Incorporating Water into the South Africa TIMES Model (SATIM-W)

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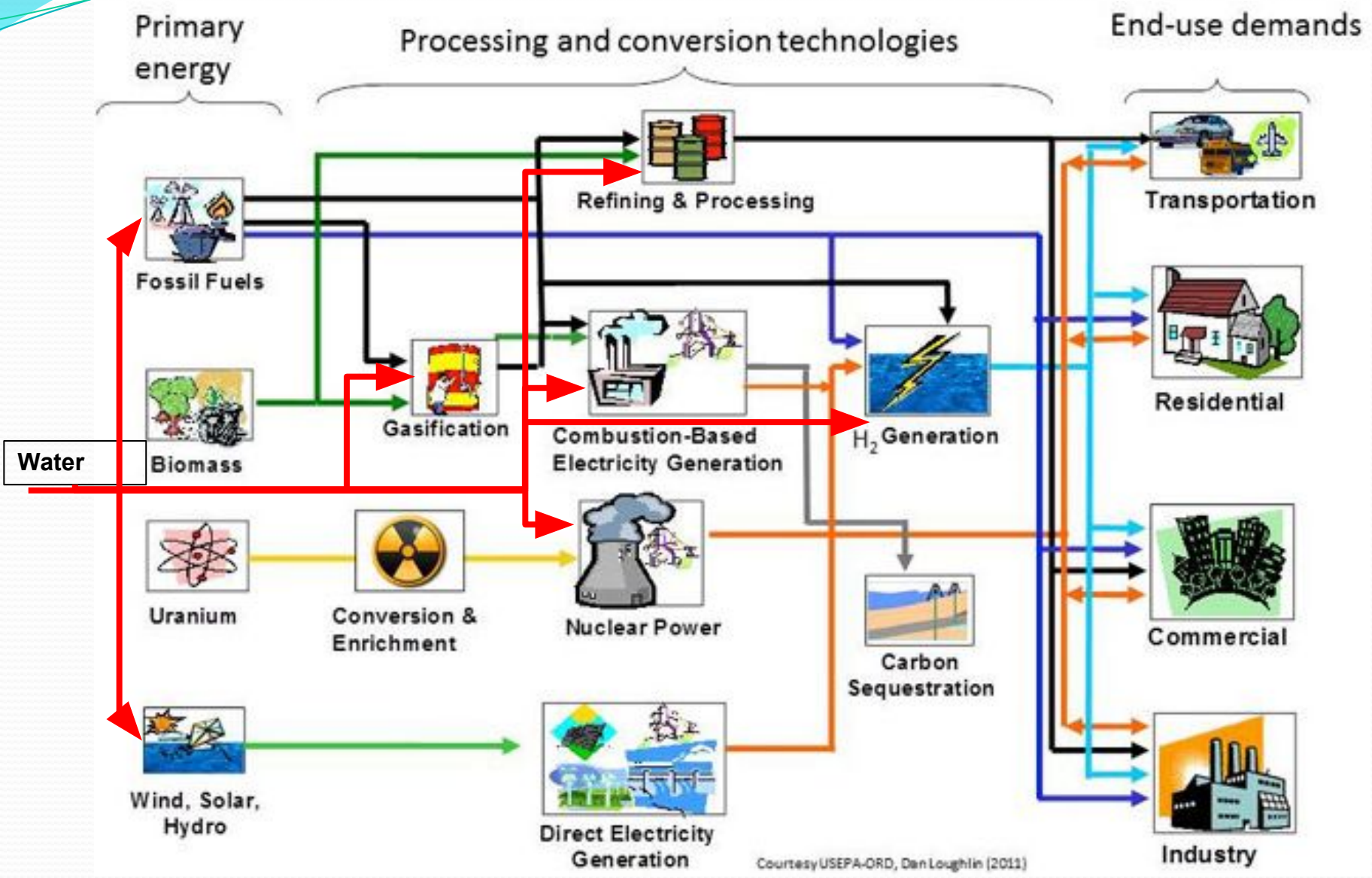
Outline

- Brief introduction to TIMES energy model generator and the SATIM model
- Incorporating water in an energy model
- Chosen methodology for SATIM-W
- Open discussion

