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Equity and energy in global solutions to climate change

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ABSTRACT

This paper explores the prospect for achieving an equitable allocation of country-specific carbon dioxide emissions from the energy sector within the framework of the Cancun climate stability target, as represented by Representative Concentration Pathway 2.6. Three allocation principles are considered, with the primary one (Egalitarian) based on equal per capita emissions for all countries by 2050. The two secondary allocation principles, termed Emission-based and GDP-based, distribute allowable emissions according to cumulative historical emissions and cumulative historical GDP respectively. Neither of these two allocation principles can deliver equal per capita emissions by 2050. Only when a global average constraint factor is introduced, designed to enable countries with less than allowed global average per capita emissions in any year to increase their emissions to this level, can emissions parity (the Egalitarian principle) be achieved by 2050. Finally, it is argued that achieving the widespread agreement needed to achieve climate stability is likely to be difficult, given both the size of reductions needed, especially by high-emission countries, and the inadequacies of the technical fixes proposed.
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Introduction

Since the Conference of Parties of the United Nations Framework for Climate Change (COP UNFCCC, 2010) (the Cancun agreement), consensus toward climate change has been to stabilize atmospheric GHG concentrations to limit the average temperature rise to below 2 °C. Emission scenarios, or more recently, Representative Concentration Pathways (RCPs), have been frequently used to explore the possibility of achieving such targets (van Vuuren et al., 2011a, 2011b; Organization for Economic Cooperation and Development (OECD), 2012; Intergovernmental Panel on Climate Change (IPCC), 2013, 2014). According to the IPCC, the various RCPs 'are identified by their approximate total radiative forcing in year 2100 relative to 1750: 2.6 W/m^2 for RCP2.6, 4.5 W/m^2 for RCP4.5, 6.0 W/m^2 for RCP6.0, and 8.5 W/m^2 for RCP8.5.' The IPCC decided that these four scenarios 'would not be developed as part of the IPCC process, leaving new development to the research community' (Van Vuuren et al, 2011b). Of special interest here is RCP2.6, which aims to achieve climate stability by 2100.

Van Vuuren et al. (2011a) explored the technical feasibility of achieving the reductions in greenhouse gas (GHG) emissions needed to meet RCP2.6. They found that RCP2.6 could be met by reducing GHG emissions, such as CO_2 from global fossil fuel combustion, by using a combination of increased technical efficiency, wider use of renewable and nuclear power, the use of fossil fuel carbon capture and storage (CCS) and, to obtain negative carbon emissions, large scale use of bioenergy CCS (BECCS). In doing so, they assumed that rapid deployment of new technologies is both possible and necessary. Importantly, non-technical measures based on behavioural change (e.g., demand reduction (Moriarty and Honnery, 2010)) were not considered. Interestingly, van Vuuren et al. (2011b) assumed that for RCP2.6, the world GDP growth rate will be even faster than for the three other RCPs, despite greater emission reductions. Further, the authors concluded that reducing emissions to limit warming to less than 2 °C cannot be achieved without broadening the participation of countries in mitigation actions; the reductions needed cannot be allocated to high emitters alone.

One of the recommendations for further research was to identify national emission pathways that may be acceptable to all parties involved in climate negotiations. Van Vuuren et al. (2011a) detail a purely technical route to achieving RCP2.6, but non-technical factors will also be important (Morgan and Waskow, 2014). For example, the level of economic development of a country could severely limit its capacity to transition to a low carbon energy economy, particularly if it has access to a cheap supply of coal and limited access to renewable energy. Further, the cost of shifting from a fossil fuel based energy sector in countries with significantly lower standards of health and education could place an unacceptable burden on their capacity to lift these standards, and limited access to renewable energy resources could exacerbate this burden.

An important aspect of acceptability is the perceived fairness of any GHG allocation. The need for fairness in outcome, and the recognition of

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differences among countries are recognised in the UNFCCC principle of common but differentiated responsibilities (Winkler and Rajamani, 2014). It has been argued that each country having equal GHG emissions per capita provides the fairest distribution of emissions (Höhne et al, 2014; Kitzes et al, 2008; Singer, 2006). This approach, which stresses the equality of the rights of individuals, is often termed egalitarian (Cazorla and Toman, 2001). However, given the large disparity in present country level per capita emissions, achieving such a result within the constraints of RCP2.6 is likely to take time, suggesting the need for a methodology to allocate emissions until equal per capita emissions can be achieved. Also known as effort-sharing (Höhne et al, 2014), a number of approaches, based on different principles, could be used to arrive at equal future per capita emissions (e.g., Cazorla and Toman, 2001; Singer, 2006; Pierrehumbert, 2013; Zhang and Shi, 2014). For example, allocation of future GHG emissions could be based on the country's contribution to global emissions, or on a country's economic capacity to reduce GHG emissions. These are shown in Table 1 as secondary allocation principles, with equality in emissions being the primary aim. Note that the secondary allocation principles can be applied independently of the primary principle. In this paper the secondary principles are first applied in turn, then each is applied together with a constraint designed to achieve equality in emissions.

Besides those listed above, additional factors often cited as being important to the development of equitable allocations of future GHG emissions are: a country's historical contribution to the problem, inequities in burdens from the impacts of climate change, and intergenerational equity (Giddings et. al., 2002; Sovacool, 2013; Thomas and Twyman, 2005).

