# SMALL SCALE HYDROELECTRIC POWER WORKSHOP

## SMALL SCALE HYDROELECTRICITY ISSUES AND PROSPECTS

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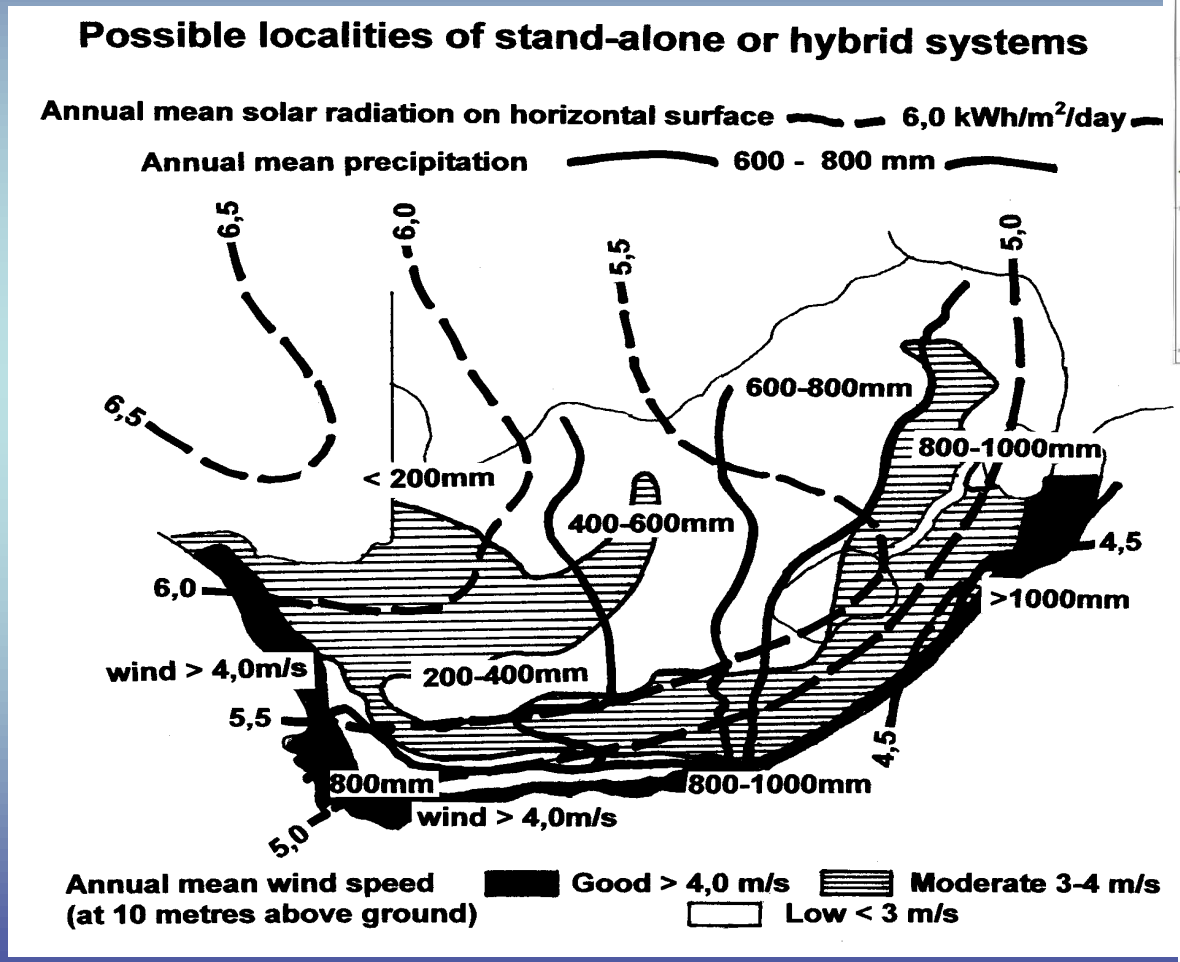
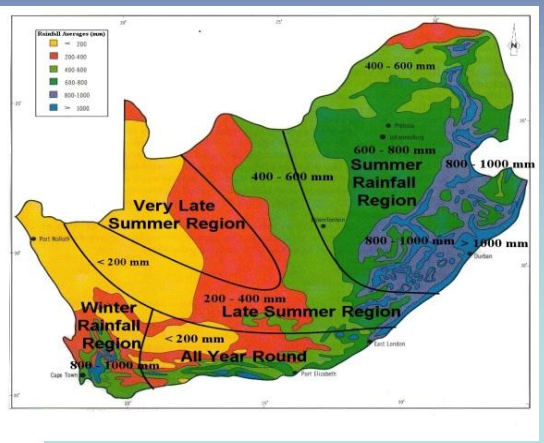
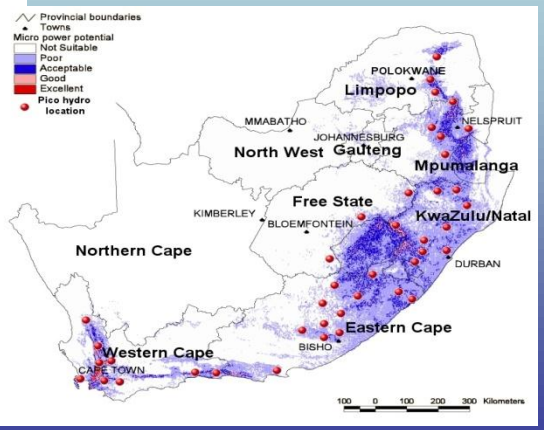
# GREEN ENERGY FROM RENEWABLE ENERGY SOURCES

- Government's target of 10 000 GWh from RE sources by 2013 (still a national goal)
- Targeted RE sources for development:
  - (i) biomass
  - (ii) solar radiation
  - (iii) wind
  - **(iv) <u>small scale hydropower (<10MW)</u>**
  - (v) eventually also ocean wave/tidal power

