SATIM-W Reference Scenario

Energy Research Centre
University of Cape Town
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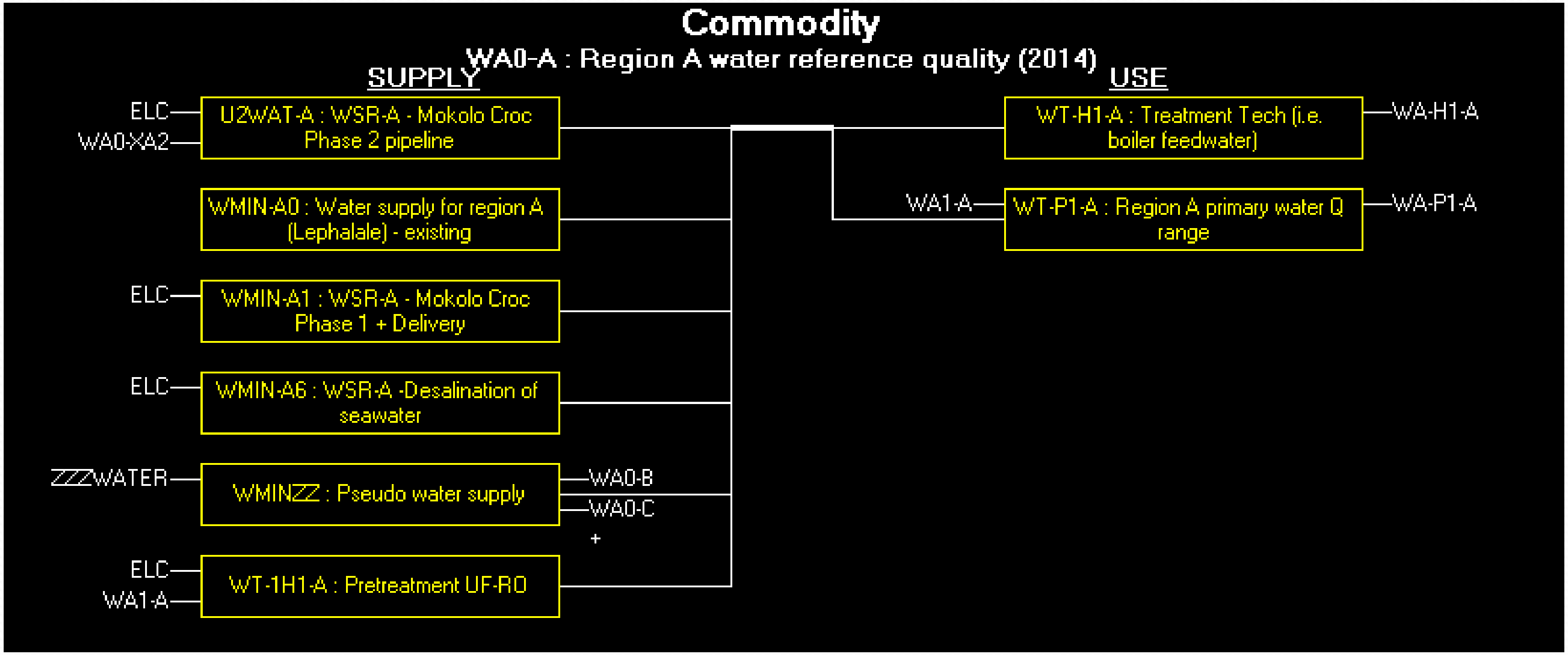
DecisionWare Group
Policy Analysis for
Energy, Economy and Environment

ERC
ENERGY RESEARCH CENTRE
University of Cape Town

Outline

- Integrating water into SATIM-W
- Key assumptions underlying the Reference Scenario, and their sources
- Resulting energy use and investment requirements till 2050
- Associated water consumption and investment needs till 2050
- Open discussion

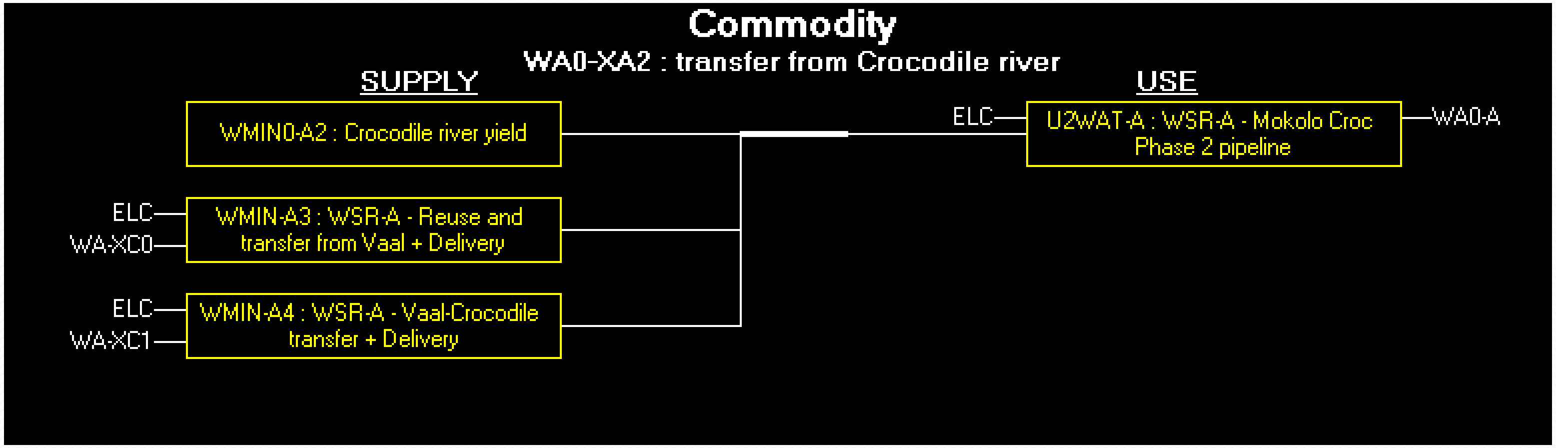
SATIM-W Water Infrastructure REWS - Supply



- The water subsystem is introduced into SATIM-W by means of explicit water supply and infrastructure options for each of four major water regions (WSR) where major energy facilities are found.

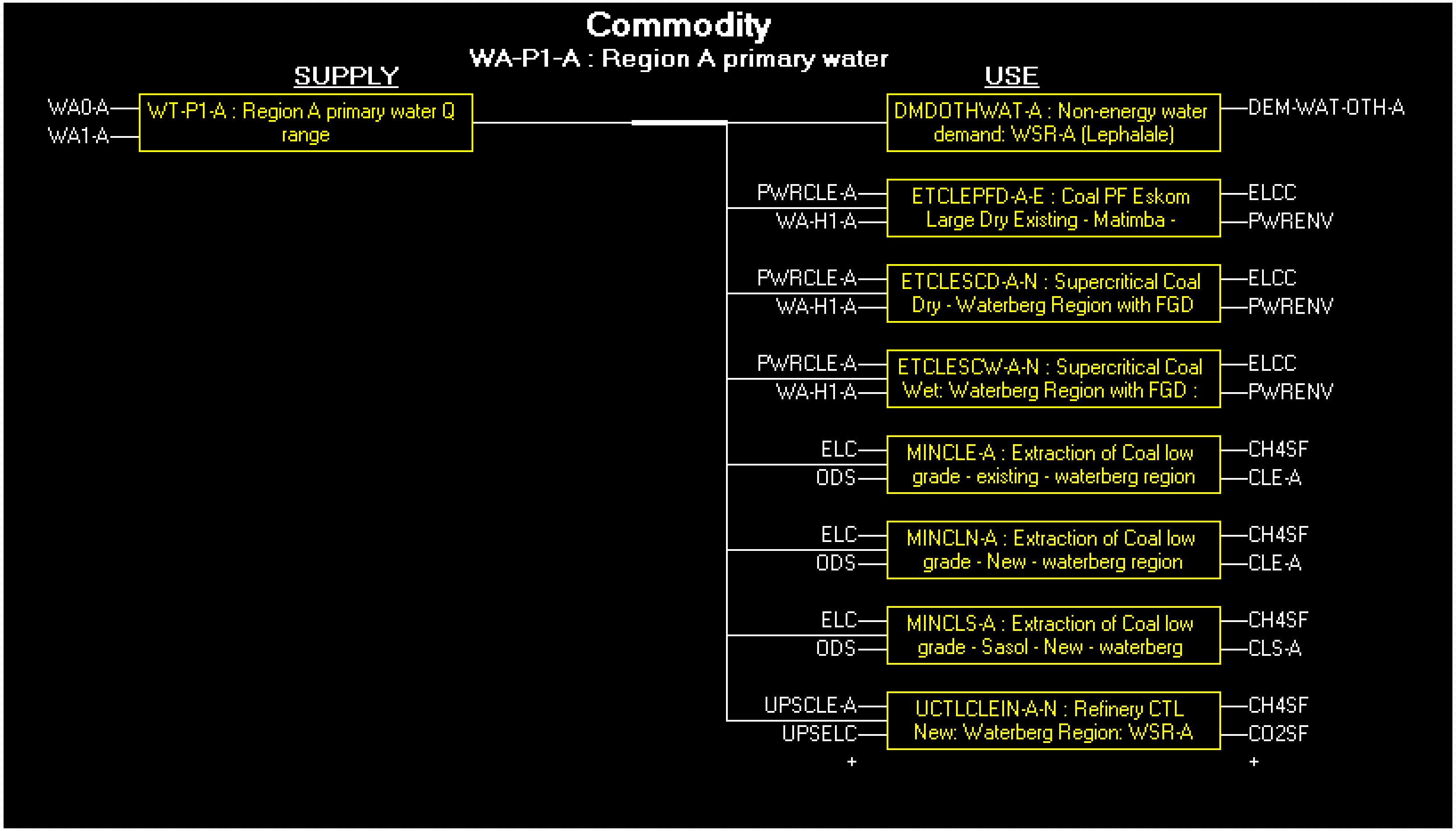
SATIM-W Water Infrastructure Data Snapshot

Process	Parameter	Units	Commodity	Limit	Value
WSR-A MCWAP Phase-2	Variable costs associated with activity of a process	2010ZARm/uvol	-	-	0
	Bound on total installed capacity in a period	uvol/a	-	UP	332
	Process efficiency tied to primary commodity	dec fractn	Region D Reference Quality Water		1
	Investment cost for new capacity	2010ZARm/uvol/a	-	-	52.41
	Fixed operating and maintenance cost	2010ZARm/uvol/a	-	-	0.16
	Discrete capacity investment	2010ZARm/uvol/a			166.00
	Dependency linkage (pre-project requirement)	**WMIN-A1 (Phase 1)**			
	Lead-time required for building a new capacity	no. yrs	-	-	6
	Technical lifetime of a process	no. yrs	-	-	100
	Auxillary input commodity	Mm3/PJ	ELC	-	0.0031



- Key data is an upper limit on yield, name of the water supplied, investment cost for new infrastructure, operating cost, option dependency indicator (here WMIN-A1 must be built, though more expensive, before Phase-2), construction time, lifetime, and amount of electricity needed for unit of water produced.

