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Are Rural Energy Access Programs Pro-poor Interventions?

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Abstract

This perspective article discusses whether energy access programs in rural Sub-Saharan Africa reach the poor in a way that most policy actors claim. We examine on- and off-grid electrification as well as improved cooking. The success of pro-poor development is predicated on the programs targeting on the ultra-poor or enabling their intended poor recipients to unlock their productive potential. We therefore focus on which groups connect in typical access programs as well as on the triggered productive use potentials. Backed by the most recent literature, we argue that energy access interventions do not naturally deliver on poverty alleviation targets. If the pro-poor claims are to be met, programs need to improve their targeting. Especially for electrification, justifying investments with a rights-based argument and hence irrespective of whether they trigger broader economic development appears legitimate. This would nevertheless imply that care must be taken to also reach those too impoverished to afford improved energy access, requiring, for example, subsidization of connection costs.

JEL-Codes: H54, O13, O21

Keywords: Energy access; rural electrification; modern cooking energy; sub-Sahara Africa

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1. Introduction

It is consensus that access to electricity is a prerequisite to the provision of basic services and economic growth. Access to affordable and clean energy, which also includes access to improved cooking technologies, is therefore envisioned by the Sustainable Development Goals (SDGs) to improve livelihoods in low-income countries, not least in rural areas of sub-Sahara Africa (SSA) where energy-access deficits are most pronounced. In this perspectives article, we ask whether energy-access programs lead to pro-poor development – and which types of interventions do so more effectively. Most international donor organizations and many national governments justify investments into energy access with pro-poor narratives (see AfDB 2024, EBRD 2018, and ESMAP 2024, for example). While providing energy access to hitherto unconnected people will never be to their detriment, and in that sense energy access is always pro-poor, we contend that most policy actors have a higher bar for what pro-poor means: either especially the poorest of the poor should be reached, or energy access should help people who are not at the bottom of the pyramid but still poor by international standards to develop out of poverty. In the present paper we examine whether one of these two or both are likely to be achieved in energy access programs. In discussing these points, we distinguish between improved cooking technologies, more specifically energy-efficient biomass cookstoves (EEBCs) and clean fuels[1], as well as electrification in the form of the centralized grid, mini-grids, and stand-alone solar.

Our perspective article discusses the latest evidence from the energy-access literature on whether rural energy access programs typically reach the poor. It is not a systematic review, but more of a narrative review (Sovacool et al. 2018). The perspective is informed by our experience working in the energy sectors of different SSA countries and several impact evaluations we have conducted. Drawing on this interactional and contributory expertise (Collins & Evans 2002), we substantiate our perspective with a selection of what we consider the most relevant literature, thereby comple-

[1] In rural SSA, providing access to improved cooking technologies usually implies the dissemination of low-cost EEBCs. Liquefied Petroleum Gas (LPG) is hardly available in rural SSA and establishing supply chains is prohibitively expensive. Pilot projects for other clean stoves like gasifier stoves or biogas have largely failed (Carrión et al. 2021; Falama et al. 2024; Puzzolo et al. 2016; Rupf et al. 2015).

menting existing systematic reviews[2]. We fully acknowledge the subjectivity of our perspective but strive for an intelligible line of argumentation that will confirm priors of some readers, convince a few others and at least provoke further thoughts among those who remain unconvinced.

Throughout the analysis in this paper, we consider both of the two pro-poor interpretations mentioned above: whether the poorest of the poor are reached directly, and whether energy access provides people with the opportunities to release their productive potential who might not be the poorest of the poor but are still poor by international standards (Reddy 2021; World Bank 2022).[3] For example, pro-poor development effects can unfold by providing direct benefits to those gaining access to affordable and clean energy, who may still be poor despite typically being among the better-off in their communities. Beyond direct effects, pro-poor effects can unfold by indirect spillover effects from those who have received access to those who still lack energy access. Most notably, enterprises newly connected to the electricity grid can generate externalities leading to more income also among poor non-connected households. We therefore dedicate special attention to productive use of energy as a key mechanism through which pro-poor effects may emerge in access programs. Likewise, externalities are also possible for schools and health centers.

