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The pace of coal plant closures in the context of climate action

ESRG

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Outline

- Why coal: background and global trends
- Why coal: insights from global climate models
- Why coal: local context
- What variables impact results of coal fleet performance in local energy modelling studies?
- Results from major local analyses – IRP/NBI/UCT/CSIR-Meridian
- Key results: despite different variables/drivers, coherent view on the coal fleet as the major area of mitigation
- … But more work needed on key aspects

Why do we need to examine the role of coal? Global context

- **Coal is a large source of warming and emissions**

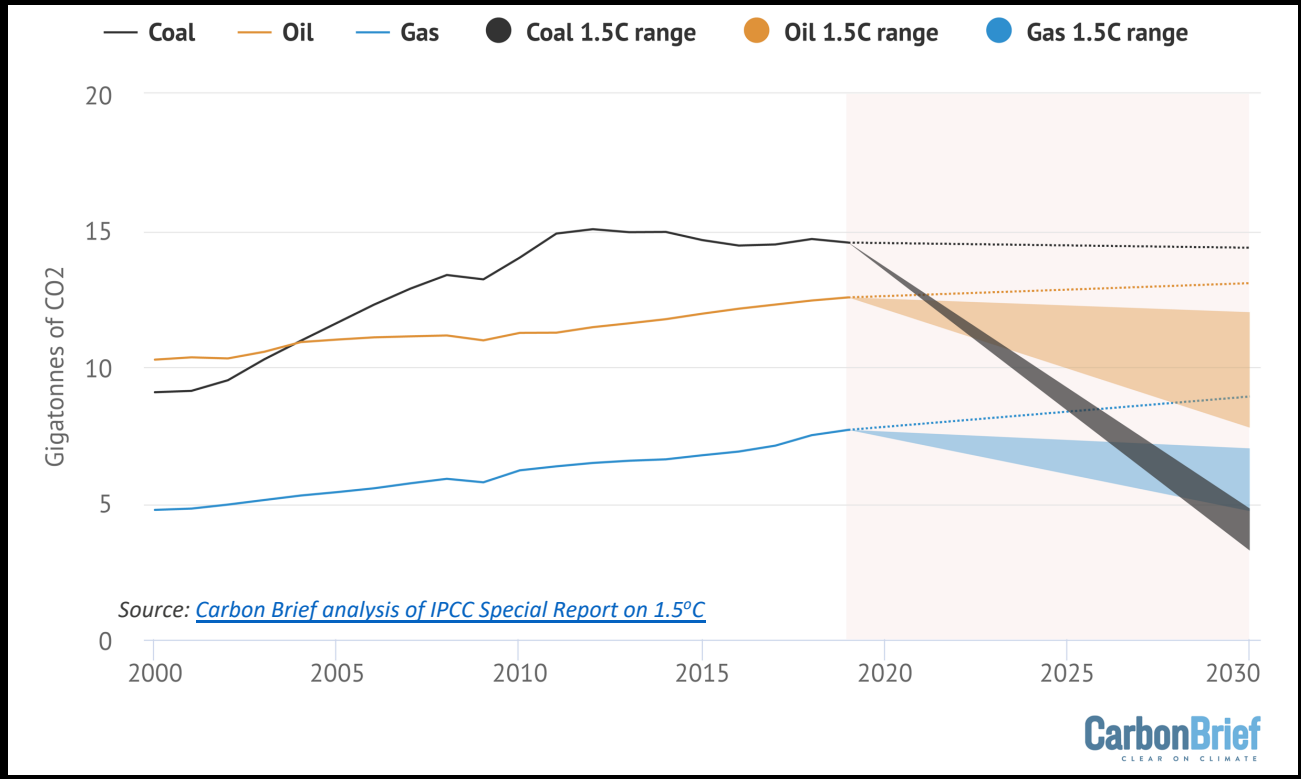
- Strong action to cut emissions from coal is essential for limiting global warming to below 1.5ºC (IPCC).
- Coal is the most emissions-intensive fossil fuel, and is the single largest source of global temperature increase, already responsible for more than one-third of warming (IEA, 2019).
- Coal use is around 40% of global fossil fuel and industrial emissions (14.7 Gt CO_2 per year in 2018) (Global Carbon Project, 2019).
- Approx two-thirds of global coal-related emissions are in the power sector, where technically feasible and cheaper alternatives to coal are already widely available
- Economic and technological trends highlight a slowing demand for coal and a structural decline in key markets
- but these trends are currently insufficient for achieving 1.5 or 2ºC pathways in two key ways:

  i) the global pipeline of new coal plants, while shrinking, remains large; and

  ii) the retirement of the existing fleet is happening too slowly to be consistent with 1.5C or 2C global pathways (Pfeiffer et al, 2016, Cui et al, 2021, UNEP 2017 – Merven et al for a review)

Insights from global climate modelling

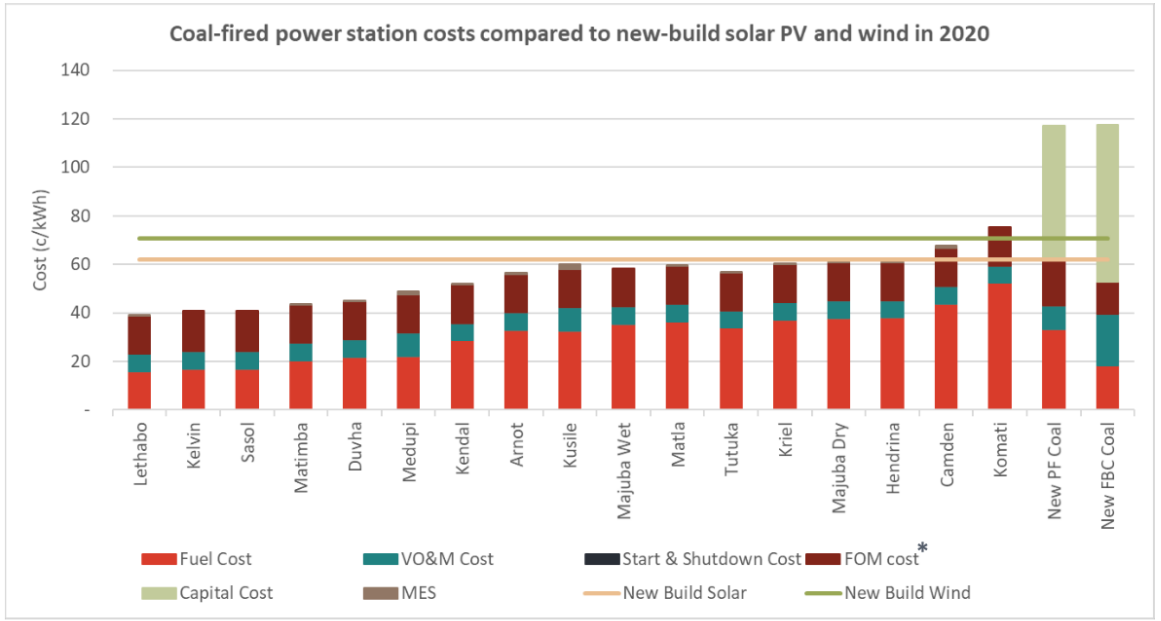
- Paris Agreement goal of “well below 2°C” = emissions from coal must fall to at least between 4.4 Gt and 8.5 Gt by 2030.
- To limit warming to below 1.5°C , emissions from coal must fall to between 3.3Gt to 4.8Gt by 2030.
- These targets translate to a 50-78% fall in absolute coal use over the next decade (67-78% for 1.5°C scenarios), which represents an unprecedented decline in fossil fuel use
- (The IPCC Special Report on 1.5°C found that the use of coal power shows a steep reduction in all pathways and would be reduced to essentially 0% of electricity by 2050 (IPCC, 2018), without CCS (since residual emissions would still be too high to be compatible with 1.5C).
- Coal use overall falls to 1-7% of primary energy, with CCS (pg 34) in sectors without current alternatives



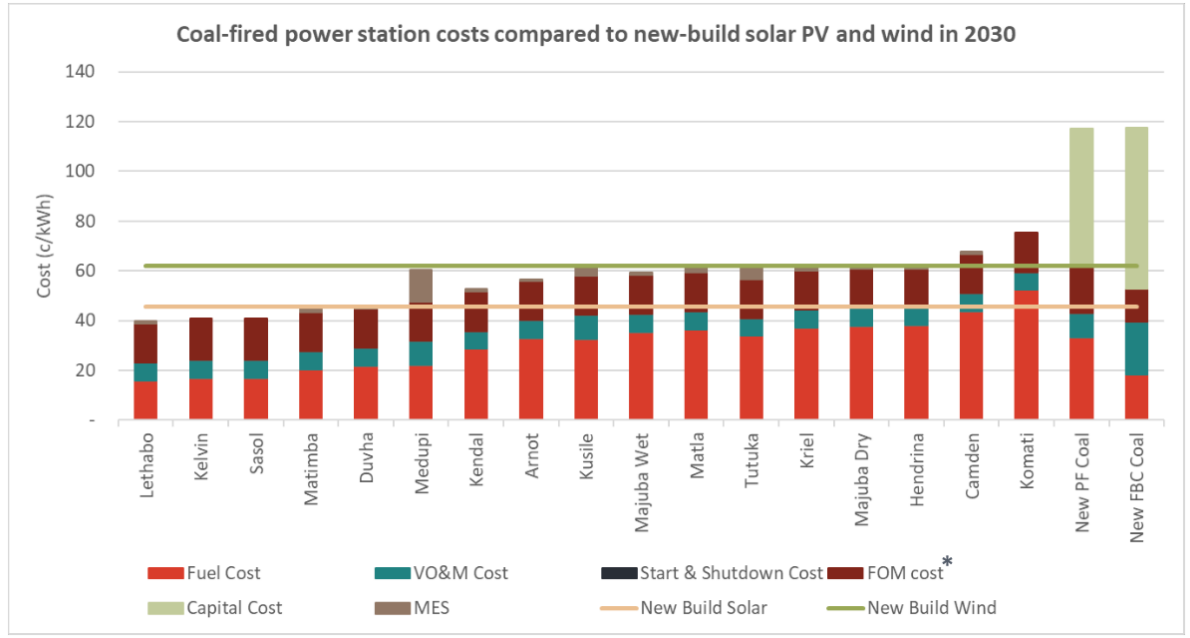
All 1.5°C pathways in the IPCC SR1.5C show rapid cuts in coal emissions this decade