SATIM-W Water Infrastructure REWS - Consumption

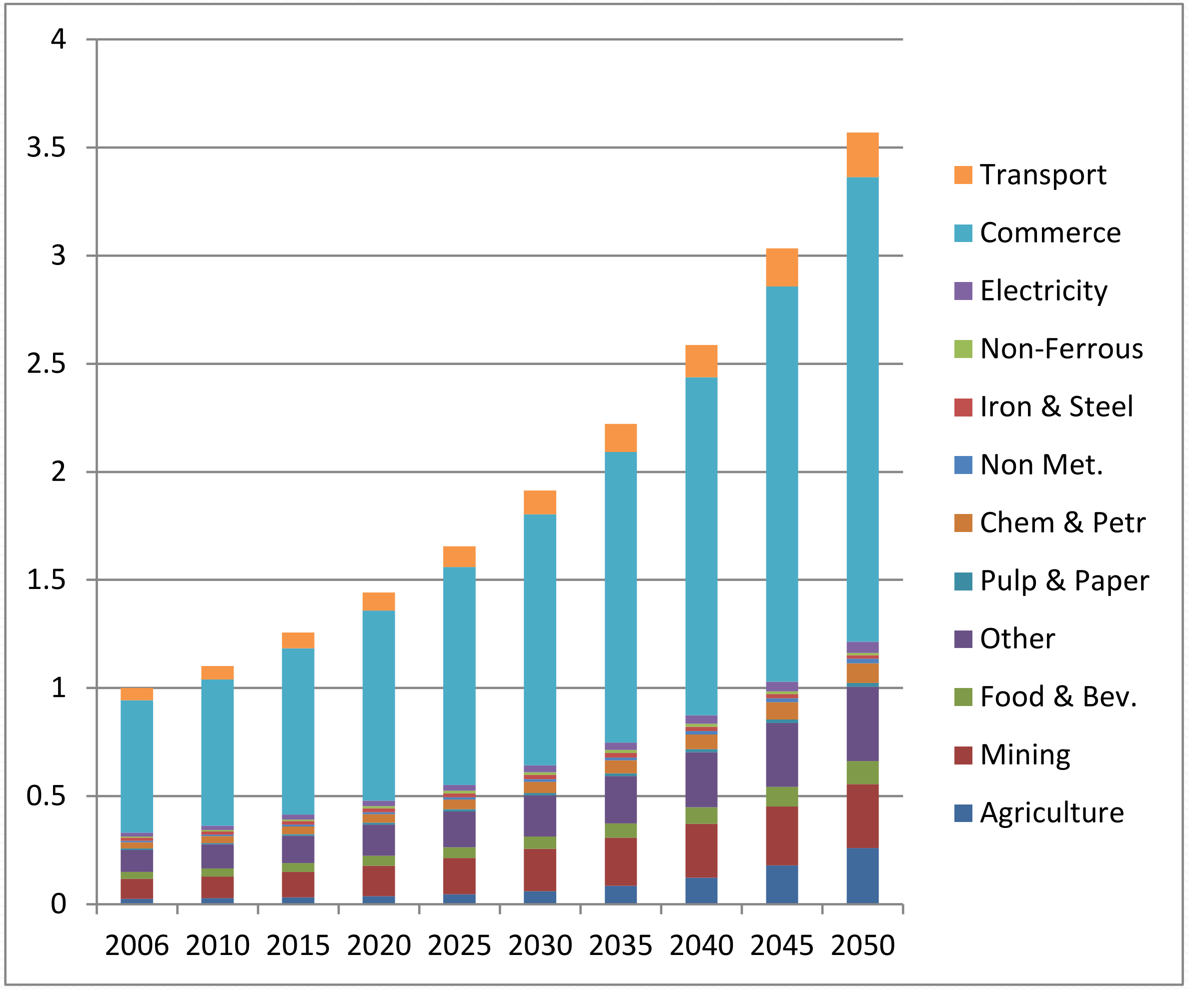


- The supplied water then feeds the water consuming energy technologies in each WSR.

Key Energy Data Needs & Sources

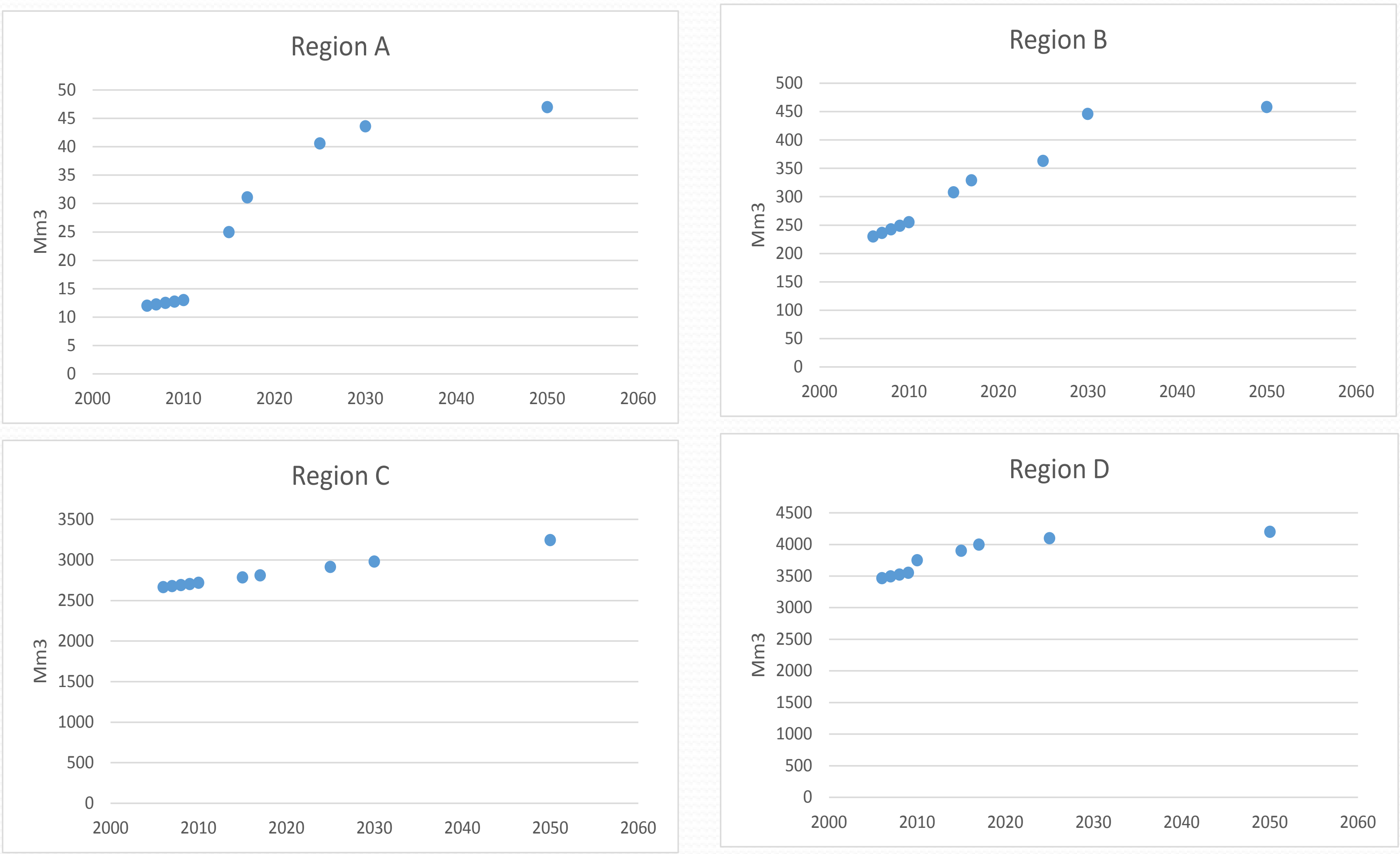
Data Requirement	Source
Energy Balance	Department of Energy (2006,2009), International Energy Agency (2009)
Electricity and Natural Gas Balances	Eskom, SASOL
Power Sector Industry Transport Residential and Commerce Agriculture;	Eskom, EPRI (IRP), SASOL, ERC (2013), StatsSA Industry Publications (e.g. Annual Reports, Technical Reports)
Existing power plants	Eskom
New power plant types (e.g. wet-cooled supercritical, sea-water open-cycle cooled)	Key data and assumptions for non-IRP power plants are documented in the Thirsty-Energy Task 2 SATIM-W method report.

Energy and Water Growth Assumptions



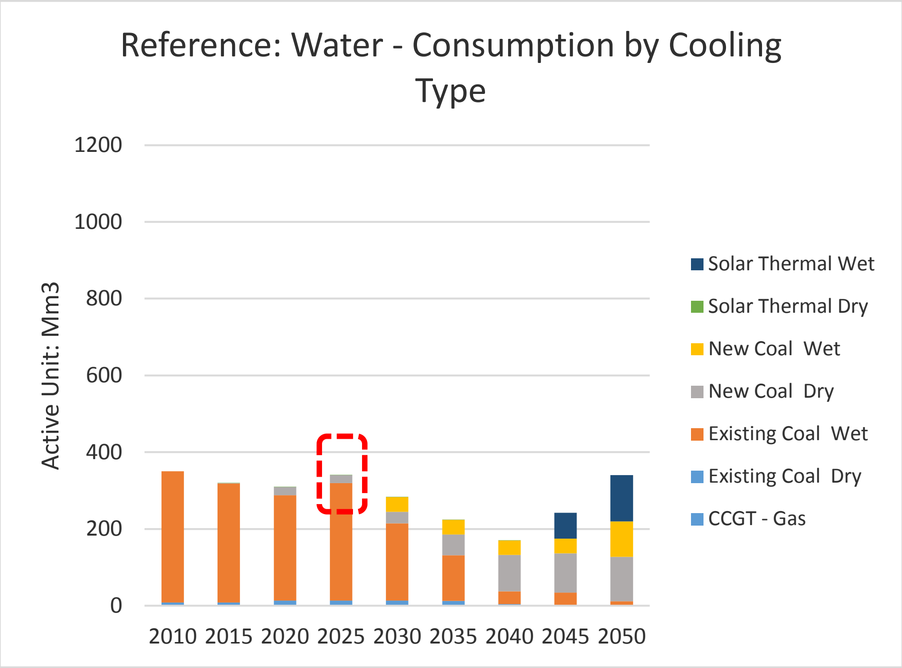
- Average 3%/year GDP growth is the main driver for the demand for energy services which must be met by SATIM-W.

