Unconventional hydropower the hidden opportunity – the South African experiences



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WATER RESEARCH COMMISSION
55 YEARS
Supporting Sustainable Water Futures
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Layout of the presentation

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- Examples
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  - City of Tshwane - Various
  - Mhlontlo LM – Kwa-Madiba
- Lessons learnt

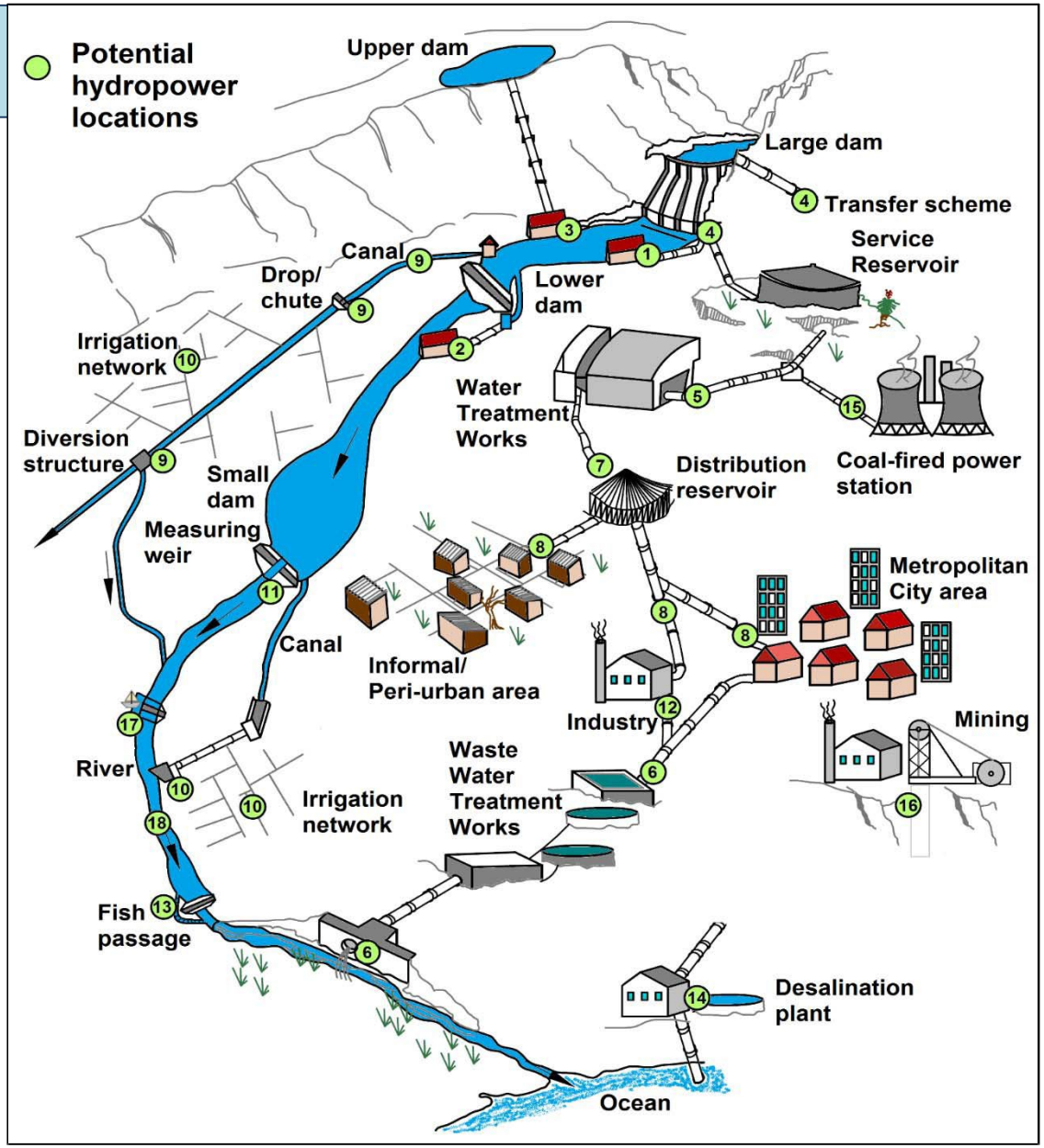


Introduction

- South Africa, the country with 3rd largest installed hydropower capacity in Africa, produces less than 5% of its total electricity generating capacity from hydropower.
- SA doesn't have many conventional hydropower opportunities as in Africa and the rest of the world.
- However, large quantities of water are conveyed daily under pressurized and/or gravity conditions over large distances and elevations (canals, pipelines etc.)
- There are also opportunities at other existing water infrastructure and unconventional opportunities.