# NATURAL DISTRIBUTION OF RENEWABLE ENERGY RESOURCES IN SOUTH AFRICA



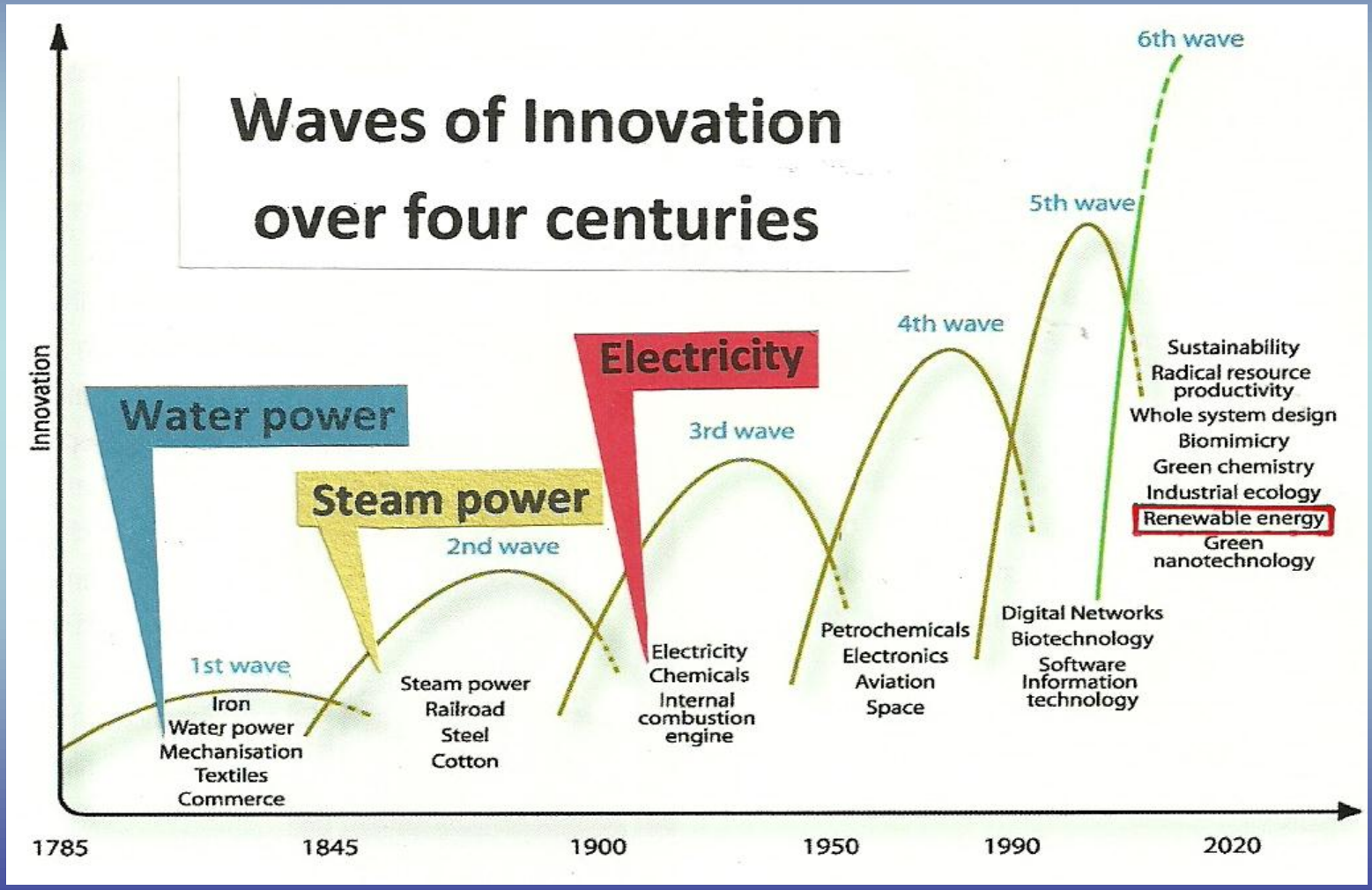



# CONVERSION EFFICIENCY
## for various RE technologies

| Technology: | Efficiency (%) |
|---|---|
| • Biomass | 20 – 35 |
| • Hydropower | 60 – 80 (95) |
| • Solar | up to 30 |
| • Wind | up to 60 |
| **Energy conversion device:** | |
| • Water wheel | 40 – 80 |
| • Water turbine | up to 95 |
| • Steam turbine | up to 45 |
| • Solar panels | up to 35 |

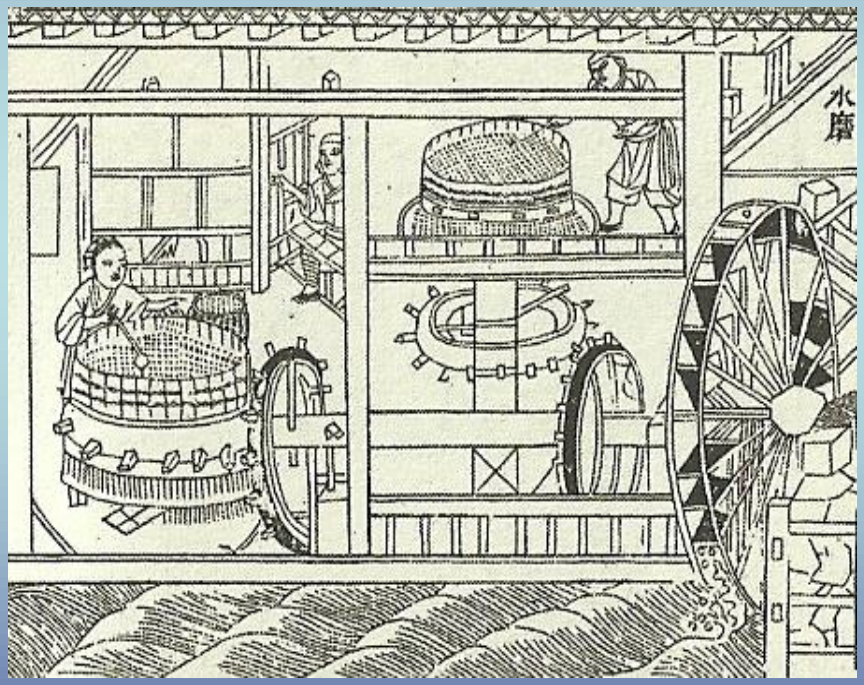
**Efficiency** = ratio of the useful output to the required input

# Utilisation of water power by western cultures (since 18th century)



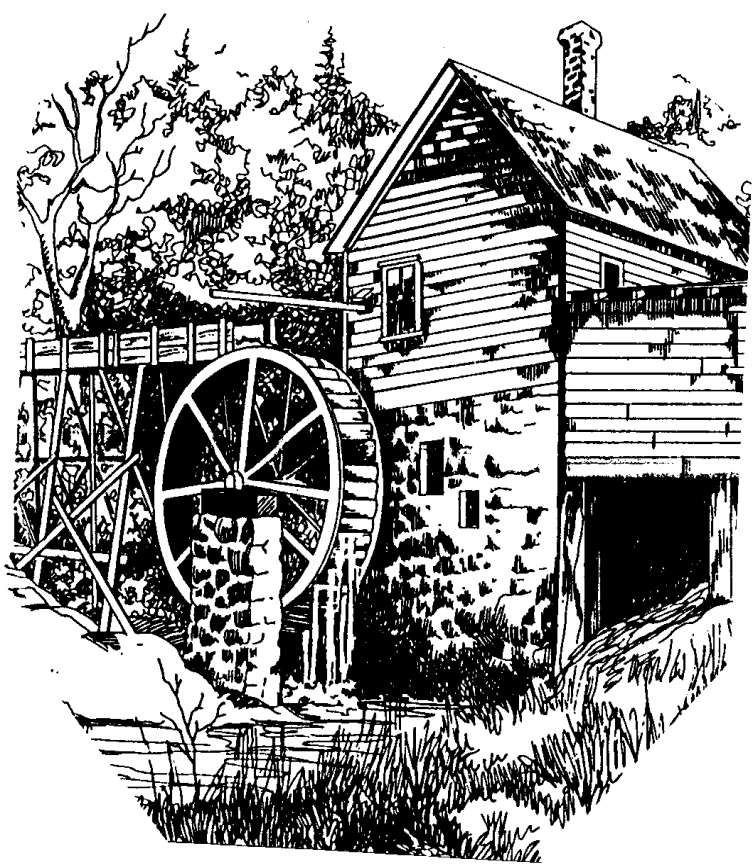
# Popular Chinese Encyclopedia *"Nung Shu"* published in 1313

