The South African Risk Mitigation Power Producers Procurement Programme (RM4P):

A techno-economic evaluation of the underlying design of the request for proposals (RFP) and the resultant impact on the outcomes of the RM4P

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Executive Summary

The risk mitigation power producer procurement programme (RM4P) that was launched in December 2019, made use of a gas-dominated procurement process that rendered the request for proposals at best awkward, at worst fatally flawed.

A delayed submission deadline, 24 briefing notes between issue date and final submission deadline, hundreds of clarification questions, and multiple rule changes mid-process, attest to this.

Unsurprisingly, many of the rules, restrictions, terms, and conditions of the RFP, such as not being allowed to charge from the grid at night, or not allowing shared storage usage among facilities, have little to no impact on gas-dominated projects, such as the three Karpowership projects. This is not so for projects dominated by solar photovoltaic (PV), wind, and energy storage systems (ESS). The combined restrictions imposed by the RFP serve to increase bid tariffs for renewable projects by more than 50%. This in turn renders gas-dominated projects as seemingly, but erroneously, cost-competitive.

Modelling clearly indicates that if the RM4P was aligned to the current and future renewable energy independent procurement programme (REI4P) bid windows, and optimally integrated with all of the existing grid and storage assets, it would be possible to more than halve the tariffs, thus saving Eskom, and ultimately the South African electricity consumer, eight billion rand (R8b) per year, or one hundred and sixty billion rand over the term of the power purchase agreements.

R 160,000,000,000 saving possible

The impact of a truly technology agnostic procurement process, is neatly summarised in the bar chart below. For a full explanation, see page 15
The recommended modified procurement process renders all gas-dominated projects, including the three Karpowership projects, as redundant, purely based on price. If we add in carbon emissions, environmental impacts, health risks, gas price and exchange rate risk, it is no contest.

The current preferred bidder projects collectively produce over four million tonnes of CO$_2$ emissions annually, or eighty million tonnes over the duration of the PPAs. Of this, the three Karpowership projects contribute 90% of the total, as shown in the bar chart below.

A revised, flexible risk mitigation procurement process is recommended that is based on locality-adjusted feed in tariffs for PV and wind, and a lease-based energy storage system (ESS) procurement process, where ESSs are allowed to be strategically placed on both the transmission, and the distribution grids, including municipal distribution grids, and are under the control of the systems operator.

A premium would be placed on time to commercial operation date (COD), with incentives for early COD, and penalties for late COD, thus adding new generation capacity to the system in the shortest possible time, noting that more than 600 days have lapsed since the RM4P was first initiated.
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1. Introduction

a. Background

Stage six load-shedding was implemented in South Africa in early December 2019, as planned and unplanned outages at the Eskom coal-fired power fleet reached record highs. The stalling of the process to procure new generation capacity, with the last official round of the renewable energy independent power producers procurement programme (REIPPPP) in 2014, had placed the whole system in a precarious, near permanent state of supply shortage.

b. Justification for this techno-economic report

Based on the lack of clarity in the RFP, especially as regards the technical and financial elements of the programme, it was deemed appropriate to undertake a detailed techno-economic evaluation of the impact of the gas-orientated rules and restrictions so prevalent in the RFP documentation. Assessment of the RFP indicates that the document was in all likelihood designed for a gas procurement programme that was altered and modified in an attempt to claim a “technology agnostic” process. One of the key results is that the terms and conditions of the RFP (rules) have a disproportional negative effect on wind, solar, and storage hybrid projects as opposed to gas-dominated, and especially gas-only projects, typified by the three Karpowership projects, at Richards Bay, Coega and Saldana Bay.

The effect of this is that although the RFP allowed for any kind of technology-mix solution (technology agnostic), the impact of the rules and regulations were anything but technology agnostic, and they have very different impacts on the different technologies. The unnecessarily high tariffs of the winning storage-backed wind and solar projects serve to underscore this assertion.

Unsurprisingly, many of the restrictions, terms and conditions of the RFP have little to no impact on gas-dominated projects. This is not the case for projects dominated by solar photovoltaics (PV), wind, and energy storage systems (ESS). The combined terms and conditions imposed by the RFP serve to increase bid tariffs for renewable-dominated projects on average by more than 50%. This in turn renders gas-dominated projects, exemplified by the three Karpowership projects, as seemingly, but erroneously, cost-competitive.

