

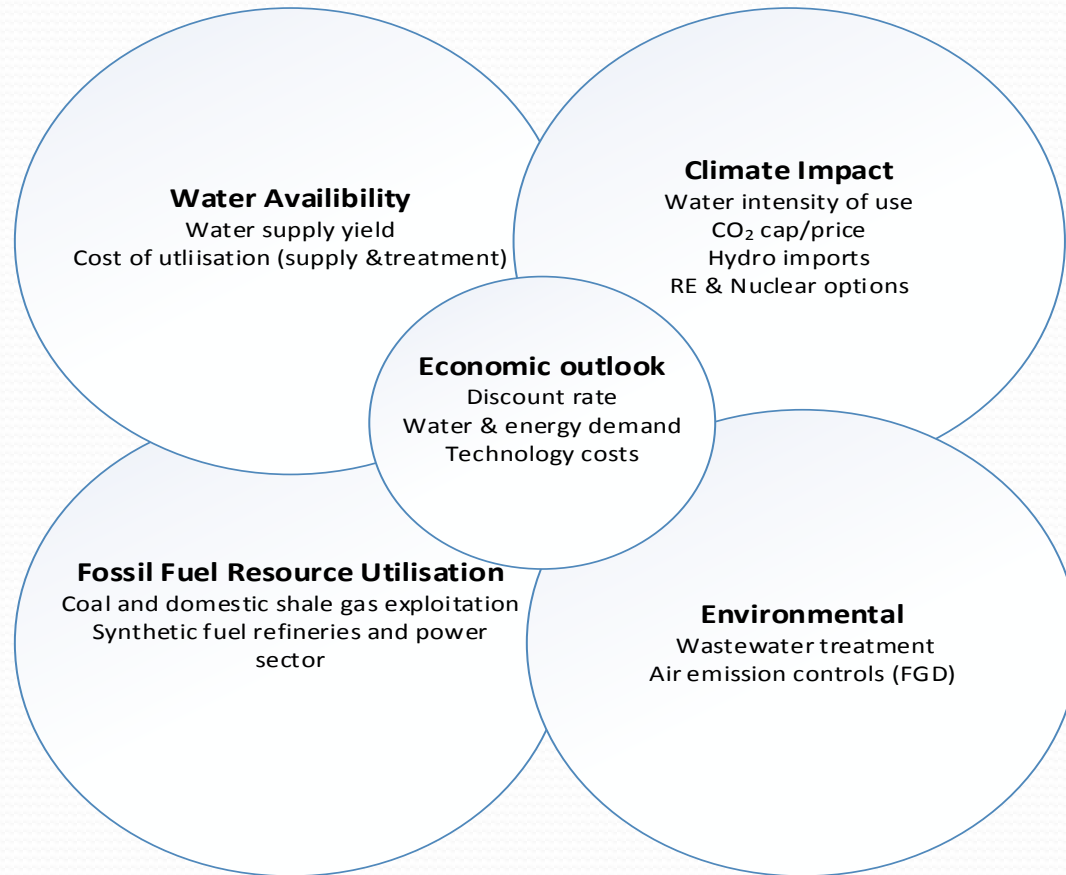
SATIM-W Preliminary Analysis

Energy Research Centre
University of Cape Town
29th April 2015

Outline

- Definition of the alternate scenarios examined
- Key metrics to inform decision-making
- Comparison of selected scenarios
- Open discussion

Analysis Areas



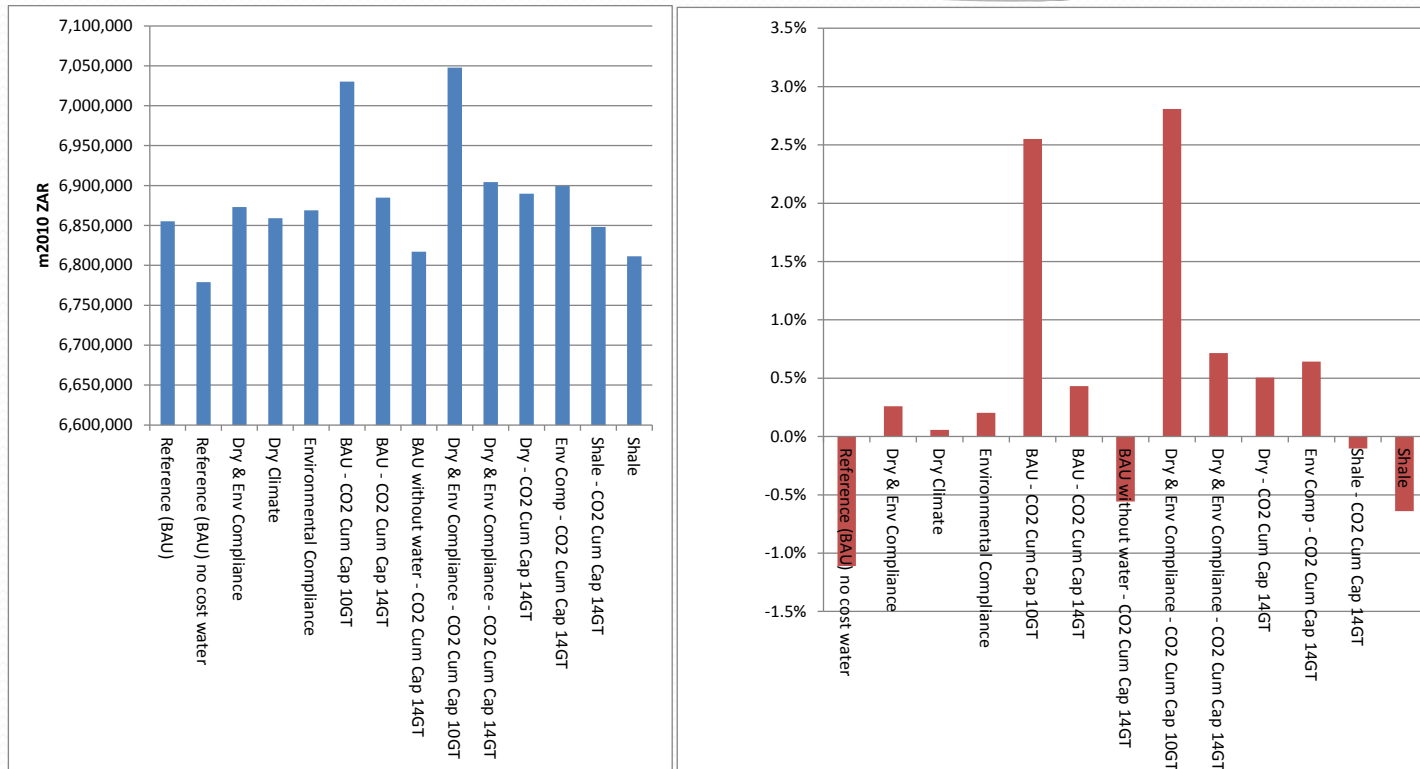
Themes explore the interaction of the various factors that would influence planning decisions in the energy supply sector from a water and energy perspective

Scenarios Investigated

Thirsty Energy South Africa SATIM-W Scenario Matrix					
	Scenario Area	Shale gas	Drier Climate / Water Stress	Environmental compliance	CO ₂ cap / limit / tax
	Scenario Description	Shale gas extraction limited to 40 tcf otherwise	Drier climate: increasing non-energy water demand and reduction in water supply	FGD retrofit to older coal power plants. New build plants are assumed to be built with Wet-type FGD.	A cumulative CO ₂ cap set at 10/14Gt by 2050
	Scenario Adjustments for run	remove OFFSHALE Add: SHALE	add: SUP_WAT4D remove: SUP_WAT4	add: E	Add C10/14 or CTAX#
	Scenario Indicator	S	D	E	C/L/T#
Case Description	Case Name				
Reference (no shale)	BAU	S000	ODOO	OOEO	S_OOOC#
No Water Cost (no shale) Add: SUP_WAT-NIL	BNW				S_NWC#
Shale					S_SOOC#
Drier Climate		SDOO		ODEO	S_ODOC#
Environ. Compl.		SOEO			S_OOEC#
Drier Climate and Environ.Comp.		SDEO			S_ODEC#
Shale, Drier Climate and Environ.Comp.					S_SDEC#

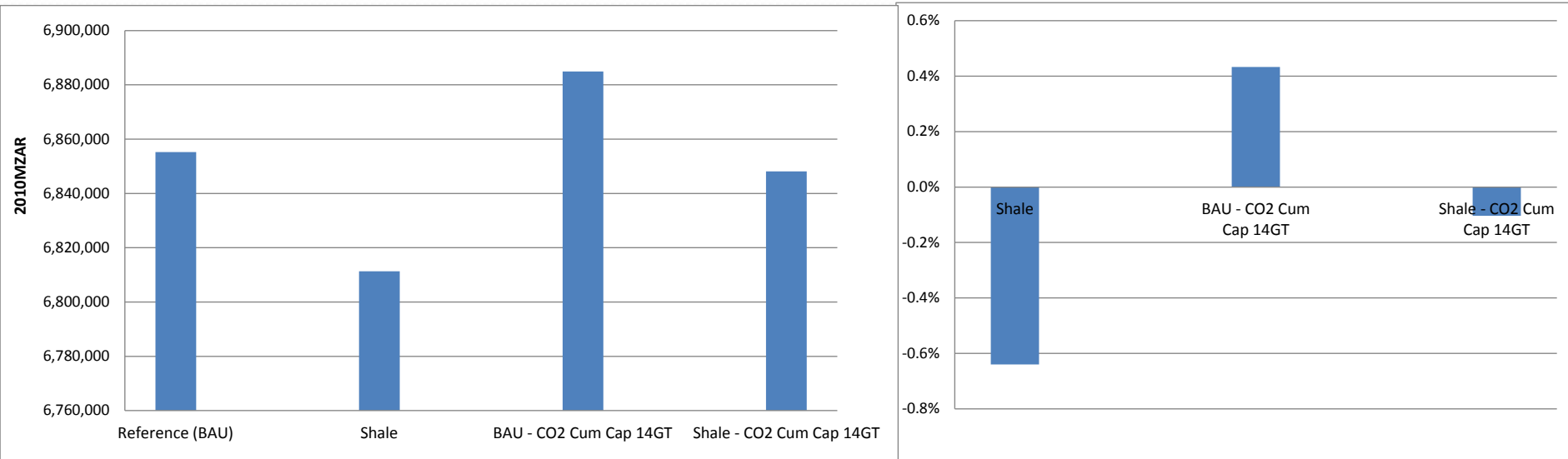
- A broad set of scenarios were run to look at uncertainties associated with the role of Shale gas, implications of more stress on the water system, and stricter environmental requirements, with each of these examined under a carbon constrained world.

