Can Water Constrain Our Energy Future? - Preliminary Results from South Africa

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WATER PARTNERSHIP PROGRAM

ESMAP Energy Sector Management Assistance Program

Korea Green Growth Partnership

WORLD BANK GROUP

Thirsty Energy Case Study in South Africa

- The World Bank has partnered with the Energy Research Center (ERC) of the University of Cape Town to incorporate water constraints in their energy planning tools.

- The ERC has developed and maintained an least cost optimization energy systems model for South Africa on the TIMES/MARKAL platform called SATIM. (http://www.erc.uct.ac.za/Research/esystems-group-satim.htm)

- Before this project water was only represented and tracked in SATIM as a commodity. Its cost and regional aspect was not reflected at all.

- The World Bank's Thirty Energy initiative in South Africa has completed the development of an integrated energy-water model and preliminary results have been produced and will be briefly discussed in this presentation.

Water-Energy Planning in South Africa

Department of Energy

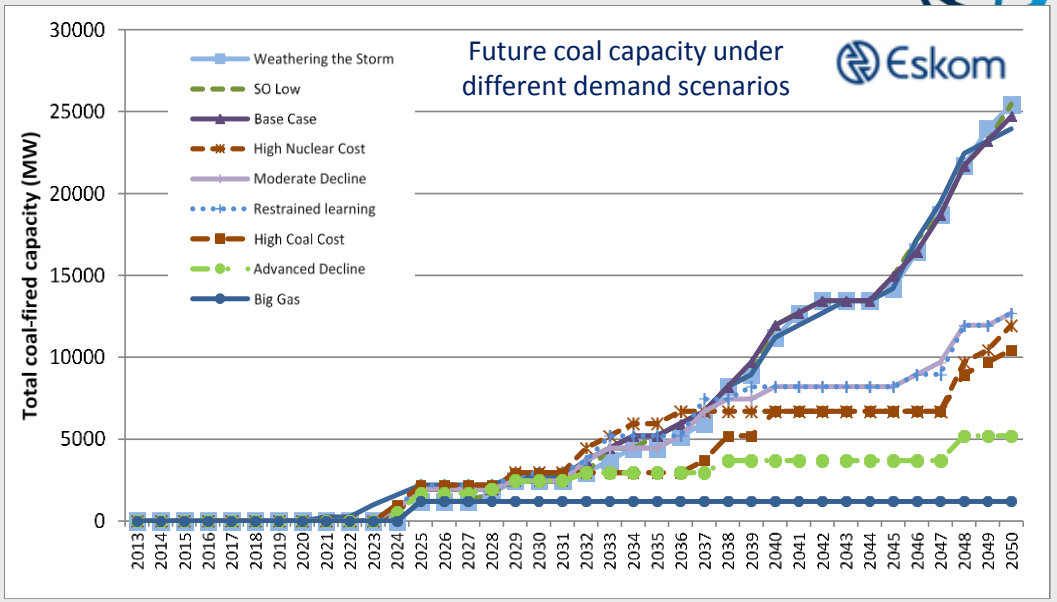
- Energy planning conducted at the national level
- *Integrated Energy Plan*
- *Integrated Resource Plan* (Eskom)

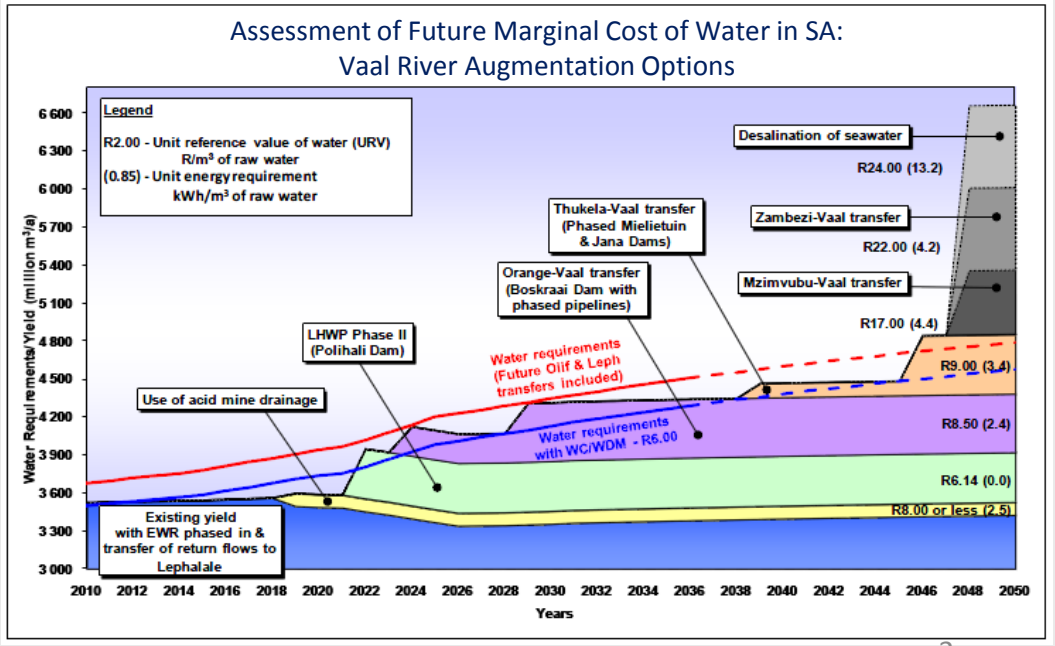
Department of Water and Sanitation

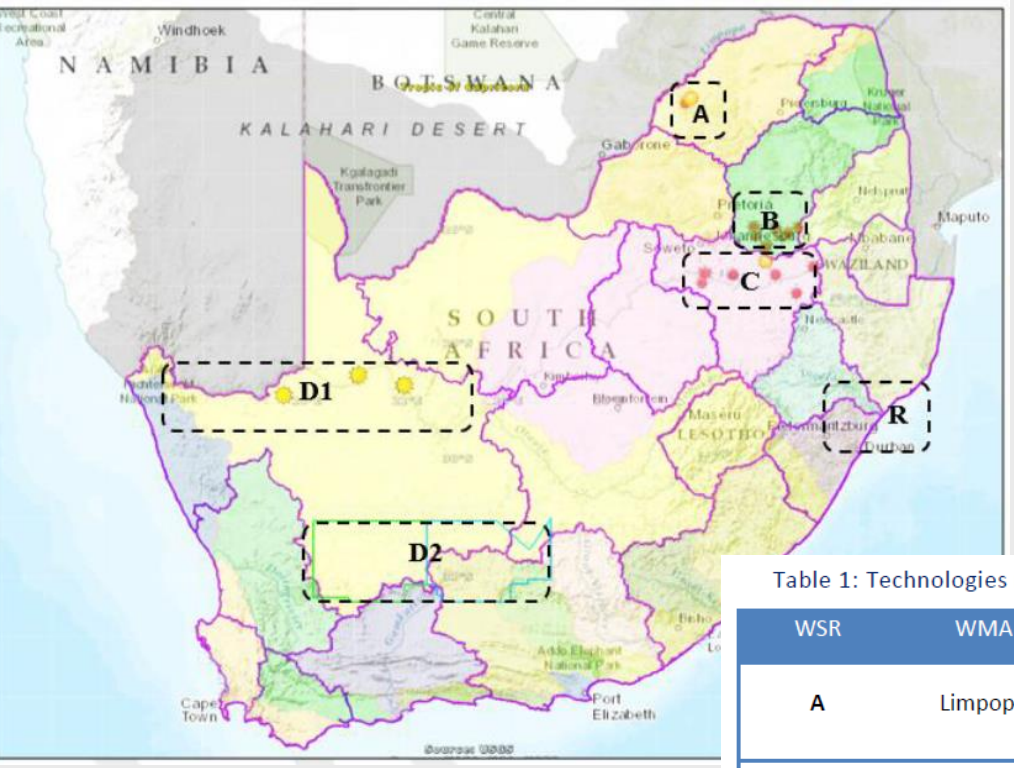
- Water planning conducted regionally with different scenarios of future water demands
- *Assessment of Future Marginal Cost of Water in SA*

Separate studies may not capture the full water-energy linkage.

SATIM-W is addressing this shortcoming by integrating the water and energy supply chains from source to end-use.







Developing the SATIM-Water Model:

1. Matching energy producing regions with water resource areas (WMAs) in South Africa

Need to "geo-reference" somehow the power plants and energy facilities in order to regionally constraint the amount of water available :

by assigning the different power plants and energy extraction locations to their basin

Table 1: Technologies represented in SATIM-W for Phase 1 implementation by water supply system.

