Session: From incremental to radical transformation: reconciling energy systems with 2°C carbon budgets **OR** 3.4 Alternative development pathways for the Global South

Title: A Safe Operating Space for Development?

Summary: Human development achievement and global climate change policy are intimately linked though the provision of basic goods and services. Given prevailing technologies, such provisions will require an expansion of energy use and greenhouse gas (GHG) emissions. In this paper, we attempt to quantify a fair 'operating space' for development – a body of energy consumption and GHG emissions that may be necessary for developing regions to spend in order to preserve their future access to basic goods and services. We assess 'development as usual' ("DAU") projections using an elasticity approach for four regions: Africa, India & South Asia, China & Centrally Planned Asia, and Latin America. The respective sizes of each operating space are significant in comparison to the global carbon budget, have varying dynamics over the following four decades, and are highly consequential for the equitable allocation of global emissions rights.

Introduction: Despite the numerous proposals for fair burden-sharing (Baer et al., 2009; Chakravarty et al., 2009; Raupach et al., 2014), there has been very little elaboration on what constitutes a fair quantity of emissions *necessary* for development. This is a prescient issue in the context of on-going international negotiations, where it is now recognized that the participation of all major emitters, including key developing countries such as India and China is required to break the climate impasse (Grasso and Roberts, 2014). The enthusiasm of these countries to join a climate change deal will almost certainly be tempered by the 'right to development' (Baer et al., 2009), with likely consequences for the emissions trajectories of the global North and the viability of a low stabilization scenario (Anderson and Bows, 2011). In this paper, we seek to establish the actual energy and emissions necessary to achieve high development outcomes. In particular we measure development outcomes directly, rather than as a function of increasing per capita incomes; this follows from multiple recent critiques of GDP as an indicator of general progress (Costanza et al., 2014; Stiglitz et al., 2009).

Methods: Much recent work has focused on the interaction between human development, energy use and carbon emissions, with a particular emphasis on the non-linearity of the well-being-environment relationship (Costa et al., 2011; Dietz et al., 2009; Jorgenson, 2014; Lamb et al., 2014; Mazur and Rosa, 1974; Rao and Baer, 2012; Rao et al., 2014; Steinberger et al., 2012, 2010). We build on this literature by performing yearly cross-section regressions on 3 pairs of country development and environmental impact indicators: life expectancy, access to basic needs and GDP per capita as dependent variables; per capita final energy consumption and GHG emissions as independent variables (Fig. 1). Access to basic needs is a composite indicator comprising six dimensions of the bare minimum requirements for development (access to sanitation, electricity, water, food supply, education and a survival rate).

Following Steinberger et al. (2010) and Costa et al. (2011), we estimate hyperbolic saturation curves from historical data, on the basis of which we project future energy and emissions for 'development as usual' (DAU). This scenario incorporates the observed autonomous improvement in the efficiency of delivering human development, but assumes no near-term climate policy. A development operating space of energy and emissions is projected in each region under DAU, up to a threshold level for each indicator.

In the final stage of our analysis, the DAU scenarios are compared to a cost-based allocation regime from the MESSAGE model. Specifically, a scenario is selected from the LIMITS project, comprising 2^{o}C

stabilisation (66% probability), with delayed policy action until 2020 and equal relative GDP losses across all regions (Tavoni et al., 2014). This illustrative scenario allows us to contrast a development based allocation of emissions rights with one in which only economic efficiency is prioritised.

