Electricity

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Slide 2: *Generating Electricity*

- Power stations convert fuels into electricity. Coal and gas are burned to heat water and turn it into steam. The steam, at very high pressure, is then used to spin a turbine. The spinning turbine causes large magnets to turn within copper wire coils - this is called the generator.
- In 1831 Michael Faraday discovered that if magnets and a conductor (e.g. a piece of copper wire) move concerning one another, electricity can be generated.
- Faraday found that the mechanical energy used to move a magnet inside a wire loop (coil) could be converted into electrical energy, flowing through the wire.
- Faraday's discovery could be summarised as the flow of electrons when a wire loop or coil rotates in a magnetic field.

Slide 3: *Generating Electricity*

- A generator converts mechanical energy into electrical energy. That is when a wire loop or coil rotates in a magnetic field.
- A generator consists of a coil, magnets and split rings.

- The magnets can be permanent magnets or electromagnets which produce a magnetic field.
- The ends of the coil wires are connected to the split rings.
- The electric current flows from the coil to the external circuit using brushes which come into contact with the split rings.
- It is this discovery which has led to the development of modern power plants, providing a constant and reliable supply of large quantities of electricity to consumers.

Slide 4: ***SA Power Grid***

- Eskom is a utility company which generates and distributes electricity. It transmits electricity throughout South Africa utilizing a national transmission system, from where it is distributed to the end users.
- Eskom also delivers bulk supplies to approximately 180 municipal distributors.
- Transmission lines link power stations all over South Africa.
- Pylons support
- transmission lines.
- 'Transmission' means 'to send from one place to another'.
- Transmission lines are manufactured predominantly from aluminium and copper, with steel wire for structured integrity.
- The network of transmission lines is called the National Grid.
- Eskom also imports electricity from neighbouring countries such as Mozambique and exports to neighbouring countries such as Namibia and Botswana.

Slide 5: ***Electricity supply: South Africa***

- Electricity is produced from a variety of sources. i.e. coal, gas, nuclear, wind, solar, hydropower, biomass etc.
- The electricity produced is at high Voltages (22kV) this Voltage is then stepped up using step-up transformers for transmission up to 765kV.
- The electricity is then transmitted at high Voltages using transmission lines to the transmission substations.
- Eskom uses transmission lines ranging from (132kV,275kV, 400kV and 765kV)
- The high voltages are stepped down at distribution sub-stations using electric transformers to lower voltages.
- These lowered Voltages are then fed to the Distribution substations.
- The transformers at the distribution substations also step down the voltages.
- Electricity is then distributed to consumers using the 22kV/ 11kV lines seen on the normal wooden poles.
- At a household, the Voltage from the outlet/ plug will be 220/240 Volts ready for use.

Slide 6: ***SA Electricity Supply***

- Coal, oil, gas and nuclear fuels can be used for heating water, converting it into steam at high temperatures and under high pressure.
- This is done in boilers or reactors.

- The steam, which is usually heated up to temperatures of between 500 °C and 535 °C, is released to turn a large turbine that is connected to a generator to generate electricity.
- In this way, the energy in the fuel is converted into electrical energy.
- Alternatively, gas turbines are used to generate electricity. Gas or liquid fuels (diesel in the case of Eskom) are used in an engine very similar to an aircraft jet engine to drive an electric generator.
- In SA Eskom relies on coal-fired power plants to produce approximately 85% of its electricity.
- Eskom uses over 1 192 million tons of coal per annum.
- In 2014/2015 Eskom's coal-fired power plants produced 223.4 million tons of CO_2.
- During 2014/2015 Eskom had a nett power-generating capacity of 42 090 MW (megawatt).
- In 2014/2015 Eskom sold 226 300 GWh (gigawatt-hour) of electricity.

http://www.eskom.co.za/IR2015/Documents/Eskom_fact_sheets_2015.pdf

Slide 7: ***South Africa's Electricity Supply: Some Power Stations (http://www.eskom.co.za)***

