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journal homepage: www.elsevier.com/locate/rserFinancing renewable energy in Africa – Key challenge of the sustainable development goals[☆]Gregor Schwerhoff^{a,*}, Mouhamadou Sy^b^a Mercator Research Institute on Global Commons and Climate Change (MCC), Torgauer Straße 12-15, 10829 Berlin, Germany^b African Development Bank, Research Department, CCA, Avenue Jean-Paul II, BP V316 Abidjan, Côte d'Ivoire

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ABSTRACT

Given the challenge of offering a development perspective to a rapidly growing population, it might be tempting for Africa to pursue a strategy of fueling growth with the cheapest source of energy available and take care of the environment later. Such an approach, however, would disregard the social cost of fossil fuels, which the population would have to bear. Using the Sustainable Development Goals as a benchmark for inclusive and sustainable growth we identify the synergy effects provided by renewable energy. Already, substantial efforts of financing the additional cost of RE are under way. An analysis of possible leverage points, available instruments and involved actors shows that there remains a large additional potential.

1. Introduction

In September 2015, the UN General assembly adopted the Sustainable Development Goals (SDGs), which contain 17 goals including ending poverty and hunger, improving health and education, combating climate change, and protecting forests [100]. Increasing the production of renewable energy (RE) can contribute to many of these goals. Any serious effort to achieve the sustainable development goals will thus generate a high demand for RE. This creates an additional need for financing, which has been recognized by the African Renewable Energy Initiative (AREI). We analyze how current efforts by the international community and actors within Africa¹ to finance RE perform and how the remaining shortfall can be addressed.

RE has strong synergy effects on the SDG for three reasons. First, and most evidently, it provides energy, which provides the basis for making progress on a number of goals. In Africa, energy is currently a bottleneck for economic growth and thus for reducing poverty [6,25]. Energy has the potential to make agriculture more productive and thus contribute to food security [74]. Further, it has been shown to improve education and even to enhance gender equality [16]. Since RE allows countries to become independent from fuel imports it also contributes

to the goal of ensuring a reliable and sustainable form of energy.

Second, RE does not cause the local damage which some of the currently widespread alternatives, like traditional biomass and coal, cause. It could thus make a contribution to the goal of ensuring healthy lives by replacing the source of indoor air pollution [95] and by improving local air pollution from co-emitted air pollutants [107]. It could also improve the welfare of women as the burden of indoor air pollution is currently placed disproportionately on them [20]. In addition, it would promote the sustainable use of ecosystems, in particular forests, by replacing the need to collect firewood [77]. RE is particularly suitable to replace the sources of indoor air pollution as it has been shown to be economically competitive in remote, rural areas, because it can be deployed in a decentralized way [17].

Third, RE generates hardly any CO₂ and thus hardly accelerates climate change. While combating climate change is itself one of the SDG it has an effect on the long term prospect of reaching almost all of the other SDG. The damages of climate change as detailed in the IPCC [49] report are so broad and so harmful that any unsustainably achieved progress on the SDG could be short-lived. The damage to agriculture activities is a direct threat to food security, but also to economic growth on a continent heavily relying on agriculture. In

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¹ We focus on the continent of Africa. When statements refer only to Sub-Saharan Africa, this is made explicit.

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addition it has been shown that increases in food prices increase poverty [51], thus counteracting effort on reducing poverty and inequality. Other effects of climate change have been shown to affect health adversely [37].

Given these benefits of RE for sustainable development, it could be asked why there is any need for outside support for financing RE. A first reason for the need for support is that the social benefits far outweigh the private benefits for the investor. International organizations could thus use their means to align the needs of society with the investor's incentives. A second reason is the sheer size of the financing challenge, which slows down growth in Africa [24]. The purpose for international organizations like the World Bank and the African Development Bank is to reduce global inequality. Reducing the bottleneck of insufficient RE in Africa could prove to be an investment with an extremely high social rate of return.

Finally, there is a more subtle reason for the need for outside support of RE. Generating energy with fossil fuels and with renewable energy has very different investment profiles. Fossil fuel facilities are relatively inexpensive to set up, but require high recurring costs as fuels need to be purchased constantly. RE facilities are expensive to set up, but the energy source is for free or a minor cost factor, so that mainly operation and maintenance cost remain as recurring cost. Which type of investment is most efficient thus depends on the interest rate faced by the investor. In Africa, it is typically the government investing in energy generation. The governments of the continent and also other investors in energy infrastructure, however, can borrow at the market only at high cost so that they are naturally inclined to favor investments in fossil fuel based electricity generation [90].