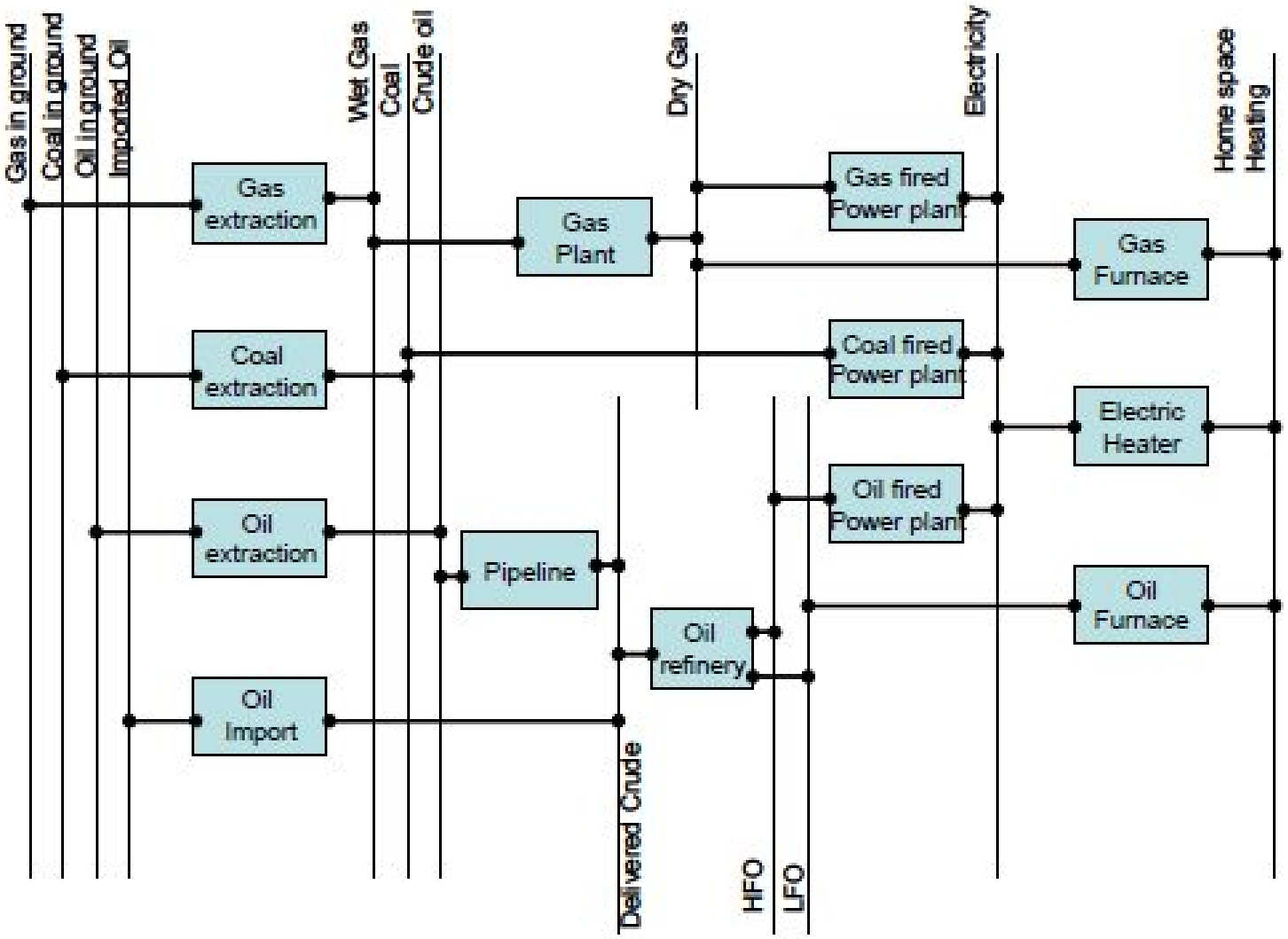
Simplified Reference Energy-Water System



Key Aspects of TIMES

- Encompasses an *entire energy system* from resource extraction through to end-use demands
- Employs least-cost *optimization*
- Identifies the most *cost-effective* pattern of resource use and technology deployment over time
- Provides a framework for the evaluation of mid-to-long-term *policies and programs* that can impact the evolution of the energy system
- Quantifies the costs and technology choices, *and associated emissions,* that result from imposition of policies and programs
- Fosters *stakeholder buy-in* and consensus building
- Is a *widely used international standard* under the auspice of the IEA-ETSAP (www.iea-etsap.org) Implementing Agreement

Example of Competition between Supply Pathways Characteristic of a TIMES model



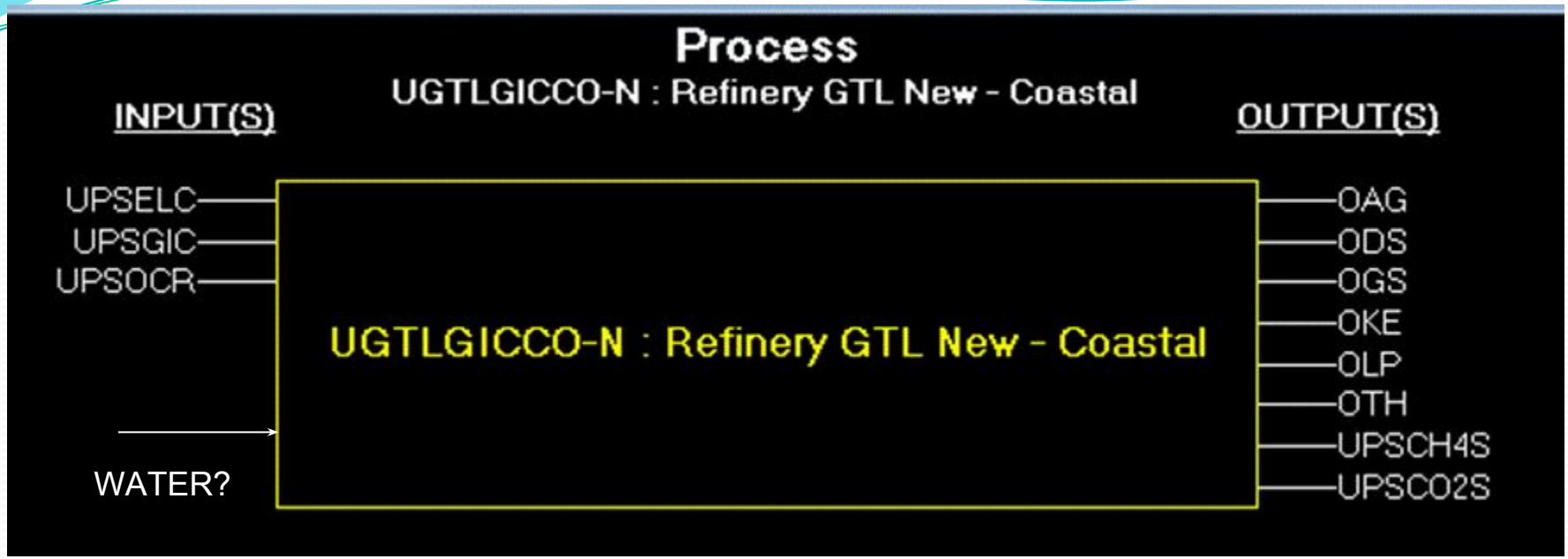
Introduction to SATIM (1/2)

