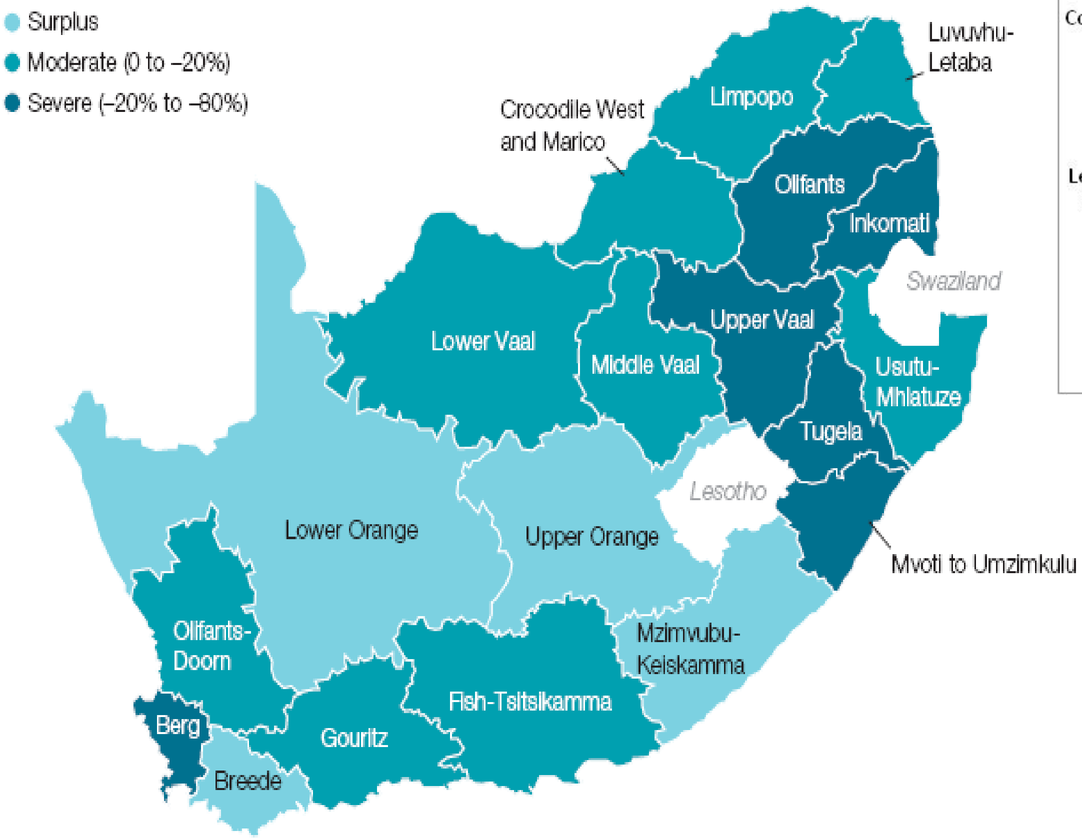
Energy-Water Nexus Analysis Workshop

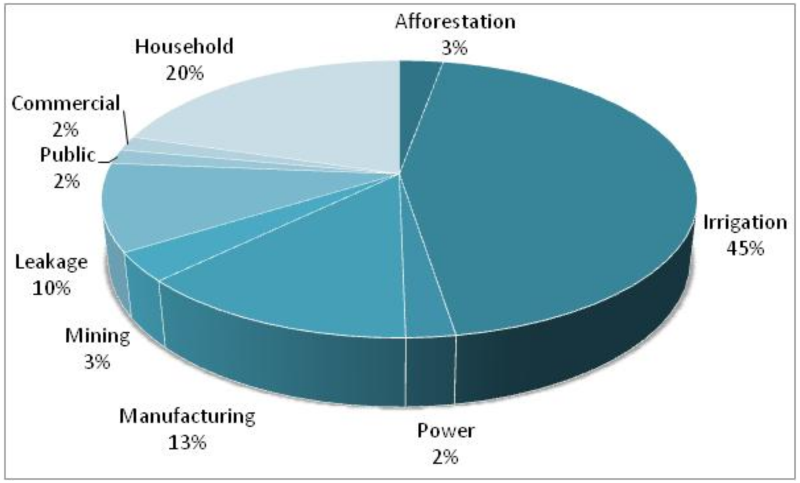
29-30 April 2015

Overview of SA Water

Gap between existing supply and projected[1] demand in 2030,
% of 2030 demand



Source: WRC, DWAF, Statistics South Africa, 2030 Water Resources Group, McKinsey



★ ***2030 projections depict net deficit of 2.7 billion cubic meters. (Estimated supply = 15 billion cubic meters)***

Under plausible climate change scenario, deficit could increase to 3.8 billion cubic meters

Perspective: The basic water requirement to sustain human life is 18.25 cubic meters per year per person.

Executive Summary: Water in SA

- South Africa faces a number of water challenges and concerns including the **security of water supply and water resource pollution** due to increasing usage and impacts from land-based activities.
- **Fresh water (surface) resource are at its limit in most areas**
- Sufficient alternative potential water available through:
  - Improved efficiency & water loss management, re-use, local resource optimisation (groundwater), improved control, resource protection, desalination, transfers, systems optimisation;
- However, accessibility is conditional and at a cost:
  - Requires effort & timeous implementation
  - Spatial challenges (including re-allocation)
  - User/sector viability challenges
  - Water quality & habitat a major concern;
- Need to “stretch” water, funding and infrastructure;
- Major social, economic, environmental risks .

Executive Summary: NWRS 2 Key Messages

- Sectors, including energy, must become strategic partners & commit to effective water-resource planning, management and use
- **Water plays a central role in national planning initiatives, e.g. energy security**
- **Energy sector, including Eskom, highly dependent on reliable supplies of water**
- **Water sector highly dependent on a constant & reliable supply of electricity to move or transfer water**
- Energy production capacity expected to increase as the DOE planning significant investment in new power generation capacity
- **Power stations are located in water-scarce areas & strain available water resources**

Executive Summary: Water in Eskom

- Despite Eskom being classified as a **Strategic Water User** (2% of available water resources) with **high assurance of water supply**, the ability to meet this assurance is at risk due to:
    - **Water usage trends increasing beyond available catchment yields and current capacity limits of the water infrastructure and potential climate change impacts;** and
    - **Practices which reduces the available resource and supply** such as illegal abstraction and use, unaccounted for water losses, dilution of pollution, inefficient water management practices and inadequate infrastructure maintenance.
- Eskom's **license to operate is under pressure** due to:
    - Non-compliance to some water use license conditions;
    - **Increasingly stringent legal requirements imposed by the Regulator on Eskom's operations to prevent pollution and protect water resources**
- **Eskom continues to influence energy policies with other key sustainable development issues, most notably water, agriculture/food, and climate change**

Importance of water to Eskom
Water use and water risks

Water use

Eskom water use:
FY2013: 334 Mm^3/a

Water volume requirements peak in 2021 at 380Mm^3/a

By 2030, water requirements reduce to 275Mm^3/a

Future locality for new power stations:

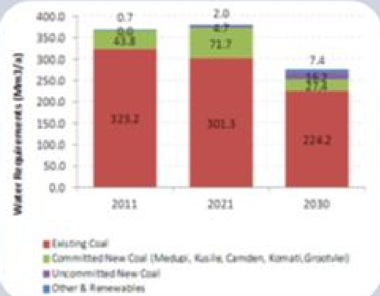
- Coal-fired: Waterberg Soutpansberg, Free State, Mpumalanga
- CSP/Solar – N.Cape
- Nuclear, Wind, OCGT / CCGT – Coast