Total System Cost Across Scenarios



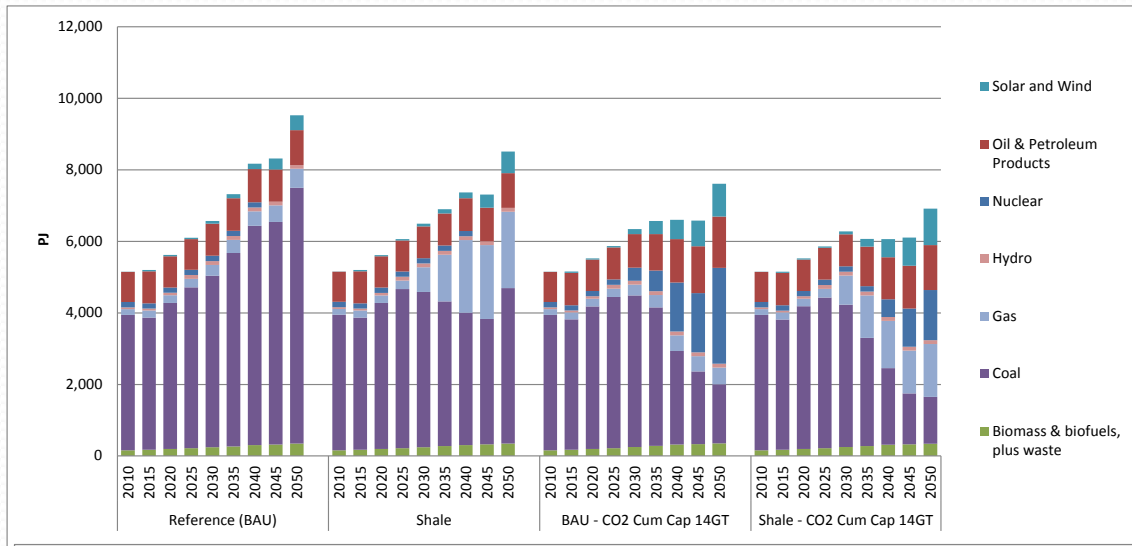
- Accounting for the requirements and cost of water costs adds 1.1% to overall total system cost
- Environmental compliance adds 0.2%
- Shale drops system costs to -0.6%
- A 14GT limit on CO₂ emissions increases system costs by 0.4%, but when both environmental compliance and a dryer climate are considered, a 10GT limit raises costs 2.5% and 2.7%

BAU & Shale / CO2 Cap Energy System Cost

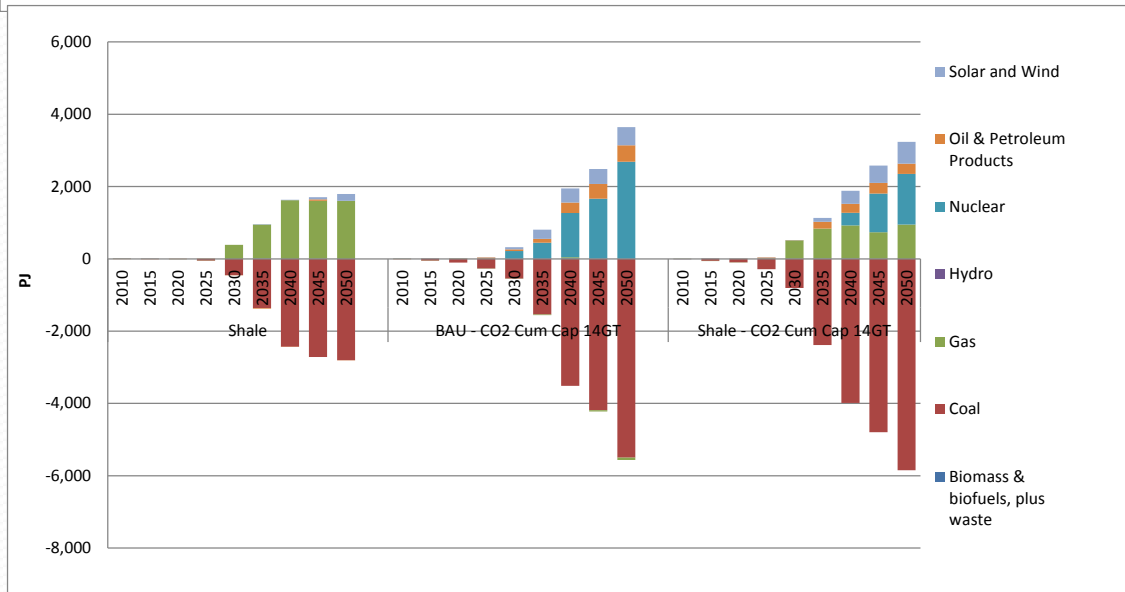


- Shale gas costing 60 ZAR/GJ (at the extraction site) lowers total system cost 44BZAR or by about 0.6%
- A 14Gt CO₂ cap raises the system cost by 30BZAR or 0.4%
- Shale gas helps achieve the CO₂ cap at almost the same system cost as with BAU

BAU & Shale / CO2 Cap Primary Energy (net of Exports)

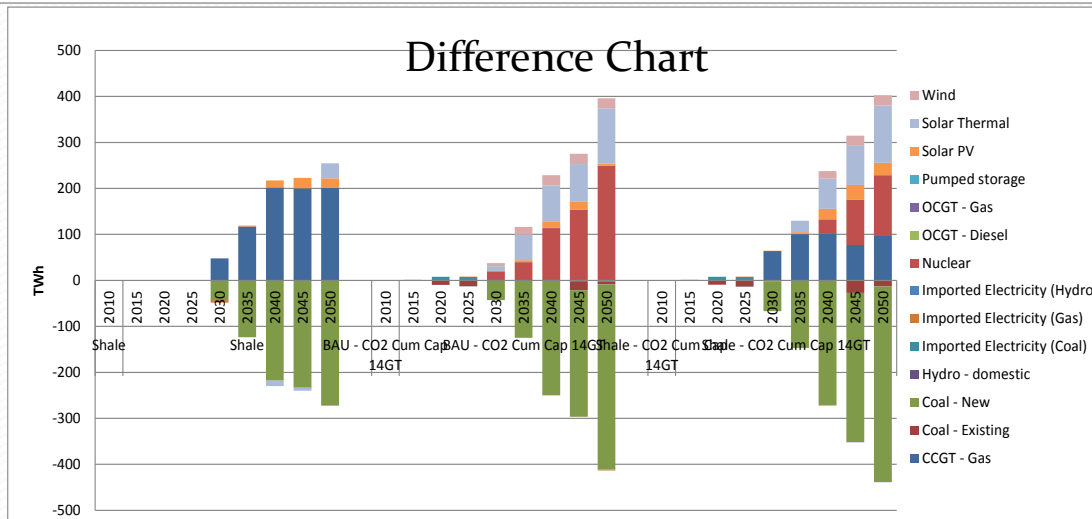
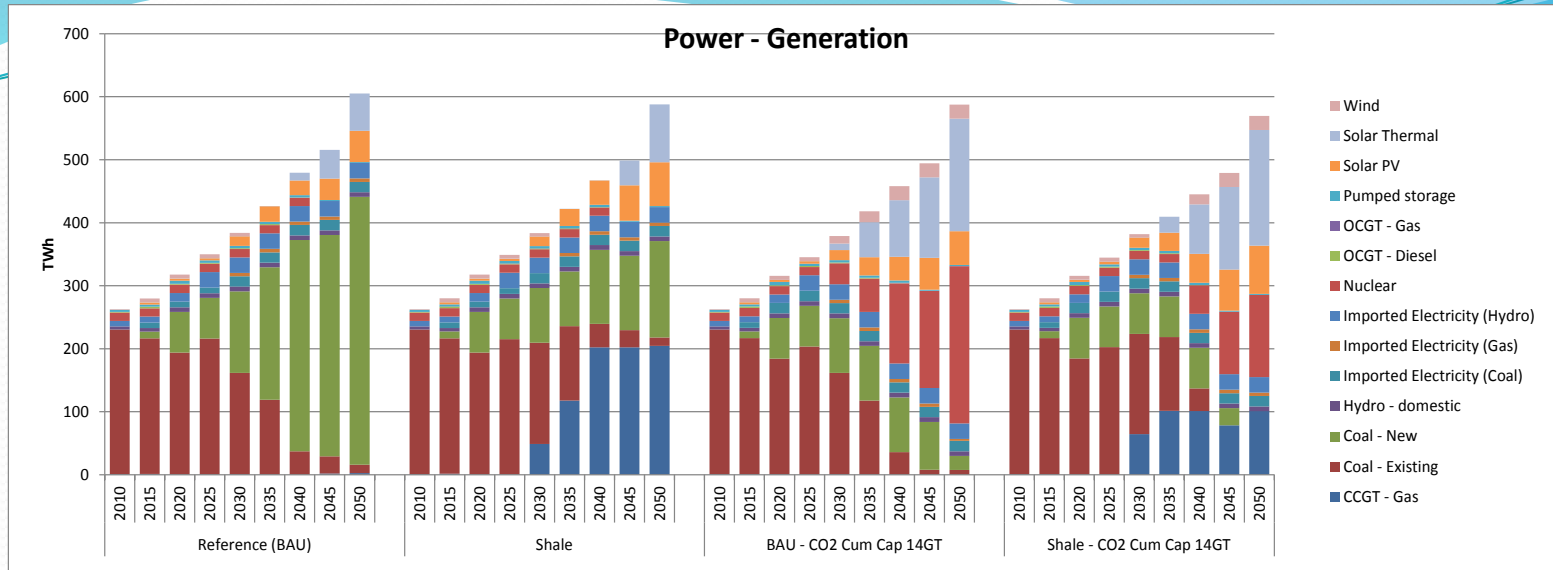


- When Shale gas is available it displaces coal
- Nuclear displaces a lot of coal in the capped scenario without Shale
- Coal in the final years of CO₂ capped scenarios is mainly going to Industry, with some to Commercial



