Executive Summary
Distributed Generation White Paper

Mozambique's electricity sector is going through a period of transformation, with changes to the legal and regulatory framework to enable the country to seize the opportunities offered by the global trends towards the decarbonisation, decentralisation, and digitalisation of power systems. A prominent innovation resulting from these global trends is the rise of distributed generation, which broadly refers to generation installed 'behind-the-meter' at the point of consumption and is connected to the grid to allow for the export of surplus electricity generation.

Solar PV distributed generation is often implemented through a net metering or net billing scheme, or, alternatively, a feed-in-tariff programme. Under a net metering or net billing scheme, an end-user offsets the electricity it has exported from its distributed generation against its consumption of grid electricity, with a net reduction in the bill.

Mozambique's Electricity Law (Law 12/2022, of 11 July) enables the use of distributed generation by recognising individual and collective self-generation and allowing for generation primarily intended for self-consumption to be connected to the national grid, and sell into the grid, electricity generation that is surplus to the owners' own requirements without needing a concession. The precise terms and conditions will be set out in the regulation implementing the Electricity Law (12/2022).

This *Distributed Generation White Paper* sets out the direction for the scaling up of distributed generation in Mozambique. In doing so, it highlights key opportunities associated with supporting the scaling up of distributed renewable energy generation through a net billing system or similar in Mozambique. In line with the Electricity Law, we use the following definition for distributed generation in this White Paper:

> "Distributed energy generation includes electricity generation from variable renewable sources that takes place near the point of consumption on the consumer's side of the electricity meter, with a predetermined output limit, for the primary purpose of self-generation, and which is connected to the distribution component of the National Electricity Grid with the option of transferring surplus electricity generation to the grid".

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Implementation of a net billing or net metering tariff framework will require appropriate regulation

For variable renewable distributed generation to be implemented through a net billing or net metering tariff mechanism, the regulation should include two key elements:

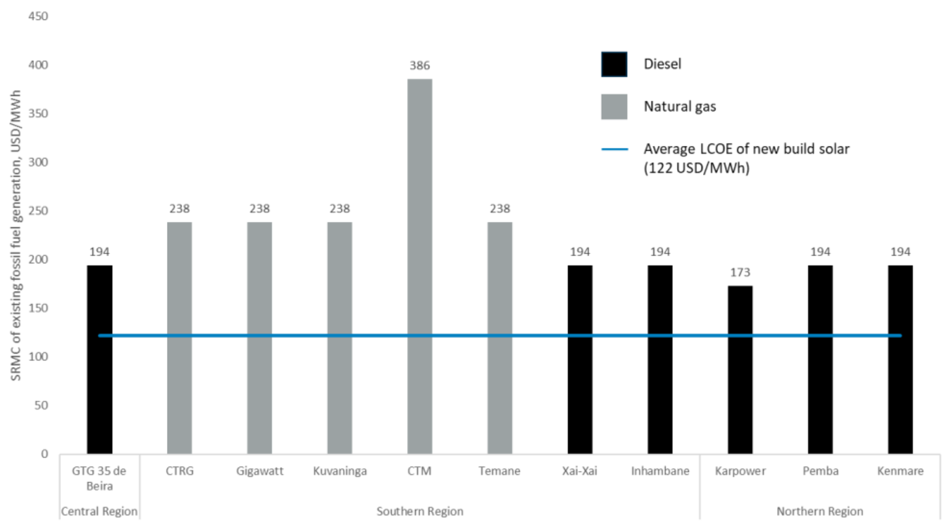
— Specify technical requirements for what is considered generation of electricity for individual use and consumption that allow for appropriately sized (eg. capacity equal to the consumer's maximum demand) renewable energy generation facilities. It is important to note that these technical conditions can be set generally to allow for other types of generation for self-consumption, also exempt from concession, however these should be remunerated through a separate mechanism to net billing.

— Prepare implementing regulation for the remuneration of surplus power sold into the grid by electricity generation facilities used for generation of electricity for individual use and consumption through a net billing arrangement.

Distributed renewable generation can reduce the overall cost of generation and electricity suppy as well as to contribute to the stability and quality of grid supply.

