreds of years to come, before atmospheric temperature finally starts to fall again.[49]

What do these figures suggest for the consequences of national decisions to give up nuclear energy? At first glance, the opportunity costs of early reactor shutdowns appear rather moderate. If we assume that, in the year 2009 alone, all the world's commercial reactors combined saved 19,000 lives, this benefit amounts

[46] Tyndall Centre, *Review of research*, p. 16.

[47] Pushker A. Kharecha and James E. Hansen, 'Prevented mortality and greenhouse gas emissions from historical and projected nuclear power', *Environmental Science and Technology* 47: 9, 2013, pp. 4889–95 at p. 4893.

[48] Robert H. Socolow and Alexander Glaser, 'Balancing risks: nuclear energy and climate change', *Daedalus* 138: 4, Fall 2009, p. 32; IEA, *World energy outlook 2008* (Paris: OECD, 2008), p. 398.

[49] Remember the 300-year average lifetime of atmospheric CO_2 (n. 26). To keep the following calculations simpler (and also more conservative), I ignore the prolonging effects to be expected from the thermal inertia of the oceans. I also assume constant effects since there is no apparent reason to presume that future health effects of global warming will be less grave than those facing us today.

(on average) to roughly 1.5 lives spared per reactor-year, given a cumulative sum of more than 13,000 reactor-years until 2009.[50] Accordingly, shutting down ten reactors 20 years prior to the end of their lifetime would eventually result in the total loss of a mere 200 reactor-years and so cause about 300 extra climate-related fatalities (together with an extra of about 40,000 people going hungry).[51] Some people might consider this an acceptable opportunity cost for ending the exposure to the risks of nuclear accidents (even though it would have to be paid by people living in developing countries for the safety of energy consumers in wealthy countries). However, such a calculation would overlook the long-term impact of the decision, as the 300 extra deaths are just the figure *for a single year* (in the period after the date for which the reactors had originally been scheduled for decommissioning). Yet the effects of an extended use of coal power would not end with the final shutdown of these plants. When we factor in the 300 years the average carbon dioxide molecule stays in the atmosphere (and thus continues to heat the planet), we arrive at a far higher total: 90,000 lives.

Moreover, these figures reflect only the fatalities GHG emissions cause in developing and least developed countries, while ignoring those caused by coal-fired stations in their own region. The fine particles set free by these plants harm local populations by causing lung cancer as well as respiratory and cardiovascular diseases. A study commissioned by the environmental NGO Clear the Air concluded that US coal-fired plants would cause the premature death of *at least* 2,000 US citizens per year even if the most advanced emission controls were to be installed; without such technical upgrades, the actual figure is about 24,000 extra fatalities.[52] A more recent report issued by the Health and Environment Alliance claims that in the year 2009 coal-generated power caused more than 18,200 premature deaths in the 27 EU member states—twice as many as the Chernobyl disaster will eventually claim from cancer, according to the WHO.[53] Using similar calculations, Kharecha and Hansen estimate that between 1971 and 2009, the worldwide operation of nuclear power plants prevented around 1.8 million deaths.[54] These local deaths caused by coal-fired stations make it even harder to argue that a government's duty to protect national citizens can justify relinquishing nuclear energy before coal power. Moreover, these figures show that even with a successful introduction of carbon capture and storage (CCS) technology (which would reduce GHG emissions), prolonging the use of coal-fired stations would remain a very problematic policy option.

As these approximations of likely damage strongly indicate a stark asymmetry *in favour* of nuclear energy, the risks it entails for its users in the developed countries

[50] See the chart in World Nuclear Association, *Safety of nuclear power reactors*, http://www.world-nuclear.org/info/Safety-and-Security/Safety-of-Plants/Safety-of-Nuclear-Power-Reactors/, accessed 5 Jan. 2015.

[51] Given that in 2009, 13,000 accumulated reactor-years prevented 2.7 million people from going hungry, a single reactor-year benefits some 200 people.

[52] Conrad G. Schneider, *Dirty air, dirty power: mortality and health damage due to air pollution from power plants*, http://www.catf.us/resources/publications/files/Dirty_Air_Dirty_Power.pdf, accessed 15 Jan. 2015, p. 4.

[53] Health and Environment Alliance, *The unpaid health bill: how coal power plants make us sick*, http://www.env-health.org/IMG/pdf/heal_report_the_unpaid_health_bill_-_how_coal_power_plants_make_us_sick_final-pdf.pdf, accessed 5 Jan. 2015, p. 24.

[54] Kharecha and Hansen, 'Prevented mortality', p. 4891.

hardly overrule the harm principle. Of course, as the number of reactors declines over the decades to come (as more and more of them reach the end of their operating time), the amount of carbon dioxide emissions avoided will also come down. But so will the risks associated with the continued use of nuclear power. Hence, the cost–benefit asymmetry mentioned above will be little affected. In the light of this analysis, those in the developed world who want to call the harm obligation into question by pointing to the health risks reactors imply for their own nations would need at the very least to show that the imbalance is much smaller than suggested here (or that it even favours the replacement of reactors with coal-fired plants). Simply taking cover behind the various uncertainties of climate change and nuclear power production is not a moral option.