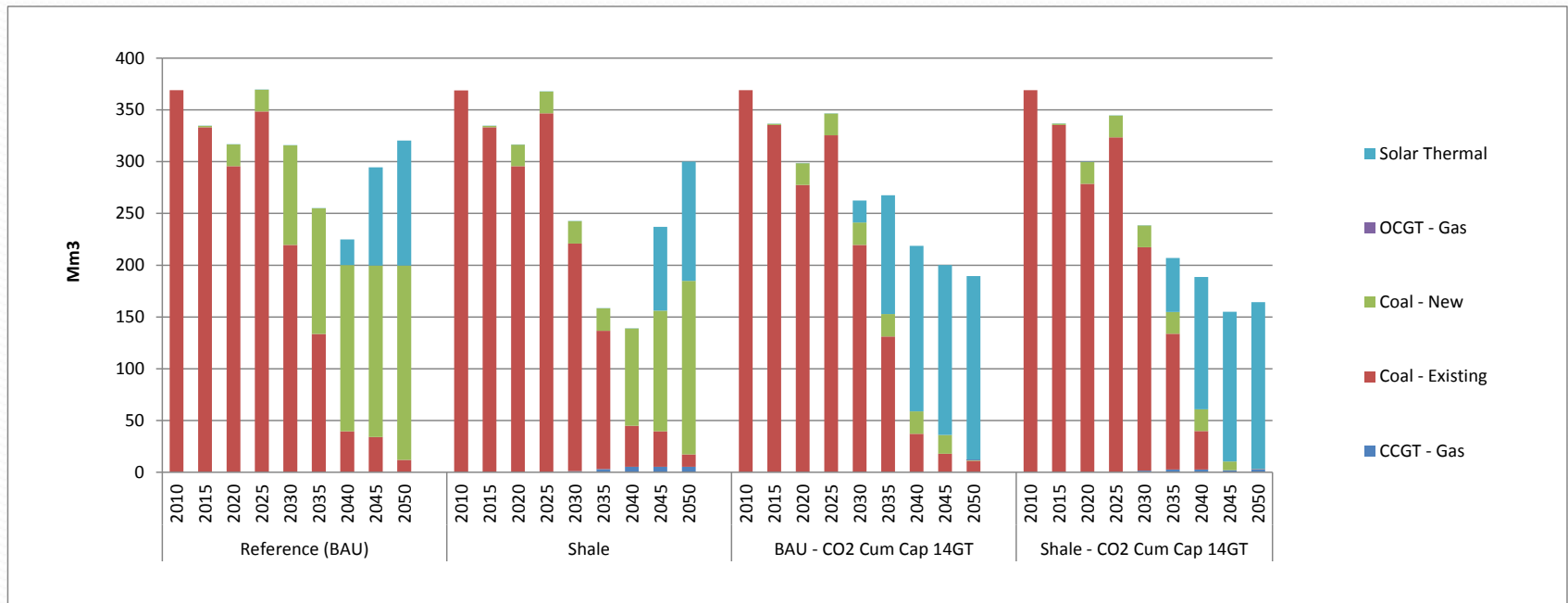
{Note that 1kWh of wind/solar electricity consumes 1kWh of wind/solar primary energy}

BAU & Shale / CO2 Cap - Electricity Generation & Capacity



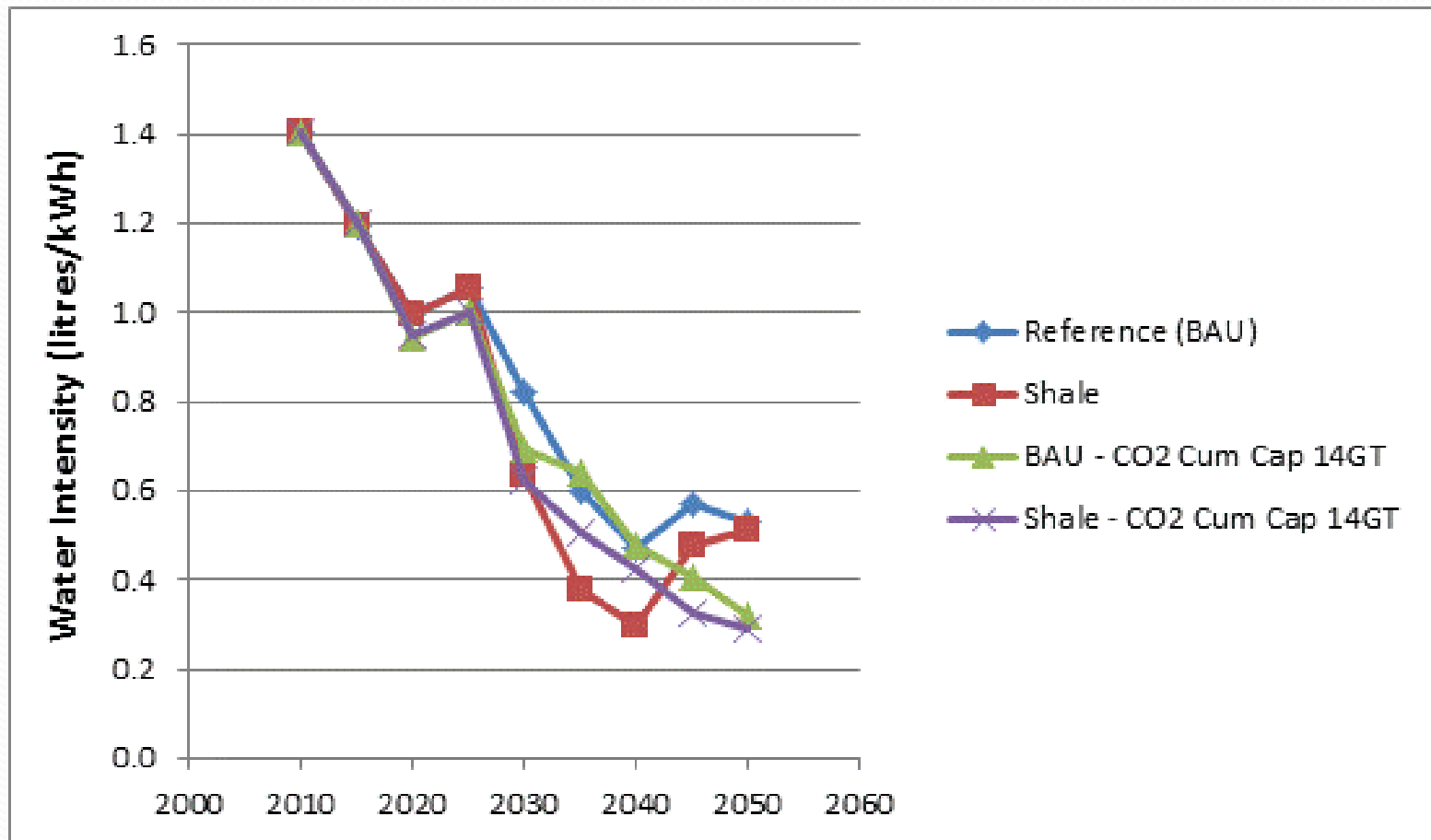
- Shale allows a bit more variable renewables into the generation mix
- Nuclear and renewables are turned to heavily to meet the CO₂ cap without Shale
- 3GW of existing coal capacity is almost “stranded” in the later years under the CO₂ cap
- Shale delays nuclear to 2040 and eliminates almost all coal generation with the CO₂ cap

BAU & Shale / CO2 Cap Water Consumption by Plant Type



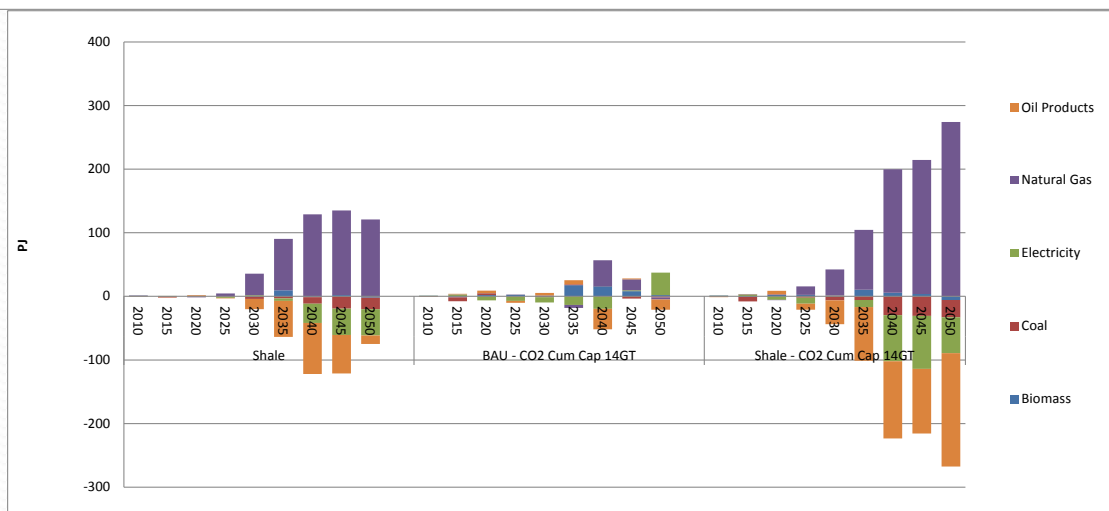
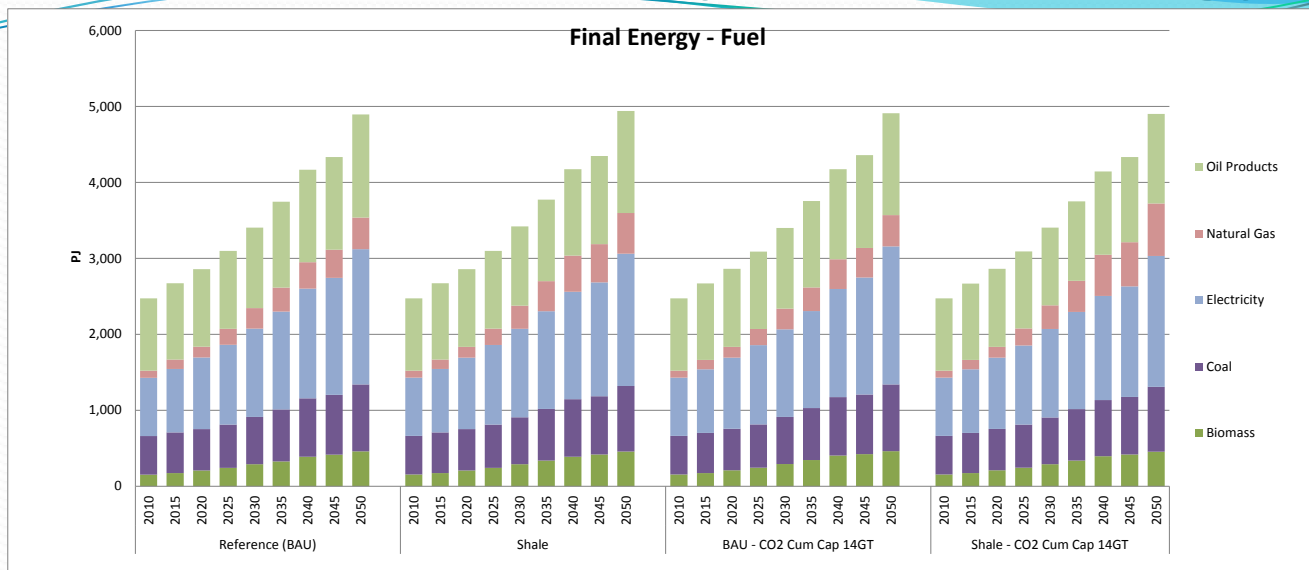
- Water requirements for electricity is reduced with the availability of Shale gas due to the much lower consumption of water by CCGTs that displaces new coal
- A 14GT CO₂ cap substitutes nuclear and renewables for coal, doubling the solar thermal capacity by 2050, about a third of which is wet-cooled which dominates the demand for water for power by 2050
- Availability of Shale gas under a CO₂ cap sees a 15% reduction in water consumption by 2050, displacing coal, and enabling a 55% increase in Solar PV capacity
- A CO₂ cap with Shale gas also drives a modest shift to dry-cooled solar-thermal generation but significant wet-cooled capacity remains
- Water consumption for Shale gas production is relatively modest, but regional issues and peak requirements need to be factored in as well