- South African TIMES Model (SATIM)
- Partial equilibrium linear optimisation model capable of representing the whole energy system, including its economic costs and its emissions
- Sectoral Representation – Supply side (Primary Energy, Electricity, Liquid Fuels) & Demand side (Residential, Commercial, Industrial, Transport, Agricultural)
- Methodology & assumptions in the public domain – see ERC website

Introduction to SATIM (2/2)

- A number of years of development - 2003 IEP, 2007 LTMS being major development phases
- Not all sectors are equal - funding has driven detail in the electricity and road transport sectors but agriculture, for instance, is very basic
- SATIM has used IRP and IEP extensively to refine assumptions but also has in turn been used by IEP and recent MPA study
- The aim is to keep making incremental improvements and maintain SATIM as a fully public resource

Incorporating Water into SATIM (1/2)

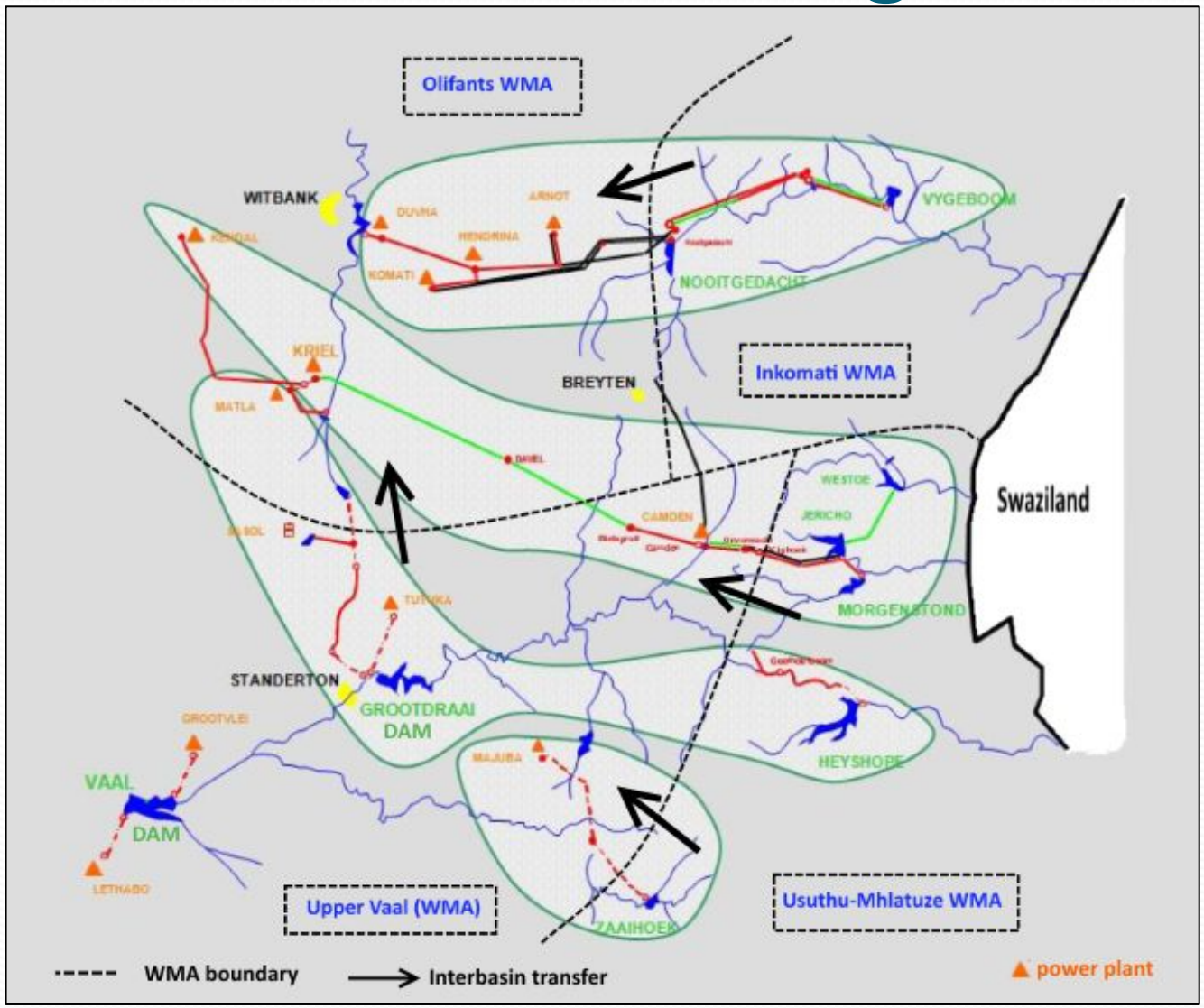


- There are a lot of technologies in a TIMES model, but they are not represented in a lot of engineering detail (that may sit in supporting models), rather capture linear relationships between process inputs/output and associated technical and cost characteristics
- The complexity arises from the size of the system
- In addition to the energy commodity inputs and energy and emission outputs above we parametrize efficiency, capital cost, O&M cost, lead time, life etc. so that the cost of supplying energy can be optimised between choices
- There is no reason why water can't be treated like any other commodity, and the associated infrastructure required to supply it represented as well

Incorporating Water into SATIM (2/2)