Opportunities?

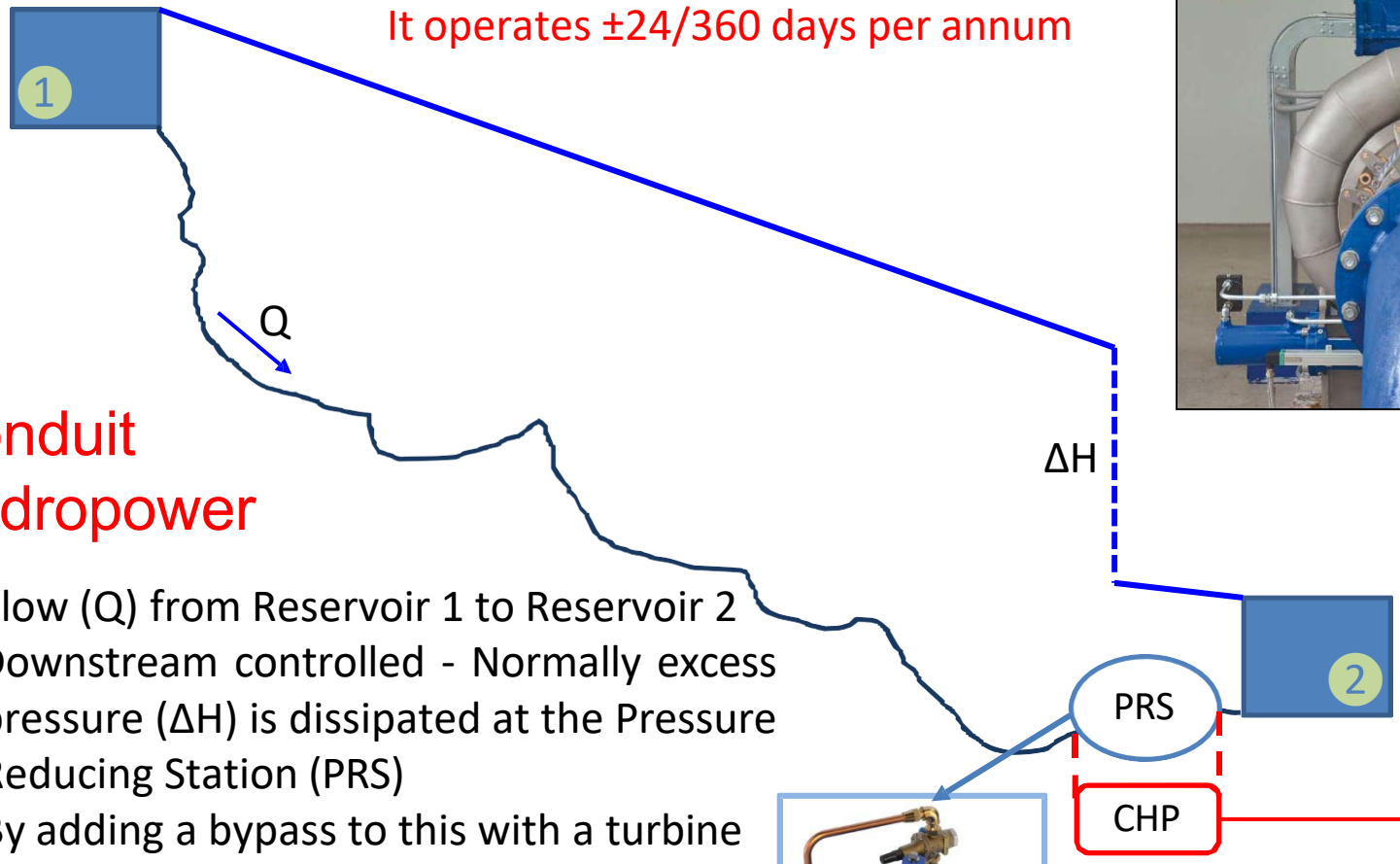
- Hydropower opportunities
- River, dams
- Existing hydraulic infrastructure – dams, weirs, pipelines, canals etc.



Opportunities?