BAU & Shale / CO2 Cap Water Intensity by Scenario



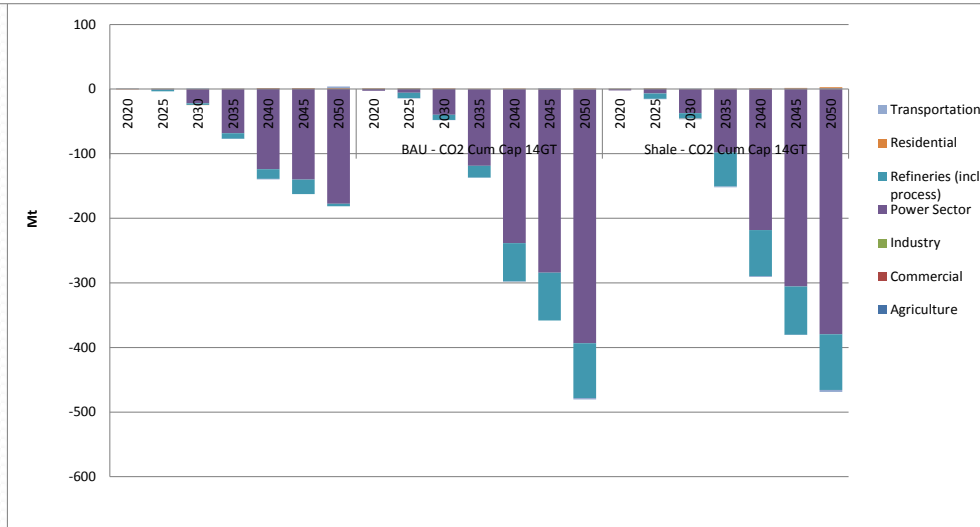
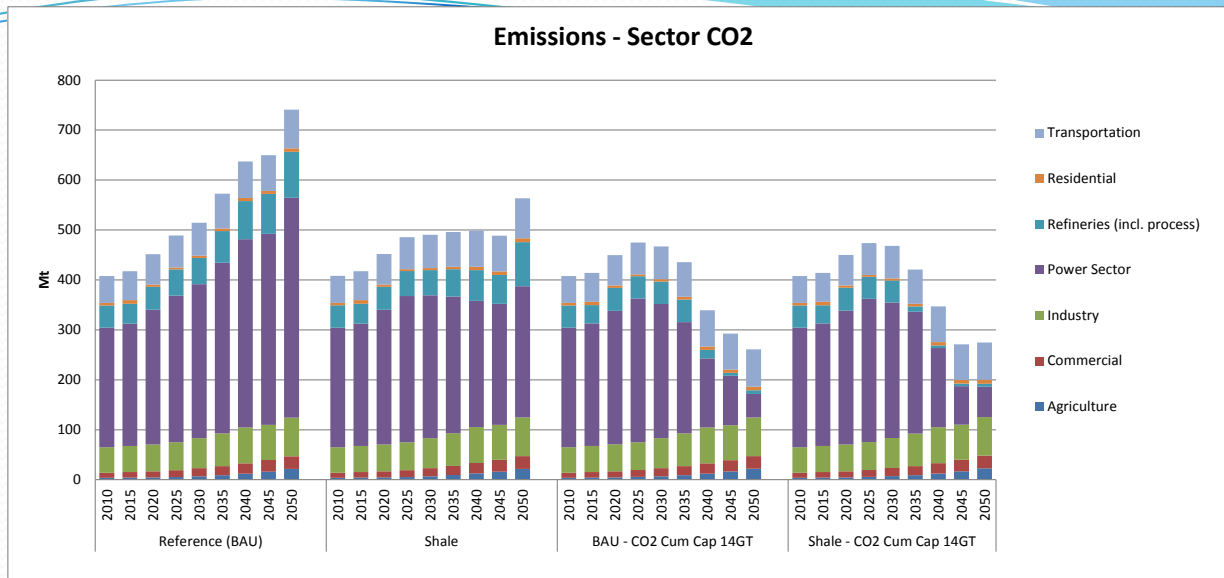
- The retiring of the wet-cooled coal plants markedly brings down the water intensity of power production
- Investment in renewables, driven by CO₂ cap, increases this downward trend

BAU & Shale / CO2 Cap - Final Energy by Fuel



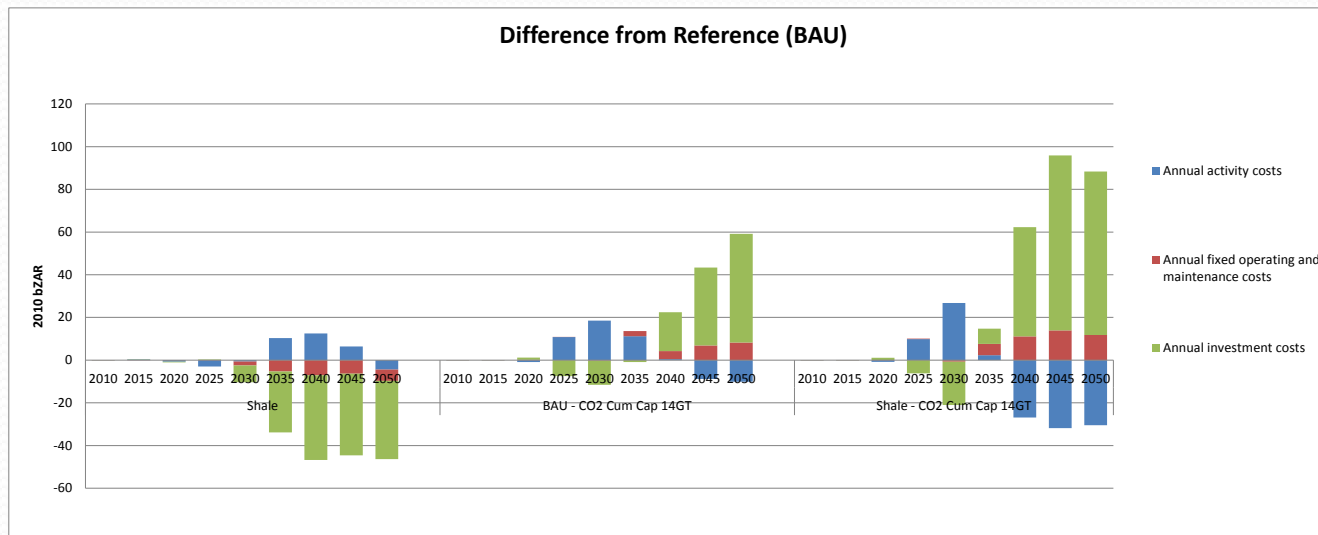
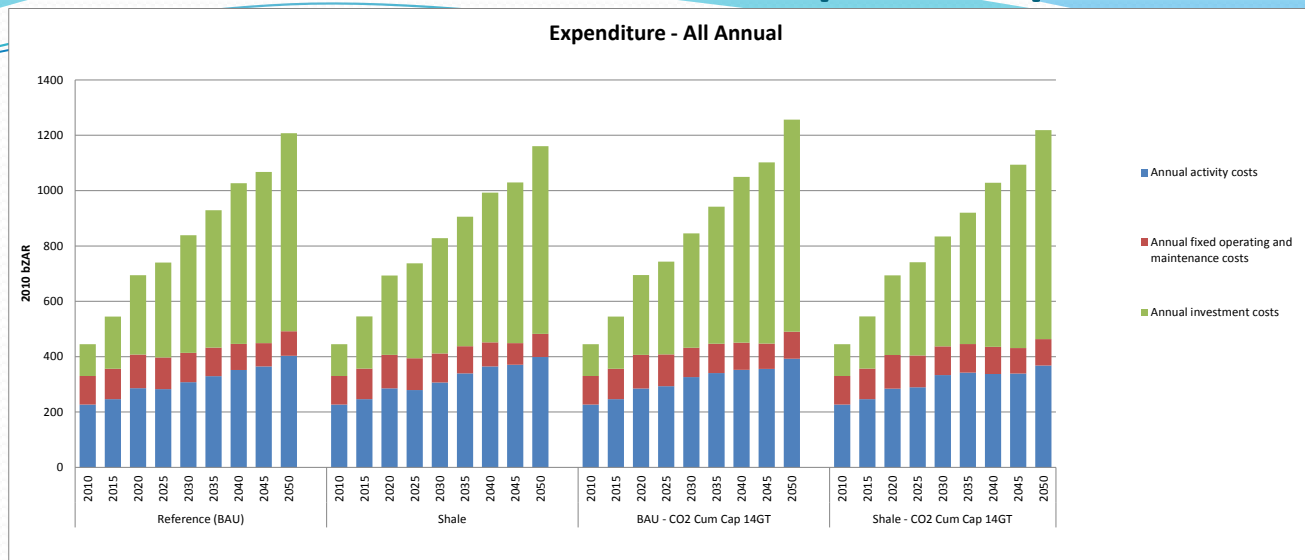
- Limited demand device options are mostly taken up in the Reference, leaving little room for additional demand-side actions under the CO₂ constrained scenario
- Gas replaces some coal, electricity and oil products, when Shale is available and CO₂ Cap is imposed