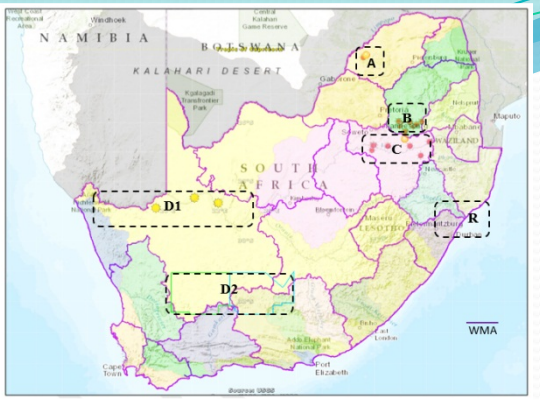
- Aligning major water intensive energy processes (e.g., mining, power plants, refining) with their water supply regions
- Leveraging the long term reconciliation studies for water undertaken under the DWS National Water Resources Strategy (similar timeframe to energy models)
- Determining the water consumption, quality & treatment requirements of each process
- Determining the energy requirements for each water supply option
- Introducing marginal water cost supply curves or representing the water infrastructure schemes in SATIM

Aligning water &energy views of the world - Regions



Water Supply Regions (WSR) in the energy model need to be aligned with the Water Management Areas (WMA), and inter-basin transfers captured.

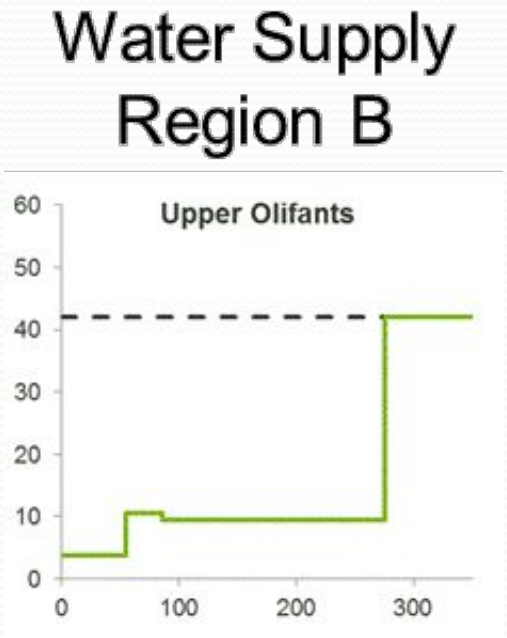
SATIM-W WMA/WSR Mapping & Energy Activities

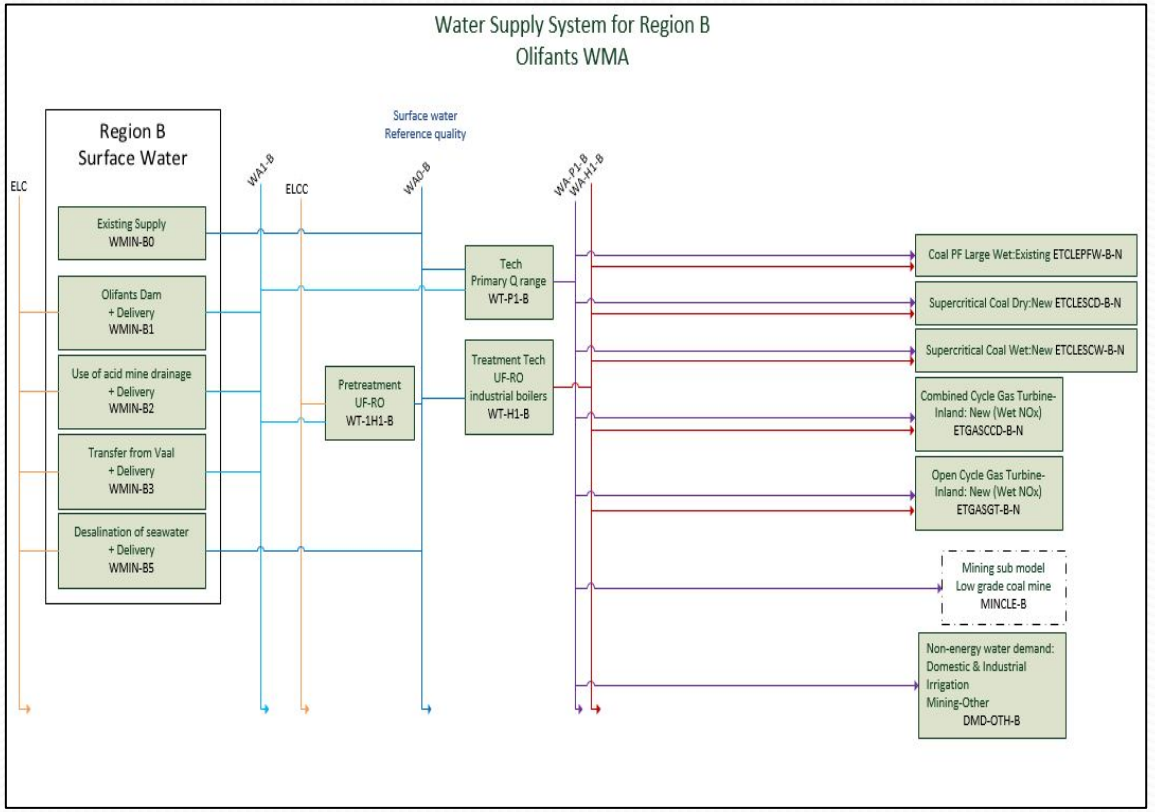


WSR	WMA	Country Region	Activity
A	Limpopo	Lephalale	• Open-cast coal mining • Coal thermal power plants with FGD option • Coal-to-Liquids refineries
B	Olifants	Mpumalanga, Witbank	• Open-cast & underground coal mining • Coal thermal power plants with FGD option.
C	Upper Vaal	Mpumalanga, Secunda	• Open-cast & underground coal mining • Coal thermal power plants with FDG option • Coal-to-Liquids refineries • 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 Terminal	• Coastal open-cycle coal power plants with seawater cooling and seawater FGD option