Local context

- Need to consider local dynamics, costs, distributive effects which global analysis misses
- New RE is already the cheapest new build option and could rapidly outcompete existing coal plants
- Coal is largest source of emissions and power alone is 43% of emissions, making export highly carbon-intensive
- SA has highest dependence on coal in G20
- High reliance on coal has energy security implications: aging fleet
- New coal accompanied by economic risk: new coal plants in IRP 2019 would increase emissions by 289Mt to 2050 and costs by R23bn in the power sector
- 11 different local studies show that new coal plants are uncompetitive in South Africa and are not part of a 'least cost' system (Merven et al)
- Eskom net zero commitment approved by IMC in 2021; SA-LEDS aims for net zero around 2050



*A capacity factor of 65% is assumed for the calculation of FOM cost per kWh



*A capacity factor of 65% is assumed for the calculation of FOM cost per kWh

Deep challenges around air pollution compliance and Eskom's financial situation

- Eskom highly capital constrained and needs to invest heavily to meet air pollution rules
- Deadly Air case: government must hold emitters accountable
- ~5000 premature deaths in Mpumalanga per year
- Asthma levels double the national background (1 in 4 households)
- Challenges with capital and with taking plants off to retrofit them
- Limited analysis considering the intersection of air pollution compliance and climate action
- Older work showed that some plants retrofitted and some are retired early to meet climate and air pollution targets (McCall et al, 2019) – more retirements when more ambitious climate targets are pursued

Local modelling studies

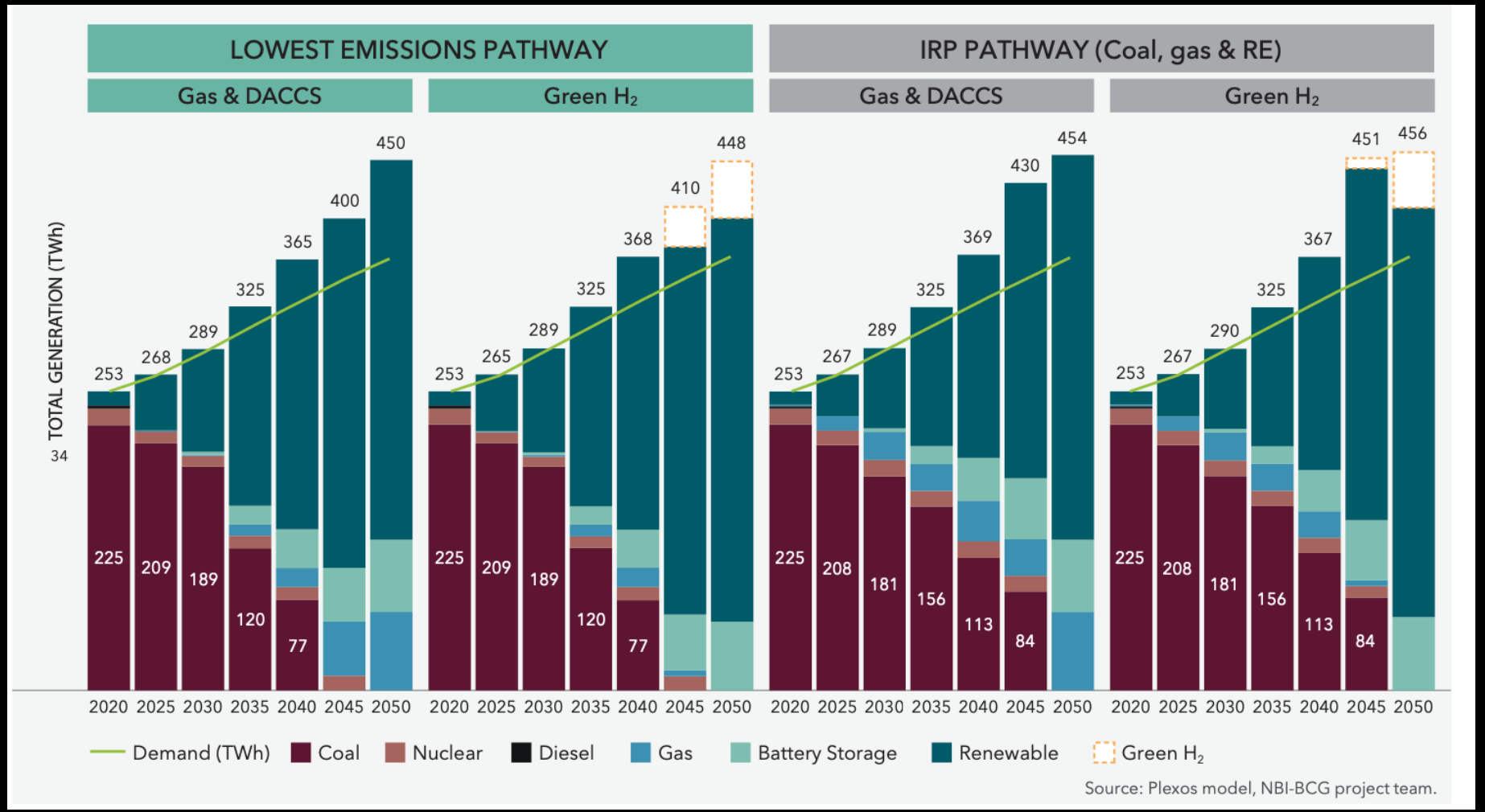
Understanding what drives energy modelling results and why they may differ in their details

- Demand forecast: how much electricity the country will need, driven by GDP levels and economic structure
- Eskom's coal fleet performance – how much the plants can theoretically produce and how this changes over time, as well as parameters like minimum annual use (load factor) and expected lifetime
- Greenhouse gas emission budgets: what South Africa can emit as part of its fair share of global emissions budgets for a given limit on temperature rise (eg budgets for 2C vs 1.5C and probability of meeting those limits; as well as method for calculating the national share)
- End year emissions (whether a budget alone or budget plus national net zero)
- Type of model: power sector only, full sector – demand sectors like transport/industry can alter the pace of power sector decarbonisation
- Air quality compliance: whether and how studies deal with air pollution compliance - capex, opex, life of plant.
- Costs and availability of alternative options: what prices for new RE will be realised? How much can be built and how quickly? Is gas available? Is capital available and at what cost? **coal use in other sectors is much trickier to replace
- **And yet remarkable consistency about the role of coal pplant closure in cost-effectively meeting mitigation targets in local modelling analyses**

Low emissions pathway vs IRP Net Zero (NBI)

Lowest emissions: coal off by 2042 (3.5Gt budget)

IRP coal retirement trajectory and 2049 ramp down (4.4Gt budget



Low emissions pathway vs IRP Net Zero (NBI)

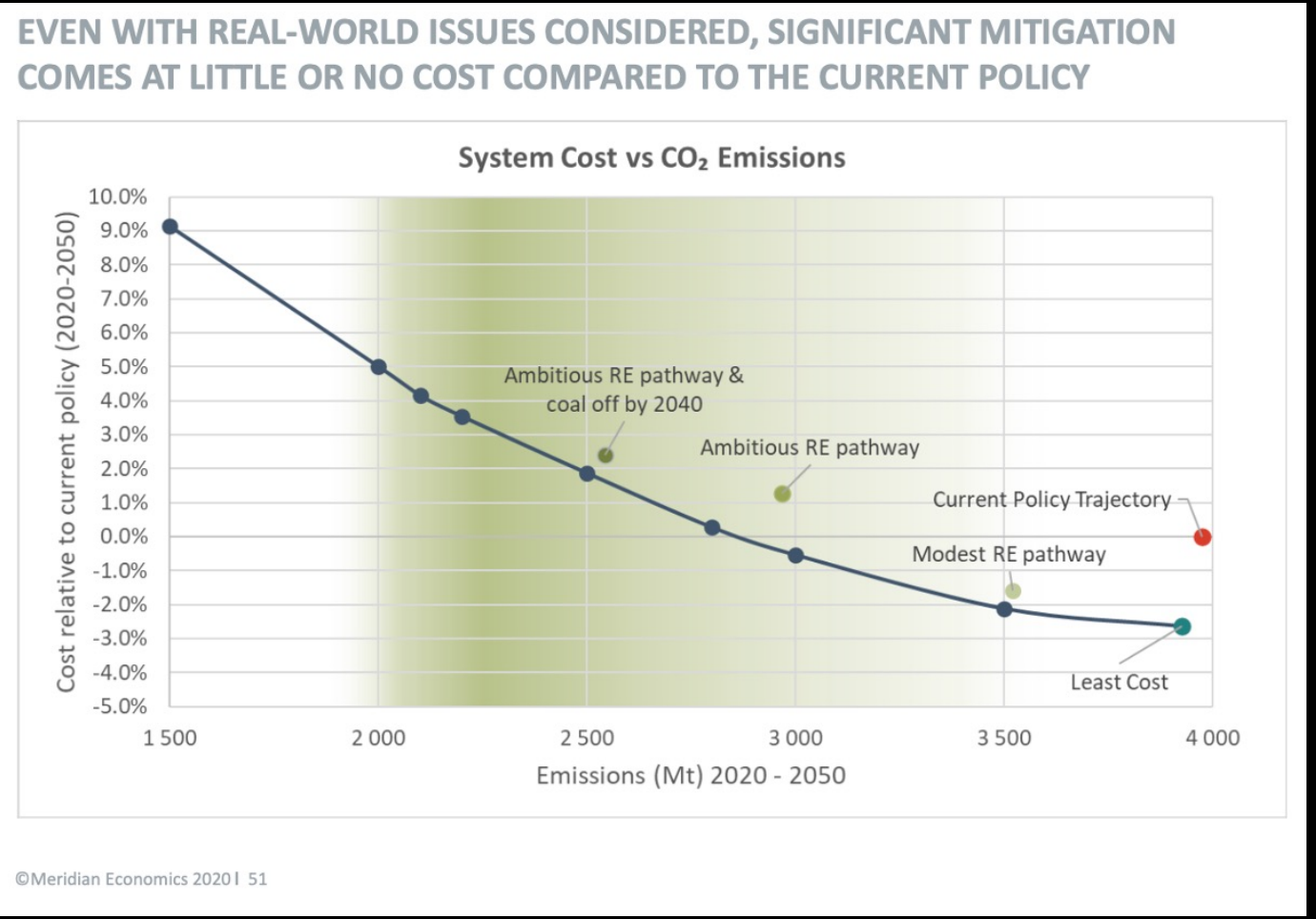
Lowest emissions: coal off by 2042 (3.5Gt budget)

