CENTRE FOR RENEWABLE &
SUSTAINABLE ENERGY STUDIES

Hydro Energy

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science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

Eskom

Hydro Energy

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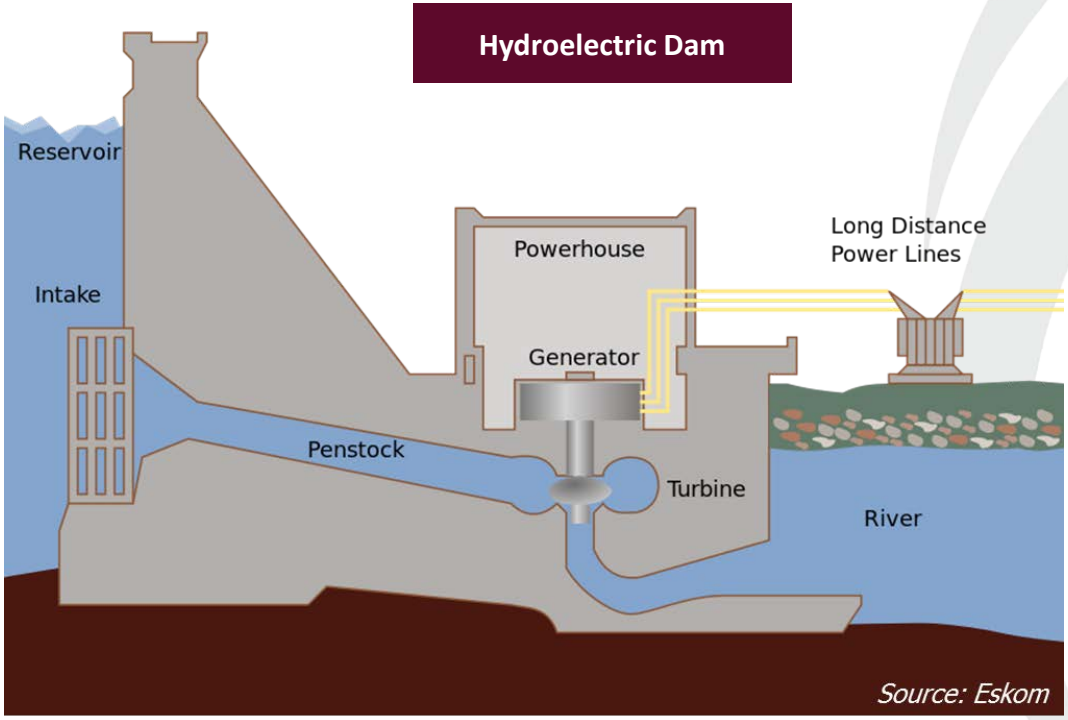
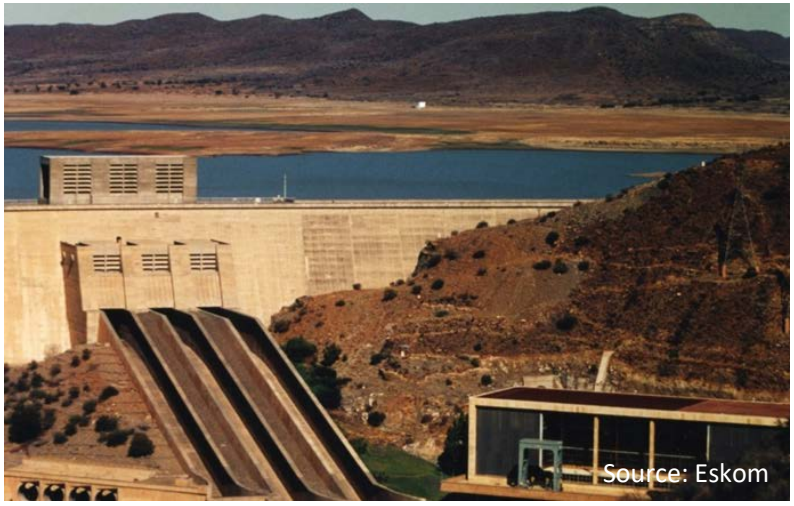
- **Hydroelectric power** refers to the generation of electric power through the extraction of energy from moving water streams.
- A large fraction of **radiation** reaching the Earth's surface is **absorbed by the oceans**, warming them and adding water vapour to the air.
- The **water vapour condenses** as rain to feed rivers in which dams can be built and hydroelectric turbines installed to extract the energy of the flowing water.
- **Moving water** can be extremely powerful.
- The **kinetic energy** of flowing water can be used to drive **hydroelectric turbines** to produce electricity.