It operates ±24/360 days per annum





Conduit Hydropower

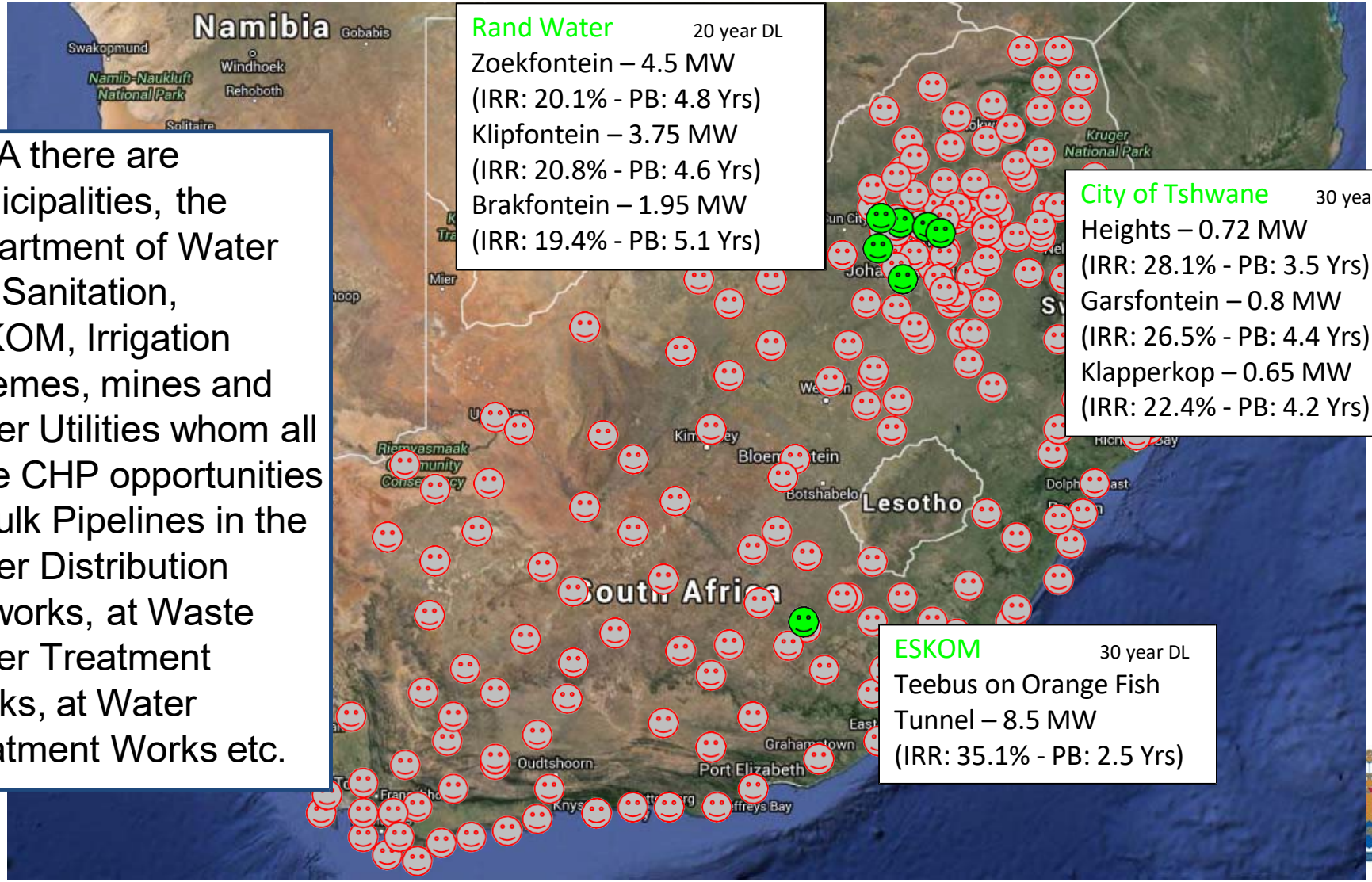
i) Flow (Q) from Reservoir 1 to Reservoir 2
ii) Downstream controlled - Normally excess pressure (ΔH) is dissipated at the Pressure Reducing Station (PRS)
iii) By adding a bypass to this with a turbine allows the generation of hydroelectric power in a CHP plant



CHP could be installed at the end reservoir or anywhere along pipeline system

Mapping hydropower potential in South Africa

In SA there are municipalities, the Department of Water and Sanitation, ESKOM, Irrigation schemes, mines and Water Utilities whom all have CHP opportunities in Bulk Pipelines in the Water Distribution Networks, at Waste Water Treatment Works, at Water Treatment Works etc.