IRP coal retirement trajectory and 2049 ramp down (4.4Gt budget

	LOWEST EMISSIONS PATHWAY		IRP PATHWAY (Coal, gas & RE)	
TRADE-OFFS	Gas & DACCS	Green H_2	Gas & DACCS	Green H_2
SOCIO-ECONOMIC	Almost 1mn net-job years by 2035, with an additional ~1.5 net-job years in last 15 years (~2.4mn net-job years cumulatively)		Less than 0.8mn net-job years by 2035, with an additional 1.6–1.7mn in last ~15 years (2.4mn net-job years cumulatively)	
CUMULATIVE EMISSIONS	Cumulative emissions of ~3.5 Gt	Cumulative emissions of ~3.5 Gt	Cumulative emissions of ~4.4 Gt	Cumulative emissions of ~4.3 Gt
REAL RELATIVE COST (c/kWh)	Cost of 131 c/kWh in 2050 with 2–9 c/kWh higher cost in 2025–2040	Cost of 130 c/kWh in 2050 with 2–9 c/kWh higher cost in 2025–2040	Cost of 131 c/kWh in 2050	Cost of 130 c/kWh in 2050
NEW-BUILD CAPEX & TOTAL COST	Total CAPEX of ~R2.9 tn relatively evenly distributed Total cost of ~R75.5 tn	Total CAPEX of ~R3.1 tn relatively evenly distributed Total cost of ~R75.5 tn	Total CAPEX of ~R2.8 tn unevenly distributed Total cost of ~R75.3 tn	Total CAPEX of ~R3.0 tn unevenly distributed Total cost of ~R75.4 tn

A Vital Ambition (CSIR-Meridian, 2020)

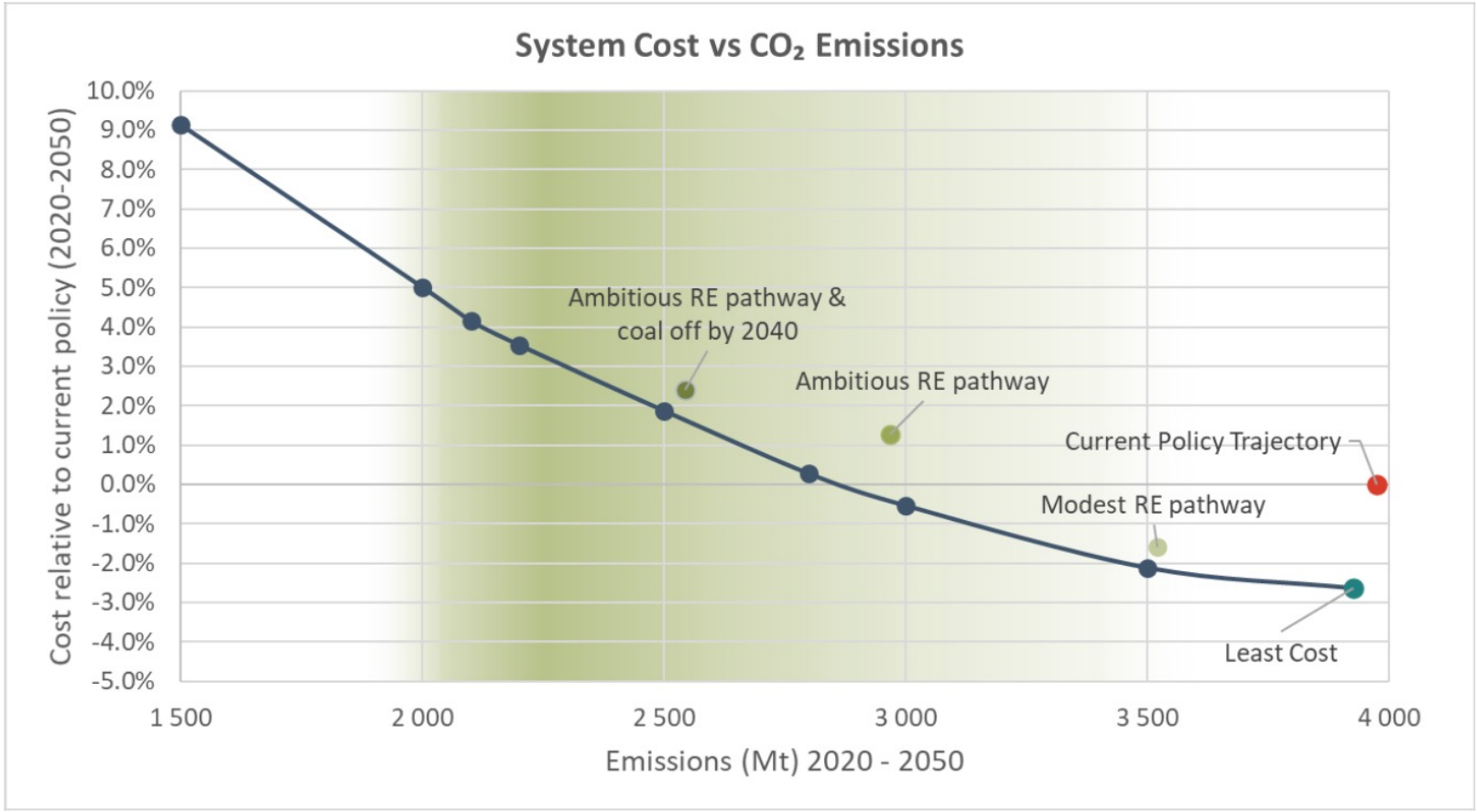
- Examines multiple carbon budgets and costs
- Looked at current policy trajectory – IRP 2019 but extended to 2050
- Looked at a least cost pathway (cheaper than IRP 2019)
- Looked at effect of methodically lowering the carbon budget and building more RE
- Coal plants can retire or run at low annual load factors (~35%)
- Partial MES compliance



CSIR (2020) "Systems analysis to support increasingly ambitious CO2 emissions scenarios in the South African electricity system," Technical Report, July 2020.

