Power Planning in a Smart Grid Environment - Case Study of South Africa

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Abstract— South Africa’s Government policy embraces the inclusion of distributed energy resources (DER), namely: renewable energy generation, embedded generation (EG) or distributed generation (DG) in the future national generation mix. The renewable energy program incorporates wind power, concentrated solar power (CSP), solar photovoltaic (PV), landfill, and mini/micro hydro, and envisages a total of 17.8 GW of electricity generation from renewable energy sources by 2030. By implication, the number of generators connected to the Eskom Transmission and Distribution networks will increase significantly over this period. Eskom, South Africa’s dominant national electric power utility is responsible for the distribution network in predominately rural areas and smaller towns. The distribution in the cities is performed by the local municipalities. Most of the new initiatives such as increased distributed generation, advanced demand side management and plug-in electric vehicles will affect the way in which the distribution network is planned, designed and operated. This paper addresses South Africa’s renewable energy program and Eskom’s renewable energy generation grid connection process. It then proposes a standardized approach on the best practice in which distribution networks should be planned, designed and operated in South Africa using the SMART Grid approach. Challenges for integrating DER into the existing grid are discussed, as well as strategies to support DER grid integration which can be adopted by other electric utilities.

Keywords: Renewable Energy, Grid Connection, planning criteria and network studies, SMART Grid.

I. INTRODUCTION

The electric power network in South Africa is divided into seven geographical operating units, each with a transmission and a distribution network (sub-transmission, distribution voltages), including re-distributors (e.g. municipalities). Most of the country’s base generation is thermal and is situated in the northern and north eastern regions (Limpopo and Mpumalanga provinces respectively). A nuclear power station with 2x 955 MW units is situated in the Western Cape Province. Pumped storage schemes at Drakensberg (1000MW) and Palmiet (400MW) are supplemented by Ingula (1300MW) under-construction; situated in the KwaZulu-Natal province. Open Cycle Gas Turbines (OCGTs) provide 2416MW installed capacity.

South Africa is a net exporter of power (2000 MW) and interconnected with five neighboring countries; Namibia at 220 and 400kV, Botswana at 400kV, Swaziland at 400kV, Mozambique at 275 and 400kV, and Lesotho at 132kV. Energy import into South Africa is from Mozambique via 2 x 533kV DC lines (1700MW). The 2012 national peak load was approximately 38GW.

Power transmission voltage levels in South Africa are at 765kV, 400kV, 275kV and 220kV; while 132kV, 88kV, 66kV, 44kV, 33kV, 22kV, 11kV and 6.6 kV form part of the sub-transmission and distribution network. Electric power delivery systems are predominantly overhead lines in South Africa; while medium voltage (MV) distribution networks within urban areas are 11kV buried cables. Power networks in rural areas are predominately 22kV overhead lines [1].

The South African generation capacity is mainly coal based due to large coal reserves. The Government’s plan is to change this and the expected 17 800 MW for renewable energy is to represent about 20% of installed capacity by 2030 as illustrated in Table I.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Existing Generation &amp; 20 year plan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity MW</td>
</tr>
<tr>
<td>Coal fired</td>
<td>37775</td>
</tr>
<tr>
<td>Hydro-electric</td>
<td>661</td>
</tr>
<tr>
<td>Pump storage</td>
<td>1400</td>
</tr>
<tr>
<td>Gas turbines</td>
<td>2 426</td>
</tr>
<tr>
<td>Nuclear</td>
<td>1910</td>
</tr>
<tr>
<td>Renewable energy</td>
<td>3.15</td>
</tr>
<tr>
<td>Available Capacity</td>
<td>44 115</td>
</tr>
<tr>
<td>Foreign imports</td>
<td>13 038</td>
</tr>
<tr>
<td>Local IPP &amp; co-gen</td>
<td>4 107</td>
</tr>
</tbody>
</table>
II. SOUTH AFRICA’S RENEWABLE ENERGY SITUATION

A. Background

In March 2009, the National Energy Regulator of South Africa (NERSA) released the Renewable Energy Feed in Tariff (REFIT). The new REFIT is the culmination of a study initiated in 2007 designed to facilitate the introduction of renewable energy generation into the electricity network. This is in an attempt to meet the target of 10 000 GWh from renewable energy sources by 2013, a target set in the 2003 Government White Paper on Renewable Energy [2]. The main aim of the target is to progressively reduce carbon-based power generation, and move towards sustainable energy sources.

