ELECTRICITY TARIFF IMPLICATIONS OF INCREASING ADOPTION OF BEHIND THE METER TECHNOLOGIES IN AN AFRICAN CONTEXT

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Overview

Under a volumetric electricity tariff (in €/kWh consumed), the installation of rooftop solar PV presents a significant challenge to cost recovery for regulated utility investments. As a result, there has been an extensive debate in countries with liberalised power systems, such as Europe, most part of North America and Australia, about how to redesign network charges, the regulated part of the electricity bill.

This paper looks at the regulatory implications of Behind-The-Meter (BTM) technologies in Africa. Applying a game-theoretical model, we illustrate the impact of BTM technology adoption under different end-user rate designs and BTM technology cost scenarios. There are several specifically African features worth highlighting. We mainly consider the following four factors. First, in Africa, not only the network charges, but the entire end-user electricity rate is typically regulated. Second, a different regulatory model for the power system is in place when compared to the well-researched European, North American, or Australian context. Different actors under the African regulatory model, which often takes the form of a Single Buyer Model, are affected in financial terms by increased BTM technology adoption by households and might require different solutions. Third, the African context requires a tailored analysis due to socio-economic differences. The current rate design relies on high-consumption, often wealthier, consumers to carry a more than proportional share of the electricity costs. Fourth and last, there are also infrastructure differences. For example, smart meters have been little used to date.

Methods

To better understand the consequences of BTM technology adoption on electricity rates and financial flows between relevant actors under the Single Buyer Model, we introduce a game-theoretical modelling framework inspired by Schittekatte et al. (2018). We firm up our analysis by the application of our modelling to a case study representing the recently announced tariff plan (2020/2025) for Egypt. We consider three consumer classes to capture the socio-economic impact of the different end-user rate designs.

In our analysis, we consider four metrics quantifying regulatory objectives: cost efficiency, equity, and cost recovery of both regulated entities i.e. the Single Buyer Entity and Distribution and Supply Company (DISCO). Applying the game-theoretical model using Egyptian data, we compute these regulatory metrics for the increasing block tariff (IBT) design, which is in currently in use, and a proposed alternative, in which we allocate an important share of the regulated costs via fixed charges to the end-user in addition to a volumetric charge equalizing the weighted average cost of generation. Inspired by Battle et al. (2020), Borenstein (2020), and Burger et al. (2020), the fixed charges are differentiated based on historical consumption levels proxying income. We compute the results under two BTM technology cost scenarios to test the robustness of the end-user rate designs.

Results

The results confirm and illustrate the regulatory favourability of the status quo IBT design under a high BTM cost scenario technology. The IBT design manages to ensure the cost recovery of the regulated investments while being perceived as being equitable.

However, under a future scenario with lower BTM technology costs, the IBT design is shown to rapidly become unsustainable. Two special characteristics of the African energy market would accelerate any utility death spiral for the DISCO, compared to its counterpart in the European, North American, and Australian cases. First, currently, under the IBT design, consumers in the highest consumption segment, paying the highest charge per kWh consumed, are relied upon to recover the DISCO's costs. As the consumers in the high consumer class are the first to load defect from the grid, the financial deficit increases at a much higher pace than the total volume of sales. Second, DISCOs need to recuperate not only the sunk network investments but also their supplied energy costs. DISCOs pay the regulated transfer price to the Single Buyer Entity to fulfil these supply obligations, which put additional financial pressure on the DISCO compared to the unbundled DSOs in most of the Western world. We rapidly end up in a regulatory trilemma where the regulated investor-owned DISCO or the regulated Single Buyer Entity would not manage to recover their costs; or in which vulnerable consumers would see a significant increase in their bills. We illustrate this result in the figure below. Counterintuitively, a load defection scenario

can result in a financial deficit of more than 100% for the DISCO in the Single Buyer Model, while this cannot happen in an unbundled setting.

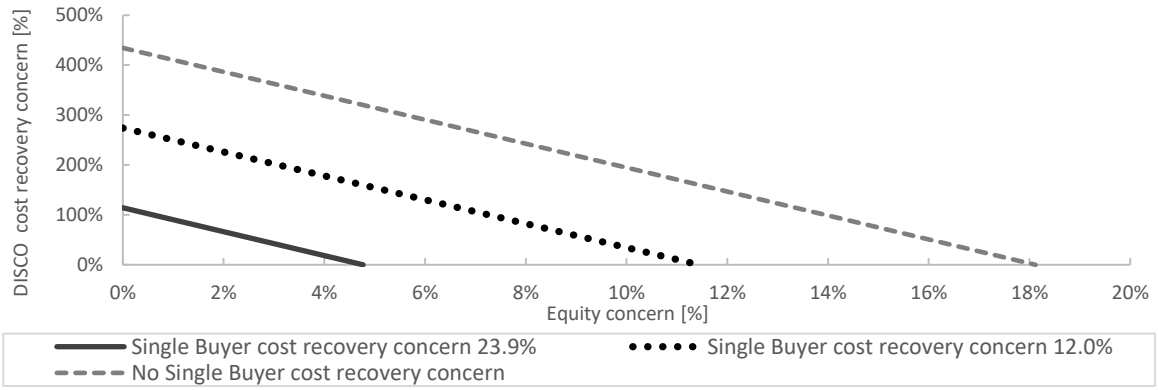

Figure: The trilemma between equity concerns and the cost recovery of the Single Buyer Entity and DISCO under a volumetric Increasing Block Tariff (IBT) and a low BTM cost scenario.

Further, we show that an end-user tariff design combing a volumetric charge that is equal to the weighted average cost of generation and a Differentiated Fixed Charge (DFC) to recover residual costs performs well according to the regulatory metrics and is robust against different technology cost scenarios. We propose to differentiate the fixed charge based on historical consumption levels to avoid distortions while maintaining existing equity considerations. Further, we illustrate and discuss three implementation issues with the DFC design, and provide recommendations on how to overcome these challenges. The challenges are: the selection of the proxy used to differentiate the fixed charge upon, inefficient grid defection, and energy efficiency concerns.

Conclusions

We find that under a future low cost BTM scenario, the current IBT design would lead to the need for frequent rate revisions, which are known to be slow and subject to opposition. The investor-owned DISCO would quickly get "financially sandwiched" between the regulated end-user rate downstream and a regulated transfer price upstream. With full cost recovery of the regulated entities being a regulatory objective in Africa's transitioning utilities or in those struggling to afford access to electricity, an accelerated death spiral would be disruptive.

We recommend that it would be advisable to reform the end user tariff to tariff consisting of a volumetric charge that is equal to the weighted average cost of generation and a Differentiated Fixed Charge (DFC). Under the present IBT design, already the (volumetric) charges have been differentiated per consumption band. The practice of charging different rates to different groups of consumers might be more easily acceptable in an African context. However, under DFC there are differentiated fixed and undifferentiated volumetric rates per consumer class and the division in different consumer classes is based on historical and not current consumption data. We advise that this transition is done gradual as a radical change of the end user tariff design would face acceptability issues.

The case study also showed that merely revising the end-user rate design is not enough. Wider reforms are needed. More specifically, the efficient functioning of the alternative DFC design is conditional upon a revised regulated transfer price. This finding implies that BTM technologies, competing with centralised generation, add to the need for the efficient utility generation cost signalling and as such provide an additional argument for the establishment of a well-functioning electricity wholesale market in the medium or long term.

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