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Seven key considerations for South Africa as more Renewable Energy is added to the energy mix

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Globally there is a transition to more renewable energy in electricity generation capacity, and renewable energy (RE) electricity capacity is forecast to increase by 920 GW over the next 5 years, a 43% increase (IEA, 2017). South Africa's Renewable Energy Independent Power Producer Procurement (REIPPP) Programme resulted in sizeable RE additions, and it is anticipated that RE capacity could increase further as it becomes increasingly attractive for a number of reasons, including price, and as government's commitment towards the nuclear deal wanes. Even though the latest Integrated Resource Plan (IRP) hasn't been finalised, it appears it is a given that RE capacity should increase.

In the past the debate has focused on RE versus nuclear, and although this debate has largely been resolved, it has not been without issues. In light of this a number of key debates still need to take place. This paper will examine seven key considerations that the industry should take into account during this shift to RE:

- The impact on municipalities given the importance of electricity sales in their income;
- The structure of the Electricity Supply Industry (ESI) to best include increased RE capacity in the mix;
- The future of Eskom;
- Is there a need for new generation capacity in the short- to mid-term?
- The impact on the stability of the grid;
- The impact on economic development, with an emphasis on net employment effects;
- The regulatory framework that is required to enable a smooth transition to increased RE in the energy mix.

Key words: Renewable energy, electricity supply industry, economic development

JEL classifications: L94, O13, Q42, Q43

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1. INTRODUCTION

There is a global energy transition underway as many countries increase the proportion of RE in their electricity generation capacity. The mainstreaming of Renewable Energy (RE) will have major implications for South Africa's Electricity Supply Industry (ESI), and the purpose of this paper is to discuss key issues that the industry needs to take into account as the inevitable shift from a coal-centered ESI to one that is powered by more and more RE sources takes place. The time frame is not known, but is likely to be short, as globally changes in ESI structures are taking place at a rapid rate.

In South Africa the debate has focused on RE versus nuclear energy, with both economic and political arguments dominating the discussions. These debates have been intensified by the delay in the signing of the Power Purchase Agreements (PPAs) from bid windows 3.5 and 4 of the REIPPP[5] Programme, and electricity price increases over the last decade. Over the last eight years real electricity prices have increased by 147% (calculated using data from Deloitte, 2017: 40).

The RE versus nuclear debate appears to be resolved, with the Earthlife Africa/South African Faith Communities' Environment Institute ruling effectively stalling any nuclear build in the short-term. The signing of the outstanding PPAs as well as the announcement of further bid windows towards the end of 2018 also indicates the commitment by government to RE. Although the latest Integrated Resource Plan (IRP) has yet to be finalised, the future for RE in South Africa seems positive.

As we emerge from this debate, there remains seven key considerations that need to be taken into account by the industry, policy makers and other stakeholders to ensure a smooth transition. In some respects these have not been emphasised given the prior focus on RE versus nuclear, but they now need to play a more prominent role. The intention of this paper is to present these issues, and not to resolve them, but we hope this paper assists in clarifying key questions that need answers. These issues are listed below and will be discussed in turn after a brief background into RE globally and in South Africa:

- The impact on municipalities given the importance of electricity sales in their income;
- The structure of the Electricity Supply Industry (ESI) to best include increased RE capacity in the mix;
- The future of Eskom;
- Is there a need for new generation capacity in the short- to mid-term?
- The impact on the stability of the grid;
- The impact on economic development, with an emphasis on net employment effects; and
- The regulatory framework that is required to enable a smooth transition to increased RE in the energy mix.

[5] Renewable Energy Independent Power Producer Procurement.