Hydroelectric Power: Hydro Energy Converted To Electricity



- Gravity makes **water** flow from a high to a low place. The moving **water** contains **kinetic energy**.
- **Hydroelectric power** stations are able to transform the kinetic energy in moving **water** to electrical energy.
- In a hydroelectric power station, part of a river's flow is sent through **pipes**.
- The water then turns the **turbines,** and the turbines turn the **electricity generators**.
- The water is returned to the river further downstream.
- In the conventional system, water is stored behind a **dam wall**.
- The **power station** is normally situated close to the dam wall.
- The water is **released on demand**, powering huge turbines that generate electricity.

Hydroelectric Power in SA

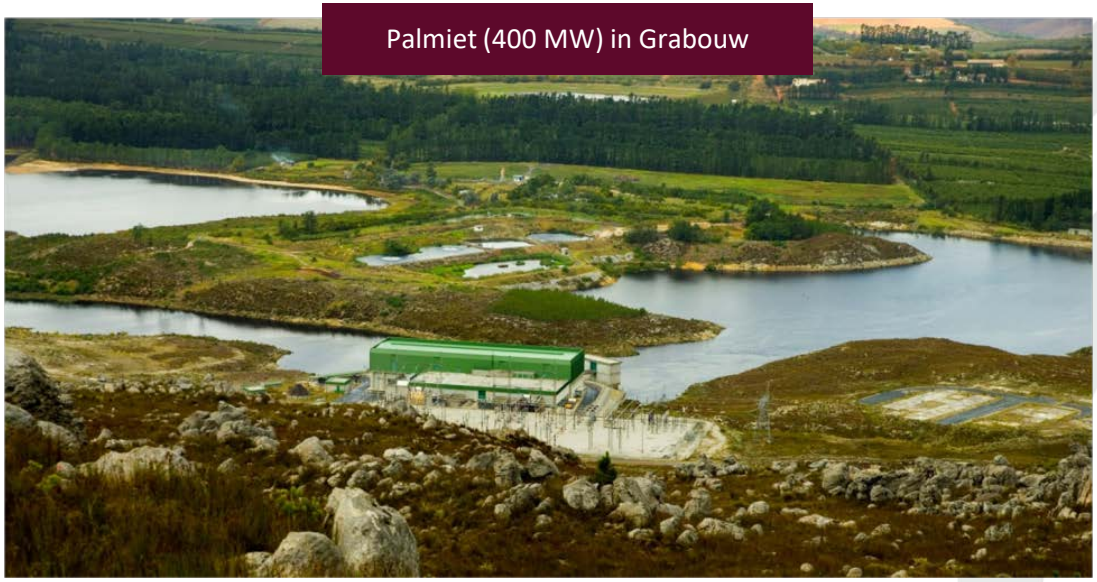

Source: Eskom


Source: Eskom

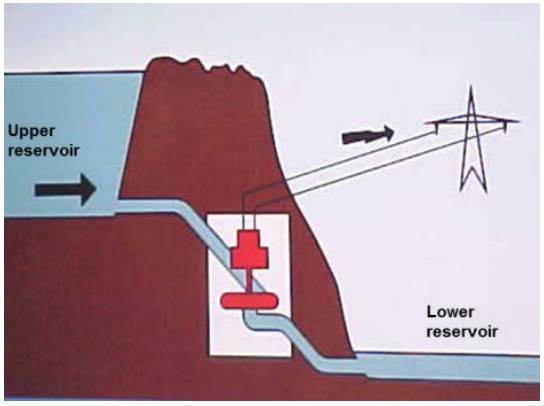
- **Eskom** operates hydroelectric power stations at both the Gariep Dam and the Vanderkloof Dam.
- In South Africa, the most important role of these power stations is the **storage of 'electricity'** in case of unexpected demand, or in case of sudden operational disturbances at one of the power stations supplying the regular demand.
- These hydroelectric plants are also referred to as **peaking power stations.**
- In mountainous countries, **hydroelectricity** is an important source of energy.