WSR	WMA	Region	Activity
A	Limpopo	Lephalale	• Open-cast coal mining • Coal thermal power plants with FGD option • Coal-to-Liquids refineries
B	Olifants	Mpumalanga, Witbank	• Open-cast & underground coal mining • Coal thermal power plants with FGD option. • Coal-to-Liquids refineries
C	Upper Vaal	Mpumalanga, Secunda	• Open-cast & underground coal mining • Coal thermal power plants with FDG option • Inland gas thermal power plants • Inland Gas-to-Liquids refineries
D1	Lower Orange	Northern Cape, Upington	• Concentrated Solar Thermal Power Plants (CSP)
D2	Lower/Upper Orange	Northern Cape, Karoo	• Shale gas mining • Gas thermal power plants • Inland gas-to-liquids refineries
R	n/a	Richards Bay Coal Export Terminal	• Coastal open-cycle coal power plants with seawater cooling and seawater FGD option

In SATIM-W the cooling systems for thermal power plants may be either closed-cycle wet-cooled or direct dry-cooled. The model is free to choose the cooling type, except for open-cycle wet-cooled plants which are restricted to the coastal region, as part of determining the least-cost energy-water integrated system.

Opportunities to Explore Key Policy Questions

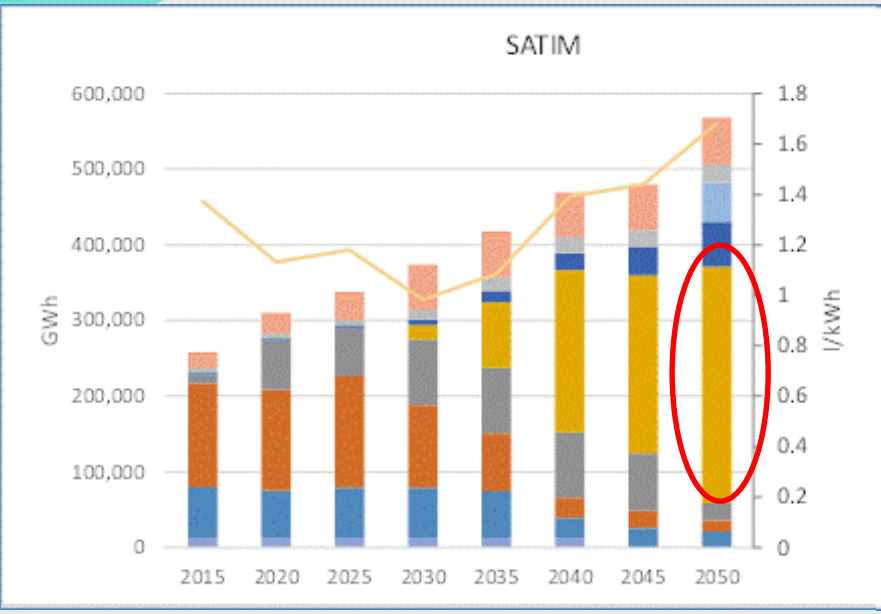
So far for Phase 1:

1. **Is Eskom's Current Dry-Cooling Coal Generation Policy Economically Justified?**
2. **How do stricter environmental controls impact coal investments in the Waterberg?**
3. **What is the impact of requiring power stations to retrofit FGD?**
4. **How does accounting for the cost of water impact shale gas production?**
5. **In a carbon constrained world, what is the likelihood of stranded assets?**

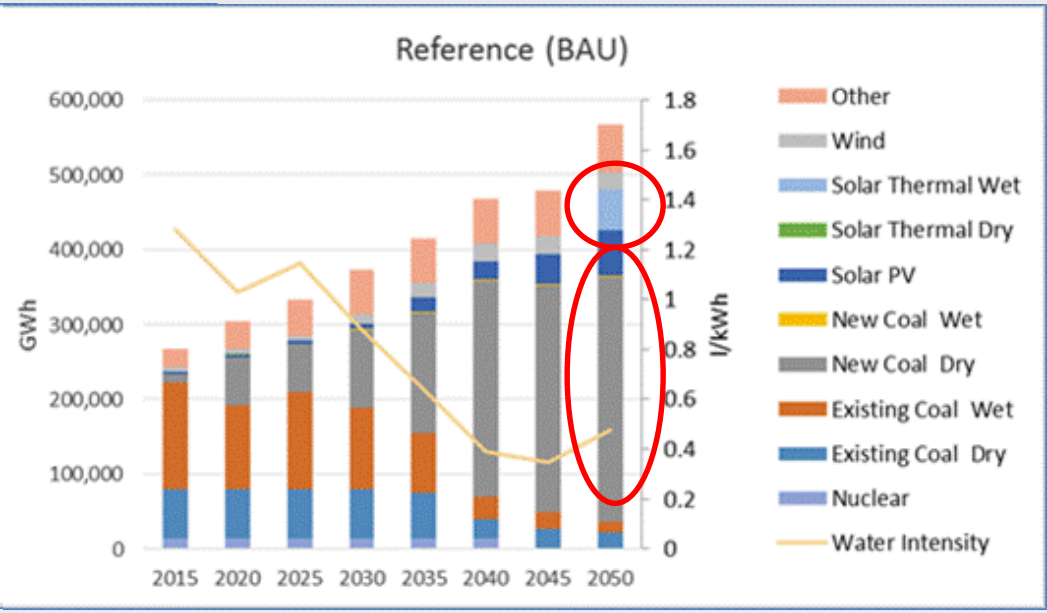
   5(a) Is Solar capacity expansion water constrained?
6. **How does climate change alter regional energy investment decisions?**

1. Is Eskom's Current Dry-Cooling Coal Generation Policy Economically Justified?

Water not Costed



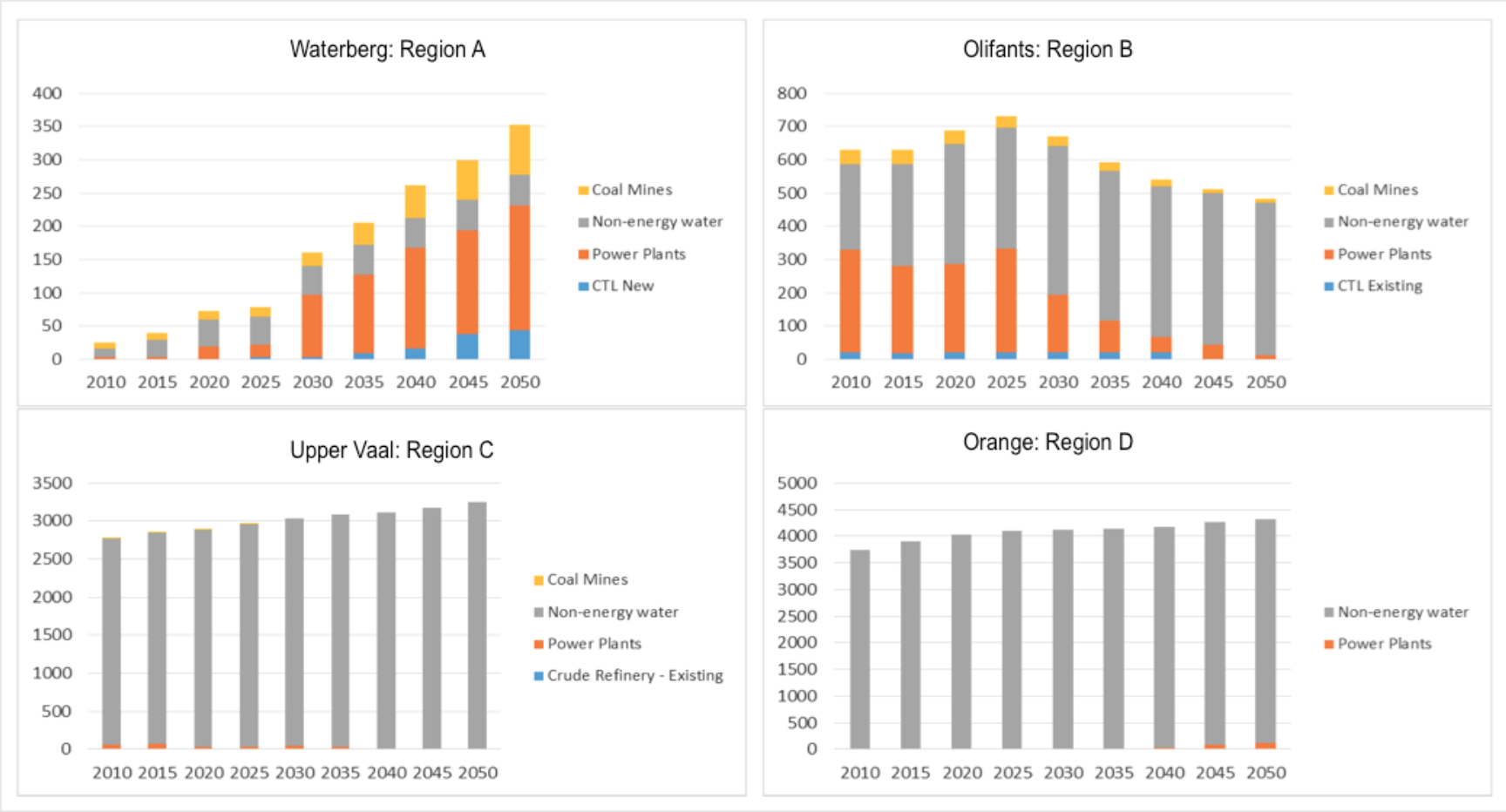
Water Costed



- When water is costed in a least cost optimisation planning model dry cooling replaces wet cooling for coal power despite efficiency penalties.
- Water intensity drops to a quarter of the 'no water cost' 2050 level.
- Why is the model choosing wet cooled Solar Thermal though?

