ESKOM'S PILOT NATIONAL CO-GENERATION PROJECT

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This paper describes the development history of the national co-generation framework that culminated in Eskom's Pilot National Co-generation Project. The objectives of the project and the draft timelines are presented. Grid Code requirements and some key technical aspects of the project are discussed.

1. Introduction

During June 2006, Eskom's Executive Committee requested the organisation to pursue the development of co-generation as a supplement to South Africa's current non-Eskom owned and operated generation base.

After some consideration, an initial target of 900MW of new co-generation plant has been established, and is proposed to be scoped, developed and to have reached commercial operation within 5 years.

2. What is co-generation?

A co-generator is a source of electrical power that is a co-product, by-product, waste product or residual product of an underlying industrial process. The Fieldstone Africa (Fieldstone) report [1] prepared for the National Energy Regulator of South Africa (NERSA) on qualifying principles for co-generator projects stipulates three types of co-generators:

Type I: projects utilizing process energy which would otherwise be underutilized or wasted (e.g. waste heat recovery).

Type II: Primary fuel based generation projects which produce, as part of their core design, other usable energy in addition to electricity (e.g. Combined Heat and Power projects).

Type III: Renewable fuel based projects where the renewable fuel source is both the primary source of energy, and is a co-product of an industrial process (e.g. use of bagasse and/or forestry waste from the sugar and paper industries).

3. Why co-generation?

Strategic reasons for pursuing co-generation include:

- Co-generation has potential to deliver capacity "quickly";
- Some co-generators may provide electricity at a lower cost than conventional generation;
- Co-generation potentially reduces investment in networks and supports distributed generation; and
- Co-generation improves industrial efficiency and is environmentally friendly e.g. Combined Heat and Power (CHP).

4. Developing the "Framework" for Co-generation

One of the initial challenges that faced the Eskom Business Development Team was how to go about creating an awareness of the initiative, coupled to generating sufficient support and interest.

Following discussions with members of the Energy Intensive Users Group (EIUG), a distributed / co-generation working group was established to work with Eskom, NERSA and industry in developing the co-generation frameworks necessary to promote co-generation in South Africa.

The first EIUG co-generation working group convened on 15 August 2006, under the chairmanship of Mr Ian Langridge, Anglo's Group Energy Efficiency Manager. Key members of the working group include Anglo American, Anglo Gold Ashanti, SAPPI, Mittal, Sasol, NERSA, Fieldstone, BHP-Billiton, Mondi, Afrox, Highveld Steel, as well as other large power users and Eskom.

At the EIUG co-generation workshop held on 13 September 2006, Fieldstone presented feedback to the committee on the NERSA framework, coupled to additional information and ideas, generated during their interactions with Eskom and other large power users. There was commonality amongst members on the proposals, and a strong belief that the proposed framework would stimulate and support the introduction of larger scale co-generation in South Africa.

The "long term" framework was presented to the Eskom governance structures where it received "in-principle" support. A similar presentation was made to the NERSA Policy Subcommittee on 14 November 2006 by the NERSA Project Manager, where the framework was considered, but not approved without additional work being required to meet approval criteria noted at the meeting.

With the potential delay introduced, Eskom, in conjunction with NERSA, set about identifying and designing a "short term" process to circumvent an excessively long approval process of the long term framework. This short term framework is now referred to as a "Pilot Project", as it will serve to be the forerunner of the long term framework developed during 2006.

The principles and thoughts surrounding the Pilot Project were tested with members of the EIUG working group on 18 January 2007, where general support for the idea was obtained. The Pilot Project was then presented to members of NERSA on 19 January 2007, where overwhelming support for both the pilot, as well as the long term framework, was received. It was agreed that Eskom would continue to seek a mandate from its own governance structures in order to roll out the Pilot Project.

Eskom then engaged Fieldstone and an international legal firm, who have commenced working with the co-generation team in compiling the tender pack, and finalising the Power Purchase Agreement/s (PPA's) in support of the framework/s.

A two day co-generation workshop was held with industry and NERSA on 13 and 14 March 2007 to deliberate on co-generation, the Pilot Project and the long term framework as well as the content of the PPA's being developed by Eskom. The workshop was well attended by industry, investors, project developers and key stakeholders.

5. The Pilot Project

5.1 Proposed Framework

The Pilot Project that will enable Eskom's fast track approach to testing and evaluating the potential co-generation market is essentially designed on a conventional tender process.