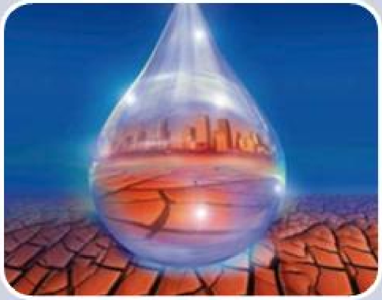
Strategic importance of water:
Current heavy reliance on relatively water intensive, wet cooled power stations

- Produce 78% of MWh
- Consume 98% water

Strategic importance of electricity:
Economic & social development requires reliable and affordable electricity

Build program R340Bn employ 50% locals





Water risks

Medium to long water resource security in question due to –

- Competing interests
- Increasing water demands and growing water deficits
- Illegal water use
- Water losses
- Climate change impacts

Adequate maintenance and reliability of water supply infrastructure

Costly and timely development of new water infrastructure

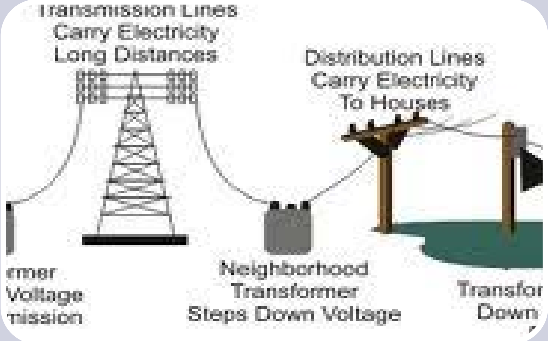
Pollution of water resources will make water unusable or drive up costs of treatment and management of waste

Climate variability will impact on yield of water resources and infrastructure availability at local, catchment and national level

Higher ambient temperatures impacting dry cooled power stations

Higher rainfall impacting on coal supply chain

Eskom value chain: Activities associated with Water Use Licenses



Primary Energy

- Coal mining
- Coal stockpiling
- Tailings dumps
- Pollution control dams

Generation

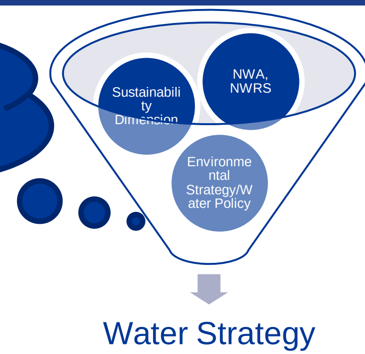
- Coal stockpiling
- Ash dump /dams
- Pollution control dams
- Bulk fuel storage
- Water Treatment Plant
- Chemical storage tanks
- Waste sites

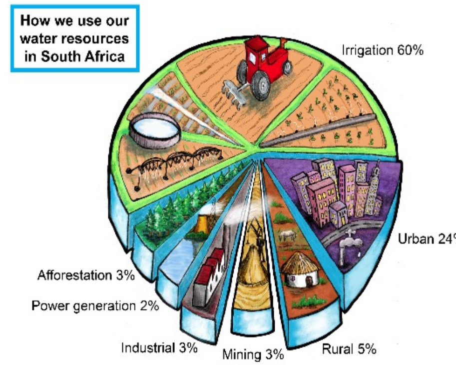
Transmission and distribution

- Bulk fuel handling
- Waste handling
- Chemical handling
- Transformer oils
- Septic tanks

Key strategic issues to address in Eskom's water strategy

Internal & External Analysis of Success and Challenges





Changing legislative requirements

- Implementation of new technology or infrastructure upgrades may be required to comply
- Additional funds could be required or amendments to existing licenses to ensure compliance

Climate Change

- Higher degree of unpredictability in weather patterns
- Impact on planning and ability of the infrastructure to accommodate extreme weather conditions

Lack of CAPEX for some projects

- Water Treatment Plant upgrades, ZLED projects deferred
- Impact on compliance and performance of the plant

Power supply constraints

- Limited opportunity for maintenance
- Impact on compliance and water usage

ESKOM'S WATER STRATEGY

Top 6 Initiatives

1. **Conduct risk assessment of the water supply infrastructure (develop and implement infrastructure health recovery plan)**
2. **Identify and implement alternative least cost solutions to achieve the same environmental objectives and amend licenses where appropriate**
3. **Identify and implement initiatives to improve operational sustainability**
4. Develop and implement Eskom's skills pipeline strategy for water industry
5. Partnership with municipalities and DWS on water sector skills development
6. Develop and implement targeted stakeholder and advocacy plan

Target State
Top 6 Metrics, 31 Mar 2020

Asset sustainability

1. Maintain security of raw water supply at 95% availability

Environmental sustainability

2. Achieve full environmental compliance and reduce legal contraventions

Financial sustainability

3. Implement alternative least cost solutions to achieve operational and environmental objectives

Operational sustainability

4. Where design specifications cannot be met achieve operational efficiency (Reduce raw water consumption to 1.34)

Eskom’s 6 point plan on climate change

Eskom

- **Diversification** of the generation mix to lower carbon emitting technologies
- **Energy efficiency** measures to reduce demand and greenhouse gas and other emissions
- **Innovation** through research, demonstration and development
- **Investment** through carbon market mechanisms
- **Adaptation** to the negative impacts of climate change
- **Progress** through advocacy, partnerships and collaboration

South Africa’s Integrated Resource Plan

- The IRP multi-criteria decision making process represented an appropriate balance taking the following into account:

  a) Reducing carbon emissions;

  b) New technology uncertainties such as costs, operability, lead time to build etc;

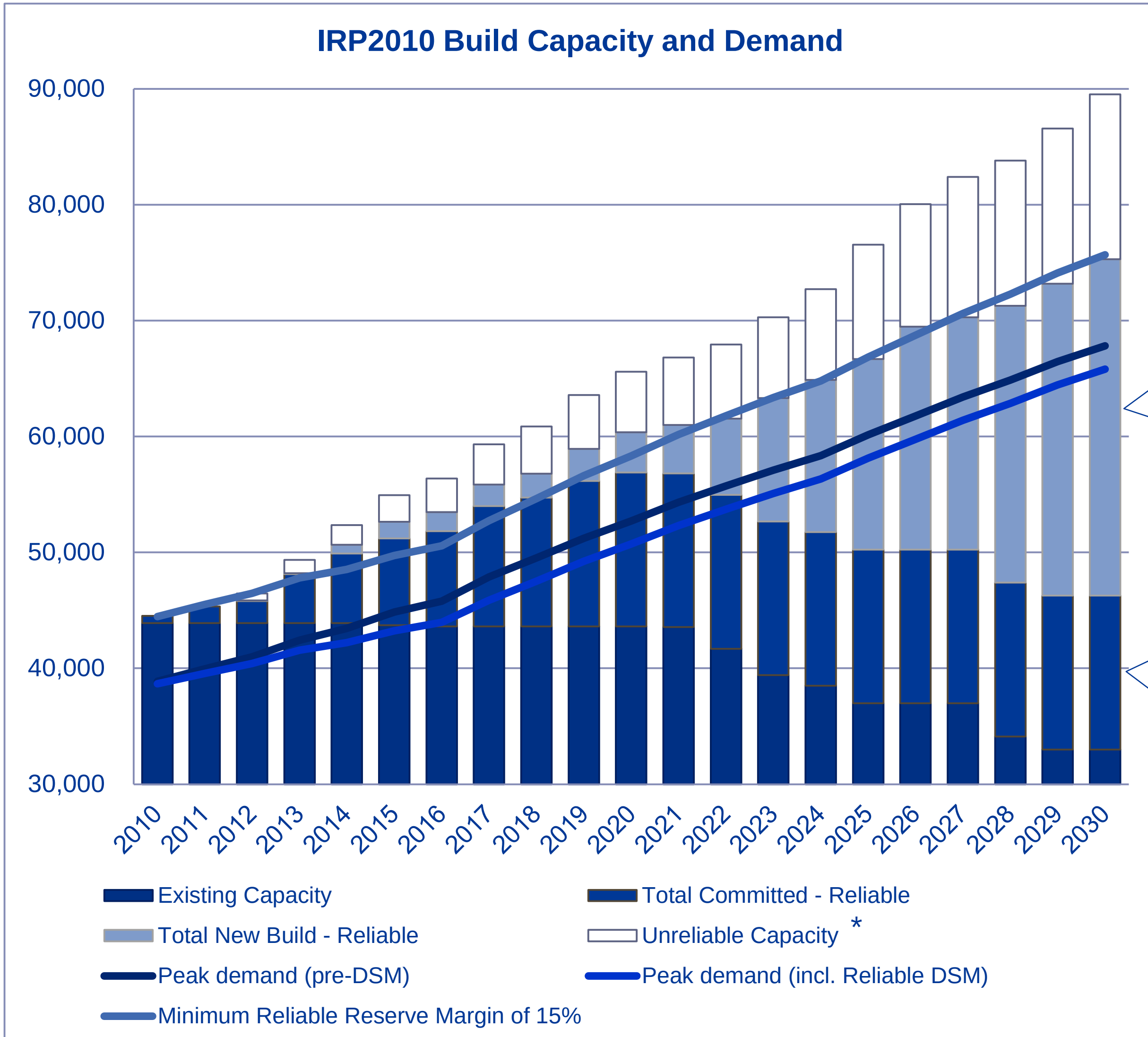
  c) Water usage;