BAU & Shale / CO₂ Cap - CO₂ by Sector



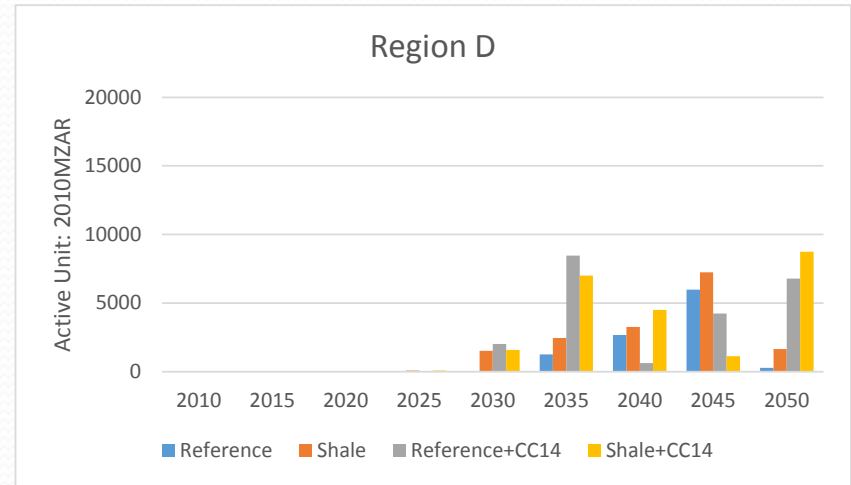
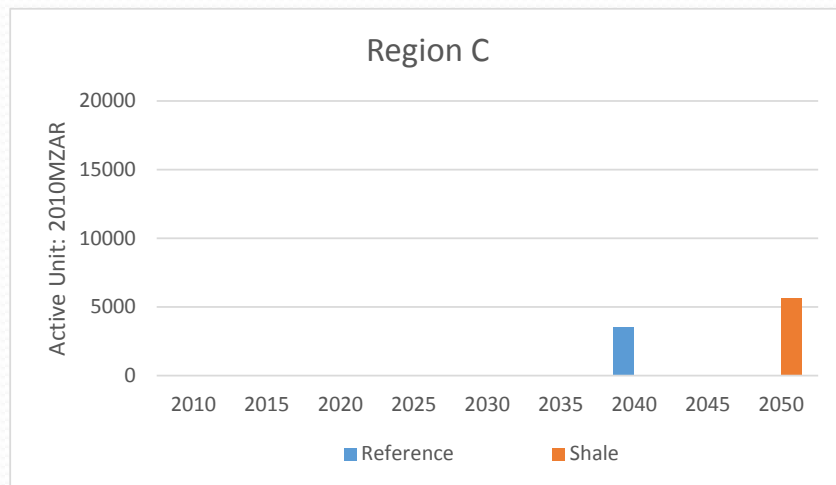
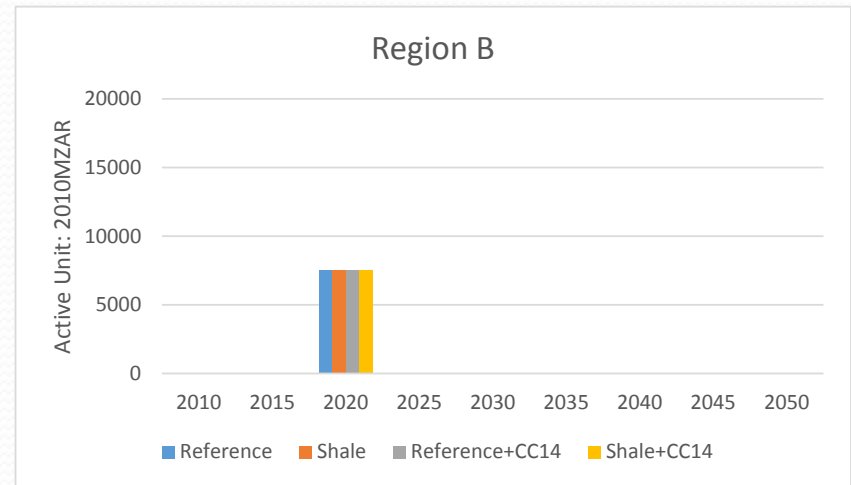
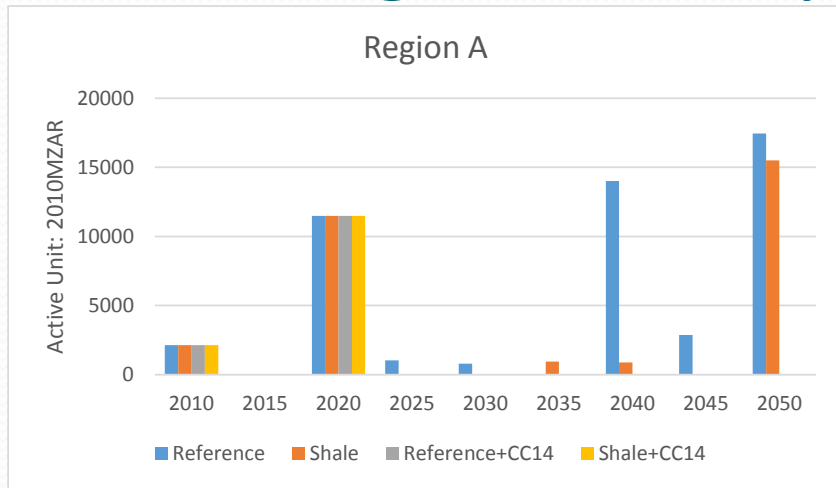
- CO₂ savings mainly come from Power and Refineries sectors, as the model takes up the limited new demand-side technology options in the BAU scenario. (Additional demand technology options are to be added.)

BAU & Shale / CO2 Cap - Expenditures



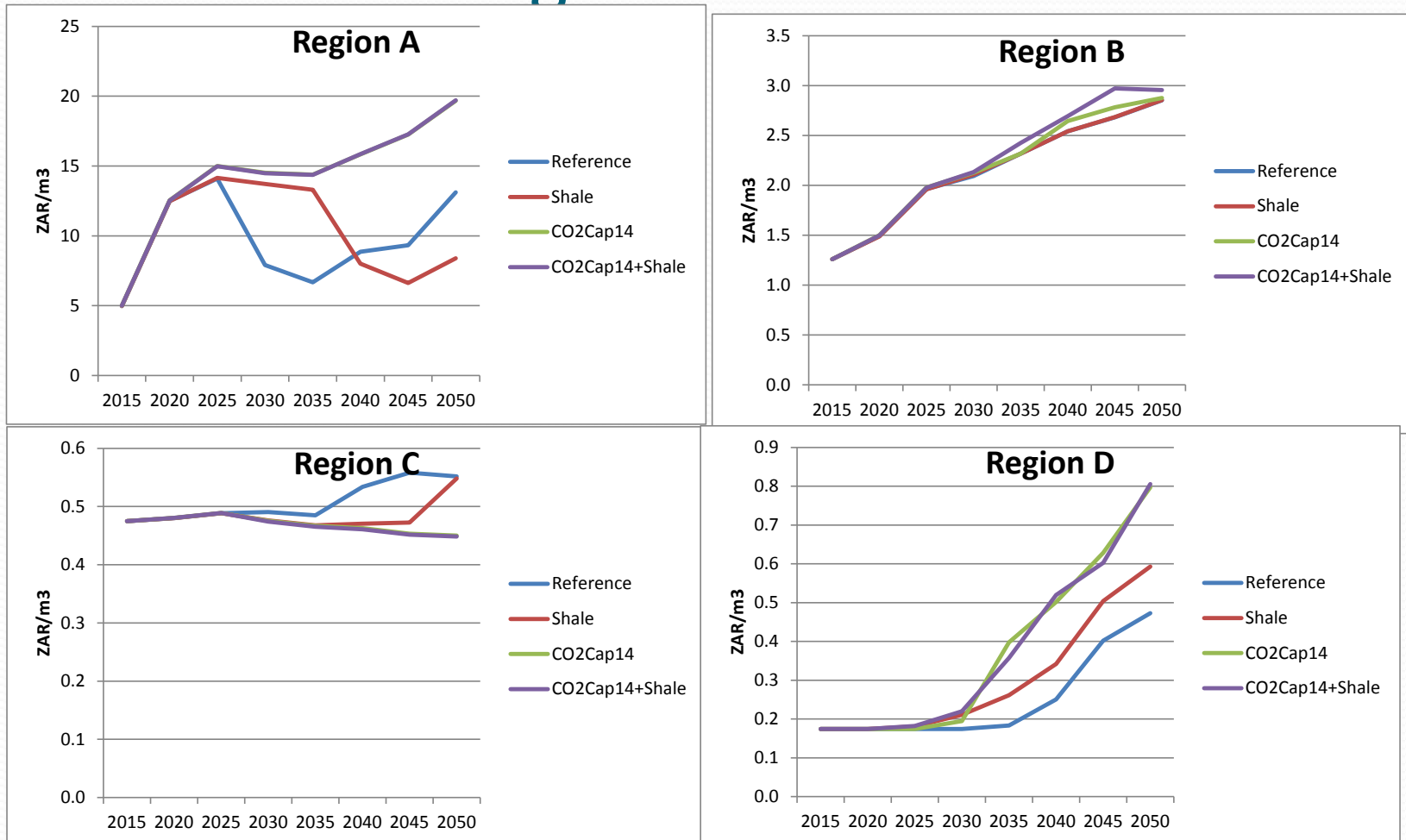
- Annual expenditures on energy-water system reach 1.2 Trillion ZAR in 2050
- Under CO₂ limits increased investment in cleaner more expensive technologies displaces some fuel expenditures

BAU & Shale / CO2 Cap Regional Lumpsum Investment



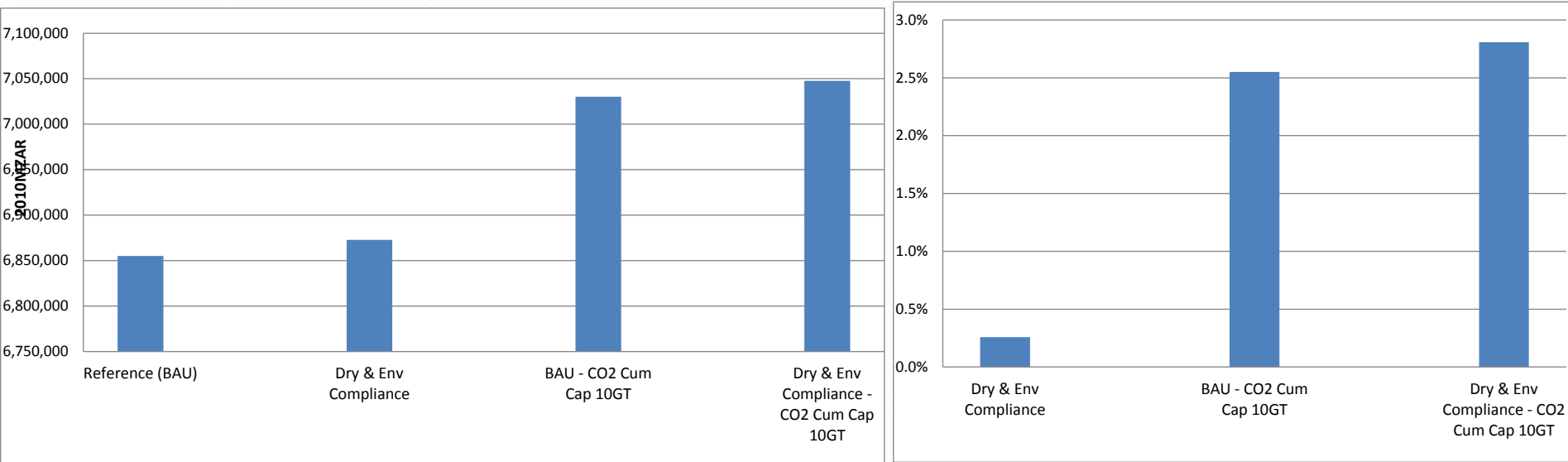
Region D and Region A is where most activity in water infrastructure investment occurs. Investment in Region D occurs in latter period while Region A has larger investment costs across the modelling horizon except in the CO₂ cap scenarios in which new coal is less attractive.