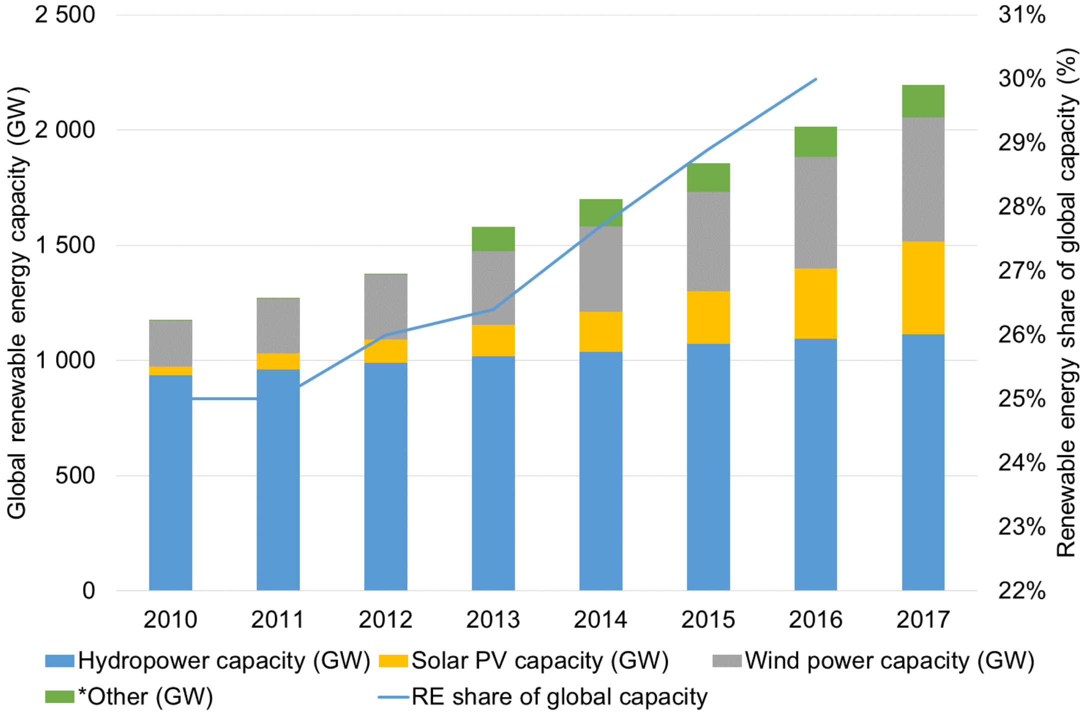
2. BACKGROUND

2.1. CHANGES IN THE GLOBAL ENERGY MARKET

Globally, the electricity sector is undergoing a fundamental change. The traditional model of a vertically integrated utility that is responsible for generation, transmission, distribution and systems operations is changing to a more decentralised model. The maturation of RE, especially solar photovoltaic (PV) and wind, technology and its rapid fall in price has played a major role in this transition. Telecommunications infrastructure and digital technologies such as smart grids are also playing an important role.[6] Smart grids (which are still in the pilot/research phase in South Africa) enable the integration of new, decentralised and renewable generation units into the power grid (SALGA, 2018a: 37).

There is a global energy transition taking place in the power sector as net capacity additions from RE sources increase year after year. The chart below shows RE capacity from 2010. Hydropower makes up the highest share of RE capacity, but it is clear that solar PV and wind capacity are increasing at a faster rate. In 2016 RE's share of total global capacity was 30%, with variable renewable energy (i.e. solar and wind) (VRE) accounting for approximately 12% (solar PV making up 5% and wind power making up 7%) (REN21, 2017a:33).

Chart 1: Global RE capacity (GW) and share of total capacity (%)



Source: data from REN21. Renewables 2011-2018. Global Status Report. Available: http://www.ren21.net/. Last accessed June 2018.

[6] Digital technologies allow devices across the grid to communicate and provide data to both grid management/operations and customers. Network digitalisation lowers service costs and improves quality (i.e. duration and frequency of outages, and time of service) (World Economic Forum, 2017: 15).

In 2017, 70% of net capacity additions were RE sources, mostly solar PV. In fact, solar PV capacity additions surpassed coal, gas and nuclear combined (Ren21, 2018: 18). This trend is set to continue, and in a recent survey 85% of experts predicted that the share of renewable power will double by 2050, and more than half estimated a share of over 80% (Ren21, 2017b: 32).

Drivers for this transition

The main drivers for this transition have been technical maturity and the resultant falling RE prices. The fall in prices has been significant – since 2009 Solar PV prices have dropped by approximately 80% and wind by between 30% and 40% (SALGA, 2018a: 24).[7] Some aspects of technical maturity include:

- Small- to medium-scale RE technologies have become cost competitive with bulk fossil fuels, which has resulted in increasing numbers of residential and business customers installing rooftop PV systems;
- The prices of batteries used to store excess electricity from VRE prices have also dropped significantly and are forecast to be between 50 to 60% cheaper by 2030 (IRENA, 2018a);
- Shorter lead times of RE technologies such as solar PV and wind. Lead times for solar are between one and four years, and for wind between three and five years. This is in contrast to coal which is between four and nine years, and nuclear which is between six and ten years on average (Parliamentary Budgetary Office, 2016: 19).

Another important driver is international commitments to reducing emissions levels and the resultant policy support. Related to this is consumer awareness and consumers have become more concerned with emissions and the environmental impacts associated with energy production.

2.2. RE IN SOUTH AFRICA

Installed capacity

South Africa's RE journey started in 2011 with the first of its REIPPP Programme bid windows.[8] Of the 49,161 MW of installed capacity, approximately 6% is RE, mostly from RE Independent Power Producers (IPPs), many of which entered the ESI under the REIPPP Programme. Under this programme about 3,110 MW of capacity has been added to the grid so far. Further REIPPP capacity should be added in due course after the signing of the 27 outstanding PPA's from bid windows 3.5 and 4 (comprising a total of 2,300 MW), and the recent announcement that a further 1,800 MW will be procured in bid window 5 (November 2018) (Creamer, 2018).

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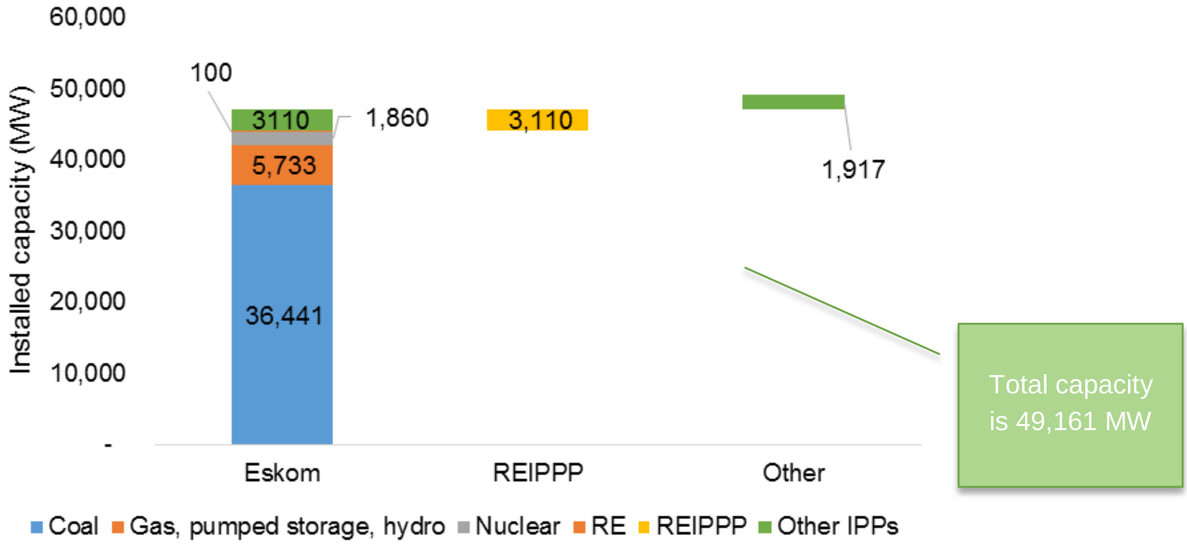
[7] The weighted average electricity costs for bioenergy for power, geothermal, hydro, onshore wind and solar PV all fell within the range of fossil fuel-fired electricity and are often the cheapest source of new generation needs (IRENA, 2017c: 48). As indicated by IRENA (2017a), by 2020, all mainstream renewable power generation technologies can be expected to provide average costs at the lower end of the fossil-fuel cost range. In addition, several solar PV and wind power projects will provide some of the lowest-cost electricity from any source (IRENA, 2017c: 4).