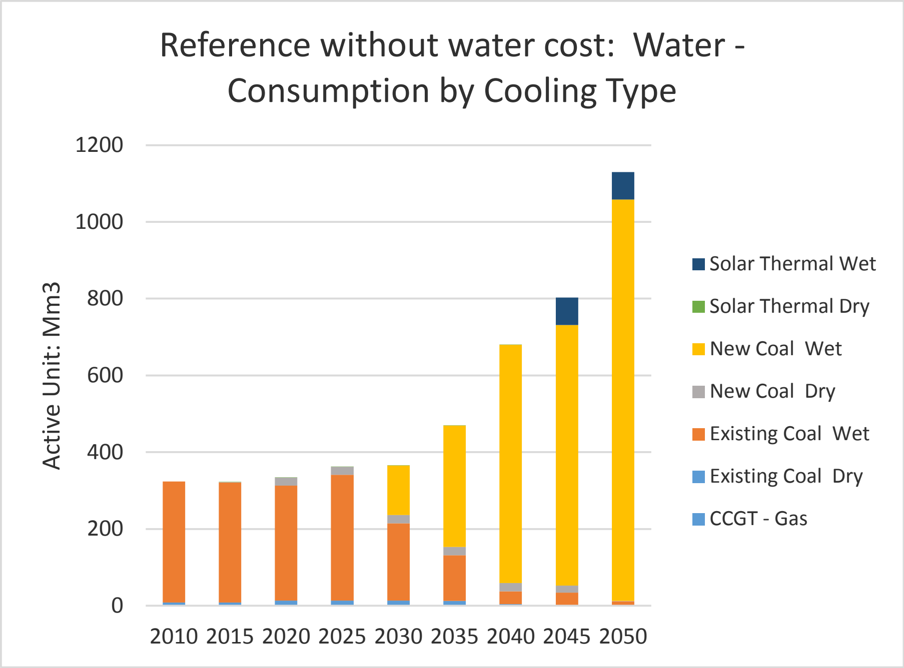
Energy and Water Growth Assumptions



- Non-energy sectorial water demands (incl EWR) derived from DWA Future Marginal Cost Study (2010) and DWA regional "Reconciliation" studies. Water demand is at present exogenous and work is underway to link to GDP.

Why cost water for energy supply?





- Without a cost for water, new coal power plants employ Wet Cooling, but when water costs are applied there is a shift towards Dry Cooling and Solar Thermal.
- Not including a cost for water lowers total system cost by building more coal-fired power plants instead of renewables, but results in an 80% increase in water consumption for power generation while producing 2% more CO2.

Scenario	System Cost		Water to Power		Power Plant Builds		CO2 Emissions	
	2010MZAR	%	Mm3	%	GW	%	kT	%
Reference (BAU)	6,855,224		14,000		117.06		17,449,206	
Reference (BAU) no cost water	-76,099	-1.11%	11,054	78.96%	-7.89	-6.74%	350,419	2.01%

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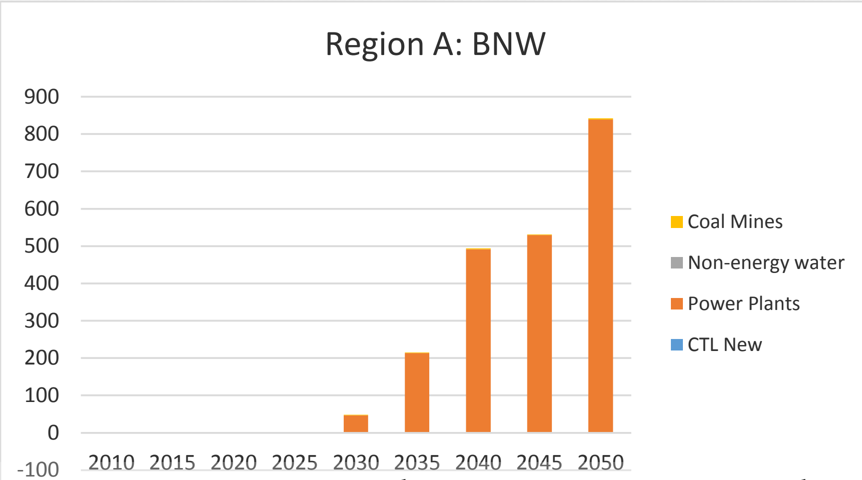
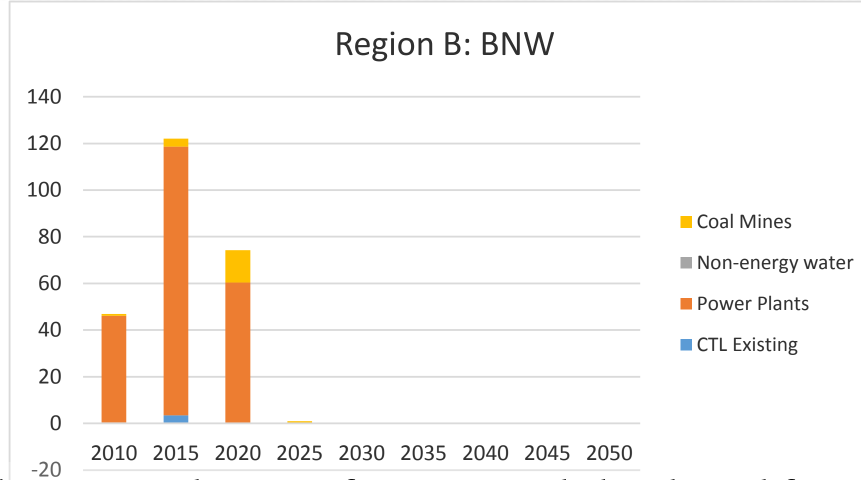
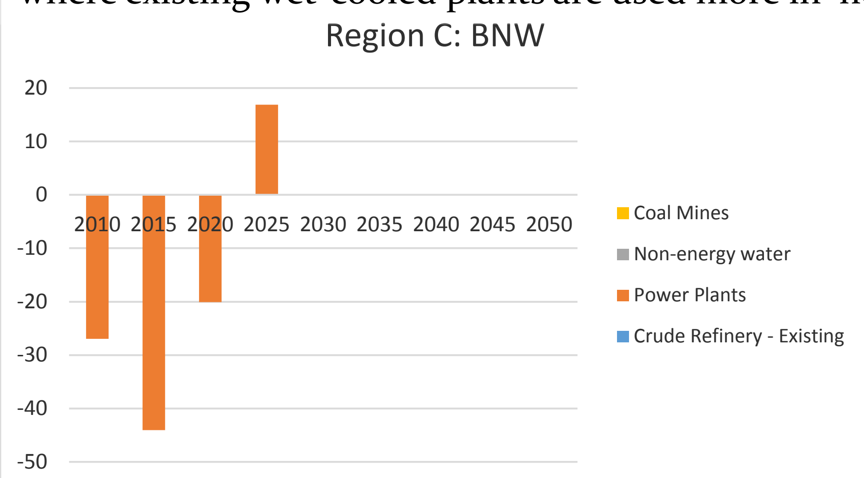
Why cost water for energy supply?

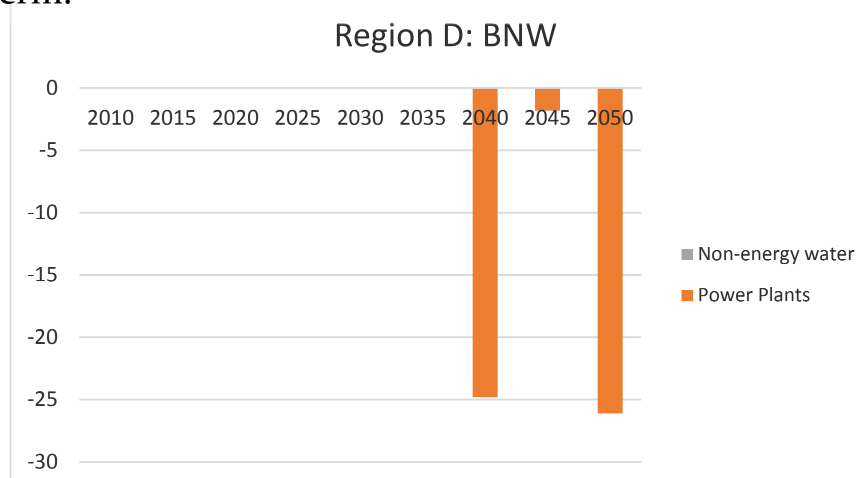
Change in water consumption for the no-cost water case



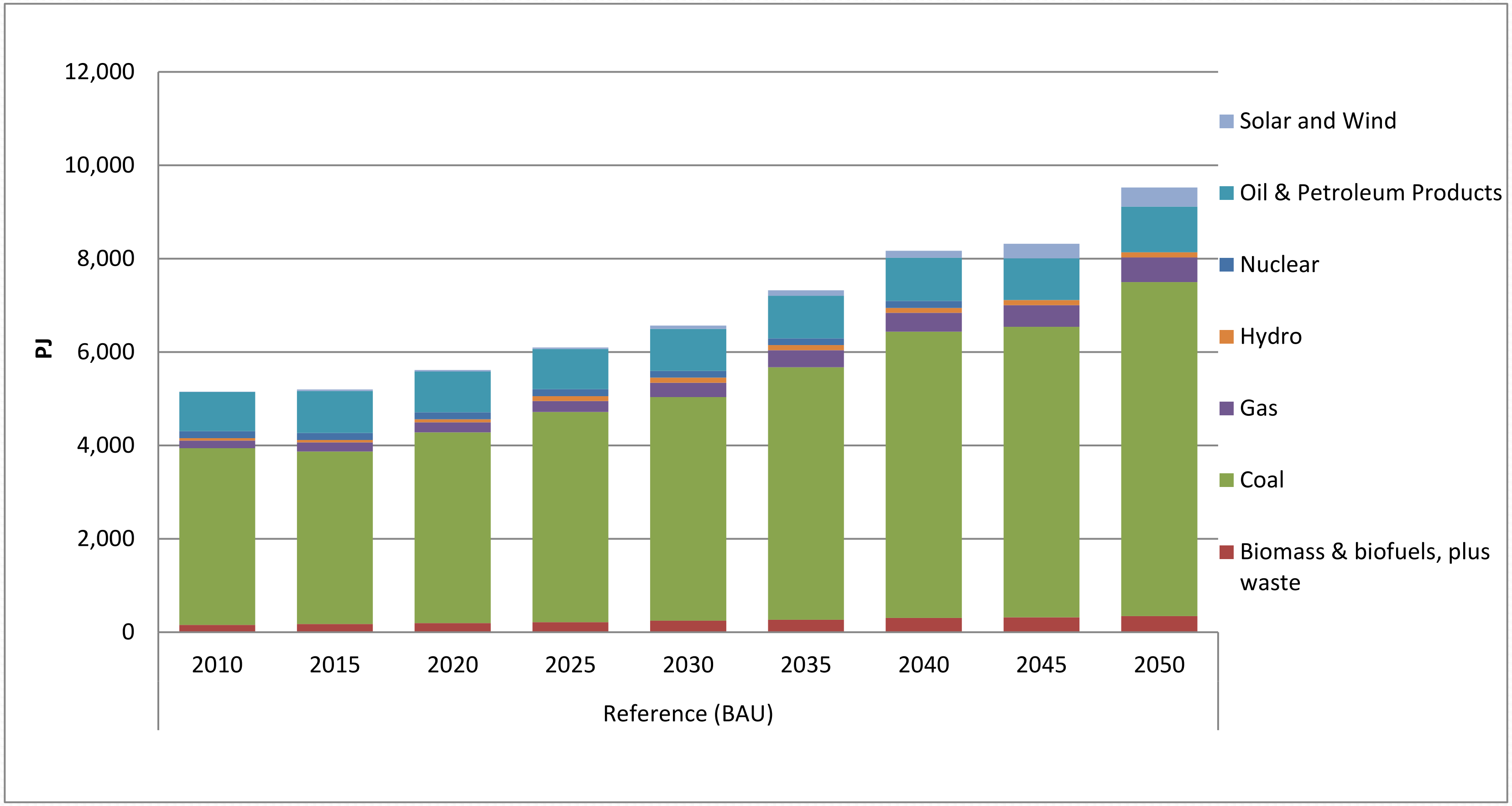


Key water –energy supply region occurs in Waterberg with greater utilisation of new wet cooled and in Olifants where existing wet-cooled plants are used more in near term.



