An assessment of new coal plants in South Africa’s electricity future

The cost and greenhouse gas emissions implications of the coal IPP procurement programme

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NERSA generation license hearings
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Who we are

- Energy systems, economics, and policy (ESEP) group
- Based at the Energy Research Centre, University of Cape Town
- We work at the interface of energy systems analysis, macro-economic modelling, and policy analysis
- National, regional, and city-scale modelling
- Energy-water nexus, integrated energy planning, energy-economic linkages and development pathways, deep decarbonisation, uncertainty analysis, coal transitions, transport modelling... amongst others!
- Maintain the South African Times Model: integrated, full sector energy model
- Undertake multi- and interdisciplinary research
Aim of the current research

- What are the implications of committing to the coal IPP programme?

- How: through the comparison of a least-cost electricity build plan against an electricity build plan where the coal IPPs are committed (Coal Plus)

- We assess total discounted system costs, additional annual costs incurred, and emissions, measured as the difference between the least cost reference scenario and the coal plus scenario

- In each case we have assessed the IPPs individually and combined, but will report only the combined results here
Current context

What has changed since IRP 2010?
What does the best available climate science tell us about coal infrastructure?
Substantial oversupply

Projected and Historical Total Annual Electricity Demand (Terawatt-hours)

- Historical Demand
- IRP2010 Base Forecast
Substantial oversupply
Substantial oversupply

Projected and Historical Total Annual Electricity Demand (Terawatt-hours)

Historical Demand
ERC (Low Demand)
EIUG
ERC Reference
IRP2016 (CSIR Mod)
IRP2010 Base Forecast

0 50 100 150 200 250 300 350 400 450 500 550

Total Annual Electricity Demand (TWh)
Falling costs of new RE capacity

Solar PV

Source: IRENA
Falling costs of new RE capacity

Onshore Wind

Source: IRENA
Paris Agreement

- Aims for “well below” 2 degrees
- Net zero emissions in latter half century
- Phase out of unabated coal by 2050 required for 2D
- Current policies still >3D; NDCs 2,8D
- South Africa’s current NDC = “inadequate” (CAT)
- Paris Agreement includes “ratchet mechanism” to increase ambition of nationally determined contributions
- SA can expect to move towards a more ambitious contribution over time
- Stranded assets – 2D requires early phase out of coal. Do we pay for a station we cannot use?
• In Pfeiffer et al. (2016), for example, it is shown that unless the plants later become stranded, no new emitting electricity generation plant can be built from 2017 onwards for 2°C scenarios.

• Many other authors have shown that coal will have to be phased out by 2050 to limit warming to 2°C and even more rapidly to limit warming to 1.5°C (Rogelj et al. 2015; Pfeiffer et al. 2016; Johnson et al. 2015; Luderer et al. 2016, Iyer et al. 2015).
Analysis of coal IPPs

Part 1: Reference scenario
Part 2: Coal Plus (committed coal IPPs)
South African Times Model (SATIM)

- Full sector least cost optimisation model
- Aims to meet demand at lowest cost subject to various constraints – implicitly means energy security goals are met, at lowest cost
- Demand derived from a linked energy-economy model (i.e. price effects of investments taken into account, unlike in the IRP)
- Based on the model developed for the DEA-PAMs project (pop, GDP growth, RE costs/learning)
- Has undergone extensive stakeholder consultation incl with industry and Eskom
Reference scenario assumptions

- 3.2% average annual growth 2015 to 2050, high growth in industrial sectors
- Includes EV uptake; no batteries
- Committed build: M&K, REIPPP up to round 3.5 (no later rounds committed)
- Higher demand forecast than EIUG
- The retirement dates of existing plants are aligned to those from IRP 2016 using a 50-year life of plant for Eskom coal plants
- except Arnot and Hendrina which we have not allowed the model to use – cold storage from start 2018 (as per NERSA disallowing in RfD)
- Medupi and Kusile are modelled to come online incrementally according to the October 2017 Eskom Medium Term System Adequacy Outlook)
Further assumptions

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<tr>
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<th>Thabametsi</th>
<th>Khanyisa</th>
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<tbody>
<tr>
<td>Plant Capacity (sentout)</td>
<td>539.7 MW</td>
<td>306 MW</td>
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<tr>
<td>Efficiency (net)</td>
<td>36.25%</td>
<td>35.5%</td>
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<td>PPA Tariff (2016 Rands)</td>
<td>1.03 R/kWh</td>
<td>1.04 R/kWh</td>
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<tr>
<td>GHG Emissions Intensity (CO₂ &amp; N₂O)</td>
<td>1.23 tons CO₂ eq/MWh</td>
<td></td>
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<tr>
<td>Final Commissioning Date</td>
<td>2022</td>
<td></td>
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<td>Project and PPA Lifetime</td>
<td>30 years</td>
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- **GHG emissions intensity:**
  - Thabametsi GHG impact assessment (CO₂ & N₂O)
- **Costs of IPPs: based on CSIR analysis**
  - PPA = Qualification price (+) Shallow grid connection cost
  - PPA = Evaluation price (−) Carbon Tax (120R/t)
Reference build plan

Electricity Sector Total Installed Capacity Least-Cost Build 2015-2050:
ERC Reference Scenario

Installed Generation Capacity (GW)

- Coal
- Hydro
- Pumped Storage
- Nuclear
- Gas
- Solar PV
- Wind
- Peaking
- CSP
- Imports
- Peak Demand
Excluded years past 2035 as it throws the scale off and 2045 and 2050 are grouped milestones, not annual… (the data is there though)
Results: reference case