We first examine who gets connected in energy access programs, which critically hinges on the cost burden of different energy access options. We then discuss which impacts materialize among residential users who are directly connected. After this, we turn to our core discussion of the productive use of energy among enterprises and households. We look at access programs with no particular targeting, followed by a discussion of targeted productive use programs and their impact potentials. Lastly, we examine potential benefits for the poor due to educational and health impacts, through direct household energy access or otherwise indirectly through improved services at schools and health infrastructure.

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[2] See Ayana & Degaga (2022), Bayer et al. (2020), Bernard (2012), Blimpo & Cosgrove-Davies (2019), Bonan et al. (2017), Bos et al. (2018), Hamburger et al. (2019), Jeuland et al. (2021), Lee et al. (2020a), Moore et al. (2020), Morrissey (2018), Peters & Sievert (2016), Pueyo & Maestre (2019), and Raitzer et al. (2019).

[3] The emphasis on productive use potentials to promote capabilities also links our paper to broader debates about the consideration of resilience and the distributional dimension of energy justice in energy-access interventions (Jenkins et al. 2016; Tiwari et al. 2022).

2. The cost burden of different energy-access options

Beyond the initial selection of intervention areas (Hinestroza-Olascuaga et al. 2021), two features of energy-access programs determine the extent to which poorer strata are reached: a) the costs of the provided technology and b) the cost-sharing ambition of the program, that is, what share the end-users must contribute to acquisition costs via fees and prices.

For on-grid electrification programs, the cost-sharing ambition is generally low, but connection fees are nevertheless often too high for considerable parts of the target population because of the extremely high costs. Therefore, only the relatively better-off households get connected. Connection rates 'under the grid' across various countries are typically way below 100% (Golumbeanu & Barnes 2013), also several years after the grid has reached the communities (Masselus et al. 2024). Impact evaluations document connection rates in recently connected areas of 60% in Rwanda (Lenz et al. 2017), 39% in Ethiopia (Bernard & Torero 2009), less than 30% in Tanzania (Chaplin et al. 2017), below 10% in Kenya (Lee et al. 2020*b*) and Burkina Faso (Schmidt & Moradi 2023). To assess how responsive households are to connection fees, Lee et al. (Lee et al. 2020b) randomized different subsidy levels for connection fees across 150 communities in Kenya. They diagnose a sharp decrease in connection rates as fees increase: While almost all households connected if connection was for free, a subsidy equivalent to 57% or 29% increased connection rates by only 23 and 6 percentage points, respectively. Hence, considerable parts of the target population – and not least the poorer segments – do not directly benefit from grid extension programs.

Programs promoting stand-alone solar face lower technology costs than grid extension, yet most programs follow a market-based paradigm requiring end-users to pay cost-covering prices. Programs oftentimes only subsidize the marketing and perhaps the market expansion and after-sales infrastructure of a solar company. Since the demand for stand-alone solar is very sensitive to the price (Girardeau et al. 2021; Grimm et al. 2020; Meriggi et al. 2021), poor households rarely afford the investment (Bensch et al. 2018; Grimm & Peters 2016; Mukoro et al. 2022). Pay-as-you-go (PAYG) schemes are sometimes proclaimed to lower the barrier for poor households (Yadav et al. 2019), but in fact PAYG schemes have been found to mostly serve the better-off strata (Barry & Creti 2020; Collings & Munyehirwe 2016; Groenewoudt & Romijn 2022). This is because transaction costs of setting up the PAYG schemes are high, especially when they are supposed to reach poor rural areas (Grimm et al. 2020; Muchunku et al. 2018), but also because PAYG is always tied to branded products, which are probably of higher quality but also more expensive (Bensch et al. 2018; Groenewoudt et al. 2020; Samarakoon 2020).