The REFIT was replaced by the Department of Energy (DoE) Renewable Energy Independent Power Producer (RE IPP) program. This is a bidding program that is in line with government policy and its tender process. The South African government’s department of energy and NERSA are targeting the addition of 17.8GW of embedded generation (EG) by 2030 [3].

B. Projected Energy from South Africa’s Integrated Resource Plan (IRP)

There is a large interest from local and overseas developers in the various renewable energy technologies. Currently, there has been an expression of interest to connect varying sizes and technologies of renewable generation to Eskom networks. These includes about 637 projects totaling 36 523 MW, being discussed and analyzed by Eskom engineers. The expression of interest is summarized in Table II. It highlights the need for proper models, data and skills to connect these renewable energy generating plants to Eskom networks.

The Department of Energy (DoE) is working closely with National Treasury (NT) on the renewable energy program for independent power producers. The size of the first program announced in August 2011 is 3625 MW from wind, solar PV, CSP and other renewable technologies. (See Table II).

<table>
<thead>
<tr>
<th>TABLE II. SUMMARY OF EXPRESSION OF INTEREST</th>
</tr>
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<tbody>
<tr>
<td><strong>Technology</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Wind</td>
</tr>
<tr>
<td>Solar photovoltaic</td>
</tr>
<tr>
<td>Concentrating solar power</td>
</tr>
<tr>
<td>Biomass</td>
</tr>
<tr>
<td>Biogas</td>
</tr>
<tr>
<td>Landfill</td>
</tr>
<tr>
<td>Small Hydro</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

The program also includes a 100MW allocation for projects in the 1-5 MW generating plant sizes categories, but has not been formally released. The total program available then is 3 725 MW. There is currently no formal program for the ≤ 1 MW size projects, for or low voltage (LV) connected renewable energy generating plants or facilities.

It is expected that new programs will be announced to support a sustainable program as proposed in the Integrated Resource Plan (IRP)[4]. Figure 1 shows MW per technology in the RE IPP program as for the preferred bidders. RE IPP 1 and 2 show allocations for bid 1 (1416 MW) and bid 2 (1044 MW), while RE IPP 3 shows the remaining capacity still to be allocated (1165 MW) between bids 3 to 5. The geographical locations of the preferred bidders to date are shown in Figure 2.

The bid submissions were closely spaced: November 2011 to March 2012. The 3rd bid has been postponed from August 2012 to May 2013 to resolve outstanding issues and improve the process. RE IPP 1 projects should be completed by mid-2014, while the others are expected to be completed by December 2016.
III. ESKOM RENEWABLE ENERGY GENERATION GRID CONNECTION PROCESS

The consultation and advising phase to the IPP’s (as shown in Figure 3) is used by Eskom Planning sections in Transmission and Distribution to:

- Check the high level feasibility of project connection.
- Identify the proposed point of connection to the grid and the scope work, i.e. independent of other applications, as if it is the only project.
- Identification of any technical issues that may require further consideration during budget quote phase, and
- Assist the Grid Access Unit to issue indicative cost estimate letters free of charge

A budget quote is provided only to the preferred bidders, after payment of a commitment fee.

Eskom lends support to the Department of Energy (DoE) and National Treasury evaluation process, providing grid capacities applicable to projects or groups of projects. As Eskom is not part of the selection process, a decision making tree is provided for managing the grid competition during process of preferred bidder allocation by DoE.

IV. TECHNICAL ISSUES AND CONNECTION CRITERIA

Historically, Eskom sub-transmission (≤132kV) and distribution (≤33kV) networks were designed to transfer power from the high voltage grid to load centers at lower voltages. Urban distribution cable networks are usually looped and operated as radial feeds to reduce fault levels and simplify protection. Rural distribution overhead networks are radial, often with limited interconnectivity [5]. Widespread EG will change the manner in which Eskom’s distribution networks are planned, designed and operated. In addition to delivering energy to end customers, distribution networks will also be used to connect geographically dispersed generation.

A. Planning limits for renewable energy generation grid connection (MV, HV and Transmission)

The relevant information on the network planning technical limits includes:

- Steady state voltage limits:
  During all loading and generation patterns, voltage rise and voltage drop need to be kept within specific limits so that voltage variation at customer points of supply are within required limits, as specified in the South African electricity quality of supply regulatory standards [7] and voltage regulation and apportionment limits standards [8]. The reverse flow of power from EGs may cause voltage rise in networks which have been designed to mitigate the effects of voltage drop. Step voltage changes may be caused by inrush currents, which occur when transformers and/or induction generators are energized from the network. A sudden voltage reduction can be experienced when a generator is disconnected. See Table III for the maximum deviation from standard or declared voltages used for planning studies.