Meridian Economics, Roff et al 2020 A vital ambition

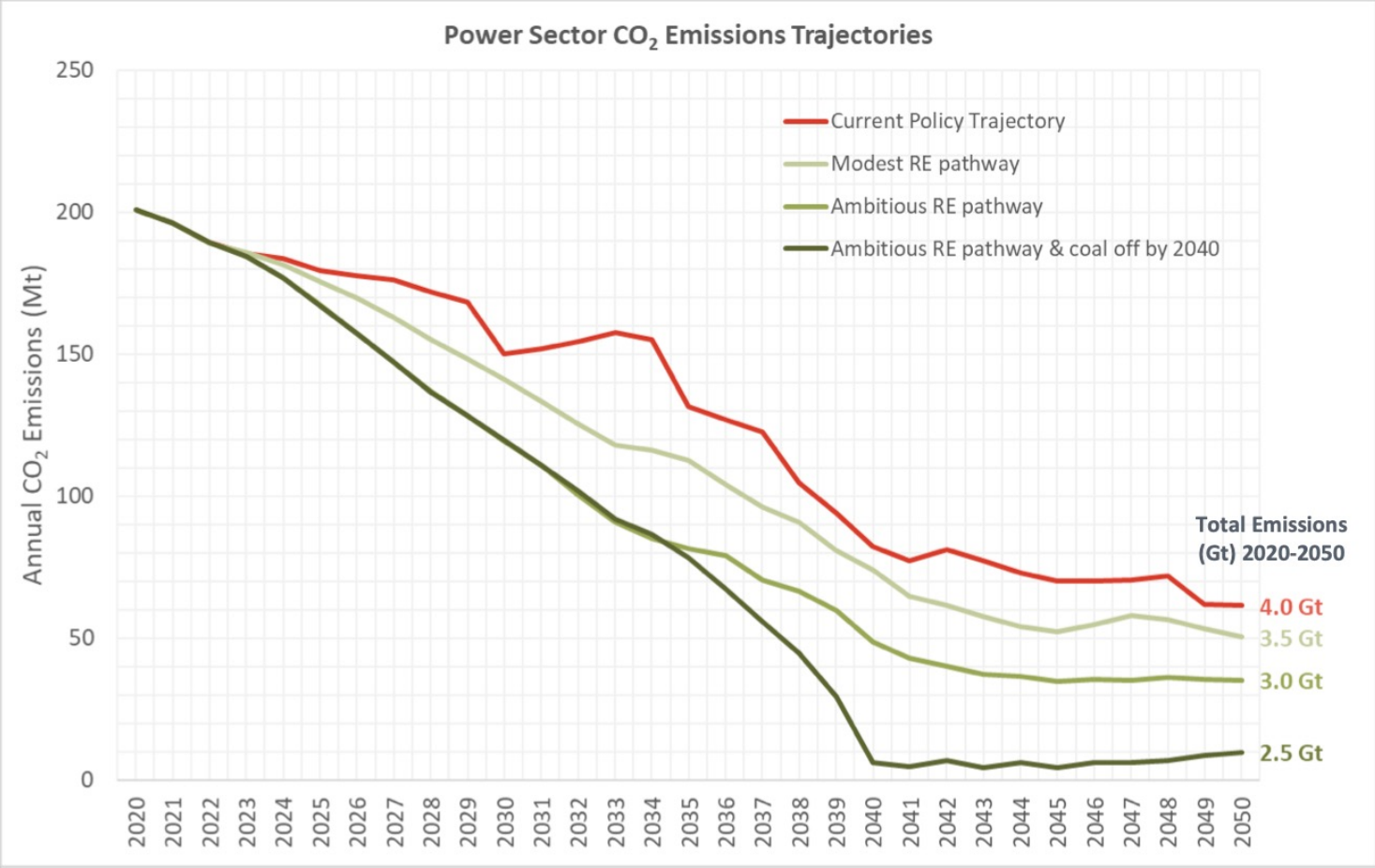
EVEN WITH REAL-WORLD ISSUES CONSIDERED, SIGNIFICANT MITIGATION COMES AT LITTLE OR NO COST COMPARED TO THE CURRENT POLICY



- **Realistic power system pathways can mitigate between 500Mt -1500Mt of CO_2 emissions compared to the current policy.**
- **A modest RE pathway** would mitigate 500Mt whilst costing less than the current policy trajectory.
- **An ambitious RE pathway** would increase the overall system cost by little more than 1% relative to the current policy trajectory, but remove more than 25% of emissions - a reduction of 1000Mt.
- Further mitigation achieved by closing all coal by 2040 reduces emissions by nearly 1500Mt, with a cost increase below 2.5%.
- Whilst the cost differences between the current policy trajectory and these mitigation scenarios are marginal, **the massive mitigation benefits are plainly real.**

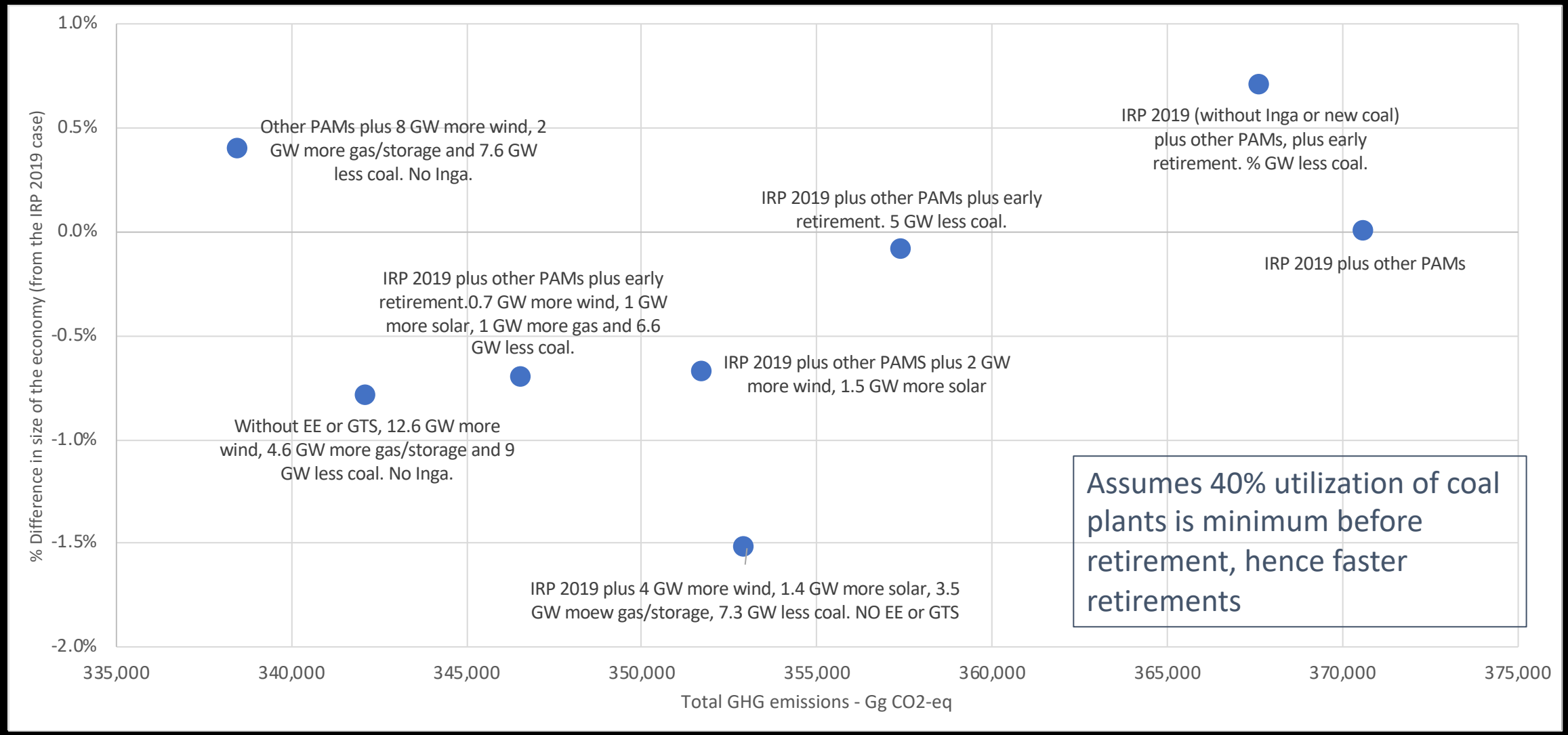
HOW CAN RSA MEET ITS MITIGATION COMMITMENTS?

AN IMMEDIATE AND AMBITIOUS RE BUILD PATHWAY IS REQUIRED

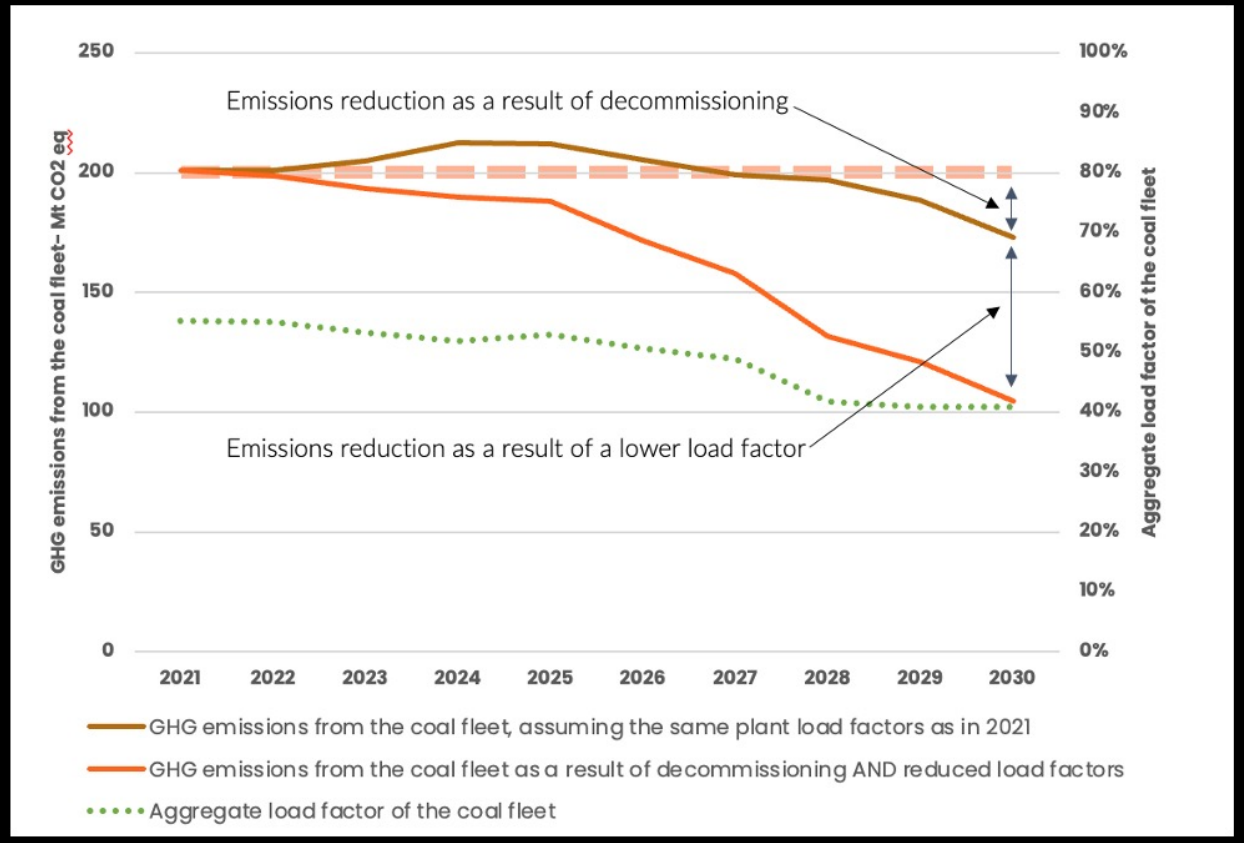


- An emissions trajectory in the region of the Ambitious or Coal-Off-by-2040 RE pathways **will be required for the rest of the RSA economy to mitigate cost-effectively** (within the Paris-aligned range).
- The Ambitious and Coal-off-by-2040 RE pathways track the same RE build pathway and emissions for the first decade.
- Following the Ambitious RE pathway's RE build **provides a valuable option** to shift to Coal-off-by-2040 should increased decarbonisation be required in the future.
- An ambitious RE build in the first decade will also **support low carbon options in other sectors, for example electric vehicles, green hydrogen and industrial electrification.**

