Mr. Thava Govender,

Group Executive Generation
Group Executive Risk and Sustainability (Acting)

1. What are the peculiarities of the power system controlled by the South African system operator?

Eskom Holdings SOC Limited is a state-owned company that generates 95% of the electricity used in South Africa and approximately 40% of the electricity in Africa. We operate 30 power stations, with a total nominal capacity of over 45,000 MW, comprising predominantly coal but also including gas, hydro, wind, solar, and nuclear. Despite the substantial growth of independent renewable energy in the sector, coal currently remains the primary source of energy. Eskom is the eleventh-largest power utility in the world, by generating capacity.

South Africa has one of the largest and most diverse geographic territories in the world, in which a single Integrated Power System (IPS) operates. The System Operator reports to the Transmission Division in the vertically integrated business of Eskom, and comprises the generation, transmission and distribution businesses.

The IPS includes nine interconnected transmission grids or regional transmission networks, each grouped into a number of customer load networks, as well as a number of generation stations, base load as well as peaking.

The transmission network includes about 48,000 km of lines, comprising voltage levels of 400 kV, 275 kV as well as 220 kV and 765 kV. The 765 kV main transmission corridor supplies power from the base load (thermal) power stations located primarily in the north-eastern part of the country (Mpumalanga), to the south-western load center (Western Cape), where the only nuclear generation plant, Koeberg, is situated. Eskom also operates two 1,414-km long 533 kV high voltage direct current (HVDC) transmission lines that interconnect South Africa and Mozambique. The distribution network comprises about 350,000 km of lines, ranging between 22 kV to 132 kV.

Although Africa does not have a fully integrated power system, South Africa's power system is integrated within a Southern African Power Pool (SAPP), operating synchronously with and including the power systems of 12 countries, namely Zimbabwe, Swaziland, the Democratic Republic of the Congo, Tanzania, Botswana, Zambia, Mozambique, Angola, Malawi, Namibia, Botswana, and Lesotho.

The IPS of South Africa is the largest part of the power pool. The size, geographic location of the IPS of South Africa and network topology place the duty of frequency regulation in the power pool on South Africa which is in charge of the development and promotion of normative documents and market regulations.

In addition, as the country's key energy player, Eskom is involved in notable energy storage initiatives – ranging from our pumped-storage schemes to our research and testing facility. Our three Pumped-Storage Schemes, namely Drakensberg, Palmiet and Ingula, have a total installed capacity of 2,732 MW. To keep abreast of new developments, Eskom has also been looking at alternative means of storing energy. About ten years ago, Eskom invested in Large Scale Energy Storage Research, testing storage technologies from mechanical storage to batteries, chemical storage, thermal energy storage, and super capacitors.

Historical peak consumption for the system in 2007 was recorded as 37,158 MW. The installed capacity in 2018 totaled 46,046 MW of dispatchable generation, including 1,600 MW High Voltage Direct Current (HVDC) international imports. An additional 1,004 MW of dispatchable generation from independent power producers is available and a total of approximately 3,800 MW of renewable generation, also mainly from independent power producers, is embedded in the South African IPS.

2. How do the power system peculiarities affect its electric mode operation?

Thermal generation, namely coal-fired power stations, is the main method of electric power generation, since South Africa possesses some of the world's largest coal resources, and it is also a relatively cheap fuel type. Thermal generation's share in the total dispatchable generation capacity of the IPS is over 76%.

Pumped-storage hydro generation plays an important role in the stability and flexible operation of reserves, even though this contributes only 5% to the total capacity of the country's power system. Pumped-storage generation is a highly flexible resource that gives a tremendous advantage for electric power mode operation, and is operated as peaking plant, together with the Open-Cycle Gas generation, with an installed capacity of slightly more than 2,000 MW (or approximately 4.3%). Nuclear generation covers only 4% of the total generation capacity of the IPS of South Africa and comprises only one nuclear facility, in the south-western part of the country.