[8] The REIPPP Programme falls under the Independent Power Producers Procurement Programme (IPPPP), which was established at the end of 2010 as an urgent intervention to increase generation capacity (DoE et al., 2016:1). It is a competitive tender process designed to facilitate private sector investment into grid connected renewable energy generation in South Africa.

The chart below shows the share of installed capacity in South Africa. Eskom coal makes up 74% of total capacity. Eskom also owns gas, pumped storage and hydro which makes up 12% of total capacity, nuclear which makes up 4% and a small amount of RE. Capacity from the REIPPP Programme comprises 6% and other IPPs make up 4% of capacity.

Chart 2: South Africa's ESI – ownership of installed capacity (MW)

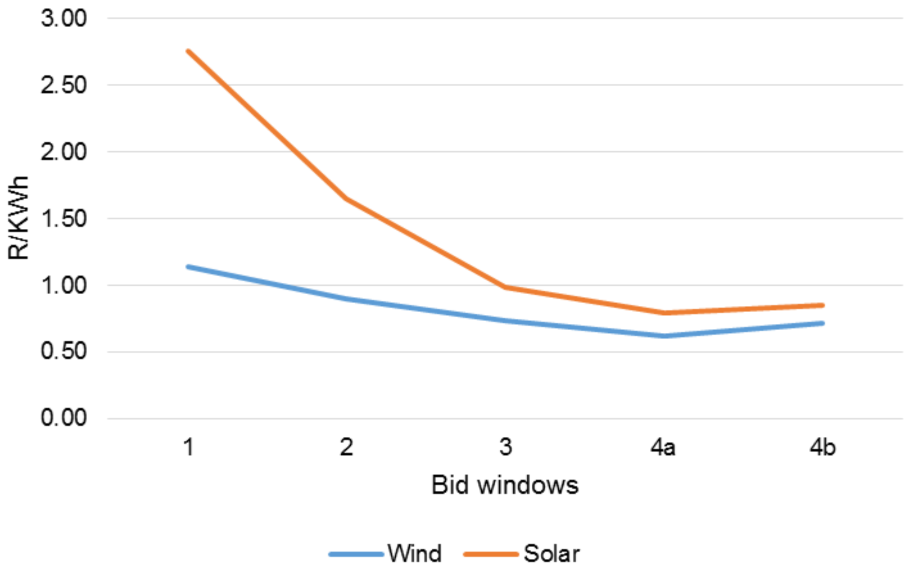


Source: chart constructed using figures from Eskom Integrated Report 2017, pg. 5 and 49.

RE costs

As mentioned above, the costs of wind and solar PV have fallen dramatically across the world. In South Africa wind and solar PV are now competitive compared to traditional technologies, despite initial high costs in the early bid windows of the REIPPP Programme. The chart below shows the fall in prices.

Chart 3: Price of wind and solar PV



Source: chart constructed using data from Eberhard and Naude (2017: 28, 29).

The latest round of renewable energy bids were approximately 40% cheaper than the bids received for the new independent coal-fired power plants in South Africa (Kruger & Eberhard, 2018). There is still some debate on the actual numbers, but according to Steyn et al (2017: 43), the LCOE of electricity from Medupi is R1.70/kWh and Kusile is R1.91/kWh. This is in contrast to the LCOE of wind and solar PV which was calculated at R0.62/kWh by the CSIR (2017: 8). These costs don't take into account the additional transmission and distribution costs required to accommodate wind and solar technologies, which could vary depending on the size and location of power plants. Refer to section 3.5 which discusses the implications of VRE on the grid in terms of stability.

Despite the apparent success of the REIPPP Programme and the decrease in RE costs, South Africa's RE adoption has not been without its challenges. The share of RE in the energy mix is still low, and the delay in signing of the latest contracts undermines the potential economic benefits from investments in the industry. The remainder of this paper is focused on seven key areas that need to be examined.

3. SEVEN KEY CONSIDERATIONS ON THE PATH TO INCREASED RE IN THE ENERGY MIX

3.1. THE IMPACT ON MUNICIPALITIES

Municipalities, as distributors of electricity, are impacted upon by the RE industry in two ways. The first is the uptake of small scale embedded generation (SSEG), such as rooftop PV, by their customers; and the second is their wish to take more control over procurement by contracting directly with RE IPPs or own generation using renewable sources.

Of the 259[9] municipalities in South Africa, 164 are licensed electricity distributors. ESI developments have a significant impact on municipalities, as municipalities are responsible for distributing approximately 40% of electricity in South Africa (Trollip, 2018: 7), and electricity revenue comprises a large share of many municipalities' revenues.