<table>
<thead>
<tr>
<th>Voltage level [V]</th>
<th>Compatibility level [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 500</td>
<td>± 10</td>
</tr>
<tr>
<td>≥ 500 No contract</td>
<td>± 5</td>
</tr>
<tr>
<td>≥ 500 With contract</td>
<td>± 7.5</td>
</tr>
</tbody>
</table>

- Fault levels:
  Connecting a generator to a network has the effect of increasing the fault levels in the network at the point of generation connection (POC). This may result in the violation of equipment fault level ratings. Generators contribute fault currents in response to network faults. The fault level is sensitive to the future location of other generation, and the future is uncertain and difficult to predict. The future fault level could increase significantly.

The grid capacity is confirmed as per DoE allocation and capacity reserved for the IPP. The proposed solutions and designs are evaluated at a Technical Evaluation Forum and approved at relevant investment committee. The lands and rights as well as environmental approval need to be acceptable. The IPP has the option of self-build of the Eskom assets, as per Eskom policy and rules. In such a case, Eskom approved consultants presents all Eskom related infrastructure designs to the Eskom Technical Evaluation Forum(s).

The financial close includes all contracting, such as the Transmission and Distribution use of system agreements, and the power purchase agreements with the Single Buyer Office. Once financial close is achieved and the budget quote is accepted, a final project schedule is agreed upon along with project execution. The various planning groups will monitor the IPP’s in the operational phase to further optimize utilization of networks.
and as such, the generation developer must also ensure that their generation plant is rated as per Table IV. This will ensure that the generating plant will be adequately rated if the fault level at the point of connection increases up to the limit in Table IV. Table IV is a design requirement. The actual fault level (as required for protection studies and settings) may be significantly lower and will change as fault levels in the network change. The equipment fault levels (considering the impact of existing generators and proposed generators) must not exceed 90% of their fault level rating.

### Table IV. Equipment Design Fault Level Limits [6]

<table>
<thead>
<tr>
<th>Equipment voltage level [kV]</th>
<th>Short circuit rating at POC [kA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>33</td>
<td>25</td>
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<tr>
<td>66</td>
<td>25</td>
</tr>
<tr>
<td>88</td>
<td>40</td>
</tr>
<tr>
<td>132</td>
<td>40</td>
</tr>
</tbody>
</table>

- **Equipment thermal Ratings:**

  Generators may cause the loading levels of individual elements (transformers, lines and cables) and to increase, specifically in cases of maximum generation and minimum load. Thermal ratings could be exceeded. The line loading might increase or decrease, depending on the size and location of the generator as well as the existing load. When connecting a generator to the network, existing lines, cables and transformers must be checked to be adequately rated to handle any increasing current. Probabilistic ampacity ratings are calculated for normal, contingency and emergency ratings for specified template temperature, e.g. 70°C.

- **Rapid voltage change (RVC):**

  Rapid voltage change (RVC) is a phenomenon in which there are changes in voltages noticeable by other customers at the point of connection. These voltage changes can be caused by changes in generation output. Rapid voltage changes can be caused by changes in generation output, tripping of plant and switching of devices. For more stable generating plants, such as a combined-heat and power (CHP) unit, cogeneration or CSP plant (which seldom trips), an RVC value of 5% is specified because rapid output changes and tripping of plant occurs infrequently. For generating plants such as solar PV and wind, their output power changes rapidly. In networks with these types of generation, Eskom needs to limit the operations of the upstream voltage control equipment and ensure that the voltage variations seen by other generation and load customers are within acceptable limits. Hence, a 3% limit is applied to all types of generation that change output power rapidly, such as solar PV and wind generation.

  The RVC limit is tested by individually tripping each generating plant (a plant may for e.g. consist of a number of turbines/generators) without allowing any voltage control correction or remedial action. The change in voltage at all points in the Eskom network must be within the limits described above (<3% for highly variable generation, and <5% for relatively stable generation). Refer to Table V for the planning rapid voltage change limits.

  For all Eskom connected embedded generators, it is a requirement that they be operated in fixed power factor for all planning studies. The default is unity power factor but the planning engineer will allow some movement from unity as per the limits for rapid voltage change. Power factor greater than or less than unity generally result in increased technical losses. Voltage control will typically only be considered for operational scenarios, and must not be a requirement for normal network operation.