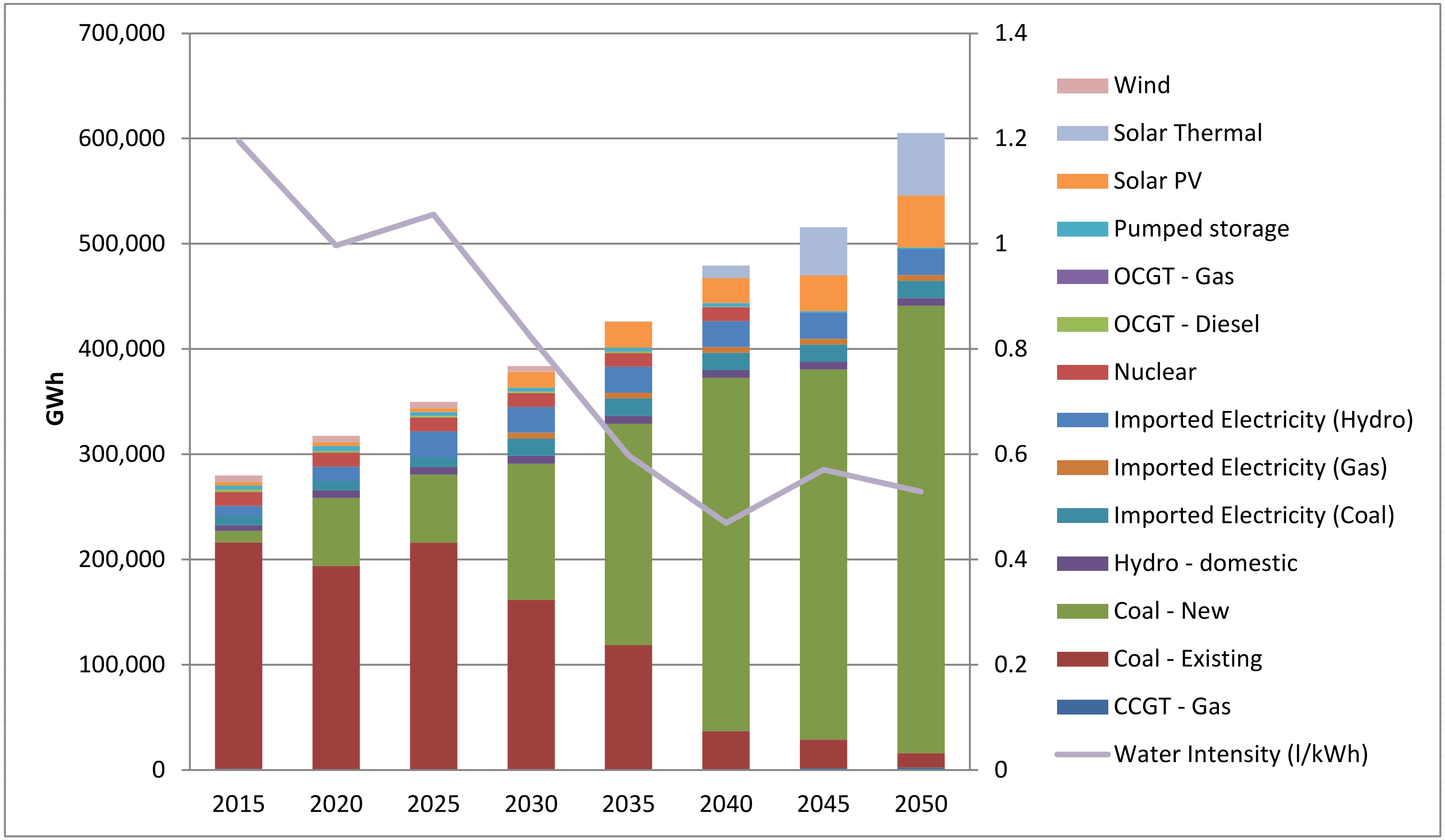


Primary Energy Supply



- Given the modest growth assumptions and expected improvements in power plant and demand device performance, Primary Energy grows slowly over the modeling horizon for a total growth of 45%, with coal rising 51% and gas 223%.

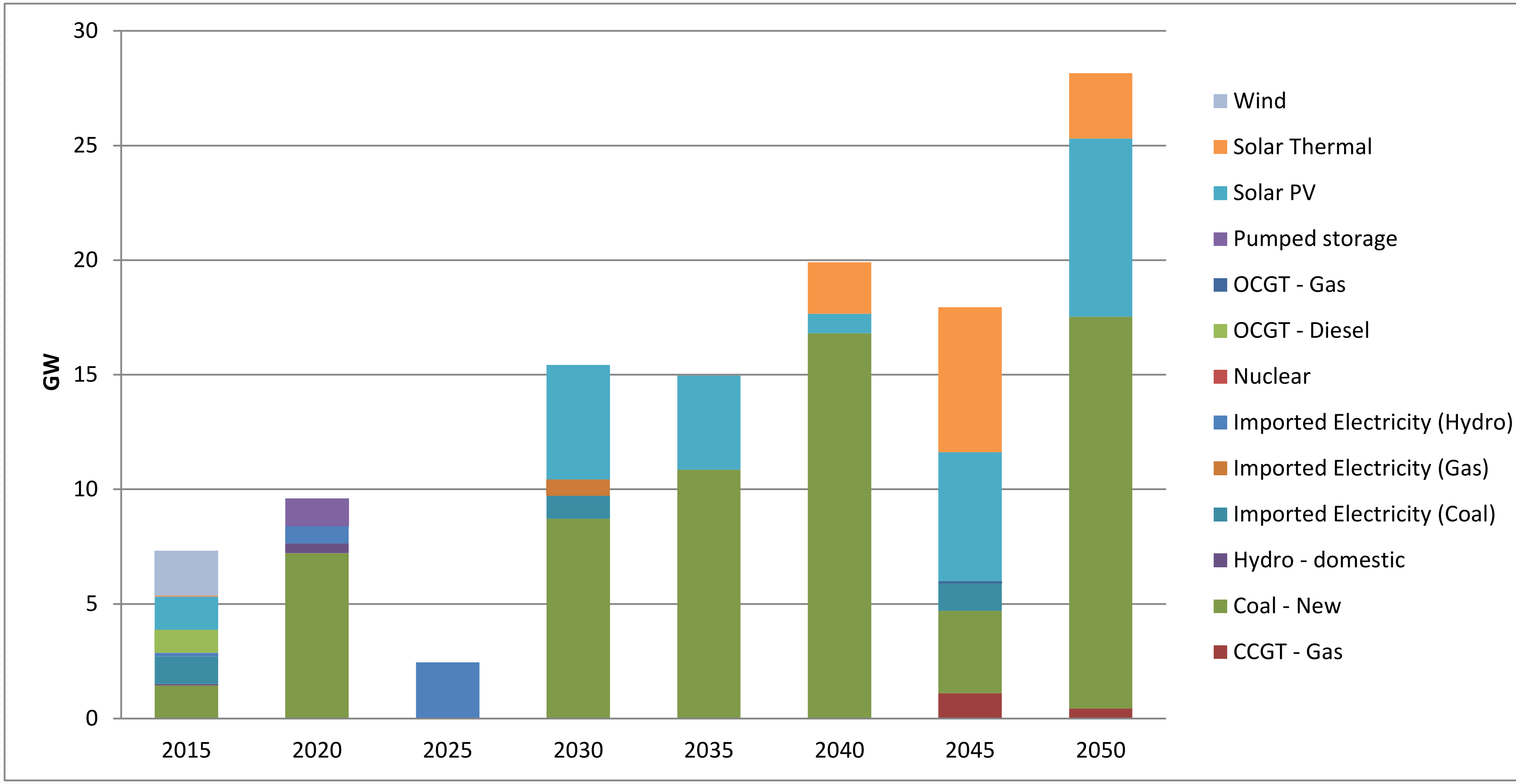
Electricity Generation & Water Intensity



- Reliance on coal-fired generation remains strong over the planning horizon, though decreasing from 87% of generation in 2010 to 72% by 2050 as solar comes into play.
- Costing for water results in a 3% to 6% increase in the levelised cost of generation over the 2020 - 2050 timeframe.
- As Dry Cooling ramps up the water intensity for electricity generation is cut by more than 50%.

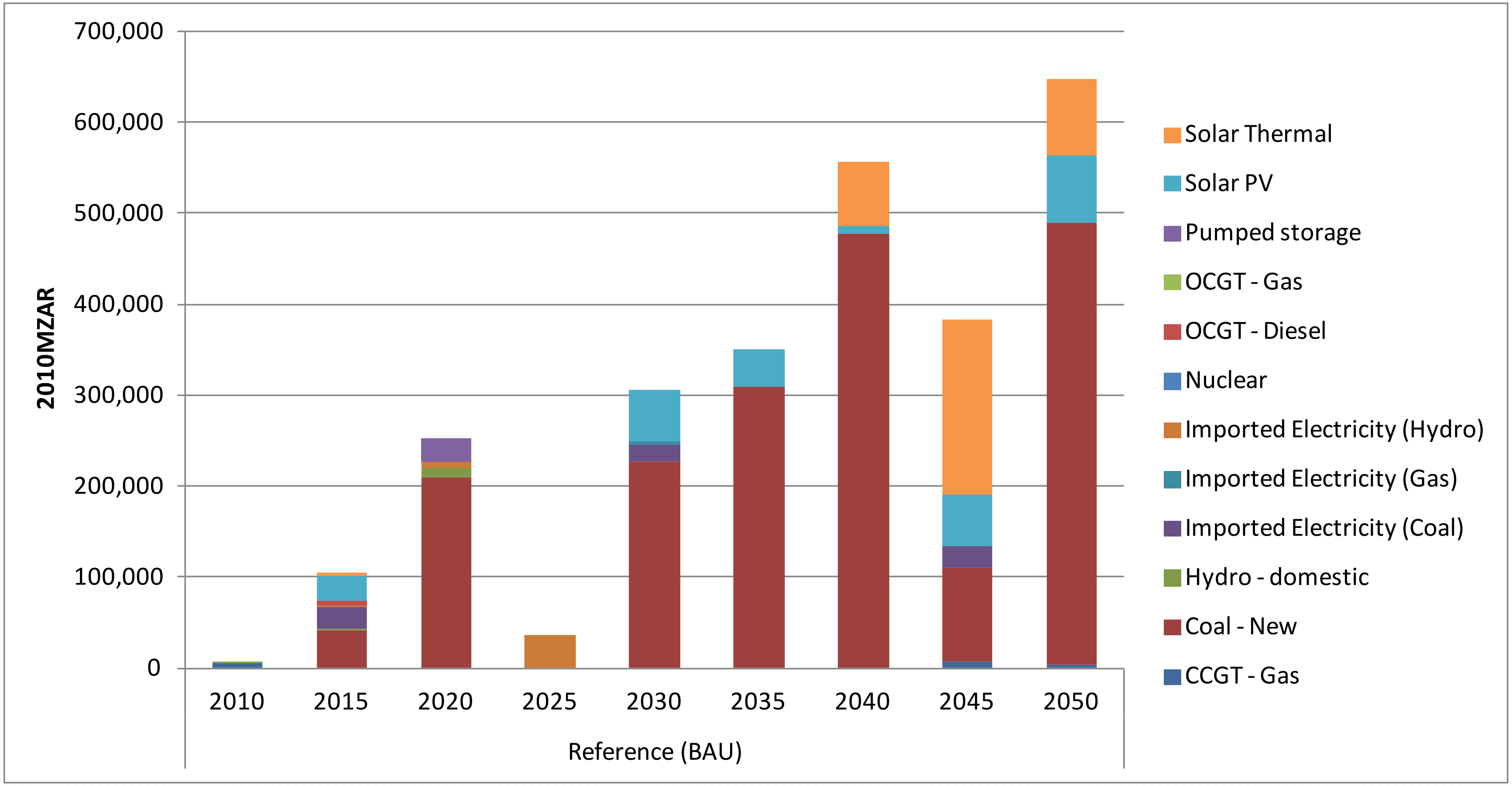
SATIM-W Reference Scenario

New Power Plant Builds



- As existing coal-fired power plants retire (largely starting in 2030) there is an enormous need to add capacity, where about 96GW of new capacity (57GW of coal, 23GW solar PV and 11GW of solar thermal) is added during the 20 years from 2030 to 2050.