Rand Water 20 year DL
Zoekfontein – 4.5 MW
(IRR: 20.1% - PB: 4.8 Yrs)
Klipfontein – 3.75 MW
(IRR: 20.8% - PB: 4.6 Yrs)
Brakfontein – 1.95 MW
(IRR: 19.4% - PB: 5.1 Yrs)

City of Tshwane 30 year DL
Heights – 0.72 MW
(IRR: 28.1% - PB: 3.5 Yrs)
Garsfontein – 0.8 MW
(IRR: 26.5% - PB: 4.4 Yrs)
Klapperkop – 0.65 MW
(IRR: 22.4% - PB: 4.2 Yrs)

ESKOM 30 year DL
Teebus on Orange Fish Tunnel – 8.5 MW
(IRR: 35.1% - PB: 2.5 Yrs)

Example: Bloemwater Brandkop reservoir

Opportunity at Brandkop Reservoir was developed



Example: Bloemwater Brandkop reservoir

- **IREM Crossflow turbine and generator**
- **Nominal voltage: three/single phase 400/230V 50Hz**
- **Generated electric power: P = ±96 kW**
- **Net head axis turbine: H = ±40 m**
- **Flow :Q = ±350 l/s**



Electric Distribution Board Mod. CT 100.000



Electronic Regulating System RMP 12000/B with water dissipation resistances



Example: Bloemwater Brandkop reservoir





Flow is controlled on downstream end

Example: Bloemwater Brandkop reservoir



Example: Bloemwater Brandkop reservoir

- Launched plant - 31 March 2015
- Supplies the entire Bloemwater head office



Max pressure and flow is controlled

Generating constant power depending on available Δh and Q

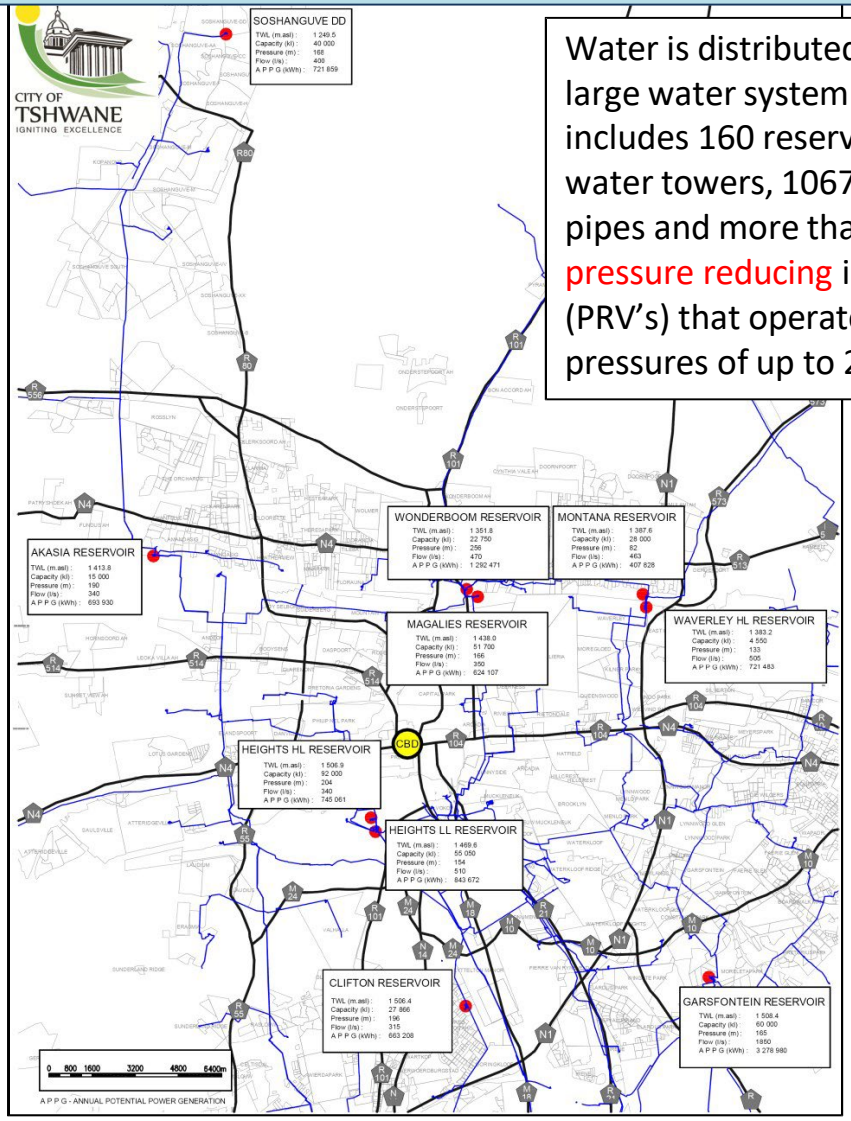
Example: City of Tshwane opportunities

Original desktop study

	Reservoir site	Estimated average capacity (kW)
1	Garsfontein	550
2	Wonderboom	330
3	Heights	380
4	Akasia	260
5	Waverley	80
	Total	1 600

Feasibility study

	Reservoir site	Estimated average capacity (kW)
1	**Garsfontein**	**740**
2a 2b	**Klapperkop**	**372** **267**
3	**Heights LL**	**265**
4	**Heights HL**	**455**
5	**Akasia**	**275**
	Total	**2 374**



Water is distributed through a large water system that includes 160 reservoirs, 42 water towers, 10677 km of pipes and more than 260 pressure reducing installations (PRV's) that operates at pressures of up to 250 m.

CITY OF TSHWANE
IGNITING EXCELLENCE

Example: City of Tshwane – Annlin Reservoir



3 x 50 kW Pump-As-Turbine



Example: City of Tshwane – Heights HL Reservoir



Example: City of Tshwane – Heights HL&LL Resv.