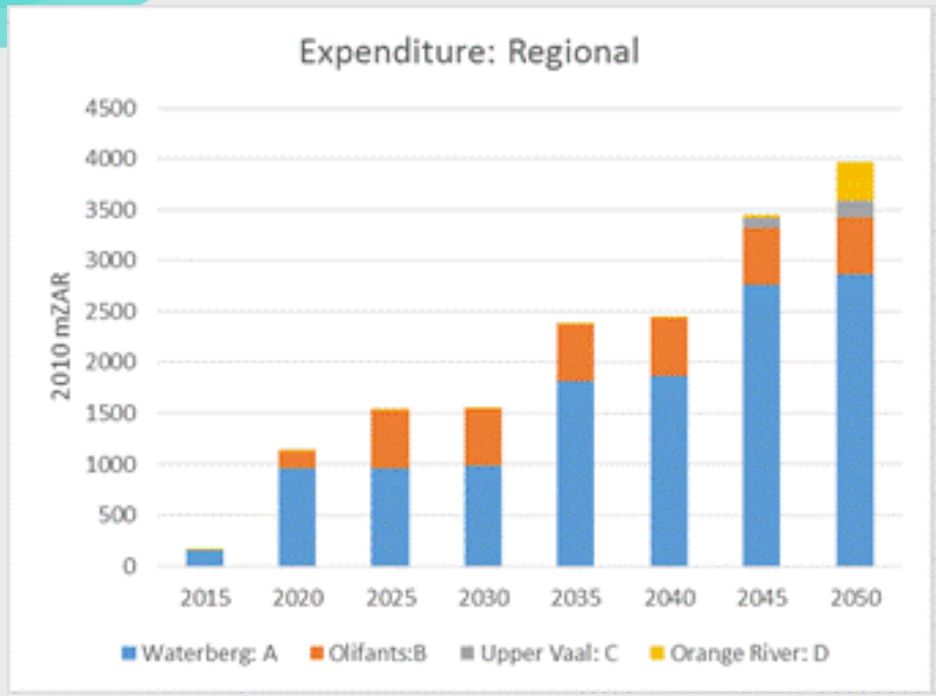
1. Regional Water Demand

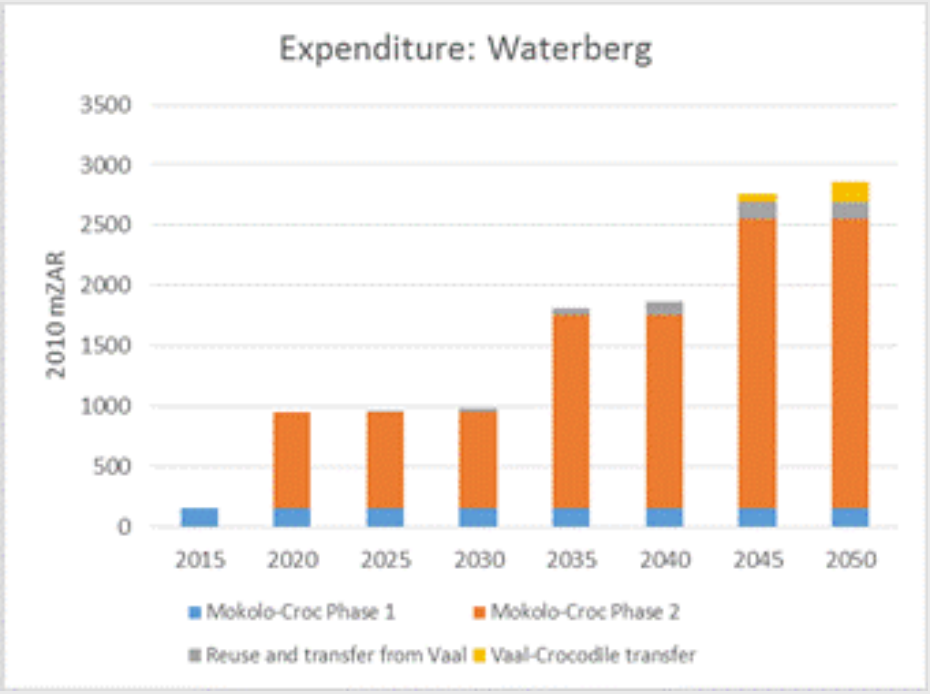
- **The Waterberg (Region A) is the region more exposed to the water-energy nexus.** Non-energy water demands dominate the other regions. In the Olifants region, water needs for the energy sector shrink substantially as existing power plants retire.



Water consumption (Mm3) by region

1. Regional Water Infrastructure Expenditure (Ref. Case)

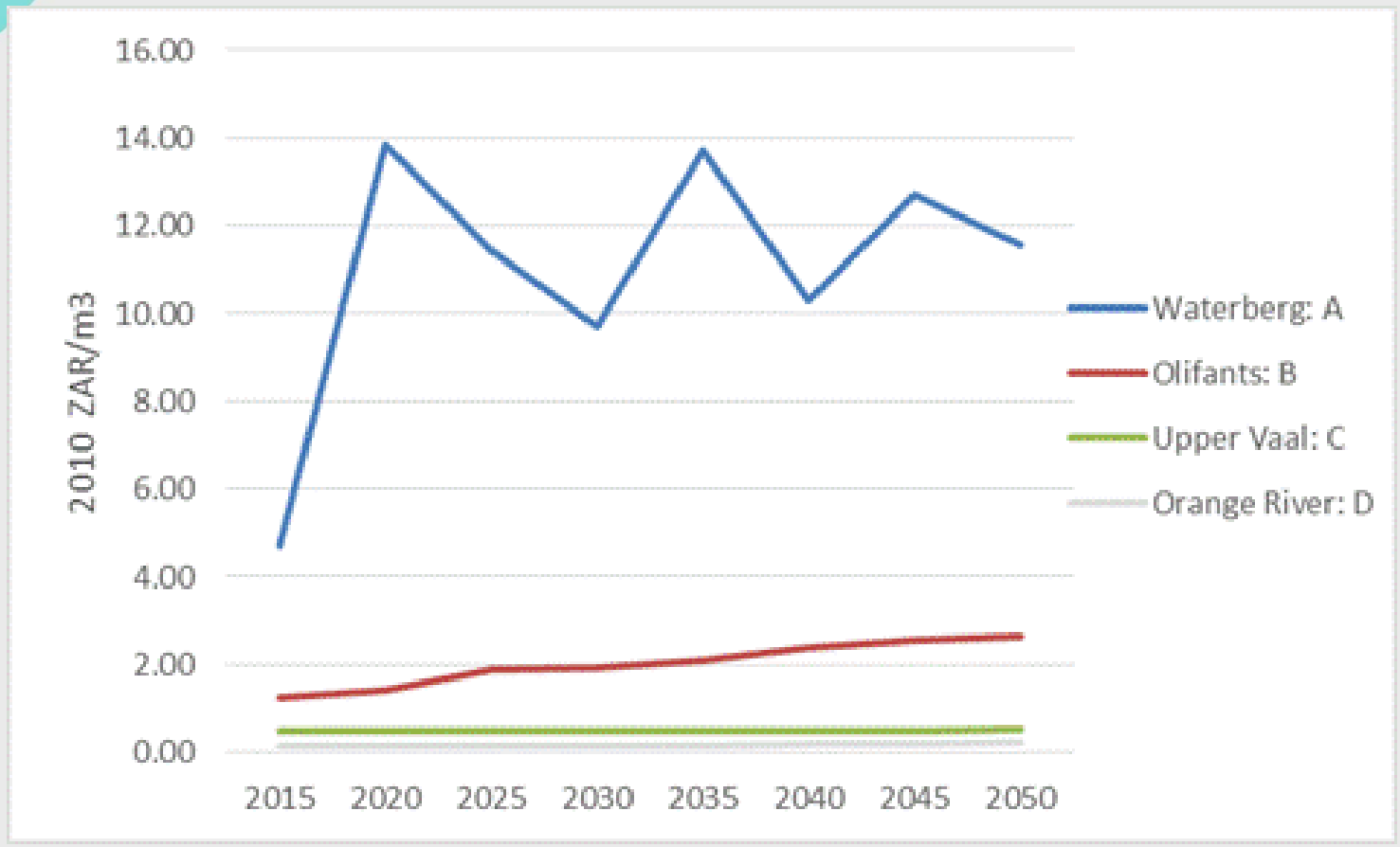




Annual Investment in Water Supply Infrastructure

- Even with dry-cooling coal generation expansion in the Waterberg requires high expenditure and drives up the regional cost of water.