BAU & Shale / CO2 Cap Average Water Costs



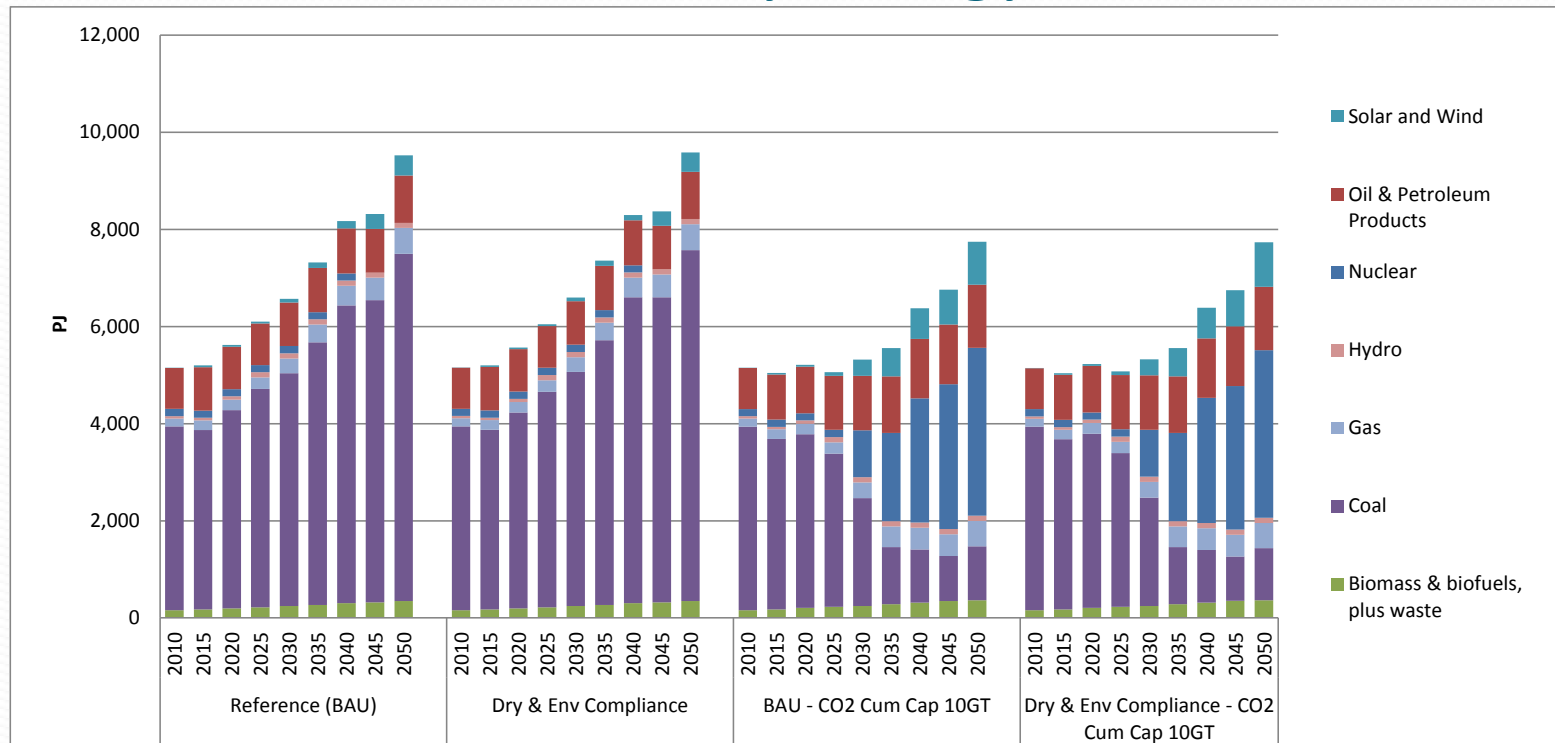
- Region A costs drop in the Reference as more energy projects take up capacity of water infrastructure. The drop is delayed with shale and doesn't happen with the CO₂ Cap
- Not much change in Regions B and C
- Region D costs go up more steeply in the CO₂ Cap scenarios.

BAU & Env.Compliance+Dry / Stringent CO2 Cap Energy System Cost



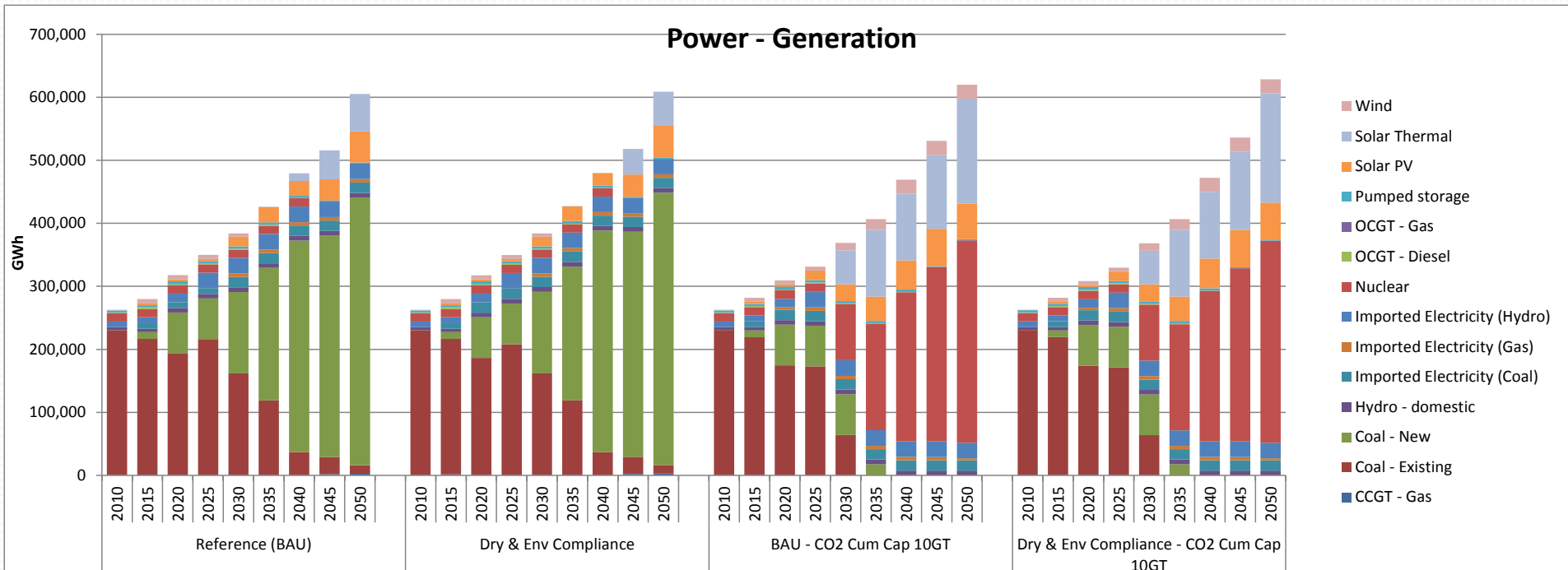
- The Dry & Environmental Compliance + the more stringent 10GT cumulative CO₂ cap is the most extreme scenario tested so far, pushing system costs up nearly 3% relative to BAU

BAU & Env. Compliance+Dry / Stringent CO2 Cap Primary Energy



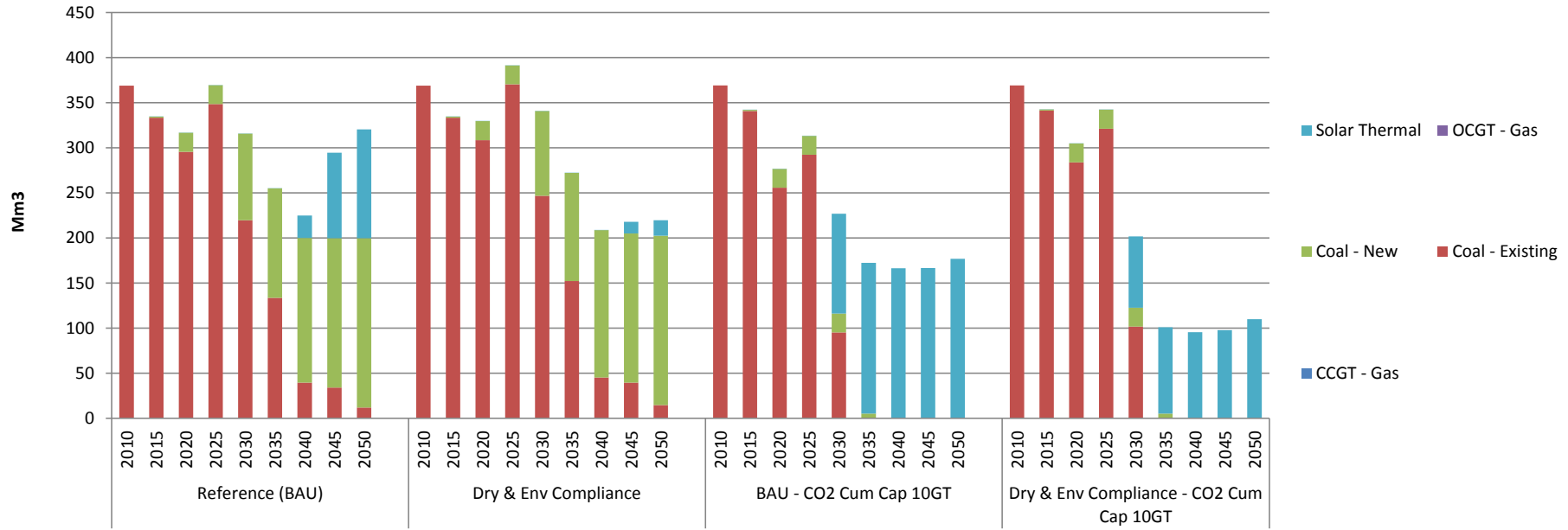
- Dry & Environmental Compliance has no dramatic impact on primary energy.
- The more stringent CO₂ cap without shale relies heavily on nuclear as seen before.

