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Bridging the energy divide and securing higher collective well-being in a climate-constrained world

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A B S T R A C T

Despite the impressive gains in available energy over the last 200 years, the associated benefits remain unevenly distributed. Bridging this divide only adds to the already daunting challenge of securing climate stabilization. In fact, efforts towards the former are more likely to conflict with the latter. To be able to address this dilemma, the relationship between energy consumption and human well-being, beyond its economic dimension, needs to be better understood. This paper aims to contribute to the emerging knowledge base, by examining this relationship using a proxy for human well-being that also considers its environmental and social dimensions. The ultimate goal of this paper is to investigate the potential incompatibility between efforts towards the achievement of higher collective well-being and those associated with climate stabilization. To this end, it provides estimates of the additional energy needed and its associated carbon emissions under different climate scenarios, and compares them with existing carbon budgets. Results indicate that even if new climate policies were adopted, emissions associated with higher well-being in all regions where improvements are needed could still reach up to one and a half times estimated 2 °C budgets, and even more so for lower temperature increase targets.

1. Introduction

Energy has played a vital role in humanity's struggle for subsistence as an essential input in food production, heat generation, and access to modern energy services. It also became a key component in several aspects of human development and well-being, such as educational opportunities, general health improvement, and food security (Martinez and Ebenhack, 2008). It has been deemed indispensable for eradicating poverty and inequality and achieving sustainable development (UNGA, 2015; WCED, 1987), a concept that postulates the existence of inextricable linkages among economic, social and environmental factors.

Despite the impressive gains in available energy over the last 200 years (Smil, 2000, 2004, 2010, 2011), the associated benefits remain unevenly divided. By 2010, over 3 billion people had an annual per capita primary energy consumption equal to or below 50 Gigajoules (GJ),[1] a rate that has been associated with a minimum quality of life (Smil, 2010).[2,3] In fact, more than one third of the world population enjoyed an average primary energy consumption rate below 30 GJ, roughly one seventh the average energy use in affluent countries.[4] Moreover, almost 1 billion people are expected to be added to the population in the least developed part of the world by 2050 (UNDP, 2015), where annual primary energy consumption rates fall below 15 GJ per capita, on average.[5] Hence, it is clear that higher levels of energy consumption will be needed to bridge the energy divide and enable the achievement of higher levels of human well-being across the globe.

Meanwhile, the burning of increased quantities of coal and petroleum-based fuels has been the major cause of human induced climate change and is, therefore, considered the main contributing factor to the upward trend in Earth's surface temperature since 1950 (IPCC, 2014). In 2010, the Parties to the Climate Change Convention agreed that, to avoid catastrophic and irreversible climate change, global average

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[1] Based on 2010 data from the World Bank (2016).
[2] According to Spreng (2005) an annual per capita primary energy consumption rate above 63 GJ would be required to achieve decent living standards.
[3] Steinberger and Roberts (2009) argue that such threshold is not constant and decreases over time. Whereas, according to Rao and Baer (2012) universal thresholds do not apply, as each country has different circumstances.
[4] Based on a calculated average of 201 GJ/capita for OECD countries using 2010 data from the WB.
[5] Based on 2010 data from the World Bank (2016).

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temperature increase should be limited to "below 2 °C" above pre-industrial levels (UNFCCC, 2010), the so-called "2 °C target".[6]

By December 2015, one hundred and eighty-seven countries that accounted for over 96 per cent of global CO_2 equivalent emissions in 2012 had submitted their "Intended Nationally Determined Contributions" outlining carbon reduction targets based on post-2020 action (Knutti et al., 2016; Rogelj et al., 2016b). However, according to recent studies (Rogelj et al., 2016b; UNEP, 2015, 2016), in the absence of additional emission reduction efforts, the estimated carbon budgets associated with the 2 °C target could be consumed as soon as 2030, and emissions would equate to scenarios that limit global average temperature increase in excess of the intended 2 °C target (median of 3.2 °C at a 66% chance).

Annual carbon dioxide (CO_2) emissions from fossil fuel burning have increased over 100% since 1970, regardless of the significant reductions in the CO_2 intensity of energy consumption seen in the same period (Blanco et al., 2014), and are expected to continue increasing, as fossil fuels are likely to remain the dominant sources of energy (Clarke et al., 2014; IEA, 2015).

In this context, the additional energy needed to bridge the energy divide and enable the achievement of higher levels of collective well-being only adds to the already daunting challenge of securing climate stabilization. To help governments and policymakers deal with this dilemma, it becomes critical to better understand the relationship between energy consumption and human well-being, beyond its economic dimension.