Distributed renewable generation presents an opportunity to lower the cost of service of electricity supply in Mozambique. While Mozambique has access to cheap hydroelectric generation from the Cahora Bassa hydroelectric dam, generation from this and other hydroelectric facilities is complemented by fossil generating facilities. Energy from these fossil fuel facilities is expensive and, as shown in Figure 1, the marginal cost of generation is significantly higher than an estimate of the average levelized cost of energy (LCOE) for commercial and industrial (C&I) scale distributed solar.

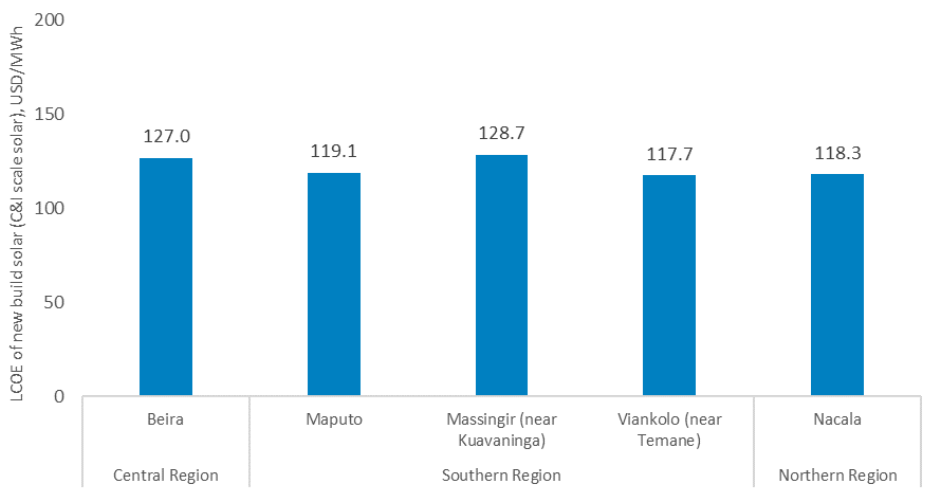
FIGURE 1. Cost of generation of fossil fuel assets in Mozambique (2023)



Sources: Consultant calculations based on Integrated Master Plan Mozambique Power System Development, JICA., World Bank Commodity Price Forecasts, and Annual Report 2021, EDM.

Figure **2** presents an estimate of the LCOE of new build solar by region, showing that the LCOE of new build solar is expected to be below the short run marginal cost (SRMC) of existing fossil fuel generation in all regions[1]. A low LCOE of new build solar relative to SRMC of existing fossil fuel[2] generation implies that the total cost of generation for the Mozambique electricity system can be lowered by developing new build solar if the generation provided by that solar is displacing fossil generation.

FIGURE 2. LCOE of new build solar generation (C&I distributed generation scale solar)



Sources: Consultants calculations based on data from Global Solar Atlas and Greenlight Consulting.
Notes: CAPEX estimates used for calculations were provided by a recent 25kWp C&I project and are reflective of CAPEX costs in 2022, exact data are confidential.

Furthermore, fragmentation of the network implies that while the total non-fossil fuel generation capacity available across the system may cover demand at a particular moment, that power may not be able to reach demand sources due to insufficient interconnection capacity as well as technical losses resulting from transmission line incapacity. Therefore, distributed renewable generation may as

[1] LCOE is calculated by region because differences in the solar resource by region result in different levels of production for a given size of generation facility, and therefore differences in the LCOE.

[2] While LCOE captures the full cost of new build renewables, it is appropriate to compare with the SRMC (which excludes capex costs) because capex is a sunk cost in the case of existing fossil fuel generation and the associated costs will be incurred regardless of the level at which those assets continue to operate.

contribute to the stability and quality of grid supply by providing the added benefit of filling supply shortfalls in some poorly connected regions.

The scale-up of distributed renewable generation can be supported through the establishment of a new net billing retail tariff class for self-producers.

There are several key design parameters that will need to be considered when developing a net billing tariff.