3. Nowadays, a number of the world's largest power systems undergo processes of unbundling the functions of power system dispatching from the network operators' structure and a transfer to the independent system operator model. Each country has its own reasons to do this. Why is South Africa still integrated?

The SA Government's White Paper on Energy Policy of 2018 sets out the country's vision, policy and principles of the electricity sector's reform.

In April 2001, the South African Cabinet approved the proposals for the electricity generation and transmission sectors' reform strategy that would realize the introduction of independent power producers and an independent system operator. Though the latter has not yet been implemented, a review is currently being undertaken about reforming Eskom and possibly the energy sector as a whole.

South Africa's energy plan is determined by the Department of Energy through an Integrated Resource Plan (IRP). The IRP also provides guidance on the opportunities for greater regional development and electricity imports, outlined in South Africa's National Development Plan.

4. What are the main challenges that your company is facing now? How do you manage them? What kind of problems does this help to reveal?

Since the establishment of the South African public utility in 1923, the South African electric power sector has overcome several serious challenges.

Most recently, due to the South African government's attempted privatization of the power utility in the 1990s, Eskom's requests for a budget to build new power stations were initially denied. This led to insufficient generation capacity from 2007 onwards as the economy was growing fairly strongly at the time. Rotational load reduction was required periodically from 2007 to stabilize the power grid, as the reserve margin was insufficient.

To resolve this problem, and also to meet the country's growing demand for energy, Eskom has undertaken Africa's largest capital expansion program of expanding its generation and transmission capacity since 2005.

Eskom's nominal generating capacity in 2005 was 36,208 MW, which the Build Program will increase by 17,384 MW, by 2022. The key generation expansion projects are two coal-fired stations generating over 9,500 MW of installed capacity, and a pumped-storage scheme which currently delivers 1,332 MW of hydro-electricity during peak demand periods. Transmission line length and substation capacity will also increase substantially. Although many challenges have been faced and overcome, other challenges are still imminent because the program has various scheduling and funding complications. After building a 100 MW wind farm, Eskom has aspirations to increase its own renewable energy fleet in the future.

Currently, one of the more serious challenges for the System Operator is integrating the renewable independent power producers into the IPS, as well as establishing an Independent System and Market Operator in order to govern an independent energy market. This will most probably involve a total restructuring of the utility's current business model.

However, it is seen as crucial that the South African private sector should play a role in addressing the future electricity needs of the country, as outlined in the draft Integrated Resource Plan (IRP) developed by the South African Department of Energy (DoE). This is expected to reduce the funding burden on Government, and alleviate Eskom's borrowing requirements. It will also introduce generation technologies that Eskom may not currently consider as part of its core function which may play a vital role in the future electricity supply options.

The draft revised IRP has important implications for the South African energy industry, particularly as regards the shift towards lower carbon-emitting energy sources. This is in line with meeting the agreements reached at the United Nations' COP 21 climate change conference held in Paris in December 2015.

South Africa's Integrated Resource Plan intends to limit South Africa's reliance on coal and to promote alternative energy sources. These alternative energy sources can provide long-term security of supply and environmental sustainability in the most affordable way over time. In this regard, Independent Power Producers will play a key role in the South African energy sector.

In May 2011, the DoE gazetted the Electricity Regulations on New Generation Capacity. The New Generation Regulations establish rules and guidelines that apply to undertaking an IPP Bid Program and procuring an IPP for new generation capacity. They also facilitate the fair treatment of, and non-discrimination among, IPPs and the buyer of the energy. However, the establishment of an independent market, including ancillary services market is still in its infancy.

The System Operator is responsible for the functioning of the technological infrastructure of the entire IPS. To fulfill the task, the company had to drastically upgrade its computer facilities and software, which was commissioned in 2005 as a new Energy Management System. In addition, the utility is at present actively developing new automation tools based on WAMS (Wide Area Measurement System) technologies.