Since carbon dioxide remains in the atmosphere for a long time (Archer, 2005; Hansen et al., 2008), historical emissions, expressed as past cumulative emissions, are often cited as being an important factor in assigning equitable emission allocations (COP UNFCCC, 1992; Miguez and Oliveira, 2011). To illustrate the importance of historical emissions, many OECD countries now have stagnant or even falling energy-based CO_2 emissions (and also primary energy use). In contrast, such emissions are rising strongly in many industrialising countries (BP, 2014). An important reason for this contrast is that the OECD countries have already built their energy-intensive infrastructure, whereas newly industrialising countries have not. Their infrastructure catch-up explains why China and India together produce and use most of the world's cement, and why China dominates world steel production (Moriarty and Honnery, 2014). Exner et al. (2014) have taken this argument even further, and advocated equal per capita *stocks* of geologically scarce metals such as copper.

Similarly, since most countries' pursuit of economic growth has usually led to increased emissions (Moriarty and Honnery, 2009, 2011), and because it provides an indication of capacity to respond technologically, past cumulative GDP could also be used to guide any future emission allocation. Gross GDP may provide a better indication of response capacity than does average GDP/capita for a given country, for at least two reasons. First, many low carbon technologies are likely to benefit from economies of scale (e.g., for CCS, BECSS, and nuclear power plants, unit costs reduce with plant size), and so are only available to large economies. Second, large economies such as India and China, even with low per capita incomes compared with OECD countries, have the capacity to develop a range of the innovative technologies that may be needed. Nor are gross GDP and average GDP per capita the only options. Chakravarty et al. (2009) have advocated an allocation system for CO_2 reductions ultimately based on the income of *individuals*, regardless of where they live, rather than on the income of nations. All high-emitting individuals in the world would be subject to a 'universal cap on global individual emissions'.

The time scales for past and future emissions are very different. While the benefits accruing from past emissions for mature industrial countries have occurred over a century or more (e.g., benefits from transport, energy, and buildings infrastructure), industrialising countries will now be required to reduce their emissions and transition to low carbon emitting technologies within decades.

Consideration must also be given to the unequal burdens on countries from the *impacts* of climate change (Morgan and Waskow, 2014). Numerous studies indicate that the least developed countries will suffer the most from climate change effects (Anand, 2004; IPCC, 2013; Mitchell et al., 2006; Sovacool, 2013), yet their contributions to global cumulative emissions have been minimal (BP, 2014). Intergenerational equity is also important. Failure to reduce future emissions could lead to global temperature rises as high as 4 °C by 2100 (IPCC, 2013; New et al., 2011), with the result that future generations are likely to experience severe climatic effects for actions not attributed to them. Furthermore, adaptation costs are likely to increase the longer we delay mitigatory action. But at the same time, it is also necessary to consider impacts on the present generation; mitigation requirements cannot be so stringent as to severely compromise well-being in the short-term (Giddings et al., 2002).

An important additional component to achieving equity in future allocations arises from the link between energy and emissions. As will be discussed later in this paper, provided energy use does not reduce in step with emission decreases, global emissions will become decoupled from total primary energy use. Equity in emissions is not therefore the same as equity in energy consumption; the attainment of an equitable emissions allocation must not come at the cost of reduced access to energy, particularly for those living in a state of energy poverty (Sovacool, 2012). Indeed, Bazilian et al. (2010) have argued that energy policy should drive climate change policy rather than the reverse.

In this paper we make use of the two secondary allocation principles shown in Table 1 to explore how a global emission pathway represented by RCP2.6 could be achieved with the additional constraint of arriving at equal annual per capita emissions by 2050. We first present individual mathematical representations of the two secondary allocation principles, Emission-based and GDP-based, each of which includes the role of historical responsibility. This is followed by a discussion of how these perform within the framework of the Human Development Index (HDI) by classifying all countries into one of three groups: High, Medium, and Low HDI. We then investigate the performance of a modification to these allocation principles, termed the global average constraint, which preferences emission allocations to countries with low per capita emissions. We conclude by discussing how failure to address equity in access to energy in our attempt to deliver a more stable climate could act to stall efforts to reach a global consensus on emission reductions.

Table 1
Emissions allocation principles and descriptions.
Source: Cazorla and Toman (2001).

Principle	Description
Primary: *Egalitarian*	People have equal rights to use atmospheric resources (i.e. equal per capita emissions).
Secondary: *Emission-based allocation*	Future emissions are allocated based on a county's net cumulative emissions as a fraction of global cumulative emissions.
GDP-based allocation	Future emissions are allocated based on a county's cumulative GDP as a fraction of global cumulative GDP.

Emission allocation methodology

As noted, the van Vuuren et al. (2011a) version of RCP2.6 provides an implementation pathway using a range of technologies to limit climate change to less than 2 °C. The allowable annual emissions under this and the other three pathways for the energy sector for the period up to 2050 are shown in Fig. 1. The business-as usual energy sector emission path, as given in the *OECD Environmental Outlook to 2050* (OECD, 2012), falls between the RCP6.0 and RCP8.5 curves in Fig. 1. The RCP2.6 limit effectively allows no more than about 800 Gt CO_2 to

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