Small Scale Embedded Generation (SSEG)

An emerging trend in municipalities is that customers are starting to generate their own electricity, because of electricity tariff increases, load-shedding, decreasing costs, and environmental awareness (SALGA, 2018b: 2). Embedded generation refers to power generation (mostly solar PV or mini wind turbines) at the point of consumption. SSEG pertains to power generation under 1MW, which is located on residential, commercial or industrial sites where the electricity generated is also consumed. The majority of electricity generated should be consumed directly on site, however when production exceeds consumption electricity can be exported onto the grid. In many instances SSEGs produce excess electricity, and thus the household or business approaches the municipality to ask to be connected to the grid and for that excess energy to be fed onto the grid.

There are opportunities and risks involved for municipalities if their customers decide to install SSEG systems. The major risks to municipalities are revenue losses and the technical and safety issues of connecting SSEG systems to the grid. According to the National Treasury, municipalities tend to provide electricity to wealthier households (whilst Eskom supplies poorer consumers) (National Treasury, 2011:149), and these consumers are more likely to be able to afford SSEG systems.

The South African Local Government Association (SALGA) has been working closely with municipalities to assist them with putting systems in place to allow SSEGs to connect to the local grid. This includes implementing metering and billing systems that allow bi-directional flows of electricity; putting application processes for SSEGs in place; and designing SSEG tariffs and obtaining approval from NERSA. As of October 2017, 34 of the 164 municipal electricity distributors allow SSEG installations, 21 have

[9] There are 8 metropolitan municipalities, 44 district municipalities, and 207 local municipalities (http://www.elections.org.za/content/Elections/2016-Municipal-Elections/More-about-municipalities/).

official application procedures, and 18 have SSEG tariffs in place (SALGA, 2017: 3-4). SSEG tariffs refer to special tariffs that are only available to customers that have installed solar PV. These tariffs consist of an import tariff, which is what the customer pays the municipality for electricity drawn from the grid, and an export tariff, which is what the customer is compensated for for any excess electricity fed onto the grid.

Revenue losses can be mitigated by the correct design of SSEG tariffs, where customers pay for electricity consumed from the grid, and are also compensated for electricity that is fed onto the grid. All customers (SSEG and regular customers) should contribute to the maintenance of the grid, and thus there is a case for reviewing the fixed and variable charges to each set of customers. It is important that municipalities control SSEGs connecting to the grid, as uncontrolled access causes safety risks, which highlights the importance of an official application process for SSEGs.

The opportunity for the municipality is that SSEGs present a source of electricity that can be cheaper than Eskom tariffs. Thus careful tariff design should prevent significant decreases of revenue if customers choose to install SSEG.

Procurement from IPPs

The structure of the South African ESI prescribes that municipalities procure from Eskom and that they are unable to contract directly with IPPs. The emergence of RE IPPs has implications for this model, as there are some municipalities that wish to purchase directly from IPPs, or set up their own RE generation facility (SALGA, 2018b: 7, 10). In theory, this would enable municipalities to buy electricity for less than the Eskom bulk tariff. However, this is currently not happening in South Africa due to licensing issues. Current licencing issues appear to be undermining municipality efforts to contract directly with IPPs. According to SALGA, the City of Cape Town is seeking to purchase power directly from a potential IPP. This IPP has not been granted a license as NERSA states it needs a ministerial determination to do so, and the DOE is refusing to gazette the determination. The issue is currently in the courts. (SALGA, 2018b: 8).

Buying power directly from IPPs would increase complexity, as long-term PPAs would need to be negotiated, and municipalities would need to compare PPA future tariffs to projected future bulk electricity prices from Eskom. Buying power directly from IPPs would also increase the complexity of electricity demand and supply planning and tariff modelling for the municipality. There is also the possibility that municipalities could start to generate their own electricity using RE plants. Some municipalities have generation licenses but with the advent of RE it is expected that this will become a more attractive option for municipalities.

Considerations

Both issues are complex and require careful deliberation, and better information on costs to resolve them. These changes necessitate that municipalities better understand their cost structures so that tariffs can be designed in such a way to ensure the financial sustainability of municipalities. It is important that cost of supply (COS) studies are done so that SSEG tariffs, PPAs and wheeling charges are optimally designed.

3.2. THE STRUCTURE OF THE ESI

The current South African ESI structure is restrictive in terms of facilitating new RE generation capacity, as the low share of RE in the energy mix attests. It is designed around a vertically integrated state-owned monopoly which is responsible for the majority of generation, transmission, distribution and systems operations. The restructuring of South Africa's ESI is part of a broader debate, but one important input into this debate is how to restructure the ESI so as to derive maximum benefit from RE technologies.

Current structure

South Africa's ESI structure is essentially the traditional model. Eskom owns 92% of South Africa's generation capacity, and is responsible for transmission. Distribution is undertaken by Eskom, the municipalities and a number of other licensed distributors.

Municipalities have the executive authority for electricity reticulation, however a large number of customers are supplied directly by Eskom as some municipalities do not provide electricity reticulation services and rely on Eskom as a distributor (National Treasury, 2011:148). Although both Eskom and municipalities are active at the distribution level, there is no competition for end-users, and end-users are served by either of the distributors depending on various factors including location.

Restructuring options

ESI liberalisation has been taking place across the world since the beginning of the 1980s, with the drivers of reform typically being energy shortages, poor financial performance of utilities, lack of investment funds, and concerns around electrification levels and affordability. There is international consensus that generation is best organised as a competitive sector, and that transmission, distribution and systems operations can operate as monopolies (Regulation Body of Knowledge).