Plant	SATIM Category	Net Capacity	Cooling Type	WSR
Matimba	Large Dry Existing	3690	Direct Dry (ACC)	A
Medupi	Supercritical New	4334	Direct Dry (ACC)	A
Kendal	Large Dry Existing	3840	Indirect-dry	B
Duvha	Large Existing	3450	Wet closed cycle	B
Kriel	Large Existing	2850	Wet closed cycle	B
Matla	Large Existing	3450	Wet closed cycle	B
Arnot	Large Existing	2232	Wet closed cycle	B
Hendrina	Small Existing	1865	Wet closed cycle	B
Komati	Small Existing	906	Wet closed cycle	B
Kusile	Supercritical New	4267	Direct Dry (ACC)	B
Camden	Small existing	1440	Wet closed cycle	C
Majuba Wet[1]	Large Existing	1980	3 units: Wet cooled	C
Majuba Dry	Large Dry Existing	1840	3 units: Direct Dry (ACC)	C
Lethabo	Large Existing	3558	Wet closed cycle	C
Tutuka	Large Existing	3510	Wet closed cycle	C
Grootvlei[2]	Small Existing	1130	Wet/Dry	C

Aligning water &energy views of the world – Incorporating water



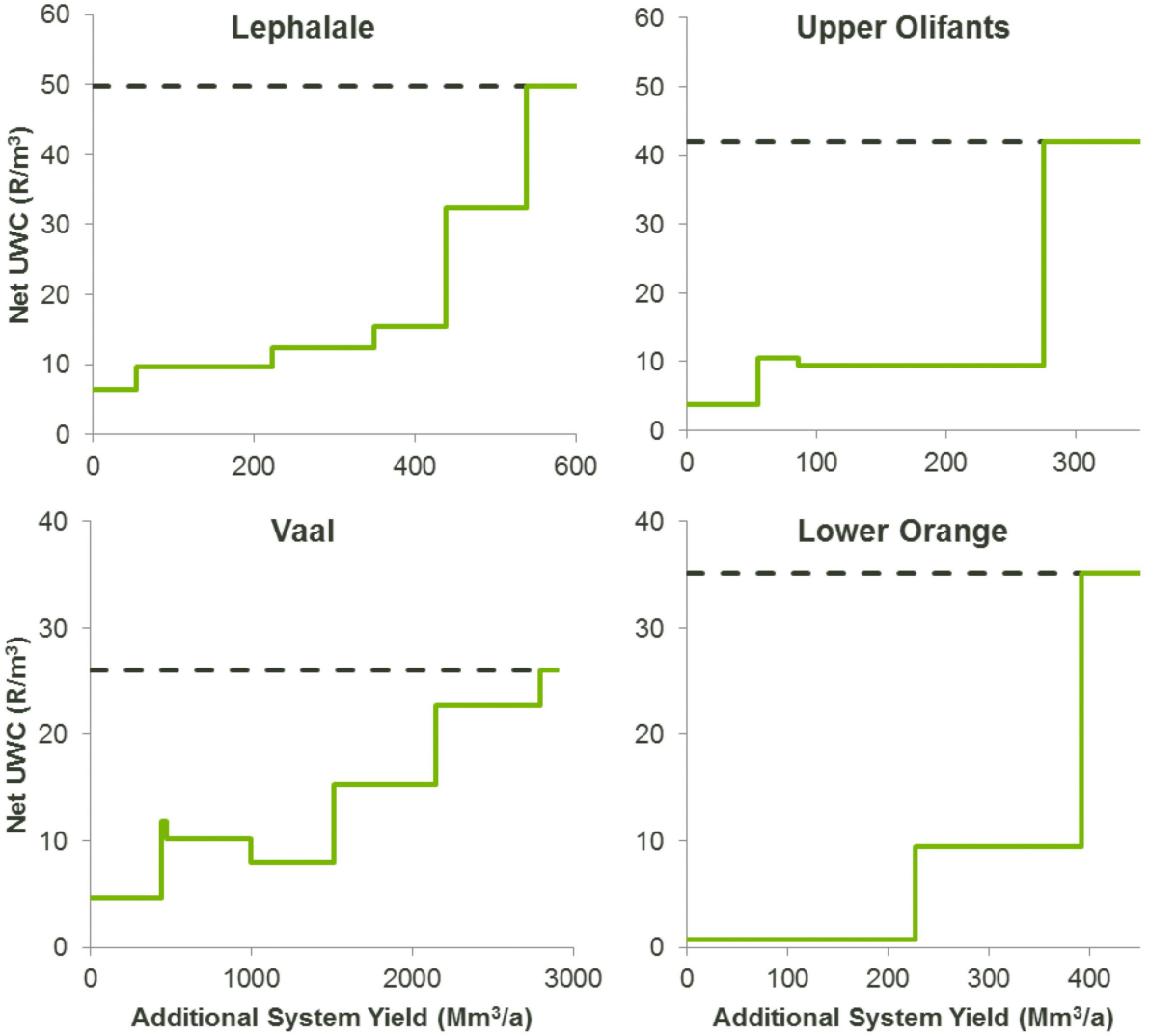


- Water flows are introduced to the RES (from supply sources to consuming processes, optionally thru the infrastructure)
- Water delivery can either be represented as marginal water supply cost curves or the infrastructure with new projects explicitly incorporated

