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Are we there yet? Improving solar PV economics and power planning in developing countries: The case of Kenya

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ABSTRACT

Despite the rapid decline in the cost of solar photovoltaic (PV) systems in the past five years, even recent academic research suggests that the cost of generating PV electricity remains too high for PV to make a meaningful contribution to the generation of grid electricity in developing countries. This assessment is reflected in the views of policymakers throughout Africa, who often consider PV as a technology suited only to remote locations and small-scale applications. This paper therefore analyzes whether, in contrast to conventional wisdom, PV is already competitive with other generation technologies. Analytically, the paper is based on a levelized cost of electricity (LCOE) model to calculate the cost of PV electricity in Kenya, which serves as a case study. Based on actual technology costs and Kenya's solar resource, the LCOE from PV is estimated at USD 0.21/kWh for the year 2011, with scenario results ranging from USD 0.17–0.30/kWh. This suggests that the LCOE of grid-connected PV systems may already be below that of the most expensive conventional power plants, i.e. medium-speed diesel generators and gas turbines, which account for a large share of Kenya's current power mix. This finding implies that researchers and policymakers may be mistaken in perceiving solar PV as a costly niche technology, rather than a feasible option for the expansion of power generation in developing countries.

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1. Introduction

Developing country governments throughout Africa face numerous challenges in the development of their power sectors. First, upgrading and expanding generation capacities and electricity grids are of primary concern in order to keep up with demand increases and to sustain economic growth. Second, providing grid-electrification or alternative off-grid solutions to those 69% of the population in sub-Saharan Africa currently lacking access to the electricity grid ([1]). Third, undertaking the necessary investments (recently estimated at USD 160–215 billion over a 10-year period by Rosnes and Vennemo [2]) and tackling possible capital constraints, skills shortages and lack of governance capacity that can prevent countries from developing their power sectors as fast or as efficiently as necessary [3]. Moreover, African governments need to decide which energy resources to exploit for power generation, and the decision on the appropriate resources is no trivial task. It involves trade-offs between economic costs (and hence affordability to consumers), security and reliability of supply, environmental concerns (both nationally, and, in the form of greenhouse gases, internationally) and social aspects, such as local employment (e.g. [4]). In pursuing these different policy goals, African governments have traditionally relied on fossil fuel technologies (predominantly oil and gas) and large-scale hydropower, which has for a long time been the workhorse of sub-Saharan Africa's power sector [5].

Only in more recent years have countries in the region started to consider other alternative power generation technologies from nuclear power to a range of renewable energy technologies, such as biomass, wind, geothermal and solar energy. For instance, several large-scale wind and geothermal energy projects have already been realized in a number of African countries from the Sahel to the Cape of Good Hope [6], and governments and energy planners generally seem to accept that these two resources can constitute viable energy supply options. Other renewable energy technologies, on the other hand, are usually not yet considered economically feasible and are therefore confined to small-scale off-grid electricity generation. Solar energy is probably the most prominent example of such a renewable resource that, while offering huge technical potential, is perceived as economically unattractive for contributing to power generation on any significant scale by most experts and policymakers (e.g. [3]). Thus, after years of academic and political debate, there appears to be almost a consensus that the use of solar energy technologies should be confined to the electrification of households, villages, health-centers etc. far from the centralized grid, where these technologies already offer high economic returns [2].

However, recent rapid declines in the costs of solar energy technologies, especially solar photovoltaic (PV), give rise to the question whether the economic potential of these technologies for large-scale power generation is actually under-appreciated both by academic researchers and by decision-makers in African countries. Between 2008 and 2009 alone, prices for solar PV modules – which are the most important component of solar PV systems – decreased by some 50%, suggesting that the economics of using solar power have improved substantially in the past few years. However, much of the analysis on future power generation globally and in sub-Saharan Africa carried out by academic researchers relies on technology cost-assumptions that are 5–10 years old and thus outdated [7]. When technological change and market dynamics change as rapidly as in the case of solar energy technologies, using outdated data (even if it is only a few years old) will almost certainly lead to flawed research outcomes. Where policymakers rely on the fruits of academic research to support their decision-making, results flawed in such a way can give rise to misperceptions that may, ultimately, lead to policymakers reaching decisions that do not appropriately reflect the latest developments and thus may move the energy sector away from the economic optimum.

In this paper, it will therefore be investigated and analyzed whether misperceptions among energy planners stemming from the use of outdated data in academic research on solar energy technologies do indeed lead to an under-appreciation regarding the potential of these technologies for the generation of grid-electricity. This analysis will be done with reference to the case of Kenya, a low-income developing country in East Africa that is already one of the biggest markets for solar home systems and other off-grid solar systems for rural electrification [8]. Whereas energy planners and policymakers in Kenya promote these off-grid uses of solar energy, solar power generation on a larger scale is currently not considered economical and hence excluded from national power planning. Hence, this paper aims to shed light on the question whether this is still a justified position, given the recent improvements in the global cost of solar energy technologies, by estimating current and near-term levelized costs of electricity (LCOE) from solar PV in Kenya and by contrasting these with LCOE estimates for competing power sources.

The remainder of this paper is structured as follows. Section 2 provides the necessary background to the present study by drawing on the relevant literature on the potential and cost of solar electricity generation on a global, regional and national level. Section 3 introduces the conceptual framework and the methodology employed, while Section 4 provides information on Kenya's power sector and its use of solar energy. Section 5 presents the main results, as well as a comparison with the existing literature. Section 6 concludes with a discussion of the results and their policy implications.

2. Background

This section presents the results of recent research into the potential role of solar energy technologies for power generation, both on a global scale and more specifically in sub-Saharan Africa. Furthermore, it provides readers with information on findings from the most up-to-date academic and grey literature regarding the cost of electricity generation from solar PV systems, both globally and in specific regions and countries.

2.1. Potential role of solar energy in electricity generation

There is wide divergence in the assumed or expected role of solar energy technologies in the future supply of electricity. The Intergovernmental Panel on Climate Change's (IPCC) 2011 special report on renewable energy sources and climate change mitigation notes the very large variance of potential deployment scenarios, with electricity generation from solar energy ranging from marginal to it becoming one of the major sources of energy supply on a par with bioenergy and wind energy by 2050, depending on the modeling assumptions [10]. Likewise, the International Energy Agency's (IEA) latest World Energy Outlook contains wide variation between the different policy scenarios (see Table 1), which in the case of Africa results in the expected solar PV capacity in 2035 diverging by more than a factor of two (International Energy Agency and Organisation for Economic Co-operation and Development [1]). Similarly, the Global Energy Assessment (GEA), led by researchers at the International Institute for Applied Systems Analysis (IIASA), produces a wide range of expected outcomes regarding the share of solar energy technologies in the primary energy mix; with solar generally expected to contribute from 10 to 20% by 2050 depending on the pathway scenario. Moreover, in line with predictions from the IPCC and IEA, the GEA study also foresees only a limited contribution of solar energy technologies prior to circa 2025 [11].