Global energy transition to 100% renewables by 2050: Not fiction, but much needed impetus for developing economies to leapfrog into a sustainable future

Ram Manish, Bogdanov Dmitrii, Aghahosseini Arman, Gulagi Ashish, Oyewo Ayobami Solomon, Mensah Theophilus Nii Odai, Child Michael, Caldera Upeksha, Sadovskaia Kristina, De Souza Noel Simas Barbosa Larissa, Fasihi Mahdi, Khalili Siavash, Traber Thure, Breyer Christian

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Global energy transition to 100% renewables by 2050: Not fiction, but much needed impetus for developing economies to leapfrog into a sustainable future

Manish Ram [a, *], Dmitrii Bogdanov [a, **], Arman Aghahosseini [a], Ashish Gulagi [a], Ayobami Solomon Oyewo [a], Theophilus Nii Odai Mensah [a], Michael Child [a], Upeksha Caldera [a], Kristina Sadovskaia [a], Larissa De Souza Noel Simas Barbosa [b], Mahdi Fasihi [a], Siavash Khalili [a], Thure Traber [c], Christian Breyer [a, ***]

[a] LUT University, Yliopistonkatu 34, 53850, Lappeenranta, Finland
[b] Luiz De Queiroz College of Agriculture, University of São Paulo, Piracicaba, São Paulo, Brazil
[c] Energy Watch Group, Albrechtstrasse 22, 10117, Berlin, Germany

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ABSTRACT

This is a discussion and response to "Global 100% energy transition by 2050: A fiction in developing economies?" authored by Anthony Afful-Dadzie and published in Joule 5 (2021) 1634–1643. The preview has raised concerns around the feasibility of energy transitions towards 100% renewable energy and sustainable technologies in developing economies, after examining the article Bogdanov et al. (2021) in Afful-Dadzie (2021). Although, the author has rightly pointed out the disparity in the recent growth of renewable energy across the developed and developing countries of the world, along with highlighting a pertinent issue of 'availability of finance' for energy transitions across developing countries, the preview fails to contextualise the issue of financing energy transitions, in particular across developing countries, and has trivialised complex and cumbersome cost optimal energy transition modelling with vague and unscientific illustrations. In response, the authors of Bogdanov et al. (2021) have contextualised, clarified and confuted the issues raised in Afful-Dadzie (2021).

1. Introduction

Economic development depends on energy access, reliability and quality of supply, and in recent times on the sustainability of energy sources. Transitions to high shares of renewable energy and sustainable technologies are found to be the central cog in efforts to mitigate runaway climate change and ensuring ever-growing energy needs, particularly in developing countries, are met sustainably [1–4]. However, steep declines in generation costs of renewable energy systems, particularly solar photovoltaics (PV) and wind, combined with a recent spur in storage and flexible technologies mainly driven by batteries and green hydrogen, drive a paradigm shift in energy systems across the world [5–7]. Renewable energy now dominates investments in electricity generation systems installed around the world [8,9]. Renewable energy and complementary sustainable technologies are expected to attain very high levels of penetration in energy systems, particularly in regions well-endowed with solar and wind potential [10–12]. The fundamental results presented in Bogdanov et al. [12], and discussed in Afful-Dadzie [13], have been confirmed from an overall energy system perspective by Luderer at al. [14], and for the core finding of solar PV and battery competitiveness against fossil fuel-based electricity by Lu et al. [15]. Similar to the success of the telecom industry with rapid dispersion of mobile phones, many developing countries have a significant opportunity to leapfrog into a sustainable future with the adoption of more advanced energy technologies that are low cost, reliable, environmentally more benign, and well suited to serving dispersed rural populations [16,17].

* Corresponding author.
** Corresponding author.
*** Corresponding author.
E-mail addresses: Manish.Ram@lut.fi (M. Ram), Dmitrii.Bogdanov@lut.fi (D. Bogdanov), Christian.Breyer@lut.fi (C. Breyer).