  d) Localisation and job creation;

  e) Southern African regional development and integration; and

  f) Security of supply

These projects are scheduled to fulfil growing demand for electricity over the next 30 years while maintaining the required reserve margin



New Build Options

1. Coal (PF, FBC, Imports)
2. Gas CCGT (natural gas)
3. OCGT (diesel)
4. Import Hydro
5. Wind
6. Solar PV
7. CSP
8. Nuclear

Committed Projects

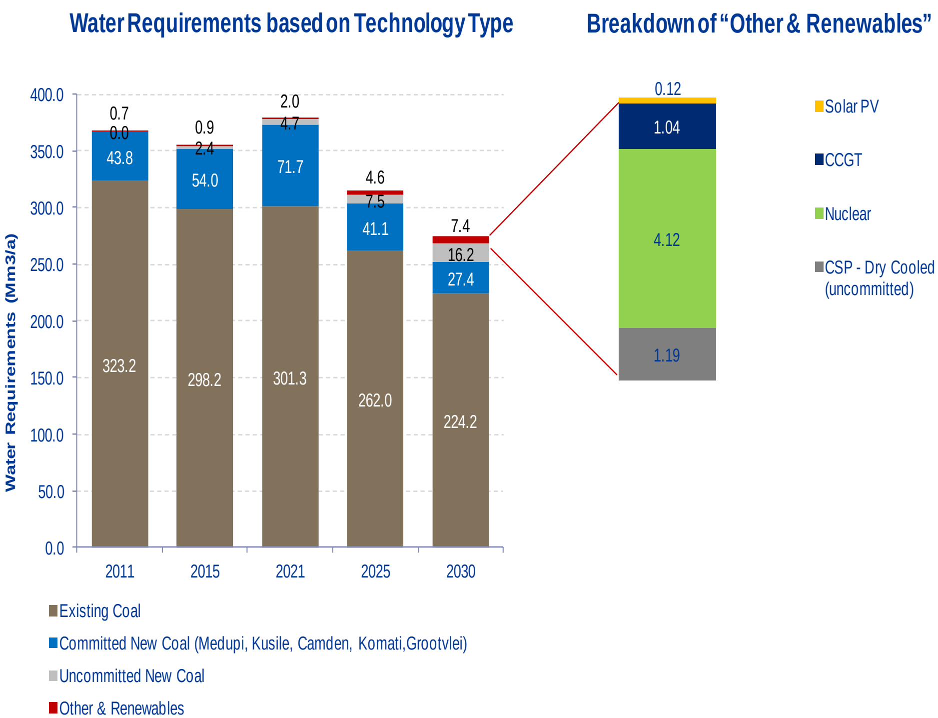
1. RTS Capacity (coal)
2. Medupi (coal)
3. Kusile (coal)
4. Ingula (pumped storage)
5. DOE OCGT IPP (diesel)
6. Co-generation, own build
7. Wind
8. CSP
9. Landfill, hydro
10. Sere (wind)

* Additional capacity if not reduced for reliable load factor ratings (e.g. Wind 30%, Solar PV 15%, Solar CSP 50%)

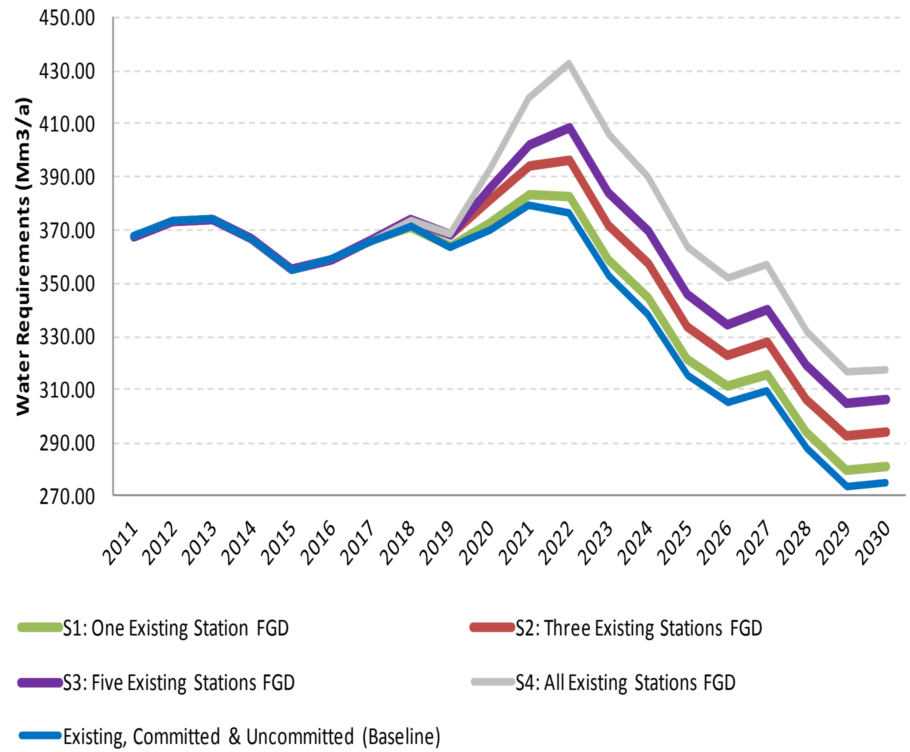
IRP 2010 projections will be significantly affected by Generation and Emission Abatement Technologies