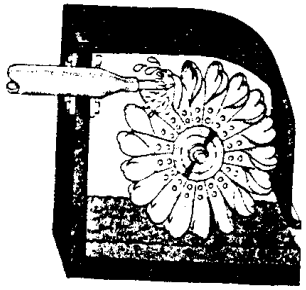
**Vertical waterwheel and its applications**



**A Chinese bucket pump**

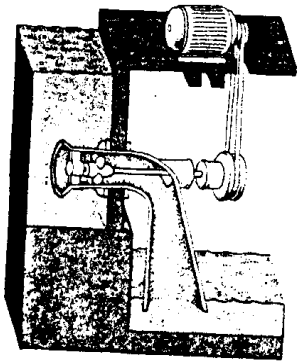
# FROM WATER-WHEEL TO HYDRO-TURBINE AND GENERATOR



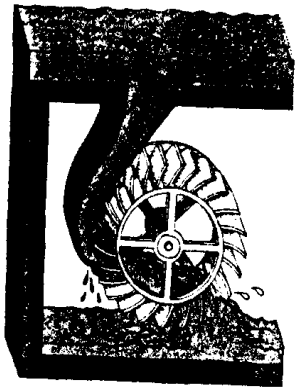


Pelton wheel

Pelton wheel



Propeller turbine



Banki turbine

# WATER - a powerful source of renewable energy

Production of **hydroelectric energy** is dependent on available **water flow** and the **gravity height** from which it falls

- **water energy** can be transformed into **mechanical energy** by means of a water **turbine,** and if connected to generator **:**
- turbine's rotation spins **electromagnets** to generate an **electrical current** which when **transformed** to high voltage can be **transmitted** to the **man-made systems.**

# FOREMOST WATER TURBINE TYPES

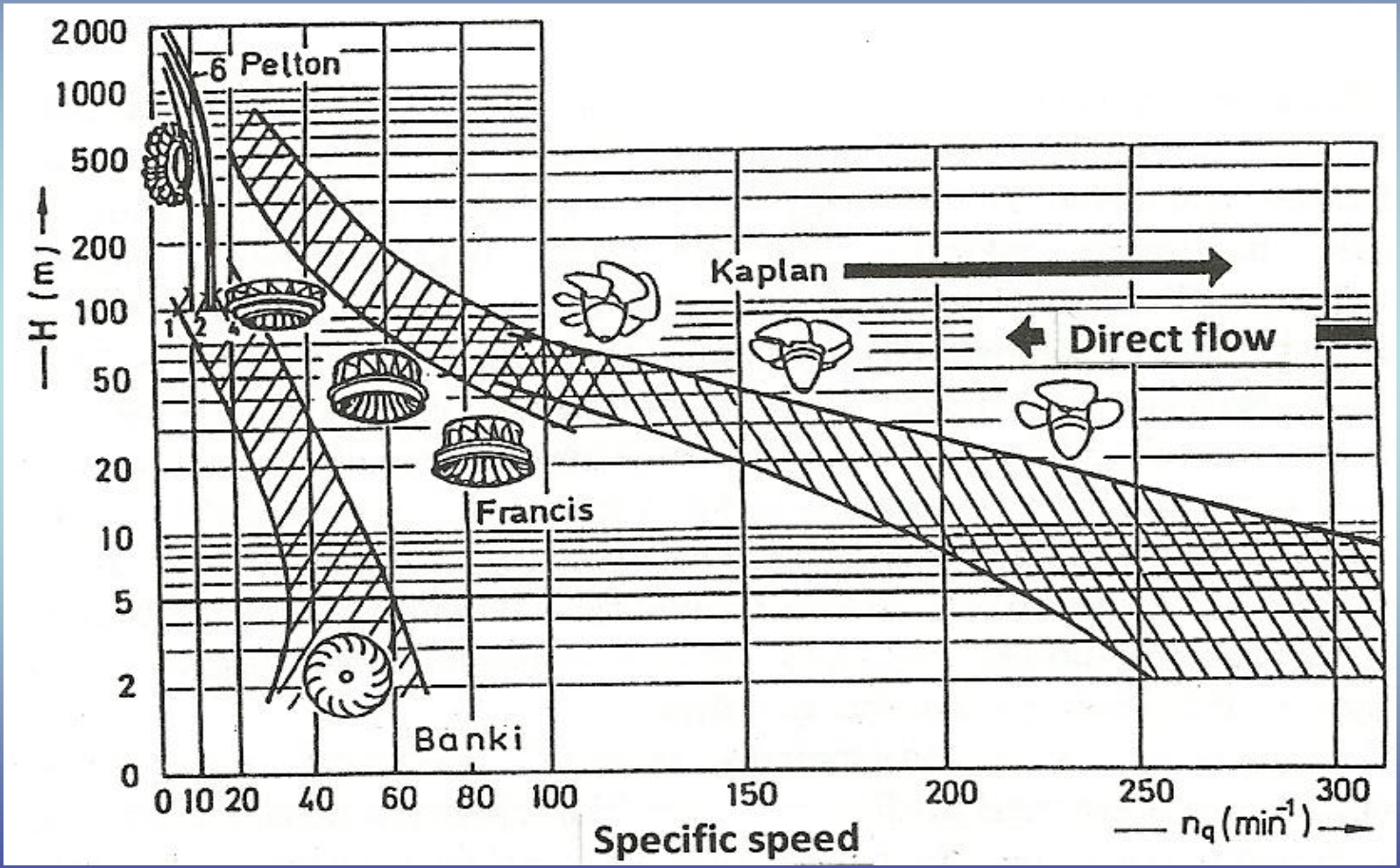
**Francis turbine:** **invented by J.B. Francis in 1870 in the USA – radial flow approach**

**Pelton turbine:** **invented by an american engineer L.A. Pelton in 1880 – improvement on conventional water wheel – radial flow**