1. Regional Water Supply Costs (Ref. Case)

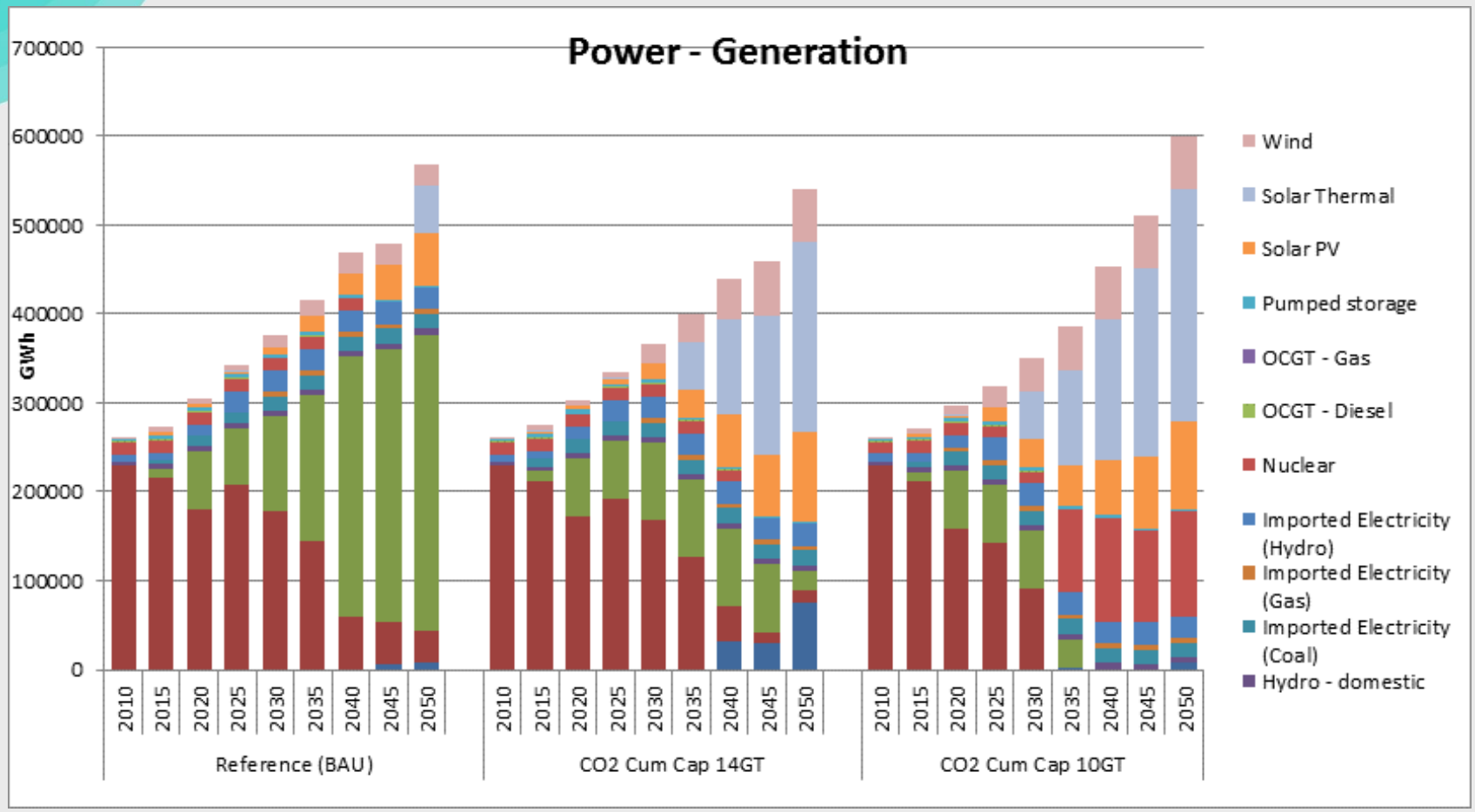


Average Regional Water Supply Costs

- With the result that an extreme regional disparity in supply costs can result.

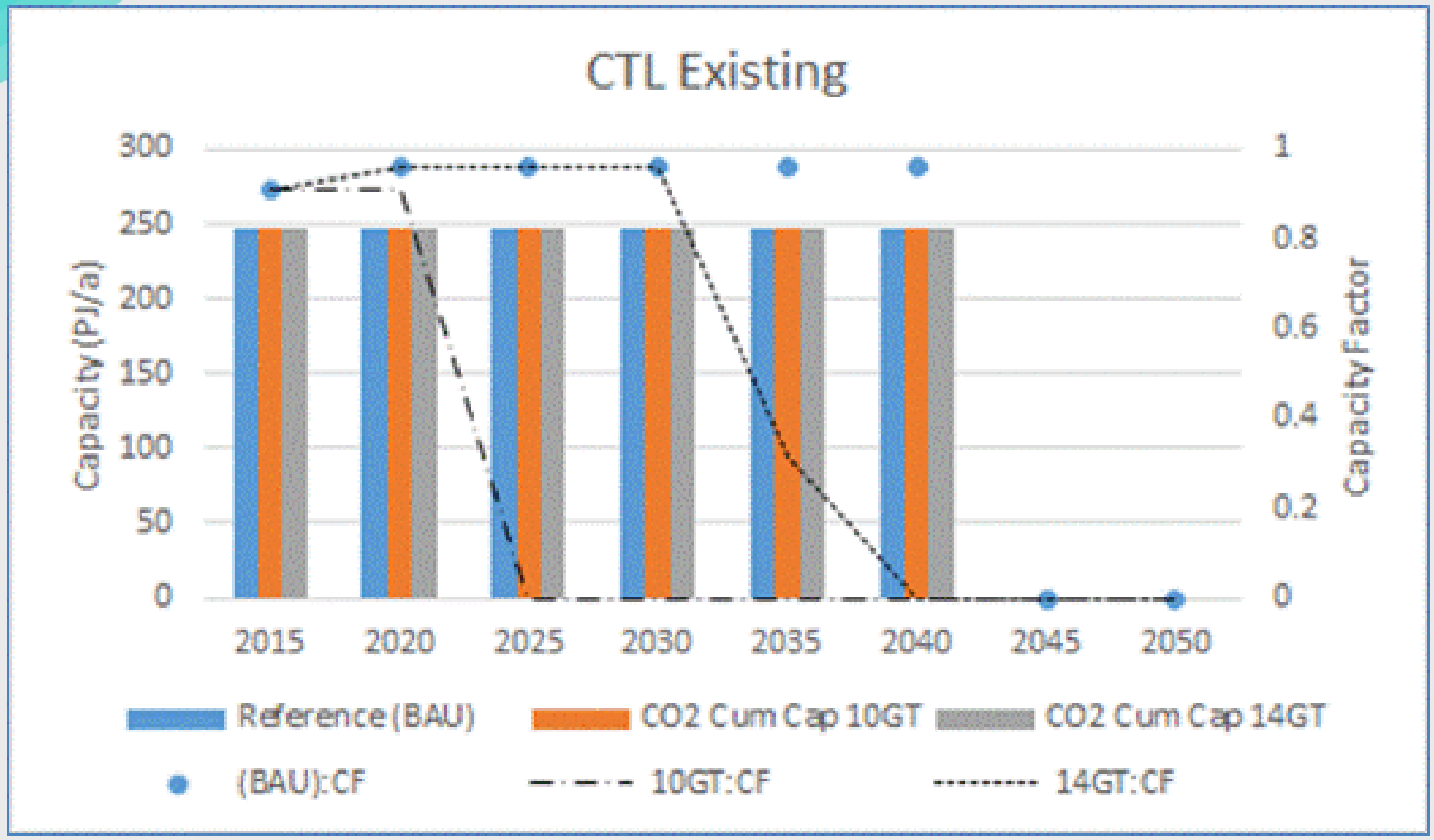
Note: The base cost is derived from the existing weighted average tariff to power plants (weighted by generation) which regionally ranges from 50c to R4/m³