Questionable options for compensation

Perhaps an earlier exit from nuclear power could be justified if it were accompanied by measures that compensate for its negative impacts? For instance, the ethics commission which recommended that Germany give up nuclear power argued that the European emissions trading system would ensure that the decision would be climate-neutral. (In effect, the commission simply assumed that other EU members would make up for any potential emissions reductions lost owing to the closure of Germany's reactors.)[55] Also, a country might promise to make good the temporary slowdown in emission reductions by accelerating them in the years to come. Finally, such a country could also increase its contributions to the global climate adaptation fund. Such extra financial resources could then be spent for neutralizing the additional health risks.[56] Unfortunately, from a moral perspective, none of these compensatory options seems satisfactory.

Shifting planned national reductions to some later period (or to some other countries) might be acceptable as long as this did not endanger an overall reduction target that sufficiently protects the potential victims of climate change. But is the developed world currently doing enough to protect climate victims? In view of the high number of people suffering and dying even today (after a mere 0.8 degree increase in global surface temperature), it is hardly possible to say yes. If we consider the global target of limiting the increase to 2 degrees centigrade, time is running out very fast: wealthy nations actually need to accelerate their mitigation efforts, and they need to do so *now*, because the effect of reductions declines the longer they are postponed.[57]

[55] Ethik-Kommission Sichere Energieversorgung, *Deutschlands Energiewende—Ein Gemeinschaftswerk für die Zukunft* (Berlin, 2011), p. 34. As a matter of fact, due to an enhanced use of coal-fired power, Germany's energy-related CO_2 emissions have markedly increased since the much-celebrated *Energiewende* was launched. See 'Green revolution? German brown coal power output hits new high', *Spiegel Online*, http://www.spiegel.de/international/germany/researchers-alarmed-at-rise-in-german-brown-coal-power-output-a-942216.html, accessed 5 Jan. 2015.

[56] Brooks, 'Climate change and negative duties', pp. 5–6.

[57] United Nations Environment Programme, *The emissions gap report 2013: a UNEP synthesis report*, http://www.unep.org/publications/ebooks/emissionsgapreport2013/portals/50188/EmissionsGapReport_2013_high-res.pdf, accessed 5 Jan. 2015, pp. xi; IPCC, *Climate change 2014: mitigation of climate change*, p. 16; IEA, *World energy outlook 2011*, p. 40.

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Moreover, there is always a substantial risk that more ambitious reduction targets shifted to other nations or later time periods will eventually not be met. Technical problems or lawsuits against new installations may severely hamper envisioned surges in renewable energies.[58] Currently, the world's nuclear plants produce roughly four times as much electricity as all forms of renewables combined.[59] Hence, even replacing atomic energy, to say nothing about the global aggregate of fossil fuel-fired power plants, would require huge investments and adjustments. So far, plans for a drastic increase in renewables are just that: plans. They may fail, just as collective reduction targets (like those envisioned in the EU certificate trading system) may be abandoned. The consequences of failure, however, would be faced not by energy consumers in wealthy nations but rather by the victims of climate change living in poor countries.

Compensating developing countries by increased contributions to a global adaptation fund would also be problematic. Again, there is no guarantee that such a fund would achieve the desired results over hundreds of years. Even if all the required financial contributions were to be paid in advance, there would remain a serious risk that the institution might become defunct over the course of the centuries (for instance, as a result of political controversies).[60] More importantly, from a moral perspective such a compensation scheme can never be more than a second-best solution. After all, climate change will force millions of people to move into higher and cooler regions. Hence it will impose on them substantial changes in lifestyles and will force them to desert buildings and places of high symbolic value to their communities. In some cases it could completely dissolve nations or ethnic communities. Accordingly, compensation without prior consent is never equivalent to harm avoidance itself. It can only be offered as an *ersatz* measure when harm avoidance fails.[61]

Conclusion: putting wealthy polluters first

An early exit from atomic energy is an immoral policy in the age of global warming. For one thing, such a policy ignores the severe damage coal-fired plants do to local populations. Hence it is difficult to justify even in purely national contexts; and it becomes still more questionable when cross-border air pollution is factored in.[62] Most importantly, however, giving up nuclear energy is incompatible with a country's international duties as it disregards the severe harm coal-fired power plants keep inflicting on the victims of climate change. Whenever they

[58] To give but one example of the potential problems: the world may face a serious shortage of the rare earths needed for the production of efficient magnets used in wind turbines and electric vehicles. See 'Rare earths and climate change', *The Economist*, 17 March 2012.

[59] Morton, 'The dream that failed', p. 12.

[60] IPCC, *Climate change 2014: synthesis report*, pp. 36–7; Moellendorf, *Moral challenge*, pp. 188–9.

[61] Jamieson, *Reason in a dark time*, p. 211. Even within (democratic) political communities, involuntary expropriation is limited to situations where a strong public interest apparently dwarfs the interests of individual proprietors. In the case of nuclear energy risks, however, there seems to be no analogous common interest that is shared by the proprietors.

[62] Health and Environment Alliance, *The unpaid health bill*, pp. 21–2.

face a choice between using coal or nuclear power, developed nations are obliged to opt for the latter. To be sure, nuclear power will not 'save the climate'. But it will save many lives among the global poor, who otherwise just would have to live with the consequences of wealthy countries' lavish energy consumption. Despite all its drawbacks, nuclear energy is not yet expendable in the wealthy North. As long as coal-fired plants in developed countries keep 'exporting' grave risks and damages to the global South, phasing out operational nuclear reactors remains an indefensible policy. Those in the North who favour such an exit policy either are focusing to an irrational extent on the risks of nuclear energy, while being strangely oblivious to the disastrous impacts of climate change, or attach much more weight to the presumed security interests of Europeans, Japanese and North Americans than to the lives of poor and vulnerable people living in developing countries.

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