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Regulatory practices and Distribution System Cost impact studies for distributed generation: Considerations for South African distribution utilities and regulators

U.J. Minnaar

Eskom Holdings, South Africa

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ABSTRACT

South Africa has introduced renewable energy generation to its grid by means of a competitive bidding process. This has been successful as it has quickly introduced renewable generation and has reduced the cost generation significantly over the three rounds of bids submitted. The introduction of distributed renewable generation has consequences for the operation and regulation of its Distribution networks. This paper reviews international practices to establish the cost and benefits of distributed generation to Distribution System Operators as well as regulatory rules that affect them. Impact studies for several European Distribution System operators are discussed and the main impacts of Distributed Generation on Distribution networks are identified as being voltage rise, increased fault levels, losses, reduced power flows upstream and the deferral of investments. Regulation of renewable generation in South Africa is compared with a range of European countries. South Africa has implemented a shallowish network charge regime for distributed generators. This lowers costs for generators connecting to the network, however this has introduced the risk of projects being unable to connect due to deep transmission networks that require funding.

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E-mail address: minnaauj@eskom.co.za

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1. Introduction

South Africa is in the early stages of introducing distributed generation onto its power system. The Integrated Resource Plan for South Africa includes the commissioning of 17.8 GW of renewable generation (8.4 GW of solar photovoltaic, 8.4 GW of wind and 1 GW of concentrated solar power) over the 2010-2030 period [1].

The first steps have been taken through the Renewable Energy Independent Power Producer Programme (REIPPP) conducted by the Department of Energy and the National Treasury in South Africa. A total of 64 projects have been awarded to the private sector, and the first projects are already coming online. Private sector investment totalling US$14 billion has been committed, and these projects will generate 3922 MW (MW) of renewable power [1]. In addition to these projects there is also demand for the connection of roof top solar photovoltaic generation by small power users such as urban residential and commercial electricity users.

2. Introducing renewables onto the South African grid

The REIPPP programme in South Africa was structured as a competitive bidding processing where the first bids were received during late 2011 and the first renewable generation started producing electricity by November 2013 [2]. By the end of 2014 approximately 600 MW of wind and 1000 MW of solar PV capacity had been commissioned and generated 2.2 TW h of electricity during the 2014 calendar year [3].

These early outcomes of the competitive bidding process have highlighted a number of successes for South Africa in introducing renewable energy to its existing electricity generation capacity. South Africa has attracted a wide range of local and international developers and investors who have contributed a significant amount of private capital and technical expertise into renewable energy in South Africa. Across the three rounds of bidding completed to date competition was fostered which in turn led to significant price reduction.

Table 1 illustrates the significant price reductions obtained for wind, PV and CSP across the three rounds of bidding with reductions of 42% and 68% for wind and PV respectively. A major success of the process has been the speed of the process in which three rounds of bids were completed in three years and many of the projects are either under construction or in operation already.

South Africa has favourable conditions for solar generation throughout most of the country, however the solar projects submitted and developed to date have been situated in the so-called "Solar Corridor", a concentrated zone of clustered solar electricity plants that deliver power to the grid via a common connection. Situated in the Northern Cape Province this area has been selected because it has consistently very high solar radiation (> 2200 kw h/m^2), flat and sparsely populated land, good transport and the Orange River as a reliable water source [4].

Table 1
Bid prices per technology (ZAR cents/ kW h-2011) across three bidding rounds [2].

	Round 1	Round 2	Round 3
Wind	114	90	66
PV	276	165	88
CSP	268	251	146

Fig. 1 illustrates solar irradiation in South Africa, along with the Solar Corridor, which is situated several hundred kilometres from South Afica's major cities e.g. Johannesburg and Cape Town

The benefit of bidders locating their solar PV farms in this area with high solar irradiation is that it leads to the lowest cost of solar energy generation which in turn results in lower generation tariffs. However, being an area with a low population density, this will require grid reinforcement at both transmission and distribution level [5]. Alternatively, moving solar PV farms closer to the major cities in South Africa would result in a slight increase in the cost of generation due to lower levels of solar irradiation, while lowering grid expansion costs.

While the introduction of renewable energy to the South African grid is considered a success and the process has been well-managed it does have consequences for the operation and management of the Distribution networks to which these will be connected. This paper reviews international practices to establish the cost and benefits of distributed generation to Distribution System Operators as well as regulatory rules that affect them. A further aim is to identify practices and regulation that regulators and distribution utilities in South Africa should consider for successful integration of renewable power sources onto the distribution grid.

3. The distribution utility and distributed generation

3.1. The distribution business model

To provide context to a discussion on (a) the impact of increasing levels of distributed generation and (b) the impact of related regulation on the Distribution business, the revenue stream business model for a Distribution System Operator (DSO) is reviewed. The costs and revenue streams are illustrated in Fig. 2 [6].

Fig. 2 illustrates that the main revenue streams of a DSO are network charges, namely:

- Use of System (UoS) charges (per kW h and/or per kW) received from customers and (in certain countries) from producers e.g. distributed generators.
- Connection charges from consumers and EG operators.

The main costs of a DSO are:

Capital expenditures-investments in the network, extension of the grid, reinforcement of existing lines and transformers or investments in other supporting devices. This includes investments in distribution network assets such as transformers, switchboards and cables, and the consequential depreciation costs and repayment of debt

Operational expenditure which includes:

- Maintenance of the network.
- Use of system (UoS) charges paid to the transmission system operator (TSO).
- Electricity to cover energy losses.