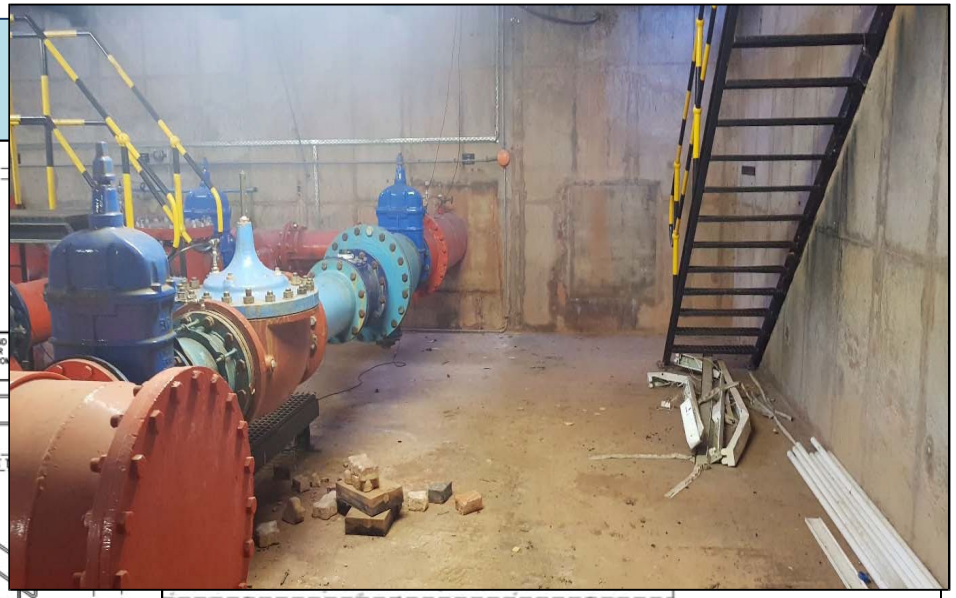


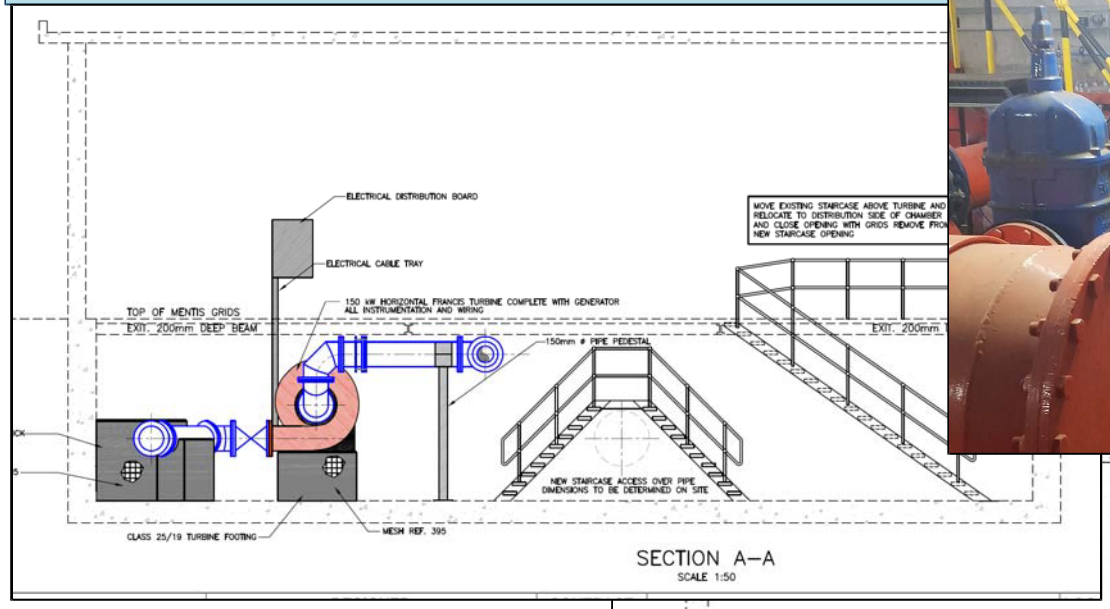
- Example of new PRS incorporating 265 kW and 455 kW Francis turbine designs.