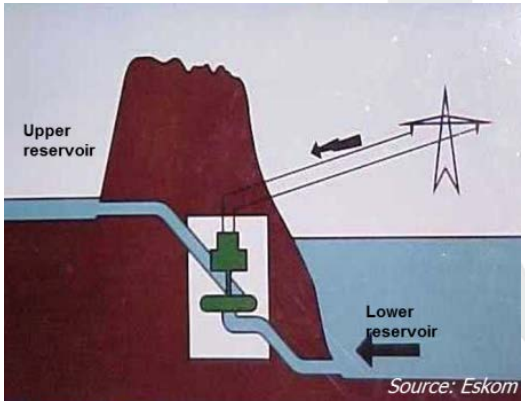

Source: Eskom

Hydroelectric Power: Pumped Storage Plant



Palmiet (400 MW) in Grabouw





- A **pumped storage plant** is currently the only practical way of storing 'electricity' on a large scale.
- This type of system has a power plant located between two dams, the **upper reservoir** and the **lower reservoir**.
- During peak hours where there is a high electricity demand, the turbine is switched to **generation mode** and produces electricity to feed the grid.
- It then uses a **reversible/two way pump turbine** which, during low electric demand periods, pumps the water from the lower reservoir to the upper reservoir.
- The idea is simply to use **surplus electricity** available at night or on weekends during low demand periods to pump water to a mountain-top reservoir.
- In South Africa we have two such systems in operation: at **Palmiet** (400 MW) and **Drakensberg** (1 000 MW), whilst Ingula (1 332 MW) is still under construction.

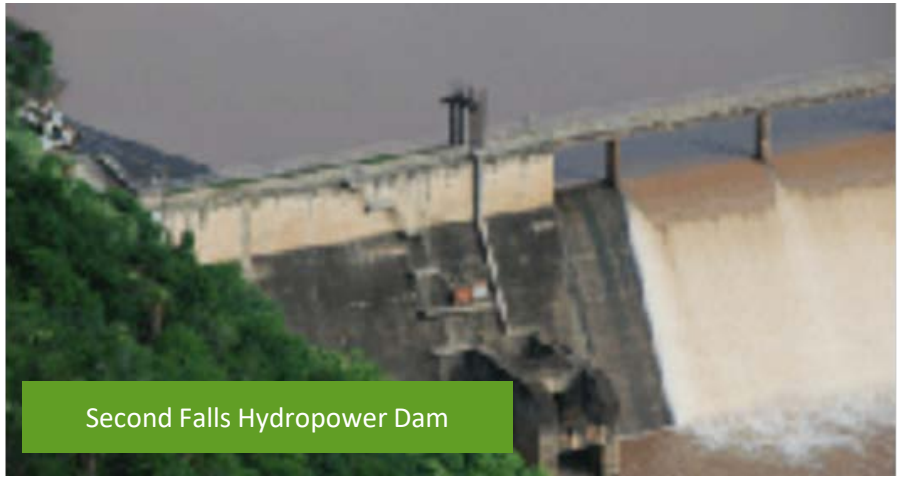
Hydroelectric Power: Pumped Storage Dams

Ingula intake canal

- The **Ingula** Pump Storage dam is situated in **KwaZulu-Natal** in the Drakensberg area.
- It has a power generation capacity of **1 332 MW** from four separate units.
- These dams also play a significant role in **stabilizing the grid**. Not only when needed on peak periods but also to maintain load on off-peak periods.

