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**Access to electricity in Sub-Saharan Africa: from an urban/rural frontier to a market frontier?
A pricing analysis**

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Sub-Saharan Africa (SSA) occupies a special position when it comes to achieving universal access to electricity, the goal of SDG7. The rate of access has progressed significantly. However, in a *business-as-usual* scenario, if the combination of public (governments and national companies) and private investment were to continue at the current pace, the goal of universal access to electricity in SDG7 would not be achieved. On the one hand, this *Business as Usual* trajectory is based on the extension of the centralized grid, but it also benefits from an increase in territorial coverage based on decentralized technologies. By the way, minigrids of 2nd generation (diesel and hydro) and, more recently, minigrids of 3rd generation (solar power), provide access to previously unserved peri-urban and rural areas. Last but not least, solar-based standalone systems are paving the way for even the most remote areas.

Inspired by the main international financial institutions, a consensus seems to be emerging to accelerate this trajectory. It is based on the massive implementation of solar minigrids, including storage capacities, whose full levelized costs have fallen rapidly and sharply. And these costs are set to fall further, not least due to the increase in load factors made possible by good-quality production and, consequently, by a steady rise in consumption. These forecasts, which have been translated into comprehensive public policy projects in some countries, most often assume that the production capacity installed via minigrids will eventually be integrated into the main grid.

In SSA, access to electricity is set to increase as the power system evolves (Foster et al. 2021). While the supply side and its organization to achieve this objective are now well designed (ESMAP 2022), on the demand side the analysis remains fragile, subject to the variability of macroeconomic growth conditions (Egli et al. 2023). As the Covid 19 crisis abruptly reminded us, these conditions are a limitation of the electrification schemes envisaged.

The purpose of this paper is to review the pricing conditions developed. Indeed, only tariffs that make it possible to contextualize the growth of access both in relation to the technical progress affecting supply, and in relation to the calibration of demand based on objectifiable data, and in particular the income structure of consumers in the economies concerned.

Where do we stand?

In SSA, average electricity selling prices are around \$0.130 to \$0.140/kWh. These selling prices do not cover the cost of providing the service to different types of customer. In most countries, they do not even cover investment costs. Subsidies make up a significant part of the main grid loop. The electricity sector itself is therefore far from generating the surpluses needed to self-finance the investments required to extend the service, even though national utilities have a diversified "toolbox of

technologies" at their disposal, enabling them to meet i) additional demand by extending the network to areas with qualified and substantial needs, justifying the high investment cost of the lines, and ii) to envisage the regulatory incorporation of minigrids in the future as the main grid is extended.

The Ramsey-Boîteux theorem has established that marginal cost pricing allows the selection of optimal capacity while controlling fixed production costs (Hansen & Percebois 2019). This pricing principle therefore enables users to pay a price that corresponds to the cost actually borne by the community as a result of their presence on the market. Differentiation is based on the cost of energy demand. This pricing principle also assumes modulation between different classes of users: pricing according to voltage level, time of day or year. The advantage of such a mechanism is that it does not distort the cost structure, making it easier for operators to achieve financial equilibrium.

A assessment of tariffs applied in SSA by integrated electricity companies (Michel & Vessat 2023), covering the market extensively, showed that:

For SSA households connected to the grid, the limitations inherent in access to electricity stem more from their economic situation, in particular their income level - income poverty - than from their location.

Beyond this, the ineffectiveness of the tariff structures provides an important explanation for the continued massive lack of access:

- First, progressive tariff structures turn out to be regressive, especially at the first consumption block or lifeline tariff. However, the sensitivity of this regressive nature decreases when access is improved and better distributed between urban and rural consumers. This means that these conditions favour stabilising consumer behaviour, which in turn stabilises the revenue of utilities;
- Second, the regressive pricing implemented by power companies in SSA tends to greatly benefit productive activities;
- Third, household poverty at the lowest income level confirms the direct link between monetary poverty and access. Nevertheless, we observed shifts in the threshold consumption for these households, suggesting that the untapped opportunity to carefully targeted electricity pricing could be implemented in urban and rural areas to match consumer targeting with improved access.