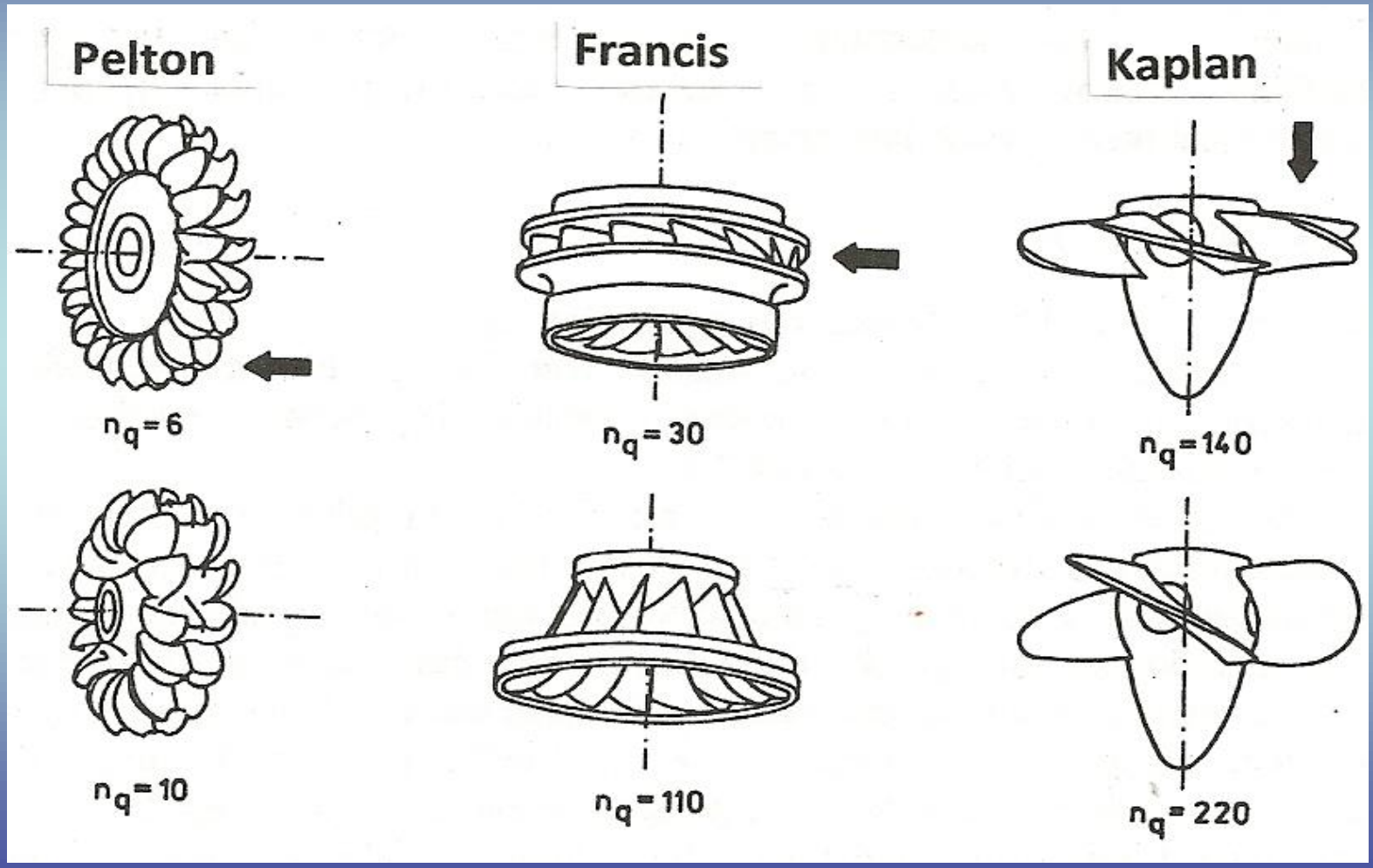
**Kaplan turbine:** **invented in Austria by V. Kaplan in 1913 – flow change from radial to axial**

**Direct flow turbines:** **Swiss Estcher Wyss improved on the Kaplan turbine type in 1933**

# SELECTION OF TURBINE TYPE (specific speed vs head)



# BASIC CHARACTERISTICS OF TURBINE RUNNER



# WATER TURBINES R&D

- Water turbines enable provision of dynamic balance to the electrical grid, much faster than traditional steam turbines
- Focus in water turbines R&D is currently aimed toward more optimal operation
- Key aim is to improve on “deep part load”

  (WT operation below the half of its rated power) – causing the pressure oscillation problems
- Reduction of oscillation amplitudes can minimise the plant maintenance & outages

# HYDROPOWER DIVERSITY OF SCALES

| Category: | Power output: | Typical generation time (%) |
|---|---|---|
| • Pico | up to 20 kW | 10 – 35 |
| • Micro | 20 to 100 kW | 10 – 35 |
| • Mini | 100 to 1 MW | 10 – 75 |
| • Small | 1 to 10 MW | 35 – 85 |
| • Macro | > 10 MW | 35 – 95 |

**NB:** Small scale hydropower < 10 MW is acknowledged internationally, however countries e.g. China recognises SHP up to 50 MW..

# BENEFITS FROM SMALL SCALE HYDROELECTRICITY GENERATION

1 MW hydroelectric plant can in a typical year replace:

- 300 tons of fossil fuel
- can avoid the emission load of some 3200 tons of carbon dioxide; and
- 20 tons of sulphur dioxide
- while supplying electricity needs of some 1000 sub-urban households

# STUDIES EVALUATING HYDROPOWER POTENTIAL IN SA

- Baseline Study on Hydropower in SA (2002)
- Renewable Energy Market Transformation (REMT) study compiled in 2003 (World Bank)
- **White Paper on Renewable Energy approved in November 2003**
- Economic and Financial Calculations & Modelling for the RE Strategy Formulation compiled in 2004
- **Status of Hydropower in SA (March 2010)**

# HYDROPOWER POTENTIAL IN SA
## (2010 update)

| | Installed capacity (MW) | Estimated potential (MW) |
|---|---|---|
| • Macro hydro (>10 MW) | | |
| (i) imported hydro | 1450 | 36400 |
| (ii) pump storages | 1580 | 10400 |
| (iii) dams/transfers | 662 | 6990 |
| • Small hydro (<10 MW) | 38 | 247 |
| TOTAL (excluding imports) | 2280 | 17667 |

# **INTERGATED RESOURCE PLAN (IRP2010)** estimates by SESSA/IHG

Realistic conventional “green” hydropower uptake curve (as in 2011)

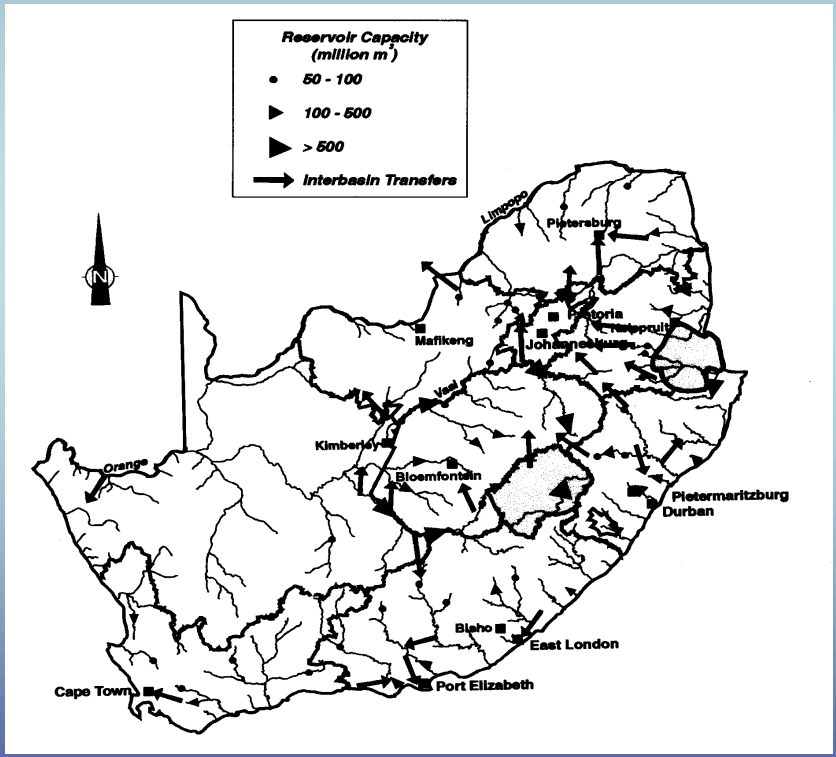
| | |
|---|---|
| Firm 300 MW by | 2016 |
| another 400 MW by | 2020 |
| further 1 100 MW by | 2030 |