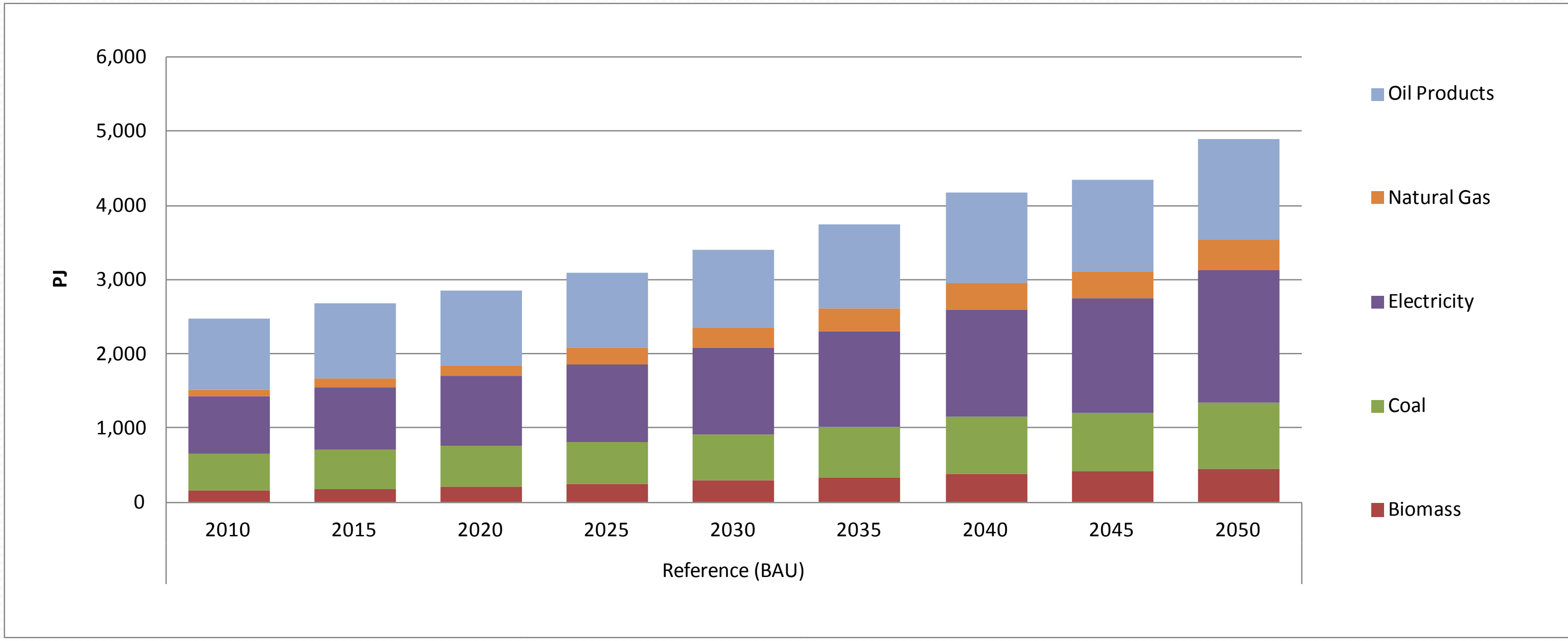
New Power Plant Investment Requirements



- To meet the need for additional generating capacity as existing coal plants retire over 2.2 trillion Rand is required during the 2030-2050 timeframe.

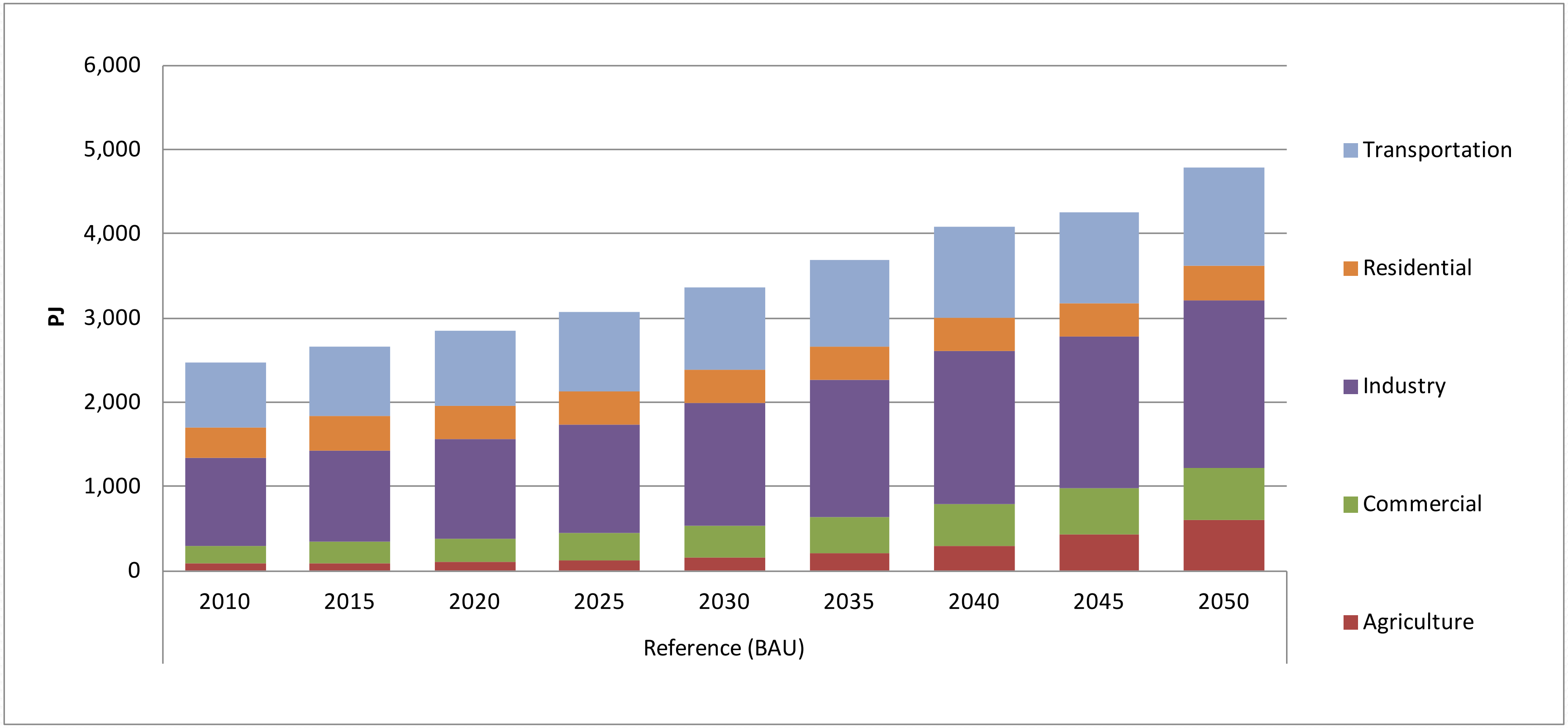
SATIM-W Reference Scenario

Final Energy by Fuel



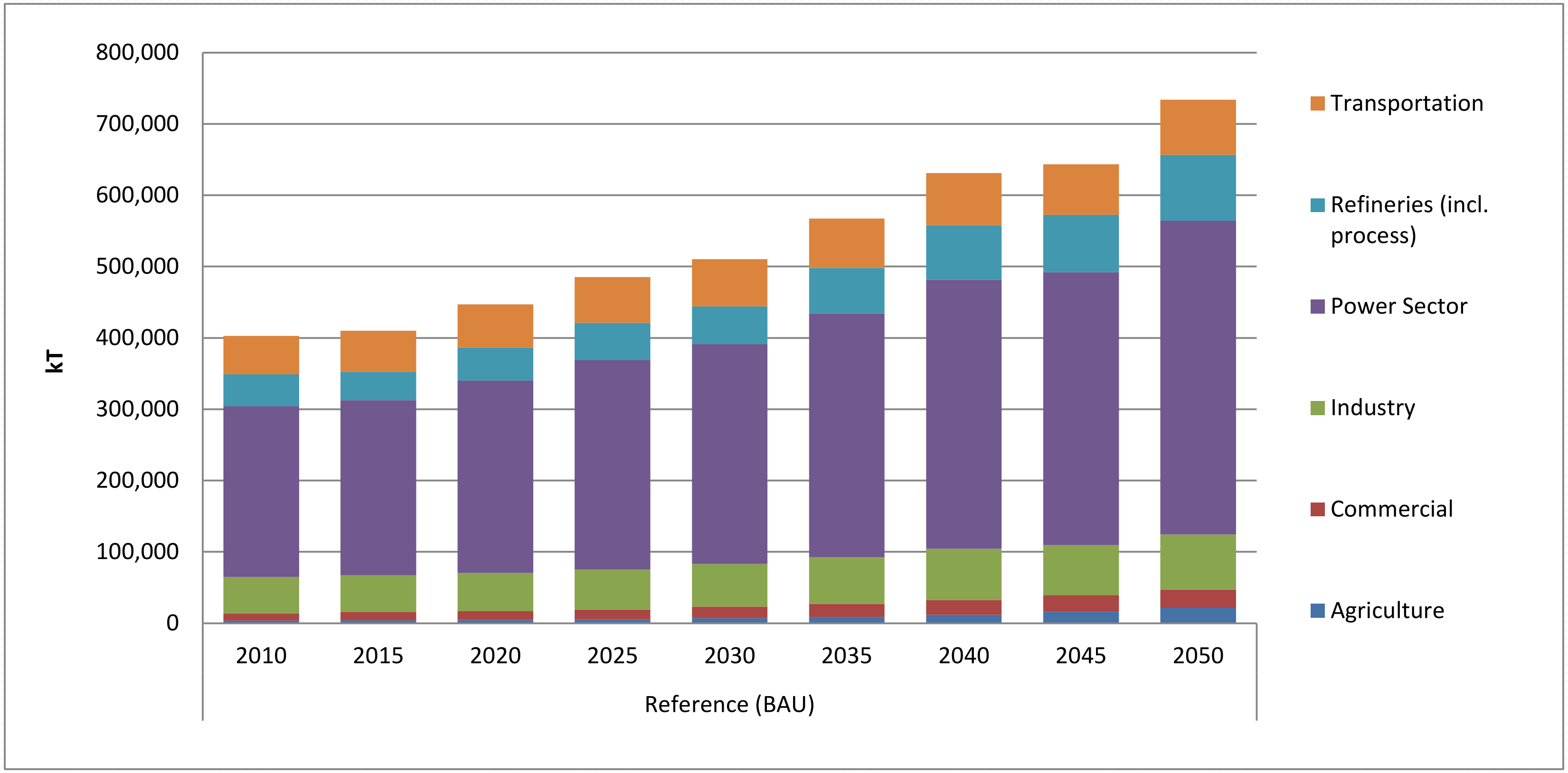
- Even with the modest growth assumptions final energy requirements still nearly double~~s~~ over the planning horizon, with electricity growing from 31% to 36%, gas from 4% to 8% and biofuels from 6% to 9%, while direct consumption of coal falls from 21% to 18% and oil products from 39% down to 28%.