In addition, the contributions of public policies to promote access vary due to the heterogeneity of sub-Saharan countries. But, overall, current pricing instruments do not support the trade-off between cost recovery for electricity operators and the expansion of electrification. Reducing the regressive nature of pricing could be achieved under certain conditions.

- Better segment progressive tariff blocks by creating more significant price differences. Since electricity consumption remains a function of income, the tariff for higher blocks could be raised, working with tenable hypotheses on the percentage of income spent on electricity. Substitution effects could be moderated by higher quality energy services.
- Develop a lifeline tariff, which now characterises the first consumption block and has become a source of exclusion for consumers in the next block, based not on the volume of electricity used but on a basket of energy services designed to help households stabilise their current income and improve it in the future. An evolving lifeline tariff could be paired with a temporary exemption from connection fees.
- Rein in the benefits to large businesses and industry from regressive rates.
- Use an abundance of caution in trying to replicate successful tariff reform from one country to others. The way in which additional gains in access are achieved appears to be sensitive to each country's general access conditions (Few et al. 2022). For example, while opening up

progressive pricing seems necessary in countries with high access rates and low energy poverty, it may not be appropriate in countries with high energy poverty. Similarly, distinguishing between rural and urban base tariffs, and thus differentiating the use of subsidies, would be useful in countries with more advanced access, but would not deliver access gains in countries with high energy poverty.

- Setting a threshold beyond which grid access subsidies do not generate gains would improve the distribution of subsidies between grid-connected and decentralized electricity, if the conditions for this reallocation could be defined on a territorial basis, even within a single country.

In rural and peri-urban areas, high investment costs (due to rural remoteness) have been an obstacle to electrification, with higher kWh costs than in urban areas. Today, minigrids based on variable renewable energies, notably solar, with lower LCOEs, are likely to attract private investors. A priori, these investors need to be sure of being able to balance costs and make their investments profitable. However, private developer strategies based on minigrid portfolios could partly overcome this constraint, thanks to economies of scale. Pricing is the other part of the equilibrium process. In this case, as in urban areas, subsidies to investors and consumers are also considered essential. Numerous studies now estimate the willingness to pay of rural dwellers (Sievert & Steinbuck 2020; Michel & Vessant 2023). As the latter increases with income level, the design of social tariffs remains a decisive factor in targeting the volume of consumption required for the sustainable operation of these decentralized production systems. One of the challenges ahead is the possibility of moving towards a level of daily consumption that justifies investment, and thus the possibility of increasing electricity use, particularly productive use, in a context of limited income.

The paper assesses the pricing axes put forward in the grey literature devoted to minigrid expansion, and discusses the following conditions and contradictions.

Among the conditions,

- public subsidies are seen as a lever effect in the deployment of minigrids by private developers, in a context of scarcity of both public funds and indebtedness;
- the expected income effect of access in rural areas is also a condition for the deployment of minigrids. The latter is conditional on private indebtedness for the acquisition of productive equipment, enabling African agriculture in particular to move up the value chains involving its main products. The expected amortization periods (of the order of 5 years) are not very long, but need to be considered in relation to the income structure and its evolution;
- the strategic question of stranding assets in a regulatory context that may be unclear to private investors in the case of the arrival of the main network is still rarely addressed

Among the contradictions,

- current forecasts for minigrids seem to ensure continuity of service, which is what consumers are looking for, but the installed capacity mentioned above means that the development of productive activities enabling rural consumers to increase their income through access to electricity is fragile;
- the allocation of scarce public subsidies between the grid and its extension, on the one hand, and the financing of minigrids, on the other, is likely to be arbitrated by a market power acquired by higher-income consumers seeking a higher quality of energy service. Under these conditions, a market frontier within the urban areas already served could then replace the existing urban-rural frontier, precipitating the question of the growth of stranded assets linked, this time, to the main grid.

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