Improved cookstove promotion programs are also mostly implemented under the market-based paradigm, but costs of the technology are much lower, especially for EEBCs. At the same time, the price-responsiveness of improved cookstove demand is well established – including the diagnosis that many households in rural areas cannot afford the investment (Beltramo et al. 2015; Bensch & Peters 2020; Munyehirwe et al. 2022; Pattanayak et al. 2019). Therefore, the cost-sharing approach screens out poorer households, especially in rural areas where the woodfuel is collected, not purchased so that no monetary savings can occur.

3. Main impacts on the poor: Savings in time and money

We now discuss potential pro-poor effects that can be identified for those with direct access to energy. For electricity, most important direct effects are on quality of life and convenience, which is noteworthy, but it lacks transformative potential. Electricity access can lead to monetary savings if electricity is indeed cheaper per kWh than what was used at baseline. Even then, the net savings effect on the household budget is either negligible or even negative, since new and often consumptive (not productive) energy services are used, such as television. Savings potentials are also limited for households who only consume lighting, because people use cheap light-emitting diode (LED) torches or non-branded solar products to meet their basic lighting needs in the absence of electricity access (Bensch et al. 2017; Grimm & Peters 2016; Groenewoudt et al. 2020).

The most accentuated impacts with some transformative potential occur for households who gain access to an EEBC. Firewood savings in rural areas for appropriate EEBCs that are also regularly used are between 15 and 40% (Bensch & Peters 2015; Mekonnen et al. 2022; Munyehirwe et al. 2022; Usmani et al. 2017). Since firewood collection time, especially in biomass-scarce regions, is often in the ballpark of 8 to 12 hours per week, it is easy to see that such firewood savings rates have considerable impacts on people's time constraints (Krishnapriya et al. 2021). Purchasing firewood is much rarer in rural SSA, but for those who do purchase, the savings are considerable.

4. Productive use in energy-access interventions

Technically, the grid and sufficiently sized mini-grids provide powerful electricity that can be used for energy-intensive machinery and three-phase current. Productive use potentials for grid electrification hence constitute the upper bound of productive use potentials related to energy access. If productive use does not emerge in the wake of grid connection, it is unlikely to emerge when lower-powered stand-alone solar systems or smaller-scaled mini-grids are promoted.

Overall, recent impact evaluations suggest that the productive use of electricity in newly connected regions is very limited. Technical potentials are not exploited, and consumption remains on a very basic level. What is more, most enterprises in grid covered rural areas are shops, bars, tailors and hairdressers, and home businesses in households are rare. They use electricity for lighting and small appliances like electric shaver, entertainment devices and fridges, sometimes complemented by offering phone charging. Usage of grid electricity for irrigation is rare since pumps are mostly needed in plots that are too far away from the grid. Only few enterprises are typically found in rural areas that do use powerful electric machinery (in most cases welders, carpenters, and mills). All these enterprises have in common that they mostly serve local demand. Products are very rarely sold to regional or urban markets.

These patterns have been observed in several impact evaluations covering both enterprises and households in different countries. Chaplin et al. (2017) use a difference-in-differences (DiD) design to evaluate a large-scale grid extension program in Tanzania and observe very little productive take up in enterprises or through home businesses. In a different part of Tanzania but also using a DiD design, Bensch et al. (2019) confirm these findings. Lenz et al. (2017) evaluate a country-wide grid roll-out program in Rwanda, using a mixed-methods DiD identification strategy. They also observe very low electricity consumption levels among enterprises and households, mostly for lighting. Lee et al. (2020b) as well do not find productive take-up among households in their sample in Kenya. Also in Kenya, the low consumption levels reported in Taneja (2018) suggest little or no productive use.

One valid concern about all these studies is the short-term evaluation horizon: they examine adoption and impacts 2 to 5 years after connection. Masselus et al. (2024) therefore provide a 10-

year long-term evaluation of the Lenz et al. (2017) sample and find that the consumption and take-up patterns have not changed. Similarly, seven years after grid connection, Peters et al. (2011) observe very modest productive take-up among enterprises in Benin.