BAU & Env.Compliance+Dry / Stringent CO2 Cap Electricity Generation



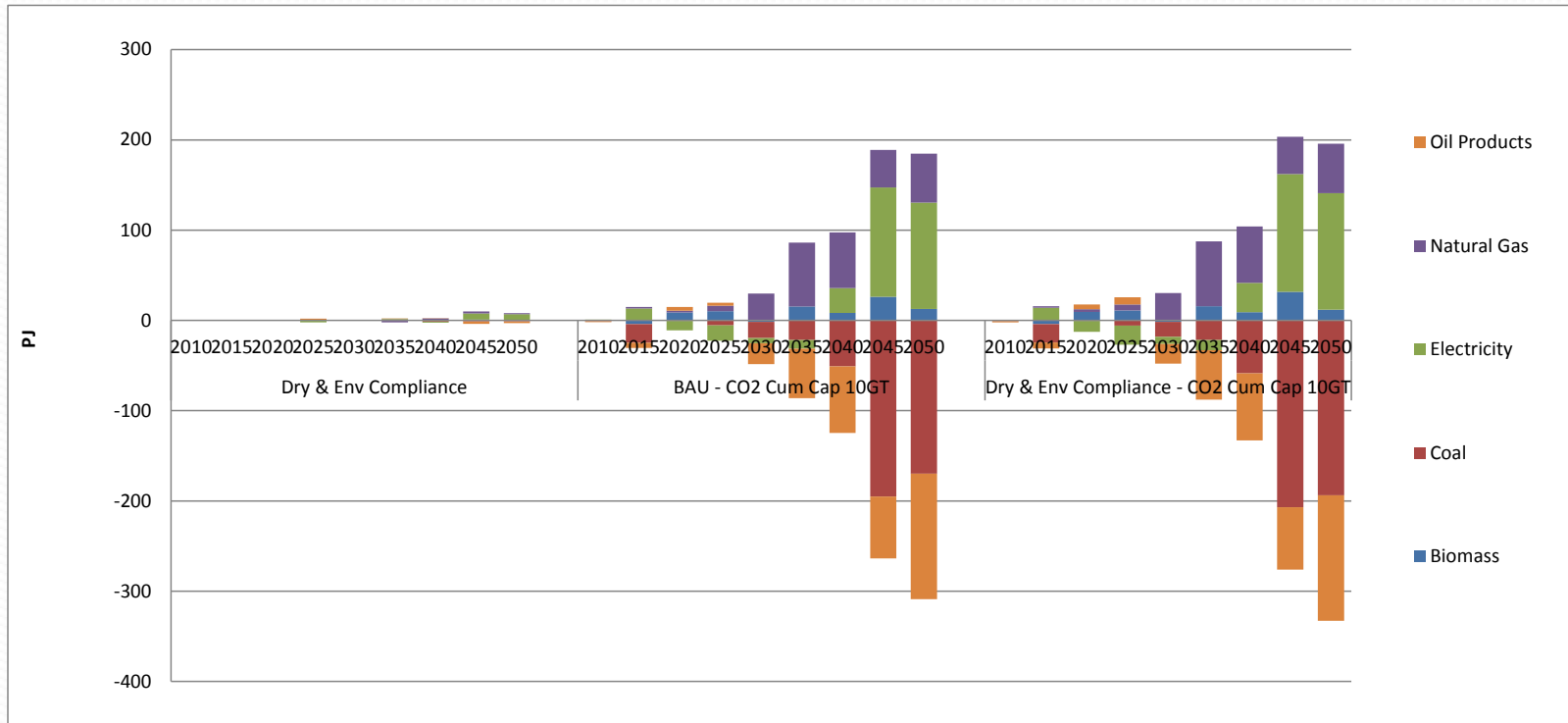
- The 10GT CO₂ cap is similar to 14GT, except no coal generation after 2035 resulting in some “stranded” assets
- The Dry scenario pushes solar thermal out
- Electricity demand goes up slightly in the more stringent CO₂ cap cases indicating some fuel switching to electricity taking place

BAU & EnvComp / CO2 Cap Power Plant Water Consumption by Plant Type



- The water demands of retro-fitting FGD are not significant in the context of total system demands
- The Dry climate sensitivity case did not reduce new coal capacity, though it does reduce/stop running some of them, and trims the proportion of wet-cooled solar thermal capacity
- The more stringent 10GT CO₂ cap limits new coal to little more than committed builds, with renewables and nuclear sharing new capacity additions resulting quicker than for the 14GT CO₂ cap but is almost the same in 2050.
- The imposition of the Dry scenario shifts solar thermal production to dry-cooled

BAU & Env.Compliance+Dry / Stringent CO2 Cap Final Energy by Fuel

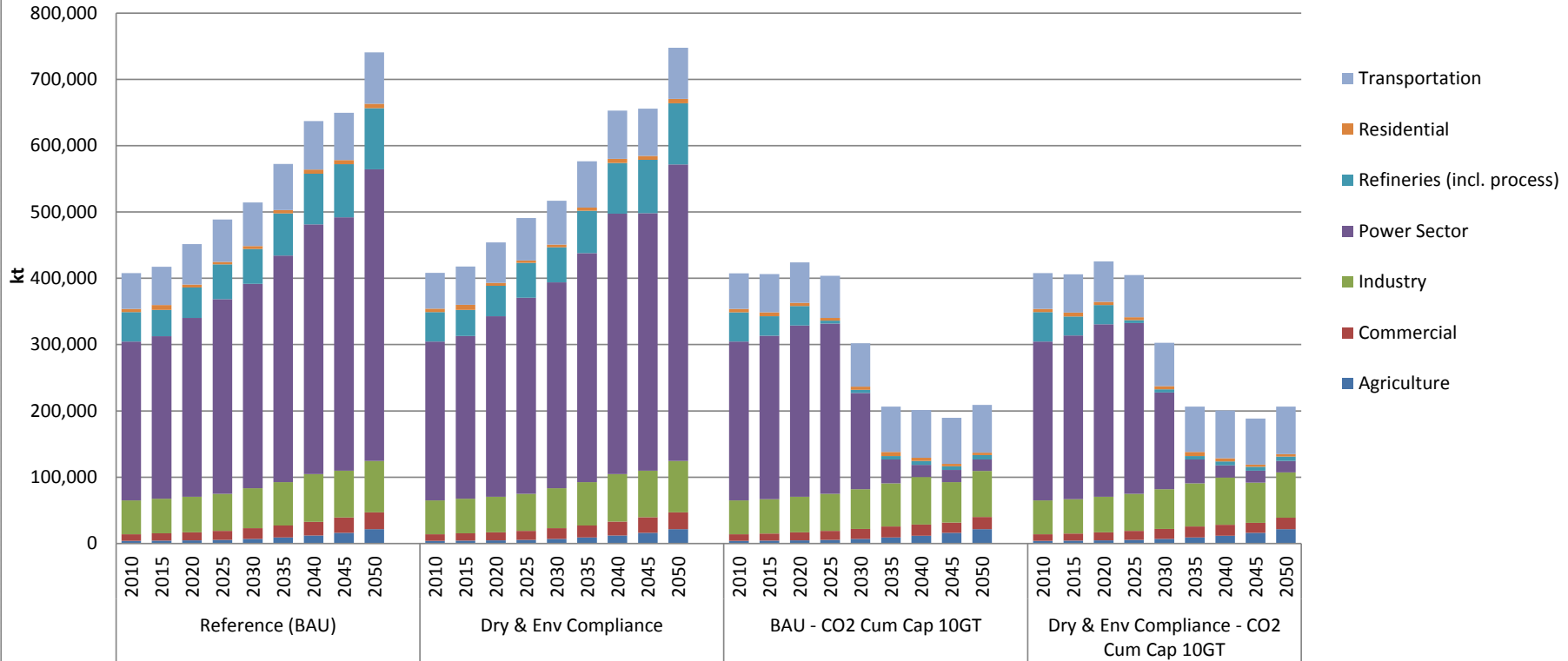


- Electricity substitutes for direction consumption of coal and CNG replaces some oil products used for transportation.