The most commonly proposed models for ESI reform are the single buyer model, the wholesale competition model and the retail competition model. These models build on the previous model, and each represents a more competitive state than the model that preceded it.

Table 1: Models of ESI reform

Single buyer model	In the standard single buyer model, there is a single agency that buys electricity from competing generators. This single buyer is usually the vertically integrated utility that was previously the monopoly. The single buyer continues to own all existing generation, transmission and distribution and competes with IPPs at the generation stage.
Wholesale competition model	The wholesale competition model is characterised by competition in generation (new and existing). Generation, transmission and possibly distribution that were previously carried out by the vertically integrated utility are separated and the utility becomes a transmission company (or transmission and distribution company if these functions are not separated). The key characteristic of the wholesale competition model is the fact that the transmission company is not active in generation.
Retail competition model	Retail competition is an extension of wholesale competition and extends competition to all retail customers. That is, all customers are able to choose their own suppliers. They may purchase from these suppliers directly or through retailers of their choice. Retailers purchase electricity upstream and sell it to end-users. Retailers act as intermediaries and as such are able to operate without owning any infrastructure. They supply electricity by paying a tariff for the use of infrastructure that is put in place by distributors. Distributors also compete with retailers by offering retail services. As in the wholesale competition model, the market for generation is competitive. The utility does not participate at all in generation but provides the transmission (and possibly distribution) system.

Source: Genesis.

International evidence

Countries with high shares of VRE often have liberalised wholesale power markets (i.e. the second model). In these countries the systems operator plays a critical role in balancing supply and demand. The creation of an Independent Systems Market Operator (ISMO) is thus an important step in the energy transition. However, empirical evidence from countries with high VRE shares reveals that there is no common path to or generic ESI structure for a high renewables grid.

In a recent review of nine countries with high shares of RE[10] (Wynn, 2018), it was found that the ESIs of these countries ranged from vertically integrated, state-owned monopolies to fully liberalised wholesale markets. For example, South Australia's ESI has 48% of generation from RE and is a highly concentrated wholesale market; Uruguay has 32% RE in its generation mix and its ESI consists of a vertically integrated state owned company that owns half the generation assets; Spain has 23% RE in its generation mix and has a wholesale market ESI; and California, with 15% of its generation from RE, operates a retail competition model.

[10] These countries (with shares of RE in electricity generation) are: Denmark (52.8%); South Australia (48.4%); Uruguay (32.2%); Germany (26%); Ireland (24.6%); Spain (23.2%); Texas (18%); California (15%); and the state of Tamil Nadu, India (14.3%).

Considerations

The current ESI structure has been described as outdated and not fit for purpose, and restructuring has been on the agenda for over 20 years with no major changes to the structure. Eskom as the primary generator and gatekeeper of systems operations, transmission and much of the distribution infrastructure has an inherent conflict of interest when faced with competition from RE sources. Any restructuring that does take place should make competition more effective at the generation level to assist the transition to RE.

3.3. THE IMPACT ON ESKOM

The impact on Eskom of more RE in the electricity generation mix is inextricably linked to the structure of the ESI. If South Africa is able to take advantage of the RE transition, Eskom's business model may need to change. This is also part of a broader debate given Eskom's current financial state, which has been well documented. Eskom's profitability has been falling since 2006/07 despite increasing revenues; and revenues have increased not as a result of increased sales, but because of tariff hikes (Parliamentary Budget Office, 2017:5-7). Eskom's dire financial situation has been caused by a number of factors:

- Weakened demand for electricity in South Africa combined with rising electricity prices (referred to as the utility death spiral[11]);
- Rising costs associated with its aging fleet (ongoing maintenance and refurbishment to meet legislative standards), cost overruns at Medupi and Kusile, and increased coal prices;
- Credit rating downgrades have made it more expensive to fund its capital requirements.

In addition, RE is also having an impact on Eskom. RE generated electricity is now cheaper than electricity generated from fossil fuels, and SSEG is displacing demand. There are several economic reasons under the current ESI structure for Eskom being disincentivised from increasing the share of RE in the energy mix: RE's perceived inability to deliver base load, the costs of the PPAs in light of Eskom's financial situation, and the current over-supply of capacity. Eskom only has a small amount of RE capacity (the Sere wind farm) and purchases RE electricity from IPPs, but it could be an option for it to ramp up its own in-house RE generation capacity.

Considerations

Given Eskom's importance to the South African economy in terms of its assets, its employment and the magnitude of the funds already committed to ensure its sustainability, the implications of any further worsening of its financial situation are enormous. The utility death spiral should not be treated as inevitable and careful consideration needs to be given to Eskom's future.

[11] A utility death spiral occurs as follows: Increasing electricity prices leads to declining sales, which results in Eskom having to recover the same cost base from a shrinking customer base. The effect is another increase in electricity tariffs, which triggers a further reduction in sales volumes, as it's now financially viable to self-generate by installing SSEG. And the cycle continues.