There is a different strand of literature that uses secondary data. This literature features several studies diagnosing positive impacts of grid-extension electrification (see Lee et al. 2020a for a review). Ankel-Peters and Schmidt 2023 argue that the key difference is that secondary-data studies cannot use well-specified interventions but have to rely on proxy measures to identify where electrification happened; they additionally note a higher risk of publication bias in secondary-data studies, due to lower incentives to pursue towards publication with a null result than with primary-data studies given the high costs of data collection. Moreover, only few secondary-data studies examine countries or regions in SSA (Hamburger et al. 2019; Peters & Sievert 2016). Regardless of the deeper reasons for the divide in findings between these two types of studies, we argue that the impact evaluation literature referred to above is more relevant for program evaluation purposes and project specific cost-benefit considerations in rural SSA.

The literature on stand-alone solar and mini-grids confirms our assertion of modest productive use and impacts of programs promoting these technologies (Aklin et al. 2017; Bensch et al. 2018; Duthie et al. 2024; Grimm et al. 2017; Kizilcec & Parikh 2020; Radley & Lehmann-Grube 2022). Most improved cooking programs target households, not enterprises. Widespread productive applications of improved cookstoves are in restaurants and in some contexts in local beer breweries (Grimm & Peters 2015). Here, they likely lead to higher productivity, but probably not in a transformative way – also since, as discussed above, these enterprises mainly cater to local demand.

5. Targeted productive use interventions

Electricity demand stimulation and energy-access interventions that specifically target users with high productive potential is a natural response to the low take-up diagnosis evidenced in the previous section (Lukuyu & Taneja 2023). In fact, many donors focus their energy access and electrification portfolio on productive uses (see for example ESMAP and SE4All). For example, a mini-grid intervention could select only villages that host a so-called anchor customer (Peters et al. 2019). In practice, however, this proves difficult, as such anchor customers in remote areas are rare and identifying them often fails (Duthie et al. 2024). Mini-grid placement according to irrigation potentials is another option (Wamalwa et al. 2023). Lukuyu et al. (Lukuyu et al. 2022) propose a technique to detect such potentials based on existing diesel-fed irrigation pumps using remote sensing data.

Another approach is to target potential productive users with stand-alone solar-powered machinery. Solar-powered water pumps are particularly attractive because of their independence from the grid and portability. Increasing agricultural productivity via irrigation additionally circumvents the barrier to many other productive uses in rural areas, which is a lack of market access. Most parts of rural SSA are well integrated into markets for agricultural products. Expanding agricultural production is hence more straightforward than for artisanal or manufactured products (Peters & Sievert 2016). While proof-of-concept evidence for solar-powered irrigation exists (Burney et al. 2010), a broader view on the thin literature suggests that promotion at scale encounters various problems: groundwater depletion, operational problems ranging from maintenance problems to lack of power on cloudy days (Closas & Rap 2017) and unresolved regulatory questions like land-tenure (Chokkakula & Giordano 2013). Solar-powered water pumps also compete with diesel, which under many circumstances is the more economically viable energy source from the farmers' perspective (Smith & Urpelainen 2016; Xie et al. 2021).

Diesel is indeed a hazard to impact potentials of targeting approaches because potentials for obvious productive uses such as milling and pumping are typically already exploited in regions not covered by the grid, by using diesel-powered generators, pumps or mills. Less obvious productive potentials are much harder to identify. Therefore, targeting programs must either increase the risk they take and aim at not-so-obvious productive potential hitherto untapped by diesel-driven appliances. If the program supports the conversion of existing productive uses from diesel to solar or other sources of electricity, impact potentials are limited to reductions of fuel costs and emissions.

Reliable evidence on targeted energy-access programs is very scarce. Development practitioners' priors on such programs are often shaped by experience and anecdotes from small-scale pilot projects. Tacit knowledge like this is not irrelevant, but it needs to be considered that small-scale pilot projects often are successful because they are small-scale and pilot. That is, the level of care the project receives from implementers are hard to replicate at scale. Once they are scaled, the increased supply of the supported production (e.g. irrigated vegetables) may find it harder to find sufficient demand. Nevertheless, productive use impact prospects for a program featuring a well-crafted targeting are certainly higher than for the typical non-targeted electrification program. In case they prove successful, a pro-poor effect is very plausible. In any case, also targeted approaches will require subsidization to overcome the limited purchasing power and liquidity constrains in the high-risk investment setting that rural entrepreneurs typically face.

