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Solar electric cooking in Africa: Where will the transition happen first?☆

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ABSTRACT

Whilst the rapid spread of solar photovoltaics (PV) across Africa has already transformed millions of lives, it has yet to have an impact on the main energy need of poor households: cooking. In the context of falling global PV prices, recent advancements in battery technology and rising charcoal/fuelwood prices in severely deforested regions, the door is opening for a potentially transformative alternative – solar electric cooking (PV-eCook). While initial investigations focused on solar home systems sized for cooking (cooking device, battery storage, charge controller and PV array), it has since been shown that battery-supported electric cooking (eCook) can also strengthen national, mini, micro and nano grids. This paper presents a multi-criteria decision analysis (MCDA) based methodology, accounting for a wide variety of socio-cultural, political, technical and economic factors which are expected to affect the uptake and potential impact of eCook across a variety of African contexts. It shows the concept has considerable viability in many African countries, that there are significant sizeable markets (millions of potential users), and that within the next five years the anticipated costs of eCook are highly competitive against existing 'commercialised polluting fuels'.

1. Background

Approximately 3 billion people use biomass for cooking [1]. This pervasive use of solid fuels – including wood, coal, straw, and dung – with traditional cookstoves results in high levels of household (HH) air pollution, extensive daily drudgery to collect fuels and manage fires, and serious health impacts. Smoke from cooking indoors with biomass is associated with a number of diseases, including acute respiratory illnesses, cataracts, heart disease and even cancer [2,3]. Women and children are most frequently exposed to indoor cooking smoke in the form of small particulates up to 20 times higher than the maximum levels recommended by the World Health Organization (WHO). It is estimated that smoke from cooking fuels accounts for nearly 4 million premature deaths annually worldwide.[1]

Greenhouse gas emissions from nonrenewable wood fuels alone total a gigaton of CO_2e per year (1.9–2.3% of global emissions) [4]. The short-lived climate pollutant black carbon, which results from incomplete combustion, is estimated to contribute the equivalent of 25–50% of carbon dioxide warming globally – residential solid fuel burning accounts for up to 25% of global black carbon emissions [5]. Up to 34% of woodfuel harvested is unsustainable, contributing to climate change and local forest degradation. In addition, approximately 275 million people live in woodfuel depletion 'hotspots' – concentrated in South Asia and East Africa – where most demand is unsustainable [4].

It is well known that open fires and primitive stoves are inefficient ways of converting energy into heat for cooking. While there has been considerable investment in improving the use of energy for cooking, the emphasis so far has been on improving the energy conversion efficiency of biomass via the development and marketing of Improved Cookstoves (ICS/ICs). Indeed, the foreword to a recent overview of the state of the art in ICS [1] aspires to a world where this situation changes but notes that the use of biomass for cooking is likely to continue to dominate through to 2030 due to population growth, a conclusion shared by the

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[1] More than the deaths from malaria and tuberculosis combined. Moreover, UNICEF [63] highlighted that as many as 1 in 10 deaths, or 600,000 per year, of children under five years old was attributed to this form of pollution.

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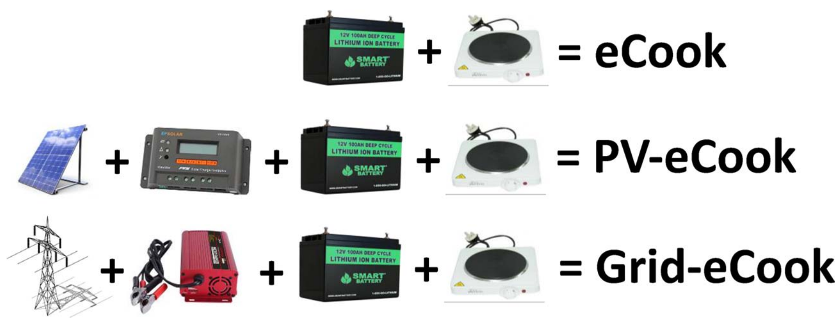

Fig. 1. Pictorial definitions of ‘eCook’ terminology used in this paper.

IEA[2]/World Bank SE4All[3] [6] GTF.[4]

They state that “the ‘business-as-usual’ scenario for the sector is encouraging but will fall far short of potential” ([6], p. 9). They note that with current trends, globally over 180 million households will gain access to, at least, minimally improved cooking solutions by the end of the decade. However, ‘business-as-usual’ will still leave over one-half (57%) of the developing world’s population without access to clean cooking in 2020, and 38% without even minimally improved cooking solutions. Even more worryingly, this existing scenario still depends considerably upon transitions to ICS (where emissions, whilst reduced, remain high) [7] or liquid fuels like kerosene. The damaging health implications of the latter are increasingly being recognised, leading the WHO to create a new classification of ‘polluting fuels’, which includes solid fuels plus kerosene [8]. The report also states that the uptake of ‘cleaner’ stoves is barely affecting health outcomes, and that only those with forced gasification make a significant improvement to health.