- **These are some of the power station run by Eskom in the country.**
- Located 300 metres downstream of the Gariep Dam wall on the banks of the Orange River, in the Eastern Cape. The power station has a 360MW installed capacity and have been operating about 96% of the time in the past three years.
- Ankerlig gas station is a peak up station running on diesel situated in Atlantis Western Cape. Its role is to supply energy during peak hours and during emergency situations. It has an installed capacity of 1327MW.
- Ingula Pump Storage is located in the Drakensburg, Ladysmith. This station runs during peak periods as and has an installed capacity of 1332MW. The station started operations in 2016.
- Medupi Coal fired power station is a base load station located west of Lephalale, Limpopo province. This station has an installed capacity is 4800 MW divided into six units of 800 MW each.
- Sere wind farm is located close to Koekenaap town in the Western Cape. This station has an installed capacity of 100MW.
- Koeberg Nuclear Power Station located in Melkbostrand om the west coast of the Western Cape. This station has an installed capacity of 1940 MW divided into two units of 970MW each. The station is used as a base load station.

Slide 8: *Supply vs Demand: Electricity Demand Pattern*

- Much of the electricity and electronic equipment we use depend on voltage and frequency remaining accurate and constant.
- So, the instantaneous amount being fed into the grid (i.e. electricity generated) must always match what the consumers are taking out. This varies not only from day to day but from minute to minute.
- As demand increases, more stations must be brought online.
- The pattern of the daily demand can be predicted fairly accurately, unless something unexpected happens, such as a sudden deterioration in the weather.
- The first peak period in a day usually starts at about 06:00 in the morning and last until about 10:00.
- The main peak period is normally from about 17:00 until 21:00.

Slide 9: *Supply vs Demand: The Energy Balance Problem*

- Electricity supply should be consistent and reliable.
- Electricity has to be generated as needed since batteries are not capable of storing enormous quantities.
- There is no realistic way yet to store large quantities of electricity required for distribution to the user, besides large pump-storage schemes like Palmiet, Drakensberg and Ingula.

Practical Example of Energy Supply vs. Energy Demand:

- To supply electricity to a 220 W computer used 365 days per year, 938 kg coal is needed – that is almost one ton or a whole bakkie load!

Slide 10: *Supply vs Demand:* Load shedding

- ***WHAT CAUSES LOAD SHEDDING?***
- This coursed by an imbalance in supply and demand, specifically when the demand is more than the Supply. This is usually coursed by failure on some generation units (Base Stations).
- Normally there are power stations that run 24 hours a day (Base Stations).
- On peak periods (Morning and late afternoons), the peak up stations are put online to match the demand.
- When this demand cannot be met the power utility is forced to shed load so that the grid doesn't collapse.
- If a collapse would occur it would take up to a month to re-energise the country.

Slide 11: *Renewable Energy Sources: Alternatives to Fossil Fuels*

There are many other methods by which electricity can be generated, for example, by harnessing solar and wind energy. The main renewable resources used today are:

- **Sun:** There are two main conversion types.
    I. Photovoltaic (PV), converting direct sunlight into electricity

II. Concentrated Solar Power (CSP), use the sun's rays concentrating them into one point to produce very high temperatures to produce steam from heating water.

- **Wind:** Moving wind drive wind turbines to produce electricity.

Slide 12: ***Renewable Energy Sources: Alternatives to Fossil Fuels***

- **Hydro/Water:** There are two main types
  I. Hydroelectric Power, extraction of energy from moving water streams. Here a hydropower station is placed near a running river stream and a hydro-electric turbine is used to convert the energy from the moving water to electricity.
  II. Pumped Storage Power: power plant is placed between two dams, one in the upper level and the other in the lower level. Electricity is generated by extracting energy from moving water from the upper-level dam (generation mode) and when there is less demand on power water is pumped back up to the upper-level dam from the lower level dam. These are used as electrical storage systems.
- **Ocean: tidal, wave and ocean current energy**
  Using Wave Energy Converters (WEC), tidal energy, wave energy and ocean currents are converted into electrical energy.