Level of compensation for energy supplied to the grid

Compensation for energy supplied to the grid should reflect both the avoided cost of alternative generation to the utility (assumed to be the SRMC cost of displaced fossil fuel generation), and the cost of supplying energy to the grid (assumed to be the LCOE of the distributed renewable generation). If the level of compensation is above the LCOE of distributed renewable generation, self-generators will have an incentive to participate in the scheme. If the level of compensation is below the SRMC of displaced fossil fuel generation, the utility can achieve cost savings from the scheme.

Level of fixed or capacity charge for net billing customers

Mozambique already has a two-part tariff for most consumers, with a per unit volumetric component for recovering variable costs and a fixed component for recovering fixed costs, while large consumers have a three-part tariff, with an additional demand charge to recover capacity costs. If, , through a cost-benefit assessment it is quantified that distributed generation will impose additional costs on the grid, then the fixed component might need to be set higher for net billing customers, or a capacity charge introduced for such customers. However, care will need to be taken to ensure the fixed component is not set so high as to disincentivise participation in the scheme.

How energy supplied will be compensated

Net billing provides administrative simplicity over a feed-in tariff in that payments do not need to be made to the consumers as power supplied is compensated through offsetting against the bill for power consumed. However, the period for offsetting needs to be determined as well as what happens with any surplus credit (should the self-generator supply more energy to the grid than they consume from the grid during the period) at the end of that period.

Net-metering provides administrative simplicity for residential/domestic customers by:

— Providing an easily accessible route to market for self-consumption facilities who are not regular participants in an electricity market that is currently dominated by monopoly incumbent.

— Lowering transaction costs (eg. lawyers fees etc) for small facilities for whom the costs of entering a bilateral bespoke contract may be prohibitively high.

— Addressing knowledge and negotiating asymmetries between self-consumers and the utility or aggregator purchases on fair prices and terms.

— Providing greater clarity, and empowering the consumers to better manage their bills.

Requirements for eligible generation to be variable renewable

Under the scope of this whitepaper, net billing tariffs are considered for variable renewable energy only (wind, solar, and run-of-river hydro). By providing the industrial and commercial consumers with a guarantee that all power generated by their system will be used (either by themselves or through export to the grid), an adequate tariff setting through net billing should provide certainty for those consumers that their investment in a generation facility will yield a positive return. Because other forms of generation can be turned off when not in use, other remuneration models might be more adequate for injected surplus of electricity. It is therefore recommended that the net billing tariff be limited to variable renewable generation (wind, solar, and run-of-river hydro).

Maximum size of eligible generation and definition of surplus electricity

Net billing schemes are intended to compensate surplus electricity generated by industrial and commercial generation facilities intended primarily for self-consumption. As such the natural capacity limit for any generation facility participating in net billing is the maximum demand of the consumer installing that generation.

Review the scheme once predetermined thresholds are reached to guarantee system security

It is recommended cycles for ongoing distributed generation grid integration studies are determined to check for system security concerns and cross-reference with planning of necessary grid reinforcements investments. Penetration thresholds can be used as references for each study cycle, and once each is close to being reached , new studies should be conducted to see the impact distributed renewable energy is having on the grid, assess the grid's ability to host further distributed renewable energy, and identify any grid upgrades that are needed. Technical reviews of the system in this manner should be conducted on an ongoing basis to ensure long term stability of the grid and sustainability of distributed generation growth.

Metering requirements

Net billing requires a consumer to install appropriate metering hardware to separately measure power coming from the grid and power delivered to the grid. Requirements will have to be in place to ensure customers participating in net billing have appropriate billing infrastructure installed.

In the case of net-metering with residential or small commercial customers, the availability of the appropriate metering hardware will need to be secured and regulatory provision made for the apportionment of the cost of installation.

Successfully scaling up distributed generation in Mozambique in a sustainable manner will require a range of stakeholders to engage with the topic and implement key activities.

For this reason a roadmap to outline the key actions that need to be taken and provide an indicative guide to the sequence and relevant responsibilities has been prepared. The roadmap includes ten key activities as shown in Figure 3.

FIGURE 3. Overview of tasks in roadmap