Aligning water & energy views of the world – Costing water

- Marginal Water Supply Cost Curve (MWSCC)
  - Exogenous determination of the various water supply schemes
  - Supply cost curves indicating how much water can be supplied by each source through the various schemes thereby delivering water at a given price
  - Each curve is climbed to determine the final cost of water for the system
- Depicting Infrastructure [SATIM-W approach]
  - All steps associated with delivering water (supply, infrastructure, pre-treatment) are fully represented
  - SATIM-W determines the supply schemes employed and thereby the (marginal) cost of water endogenously
  - Special handling developed to sequence dependent less expensive schemes that require a more expensive option be put in place first (e.g., Waterberg Phase 1&2)

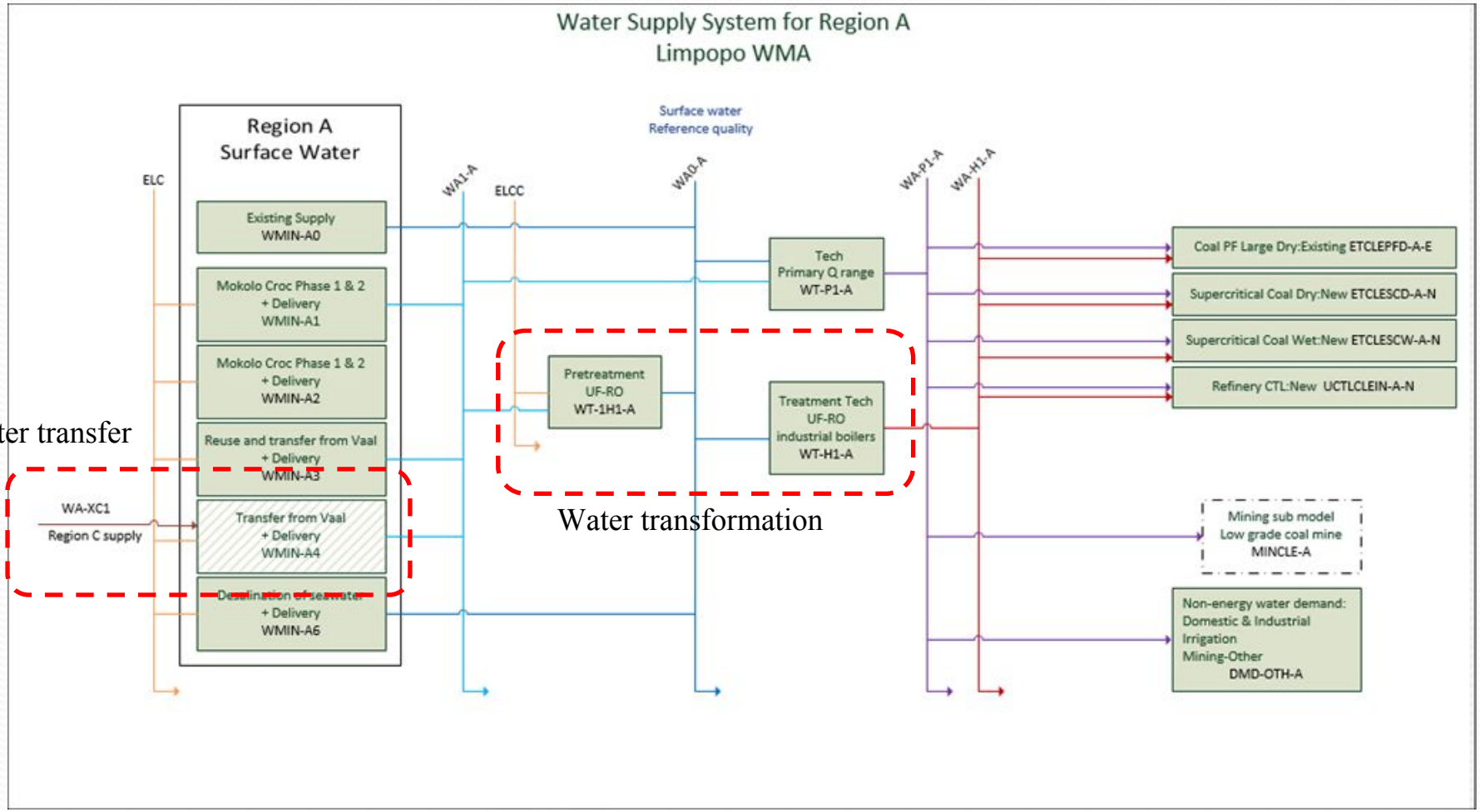
South Africa MWSCC by WMA



- Number of steps in the supply curves are determined by the various infrastructure delivery options
- Curve reflects the required sequencing of projects