5. In a carbon constrained world, what is the likelihood of stranded assets?



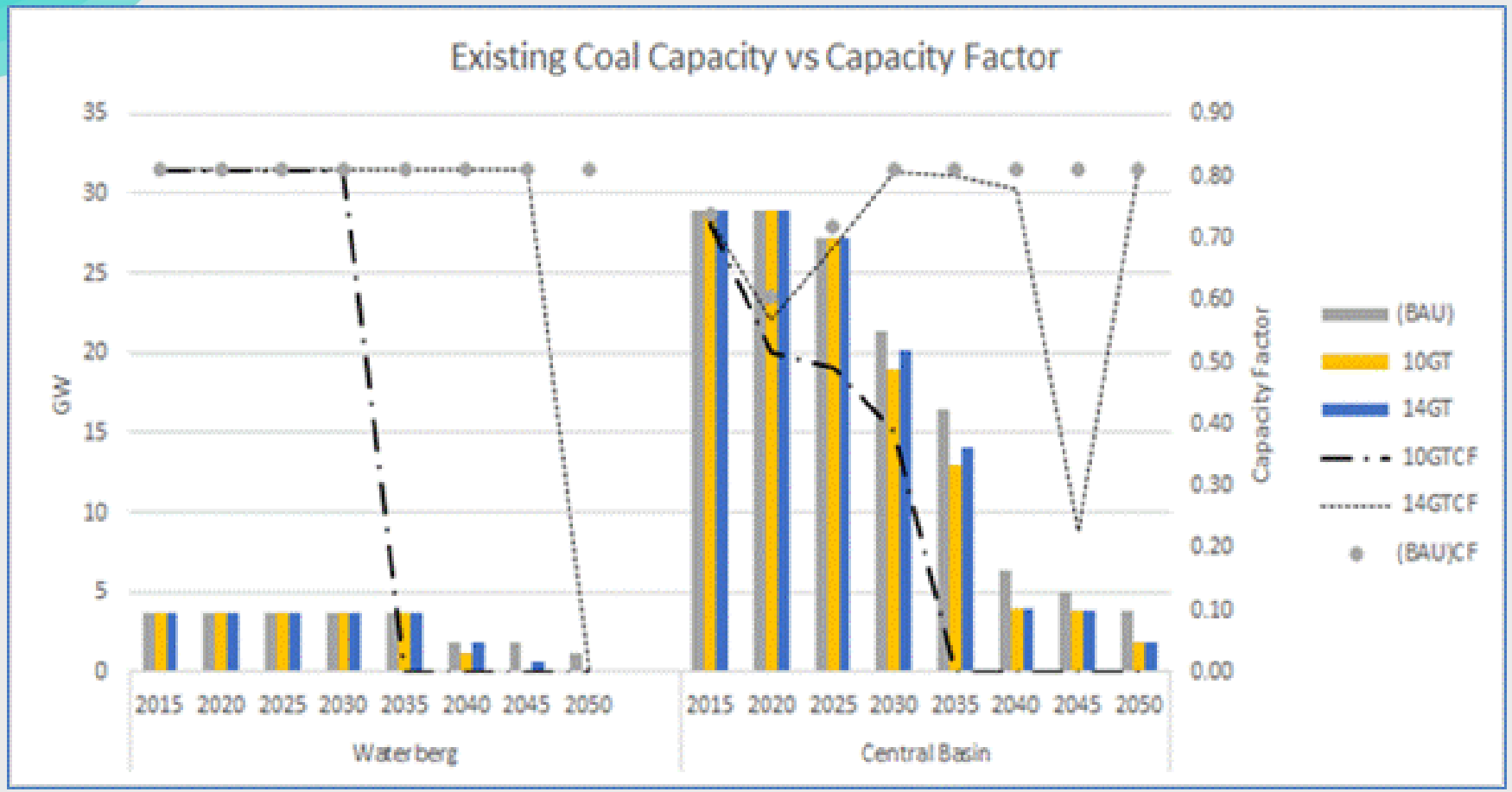
- Modelled with 14 & 10 Gton CO2 Cumulative Caps
- Solar Thermal, PV and wind dominate generation by 2050
- For 10 Gton Cap significant Nuclear by 2035

5. In a carbon constrained world, what is the likelihood of stranded assets?



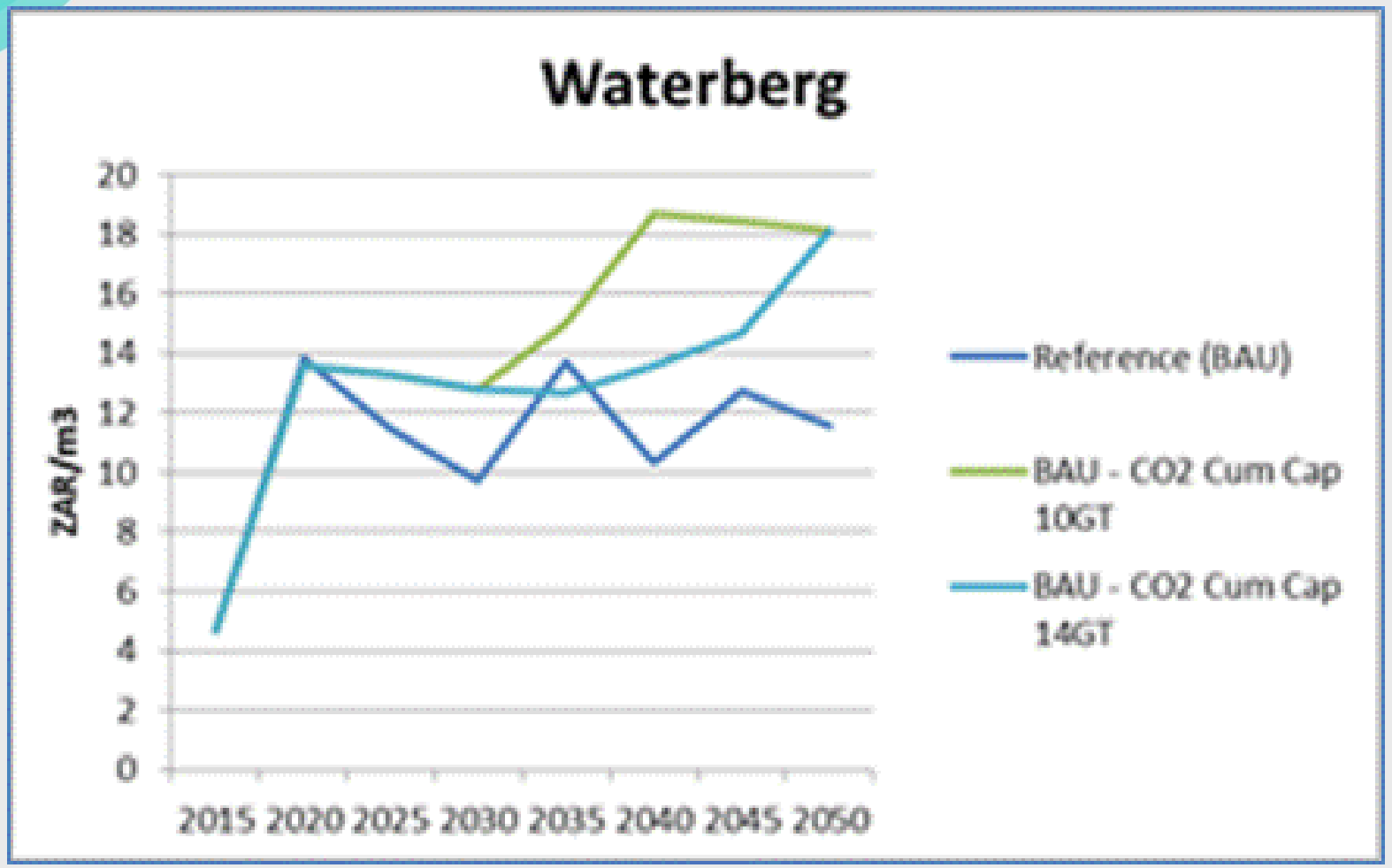
- **Coal to Liquids Capacity Shuts down Early**

5. In a carbon constrained world, what is the likelihood of stranded assets?



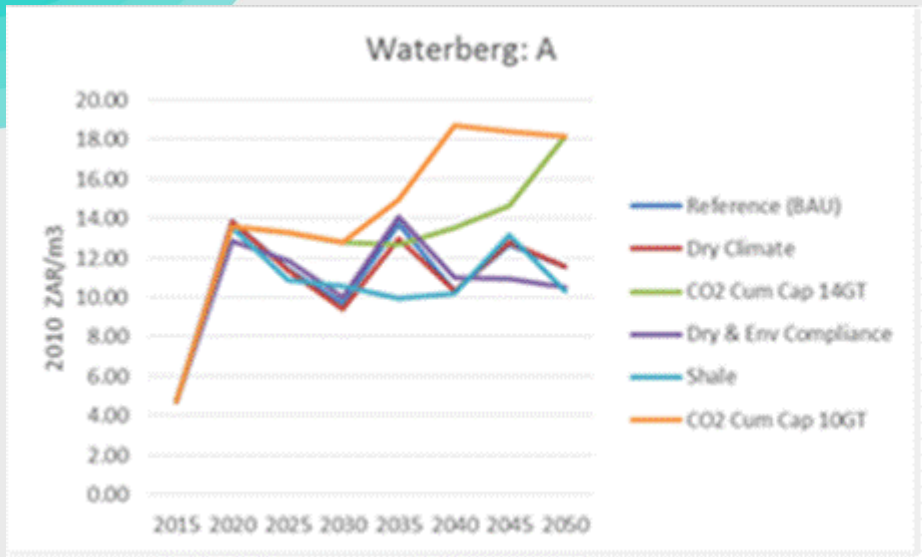
- The model also chooses to underutilise coal generation assets