Totaling to 1 800 MW over next 20 years

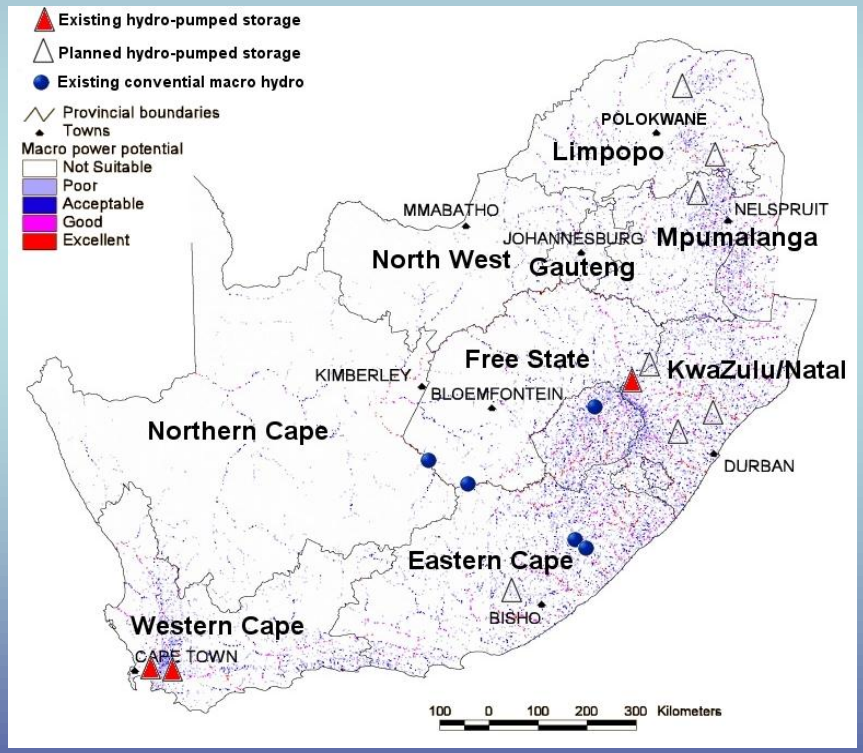
**NB:** SA overall development potential of “green” hydropower is estimated at 7 237 MW excluding imported hydropower and pumped storages

# PRESENT WATER SUPPLY/HYDRO INFRASTRUCTURE IN SA

## Existing water transfers located around SA




## Macro hydropower distribution in SA



# KEY OPPORTUNITIES IN SMALL SCALE HYDROPOWER DEVELOPMENT IN SA

- Refurbishment/upgrading of existing plants
- Hydropower retrofit to existing /new dams

  (several of 320 large dams in SA are suitable)
- Inter-basin Water Transfer Schemes

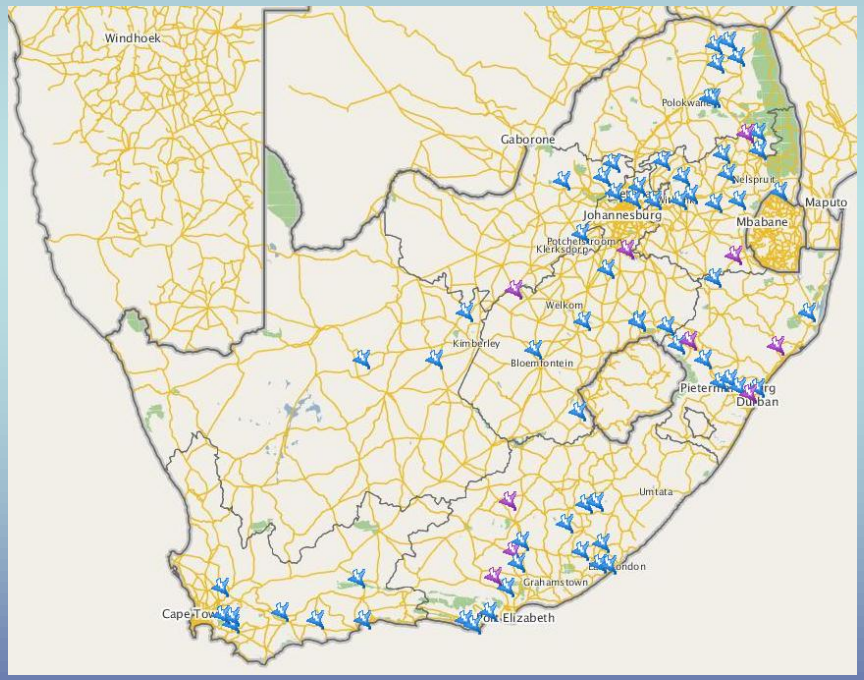
  (gravity flow between components of such schemes)
- Water Utility/Municipal water supply installations

  (primarily in line hydropower on the pressure conduits )
- "Greenfield" hydropower sites (available more than 5000 MW around SA if combined with water supply)

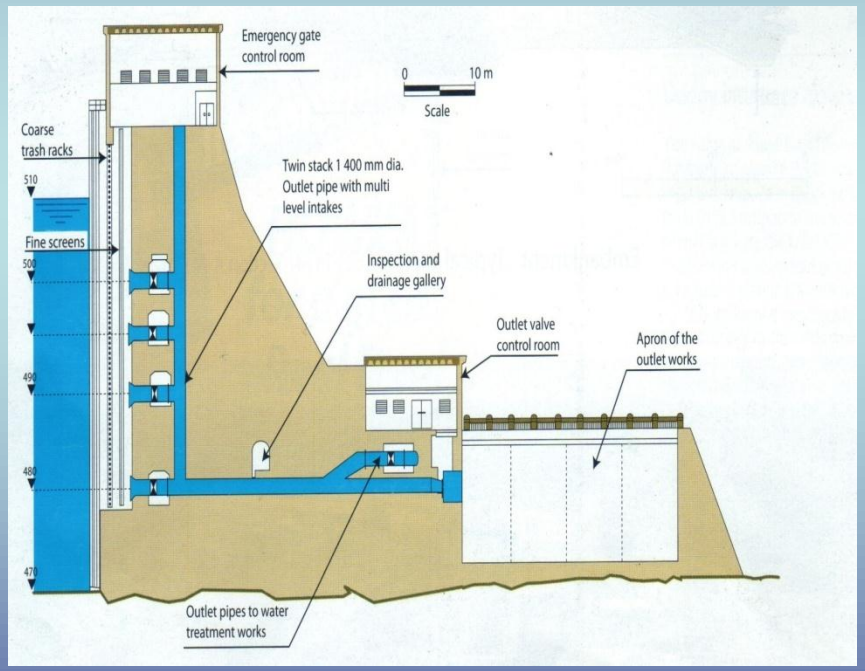
  NB: hydroelectricity plants to be synchronized with the national grid requirements