Given the need for outside support we survey current efforts and assemble possible leverage points for future action. The large gap for additional RE capacity has its roots in the currently very low electricity supply in Africa as well as the very strong growth both in terms of population and in economic terms, which is expected in the remainder of the century. Currently active climate funds use their limited funds for capacity building and pilot projects, but are in no position to contribute directly to ramping up capacity significantly. Increasing the international financing volume is thus an obvious approach to improve the situation. Reducing inefficiencies, providing a reliable investment framework and actively involving the private sector are further promising approaches.

In Section 2 we will review the existing evidence on the synergy effects of energy on a number of objectives formulated in the SDG. In Section 3 we analyze the challenges currently faced by African investors for financing the specific investment profile of RE. These are matched with already existing efforts of assisting Africa, including the large funds, in Section 4. In Section 5 we provide a systematic approach to future solutions along the lines of possible leverage points, available financial instruments and involved actors. Section 6 concludes.

2. Renewable energy and the sustainable development goals

In Africa, RE has a large potential to contribute to the SDG in a double sense. In the first sense RE has strong synergy effects and allows improvement on many of the goals at the same time. In the second sense, RE are particularly well suited for Africa due to the favorable natural conditions.

Here, we show the link between RE and 10 out of 17 SDG as formulated in United Nations [100]. The ten were chosen as those where the RE effect is most salient. A full list of the SDGs is given in Appendix Appendix A. For most of the SDG we structure the discussion of the effects of RE into a first part with the direct effects of energy availability and reduced local damages and a second part which highlights the potential to avoid the damages to the particular goal through climate change.

Climate change is a global problem and Africa currently contributes only a small fraction of the emissions which cause climate change.

Nevertheless, Africa has an important role for mitigating climate change and thus in reducing the adverse effects of climate change on the achievement of the SDGs. There are several reasons why early mitigation efforts in Africa are important. First, Africa's participation would facilitate global cooperation. Second, Africa would avoid making itself dependent on carbon intensive energy supplies [101]. Finally, without mitigation efforts Africa would become a major emitter of carbon emissions by the end of the century.

The increasing role of Africa for global mitigation efforts has been documented repeatedly. The United Nations Population Fund (UNFPA) expects the working age population in Sub-Saharan Africa to increase by 150% between 2015 and 2050 [99]. According to the World Economic Outlook of the International Monetary Fund, GDP growth will be above 5.5% per year from 2015 to 2019 in Sub-Saharan Africa. The shared socio-economic pathways (SSPs) expect in a "middle-of-the-road scenario" that GDP in Sub-Saharan Africa will grow with an average annual rate of 3.5% until 2100, so that it almost reaches the development level of the US today [68]. Given this evidence, Africa has a high level of control over how much climate impacts it will have to face.

RE investments can have synergy effects across many of the SDG. However, no single investment can realize all of them at once, because not all households can benefit from the same type of RE provision. Many households are so remote from the national electricity grid that it is not efficient to connect them to it [87]. For these remote communities it would be more efficient to build local microgrids, which deliver the same level of services. Only very small villages cannot be serviced economically with microgrids, so that solar home systems are the better option [13]. Realizing the full range of benefits discussed below would thus require financing solutions for the national grid, microgrids and solar home systems.

GOAL 1 End poverty in all its forms everywhere and **GOAL 10** Reduce inequality within and among countries.

One effect of large-scale RE provision would be to free the financial and time resources of the rural population used for procuring energy. Millions of households spend more than a third of household expenditures on energy and sometimes more than 6 h a day gathering fuelwood [96]. A second effect would be to provide an essential input for consumption and production. 620 million people in sub-Saharan Africa remain without access to electricity [46] and 19 countries, mostly in central and east Africa, have electrification rates below 20% [36]. Kirubi et al. [59] Ahlberg and Sjöstedt [3] show that electricity, in this case from microgrids, can significantly improve worker productivity in rural households.

By mitigating climate change, RE can reduce the poverty risks of climate change. The risk of reduced crop productivity and adverse effects on livestock due to heat and drought stress is very high in Africa [49]. Reduced agricultural productivity will increase food prices and severely increase poverty among vulnerable groups such as the urban poor [38], leading to a slowdown in poverty reduction in Africa [91]. Next to these direct effects Leichenko and Silva [67] name several indirect effects working through the mechanisms described below for other SDG goals: Climate change can reduce ecosystem services on which subsistence agriculture relies strongly. It has adverse effects on health which then reduces the capacity to earn a living. Finally, it may cause instability and thus slow down economic growth.

GOAL 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Increased efforts to provide RE will make more energy available, which can increase agricultural production and thus provide the means for assuring food security and ending hunger. The intensification of land use during the Green Revolution relied on mechanization and the use of fertilizers and pesticides, all of which is energy intensive [29,58]. Mushtaq et al. [74] show that rice yields can increase by a factor of more than three through higher energy input. Energy input rises even more than proportionally with food production [86]. While it will be

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