Eskom

IRP 2010 Water Requirements based on Technology Type



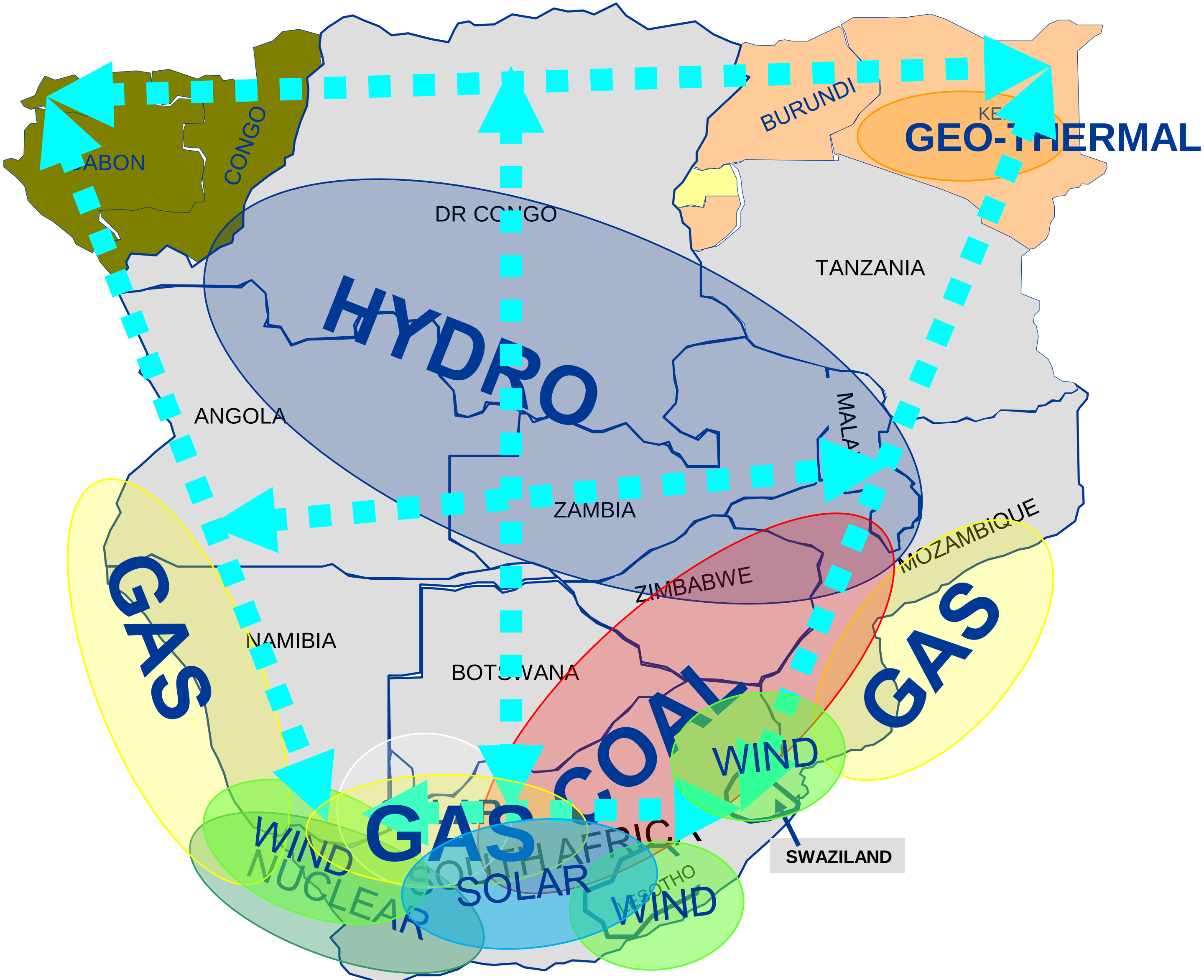
Future Water Demand FGD Scenarios Modelled



Water consumption will increase as flue gases are required to be scrubbed to a higher purity and power station efficiency is reduced. Carbon Capture and Storage would increase water volumes by between ~30% and 100%. Power station locations might be affected by the availability of geological formations to sequester CO_2.

1923-2013

Potential Energy Future – 2050!



The picture on electricity generation is mixed:

- Irrigated first-generation soy- and corn-based biofuels can consume thousands of times more water than traditional oil drilling, primarily through irrigation.

- Among conventional power plants, **gas-fired plants consume the least amount of water per unit of energy produced**. **Coal- and oil-fired plants consume roughly twice as much water as gas-fired plants**. **Nuclear consumes approximately three times as much (higher water withdrawals)**

- **Wind and solar photovoltaic electricity consume minimal water** and are the most water efficient forms of conventional or alternative electricity production, primarily when they are cleaned.

- The installed base of the solar thermal form of electricity generation (as opposed to photovoltaic) consumes twice as much water as coal and five times as much as gas-fired power plants.

The picture on electricity generation is mixed:

- **Natural gas produced by a technique called hydraulic fracturing is a game-changer that could alter the entire energy mix of transportation fuels and electricity generation**. The main water issue here involves pollution; however, additional research is needed on consumption

- **Carbon reduction technologies have vastly different water impacts**.

- One of the "cleaner" coal technologies, the integrated gasification combined cycle process, reduces a coal plant's water consumption by half, while also reducing carbon emissions and other pollutants.

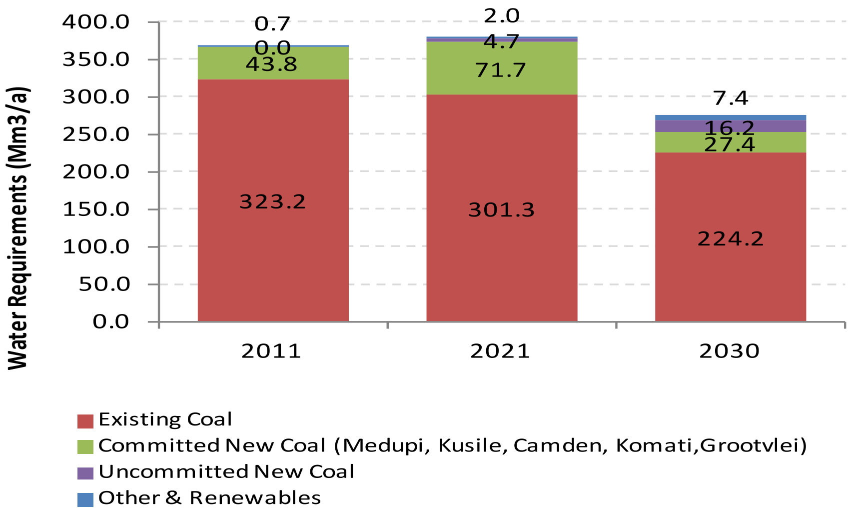
- **Carbon capture technologies could increase a coal plant's water consumption by 30%-100%.**

- Oil and natural gas are also becoming more water consumptive.