- This one site will generate R6.4 million/annum of renewable electricity.
- Reduction of 5440 tons CO_2/annum

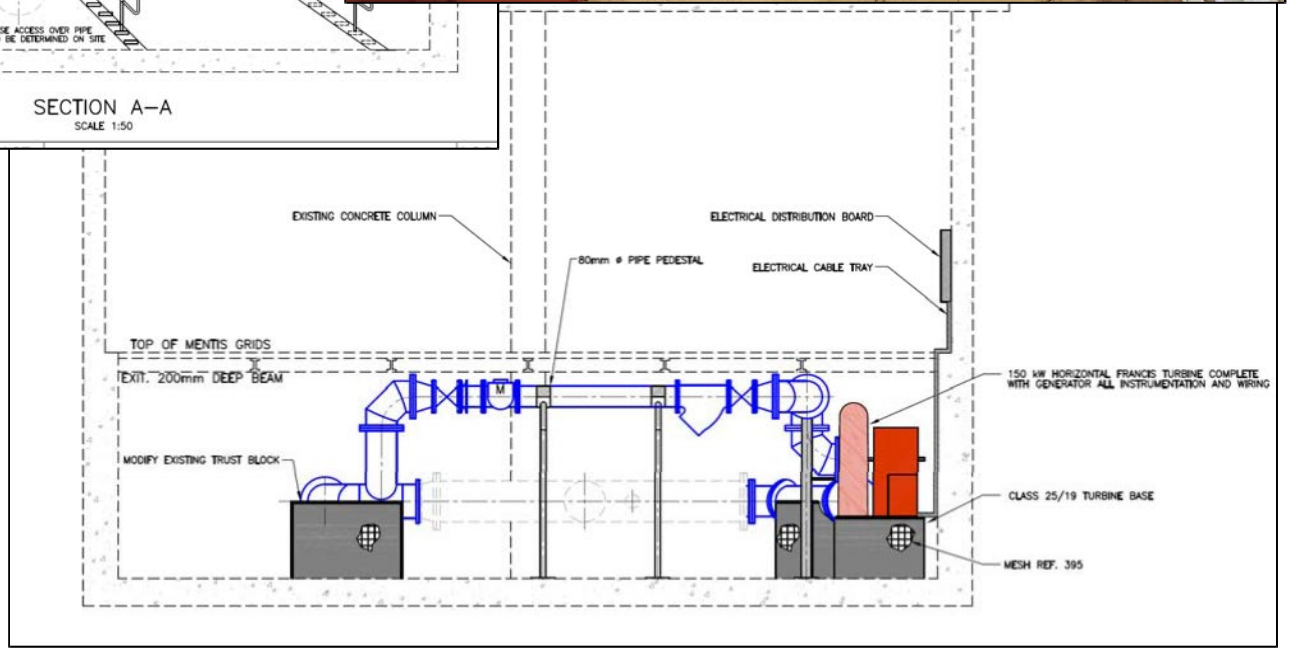
Example: City of Tshwane – Heights HL&LL Resv.