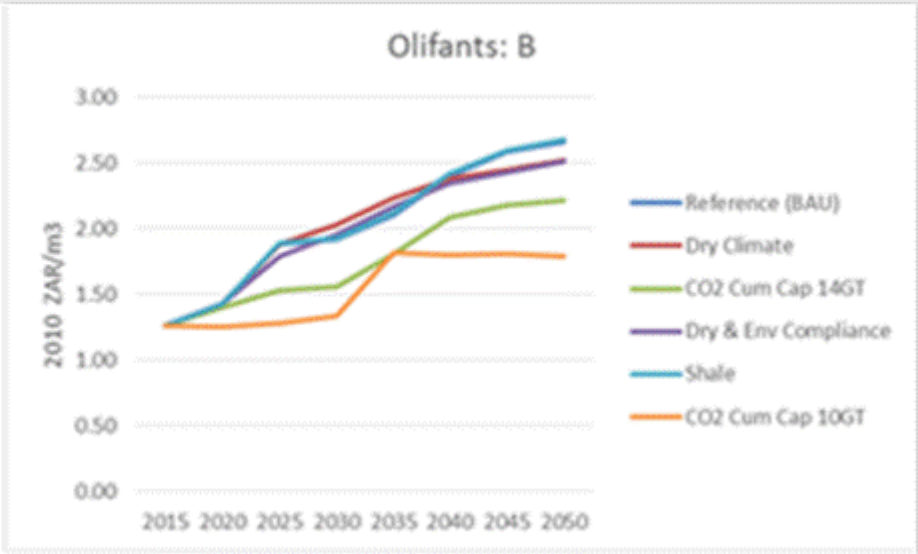
5. In a carbon constrained world, what is the likelihood of stranded assets?

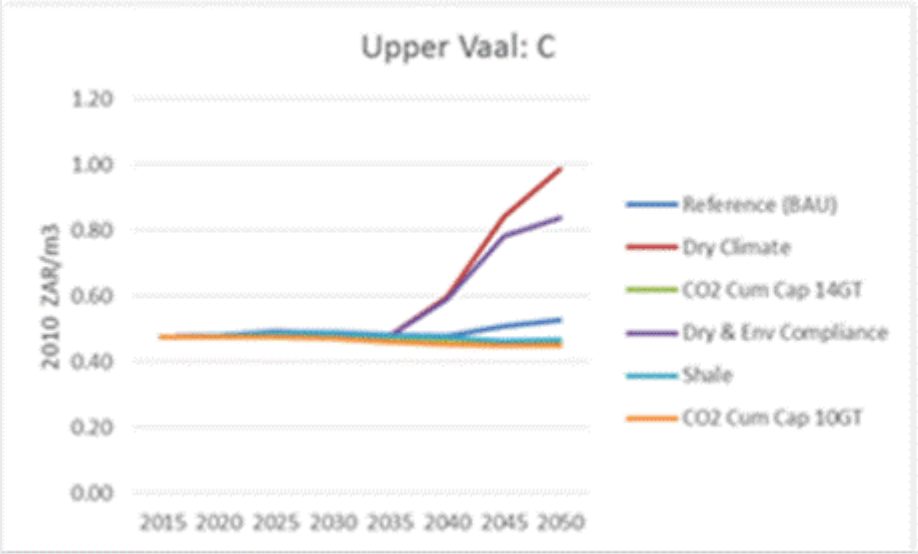


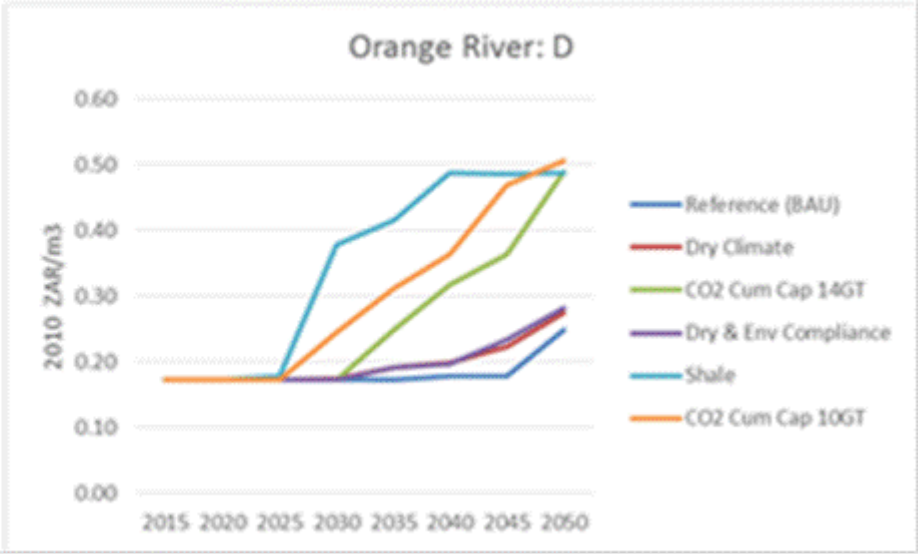
- But now we can also see that water assets are stranded under carbon constraint with premature escalation of water costs

5. (a) What about the Orange River Basin and RE?









A World Bank Initiative

thirsty energy

Thank You

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ERC
ENERGY RESEARCH CENTRE
University of Cape Town

WATER PARTNERSHIP PROGRAM
ESMAP Energy Sector Management Assistance Program
Korea Green Growth Partnership
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Further Background Slides

Thirsty Energy initiative

GOAL: to contribute to a **sustainable management and development** of the water and energy sectors by **increasing awareness and capacity** on *integrated planning* of energy and water investments **identifying and evaluating trade-offs and synergies** between water and energy planning.

1. **Rapid assessments in priority basins/countries**
2. **Implementation of case studies using existing tools when possible**
3. **Knowledge dissemination, advocacy and capacity building**

Partners

Form stronger alliances. The challenge presented by the nexus is too large for any country, region, development finance institution or implementing agency to tackle alone

Funding Partners:

- Water Partnership Program (WPP)
- ESMAP
- Korea Trust Fund for Green Growth

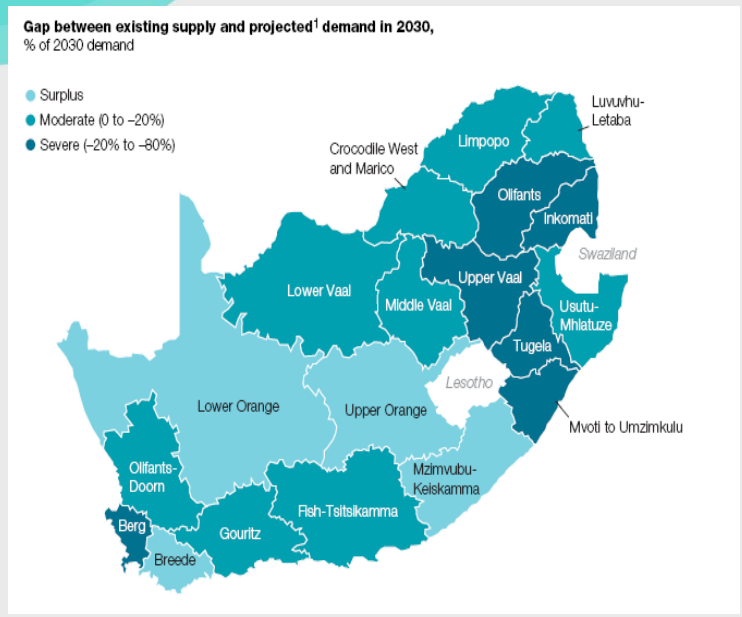
Private Sector Reference Group

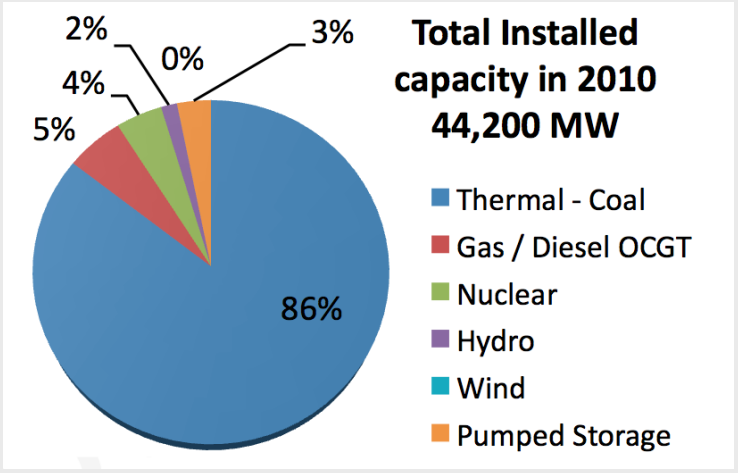
- Abengoa
- Électricité de France (EDF)
- Alstom
- Veolia

Other collaborating partners

- International Energy Agency (IEA)
- Stockholm International Water Institute
- World Resources Institute (WRI)
- UN Water / Sustainable Energy For All
- GIZ
- Others

South Africa:
the case of a Water Scarce Country





Water scarce country with very stressed basins in terms of water allocation. Existing water supply systems at or approaching capacity: 97% of existing supply allocated.