Water Requirements based on the Policy Adjusted IRP 2010 Projected to peak in 2021 with significant demand in the Waterberg and Mpumalanga

Water Requirements Modelling

Projected Future Water Requirements



Water Demand Projection:

•Water volume requirements peak in 2021 at 380Mm^3

•By 2030, water requirements reduce to 275Mm^3 (mostly due to decommissioning of existing coal)

Scenarios: Compared to the Baseline, 2030 water requirements will increase by:

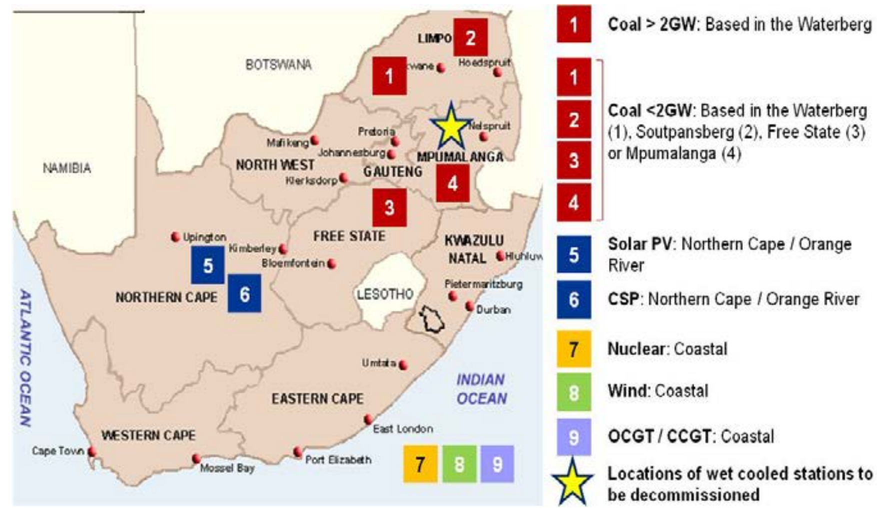
•23Mm^3 - if coal replaces new nuclear capacity and FGD retrofitted on new coal power stations

•43Mm^3 - if Coal power stations are decommissioned and FGD is required on existing, committed and uncommitted fleet

•174Mm^3 - if there is no decommissioning, and FGD is required on all existing and new coal.

Location Impacts

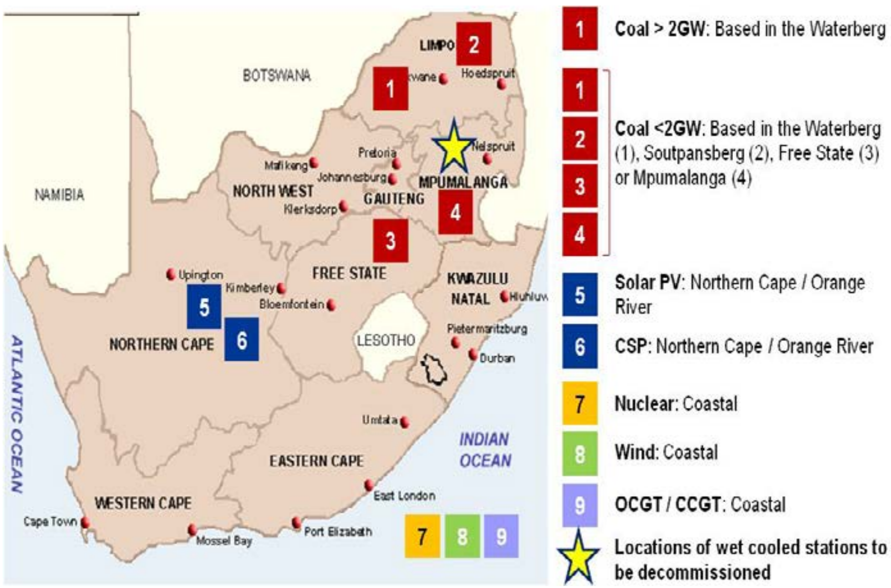
Potential locations of planned new capacity



The following factors influence the future locality for new power station:

- Large coal-fired power station will most likely be developed in the Waterberg & smaller coal-fired power stations developed in Waterberg, Soutpansberg, Free State or Mpumpalanga due to the size of respective coal deposits in these locations.
- CSP/Solar power stations will probably be established in the Northern Cape due to availability of high solar irradiation
- Nuclear, OCGT and CCGT will probably be located at the coast due to lack of large available inland water resources and most fuel will be required to be imported.
- Wind will probably be on the coast due to wind availability

Coal Power Generation location and future coal and power station planning



Coal mining location and Water Catchment Impacts

- Large coal-fired power stations will likely be developed in the Waterberg & smaller coal-fired power stations developed in Waterberg, Soutpansberg, Free State or Mpumalanga.
- Decommissioning of older stations in the Olifants Catchment could make additional water available from 2023 for other uses, including mining.
- Limpopo and Mokolo systems are strained and needs water transferred in via an inter-basin transfer system.

Water use assumptions

Limpopo

- Water use for coal mining in the Limpopo is significantly higher than for Mpumalanga due to the coal, lower rainfall and increased evaporation losses. Water requirements for a mine of 16 Mt/a required for a Medupi Power Station will require up to 6 Mm^3/a to mine and wash coal. Similarly a mine of 10 Mt/a will require up to 4 Mm^3/a to mine and wash coal.

Mpumalanga

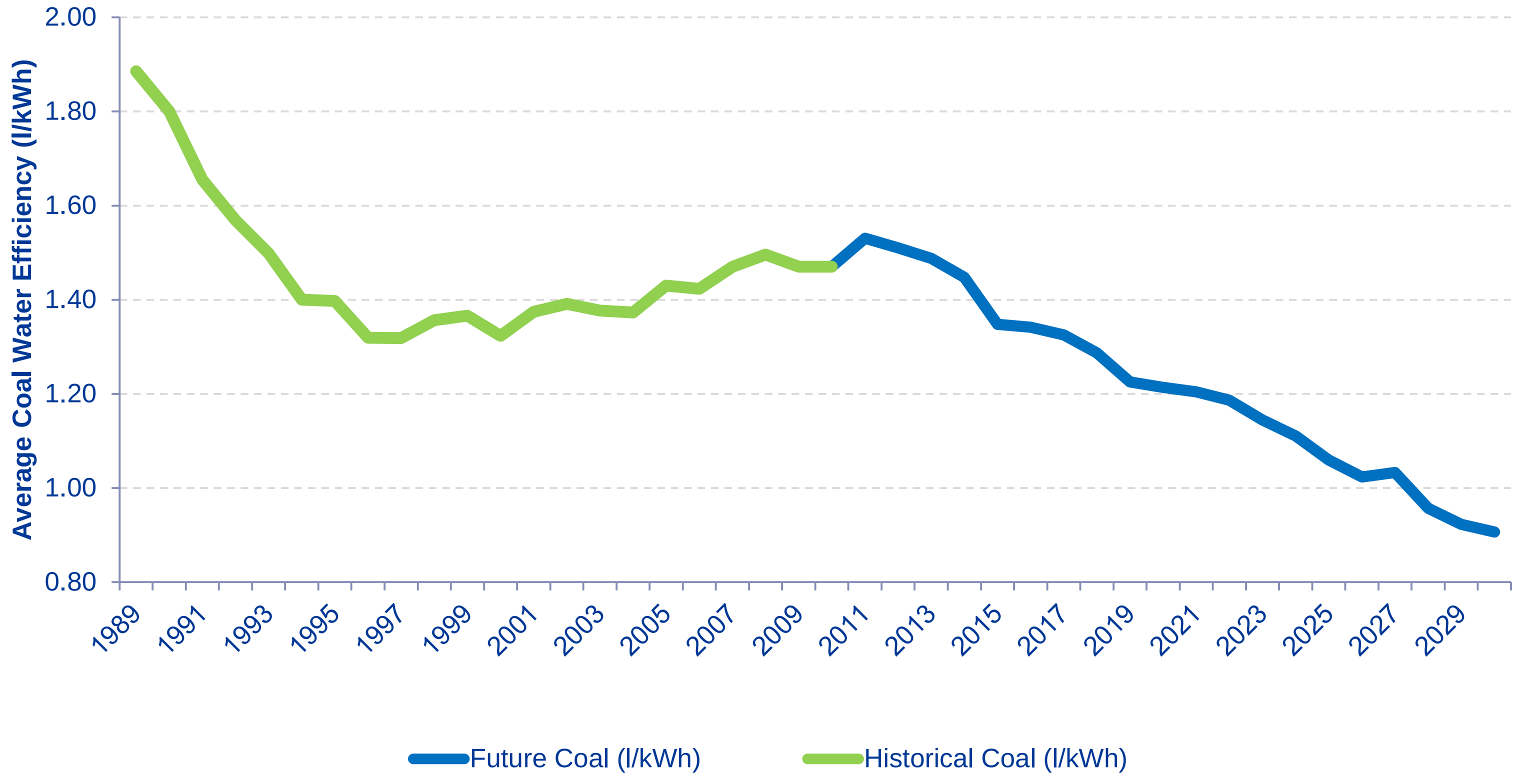
- Coal mines in this area generally have a small water use on start-up but once even moderate excavation depths are reached, there is excess water in the mine which has to pumped out. According to Coleman (2011), water use by these mines are reducing over time.
- With regard to future mining activities, Gunther (2011) reiterates that coal mines in the upper Olifants catchment suffer from excess water and hence the water requirements of the coal mining sector is decreasing and not increasing.