Hydroelectric Power: Run-off-river Systems

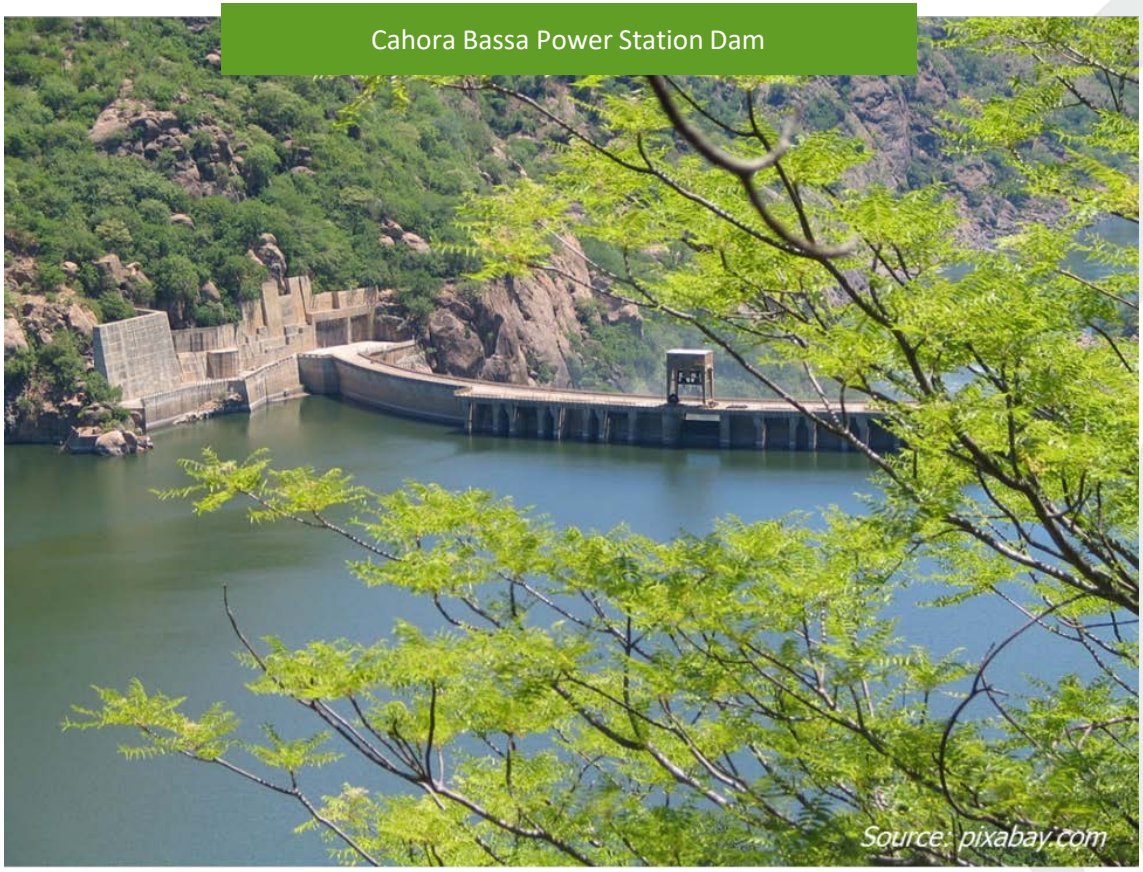

Collywobbles Hydropower Dam


Second Falls Hydropower Dam

- There are also many other small **hydroelectric stations** in South Africa, some privately owned, some Eskom stations and some owned by municipalities.
- They range from **15kW to 3MW power generators.**
- Some municipalities use **hydropower turbines** in their water treatment plants.
- This technology has a potential for **rural off-grid electrification**.

Large Dams: Cahora Bassa, Mozambique

Cahora Bassa Power Station Dam



- **Cahora Bassa** is a hydroelectric power station located in Mozambique that supplies power to South Africa.
- South Africa imports about **9 000 GWh** per year from Cahora Bassa hydroelectric generation station.
- Transmitting +/- 533kV DC over the distance of approximately 1400 km
- The power line can transmit **1 920 megawatts.**

Large Dams: The Issues

Benefits

There are potential economic benefits, such as:

- **Sustains** livelihoods (fresh water, food supplies)
- **Flood** control
- **Hydroelectric** power

