Integrating renewable energy into the grid: The Eskom approach to grid connection – studies, data exchange

AFRICAN UTILITY WEEK

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Overview of connection process

Consultation
- Prospective applicant contacts Eskom

Connection
- Pre-project Planning phase

Operation
- Long-term operations

Concept phase – Budget Quotation (BQ)
Assess alternative concept design solutions.
Identify land and rights, servitudes dependencies.
Perform preliminary design.
Prepare and issue a Budget Quotation.
All expected connections need to be considered. High accuracy level (abt 85%).
Assess likely connection options.
Prepare planning report and issue an Indicate Cost Estimate (ICE).
ICE treats all applications independently. Lower accuracy level (abt 60%).
Overview of connection process

- Indicative Cost Estimate (ICE):
  - Checks the high level feasibility of connection
  - Identifies the proposed point of connection to the grid and the scope of work - independent of other applications
  - Identification of any technical issues that may require further consideration during BQ

- Budget Quote (BQ):
  - More detail regarding grid connection
  - Considers interdependency with other applications, and dependencies such as lands and rights & environmental
Network Studies per application: Steady state load flow & fault level

- Load flow study to verify:
  - If voltages at the connection point and at other points are within permissible limits
  - Power flows on the affected lines/transformers are within current carrying capacity of the lines/transformers i.e. thermal loadings
  - Technical losses as generators may have a significant effect on network losses. A generator can lower or increase losses depending on its location and the network configuration
Network Studies per application: Steady state load flow & fault level

- Load flow study to verify:
  - **Rapid voltage change** to check voltage variations, generation rejection & generation output variations (voltage variations as will be experienced by other customers)

- **Short circuit studies** to verify:
  - Short circuit current ratings of equipment and violation due to the additional short circuit current contribution
System level studies

- These are studies done by the utility analysing the system wide interaction of all generation (existing and new)

- These typically include the following:
  - Traditional transient stability (dynamic) studies
  - Low voltage ride through (LVRT) studies
  - Other specialized studies e.g. SSR
System level studies

- For planned future generation, generic models are used - these models are informed by the Grid Code i.e. the “future” generator is assumed to be Code compliant

- For “as-is” operational studies, detailed and verified dynamic models of the generators are used - only available after plant commissioning
Typical studies performed by the generator developer

- Performed as part of plant design for Code compliance
- Includes all studies to design and confirm the required steady state and dynamic response
- These studies may include the following:
  - LVRT
  - Harmonic studies
  - Flicker analysis
  - Reactive power range and compensation
Grid Code specifications

- Active power control (frequency control)
- Reactive power control (e.g. PF, Q or V control)
- Reactive power capability
- Low Voltage Ride Through (LVRT)
- Signals, communication and control
- Electrical dynamic simulation models
- Etc.
Grid connection data exchange: General

- Generic Code compliant generator models are used for initial grid integration studies – as such, only basic data is required for initial studies (typically steady state studies)

- Validated “actual” generating plant models are only available post commissioning
Grid connection data exchange: Information from Generator developer

- Physical location of the plant (e.g. GPS coordinates)
- Type of generator e.g. Solar PV, Solar CSP, Wind
- Maximum exporting capacity into Eskom network (MW)
- Fault current contribution (MVA) from the generating plant
Grid connection data exchange: Information provided by Eskom

- Eskom will provide the following network data:
  - The network impedance and fault level
  - Supply substation Single Line Diagram (SLD)
  - Details of equipment (such as conductor type, length, size) between the supply substation and the POC
  - Loading and fault level ratings of the above equipment
  - Information on present network performance and Quality of Supply (QOS) levels
  - Level of network redundancy to the POC
Generator plant simulation models

- The utility requires an aggregated model of the generating plant which represents the generating plant response at the point of connection.
- An understanding of what is happening at each generator is not required by the utility.
- The developer requires detailed models of the entire generating plant installation (design and code compliance) including all generator, transformers, lines/cables, controller, reactive power devices etc.
Generator plant simulation models: Detailed wind farm

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Generator plant simulation models: Aggregated wind farm
Network capacity analysis technical criteria ≥20MW

- Multiple scenarios: e.g. high gen, low load
- Voltage limit compliance with Power Factor: 0.975 lag to 0.975 lead
- Fault levels < equipment ratings
- Rapid Voltage Change (RVC):
  - “Constant” generation: <=5%, at power factor of 0.975
  - “Variable” generation: <=3%, at power factor of 0.975
Conclusions

- Eskom connection process provides for quick high level feedback (ICE) followed by more detailed quotation (BQ)
- Utility grid connection studies are limited to steady state load flow and fault level calculations
- Dynamic studies need to be performed on a system level for multiple generators
- Grid Codes are critical – allow simple data exchange for connection studies
Conclusions

- Utility only interested in characteristics of the generator plant at the point of utility connection
- Aggregated models are suitable for utility studies
- Detailed models of the generation plant are required for design, including compliance with Code requirements
- Utility requires clear criteria against which study results will be assessed (voltage range, thermal loading, fault level, rapid voltage change)
Thank you

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