Low NDC range- 2030 scenarios (ESRG)



Early retirement versus reduced operations?

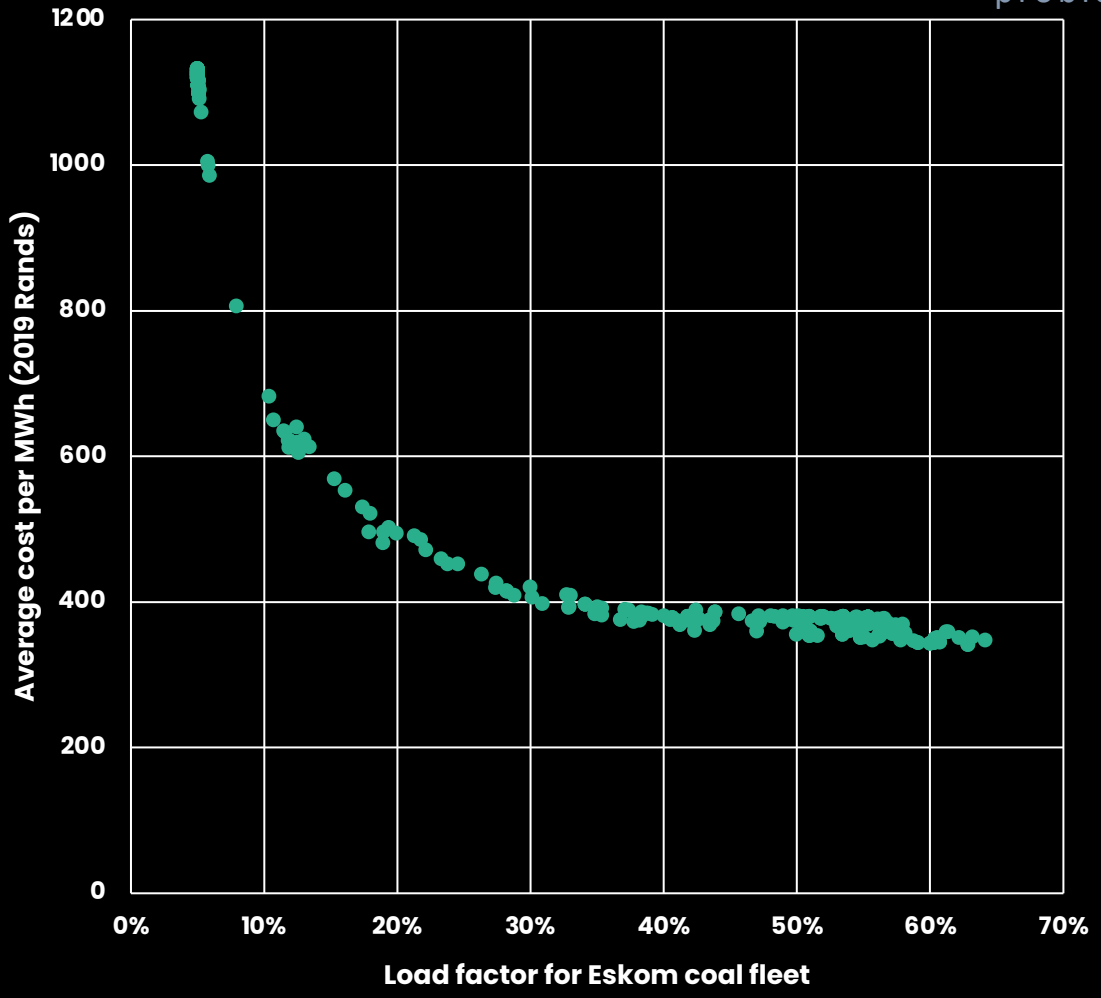


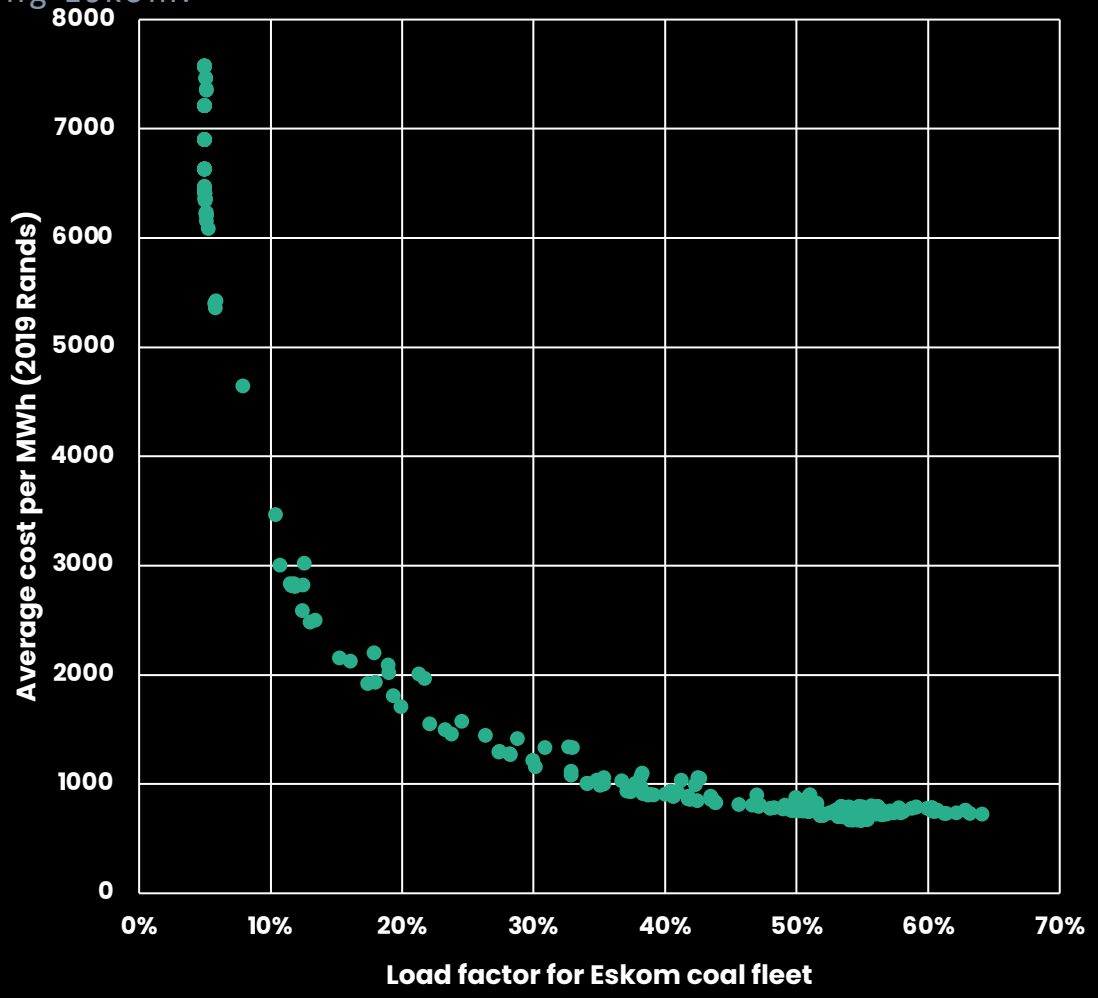
Source: Dr Andrew Marquard based on ESRG modelling for lower NDC pathway

- Need to assess the trade-offs and benefits between keeping plants on and running at low levels versus earlier closure
- CSIR analysis used 35% load factor before plants ‘endogenously retire’
- ESRG has explored down to lower levels in other work (5%)
- Meeting low NDC range in 2030 requires annual load of around 40% AND planned retirements
- Longer-term, ambitious fair share modelling sees even lower annual levels of use (35-5%)