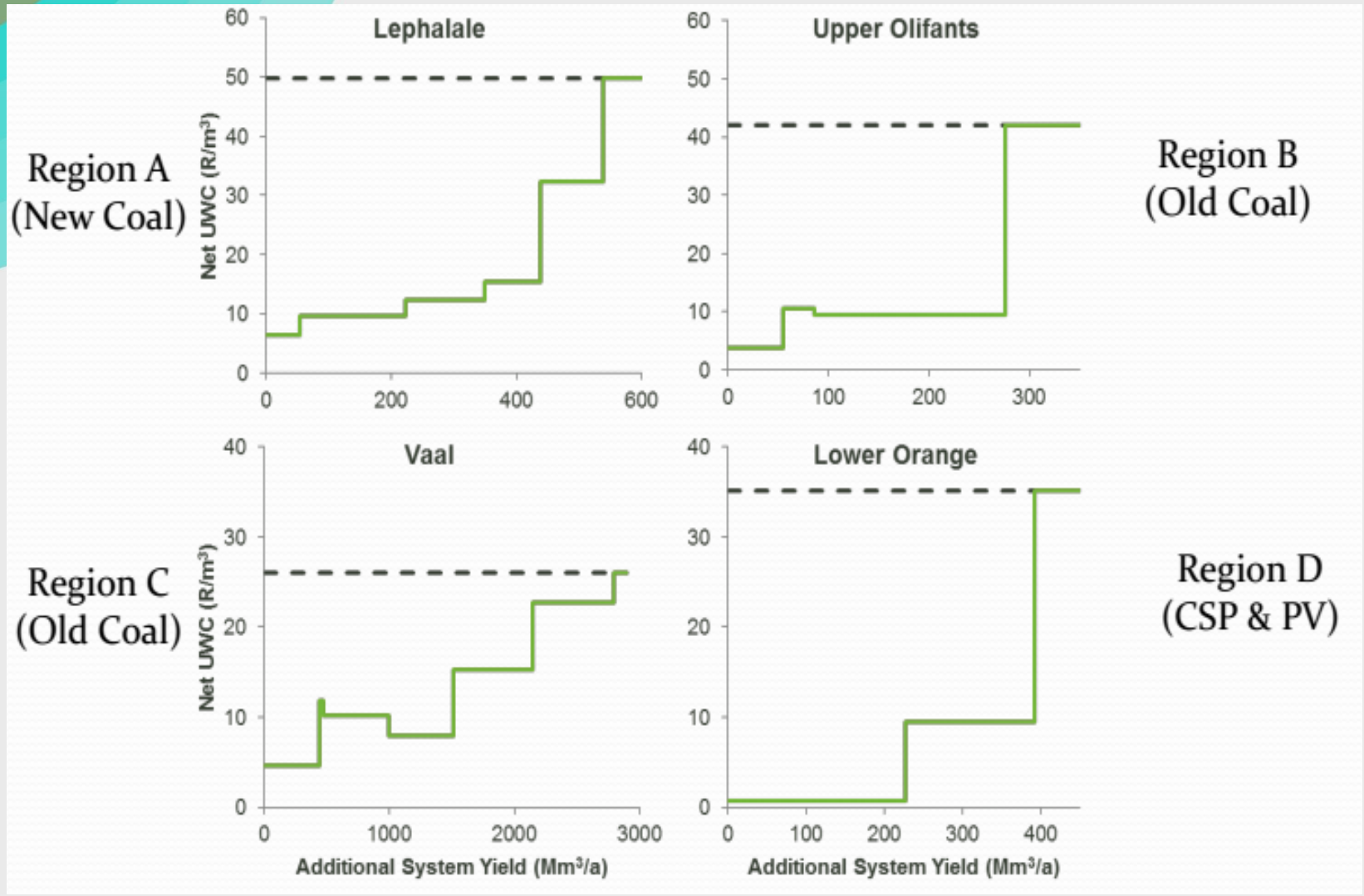
Coal Thermal Power plants account for almost 90% of the power capacity installed

Competition for water across sectors will increase – Power plants have priority, which could negatively affect other sectors such as agriculture

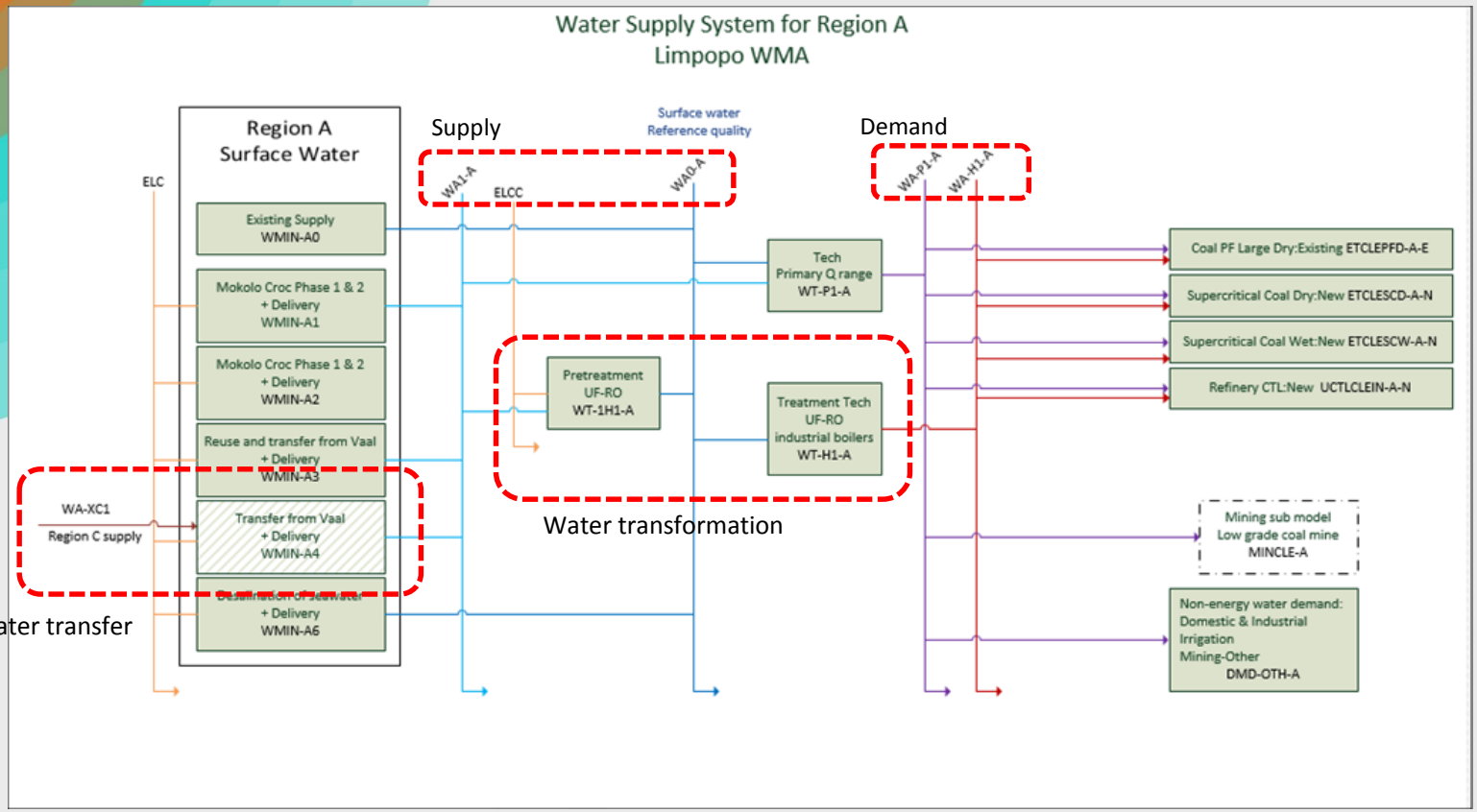
Fracking for Shale Gas is being explored, which will put additional pressure on water resources