### Table V. Rapid Voltage Change Planning Limits [6]

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Basis</th>
<th>Normal</th>
<th>Contingency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid voltage change (sudden loss of generation)</td>
<td>Non-fluctuating generation i.e. more stable (disconnection due to fault or inadvertent trip)</td>
<td>&lt;=5%, at minimum leading power factor of 0.975 for gen plants &gt;= 20 MW and &lt;=5%, at minimum leading power factor of 0.9875 for gen plants &lt; 20 MW</td>
<td>&lt;=5%, at minimum leading power factor of 0.95 for all gen plants &gt;=20MW and &lt;=5%, at minimum leading power factor of 0.975 for all gen plants &lt; 20 MW</td>
</tr>
<tr>
<td></td>
<td>Fluctuating generation such as solar PV or wind generation</td>
<td>&lt;=3%, at minimum leading power factor of 0.975 for gen plants &gt;= 20 MW and &lt;=3%, at minimum leading power factor of 0.9875 for gen plants &lt; 20 MW</td>
<td></td>
</tr>
</tbody>
</table>

- **Network reliability:**

  The ability of local generation to improve network performance may be dependent on the ability to island and supply customer loads in the event of network faults that would otherwise result in outages. In South Africa, generating plants are generally not allowed to island [1]. An n-1 condition means that one single circuit, or one item of plant is out of service. For each n-1 condition, the technical thermal, voltage, rapid voltage change and fault level studies need to be performed for the combinations of generators and load to identify any potential problems. The EG generator connections are not designed with n-1 criteria; unless specifically requested by the IPP.

- **Technical losses:**

  Generators may have a significant effect on network losses. A generator can lower or increase losses depending on its location and the network configuration. Technical losses may increase or decrease due to changes in equipment loading. The impact of technical losses is dynamic and will vary significantly as the network changes, load changes and additional generation is connected. A generator could initially cause a reduction in losses, but as the local generation grows so it may cause technical losses to increase. Technical loss optimization is done when assessing technically viable connection options.

- **Transient stability:**

  Transient stability studies are not performed for generators connected to distribution MV networks, depending on the size and location of the generating plant(s).
B. Renewable energy generation grid connection philosophy

It is a grid code requirement that all grid connected generators must have certain capabilities e.g. the generator must be able to provide the PQ capability as required by the codes.

It must be noted that for all grid connected generators, Eskom specifies the control mode and associated power factor which must be within the generator capability. In distribution and sub-transmission networks, the voltage at the medium voltage level is typically controlled with on load tap changing transformers (OLTC). Here, the X/R ratio is typically lower than in transmission systems, the effect of reactive power (Q) is less for voltage control (transmission networks are in fact more sensitive to voltage drop). In transmission networks, X/R ratio is high; this implies that a slight change in Q has significantly high changes in voltages. Renewable generation (e.g. solar PV and wind) cannot be scheduled; hence active power P can only be constrained, but not ramped up. The reactive power Q can be controlled in Q control, power factor control and voltage control modes. Power factor control means that the reactive power output of the generator is maintained in proportion to the MW output such that the power factor remains constant regardless of the terminal voltage. PF control can result in excessive Q flow if set to account for the worst case voltage contingency (for example during light load conditions), which in turn can result in increased losses. Voltage control is achieved by adjusting the amount of reactive power injected or absorbed into the network. The ability of a generator to regulate its voltage is hence dependent on its reactive power range AND the inductance of the network supplying the generator. Q control is achieved by setting the generator to produce a constant value of reactive power; irrespective of the power output or voltage level.

All distribution and sub-transmission network connected generators should be planned to be operated in fixed power factor (PF) control mode. Voltage control is only considered for operational scenarios.

In the transmission systems, where the X/R ratio is high, the voltage magnitudes are almost solely determined by the reactive power flows. The main voltage control is performed by generating plants which are connected to the transmission system. However, switchable shunt capacitors and reactors are used to compensate for reactive power imbalances.