Different generation technologies have varying water use consumption rates

	Technology	Water (l/MWh) (l/MWh)	CO2 Emissions (kg/MWh)	LCOE (ZAR/MWh)	LCOE (ZAR/MWh)
COAL	Sub-Critical Dry Cooled + Dry Ashing [3]	129	995	12	
	Super-Critical PF (SCPF) [1]	94	852	538	522-553
	Super Critical PF + Wet FGD [1]	281	869	612	591-632
	Super Critical PF + Semi-Dry FGD [1]	219	864	673	
	SCPF + Wet-FGD + Amine CCS [1]	308	122	1,046	
	Sub-Critical CFB + Sorbent [1]	98	883	570	552-587
	Super-Critical CFB + Sorbent [1]	96	871	558	
	Sub-Critical CFB + Sorbent + Amine CCS [1]	138	125	974	
	Super-Critical CFB + Sorbent + Amine CCS [1]	136	123	954	586-621
GAS	OCGT [3]	20	835	1,397	1,397
	IGCC [2]	115	820	713	686-740
	CCGT [2]	22	384	460	460
	IGCC + CCS [2]	554	252	753	
	UCG [2]	126	708	391	357-425
	UCG + CCS [2]	571	282	433	
	Nuclear [2] (Excl. seawater cooling)	50	-	825	811-839
REN	Wind [2]	-	-	903	754-1052
	Solar - Parabolic Trough [2]	270	-	2,023	1945-2101
	Solar - Central Reciever [2]	315	-	1,617	1570-1663
	Pumped Storage Scheme	850	-		

Source:
1) EPRI Clean Coal Technology Roadmap for South Africa (2007)
2) EPRI Power Generation Technology Dat for Integrated Resource Plan of South Africa (2010)
3) Based on Eskom Existing Fleet Data

IRP 2010 (Policy Adjusted) Coal Water Use Efficiency Projection

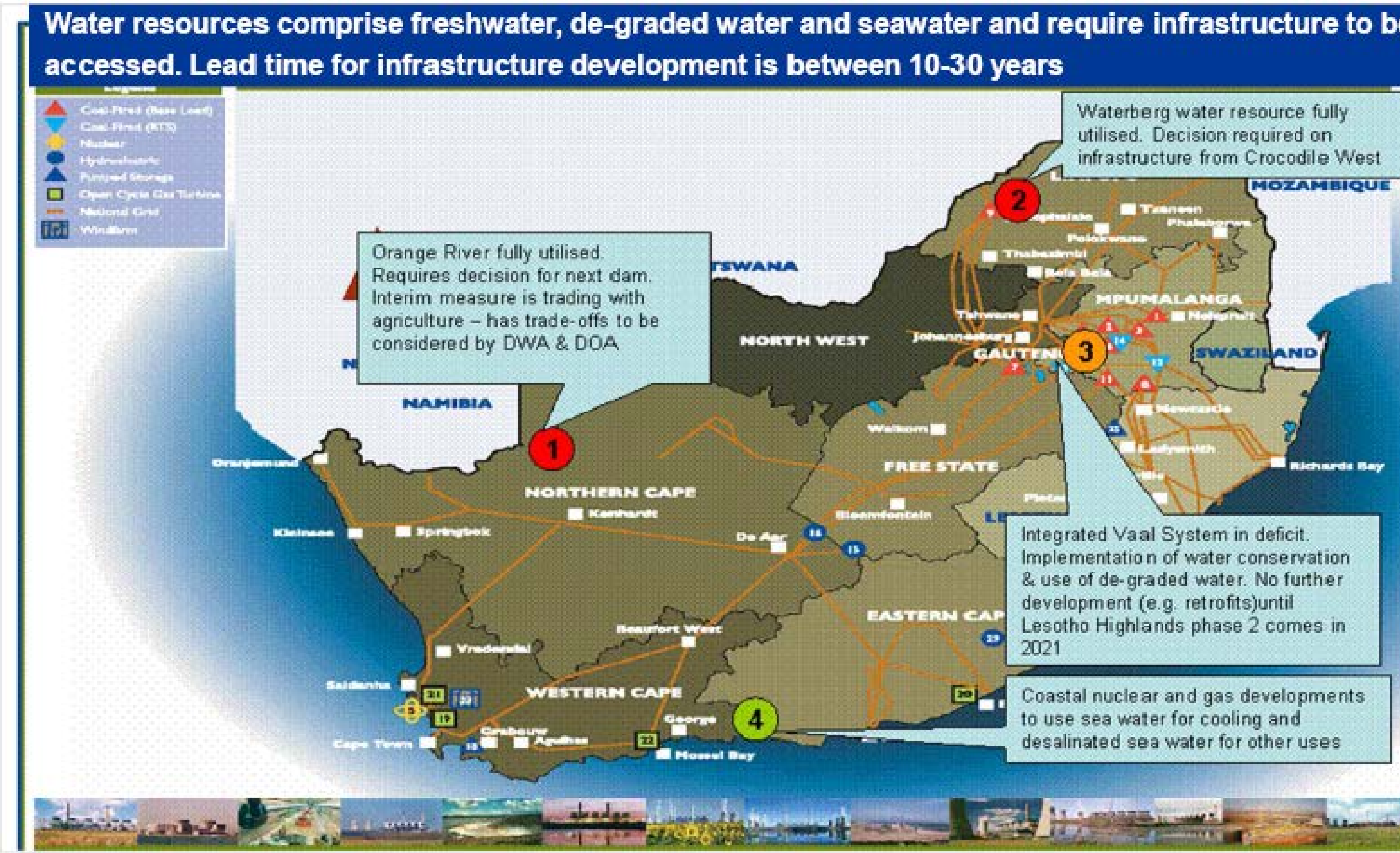


ESKOM has already reduced overall specific water consumption from 2.85 L/kWh in 1980 to 1.35 l/kWh in 2011 and expects to further reduce it to 1.34 l/kWh by 2020

Strategic Assessment on potential water related scenarios and IRP

- Future energy mix will determine the future water requirements going forward
- The siting of power plants in relation to the availability of water for power generation and associated primary energy developments are expected to become major issues
- Siting of power generation plant at the coast: waste water use, use of sea water desalination and sea water for once through cooling
- Emission abatement technologies such as Flue Gas Desulphurisation and Carbon Capture Storage increases water demand considerably when applied to power stations.
- The Energy Plans are not technology or site specific to provide adequate information for long term national water planning. The Integrated Resource Plan 2010 published by DoE has made a lot of strides in closing this gap by identifying possible future technologies. Key considerations:
  - Life extensions of existing power stations
  - Choice of main cooling technology: Dry vs Wet; Eskom vs IPPs
  - Lead times for major augmentation (inter-basin transfer) schemes – 10 years
  - Emissions abatement technologies requiring water
- Water efficient technology choices need to be incorporated into the IRP