# POTENTIAL FOR HYDROPOWER RETROFIT TO SA DAMS

**Retrofit potential between 300 kW and 3 MW to dams**




**Typical section of a dam with retrofit potential**



# SMALL SCALE HYDROPOWER SUITABLE DAMS

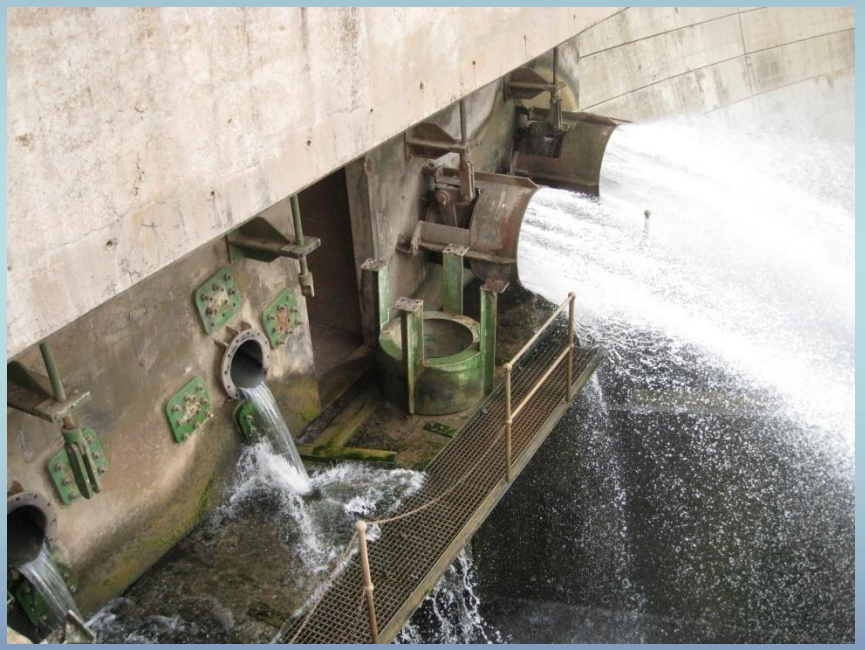
A sample of existing dams suitable for small scale hydropower development:

- **Hartbeespoort Dam (up to 10 MW) - DWA**
- Vaal Dam (3 MW from only 3 outlets) - DWA
- New Paris Dam (2,4 MW) – Local Authority
- Lubisi Dam (1,5 MW) – DWA

Lubisi Dam (at present)

- Spioenkop Dam (1,5 MW) - DWA
- Laing Dam (1 MW) – Local Authority
- Midmar Dam (1 MW) - DWA

# LUBISI DAM (E. Cape)
## river outlets - dilapidated

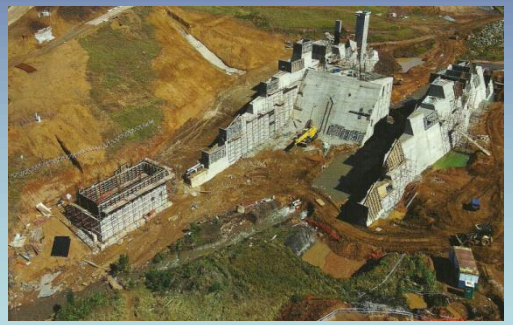


# DWA standing on hydroelectric development (since August 2010)

- DWA acknowledged that certain dam sites may be used for commercial purposes (20 existing dams considered with a pilot study at Vaal Dam)
- Water Use License may be issued providing that requirements of NWA are satisfied (Act No.36 of 1998, Section 4, 12 and 27 particularly)
- Public Private Partnership (PPP) models are to be applied in hydropower development
- DWA determined tariffs on hydroelectric energy output (SHP is to pay for the use of a resource)

# The dams in SA are being build without the SHP addition !?!?!

The dams which are being build at present in South Africa:



Mhlabatshane Dam

- De Hoop Dam by DWA – no hydropower
- Mhlabatshane Dam by Umgeni Water – no hydropower
- Ludeke Dam by Mbizana LA – no hydropower
- Spring Grove Dam by DWA – no hydropower

NB: Namibia to build Nekartal Dam for irrigation with 1 MW hydropower installation.

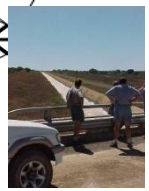
# HYDROPOWER FROM INTER-BASIN WATER TRANSFER SCHEMES

"Best-to-develop" existing Inter-basin Water Transfer Schemes for hydroelectricity generation:

- Assegaai to Vaal WTS (23 MW)
- Breede to Berg WTS (5 MW)
- Buffalo to Vaal WTS (1,5 MW)
- **Orange-Fish-Sundays (25 MW)**
- Usutu to Vaal WTS (5 MW)

Future transfer: Mooi to Umgeni (? MW)

# ORANGE-FISH-SUNDAYS
## Water Transfer Scheme



# “GREENFIELD” HYDROPOWER POTENTIAL IN SA

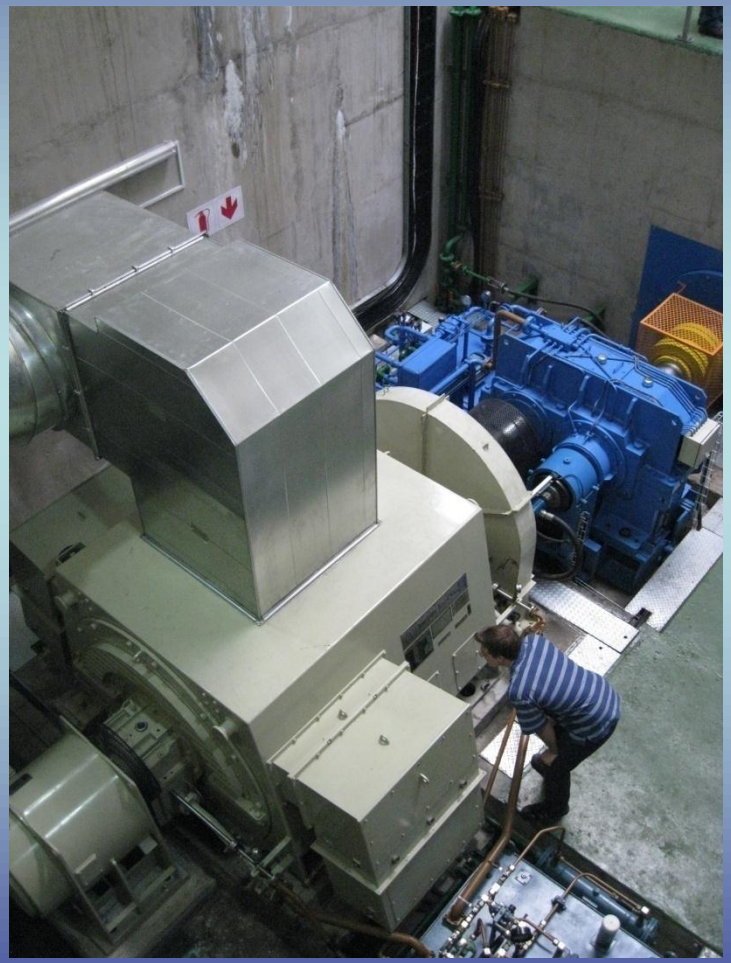
There are several perennial river systems suitable for development of macro/small scale hydropower:

| | | |
|---|---|---|
| • Mzintlawa River | Eastern Cape | 66 MW |
| • Lower Mzimvubu | Eastern Cape | 450 MW |
| • Tsitsa River | Eastern Cape | 200 MW |
| • Tina River | Eastern Cape | 50 MW |
| • Lower Orange | Northern Cape | 20 MW + |
| • Thukela River | KwaZulu Natal | 5 200 MW |