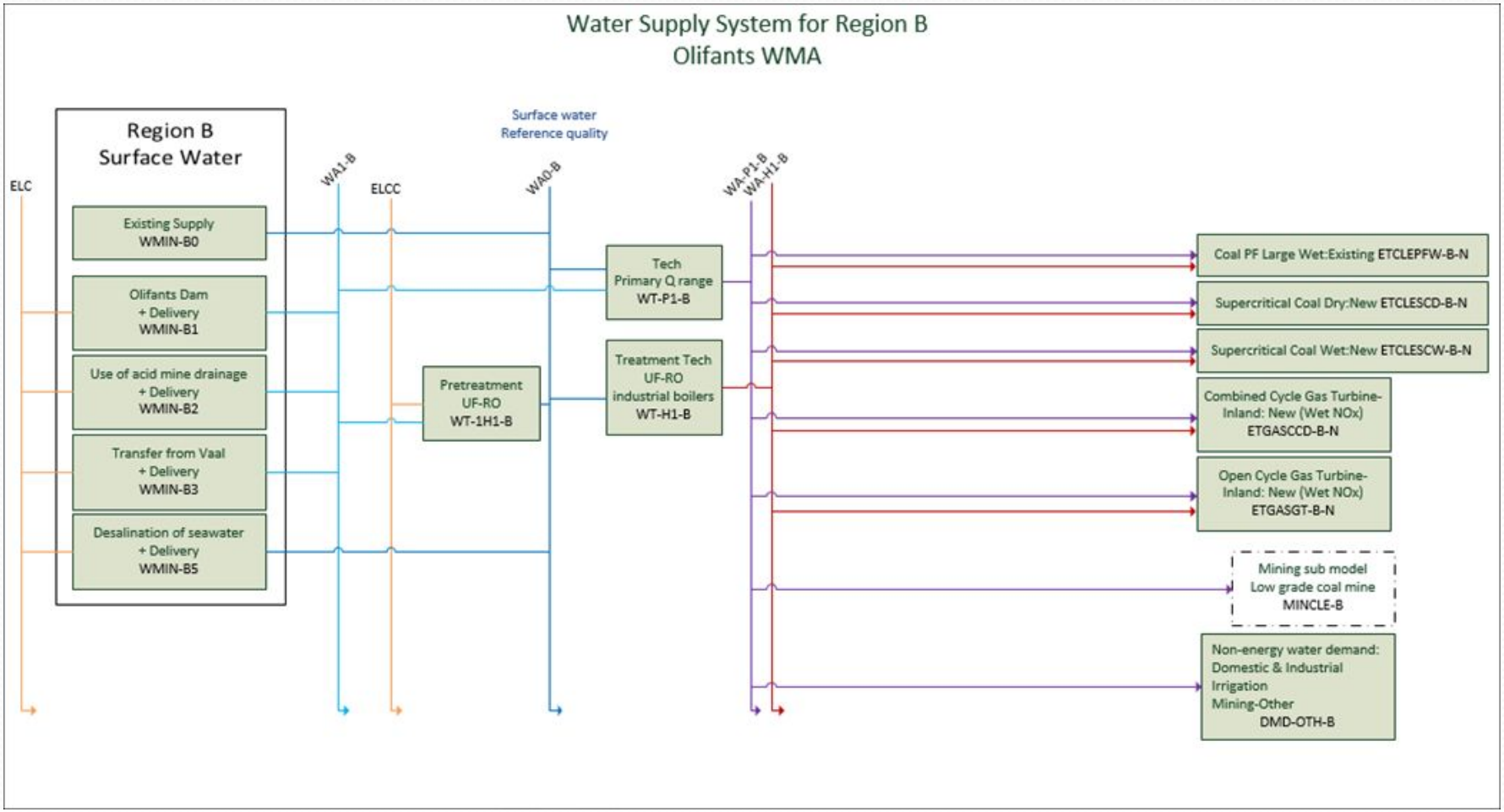
Scheme Marginal Supply Cost = Capital $_{(Scheme + Delivery)}$ + Fixed_OM (%Capital) $_{(Scheme + Delivery)}$ + Var_OM$_1$ (Energy cost of conveyance (endogenous)) $_{(Scheme + Delivery)}$ + Var_OM$_2$ (Administrative charges)

SATIM-W Infrastructure Representation – Limpopo WMA



- The implementation of the supply schemes accounts for the energy for water conveyance (delivery and interbasin transfers). Also shown is the representation of the energy for the transformation of different water quality types: end-use and source.
- Note that the degraded water supply schemes as shown are not reflected in current model results.

SATIM-W Infrastructure Representation – Olifants WMA



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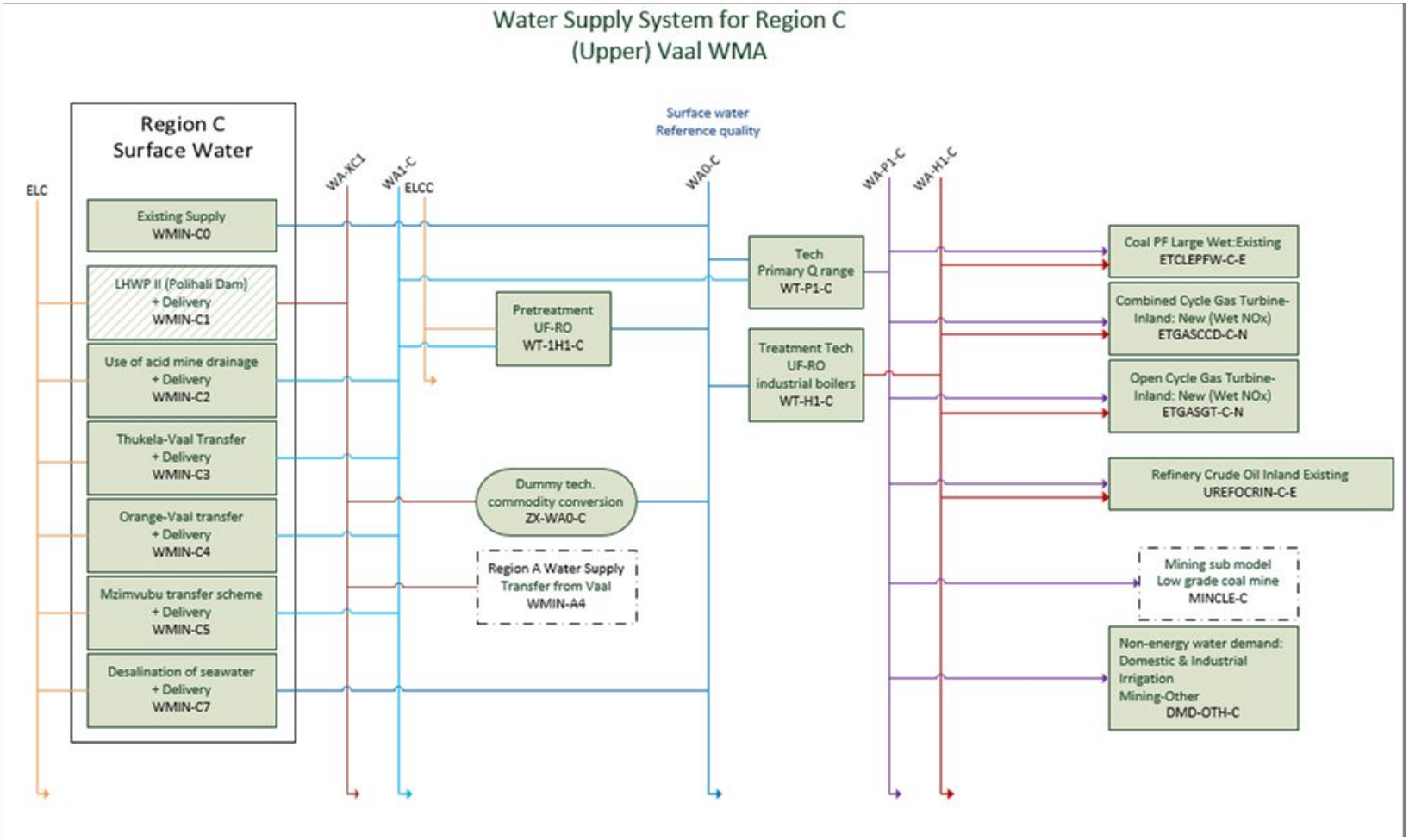
SATIM-W Infrastructure Representation – (Upper) Vaal WMA