Slide 13: ***Renewable Energy Sources: Alternatives to Fossil Fuels***

- **Geothermal**:
  This uses energy stored in the earth crust in the form of the molten rock, where heat is extracted to produce steam, thus producing electricity.
- **Biomass:** Many different processes can be used to produce electricity, mentioning a few:
  I. Anaerobic digestion, this is where microorganisms are used to break down organic material into combustible gas (biogas (CO_2 and CH_4)) in the absence of oxygen to generate electricity.
  II. Combustion, direct burning of organic material to produce steam and generate electricity.

Slide 14: ***Renewable vs Non-Renewable: Comparison of Energy Technologies***

- At this point, we are still making use of more non-renewables rather than renewables.
- This is due to SA's cheaply available electricity environment (based on coal) and the capital costs of erecting renewable energy plants.
- However, this situation is changing.
- Electricity costs are rising yearly and will continue to do so.
- Mining costs of coal, our main source of energy, are rising.
- The accompanying environmental impact of burning fossil fuels is escalating.

- At the same time, the research and development of renewable energy technologies are becoming better and cheaper.
- The demand for renewables is becoming bigger.
- Subsequently, it is becoming cheaper to install renewable energy.
- This means that renewable energy is becoming a viable option for generating electricity as an alternative to non-renewables

Slide 15: ***Renewable vs Non-Renewable: Comparison of Energy Technologies***

Slide 16: ***South Africa's Future Electricity Supply***

- The Department of Energy initiated the Integrated Resource Plan (IRP) for Electricity in 2010.
- The IRP sets out the new build plans for South Africa's future diverse electricity supply from 2010 to 2030.
- It is a dynamic plan which investigates various scenarios and outcomes, constantly being updated.
- It set the groundwork for the REIPPPP.

Slide 17: ***REIPPPP: Renewable Energy Independent Power Producer Procurement Programme***

- Decisions will have to be made as to whether to invest in renewable energy systems or to carry on burning fossil fuels and paying the environmental cost that is linked to releasing more and more CO_2 into the atmosphere.
- The National Energy Regulator (NERSA) is a regulatory authority whose mandate is to regulate the electricity, piped-gas and petroleum pipelines industries in terms of the Electricity Regulation Act of 2006.
- The Renewable Energy Independent Power Producer (IPP) Bid Programme and the procurement of an IPP for new generation capacity were gazetted by the Department of Energy (DoE) in May 2011 (Eskom, 2015).
- The National Development Plan calls for the procurement of "at least 20 000 MW of renewable electricity by 2030" and the decommissioning of 11 000 MW of ageing coal-fired power station.
- In the 2014 report on the South African IPP Procurement Programme, Anton Eberhard, member of the National Planning Commission, indicated that an investment of 3 922 MW renewable-energy-generating capacity has been secured in the first three bidding rounds and it is judged to be highly successful by the programme stakeholders (Eberhard, 2014).

Slide 18: REIPPP VS recently built Coal-fired power stations

- There has been a significant change in the prices from renewable sources since the inception of the IPP process.
- In 2011 when the first bidding round started, the price per kWh was very high. PV selling at R3.65/kWh to less than R1/kWh in bid window 4.
- As the technologies advanced and improve the prices have reduced significantly.

- PV has shown the most reduction in prices over this period.
- There is now a fair competition between fossil and renewable energy looking at the generation price of R1.10/kWh and R1.20/kWh from Kusile and Medupi stations respectively, whereas renewables like PV and hydro are below R1/kWh todate.

Slide 19: ***Renewable Energy Targets: European Union***

- The EU is working to reduce the effects of climate change and establish a common energy policy.
- By 2020 renewable energy should account for 20% of the EU's final energy consumption (8.5% in 2005).
- The latest figures available are that the share of renewables in energy consumption in the EU rose further to 16% in 2014. (Eurostat news release Feb 2016)

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Ref. http://www.energy.eu/#renewable

http://ec.europa.eu/eurostat/documents/2995521/7155577/8-10022016-AP-EN.pdf/38bf822f-8adf-4e54-b9c6-87b342ead339