Final Energy by Sector



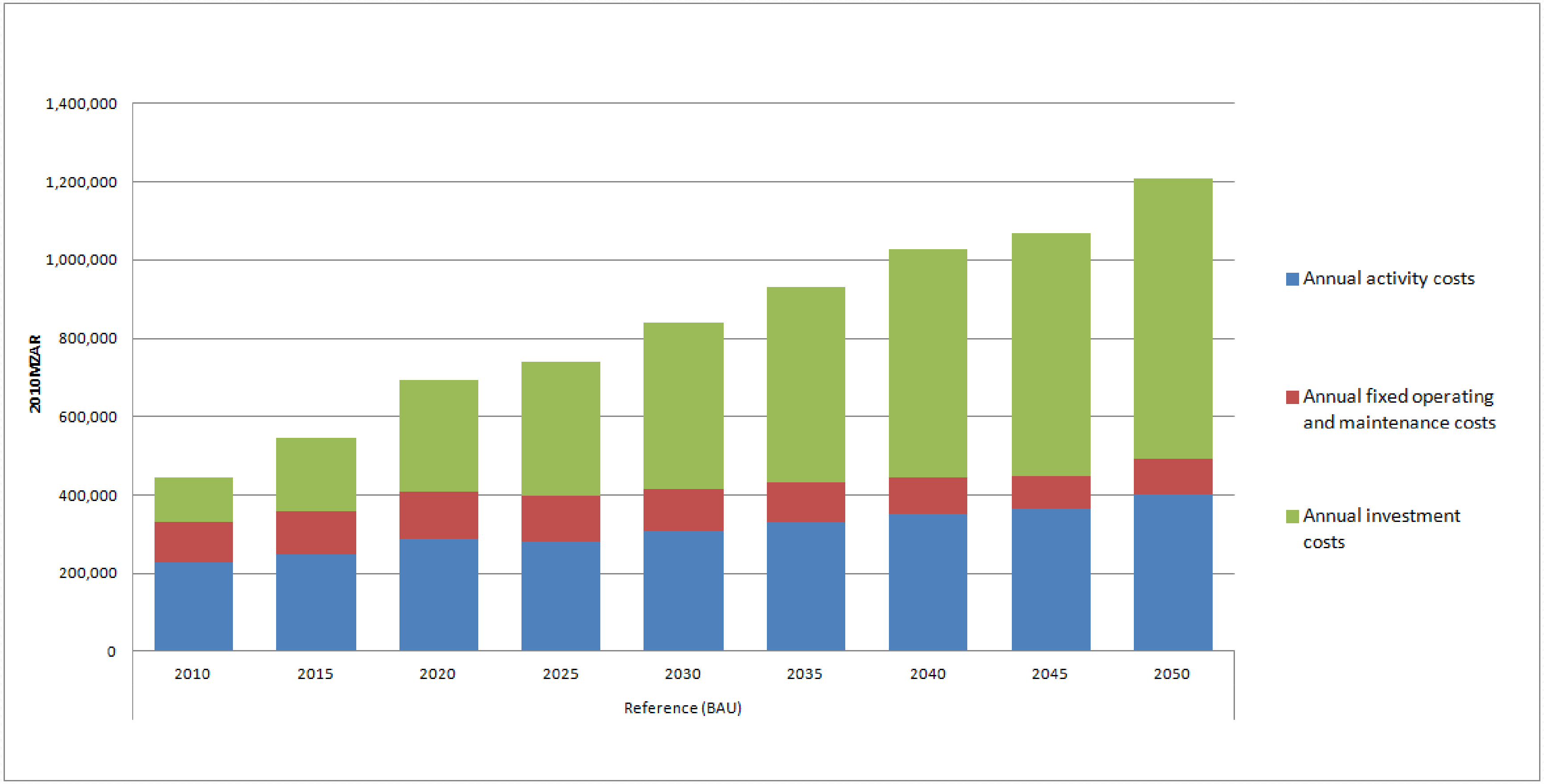
- Industrial energy consumption continues to have the dominate sectoral share - remaining at 42% of total demand.

CO_2 by Sector



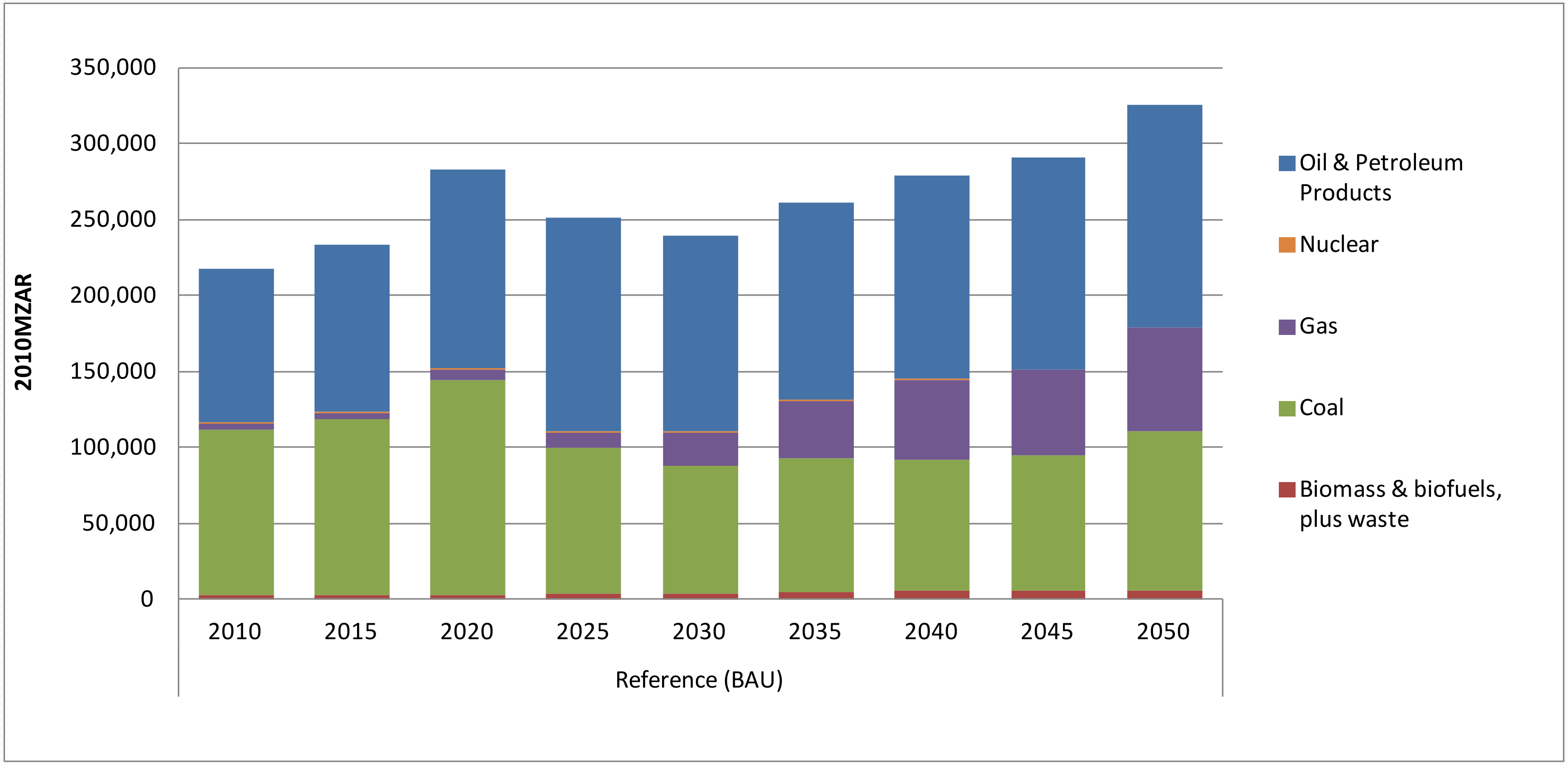
- CO2 emissions grow 82% over the planning horizon with about 60% of total emission arising from the power sector.
- CO2 increases another 2% in the no-cost water case

Annual Expenditures



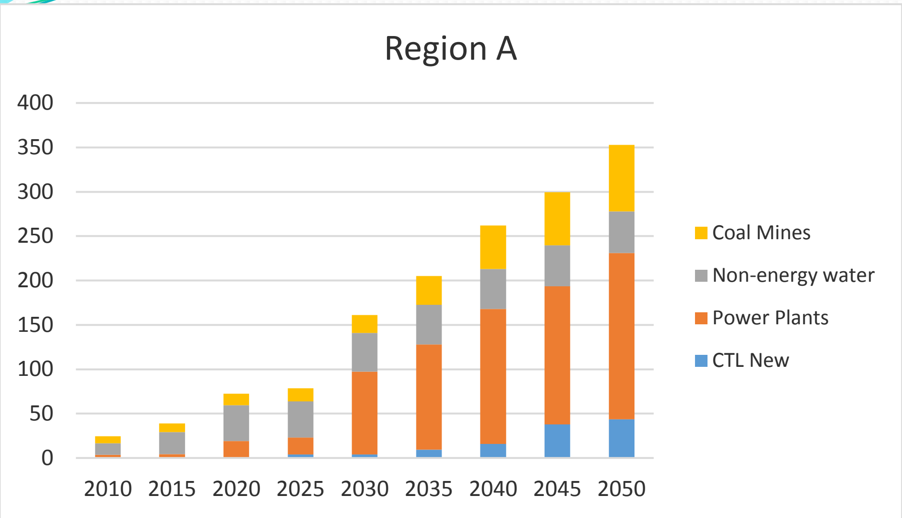
- Annual expenditures show the increasing annualized investment cost needed for new technologies to meet the growth in demand and to replace the retiring stock of power plants and demand devices over the planning horizon.