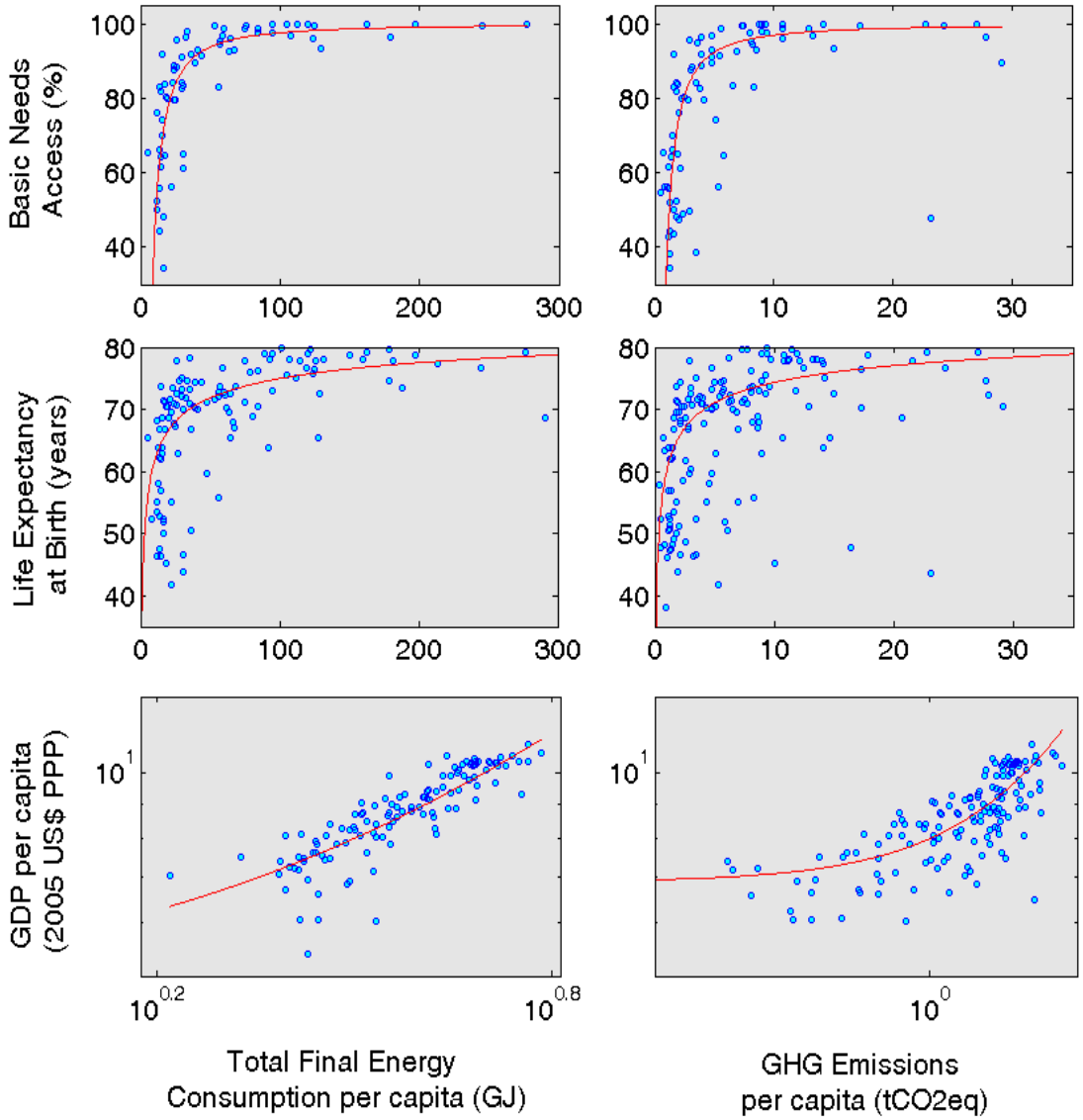

Figure 1: Cross section regressions on 3 indicators of development (y-axis) and 2 indicators of environmental impact (x-axis) in 2010

Results: We find a rapid autonomous decoupling rate between life expectancy and the environmental impact variables, a relatively shallower decoupling rate for basic needs access (emphasising that it is a more stringent criteria of development, or cannot be as easily decarbonised) and a shallower still decoupling rate for income. Further, the efficiency of human development achievement is regionally distinct, with Latin America and India & South Asia performing relatively better than the other two regions. These differences, as well as disparate levels and rates of change in current development achievement lead to highly diverging estimates of operating space for each region. Figure 2 depicts the annual energy and GHG emissions for achieving human development in Africa, in comparison to a baseline and mitigation scenario from the MESSAGE model. The results range in sensitivity (the coloured area for each indicator) depending on the rate of future decoupling. While the results confirm that growth in income remains the development indicator of