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2. Disparity in renewable energy capacity installations

Afful-Dadzie [13] has pointed out that the development of renewable energy capacity additions in developing countries is rather slow compared with developed countries. This is the case to a great extent as indicated by the annual statistics presented by the International Renewable Energy Agency [18]. However, renewable energy is already making a positive mark within the Global South with many developing countries employing renewable energy sources rapidly. Developing countries began to include renewable energy technologies as part of their development strategies given the correlation between the decarbonisation and sustainable development agendas. In the last few years, these nations invested more in these technologies than developed nations, when viewed on a per gross domestic product basis [19]. As of now, Kenya is leading in off-grid solar power systems with over 750,000 PV systems sold across the country owing to its favourable policies attracting investments in providing electricity access [8,20]. Countries like Brazil and Costa Rica use renewable energy as their primary energy source. Renewable energy accounts for 85% of Brazil's energy supply and 90% of Costa Rica's energy supply [8]. In Brazil, about 68% of power capacity addition in 2021 comes from renewable energy, of which wind and solar PV amount to 47% and 19%, respectively [21,22]. There were five developing countries that generated more than 15% of their electricity in 2017 from modern renewable energy sources including geothermal, wind and solar PV: Kenya (47.4%), El Salvador (31.7%), Nicaragua (30.9%), Costa Rica (21.3%), and Honduras (17.1%) [19]. Solar PV continues to experience impressive cost decline and capacity growth and is increasingly discussed as the core source of energy for humankind [12,23,24]. Several developing countries are leading the way in solar PV generation shares, such as Tokelau (100%), Honduras (11.8%), Jordan (10%), Senegal (10%), Chile (8%), Eritrea (8%), India (6%) along with high shares from the two leading economies of the world, China (4%) and the US (2.6%) [25–27]. Moreover, in developing countries like Yemen, off-grid solar is the preferred electricity option among residential households with 75% urban and 50% rural households with solar PV installations [28]. In 2019, developing countries devoted approximately 152 bUSD to renewable energy development as opposed to their developed counterparts that invested about 130 bUSD in the sector [29]. Despite a difference in capacity additions of renewable energy and adoption of sustainable technologies, the growth of these technologies in developing countries has been much faster in recent years compared to developed countries and this trend is expected to continue with many developing countries leading the way.

3. Significance of emerging and developing economies

Afful-Dadzie [13] has rightly indicated that tackling climate change will need global concerted efforts and developing countries are vital in these efforts. This is already being reflected worldwide, with 165 countries having targets to increase renewable energy and not just countries either, more than 600 cities around the world have 100% renewable energy targets [8]. Collectively, developing countries have half the global renewable power capacity. China and India are rapidly expanding markets for renewable energy. Brazil produces most of the world's sugar-derived ethanol and has been adding new biomass, solar PV and wind electricity generation plants [22]. Many renewable markets are growing at rapid rates in developing and emerging countries like Argentina, Chile, Costa Rica, Egypt, Indonesia, Kenya, Tanzania, Thailand, Tunisia, and Uruguay [30].

Afful-Dadzie [13] points out that there has not been much research emphasis on energy transitions in developing countries. When compared with the amount of research for the developed countries, there is a stark difference, with most research in the last decades focussed on developed countries and regions [10]. However, acknowledging this fact the LUT Energy System Transition Model has been applied for many developing countries such as Bangladesh [31], India [32], Pakistan [33], Nepal and Bhutan [34] along with SAARC [35], the Philippines [36], Indonesia [37], and Southeast Asia [38], further countries in Africa such as Cameroon [39], Ethiopia [40], Ghana [41], Nigeria [42], West Africa [43], and sub-Saharan Africa [44,45]. Further, North Africa and Middle East [46] and Morocco [47], Algeria [47], Jordan [48] and Iran [49], as well as the South American countries of Bolivia [50] and Chile [51] and South America [52] have been explored. Developing countries are gaining significance in energy system analyses, as indicated for India [53], Indonesia [54], Ethiopia [55], South Africa [56], Jordan [57], Mexico [58] and Brazil [59] among many others. There is no ethical way around energy consumption in the Global South rising sharply for many years to come given the massive development yet to take place. Creating fair and just energy transitions across developing countries needs to allow for much greater economic growth and prosperity. Expansion and utilisation of sustainable energy resources with the transition to renewable-based energy systems is the only feasible pathway to achieve long-term economic development. On the contrary, investments in conventional technologies with low capital costs, as discussed in Afful-Dadzie [13], will hamper economic progress in the Global South with higher costs of energy in the longer term driven by highly volatile prices of fossil fuels.