The proposed framework, in summarised form, is as follows:

- **Stage 1 – Assess interest in Co-generation**
  - Expressions of Interest (EOI).
  - Developer Evaluation.
  - Notification of pre-qualification to Bidders.
- **Stage 2 – Bidding/Tender Process**
  - Bid Enquiry issued.
  - Bid Clarification.
  - Bid Evaluation.
  - Participant Notification and awarding of contracts.
- **Stage 3 – Implementation & Delivery**
  - Participant monitoring of project implementation.

Key principles governing the process and scope of the project include:

- Developing the necessary tender documentation to attract new co-generation.
- Obtaining NERSA approval to contract the new co-generation.
- Developing a technical interconnection standard for co-generators.
- Developing a standard contract (PPA) for co-generation developers which is bankable.

- Having a transparent evaluation process to evaluate tender submissions. This includes:
  - A well defined and clearly understood process;
  - Known implementation parameters;
  - Equitable treatment across projects; and
  - Determination of qualifying projects.
- Implementation of the process in a timely fashion.
- Development of a ceiling price which will be approved by NERSA (but not published) beyond which contracts will not be offered.
- Simplicity:
  - Procedural simplicity for projects to achieve regulatory approval;
  - Minimisation of transaction negotiations; and
  - Minimisation of transaction costs.

5.2 What is Eskom offering?

In the Pilot Project, Eskom is looking for approximately 900MW of new co-generation meeting the following requirements:

- The co-generation must be new build (i.e. new plant or re-commissioned plant offering new capacity). Refurbishments or upgrades to existing capacity are only eligible for the expected incremental capacity.
- It must be co-generation and not distributed or renewable generation that require renewable energy grants (i.e. must be cost effective as a stand alone co-generator).
- The co-generator must be situated within South Africa
- The net installed capacity of the co-generator must be at least 1MW.
- The co-generator must reach commercial operation within 5 years.

The "lowest" bids will win contracts provided they are not above the ceiling price set by Eskom's avoided cost model and modified by locational and timing (first on line) advantages. Maximum 15 year contracts are being envisaged with consideration being given to shorter duration contracts: 7 years minimum duration.

Operational implementation of the Pilot Project is envisaged to include:

- Each developer bids a price and returns a signed contract (PPA)
- Bid prices higher than Eskom's avoided cost will not be considered
- A standard contract (PPA) will be developed for qualifying co-generation projects which is envisaged to include inter alia:
  - Payment profiles aligned with energy needs (supporting time-of-use / peaking periods; winter vs. summer etc.)
  - Incentives for early completion
- A performance bond must be submitted in favour of Eskom to encourage timely development of co-generators.

5.3 Progress to date

An Expression of Interest (EOI) was dispatched to registered project developers and industry on 25 May 2007, and an overwhelming response was received. The results of the EOI are indicated in Fig.1 (Types of Co-generation) and Fig.2 (Projected net capacity per project). Of the 125 submissions received, only one was rejected at pre-qualification stage, this a result of the fact that the generating plant did not qualify under the definition of a co-generator. Approximately 4900MW net generation has been pre-qualified, the individual plant sizes ranging from 1.8MW up to 540MW. Some duplication is, however, evident.