Research and Innovation







150 kW, designed, procure, construct, implement, monitor and evaluate, feeding back into CoT grid

Example: Mhlontlo LM – Kwa-Madiba



Example: Mhlontlo LM – Kwa-Madiba





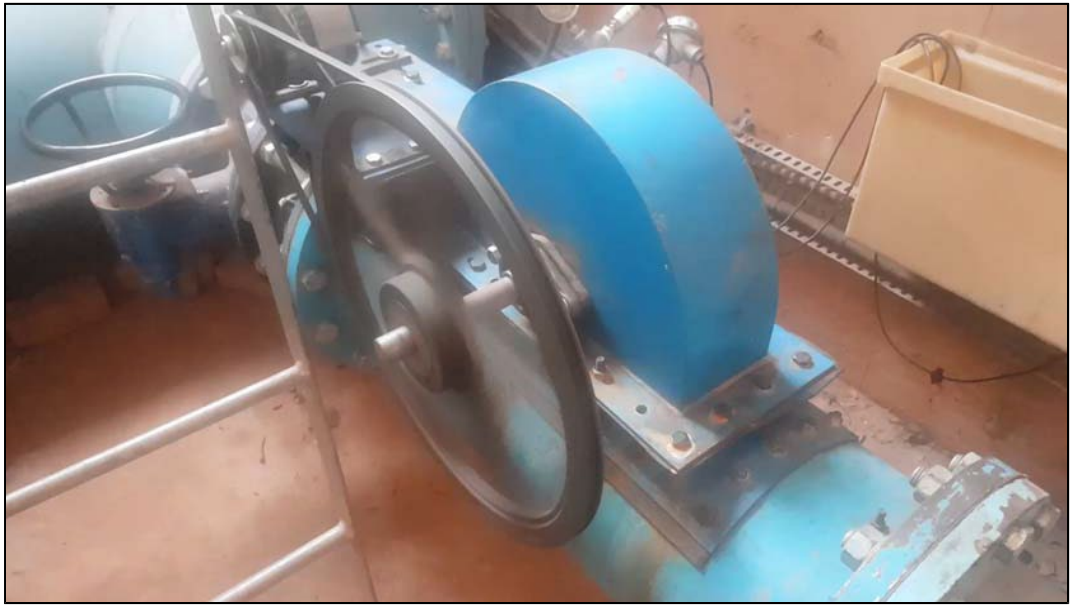


51 kW, cross flow turbine
for rural electrification

Research and Innovation

1. Conduit hydropower utilizes proven, efficient, mature technologies in innovative, unconventional places and in unique applications.
2. Further Research and Development of new innovative pico hydropower units which provides localised energy for the operational needs (telemetry, alarms, cathodic protection etc.) of the water supply and distribution network.









Energy generation from distribution systems

Description

Availability





Wind turbine





Conduit hydropower

Hydropower potential in South Africa (Barta, 2002)

Hydropower category (Power output range)	Installed capacity (MW)	Potential for development	
		Firm (MW)	Long-term (MW)
Pico (up to 20 kW)	0,02	0,1	60,2
Micro (20 kW to 100 kW)	0,10	0,4	3,8
Mini (100 kW to 1 MW)	8,10	5,5	5,0
Small (1 MW to 10 MW)	25,70	63,0	25,0
Total	33,92	69,0	94,0

OPPORTUNITIES IN SMALL SCALE HYDROPOWER DEVELOPMENT IN SA

- Refurbishment/upgrading of existing plants in ownership of municipalities or DWA: 70 GWh/a
- Municipal/water utility distribution systems - in line hydropower (for own use or supply to regional/ national grid): 250 to 500 GWh/a
- Hydropower sets to existing (new) dams (300 dams in SA are suitable): 500 GWh/a
- Inter-basin Water Transfer Schemes (WTS) (at gravity flow components): 300 GWh/a
- "Greenfield" hydropower sites (available more than 5000 MW around SA if storage regulated)

Summary

- Hydroelectric energy is a continuously renewable energy source.
- Hydroelectric energy technology is proven technology offering reliable and flexible operations.
- Hydroelectric stations have a long life.
- Hydropower stations achieve high efficiencies.
- Could use existing infrastructure/retrofitting.
- In some cases minimal environmental impact.
- Feasible solutions without subsidies.
- Base load or peak clipping options

Thank you



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