V. SUGGESTED STANDARDIZED APPROACH FOR NETWORK DESIGN WITH SMART GRID

Smart Grid (Active Management) is a new distribution paradigm about bidirectional power and data flows. With smart grid implementation, network planning is no longer a way to solve operational issues at distribution level (e.g. voltage regulation, power flow management and electrical losses minimization). This implies that network planning and operation need to be brought closer together. It is also vital for network planners to understand the long-term implications and evolution of SMART Grids. Planning methodologies by network planners should be revised to consider the following [9]:

- Move to probabilistic or stochastic grid-based approaches (not only for DER or load, but to simulate human behaviour). Deterministic approach can be no longer used - Deterministic algorithms hide the potential benefit of DG due to the worst case approach.
- Risks have to be explicitly considered in planning – Each time a decision has to be taken in an uncertain scenario the risk comes. The future distribution system will be affected by many uncertainties.
- Planning tools should be multi-faceted – Planners have to face with contrasting objectives: multi-objective programming and decision theory can help to find a “good” solution within a set different from planning alternatives.
- Planning should explicitly consider system operation – The concept of active network strongly impacts the network expansion planning since it may allow withstanding load and DG growth postponing network investments.
- Consider move to meshed network topologies
- Continuous feedback loop is required from operation to planning
- Plans should also be based on smart metering data. With the evolution of the MV distribution network management (Active networks, Smart grids) there is the need to include operational aspects into the planning process. Data from Smart Metering will allow a full load profile and daily load profiles can and should be used in modern planning
- Consider reliability assessment in all network planning aspects.

Planning for advanced smart grid systems needs to be done now, before all new generation and load devices are grid connected [10]. The following have been suggested for grid operations:

- Review protection systems
- Constantly updating Grid Codes
- Communication systems to support data exchange
- Mechanisms in place for grid users to provide ancillary services

VI. SUMMARY OF CHALLENGES FOR GRID CONNECTION OF EG IN SOUTH AFRICA

Independent power producers (IPPs) can request grid access in a similar manner to loads. The capability of the network to absorb generation is dependent on the network capacity, configuration and the magnitude of the generation. The connection of generation in electrically weak networks may require significant levels of network strengthening, with associated high costs and long implementation lead times. Network studies are required to assess the grid connection feasibility, connection options, determine a preferred option, connection scope and cost. These studies need to be performed by suitably skilled network planning, operations and protection engineers. IPPs need to be quoted at short notice; yet extensive system studies may be
required. There are additional challenges that require further work and also greater liaison with potential Independent Power Producers (IPPs), the National Energy Regulator of South Africa (NERSA) and the Department of Energy (DoE), such as:

- Generators need to know how much they will pay to access the grid. There needs to be an approved framework for these charges.
- There needs to be certainty as to whether wheeling (transferring power using a third party network) will be allowed in the current legislative environment.
- Joint environmental impact assessments (EIAs) between Eskom and the IPPs need to be investigated to ensure integration, improve accuracy and reduce time lines.

VII. STRATEGY TO ADDRESS THE CHALLENGES IDENTIFIED [11]

A. Development of Eskom internal technical guidelines and standards

Eskom has established two working groups (WG) focusing on the connection of renewables to the grid:

- Renewable Generation Grid Integration Planning WG: Focuses on EG grid connection to the Transmission, sub-transmission and distribution networks
- Independent Power Producers WG: Focuses on the process related aspects of quoting and connecting IPPs. This WG has representation from electricity pricing, network planning, network operations, controls and protection departments.

The aim of the working groups is to develop standards, guidelines and processes to support the connection of renewable generation to the grid.

B. Collaborative research and industry initiatives

A number of initiatives are being supported via Eskom’s internal Research activities, which include:

- Grid interconnection of small scale embedded generation guideline (NRS 097 series): A set of industry standards are being developed that define the utility interface for the interconnection of small scale EG to a utility network. The standards apply to embedded generators of nominal capacity of less than 100kW, connected to a low voltage (400/230V) utility network. The standards cover utility interface requirements (NRS 097-2-1 – approved), equipment type testing (NRS 097-2-2 - conceptual phase) and the Utility Framework (NRS 097-2-3 – conceptual phase).
- EG spatial data framework: In order to integrate EG into Eskom’s network strengthening and expansion planning, it is important that network planners can access renewable energy resource data that informs the likelihood and magnitude of different types of renewable generation in different geographical locations in South Africa. An inventory of different renewable energy resources (RER) datasets has been created, in which data were incorporated into GIS and develop models to help identify the likely locations and sizes of renewable energy projects.

- Linkages with international research: Considerable international research is being performed in the area of renewable generation and the associated impact on the grid. It is Eskom’s intention to leverage off international research so as to minimize duplication and ensure that requirements can be met in the minimum time at minimum cost. As such, relationships with CIGRE, IEEE, IET, EPRI, Universities and research institutes are being used to build technical capacity in renewable generation integration within Eskom.
- Training: The Eskom Distribution network planning training program is creating learning materials in a web-based electronic format. Courses are continually organized to aid Eskom engineers (network planning, quality of supply, protection, network optimization, grid planning, grid code management and operations planning) in doing detailed system studies for renewable energy integration.