Future power station developments will be constrained by the availability of and accessibility to water resources



Water projects to support Eskom operations

- Mokolo and Crocodile Water Augmentation Project (Phase 1 & 2) Limpopo SIP 1: Unlocking the northern mineral belt with Waterberg as catalyst:
  - Construction of augmentation scheme for domestic and industrial water supplies to the new Eskom / IPP power station(s) and associated mining activities and fast growing population in the Lephalale area
- Vaal River Eastern Sub-System Augmentation Project
  - Augments supplies to Eskom, Sasol & other strategic users in Mpumalanga Highveld
- Komati Water Scheme Augmentation Project
  - Alternative water supply from Vaal River to Eskom's Duvha Power Station due to pollution of Witbank Dam and allocation of Inkomati catchment water to other power stations
- Kriel-Matla Regional Mine Water Treatment Plant
  - Regional mine water treatment and re-use facility between coal mines and power stations in the Olifants Catchment. Project currently in feasibility phase

There are environmental, economic, social and technical requirements and therefore trade offs that need to be taken into account - example …

- **Technical:**
  - Energy availability
  - Dispatch ability
  - Security of supply
  - Time to construction
  - Ops and maintenance
- **Social**
  - Affordability
  - Accessibility
  - Reliability
  - Health
  - Job creation
- **Environmental:**
  - Access to energy resources (coal, solar, gas, wind, hydro, oil, uranium)
  - Water usage
  - Emissions (air pollution and CO2)
  - Resource utilisation (renewable and non-renewable)
  - Land use and biodiversity
  - Waste generation
- **Economic**
  - Cost (Capex and Opex)
  - Externalities (+ve and –ve)
  - Localisation – job creation and contribution to GDP

Identification of opportunities and constraints, but first the legislative framework of the country needs to be taken into account

Then the Legal Framework in which Eskom Operates

Constitution Of The Republic Of South Africa Act No. 108 Of 1996

National Environmental Management (NEM) Act

National Water Act

NEM: Air Quality Act

NEM: Biodiversity Act

NEM: Waste Act

Conditions of environmental approvals

Integrated Resource {Plan (IRP)

Regulators

- DoE
- NERSA
- DAFF
- Provinces
- DEA
- DWS
- DMR
- NNR

Climate Change Response Strategy: Policy Directives

List of Policy Directives as guided by the desired South African climate change mitigation outcome:

- National Climate Change Response White Paper, 2011
- The Integrated Resource Plan 2010 for Electricity Generation (IRP) and its draft update November 2013
- The Draft Integrated Energy plan (IEP), 2014/15
- Use of market-based policy measures to drive the diversification of SA's energy mix
- Introduction of the Feed-in-tariff for renewable energy;
- Introduction of the of the carbon tax policy,
- Tax on electricity from non-renewable sources and tax on fuel inefficient vehicles;
- Solar water heater subsidy.
- DEA's Mitigation Potential Analysis to promote the concept of *defining* ***Desired Emission Reductions Potential for sectors across South Africa.***

The impact of deteriorating water quality

Eskom

Water quality is deteriorating in certain catchments, for example Witbank Dam (Olifants River)

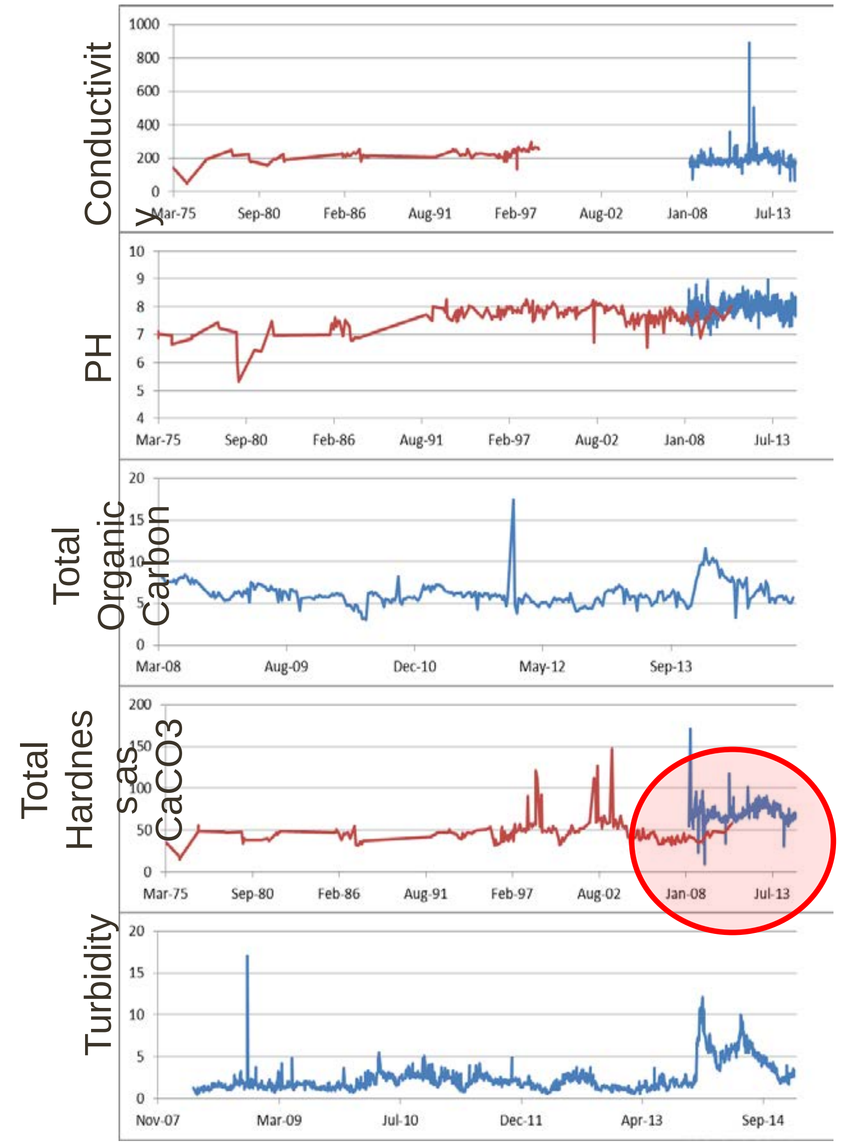
Implications:

Poor water quality impacts power stations by increasing cost to power stations and other users because of need to build purification technologies on site. Desalination plants can increase water costs by R10 to R20 per megalitre (excluding brine disposal).

With deteriorating water quality, additionally effluent would need to be managed on the power station site, potentially moving towards violation of ZLED license conditions.

At Duvha Power station a diversion pipeline was constructed to bypass the polluted areas of the Olifants river system at a cost of R1.5 Bn

Poor water quality has similar impacts on other productive sectors of the economy, reducing productivity and profitability of those enterprises. This cumulative effect is damaging to the economy.