From a climate perspective, energy transitions in the Global South demand support from developed countries, which have benefitted the most from fossil fuels and are responsible for a majority of cumulative greenhouse gas emissions. It is justifiable that developed countries have to support climate mitigation and defossilisation in other parts of the world, in particular developing and least developed countries. At the same time, the steep cost decline of renewable energy and rapid growth of energy demand across countries in the Global South make investments in renewables extremely attractive, despite the challenges of addressing climate change in an equitable and justifiable manner. Different levels of co-benefits were identified from Chinese investments in renewable energy development across Africa [60]. Driving investments in renewable energy can assist countries in providing adequate energy services to their populations, build sustainable energy infrastructures, create jobs [61,62] and induce other socio-economic benefits to alleviate poverty [63] within their societies. In addition, electricity trade between neighbouring countries brings numerous benefits for developed countries as well. For example, the US has an existing grid interconnection with Mexico to avoid blackouts during peak load hours, which has benefited the country's economy and created a significant number of jobs [64]. The same benefit applies to Mexico, which not only decreases costs but also ensures the security of energy supply [65,66].

4. Finance to enable energy transitions

Afful-Dadzie [13] presents the theory of scarcity in terms of financial scarcity that plagues developing countries during energy planning and hinders developing plans for renewable energy development. In this context, Afful-Dadzie [13] has misinterpreted the financial assumptions and approach of Bogdanov et al. [12]. Bogdanov et al. [12] present a cost optimal and climate compliant global energy transition pathway for 145 regions, 92 countries aggregated into 9 major regions with financial assumptions based on current market realities and trends validated by peer-reviewed sources. It could be argued that Bogdanov et al. [12] have not

considered different risk profiles for different countries across developing and developed regions [67]. However, representing the different risk profiles for energy investments on a global scale is a rather complex exercise as highlighted in Bogdanov et al. [68]. In addition, differentiated risk adapted costs of capital on a country basis for India [69] and Indonesia [37] but also for the whole of Africa [70] indicate an even higher attractiveness for rapid renewable energy phase-in. Moreover, Afful-Dadzie [13] has presented the theory of scarcity for a lack of availability of finance in many developing countries, which in turn poses as a major constraint on energy planning. However, the lack of finance in many emerging markets and developing economies seeking to increase energy investments depends on a range of factors, which can undermine risk-adjusted returns for investors and the availability of bankable projects. These challenges are much broader, involving the availability of commercial arrangements that support predictable revenues for capital intensive investments, creditworthiness of counterparties, availability of enabling and complementary infrastructure, and other project level factors [30]. Economy wide issues such as depleted public finances, currency instabilities and weaknesses in local banking and capital markets also raise challenges to attracting investments in energy projects [30].

Investments by advanced economies to drive down the cost of renewable and sustainable solutions is being channeled multilaterally and bilaterally between countries in the form of climate assistance. It is globally recognised that access to financing and cost of capital are critically important as renewable energy technologies are capital intensive, even though long-term operating costs are quite low. Still, international public financial flows to developing countries stimulating renewable energy has strongly grown since the early 2010s and solar and wind projects have received the majority of investments in recent years [71]. Yet obtaining financing in developing countries is challenging and expensive. Domestic and national banks are often reluctant to lend to renewable energy projects due to a lack of experience. Whereas foreign investors deem projects as risky, as local utilities may not be creditworthy. In addition, investors face currency and inflation risks in many developing countries and thus may worry about recovering their upfront investments if bills are paid in a local currency. Political risk, corruption, and inconsistently enforced regulations are also problems plaguing developing countries. It is also harder to develop any energy system without adequate infrastructure: it is harder to operate the system and sell electricity if electric grids are unreliable, and it is more expensive to build projects with inadequate roads, communication networks, and ports. These additional infrastructure risks further increase the cost of financing. In this regard, Afful-Dadzie [13] has failed to contextualise the issues of financing beyond the theory of scarcity.