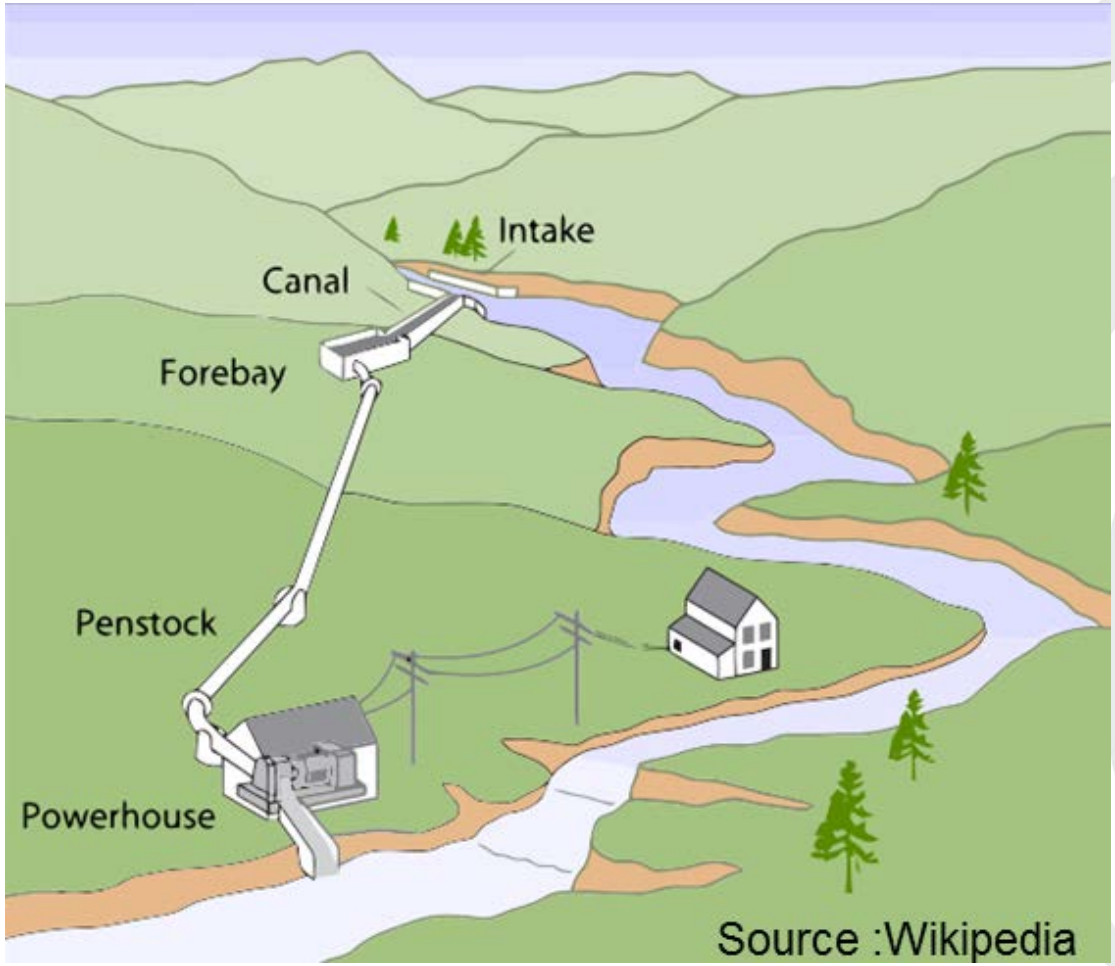
Concerns

- Significant **evaporative** water losses
- The **relocation** of people who have been or will be displaced by the rising waters
- **Siltation** that could limit the dam's useful volume.
- Loss of valuable **biospheres, archaeological** and **cultural sites**
- Loss of **habitat**

Large Dams: Three Gorges Dam, China

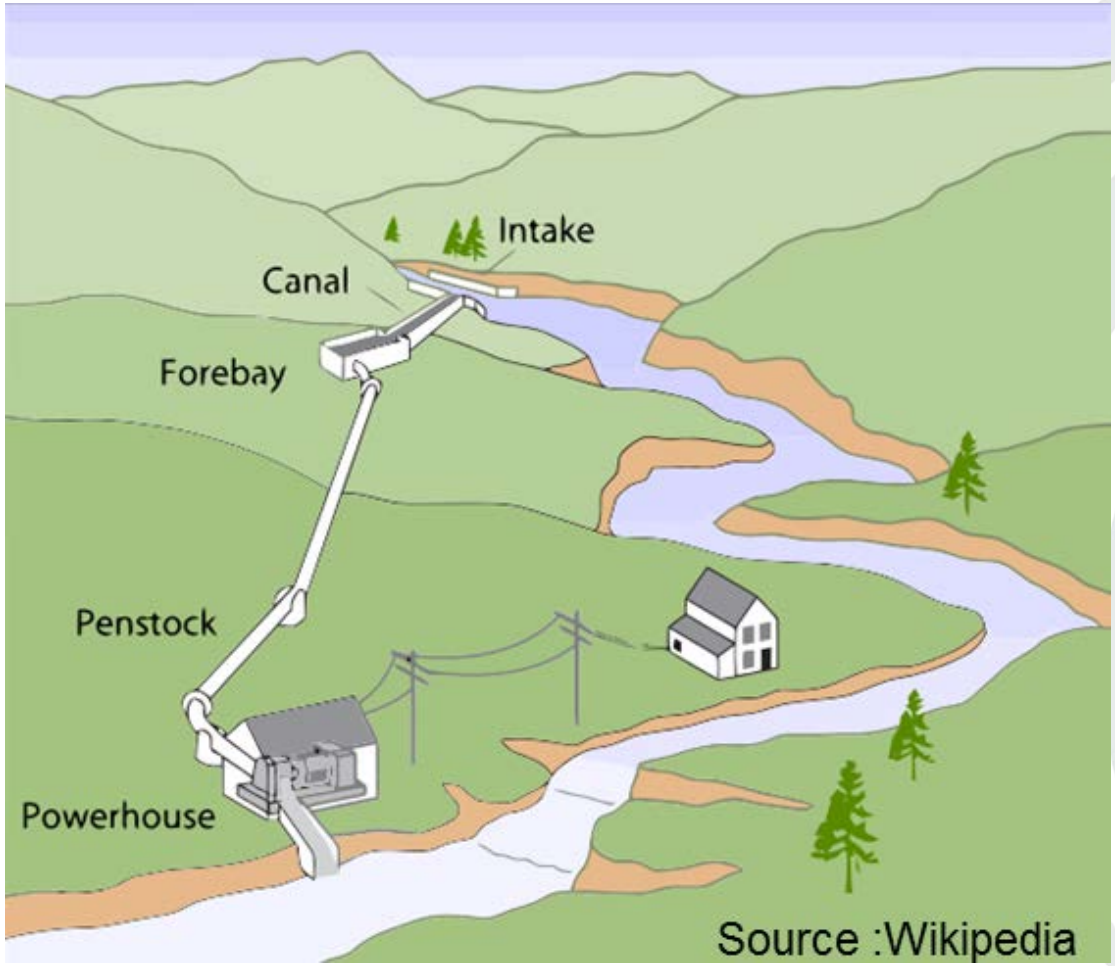
- The **biggest water storage** project in the world is the Three Gorges in China.
- The Three Gorges Dam is a hydroelectric river dam that **spans the Yangtze River.**
- The total electricity-generating capacity of the dam will reach **22 500 MW**, at which point it will be the largest hydroelectric power station in the world.
- As with many dams, there is a debate over costs and benefits.
- The **rising water level** on 7 November 2006 can be seen clearly from an aerial photo. Compare this to the water level on 17 April 1987.
- The dam was first proposed in 1919 by Sun Yat Sen and was eventually **approved in 1992.**
- The biggest opposition was due to the **displacement of more than a million people**, who lost their homes and workplaces.
- China also lost one of its valued landscapes.