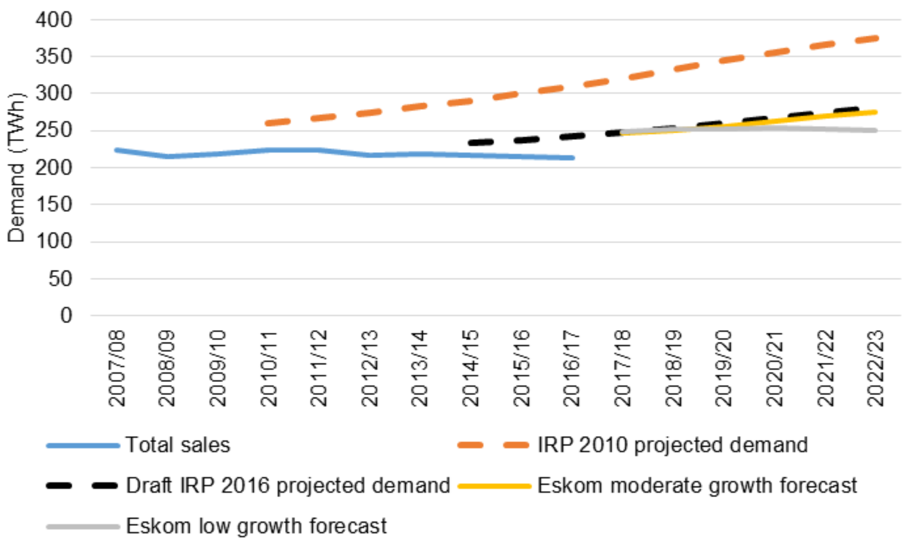
3.4. DEMAND FOR ELECTRICITY

The next key debate is whether South Africa actually needs any additional generation capacity in the near future, in light of the current excess capacity. Following several years of supply shortages, Eskom is now faced with excess generation capacity as a result of a stagnation in electricity demand and the commissioning of the large Medupi and Kusile units (4,764 MW and 4,800 MW respectively).

South Africa's electricity demand over the last 10 years has plateaued owing to a rapid increase in electricity prices, and low economic growth. Demand is currently around 78 TWhs below the 2010 IRP base case scenario projection. This significant overestimate in demand in the 2010 IRP affirms that committing to large, complex, and inflexible new build projects is a risky strategy.

The debate regarding the type of new generation capacity additions assumes that new capacity is required. However, if this is incorrect, adding any new capacity will be a costly mistake. The chart below shows that total electricity sales have not kept up with the IRP 2010 projected demand. Demand has subsequently been revised downwards in the draft IRP 2016 and in Eskom's Medium-Term System Adequacy Outlook (MTSAO), but these forecasts are still above the demand levels from 2008.

Chart 4: South African electricity sales and projected demand to 2023

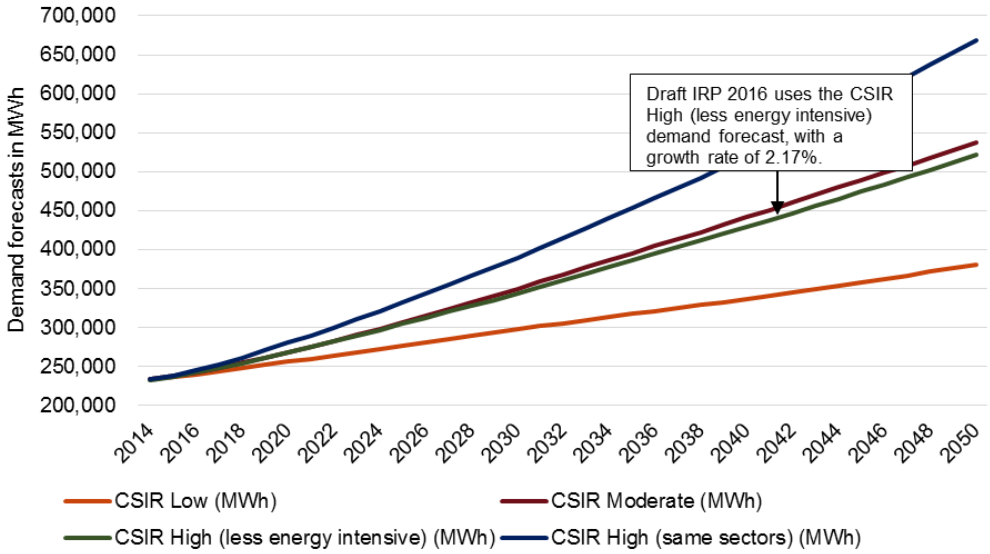


Source: Total sales from Eskom Integrated Report 2017, pg. 105; IRP 2010, pg. 51; Draft IRP 2016, pg. 16/17; Eskom forecasts from the Medium-Term System Adequacy Outlook (MTSAO) of October 2017, pg. 5.

Notes: IRP 2010 refers to the "SO Mod" scenario as this was the demand forecast used in the policy-adjusted 2010 IRP; Draft IRP 2016 refers to the "High (less energy intensive)" scenario as this is the scenario used in the draft; Eskom's moderate growth forecast corresponds to a CAGR of 2% between 2017 and 2022; Eskom's low growth forecast corresponds to a CAGR of 0.4% between 2017 and 2022.

In the long-term, the draft IRP 2016 provided projected demand to 2050 based on a number of different scenarios. There are concerns that the demand projection used in the draft IRP 2016 is still too high, despite the downward shift in the demand curve (from the 2010 IRP to the draft IRP 2016). The chart below shows the various demand scenarios generated for the draft IRP 2016.

Chart 5: Projected electricity demand to 2050



Source: Draft IRP 2016, pg. 9.

Excess capacity

According to the MTSAO, Eskom will have excess capacity of between approximately 4 and 9 GW by 2022, based on alternative scenarios[12] (Eskom, 2017b: 10). The reserve margin also gives some insight into excess capacity. According to Eskom it should be between 10% and 20% (2017: 46), but in 2016 it was 46%, and is forecast to be above 30% for the next five years (NERSA, 2018: 5).

Considerations

The current excess generation capacity coupled with uncertainty regarding the demand projections means that any new capacity additions should be carefully considered, regardless of the type. As the implications of a mistake in estimating demand are costly, this supports the approach of investing in small capacity additions as opposed to large lumpy investments that are difficult to scale back if necessary.