Afful-Dadzie [13] has illustrated some unscientific and simplified calculations comparing solar PV coupled with battery storage to a combined cycle gas turbine (CCGT) system without detailed considerations of operational factors, fuel availability along with price fluctuations of natural gas, electricity demand profiles with daily and seasonal variations of different energy sectors, outdated cost assumptions, costs of alternative technologies and many others. Whereas, Bogdanov et al. [12] have conducted a comprehensive analysis of energy systems across many developing countries and regions in an hourly resolution with an exhaustive list of over 100 energy technologies to determine the least cost energy mix, and have also estimated the capital expenditure required for the respective energy mix in corresponding years of the transition. Nevertheless, Bogdanov et al. [12] have clearly emphasised that solar PV first reduces the cost of the existing power system with almost no storage requirement, and in a second step further benefits can be realised in increasing the solar PV electricity share by utilising more battery storage. Beyond renewable energy, low-income economies undergoing rapid growth, urbanisation, and industrialisation require technologies such as storage, production of e-fuels and carbon capture as highlighted in Bogdanov et al. [12]. The fundamental finding of Bogdanov et al. [12] on solar PV-battery systems as the dominating core for electricity supply in Sun Belt countries is confirmed for the case of China as coal-based electricity has already lost its competitiveness against solar PV accelerated with PV-battery solutions [15]. The very high value of low-cost electricity beyond the power sector for the entire energy system [24] requires special attention, which is ignored by Afful-Dadzie [13]. Afful-Dadzie [13] has raised a pertinent issue of availability of finance in developing countries to enable the energy transition but has failed to interpret the findings of Bogdanov et al. [12] in a coherent manner.

5. Financing energy transitions across Africa

Afful-Dadzie [13] has emphasised the issue of energy transitions and the lack of financing plaguing countries in Africa. The global energy landscape is rapidly changing, and Africa is at a complex juncture between issues of development, energy, climate change and sustainability. The onus is on African countries to find a cross-functional solution; one which answers simultaneously to socio-economic and environmental challenges. This involves driving growth in energy supply and hence industrialisation with the adoption of a balanced mix that harnesses all energy potential in a cost optimal and sustainable manner. Although the higher cost of capital and logistics may result in somewhat higher-than-average costs for renewables and storage in certain parts of Africa than elsewhere, this is often offset to some extent by the excellent resources available across the continent [44]. However, there is no doubt that utility-scale solar PV in 2020 is cheaper than the fossil alternatives across Africa when the right regulatory and policy frameworks are in place [5,72]. This is particularly true when it is procured by means of well-structured, well-implemented auctions and tenders. It is interesting to note that even countries with high perceived investment risks are able to attract private investments in renewables at prices consistent with least-cost development, particularly when these are coupled with appropriate risk mitigation and supported by development partners. For example, the International Finance Corporation (IFC) Scaling Solar programme (based on auction design in combination with a concessional finance offering to subsidise selected bidders' debt costs) has successfully achieved record low prices in Zambia, Senegal and Ethiopia, with the Ethiopian auction result in 2020 coming in at a very competitive 25 USD/MWh [73]. Moreover, Nigeria as the largest economy in Africa aims to increase the rate of national electrification and renewable energy share in the final energy mix by integrating a 1 GWp solar PV park in the north of the country [74]. This project is being conducted by the Rural Electrification Agency in cooperation with the African Development Bank via the Sustainable Energy Fund for Africa [74]. Business model innovations play a vital role in driving renewable energy uptake, as proved by the 'Pay-As-You-Go' (PAYGo) model that has enabled energy access for millions of off-grid consumers, mostly through solar home systems, although PAYGo also has made inroads into productive applications such as solar water pumping and even clean cooking [8]. PAYGo companies typically provide either a 'lease-to-own' or a 'usage-based' payment model to ease upfront capital investments and are driving sales across the top five markets comprising Kenya, India, Ethiopia, Uganda and Nigeria [8]. In addition to solar energy, many African countries have other renewable energy resources (wind, hydropower, geothermal) that can be used to generate electricity at competitive prices

[40–43,75]. Finally, it is noteworthy that auctions are increasingly incorporating socio-economic goals that go beyond price.

A successful energy transition in Africa has the potential to contribute to long-term sustainable economic development, inclusive social progress and increased human well-being [40,76]. Thus, in Africa, where capital is expensive, efforts to reduce risk and enable the huge investments required will be central to tackling climate change. In this context, the role of development finance institutions (DFIs) along with multilateral development banks (MDBs) and national development banks across Africa are vital in enabling the energy transition and fostering economic growth [77,78]. Afful-Dadzie [13] has rightly emphasised that climate change is a global issue and developing countries predominantly from Africa will have a major role and cannot be ignored.