Economic impact of a lower aggregate coal fleet load factor

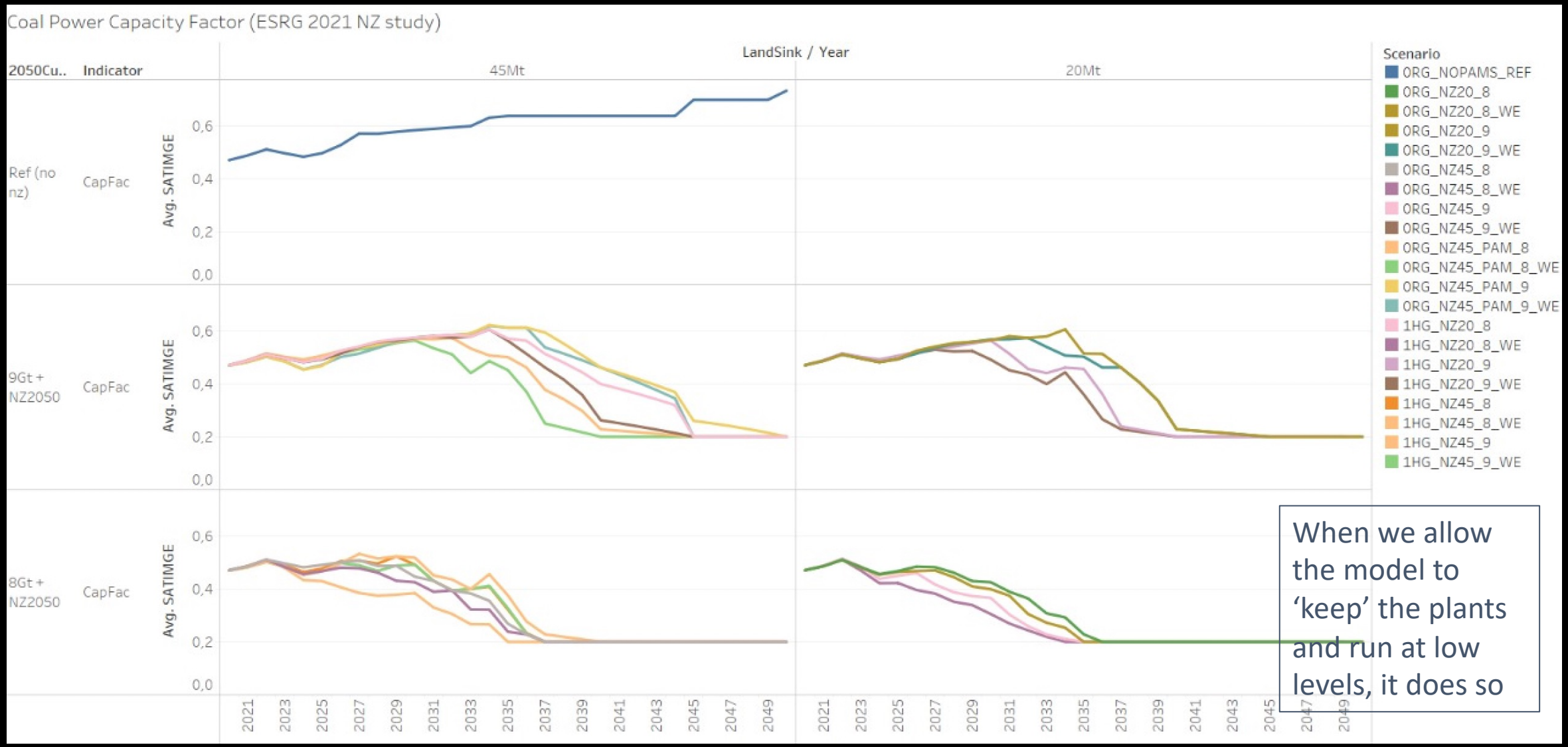
Lower load factors have a significant impact on the average unit cost of electricity generation, which needs to be taken into account in both electricity pricing policy and when assessing the overall level of support required for a just energy transition. The impact is not very pronounced above 40%. The figure on the right illustrates the potential stranded debt problem facing Eskom.





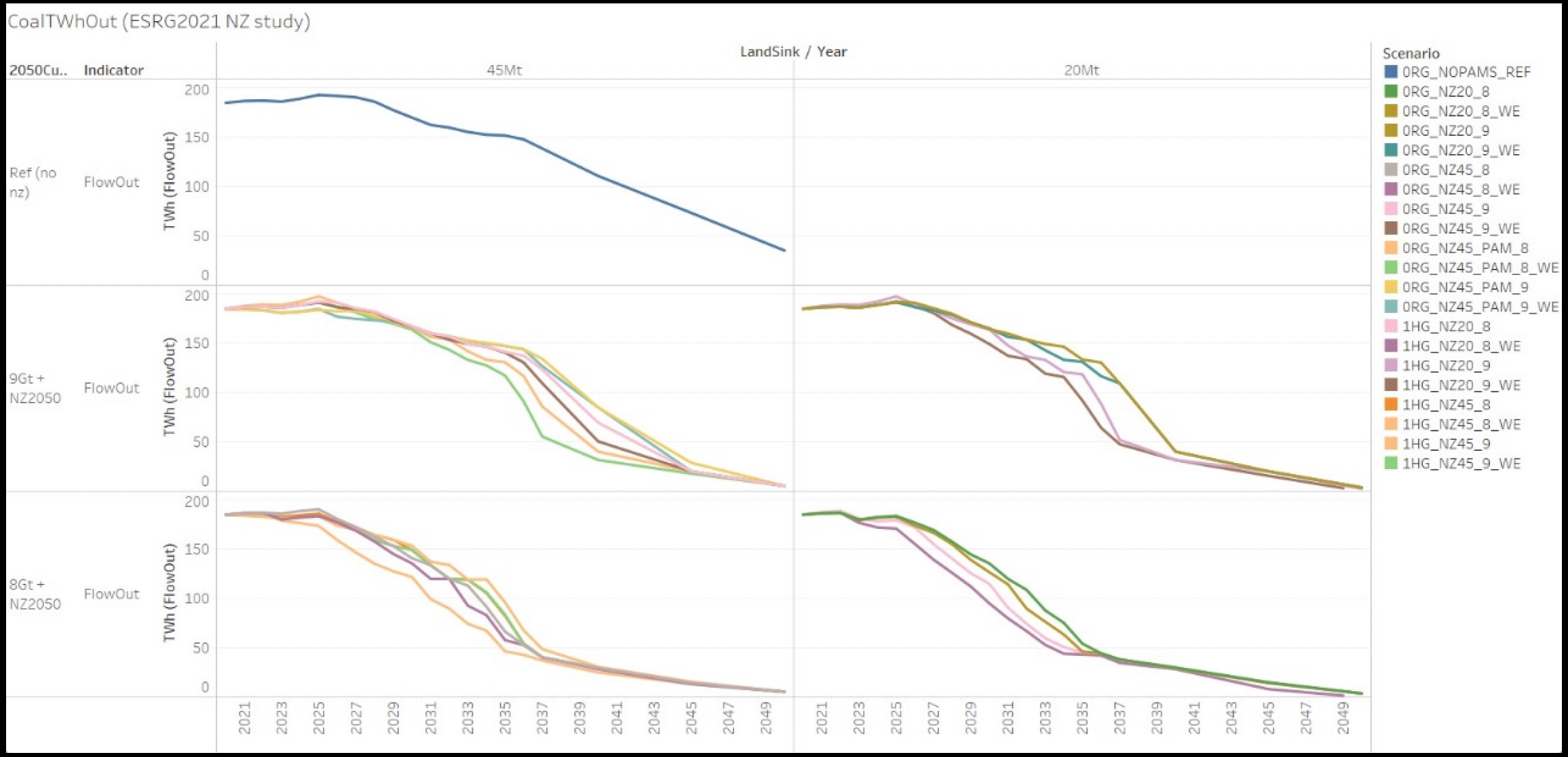
Source: Andrew Marquard, 2022
Analysis is based on declining coal fleet load factors in a variety of net zero pathways with varying GHG emissions budgets, ESRG 2021.

Coal fleet in net zero futures (ESRG 2021)