In spite of an extensive literature on the relationship between energy consumption and economic growth measured in terms of Gross Domestic Product (GDP) (Chen et al., 2012; Ozturk, 2010), including a number of studies encompassing CO_2 emissions (Omri, 2013), only a small number of studies has examined the relationship between energy consumption and human development beyond its economic dimension (Costa et al., 2011; Jackson, 2009; Lamb and Rao, 2015; Martinez and Ebenhack, 2008; Mazur, 2011; Pasten and Santamarina, 2012; Rao and Baer, 2012; Smil, 2010; Steckel et al., 2013; Steinberger and Roberts, 2009, 2010; Steinberger et al., 2012; Ugursal, 2014). Moreover, because these studies used the Human Development Index (HDI) or some of its components as proxy for well-being, they failed to encompass the third fundamental aspect of human development, the environmental dimension.

This paper aims to help overcome this shortcoming by selecting a potential proxy for human well-being that encompasses not only the economic and social dimensions of human development, but also its environmental dimension. However, its ultimate goal is to investigate the potential incompatibility between efforts towards bridging the energy divide while enabling the achievement of higher levels of collective well-being and those associated with climate stabilization. To this end, it provides estimates of the additional energy consumption in all regions where improvements are still needed, as well as the corresponding carbon emissions under different climate scenarios. It then analyses the impact that such emissions would have on estimated carbon budgets associated with achieving the 2 °C target.

This paper is organized in five sections, including this introduction. The next section provides an overview of how human well-being has been defined and measured to date. Section 3 presents the proposed quantitative assessment framework, and Section 4 presents and discusses the results obtained and compares them with regional emissions pathways associated with the climate stabilization target of 2 °C. Lastly, Section 5 presents main policy implications and future research suggestions.

[6] This target was recently revised to "well below 2°C" in the 2015 Paris Conference (UNFCCC, 2015).

2. Well-being beyond GDP

Since the Bretton Woods conference, in 1944, GDP has been used as the primary indicator of a country's well-being (Dickinson, 2011). This approach was consistent with the then prevailing utilitarian conceptualization of well-being, according to which higher income allows for higher consumption, which, in turn, provides greater unitary pleasure or utility (Gasper, 2004). Sen (1985) noted that this approach reduced well-being to being "well-off", financially or materially. In other words, measured as level of income well-being became associated with well-having. Not surprisingly, this simplistic notion has led to increasing criticism of the use of GDP as a measure of the real well-being of nations (see Adler and Seligman, 2016; Costanza et al., 2009; Osberg and Sharpe, 2011; Stiglitz et al., 2009).

Measuring a country's well-being solely in economic terms misses the key fact that the economy is a means to an end, not an end in itself. As such, GDP does not capture other intrinsic dimensions of well-being, such as educational opportunity, health and quality of life, and social networks and relationships. In addition, aiming for unending economic growth is not sustainable in a world with environmental limits. In fact, humanity's imprint on the global environment through resource use and waste production may have exceeded the regenerative and absorptive capacity of the biosphere (Barnosky et al., 2012; Rockström et al., 2009; Steffen et al., 2011), thus compromising the ability of future generations to ensure their well-being.

While the multidimensional nature and, to some extent, the intergenerational aspects associated with human well-being have been widely acknowledged; there is little consensus on how it should be defined. There is a wide range of conceptual approaches to it in the literature (see Adler and Seligman, 2016; Dasgupta, 2001; Gasper, 2004; Stiglitz et al., 2009). Dodge et al. (2012) and McAllister (2005) provide an overview of the main conceptual approaches and help navigate the confusing research base available, highlighting the focus on dimensions – either objective or subjective - and descriptions rather than definitions.

More recent research on well-being has emphasized its various forms of capital, whereby income is seen as one of different factors that contribute to the production of well-being (Mulder et al., 2005; Osberg and Sharpe, 2011; Vemuri and Costanza, 2006). As such, human well-being has also been examined under a capital-based approach, which encompasses manufactured or built capital (e.g. infrastructure and financial resources), natural capital (e.g. energy resources, mineral resources, land, ecosystems and biodiversity, water, air quality and climate), human capital (e.g. health, education, and labor), and social capital (e.g. trust, social networks, and institutions).

Notwithstanding the lack of theoretical consensus, empirical research has advanced towards quantification of human well-being at the level of nations and several aggregate indicators[7] have been developed to either replace or adjust GDP (Goossens et al., 2007; Schepelmann et al., 2010), as measure of societal well-being (Table 1).

Aggregate indicators meant to replace the GDP would try to assess well-being more directly, e.g. by assessing average satisfaction or the achievement of basic human functions. Conversely, those meant to adjust the GDP would typically begin with a key component of the GDP like personal consumption data or the GDP itself, then adjust it to reflect the social costs of inequality and diminishing returns to income received by the wealthy, add a variety of monetized environmental and social factors (e.g. housework and volunteering), and/or deduct costs associated with undesirable and/or harmful side effects of economic progress (e.g. destruction or degradation of natural capital and international debt).

[7] The term aggregate indicator in the context of this paper refers to an indicator that has been obtained by combining and weighing of individual variables/indicators that reflect different human well-being dimensions that can exist on their own, separately from the aggregate indicator.