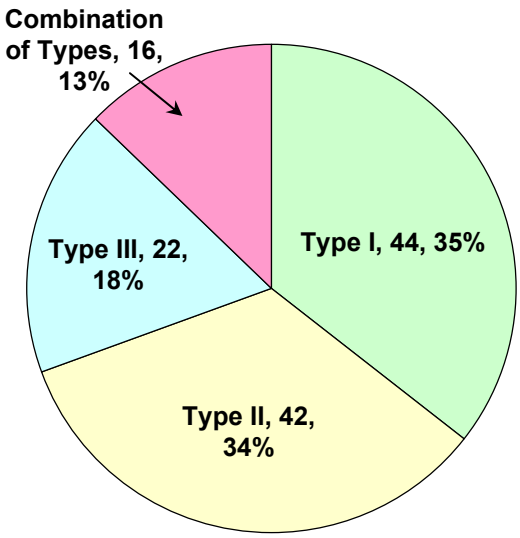

Fig.1 Breakdown of EOI's received per co-generator type

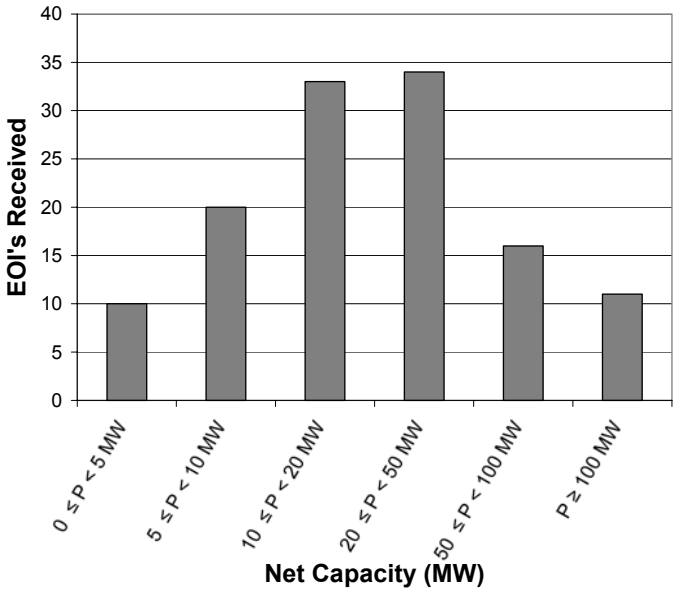

Fig.2 Net capacity per project based on EOI's received

Looking forward, the **draft** implementation programme as at September 2007 is envisaged to be as indicated in Table 1 below.

Table 1: Draft Implementation Programme (as at September 2007)

Activity	Target date
1. Expression of interest	Completed
2. Request for Tender(RFT)	
• Approval to issue draft PPA to market.	27 Sept 2007
• Issue RFT and draft PPA to pre-qualified bidders.	30 Sept 2007
• Bidder's clarification conference.	Week of 5 Nov 2007
• Updated draft PPA released to bidders.	End Nov 2007
3. Bid submission.	Mid Feb 2008
4. Bid evaluation completed.	April 2008
5. Final recommendation on PPA's to be offered.	April 2008
6. Approval to sign PPA's obtained from Eskom Board	June 2008
7. Successful bidders notified.	June 2008

6. Technical Considerations

The implementation programme in Table 1 provides a 5-month period for tenderers to complete their submissions. Part of the preparation will typically include obtaining a feasibility quote from the relevant supply authority for network expansion or upgrades that may be required to interconnect the co-generator to the utility network. Given the high number of bids expected, the short time frame, and the relative inexperience of Eskom Distribution staff when dealing with generation projects, Eskom is in the process of securing the services of suitable consultants to assist with these requests. It is envisaged that the consultant/s will be able to support all Eskom regions, and will be able to

draw on the experience of international experts in the field of co-generator and/or embedded generator interconnection. In particular, they will assist Eskom staff to conduct the relevant network impact assessment studies including: load flows, fault level calculations, and dynamic and transient studies (where required).

6.1 Grid- and Distribution Code requirements

Co-generation forms a subset of the broader concept "Embedded Generation". The draft Distribution Code [2] lays down a number of technical requirements with regard to embedded generation that will be applicable to the co-generation project. Not least of these are the requirements of the following sections of the Network Code (Draft Rev. 5):

- **Section 8.4.1.1(1):** Embedded generators of nominal capacity greater than 10MVA must comply with Section 3.1 of the South African (Transmission) Grid Code: Network Code [3] in addition to the requirements of the Distribution Code. Notable amongst the Grid Code requirements are the stipulation of the frequency vs. guaranteed operating time capability of the machine/s, and the requirements for governor and excitation control.
- **Section 8.2(4):** The Distributor shall develop a protection requirement guide for connecting Embedded Generators to the Distribution System to ensure safe and reliable operation of the Distribution System.

6.2 Embedded Generator Interconnection Standard

Eskom is currently drafting an Embedded Generator interconnection standard in fulfilment of the Distribution Code requirement, and as an input into the co-generation tender process. Some of the key technical issues included in the standard are described below:

6.2.1 Loss-of-Grid protection

Embedded Generators are normally not permitted to intentionally island with a part of the utility network. On radial networks typical of distribution systems, the opening of any circuit-breaker between the source substation and embedded generator's point of connection may serve to create an unintended power island (see Fig. 3). The reliable and secure detection of such "loss-of-grid" conditions remains one of the key challenges with regard to embedded generator interconnection protection.