6. Health and education

Energy access may not only reach the poor through economic development in the narrow sense, but also by improving their health and educational status. This might happen through immediate effects on households with energy access or indirectly via improved educational and health services in public institutions.

Positive health effects on the household level are possible if dirty kerosene lamps are replaced by electric lighting (Barron & Torero 2017). However, the LED lighting transition that rural SSA has experienced over the past 15 years changed the baseline situation. That is, kerosene is rarely used anymore in rural SSA and is replaced by LED torches and small solar lamps (Bensch et al. 2017). Household-level health effects are most widely discussed for improved cooking technologies. Simple EEBCs do not reduce smoke emissions enough to prevent significant health hazards according to guidelines of the World Health Organization. While there is some suggestive evidence that positive health effects might nevertheless materialize (LaFave et al. 2021), for example because of a reduced cooking time and hence less smoke exposure (Bensch & Peters 2015), it seems more prudent not to expect substantive positive health effects in EEBC dissemination projects (Bensch et al. 2024). The alternative option of disseminating clean stoves like LPG or gasifier stoves has proven to be very difficult in rural SSA. Even in efficacy studies where the clean stoves (or fuels) were delivered free of charge to households, no health improvements could be observed, because many households continued to use woodfuels (Jack et al. 2021; Mortimer et al. 2017).

Educational effects on the household level are most likely to materialize because of improved lighting conditions for studying at home. This has indeed been observed in Rwanda (Grimm et al. 2017), for example, but could not be confirmed in Malawi (Stojanovski et al. 2021). In sum, while positive educational and health effects might materialize on the household level under certain circumstance, it is unlikely that they will be very pronounced among poorer strata – also because adoption rates are low.

On the institutional level, it has often been claimed that the lack of electricity in rural health facilities and schools is a barrier for service provision (see for example IEG 2008 and Moner-Girona et al. 2021). Yet, often even grid-connected schools hardly use electricity for educational purposes (Lenz et al. 2017). Schools only operate during day-time hours and computers are not used in class. Anecdotes suggests that teachers, often civil servants from urban areas, tend to stay longer in a village if the grid is available. Rural health centers in regions beyond the reach of the grid mostly use a solar panel to fuel basic appliances like a fridge, a sterilizer and lighting. Fridges are otherwise also operated with kerosene or gas. Electricity hence facilitates services (and lowers costs), but it is not key. Both health services and education are incredibly important for empowering the poor to develop out of poverty. Yet, both services are mainly hampered by the combination of other bottlenecks instead of the lack of access to electricity alone, including limited budgets, lack of skilled staff and equipment.

7. Conclusion

The implications of this paper depend on what the objectives of a specific energy access programs are. We contend that many claim to reach the poorest of the poor, or at least help those who are absolutely poor to develop out of ultimate poverty. This is also in line with the perception within the SDG framework. Against this background, the point of this perspective is obviously not that energy access harms the poor. But we have emphasized that energy access interventions do not naturally deliver on poverty alleviation targets in a way that would meet the expectations of most policy actors. One response to this diagnosis is to put more efforts into intervention designs and selection of technologies to improve the poverty alleviation and the targeting on the poor. Existing approaches often strive for amplifying the productive uptake and thereby the economic development effect of electrification. We have raised important concerns about this approach, which imply that targeting efforts need to be a lot more effective and probably selective to really unleash significant productive uses. Beyond electrification, which absorbs the largest share of energy access portfolios, our analysis suggests that from a pro-poor perspective, EEBC promotion programs should be strengthened. Feasible technologies exist that require relatively little subsidization to become affordable.

With respect to electrification, it would also be legitimate to justify investments with a rights-based argument. This is partly reflected in SDG 7, but also what many national governments in SSA advocate. Following this account, providing energy access is a political goal for social reasons and irrespective of whether it triggers economic development. This would nevertheless imply that care must be taken to also reach the ultimate poor, requiring subsidization of end user prices and connection costs.

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