the least compatibility with climate mitigation, sustaining increases in Africa's life expectancy to the threshold level still requires an increase of final energy consumption from 20EJ to 50EJ between 2010 and 2040. The difference between this estimate and the allocation of energy consumption to Africa in a MESSAGE mitigation scenario is as high as 10EJ in the mid-term – a significant shortfall that highlights perhaps overly optimistic assumptions of technological change and access to key services in the integrated assessment model. Forthcoming results are expected to further highlight the non-trivial rates of change in carbon intensity that would ensure appropriate human development goals are met in the coming decades, while still maintaining a low-stabilisation climate change scenario. The results will also highlight examples of high performing low-carbon development pathways, with broad applicability for alternative scenarios of well-being mitigation.

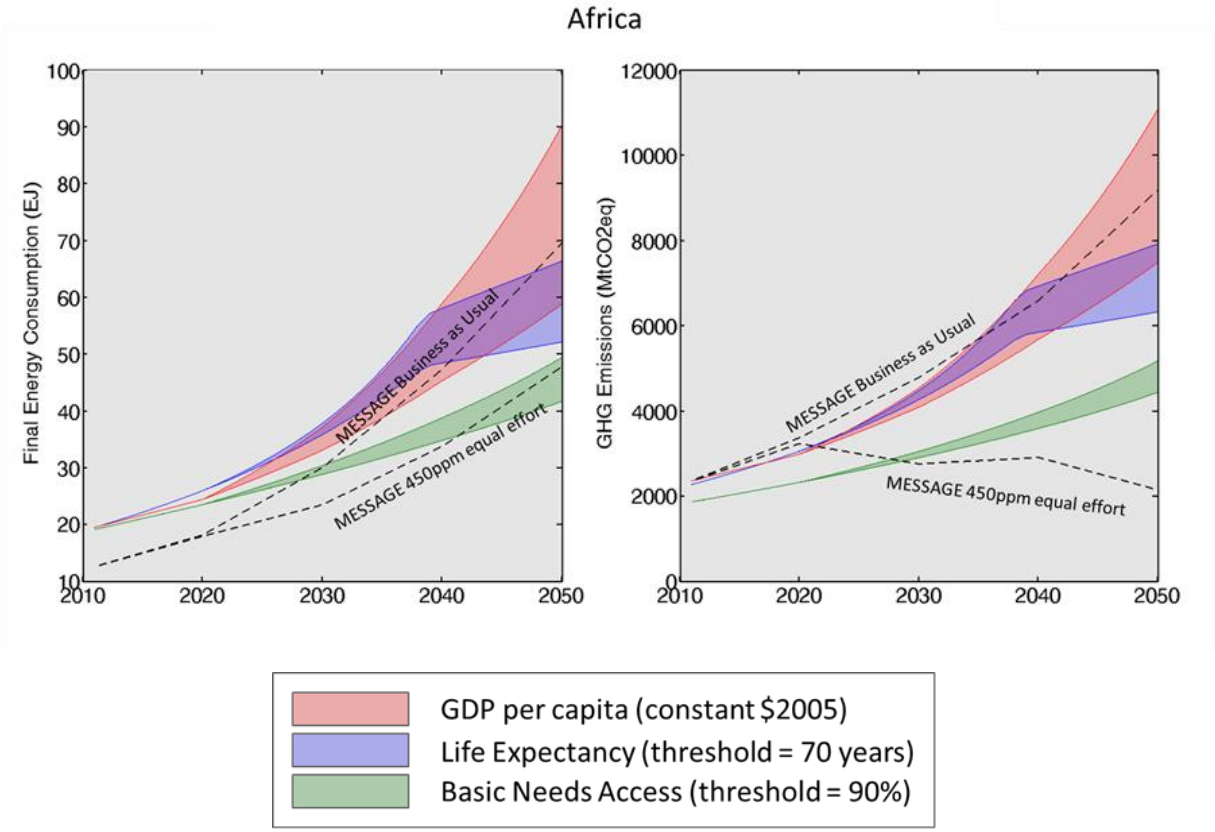

Figure 2: Final energy consumption and greenhouse gas emissions required to meet three dimensions of development from 2011 to 2050, contrasted with two mitigation scenarios from the MESSAGE model.

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