The power stations built in the second half of the 20th century form the basis of the generating facilities in the South African IPS. Taking into account the advanced age of this base load fleet, the current mammoth task is to take measures to prolong the life-cycle of the existing generating capacities, and where this is no longer cost-effective, to replace these generation plants with more cost-effective energy sources. Since the South African utility has a major social responsibility to South African society as a whole, significant political as well as socioeconomic challenges may arise when dealing with this upcoming change.

5. What tasks is the System Operator facing in the field of normative regulation in the power sector and how are you solving them?

The National Energy Regulator of South Africa (NERSA) provides independent oversight over the System Operator (SO). The SO has to guarantee security of supply in an increasingly competitive supply market, along with the complexities of managing an increase in renewable sources.

Social, political and economic conditions also play a significant role in what the System Operator is expected to do, requiring the SO to work closely with the generation sector in managing reliability of supply.

In the South African context, the funding shortages and labor issues currently make the system operator's mandate to ensure reliability of supply and economic dispatch very difficult to fulfil. There is heavy reliance on expensive supply resources and demand-side products to achieve this.

6. How is the problem of the power system development planning being solved in the IPS of South Africa?

The country's energy forecast is updated annually according to a long-term load forecast, on the basis of which a Transmission Development Plan (TDP) is developed on a yearly basis.

This TDP outlines the upcoming expansion projects for the next 10 years, and takes into account the official Integrated Resource Plan developed by the South African Department of Energy. The TDP also takes into account the current operational challenges in the IPS as one of the major drivers of the TDP.

7. For the last years the traditional state of the power sector was being changed under the influence of new technologies: distribution of RES, distributed generation, power electronics, "Smart Grid". How does the power system dispatch control mechanism react to these changes in your country?

For the most part, these changes are small compared to the thermal supply that we currently have available. All these influences can be managed in the country's system forecast. The pick-up of different technologies is increasing, however, and the system operator is now developing a model, systems, processes and products to manage these technologies for future use. As the lack of a defined electricity industry plan and the ever-increasing supply and demand options for the customer make it difficult to keep pace, we mainly respond reactively to these changes.

8. Does your power system use any economical demand response technologies? What do you think of their potential? If not used, do you plan to introduce any?

Yes. Demand response has been invaluable to Eskom during times of severe generation constraints. We have been able to recover fast from frequency disturbances when the generation reserve capacity was insufficient.

Eskom has contracted industrial customers to provide a demand response capacity of about 1,300 MW. These customers bid in this capacity daily and the bid is included when doing day-ahead scheduling. The SO currently uses two types of demand response to control system frequency.

The first is Instantaneous DR reserve; which allows Eskom to respond to a fall in the system frequency due to a sudden change in the balance between supply and demand. The purpose of Instantaneous Reserve is to arrest the frequency at acceptable limits after an instantaneous shift on the system, such as a generator trip.

The second is called Supplemental DR Reserve. Customers are contracted to respond within a notice period of 30 minutes to six hours, so that the utility can restore other reserves. This reserve remains utilized until it can be replaced by other capacity or for a maximum duration agreed upon with the supplier. The reserve is contracted annually and bids are available on a day-ahead basis. It is required to ensure an acceptable day-ahead risk and to allow time for reserve plant to be called up.

9. "Power System of the Future" term is becoming more and more popular in the global power field. What does this notion mean for you?

The fourth industrial revolution may bring us closer to realizing a "Super Smart Grid in Africa" – which is huge due to the potential of energy resources on the continent.

Advances such as energy storage, micro off-grid technologies and control systems, and the introduction of electric vehicles all offer potential opportunities for South Africa's system future.

Eskom's view is that the future grid would have to incorporate significant quantities of energy storage. As a result, we have established a world-class Large-Scale Battery Testing Facility, the first of its kind in Africa. Here the team tests lithium-ion storage batteries and sodium-nickel chloride battery technology – measuring the real-time performance of these batteries prior to widespread installation.

We are looking at a network of large batteries as a possible solution to Eskom's need for greater flexibility, which will also bring added benefits to overcoming the current network challenges.

Eskom Holdings SOC Ltd. Transmission grid infrastructure