6. Opportunity cost and leapfrogging

Afful-Dadzie [13] has emphasised that budgetary constraints entail short term thinking and hinder long term energy planning. However, it appears the opportunity cost of lost time (or the risk associated with time) is not being given enough weight in the development and implementation of energy planning. The more pressing issue for developing countries is whether they can afford the opportunity cost of a delayed transition, which could leave many with stranded energy assets in particular for fossil fuel producing developing countries [79]. Developing countries have the opportunity to avoid trapping themselves in legacy technologies that could eventually hinder economic progress. On the other hand, developing countries should look to leapfrog into a sustainable future that has better socioeconomic prospects. In this context, pathways presented in Bogdanov et al. [12] could guide energy planners and policy makers across developing countries to take informed decisions and measures with cost-effective principles [80]. Moreover, devising long-term targets based on robust research principles could attract investments and spur the development of renewable energy and sustainable technologies.

Afful-Dadzie [13] has further highlighted that there is a dearth of finance available for energy transitions in developing countries. However, the International Energy Agency [30] suggests that there is no shortage of global capital, but there is a shortfall of clean energy investment opportunities around the world that offer adequate returns to balance the risks. In 2020, the global financial wealth held by investors stood at over 200 tUSD, with a strong appetite among investors to fund clean energy projects [30]. It has to be noted that most of this wealth is concentrated in advanced economies and if energy transitions are to be successful, then developers and financiers need to increase the amount of capital allocation in renewable energy and sustainable technologies in particular across emerging and developing economies.

Fossil fuels are geographically concentrated resources and have historically been at the core of geopolitical powerplay for those countries that own, extract and market them. The current energy system thrives on scarcity and the concentration of power with large producers and consumers of fossil fuels. On the contrary, countries around the world are on the brink of transitioning to an energy system of potential abundance, in particular the Sun Belt countries of the Global South, which are mostly developing countries. Developed economies around the world have a different set of challenges. While there persists a strong momentum of economic growth, the need to cope with legacy systems and political resistance to rapid transitions could pose an immense challenge. A rapid adoption of renewables provides more independence to developing countries with the opportunity to leapfrog into a sustainable future and avoiding expensive lock-ins. It is not at all fiction that many developing countries leapfrogged in telecommunication terms by skipping landlines and jumping straight to mobile phones and the age of internet.

7. Concluding remarks

Afful-Dadzie [13] has raised an issue that is central to ongoing climate negotiations with the need for developed and advanced economies to raise climate finance in order to support developing countries to both mitigate and adapt to climate change. However, Afful-Dadzie [13] has failed to emphasise the need for developing countries to act with innovative policy and building conducive environments to attract international finance. Developing countries need to be more proactive, too, with quick and effective measures to reduce political risks and corruption, streamline licensing procedures, removing restrictions and barriers for foreign direct investments, and offer transparent, predictable, and competitive tendering/auctioning opportunities. Reforming domestic banking systems and regulating capital markets can drive and enable a future in which developing countries can build and finance these projects indigenously, while transforming into attractive markets for investors worldwide and enabling energy transitions towards fully renewable energy systems across developing countries [81]. In addition, Afful-Dadzie [13] has failed to highlight the immense opportunity for developing countries to leapfrog their counterparts into a sustainable future, benefiting the local populations. Abundance of renewable resources is one of the most important advantages of countries in the Global South and fostering renewable energy systems will become a fundamental driver for economic competitiveness, enabling sustainable development across the region. Afful-Dadzie [13] has not acknowledged the high opportunity cost of not acting on transiting towards higher shares of renewable energy and sustainable technologies for developing countries, an opportunity cost which they cannot afford. Moreover, as recent research [82] has shown, climate mitigation can pay large and immediate dividends towards improving well-being, reducing inequality and alleviating poverty across the world. Questioning how realistic a positive pathway is for developing economies seems counterproductive given the potential opportunity and ability to overcome noted challenges.

All countries around the world must shape their own energy pathways based on specific needs and available resources, and there is a lot that countries themselves can do to create and improve the conditions for large scale investments in renewable energy and sustainable technologies. In this context, research such as Bogdanov et al. [12], which presents energy transition pathways that are premised on highly decentralised energy systems across 145 regions of the world, could assist energy planners, policy makers and other stakeholders in deriving conclusive actions towards enabling the energy transition worldwide. However, the global challenge of climate change necessitates global solutions, and it is up to the international community to ensure that all countries, both developed and developing, collaborate amicably to tackle one of the most critical challenges of our time.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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