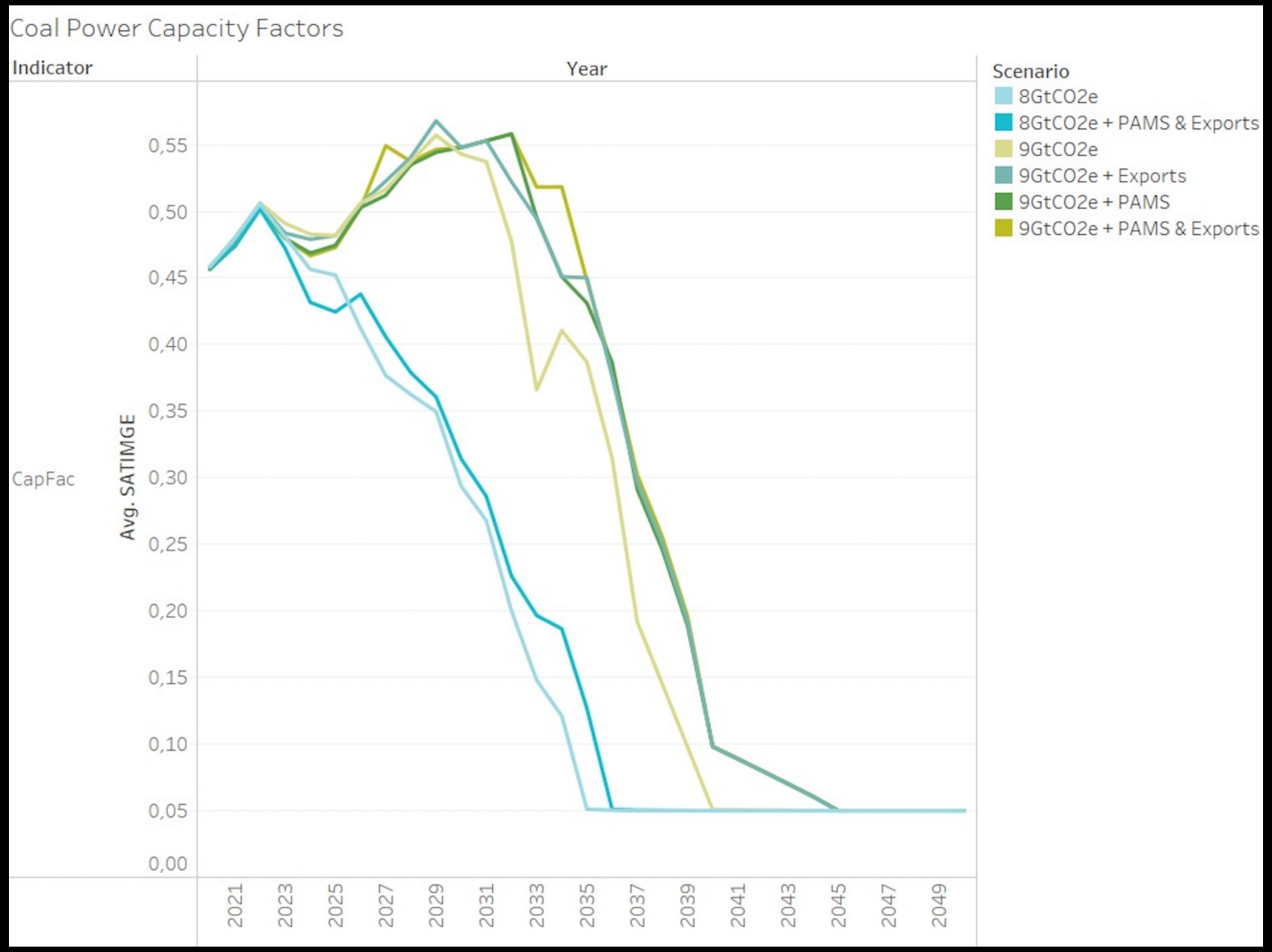


When we allow the model to ‘keep’ the plants and run at low levels, it does so

Coal power in net zero futures (ESRG 2021)



Coal fleet in NZ futures V2 (5%) (ESRG 2022)



- Budget defines how quickly the fleet reduces output ie timing of reductions – smaller budget brings forward the reduced load factors
- Overall, model 'likes' having coal plants as part of reserve
- But not to run at high levels (emissions-intensive): results show that coal plants quickly reduce to lowest level set
- But levels of fleet depends on cost of alternatives (RE plus storage vs opex of coal)

Consistent findings

- Considerably faster renewable energy roll out needed immediately – dual benefits: address supply security issues immediately, and enable Eskom the headroom to do maintenance
- In medium term, this can support improved air quality and reduce legal risks for government
- Enables flexible approach to decarbonization in the 2030s
- Supports just transition agenda if appropriately implemented
- All analyses agree that lowest cost option include reducing output and/or retiring coal plants earlier- dependent on technical parameters that need further work

Air quality compliant scenarios (coal off by 2040) (ESRG 2019)

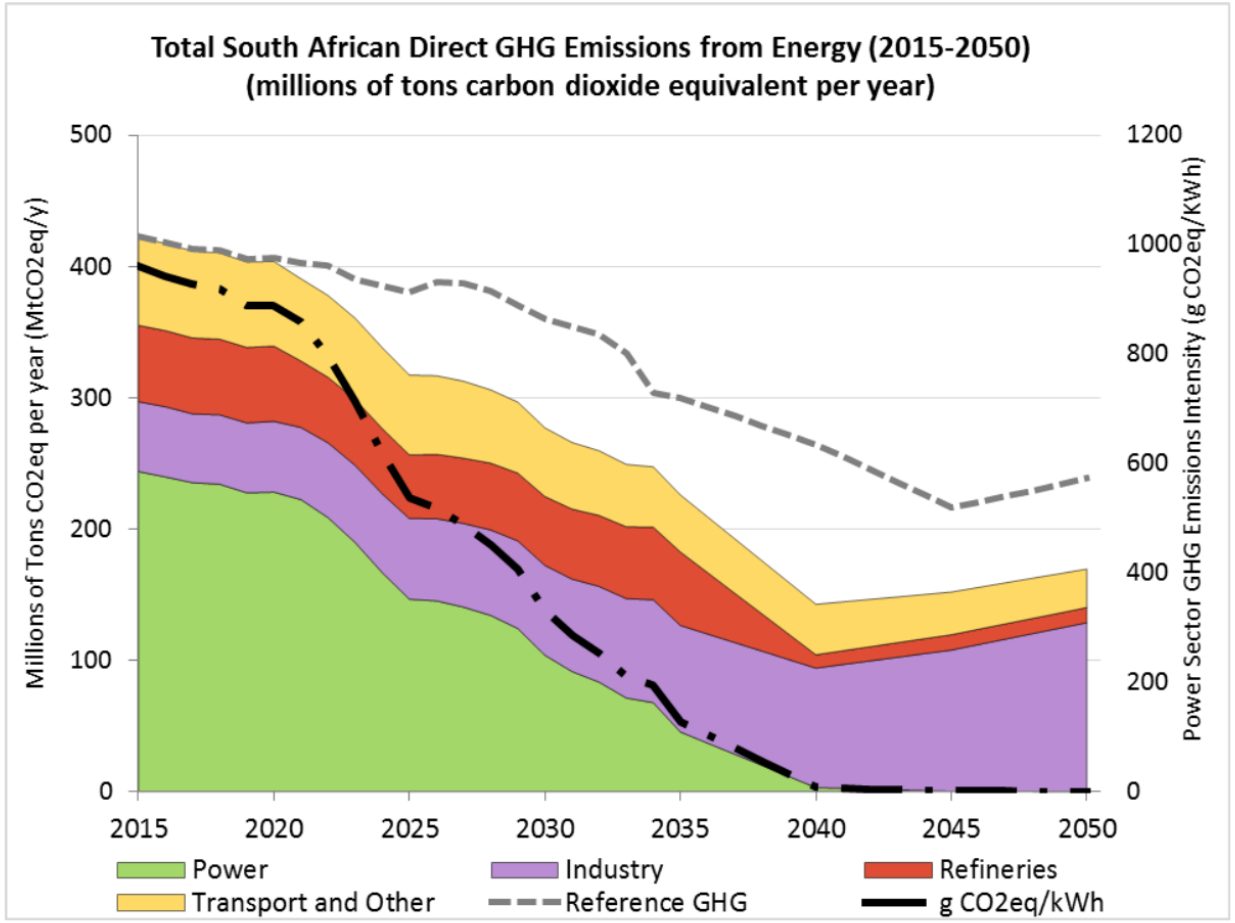


Figure A: GHG emissions in least cost mitigation scenario with carbon intensity of electricity

- Least cost air quality compliant scenario sees most of the fleet that operates post-2030 being retrofitted to meet the new plant standards
- In the carbon budget scenario, more stations retiring instead of being retrofitted for compliance with the MES.
- In total, 11GW of coal capacity is retrofitted, compared to 18GW in the reference scenario (ie 7GW earlier retirement)
- Clear need to update this analysis in light of new coal costs, MES postponements, net zero work, updated NDCs, etc

IRP 2019 and updated IRP

- IRP 2019 developed in a context where necessary speed of climate action was not yet well understood
- Pre-dates the updated Nationally Determined Contribution for 2025 and 2030
- Predates the development of a national Just Transition Framework and DMRE's JET Framework
- Assumes 50yr life of plants and excludes full compliance with the MES
- The 'carbon budget' used in IRP 2019 is based on older targets (PPD) and needs to assess the role of power sector in achieving the updated NDC, including the 1.5C compatible lower bound, as well as supporting other sectors to decarbonise
- Current policy results in power sector budget of 4-4.4Gt to 2050 (Meridian, NBI)
- Could be 1Gt lower at no cost and 1,5Gt at slight cost (NBI and Meridian)
- 2030 NDC and 2050 NZ budget for power sector is between 2.3-3.3Gt 2020-2050 (8-9 Gt CO2eq economy-wide fair share) (ESRG)
- **Hence necessary to explore in updated IRP how to lower power sector emissions by 1-2.5Gt to 2050**