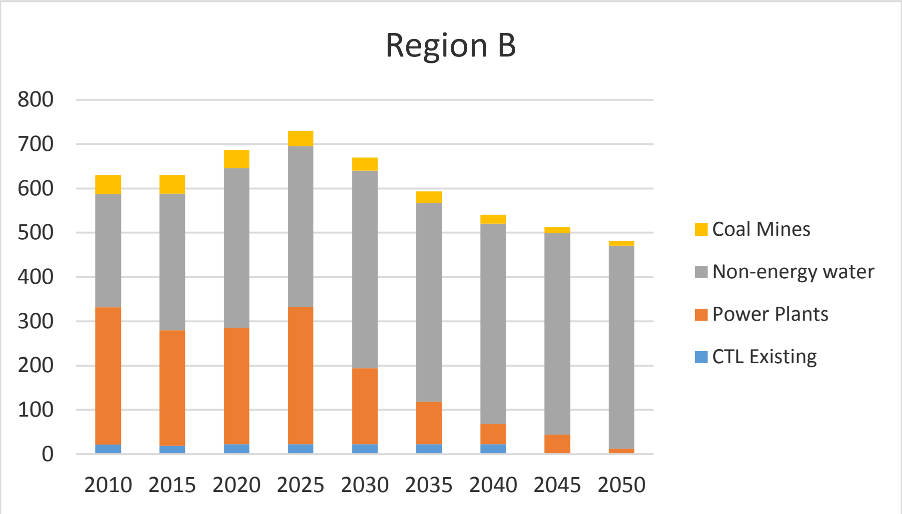
Resource Supply Costs

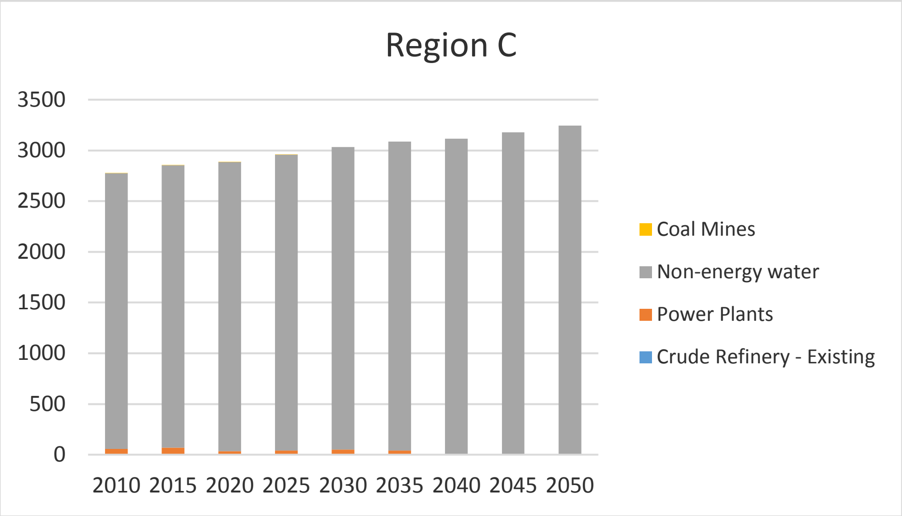


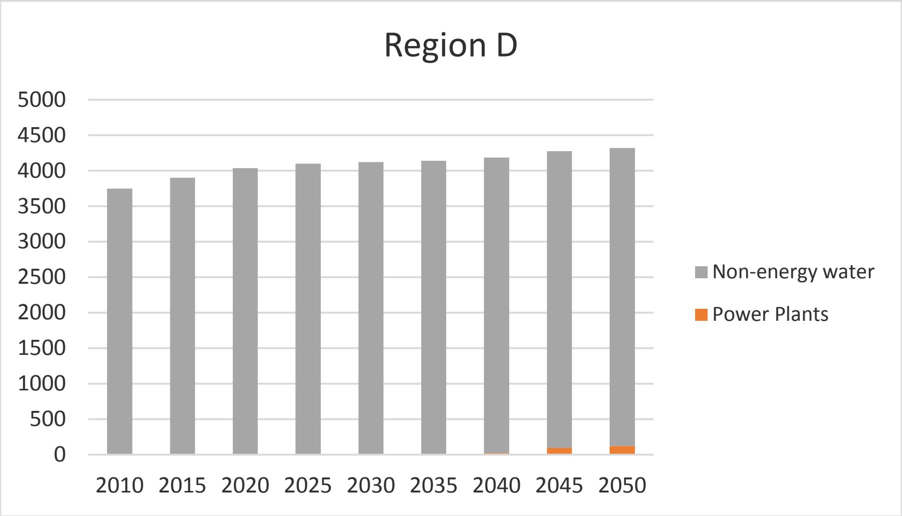
- Resource supply cost decreases after 2020 as existing coal plants are replaced by more efficient ones, although more use of gas starting in 2035 increases overall resource payments with its share of total fuel expenditures growing to almost 20% by 2050.

Regional Water Consumption



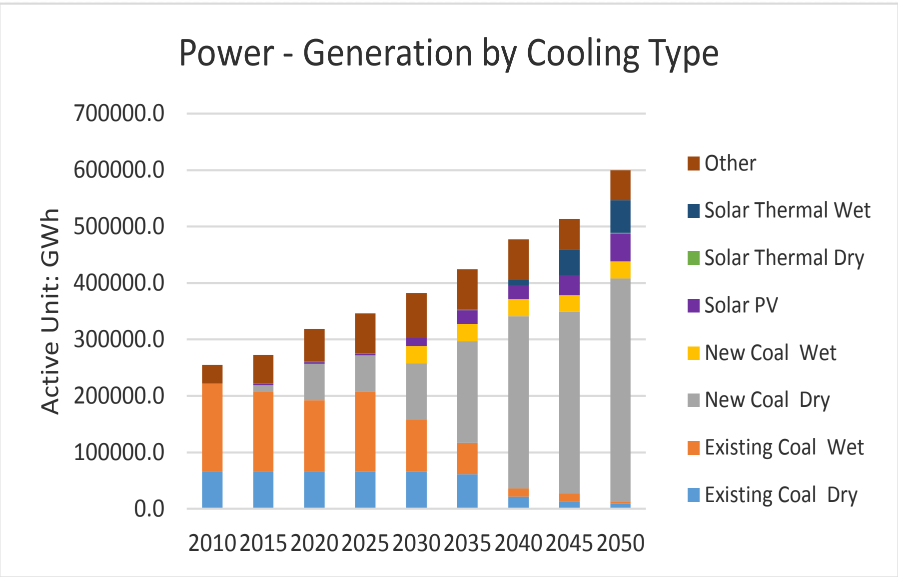


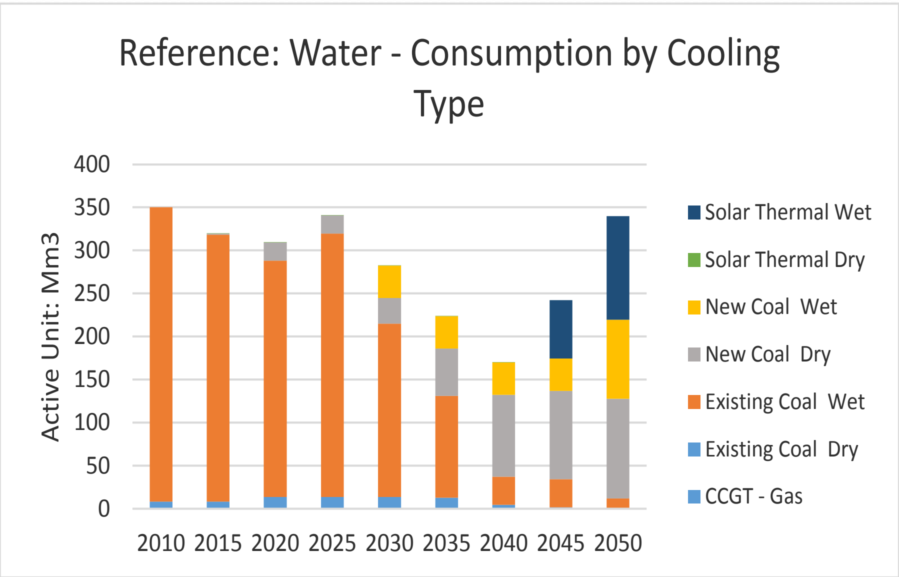




- The Waterberg (Region A) is the key water-energy region. Non-energy water demands dominate the other regions.
- In Olifants (Region B) energy water needs shrink substantially as existing power plants retire.

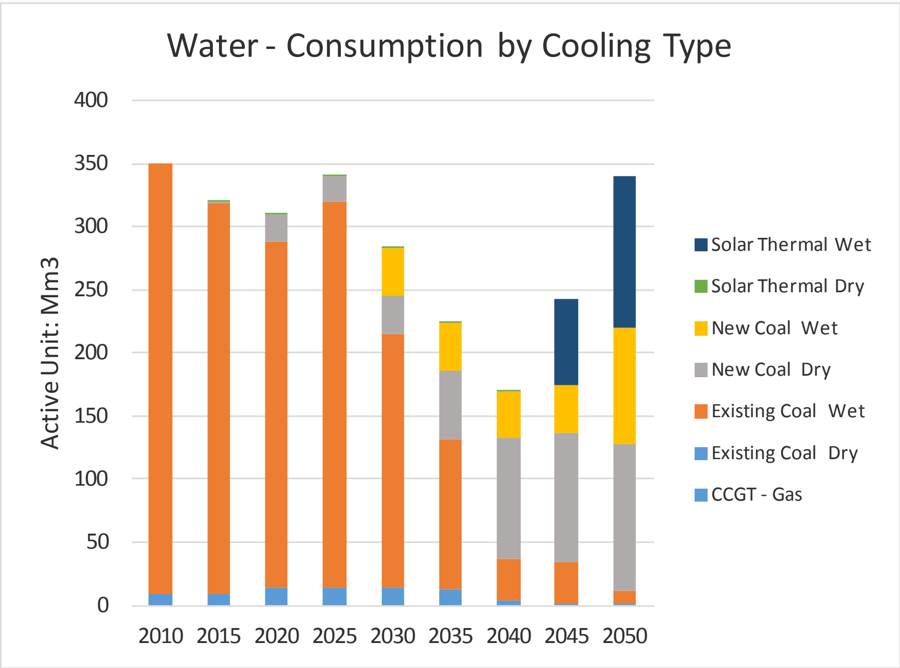
Energy Generation and Water Consumption

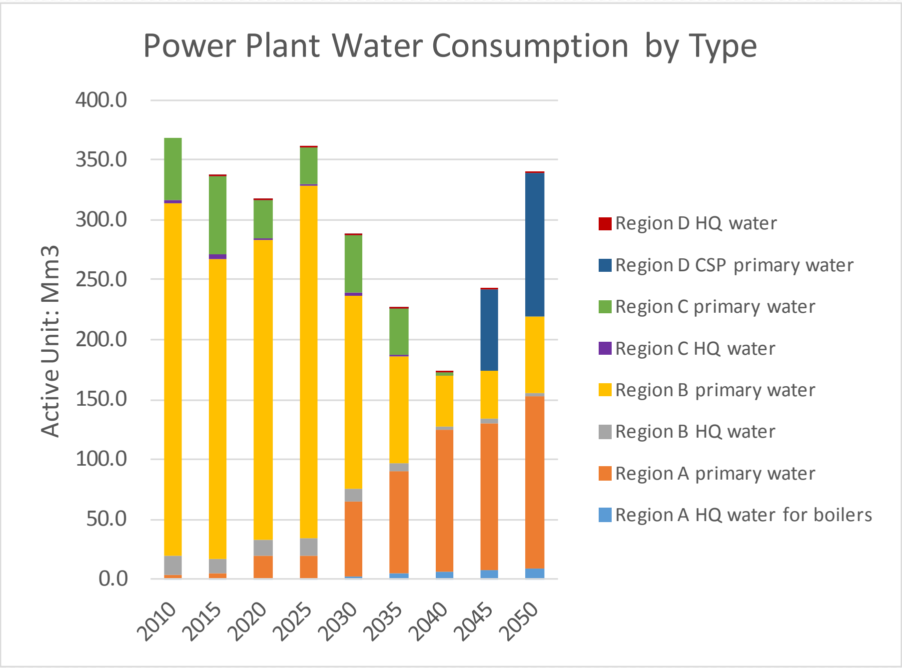




- In the latter planning period wet-cooled solar thermal plants are preferred with ~ 4 GW of new wet-cooled coal due to a basic economic benefit of allocating available water to power generation.