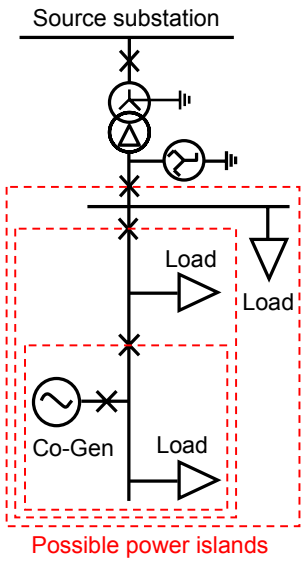

Fig.3 Possible power islands on a radial distribution system

Where required, dedicated loss-of-grid protection typically takes the form of a Rate-of-Change-of-Frequency (ROCOF) or a voltage vector shift protection relay. These relays are prone to nuisance tripping due to other events on the power system: loss of bulk generation, power swings etc. [4].

Loss-of-grid protection is much simpler in the case of co-generators that do not export power to the grid but whose output is consumed entirely by the industrial plant. A reverse power protection relay installed at the point of connection will in many cases provide adequate protection against un-intentional islanding.

6.2.2. Neutral earthing on MV interconnections

Eskom's MV distribution networks make use of resistive earthing of the neutral point so as to limit earth fault currents to the typical ranges: less than 720A (Rural networks) and less than 1600A (urban networks).

The preferred neutral earthing philosophy for MV-connected generators or generator transformers is that the MV neutral point be left un-earthed. This will serve to avoid issues of earth fault relay de-sensitization, as well as avoiding "circulating" zero sequence or triplen (i.e. 3rd, 6th, 9th etc.) harmonic currents between the distant earth connections.

A possible problem with leaving the MV star-point un-earthed is that the MV network will be left un-earthed in the event that the source circuit-breaker should open, thereby forming an unintentional island. In the case of the source tripping as a result of a line earth fault, the healthy line voltages will be raised to full phase-to-phase values. In addition, Dugan and Rizy [5] warn of possible resonant over-voltages arising from the generator transformer reactance and the line capacitance. Possible damage to surge arresters may be avoided by specifying arrester Maximum Continuous Over Voltage (MCOV) values at the full phase-to-phase voltage.

In the absence of a MV neutral earthing point at the point of connection, line earth faults will be detected by residual over-voltage protection. It must be ensured that the residual over-voltage protection is suitably graded with the current-based earth fault protection used in the distribution network.

6.2.3 Metering

Co-generators will be remunerated for energy delivered to the network at their bid price. Any power drawn by the plant (e.g. generator auxiliaries, other manufacturing processes etc.) will be billed at the standard load tariffs. This creates the requirement for the power generation to be metered at the generator terminals. The "load" charges for the plant will be calculated from the sum of the meter readings at the existing demarcation between the utility and the plant, and the generator meter readings (see Fig. 4).

The utility will own and operate all tariff meters. The location of some meters deep within an industrial plant may create problems with regard to security. Access problems may be overcome using remote meter downloading technologies.

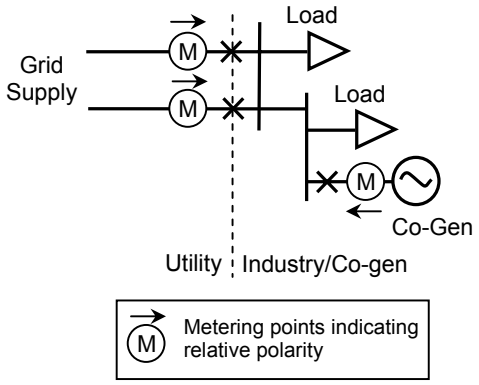

Fig.4 Conceptual metering arrangement for a co-generator embedded within an industrial plant

7. Conclusion

Eskom has embarked upon a pilot project that aims to connect approximately 900MW of new-build co-generation within the next five years. The pilot project is a result of a lengthy process involving Eskom, NERSA and many large power users that sought to develop a framework in support of co-generation in South Africa.

An Expression of Interest issued in May 2007 yielded 124 pre-qualifying responses totalling some 4900MW net generation. Individual plant sizes ranged from 1.8MW to 540MW. The process going forward is essentially designed around a conventional tender process. Only tenders whose bid price is below the (unpublished) Eskom avoided cost will qualify for contracts.

Eskom is presently finalizing the Power Purchase Agreements and technical specifications in support of the pilot project. The latter takes cognizance of the requirements of the Distribution- and Grid Codes, as well as addressing a number of

technical challenges including loss-of-grid protection, and earthing and metering requirements. Eskom will be engaging consultants to assist with the technical impact assessment studies associated with each co-generator project.

8. Acknowledgement

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9. References

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