3.5. THE STABILITY OF THE GRID

The debate regarding the stability of the grid as the proportion of VRE increases is beyond the scope of economists, but is still a critical debate that needs to take place. There has been wide scepticism about increasing the share of VRE capacity and questions as to what the upper limit is. This concern was evident in the artificial constraints placed on RE capacity in the draft 2016 IRP. These concerns stem from VRE's variability, and the issues of grid stability and technical integration. Globally, an

[12] The different scenarios refer to the two demand forecasts combined with capacity with contracted REIPPP, and capacity with additional REIPPP.

average of 5%[13] of electricity is generated from VRE sources, but there are an increasing number of countries proving that national grids can accommodate large shares of VRE (Wynn, 2018: 4).

The challenges of VRE integration

There are a number of fundamental differences between VRE and conventional generation that must be addressed to integrate wind and solar power effectively into the grid (Wynn, 2018:7). These differences include the following:

- Their daily variability may not be perfectly predictable, adding uncertainty regarding meeting electricity demand;
- VRE is often located on local distribution grids, e.g. residential rooftop PV, rather than on high-voltage transmission lines and is therefore beyond the control of grid operators, who can only see its impact on net demand;
- The lack of control may add to the challenge of forecasting and managing their variability. Even where variability is predictable, the rate of change may cause difficulties. For example, solar generation typically declines rapidly around sunset just as power demand is peaking.

Integrating relatively low shares of VRE can be managed with modest adjustments, such as improved resource forecasting, improved grid codes and interconnection standards, better real-time information flow on VRE output, and sensible planning of geographical dispersion and balancing of wind and solar power installations (IRENA, 2017a). However, integrating high penetrations of VRE may create challenges for system balancing as well as for power quality and equipment reliability. At relatively high levels of VRE deployment, additional measures are needed, including designing methods to achieve greater flexibility from existing and new system resources to balance supply and demand and to maintain grid voltage and frequency stability (IRENA, 2017a). At the same time, VRE technologies are evolving to improve the ease of integration.

International experience

Several countries have successfully integrated increasingly larger shares of solar PV and wind power into their electricity systems. At least 10 countries generated 15% or more of their electricity with solar PV and wind power in 2017, and many had far higher short-term shares (REN21, 2018). Countries leading the way in VRE penetration include Denmark (nearly 53%), Uruguay (28%) and Germany (26%); Ireland, Portugal and Spain also have VRE penetration levels above 20% (REN21, 2018).

Denmark's success in integrating and balancing VRE, for example, can be attributed in large part to the flexibility of the system. This flexibility is due to a number of factors including: (i) the ability to vary the output of coal-fired power plants; (ii) day-ahead

[13] This figure corresponds to the 12% VRE capacity reported in section 2.1.

weather forecasting and real-time updates that enable quick responses to changes in VRE output; (iii) transmission planning in parallel with new generating capacity; (iv) the coupling of electricity with heat supply, including significant capacity of biomass combined heat and power; and (v) the use of domestic balancing markets and interconnection with neighbouring grids to freely buy and sell power to balance solar and wind energy output (REN21, 2018: 152).

Uruguay has a long history of very high market share for RE electricity. Uruguay's success in integrating wind power can be attributed to: (i) forward planning, including installation targets; (ii) reducing its dependency on energy imports, including oil for thermal generation, and of electricity from Brazil and Argentina; and (ii) flexible balancing of resources that can offset the variability of wind power. Uruguay has both substantial hydropower resources, which can cover shortfalls in wind, and cross-border interconnections to two larger neighbours, such as Argentina and Brazil, which can be used to export wind power surpluses (Wynn, 2018: 37).

VRE integration in South Africa

In South Africa, only 3% of South Africa's total system load was supplied by solar and wind in 2016 (GIZ, 2017). A recent study by GIZ assessing the impact of increasing shares of variable generation on system operations found that the South African grid can accommodate a high proportion of VRE (11% by 2020 and 22% by 2030) from an active power balancing point of view at only moderate additional costs. This study advocates a wind-solar-gas system as a feasible least-cost solution. (GIZ, 2017). In addition, a study by the CSIR found that South Africa's grid could be flexible enough to cope with multiple sources of energy, and that renewables supported by gas could provide base load (Global Africa Network, 2018).

Considerations

There is still uncertainty regarding the optimal proportion of RE in the generation mix as well as the maximum capacity that the grid can accommodate. Although two recent studies have provided input into this, there needs to be consensus on this issue from an engineering point of view and any costs associated with ensuring grid stability should also be included in costing exercises.

3.6. SOCIO-ECONOMIC IMPACT

A shift to more RE in the energy mix will have implications for the South African economy, especially with respect to employment and industrial development. However, there will be winners and losers with respect to jobs and geographic regions, and any negative impacts need to be carefully considered and mitigated if possible.

International studies

GDP. Recent studies have emphasized the positive impact of increased levels of RE on GDP. The International Renewable Energy Agency (IRENA) projected a global

GDP increase of between 0.6% and 1.1% if RE is doubled in the final global energy mix by 2030 (IRENA 2016, 24). Most of this positive impact is driven by increased investment in RE deployment, and the associated multiplier effects of this investment. This study also looked at the impact on GDP of individual countries. Some countries will experience a decrease in GDP (for example, Saudi Arabia, Venezuela, Nigeria and Russia) because of the resultant drop in oil and gas exports. However, it is projected that coal exporters, such as South Africa and Australia, will experience increases in GDP of more than 1%. The reason is that South Africa and Australia are less dependent on coal exports compared to what Saudi Arabia et al are on oil and gas exports, and any negative impact on GDP due to a decline in coal exports is superseded by the positive effects of increased investment on the economies (IRENA 2016, 25-26).