# BARRIERS/CHALLENGES IN DEVELOPING HYDROPOWER

- Environment Impact Assessment (EIA)
- State (public) ownership of vital resource/ infrastructure (access, servitudes, etc.)
- **Water Use Permit as per National Water Act (No. 36 of 1998)**
- Power Purchase Agreement (PPA)
- National Energy Regulator SA license
- Funding constraints

# INTERIOR OF SOL PLAATJE (Bethlehem) HYDRO (as built)



# **INTERGATED RESOURCE PLAN (IRP2010)** REFIT replaced by REBID

- The final IRP 2010 programme allocated 75 MW for the development of conventional (green) hydropower prior to 2016 under REBID rules
- PPP principles will have to be applied in envisaged hydropower development
- The average lead time for the development of a small scale hydropower scheme (<10 MW) is between 1and half year and 3 years
- The current SHP installation cost in SA varies between Rand 10 and 20 million per MW depending on a type of installation

# BOTERKLOOF DAM
## (LHWP flows to ASH River from Katse Dam)

# SCOPE OF HYDROPOWER DEVELOPMENT WORL-WIDE

Hydropower (all types) offers an attractive solution for the national/regional grids stabilisation and convenient energy storage

- **USA** – relooking hydropower availability through retrofit to dams and new pumped storages also in-line SHP
- **European Union (EU)** – e.g. Austria, Czech R., Germany, Greece, Holland, Italy and Portugal – primarily re-evaluating existing hydropower and vigorous implementation of the SHP
- **Norway and Switzerland** – both working on optimization of existing SHP in cascade configuration and risk management
- **Asian and South American countries** – developing extensively SHP and limited macro hydropower

# 2010 SMALL HYDRO POWER STATUS (SHP) IN CHINA

- Estimated technical SHP potential: 145 GW
- Over 45 000 SHP schemes developed with total capacity of 45 GW (some 30% developed)
- 67 % of SHP schemes in private ownership
- Some 500 manufacturers and 100 scientific institutions supporting SHP development
- About 1000 design and construction units operating in the hydropower sector
- SHP sector driving economic & social development mainly in rural areas

# (MACRO) HYDROPOWER IMPORTS
## Cahora Basa (2000 MW)

# IMPORTED HYDROPOWER POTENTIAL IN SADC

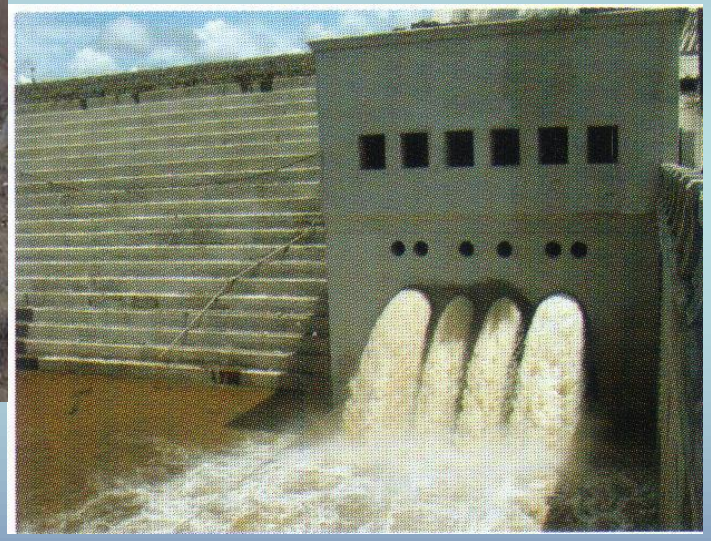

| Country | Hydropower installed capacity (MW) | Development potential available (MW) |
|---|---|---|
| Angola | 291 | 12 000 |
| Botswana | Nil | - |
| DR-Congo | 2 442 | 60 000 |
| Lesotho | 76 | 450 |
| Malawi | 245 | 600 |
| Mozambique | 2 184 | 12 500 |
| Namibia | 240 | 120 |
| South Africa | 2 267 | 17 667 |
| Swaziland | 62 | 200 |
| Tanzania | 396 | 3 000 |
| Zambia | 1 670 | 6 000 |
| Zimbabwe | 666 | 1 500 |
| Total | 10 539 | 113 890 |

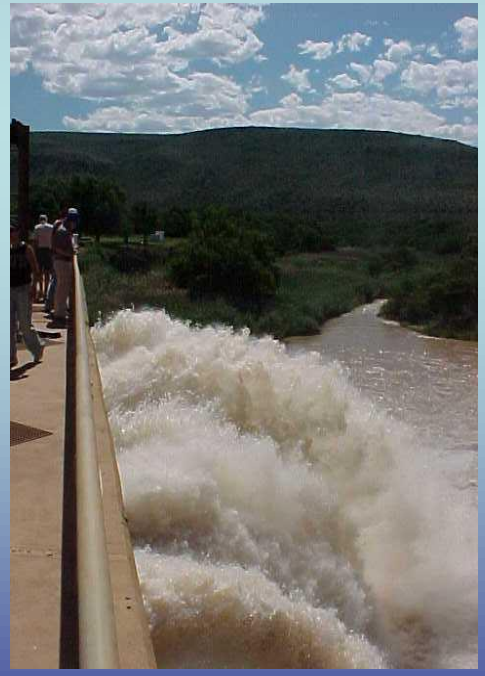
# SHP ISSUES TO BE CLARIFIED AND DELT WITH

- REIPP-SHP projects below one MW are excluded from development by the REBID rules – Is that fair?
- Commercial banks will not finance SHP projects below one MW – Where to go for suitable finance ?
- The process of permit applications from DWA and NERSA still to long to enable potential hydro bidders to satisfy REBID – offer assistance to DWA and NERSA
- Evaluate chances of possible concession or leasing of under-utilized water storages for hydropower generation
- Re-evaluate hydropower potential in the provinces of Eastern Cape and KwaZulu-Natal.

# INTEGRATED RESOURCES MANAGEMENT INCLUDES HYDROPOWER

Are we going to harness available hydropower ?



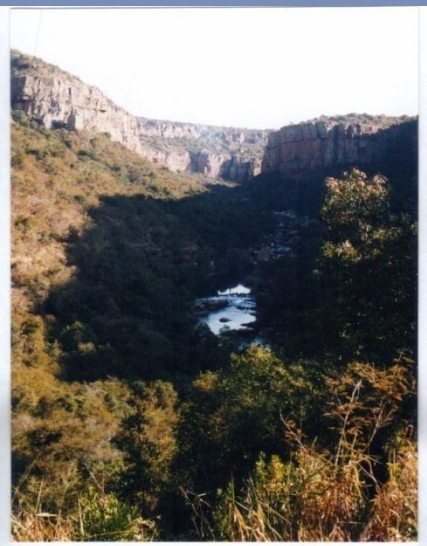


THANK YOU

# Status of small scale hydropower development in RSA

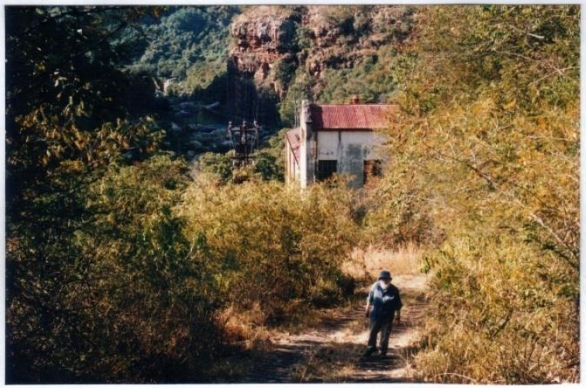
More examples of small scale hydropower installations from around South Africa