BAU & Env.Compliance+Dry / Stringent CO2 Cap

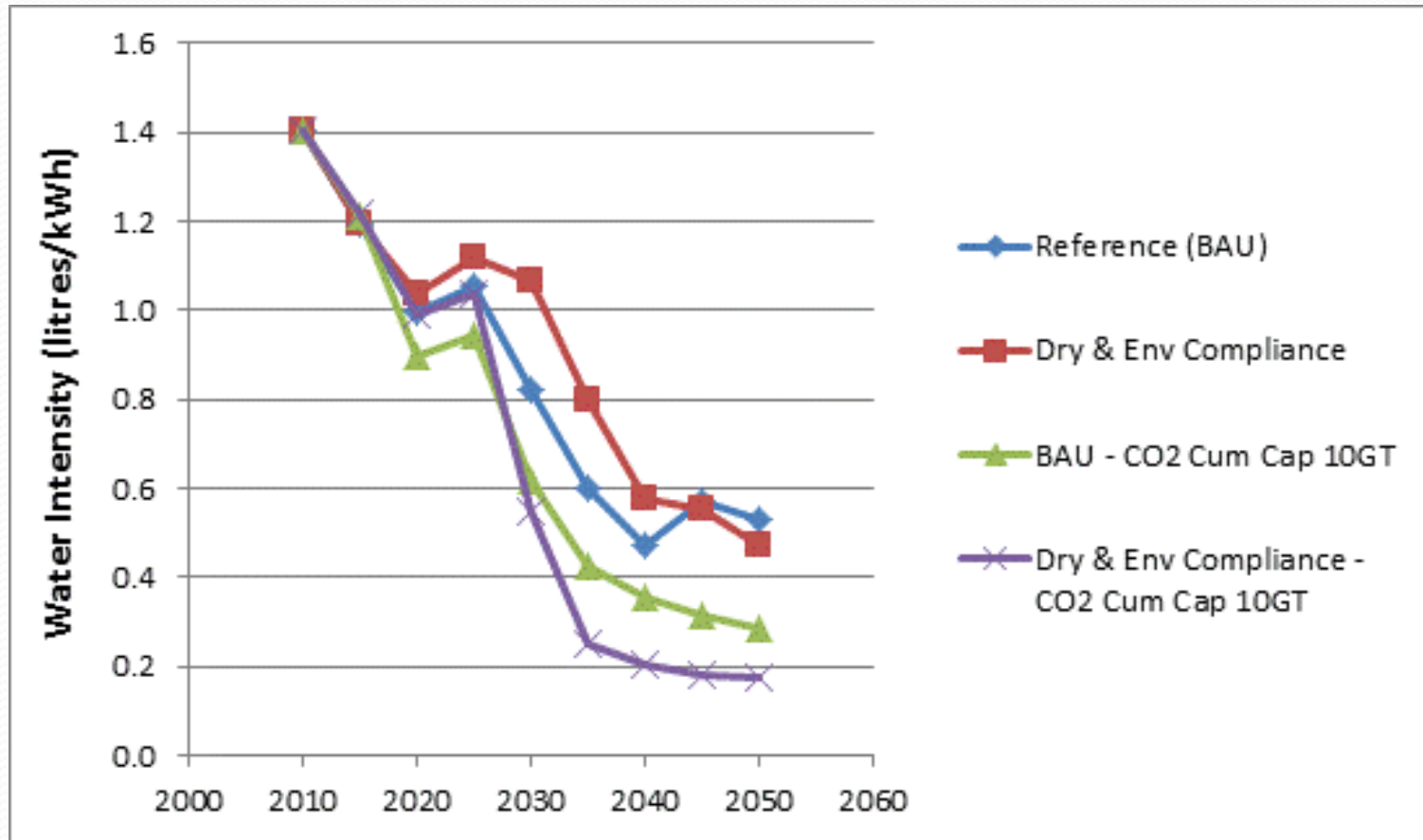
CO₂ by Sector

Emissions - Sector CO2



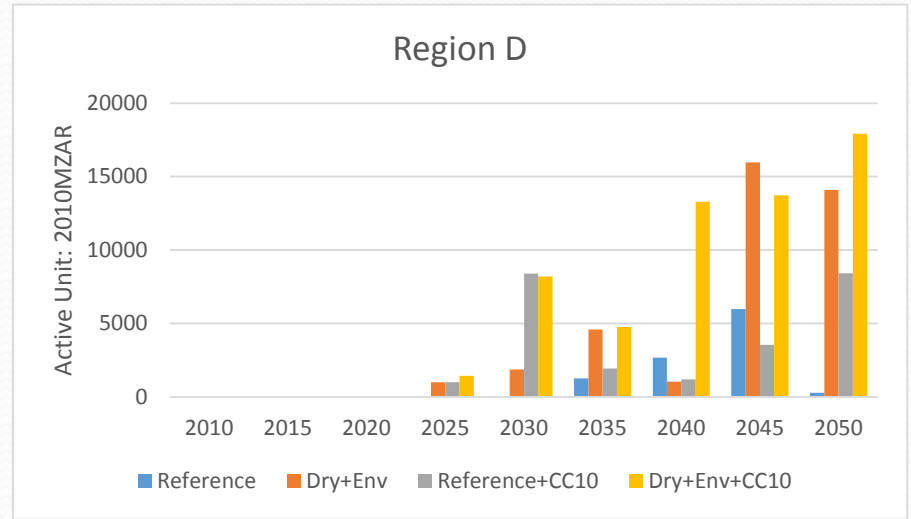
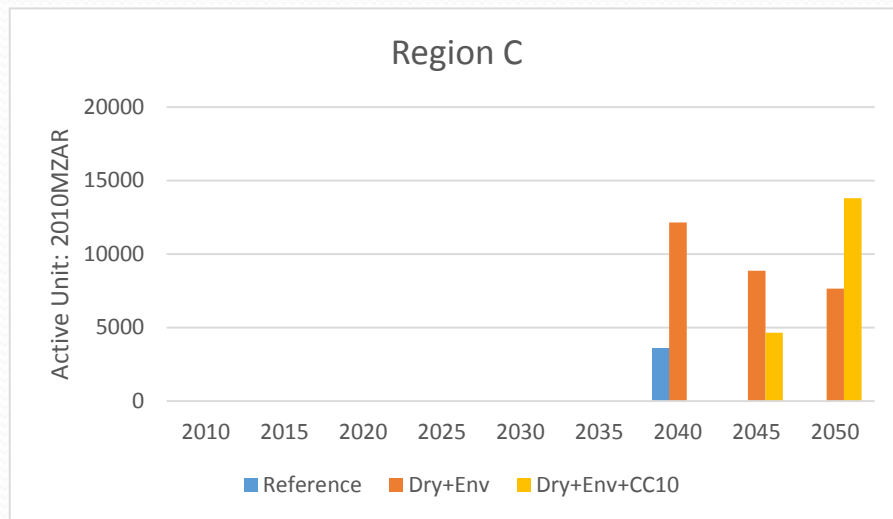
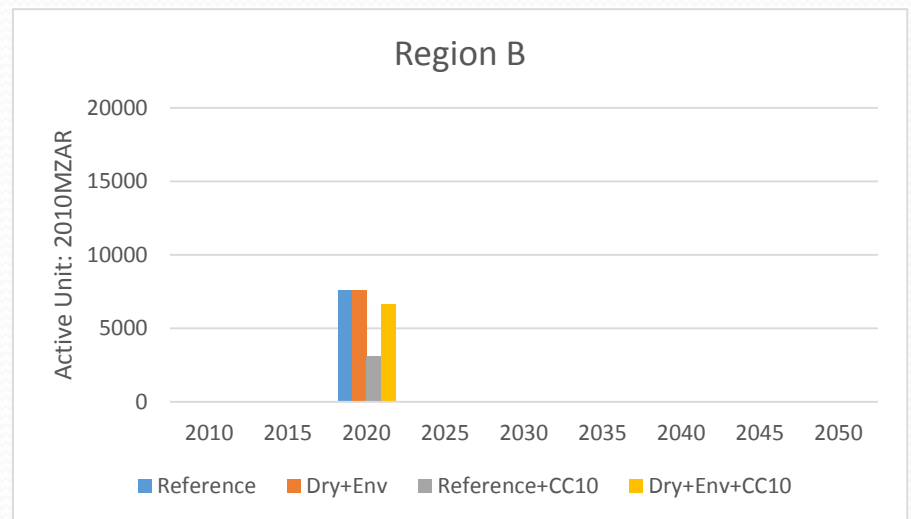
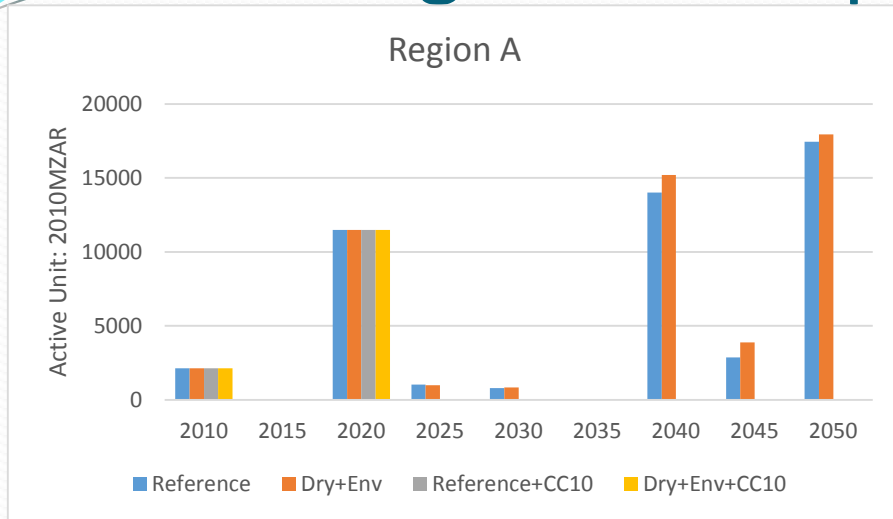
- To achieve the more stringent CO₂ cap the power sector needs to almost totally decarbonized by 2040

BAU & EnvComp / CO2 Cap Water Intensity by Scenario



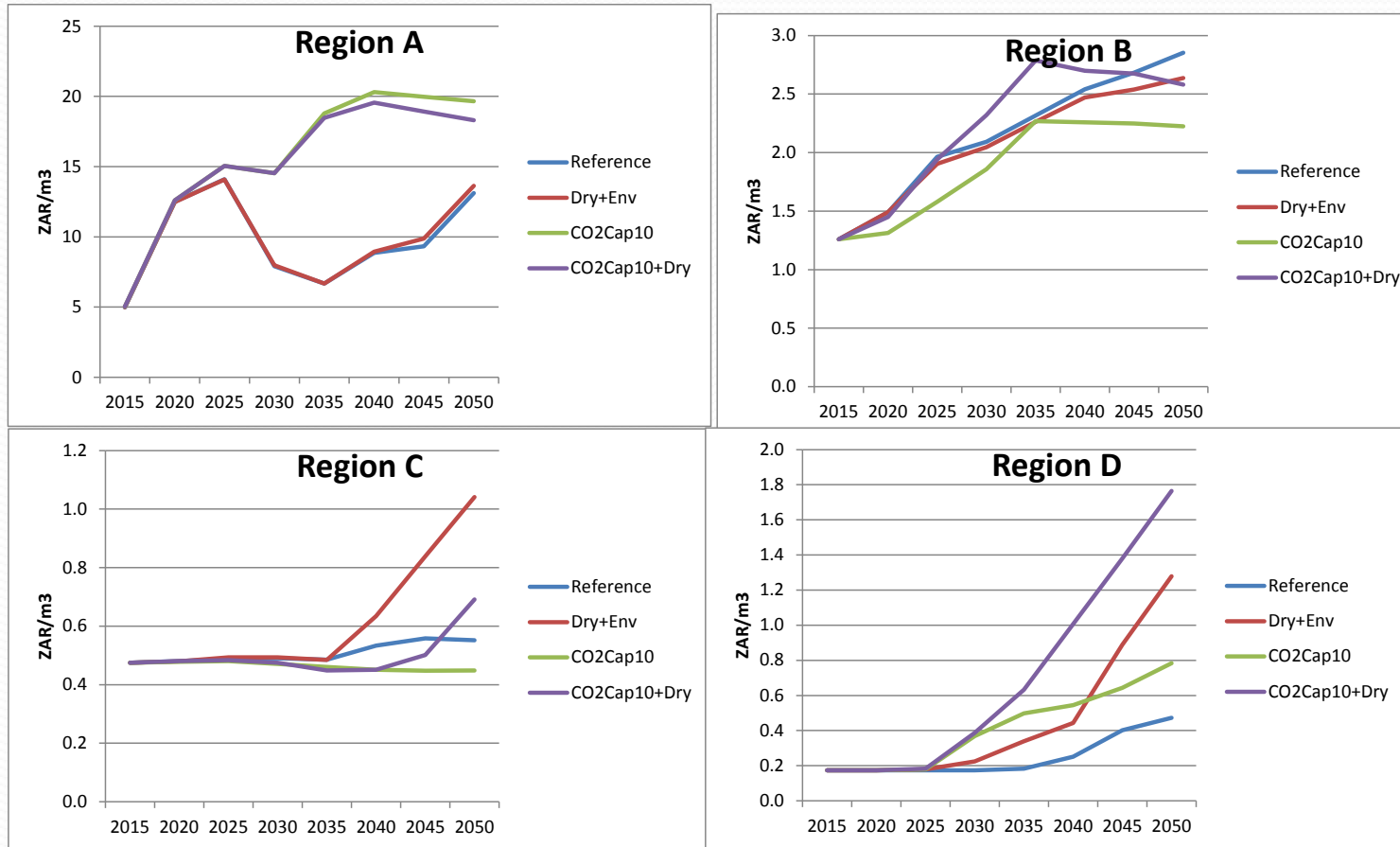
- A more stringent cumulative CO₂ cap favours less water intensive technologies bringing down water intensity of generation earlier, steeper and deeper, leveling off at about 0.2 litres/kWh

BAU & EnvComp / CO2 Cap Regional Lumpsum Investment



For the Dry & Environmental Compliance case investment in Region C occurs for water transfers.
For the CO₂ cap scenarios increased investment in Region D for water supply to Solar Thermal is noted.

BAU & EnvComp / CO2 Cap Average Water Costs



- In Region A, with early retirement of coal plants costs go up even further
- Not much change in Regions B and C
- Region D costs go up more steeply in the CO₂ Cap scenarios.

Conclusions & Next Steps

- Shale gas has potential to lower total energy system costs and could play an important role under CO₂ mitigation scenarios, pending a closer look at water requirements
- Under the more stringent climate scenarios there are concerns that there is a possibility of (partially) stranded energy and water assets
- While this first foray into a comprehensive approach examining the energy-water nexus in South Africa needs further refinement to be ready to advise policy formulation and investment, it's clear that important insights may be overlooked without taking a fully integrated approach to coordinating water and energy planning