Employment. The impact on employment needs to take into account both the gains from RE deployment as well as the losses in the displaced fossil fuel sectors. International studies have shown that overall employment in the energy sector is expected to rise as RE increases its share in the overall energy mix. This is because RE is more labour intensive than the traditional fossil fuel power generators. (Bowen 2012, 19). The reason for this is that a significant amount of employment opportunities in RE exist at the initial or implementation stages (such as construction, manufacturing and installation), and this work is generally geographically constrained and requires local, low-skilled labour (Bowen, 2012: 5).

The RE sector currently employs approximately 9.8 million people globally, and IRENA estimates that by 2050 it could employ about 25 million people. They also believe that new employment in the RE and energy efficiency sectors could more than offset (by 6 million jobs) the expected job losses in the conventional energy sector. This is as a result of shifting investment patterns and differentials in labour intensities (IRENA 2017, 10).

Local content requirements. Many countries have incorporated local content policies for RE projects (IRENA, 2017b: 10). Local content requirements are generally used to develop infant industries towards overall competitiveness in global markets. They have been used in Ontario, Brazil, Spain, Turkey, Quebec and India, for example (Kuntze and Morenhout, 2013:21).

South African experience

Part of the objectives of the REIPPP Programme is to generate employment and the development of local industries. Bid evaluation is weighted 70% for price and 30% for socio-economic criteria, which includes job creation, local content, ownership, management control, preferential procurement and enterprise development (DoE, National Treasury and DBSA, 2016: 11-12). Job creation as a result of the programme has exceeded national targets (DoE, National Treasury and DBSA, 2017:41), however critics have pointed out that there are trade-offs between job creation and the other requirements and that the full potential may not have been realised. The REIPPP Programme is anticipated to contribute 109,443 employment opportunities for South

African citizens during both the construction and operational phases, but the actual employment reported on the programme to date is 19,033 job years (DoE 2015: 97).

However, we need to be cognisant of potential job losses in the coal sector and what this means for whole communities. There are concerns that proponents of RE underestimate the impact of job losses within the coal sector (Tshwane, 2018). A recent study of the economic contributions of five longstanding power stations confirms that these stations provide substantial economic contributions to GDP, employment and households (Eskom, 2017a). In addition, long term increases in employment as a result of the shift to RE are uncertain because RE is more labour intensive at the initial phases. Individuals could then substitute permanent work in traditional fossil fuel sectors for temporary work in clean energy sectors (OECD, 2017: 8).

Considerations

International studies indicate that overall the shift to RE should be positive for South Africa. However it is important to not only look at net effects, and South African specific studies need to be undertaken to identify the winners and losers in the transition to RE. These studies should be rigorous and objective in order to identify the best path to mitigate the risks to affected industries and firms.

3.7. THE REGULATORY FRAMEWORK

There are no successful examples of “reform by default” in the electricity sector (van der Merwe, 2015: 1), and thus market system and regulatory reform needs to be well planned. Any ESI restructuring will require changes to policy, legislation and/or regulations. However, even without a major change to the ESI structure, there are improvements to the existing policy, legislative and regulatory frameworks that already need to be made to better accommodate RE.

Municipal procurement. There is a discontent between national government and municipalities with respect to energy policy, as it is developed at a national level and the municipalities provide inputs as stakeholders (SALGA, 2018b: 57). For example, municipalities are unable to implement RE targets as their energy mix is determined by Eskom generation. Some municipalities would like more control over procurement, which would involve changes to procurement regulations. For example, according to SALGA, the City of Cape Town is wanting to purchase power directly from an IPP and has been prevented from doing so because of lack of regulation clarity. Related to this is the ability for municipalities to generate their own electricity, and the policy uncertainty surrounding this.

Regarding the procurement of power directly from IPPs, SALGA has suggested that these issues could be resolved through one or more of the following interventions: (i) allocation for municipal RE projects within the IRP; (ii) a municipal IPP procurement programme implemented through the IPP office; (iii) NERSA assisting IPPs through the licensing process; (iv) municipalities being free to develop their own programmes.

Similarly, there needs to be a clear framework for municipal energy generation projects (SALGA, 2018a: 9-12).

SSEGs. There is uncertainty regarding regulations for SSEGs. NERSA published draft rules in 2015 and then recently published draft rules for registration of SSEGs, which were subsequently withdrawn. There is thus still uncertainty regarding the regulatory framework for SSEGs. Note that despite this some municipalities have developed special SSEG tariffs (11% of municipal licensees).

Considerations

Reform by default is not an option and thus policy makers need to map out a path for South Africa's ESI and design appropriate policies, laws and regulations.

4. CONCLUSION

There is no longer a trade-off between clean and least-cost energy, and thus a South African ESI with high shares of VRE is a possibility. The adoption of RE on a larger scale will fundamentally change the way the ESI operates, with significant consequences for Eskom and municipal distributors. This paper has looked at seven issues that need closer attention, and in essence it leaves us with the following questions:

- How best can municipalities manage the risks associated with self-generation by their customers and potentially benefit from cheaper RE generation capacity?
- What should South Africa's ESI structure look like to best accommodate and benefit from increased RE in the generation mix?
- What can be done to prevent the utility death spiral for Eskom and how does RE impact Eskom?
- Does South Africa even need new generation capacity in the short- to medium-term?
- Can the South African grid accommodate large shares of VRE and what are the costs associated with ensuring it can?
- Which communities and industries are going to benefit and lose from a shift to RE and what can be done to minimise any adverse effects?
- Once all of these questions have been answered, what amendments need to be made to existing policies, laws and regulations, and what new ones need to be introduced?

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