Small-scale Hydropower Plants



- **Small-scale hydro** energy varies in size but is generally seen as smaller than 10 megawatt.
- Smaller hydropower plants have received **growing attention** in the past few decades due to the growing **environmental issues** that major hydro developments have.
- Small scale installations can be separated into 3 categories: **Mini-hydro**, **micro-hydro** and **pico-hydro**
  - Mini-hydro: 100 kW to 1 MW; either stand-alone schemes or more often for feeding into the grid.
  - Micro-hydro: 5 kW to 100 kW; usually used to provide power for small communities or rural industries in remote areas, inaccessible to the national grid.
  - Pico-hydro: < 5 kW, used for generating power in rural residential, industrial and remote applications.

Small-scale Hydropower Plants



- Small-scale hydropower plants operate on the same principle as **large-scale power** plants where flowing water is used to **rotate a turbine;** this mechanical energy then turns the generator to generate electricity or electrical energy.
- **Small-scale pumped storage** also exists.
- Small-scale hydro plants normally consist of basic components such as an intake weir or settling basin, canal, forebay tank or reservoir, penstock and powerhouse containing the **turbine** and **generator**.
- Small hydropower plants can be developed and constructed at existing dams, rivers and lakes.
- In many cases, the potential for generating electricity is highly dependent on the **seasonal variation of the flow in rivers** or dams where it is constructed.

Small-scale Hydropower Plants in South Africa

Stortemelk 4.3 MW Clarens Small Hydro

Neusberg 10 MW Kakamas Small Hydro

Bidding rounds	Capacity allocated (MW)	Number of Projects
Window 1	-	-
Window 2	46.8	2
Window 3	-	-
Window 4	5	1
Total	51.8 MW	3

- **REIPPPP: R**enewable **E**nergy **I**ndependent **P**ower **P**roducer **P**rocurement **P**rogramme
- The first bidding round of the REIPPPP started in 2011. To date, four bidding rounds have been completed.
- Refer to this website for a map which provides the details of each REIPPPP project in South Africawww.eskom.co.za/Whatweredoing/Pages/RE_IPP_Procurement_Programme.aspx
- The following details can be viewed on the website:
  - Name of the project
  - Type of technology being build
  - The capacity of the power plant
  - Current status of the project

References

Slide 2: https://pixabay.com/photos/lechfall-weir-waterfall-water-225856/ and
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Slide 8: https://pixabay.com/photos/cahora-bassa-power-station-dam-242566/
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