Sources: ESKOM and Department of Energy of South Africa

Regional Marginal Cost Curves for Water Supply

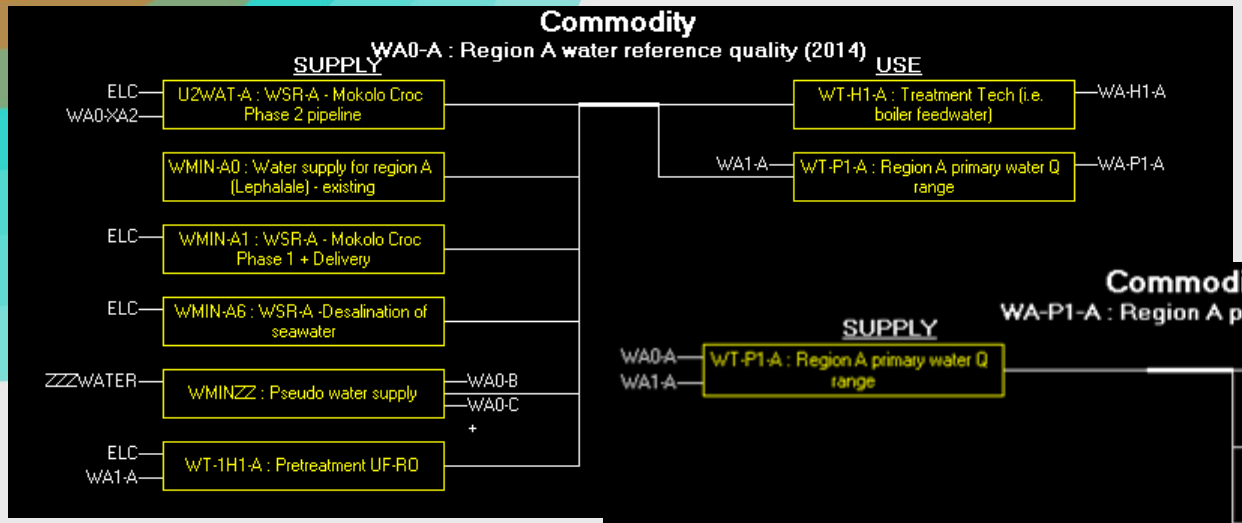


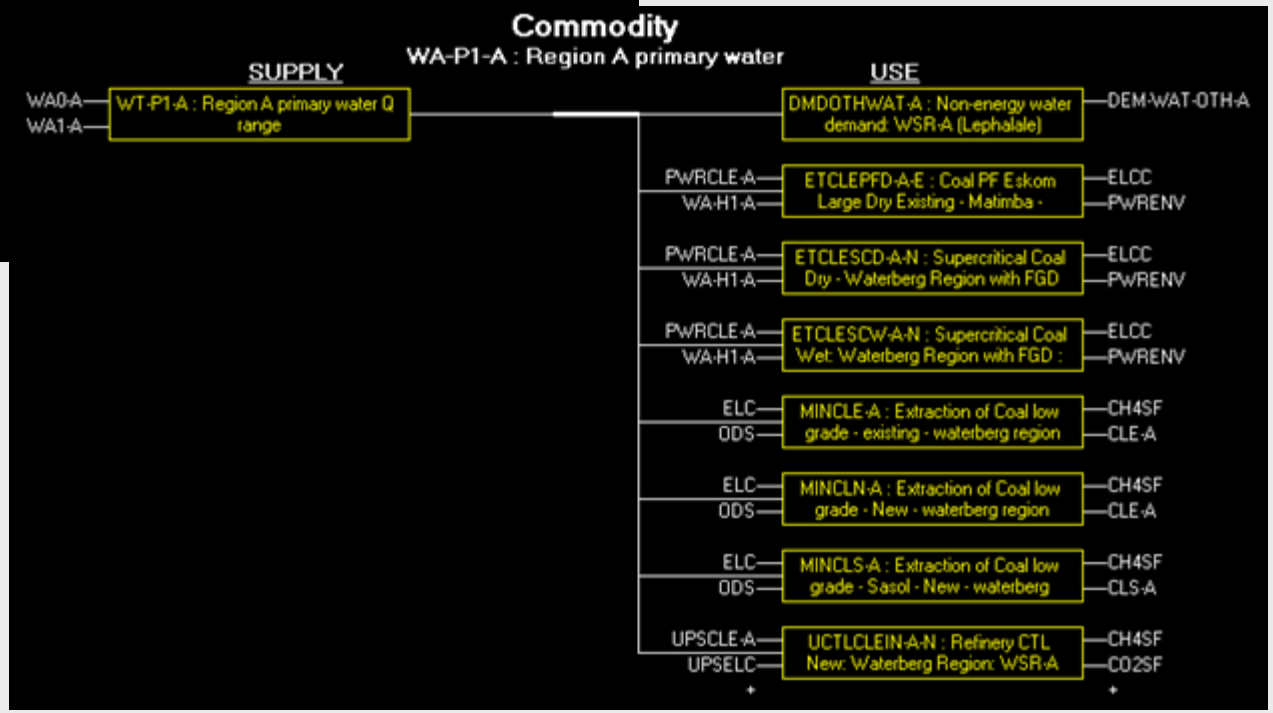
Incorporating Water Supply Infrastructure in SATIM-W



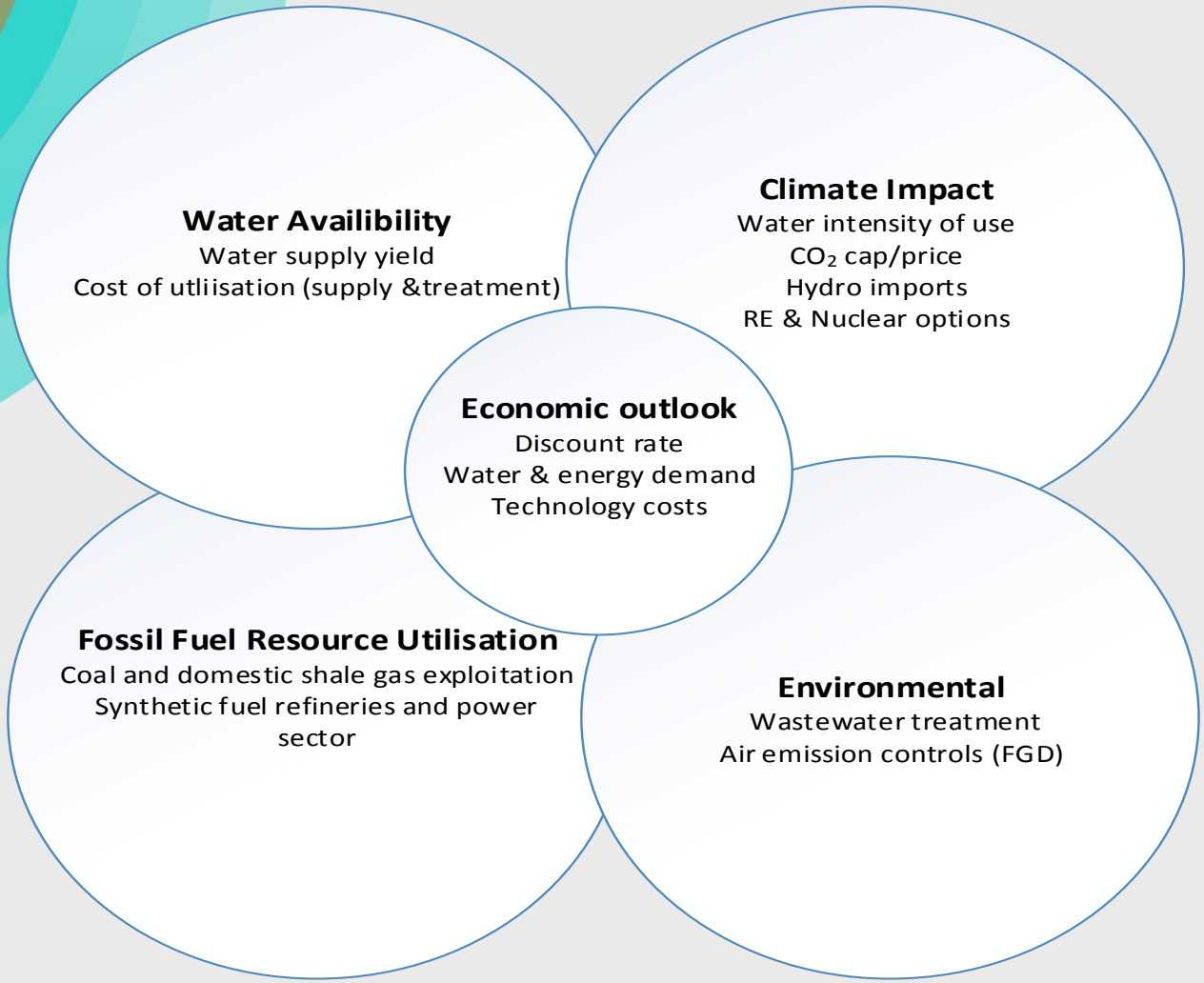
- A TIMES model can be readily adapted to track water requirements for energy (and vise versa), either by representing exogenously prepared (MWSCC) or depicting to full infrastructure build-out options available
- The water subsystem is introduced into SATIM-W by means of explicit water supply and infrastructure options for each of the (WSR) where major energy facilities are found, and their associated energy consumption (e.g. electricity for pump-stations or diesel for truck transport)

Reference Energy-Water System (REWS) as depicted in SATIM-W





Modelling the Future: Scenario Factors



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Themes explore the interaction of the various factors that would influence planning decisions in the energy supply sector from a water and energy perspective