C. Eskom Transmission Network Capacity Study to integrate Renewable energy

A study was performed to determine the capacity available on the transmission grid to connect new generation plants at various transmission substations. The first phase of this study focused on the Northern, Western and Eastern Cape area to provide guidance on where Renewable Energy (RE) plants could be connected, particularly in the short term, as well as estimating the potential connection capacity in the longer term. The connection capacity was estimated in terms of the total megawatt (MW) that can be absorbed at a specific substation. An overall MW capacity in terms of a zone based on regional network constraints was also calculated. Preliminary results indicated that a significant amount of renewable energy generation could be connected provided the power plants are geographically diversified, i.e. not concentrated in a limited number of areas. The result of the first phase of this study was made public in 2010. The publication provided information to the IPP developers and investors. The results of the connection capacity study were used to evaluate the longer term integration of large amounts of RE plants into the grid to meet the Integrated Resource Planning (IRP) requirements.

D. Eskom Input to Grid Code requirements for renewable generation

The current South African Grid Codes (Transmission and Distribution) mainly provide connection conditions for conventional power plants (viz. thermal and hydro plants). The intermittent nature of renewable energy sources, especially wind, introduces additional variability and uncertainty into the operation of the grid. To maintain the security and reliability of the grid, the Eskom System Operator has in consultation with the Electricity supply industry (ESI), developed minimum technical requirements for connecting renewable energy facilities to the transmission or distribution networks in South Africa. The new requirements will regulate all types of renewable
energy facilities behavior at the point of common coupling. Essentially, renewable energy facilities will contribute, as do other conventional synchronous generators, to the security and reliability of the electrical power system by actively participating in voltage and frequency control. There has been wide industry consultation on the document which has been submitted to NERSA for final approval and implementation.

E. Eskom liaison with South African Bureau of Standards (SABS) on wind turbine standards

On the 4th December 2009, the South African Wind Energy Association conducted a workshop to discuss the need for South African wind turbines standards. Eskom, NERSA, SABS, SANAS, DTI, DoE, Universities, Consultants, Municipalities and Developers participated in the workshop. A major highlight of the workshop was the formation of a wind turbines workgroup by SABS. Eskom has actively participated in this workgroup (WG), which was mandated to evaluate the possible adoption and adaptation of the IEC Wind Turbines standards for the South African industry. In September 2010, a decision was made by the SABS Wind Turbines Standards WG to adopt the IEC 61400 series of standards, with only minor changes. The IEC 61400 series of standards cover among others, the turbine design and operation, wind resource measurement and assessment, grid integration of wind turbines, and also communication and control issues. Eskom’s (seven members) made a significant contribution to the SABS WG.

F. Eskom process and policy initiatives

Eskom has developed a number of processes and policies to facilitate the connection of renewable generation. These include:

- The development of an application form to be completed by IPPs requesting grid integration.
- The drafting of a connection and use of system agreement.
- A proposed application and quotation process has been developed, which sets out the criteria to be satisfied before a cost estimate or quote will be provided.
- A wheeling policy, including the conditions, the charges payable and the agreements to be used under wheeling scenarios.
- A proposed framework for charges for embedded generators, including use-of-system charges and connection charges has been developed and is following formal approval processes.
- A proposal is being compiled and approved to allow IPPs to build high voltage (HV) network.
- A network and generation operating procedure (between Eskom and the generator) is in draft form.
- Contracts are being established to provide Eskom with engineering services for the assessment of embedded generation and the associated network design. These services will be used to augment Eskom Distribution resources and include coaching of internal resources.

VIII. CONCLUSION

The introduction of widespread embedded generation presents technical, planning and human resource challenges to South Africa and Eskom in particular. Eskom has met these challenges by developing standards and processes based on international practices. Eskom connection process provides for quick high level feedback followed by a more detailed quotation. The use of standards and interoperability are fundamental principles that will enable most utilities have flexibility to adjust to the changing grid requirements while integrating renewable generation, implementing smart grid systems and ensuring reduced costs. Grid Codes are critical, as it allows simple data exchange for connection studies.

Currently, about 800 MW renewable energy projects per annum are envisaged for commissioning in South Africa, as suggested by the DoE Integrated Resource Plan. New skills and processes need to be continuously developed which will help ensure that high volume, lower capacity projects are processed efficiently.

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