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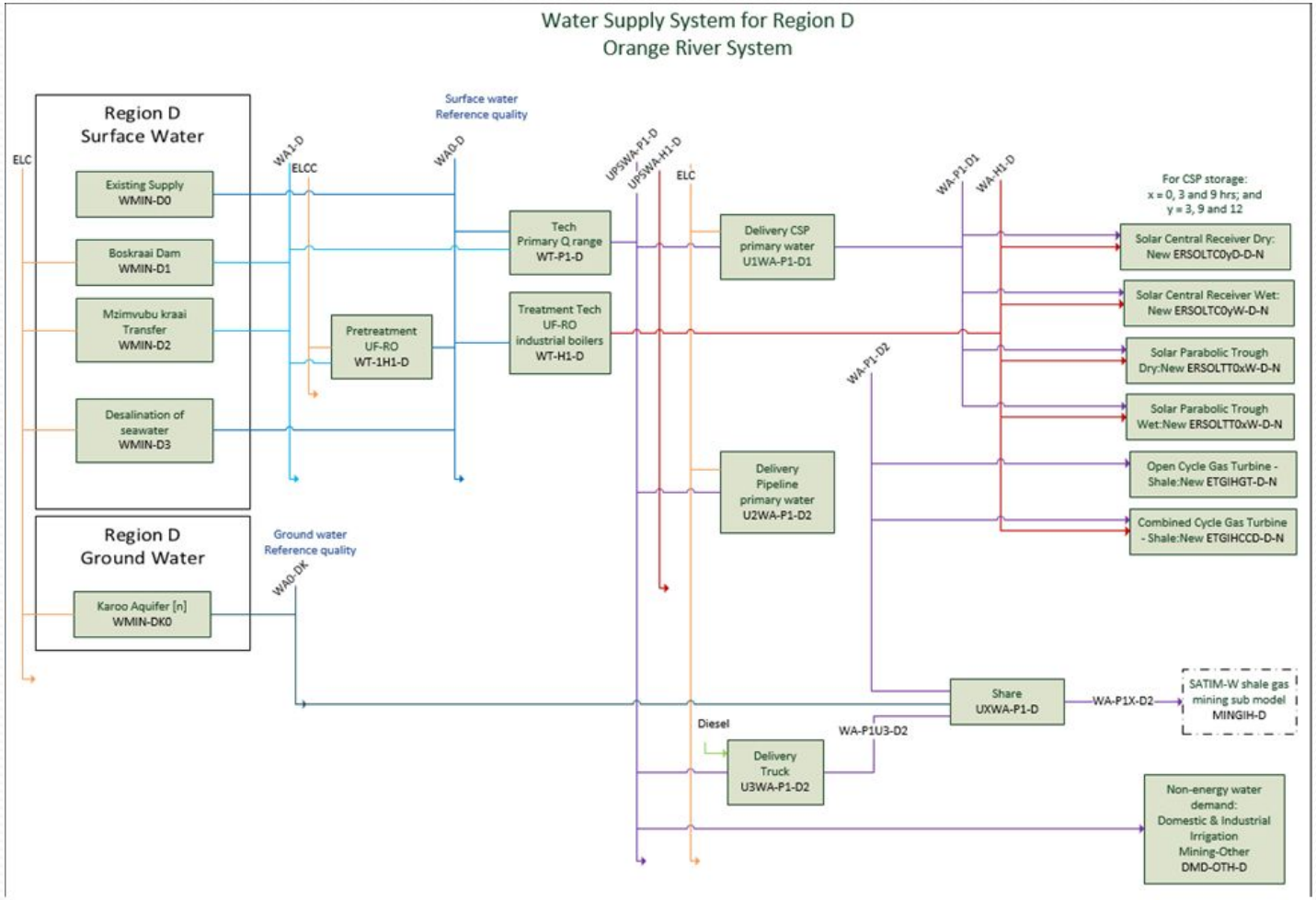
SATIM-W Infrastructure Representation – Orange River WMA



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Conclusions & Discussion

- SATIM-W has a solid representation of water to enable the energy-water nexus to be assessed in an integrated manner
- The choice to imbed the water infrastructure in the model (rather than employ cost-supply curves) provides the flexibility, where only the water supply/demand levels need to be provided by the detailed water basin models, and the resulting infrastructure decisions compare between the models
- So what's next…