# OLDEST EXISTING HYDRO IN SA

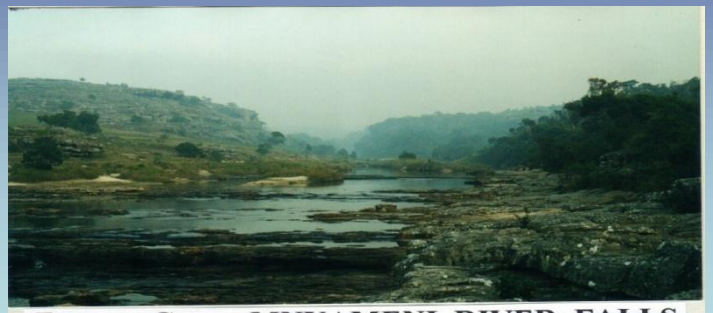


**BELVEDERE**
**2 MW Hydro**

Belvedere hydro- electric power station stands at the confluence of the Blyde and Belvedere rivers in the floor of the canyon 400 meters below Bourke's Luck Potholes. On completion in 1911 it was the largest hydro-electric power station in the southern hemisphere. It was constructed to provide electricity to power the gold crushers at Pilgrim's Rest to the west. The turbines were built by General Electric in the USA which had bought Thomas Edison's patent for a generator and for a practical electric light. As a result, Pilgrim's Rest enjoyed electric street lighting before London.

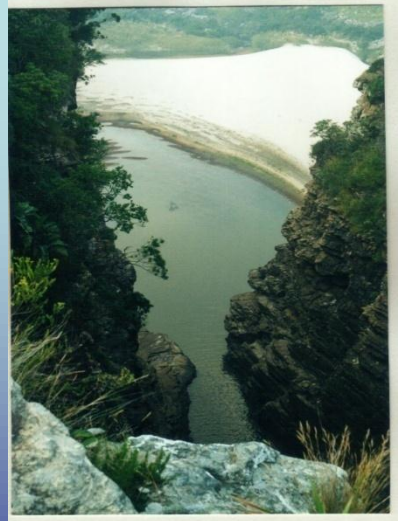


# "GREENFIELD" HYDRO SITE



**Eastern Cape : MNYAMENI RIVER FALLS**
**GPS Data : S 31° 08.944' E 30° 04.263' Alt. 183 m**

**Renewable Energy Potential : Large Hydro**

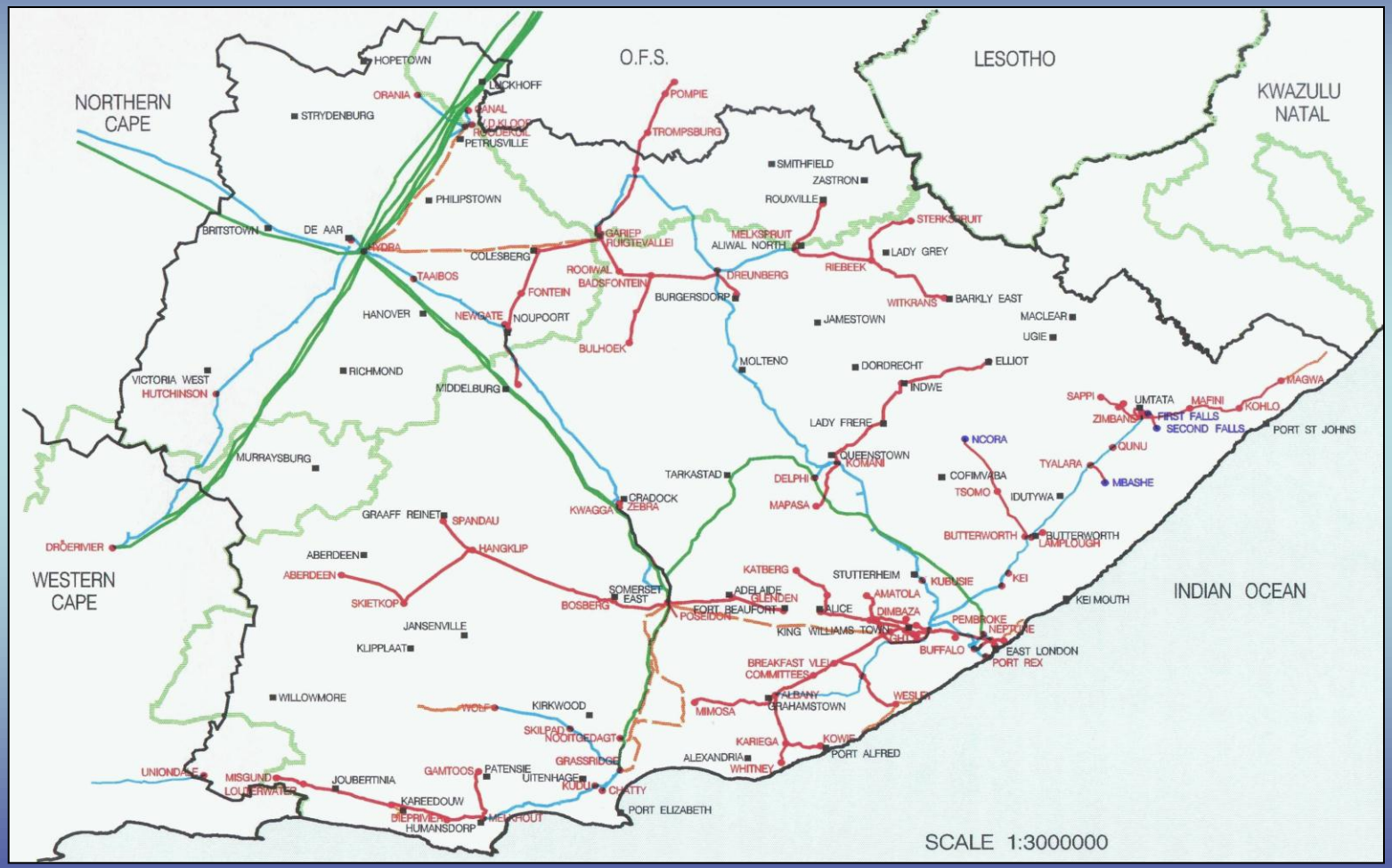


**Mnyameni River Falls (Downstream View)**

**Mnyameni River Falls (Upstream View)**

# ESKOM's Southern Region Hydros

## (1st & 2nd Falls, Mbashe and Ncora)



# Eastern Cape – Mbashe Dam & Hydro
## (bird's view of silted dam reservoir)

# Eastern Cape – Mbashe Dam & Hydro
## (heavily silted dam storage)

# ESKOM's Mbashe Hydroelectric Plant (installed capacity 3x14 MW)

# ESKOM's Ncora Hydroelectric Plant (2,4MW)

# LANTI WEIR ON INDWE RIVER (E. Cape)