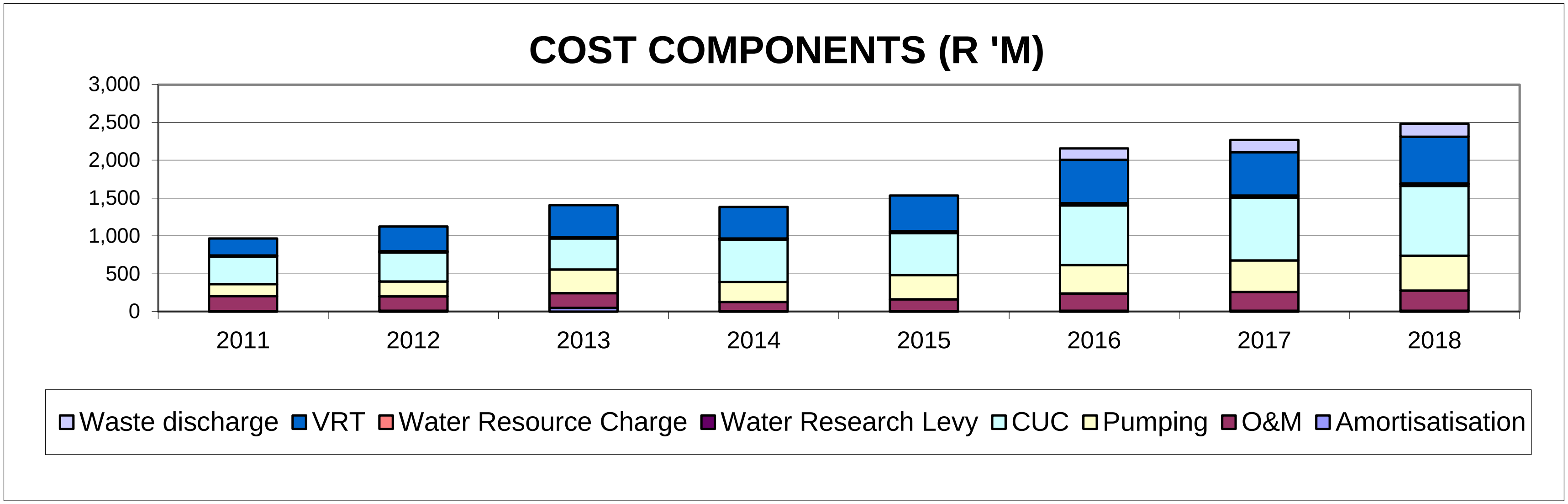


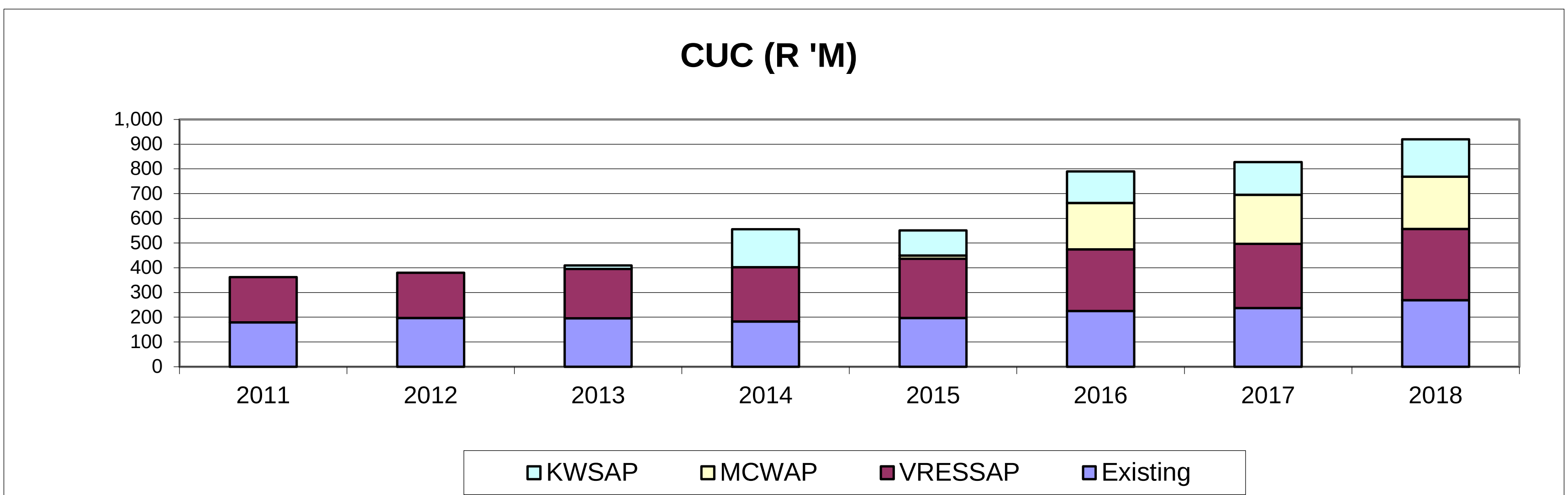
National Water Pricing Strategy

- Components of Water Tariff
  - Capital Unit Charge:
    - Capital redemption (off-budget funding)
      - To recover costs to pay new assets
    - Return on Assets and Depreciation (paid off assets)
      - Increases by PPI + 10% to allow for revaluing of DWA existing assets
  - Statutory levies
    - Volume related and increase drastically as Eskom demand grows
      - Water resource management charges
      - Water research Commission Levy
      - *Waste Discharge Charge (Polluter Pays principle)*
  - Operations and maintenance costs (pass through)
    - Operations and maintenance based on actual cost as per water supply contracts (zero based budgeting)
    - More energy is consumed to support increased transfers
    - Additional pumping and transfers are required to meet the increased water demand.
    - Increase in electricity tariff also contributes to this increase (35% increase in tariff).

- Note: CUC charges are not applicable where Eskom or other party owns the infrastructure. Most assets in this category have been paid up many years ago.

The water costs increases to Eskom are driven by capital infrastructure charges, including new infrastructure developed by DWS





Water cost risks to Eskom

- **Revised National Water Pricing Strategy (under review)**
  - The price of water does not reflect its quality or scarcity value
  - No major changes to water pricing, but does include additional water management charges, i.e. CMA, WDCS, and additional charges associated with higher assurance of supply.
  - DWS is in the process of instituting Waste Discharge Charge System – polluter pays principle.
- **The economic cost of NOT investing in water infrastructure and the cost of REGRET will be substantially higher than current water costs**
- **Cost of water will increase due to:**
  - Energy costs due to increasing electricity prices (new energy developments, climate change mitigation technologies, carbon taxes etc.)
  - Energy intensity of water treatment and supply infrastructure
  - Development and implementation of new major water augmentation schemes
  - Desalination of sea water or waste water treatment facilities
  - Water and waste treatment infrastructure required to treat declining water quality
  - Climate change related risks and adaptation costs

Eskom strategies for dealing with water allocation challenges

- Diversifying its energy mix (nuclear, gas, renewable energy), intensifying Energy Efficiency and Demand Side Management, Water Conservation and Water Demand Management, diversifying its water mix (effluent and waste water reuse) thus reducing Eskom's reliance on freshwater and thus reducing its water footprint

- Improving water use efficiency and zero waste in existing operations. Eskom has committed to dry cooling inland and sea water cooling for coastal power stations, more water efficient generation processes and technologies

- The demand for water would be increased due to the choice of air pollution abatement measures and there is scope for research and development for alternative, less water-intensive technologies to be investigated

- Desalination of seawater could provide an unlimited source of water, especially to coastal areas. The sustainability of desalination projects could be advanced if implemented in a carbon neutral manner by developing desalination projects in parallel with nuclear and renewable energy projects

- Ensure DWS water planning process and DEA's environmental requirements are integrated with the Eskom build program and DoE's energy planning leading to timely investments and delivery of water supply and treatment infrastructure

Thank you