Thank you

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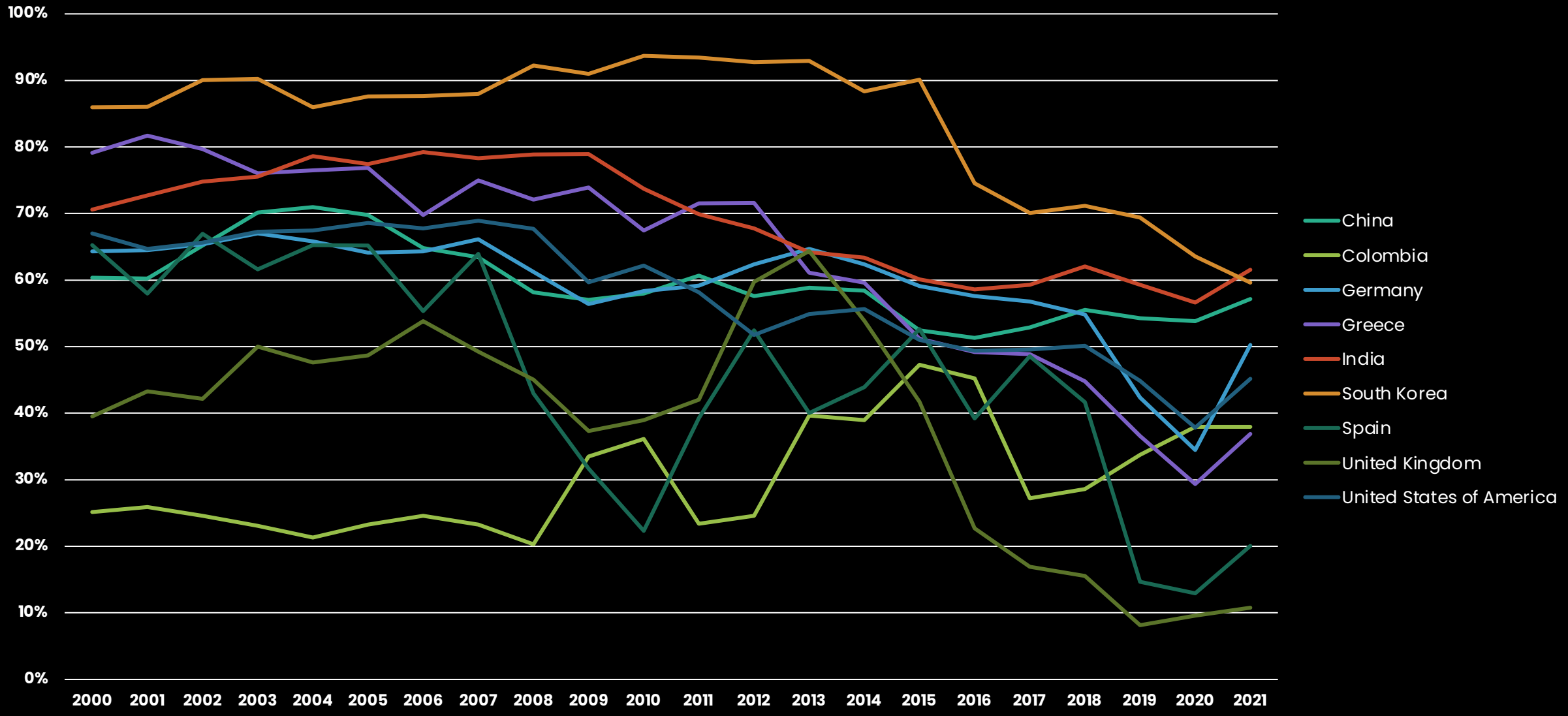
Extra slides

Coal fleet load factors have been declining internationally

In many countries these have declined to levels significantly below 41%; a 10% decline in the load factor of the South African coal fleet does not pose insurmountable technical challenges.



Source: Andrew Marquard, based on Ember's electricity data set, downloaded from https://ember-climate.org/data-catalogue/yearly-electricity-data/

International equity, Just Transition and export considerations

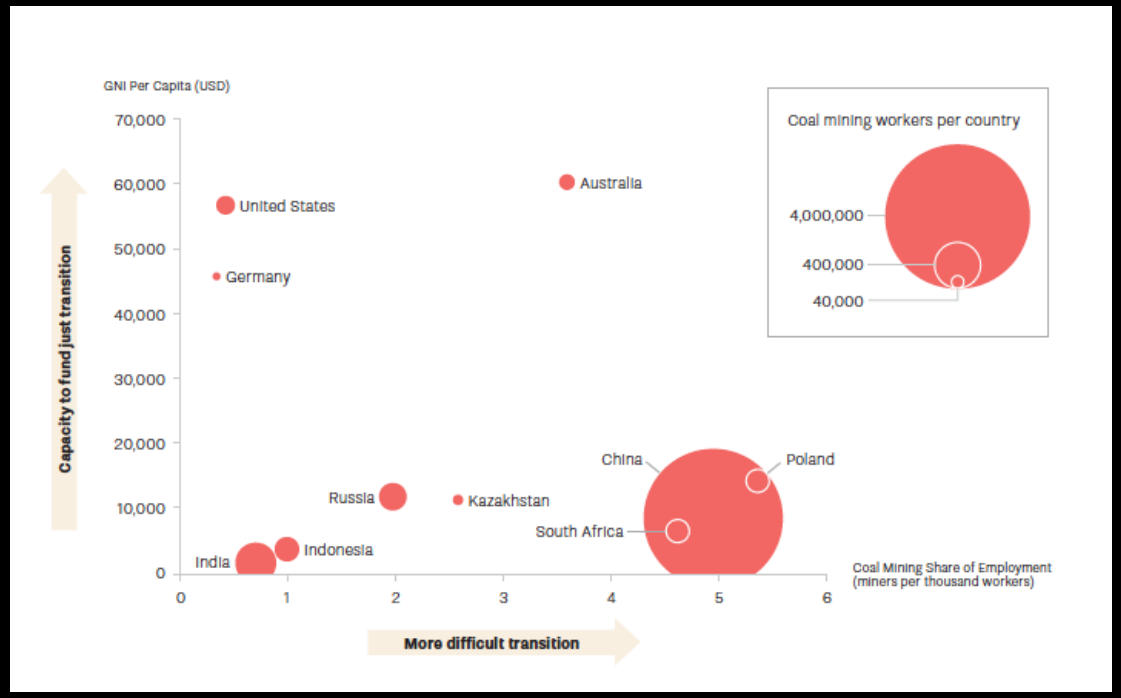
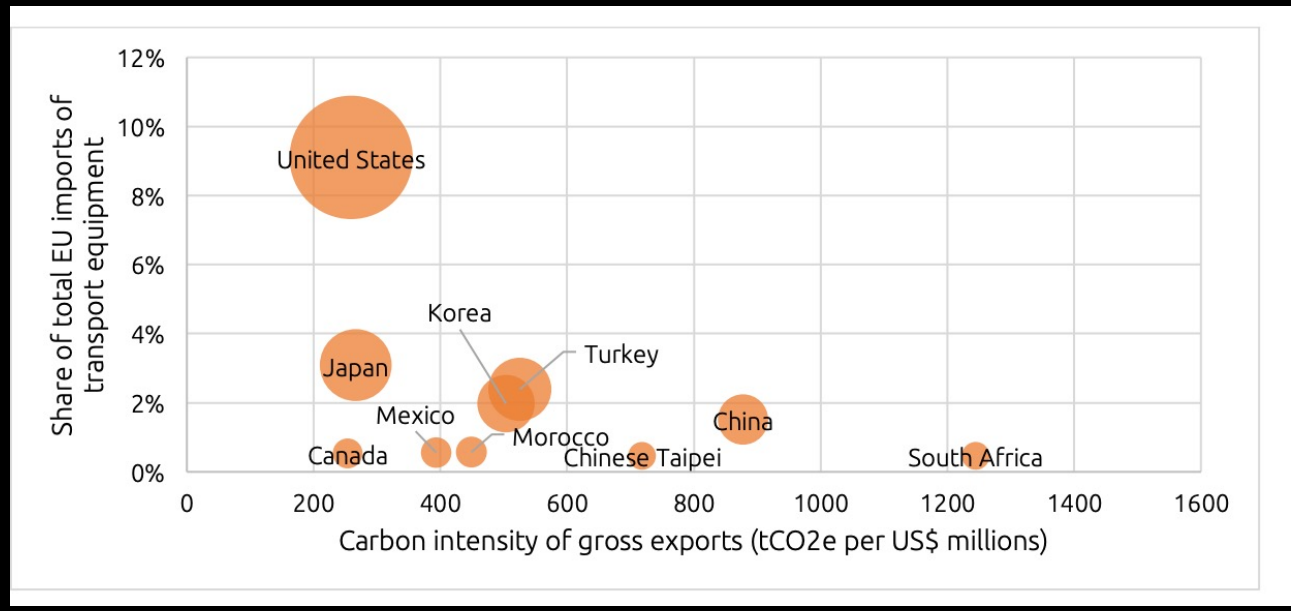


Figure 5 Coal mining share of employment versus per-capita gross national income (GNI), selected countries, 2015. Size of bubbles reflects absolute number of coal mining workers. Source: Production Gap Report, 2020



Key suppliers of transport equipment to the EU (28) with carbon intensity, 2015 (TIPS, 2022)

CSIR-Meridian notes on modelling

- **Coal fired capacity is retired when it is economically efficient to do so** given each scenario's carbon constraint – There is no requirement to continue running coal stations even if their design life has not been reached
- Although coal capacity closure is a favoured measure of mitigation success, our findings indicate **emission mitigation may be more optimally achieved by retaining coal capacity at minimum burn levels**
- Keeping coal capacity on the system but running at much lower capacity factors (minimum 35%) provides system stability/capacity while the RE is being built
- Determination of a reliably optimal station-level unit closure schedule is beyond the scope of our modelling due to lack of granular information regarding the condition of units, the exact Capex and Opex requirements and individual coal contract details
- Premature closure of coal plant in the South African context could result in a need for more gas fired power and associated gas infrastructure resulting in a costly and high-emission future locked into long term gas commitments.
- • **With each progressively tighter carbon constraint, energy generated from coal reduces**

References

- CSIR (2020) “Systems analysis to support increasingly ambitious CO2 emissions scenarios in the South African electricity system,” Technical Report, July 2020.
- Roff et al (2020) “A vital ambition”
- McCall et al (2019) “Least-cost integrated resource planning and cost- optimal climate change mitigation policy: Alternatives for the South African electricity system”
- NBI 2021 “Decarbonising South Africa’s power system”
- ESRG 2021 – Marquard et al,(forthcoming) “Modelled net zero pathways”
- ESRG 2022 Modelled net zero pathways for energy background report
- Merven et al (2020) “Assessment of new coal generation capacity targets in South Africa’s 2019 Integrated Resource Plan for Electricity “