There is an emerging body of literature which calls for much greater reflexivity in attempting to understand why, despite all of the assumed benefits of clean cookstoves and the considerable expenditure on promoting them, the results appear to be so disappointing. Khandelwal et al. ([9], p. 1) conclude that “Rural women do not prioritise ICs, but addressing their priorities requires either capital-intensive investment or challenging powerful institutions. In contrast, IC interventions are relatively cheap, decentralised, mechanical and seemingly apolitical, hence their popularity in development programmes.” Existing investment in the promotion of ICS typically begins with the mechanisms to distribute new and supposedly improved technology, rather than understanding the cooking practices of those being encouraged to adopt it. Consequently, access to cleaner cooking solutions alone is clearly not translating into sustained new patterns of cooking [10]. This has led to recent calls for greater attention to be paid to the ethnography of ‘mundane bioenergy’, the questions of how and why “families burn wood, dung, charcoal, and crop residue in cookstoves for their subsistence needs” ([11], p. 1).

Finally, where traditional biomass fuels are used either collected in rural areas or purchased in peri urban and urban conurbations, they are a significant economic burden on households either in the form of time or expenditure. McKinsey Global Institute [12][5] outlines that much of women’s unpaid work hours are spent on fuel collection and cooking. The report explores the economic potential available if the global gender gap were to be closed. The findings show that if women and men fully participate in the labor market, as much as $28 trillion, or 26%, could be added to the global annual GDP in 2025. Access to modern energy services could redress some of this imbalance and release time into the labor market.

Against this backdrop, there is surely a need to try a different approach aimed at accelerating the uptake of ‘clean’ cooking. Sustainable Development Goal 7 (SDG7) calls for the world to “ensure access to affordable, reliable, sustainable and modern energy **for all**” ([13], p. 1). Despite the combined international commitment to both increasing access to electricity and reducing dependence on biomass cooking, policy and private sector actors are treating these challenges as two separate, unrelated problems. Both of which are seen as requiring a completely new transformative strategy if they are to stand any chance of being addressed effectively within the timescales contemplated. In this paper, we explore how the use of battery-supported electricity for **cooking** could meet the twin goals of both increasing access to electricity and providing truly clean cooking to households in developing countries.

2. Introduction to eCook

In the context of falling global PV prices, recent advancements in battery technology and rising charcoal/fuelwood prices in severely deforested regions, the door is opening for a potentially transformative alternative: battery-supported electric cooking, or eCook [14–18]. Initial investigations focused on a configuration comparable to the popular Solar Home System (SHS), referred to here as PV-eCook, and consisting of a cooking device, battery storage, charge controller and PV array. It has since been shown that using a battery charger and battery to support cooking appliances during blackouts in a similar way to a UPS (Uninterruptable Power Supply) could also strengthen unreliable national, mini-, micro- and nano-grids. For grid operators, it could also offer a form of demand side management and/or create additional revenue [18]. This variant is referred to as Grid-eCook, but is not explored in detail in this article given our focus on solar PV. Fig. 1 shows the key system components that define the three terms used throughout this paper: eCook, PV-eCook and Grid-eCook.

The speed and degree to which this concept is taken up is expected to vary widely across this culturally and physically diverse continent, however its potential impact is considerable. eCook systems could play a major role in meeting SDG 7; largely by facilitating access to affordable, reliable, sustainable modern energy for all in relation to cooking.

The concept of PV-eCook has been possible since the advent of solar photovoltaic panels. With enough panels and large enough batteries, a system could deliver enough energy for cooking for a HH. However, until recently, such a device would have been unrealistically expensive for families across the developing world. A typical mention of the concept can be found in UNHCR [19], which notes that it is feasible but dismisses it as prohibitively expensive. However, continued falls in the price of the two main cost components, PV and batteries, over the last decade mean that a solar PV based eCook system could be cost effective in some markets as early as 2019, an opportunity that is now being recognised by other researchers [20,21].

Batchelor [14] noted the ongoing price falls and proposed that HH systems could be developed such that by 2020 they might have a discounted monthly cost of $12 a month – an amount that over 1 billion

[2] International Energy Agency.
[3] Sustainable Energy for All.
[4] Global Tracking Framework.
[5] The power of parity: How advancing women’s equality can add $12 trillion to global growth, McKinsey Global Institute [12].