PP Water Consumption by Source

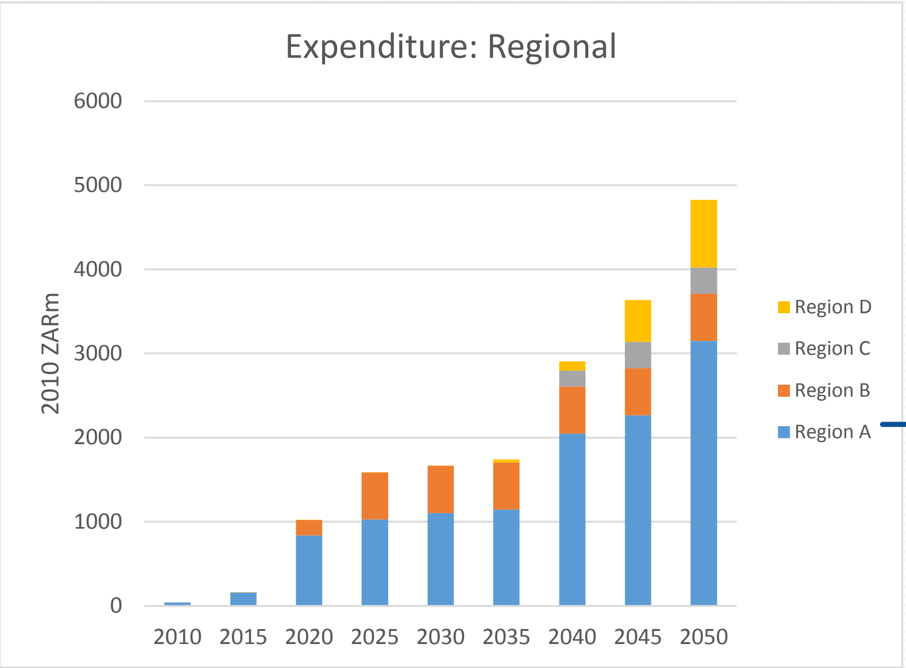


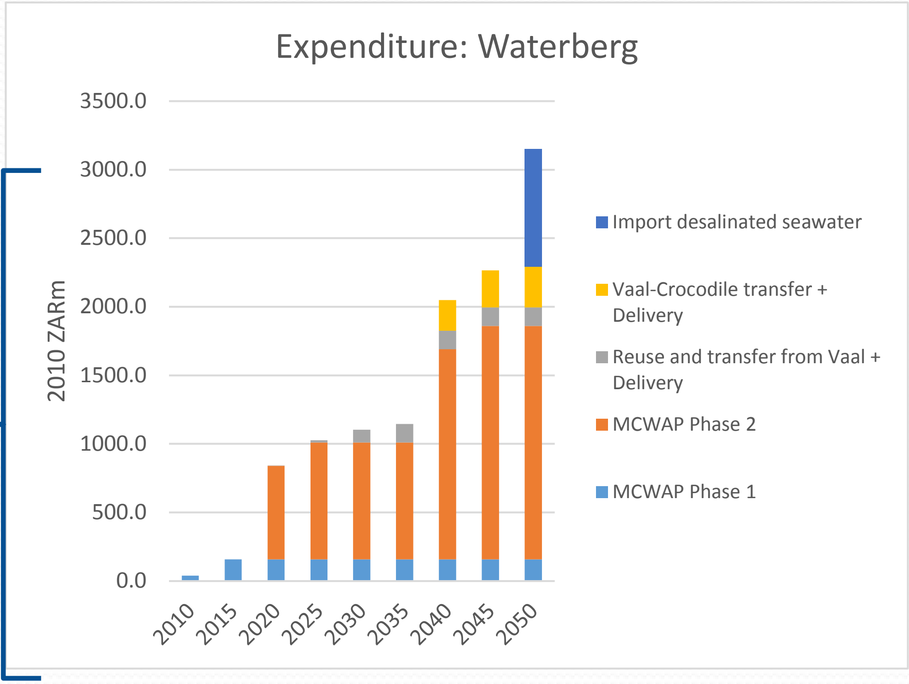


Coal	1.606	1.481	1.227	1.319	1.088	0.776	0.537	0.527	0.456
Gas	0.996	0.572	1.384	1.384	0.890	1.082	1.082	0.000	0.000
Solar	0.000	0.331	0.331	0.331	0.331	0.331	2.041	2.068	2.035
Total	1.404	1.196	0.996	1.056	0.822	0.598	0.469	0.571	0.529

- Water intensity of coal plants decrease over time while solar thermal increases ten fold due to wet cooling. Gas generation remains relatively flat over the planning horizon.

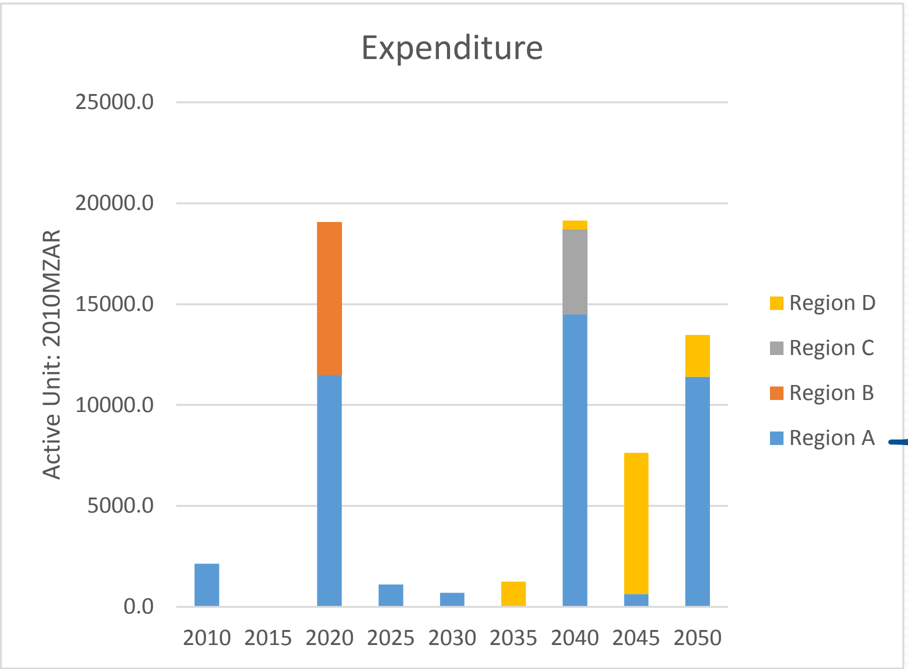
Water Infrastructure Investments Annual Payments

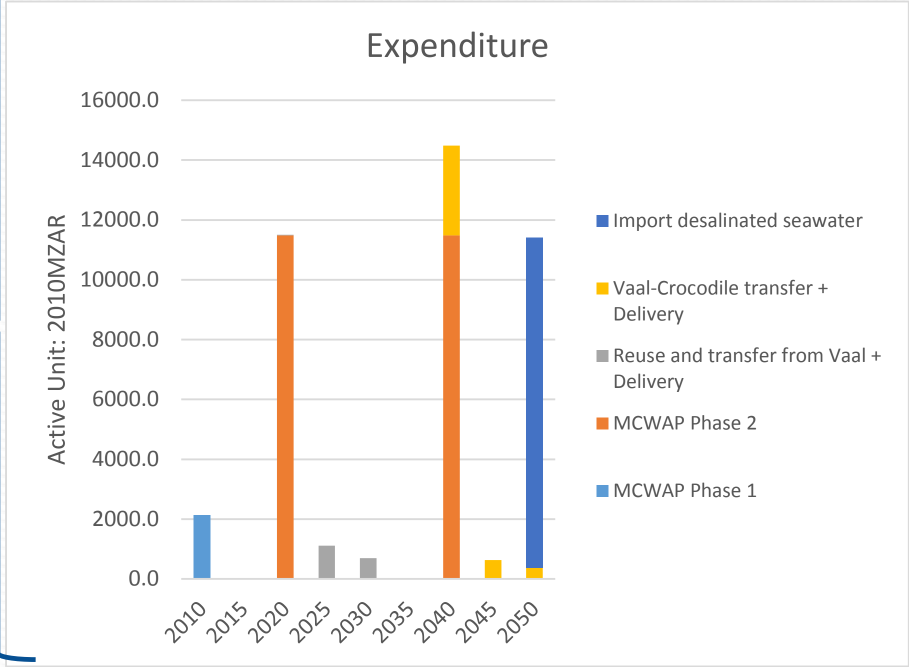




- Bulk of water for energy expenditure occurs in Waterberg. MCWAP Phase 2 is the main expense. Potential water shortage in 2050.

Water Infrastructure Investments Lumpsum Payments





- Bulk of investment in water infrastructure occurs in the late period from ca. 2040. Potential water shortage in 2050. In Waterberg this due to additional freshwater transfers and “desalinated sea-water”.

Planned Model Improvements

Water

- Impact of water treatment for coal and shale gas mining effluent
- Regional water quality impact choices
- Water-energy cost for other energy supply sectors: hydrogen, uranium mining and processing
- Disaggregate the non-energy water sectors to enable water reallocation to be examined.
  - Endogenous modelling of effluent or return flows (treatment and volumes).
  - Monthly water demand profile vs annual

Energy

- Enhance demand sector future technology options
- Add costs for expansion of the transmission lines from remote solar sites
- Reexamine characterization of wind options
- Introduce load balancing requirements as the share of renewables grows

Conclusions & Discussion

- SATIM-W is now an integrated water-energy planning capability that will get more sophisticated over time.
- The importance of considering both water & energy as part of the national planning process is clear from the integrated planning results presented, in particular that
  - not including a cost for water results in less total system cost as a result of building more wet cooled coal-fired power plants, but with an associated 80% increase in water consumption for power generation while producing 2% more CO_2,
  - whereas costing for water shifts technology choices to dry-cooling and solar , with an associated modest increase in total system cost with significantly lower water consumption and less CO_2 produced.
- Key stakeholders are encouraged to review and comment on the assumptions and resulting Reference scenario evolution of the South Africa water-energy system to ensure that they reflect best available knowledge.

Water and Shale gas