- High penetration of RE plus gas backup
- No new capacity required until 2026 due to previously low demand and M&K coming online
- Emissions are within the Paris Agreement by 2030, and NCCRWP by 2050
- Driven primarily by decarbonisation of the electricity sector (least cost mitigation option)
Sensitivity analysis: demand

- Lower GDP growth (2.4% to 2050)
- Flat demand to 2020
- Still optimistic given that we are at 1.1% GDP rate
- Everything else is equal to reference scenario
- No new capacity needed until 2028
Low demand build plan

Electricity Sector Total Installed Capacity Least Cost Build 2015-2050:
ERC: Low Demand Scenario

- Coal
- Hydro
- Pumped Storage
- Nuclear
- Gas
- Peaking
- Solar PV
- Wind
- CSP
- Imports
- Peak Demand (Low)
Power Sector Greenhouse Gas Emissions 2015 - 2050
(Million Tons CO$_2$eq per year)

- ERC Least-Cost (Reference)
- ERC Least-Cost (Low Demand)
Part 2: committing the IPPs
“Coal plus” : committing the coal IPPs

• The optimised least-cost build plan includes no new coal-fired power plants in the investment horizon to 2050.

• testing the system implications of the coal IPPs requires the plant to be “forced-in”, after which the deviation from the reference case can be quantified and analysed.
Total Energy Generation Differences with Both Coal IPPs - Reference
(Terawatt Hours TWh)

Build plan difference (Reference)
Build plan difference (Low Demand)

Total Energy Generation Differences with Both Coal IPPs Low Demand
(Terawatt Hours TWh)

- Energy Generation Difference (TWh)
  - 2022
  - 2026
  - 2030
  - 2034
  - 2038
  - 2042
  - 2046
  - 2050

- Energy Generation Differences with Both Coal IPPs Low Demand:
  - Coal IPPs: Thabametsi & Khanyisa
  - Eskom Existing Coal
  - Gas
  - Solar PV
  - Onshore Wind

- Years: 2022, 2026, 2030, 2034, 2038, 2042, 2046, 2050
- Energy Generation Difference: -8, -6, -4, -2, 0, 2, 4, 6, 8
- Terawatt Hours (TWh)
Power Sector Greenhouse Gas Emissions 2015 - 2050
(Million Tons CO$_2$eq per year)

- Coal IPPs
- Forced (Reference)
- ERC Least-Cost (Reference)
- Cumulative Additional from Coal IPPs (Reference)

 ERC LEAST-COST (REFERENCE)
Power Sector Greenhouse Gas Emissions 2015 - 2050
(Million Tons CO₂ eq per year)

- ERC Least-Cost (Low Demand)
- Coal IPPs Forced (Low Demand)
- Cumulative Added (Low Demand)

155 Mt CO₂eq Total Additional (Low Demand)

Carbon Emissions (MT CO₂eq/a)

Year: 2015, 2020, 2025, 2030, 2035, 2040, 2045, 2050

Values:
- 2015: 238
- 2020: 250
- 2025: 248
- 2030: 149
- 2035: 87
- 2040: 87
- 2045: 87
- 2050: 87

ERC: Energy Research Centre, University of Cape Town
Additional annual costs

Comparison of Costs for Electricity from Coal IPPs against Alternative Least Cost Energy Mix - Rands per Kilowatt Hour Purchased (Reference Scenario)

- Coal IPPs
- Existing Eskom Coal
- Gas
- Solar PV
- Wind
- Opportunity Cost Per kWh
Additional annual costs

Additional Costs Paid Per year - Both Coal IPPs
(nominal Billions of Rands)

- Coal Plus
- Coal Plus Low Demand
Cumulative additional costs

Total Cumulative Additional Costs Paid for Electricity (nominal Billions of Rands)

- **2050 Total Additional Cost: R60,2 Billion Rand (Low Demand)**
- **2050 Total Additional Cost: R48,4 Billion Rand (Reference)**

- **Coal Plus**
- **Coal Plus Low Demand**
Summary

- Compared to a least cost electricity build plan, the coal IPPs:
  - Increase overall emissions by approx 155-177 Mt CO2eq to 2050
  - Result in additional costs in the electricity sector every year of up to R4bn to 2025-2027 to be borne by consumers
  - Increase the overall system costs by R billion in present value terms
  - Makes planned mitigation measures redundant: eg the National Energy Efficiency Strategy saves 214Mt CO2-eq to 2050
ERA and EPP – NERSA’s role

• Objective of the ERA is to
• “ensure that the interests and needs of present and future electricity customers and end users are safeguarded and met, having regard to the governance, efficiency, effectiveness and long-term sustainability of the electricity supply industry within the broader context of economic energy regulation in the Republic”
• EPP: to balance affordability and environmental sustainability
• it would be remiss of NERSA to licence plants that are both polluting and raise the costs of the electricity sector
Conclusions

- South Africa has a surplus of baseload generation and further new capacity coming online
- Electricity costs have risen and are putting the economy and citizens under increasing pressure
- The IPPs exacerbate the situation of oversupply in the short- and medium term,
- And crowd out cheaper investments later
- The stations lower the load factors at Eskom plants and puts those plants and jobs at risk
- Severe consequences for Eskom: exacerbates the utility death spiral
- This is not in the public interest nor does it meet the objectives of the ERA and EPP
- Demand uncertainty can be ameliorated by flexible options: cheaper and shorter lead times
- If it were Eskom, these stations would be considered imprudent investments
Thank you!

Questions?
Issues arising and further research

- Phase one of our study is this analysis.
- Phase 2 will extend the analysis and combine several sensitivities (demand, costs, GHG intensity of the plants); assess costs of meeting our climate change policy with the stations included.