In addition, as per the rules of the RFP, projects are treated as individual islanded generators, and are prohibited from communicating and working in concert with each other via the national transmission and distribution grid. Worse still, none of the projects are able to interface intelligently with existing underutilised utility assets, such as Eskom’s large pumped-hydro storage fleet.

The RM4P is itself treated in isolation, with little or no cognisance of coupling the programme with the already announced new bid windows five and six of the renewable energy independent procurement programme (REIPPPP). Although the RM4P was treated as a separate emergency procurement programme, an opportunity to link it seamlessly with known future procurement rounds, so as the REI4P was missed. If this full system coupled approach were adopted, tariffs as low as forty percent of the
average winning tariffs in the RM4P are achievable, with the requisite security of supply of 2 000MW between 05h00 and 21h30 available as an inexpensive by-product. Ancillary services required in the RMI4P would also be met, and in fact exceeded.

c. Goals

There are three primary goals of this techno-economic evaluation:

i. Assessment of desirability of winning projects

In order to assess the desirability of the winning projects, five key areas were examined:

1. Cost

Cost, as expressed by the final equivalent bid tariff, is clearly one of the key criteria. For example for the national energy regulator of South Africa, NERSA, to even consider issuing generation licenses to projects, they need to be satisfied that the tariffs provide value for money, and that they are the best options when compared to plausible alternatives. This study will focus on confirming the tariffs of winning projects under the restrictive rules and conditions of the RFP, and then calculate what the tariffs could be if the rules and regulations were adjusted to be truly technology agnostic.

2. Reliability

Reliability, as expressed in the ability of projects to deliver or dispatch electricity as required by the system operator, within the delivery time window from 05h00 to 21h30 each day, is treated as non-negotiable. The techno-economic modelling undertaken uses the 2019 annual hourly data set and portrays wind and solar PV output from actual projects, albeit averaged across multiple sites.

The reliability goal was to test the ability of the various combinations of wind, solar, storage and gas/diesel making up the renewable dominated projects, to meet any dispatch requirement for more than 95% of the time within the dispatch window.

3. Flexibility

The goal as regards flexibility of the different projects to meet the RFP requirements was to model how the gas-dominated rules and regulations impact on the flexibility of renewable-dominated projects. Additionally, modelling would indicate the impact on flexibility if projects were permitted to interface with each other via the connectivity afforded by the grid. A further aim was to extend this to interaction with the full existing Eskom system, and quantify the impact that this additional flexibility would have on reliability as well as on cost.

4. Energy independence

It was deemed important to establish the full extent to which projects could offer energy independence, especially independence from risks associated with exposure to fluctuating gas prices, and dollar rand exchange rates.
5. Greenhouse gas emissions

A key goal of the techno-economic analysis is to establish the carbon emission profiles of all of the winning projects. Secondly, to establish how the emissions from the RM4P projects could be reduced by simple adjustments to the rules and regulations of the RFP to be more accommodating to all technologies, in other words, to make the rules and regulations technology agnostic.

ii. RMPP procurement process

The second goal of this report is to show how the structure of the RM4P led to the selection of preferred bidders, including all three of the Karpowership projects, that were not cost effective, offered poor value for money, and had undesirable outcomes, including unacceptable levels of greenhouse gas emissions, and other forms of environmental impacts.

iii. Alternative procurement programmes

The third goal is to outline possible alternative procurement strategies and programmes and that would seek to increase integration with the existing electricity supply, transmission and distribution system, as well as interface with existing, and underutilised storage assets. In addition, the impacts that a system integrated approach would have on costs (tariffs), and well as on reliability and emissions reductions will be established.

2. Summary of RMPP procurement process

a. Key features and rules of the procurement process

i. Project size

The RM4P sought to procure 2000 MW of dispatchable power between 05h00 and 21h30 each day. Projects were to be between 50 MW and 450 MW of contracted capacity. These size limits were reasonable, and ensured that there would be at least five, and not more than twenty eventual winning projects. As it turned out, there were a total of eleven preferred bidders.

An argument could be made that the upper size limit of 450 MW was specifically chosen, in order to accommodate large gas projects, such as, such as the Karpowerships, or indeed, land-based gas projects. Few wind, solar, and storage hybrid projects would be able to compete at the 450 MW scale simply due to the fact that most environmental impact assessments for solar PV were limited to smaller sizes of 100 MW, and wind projects to 150 MW, in line with the maximum allowable project sizes in all previous REIPPPP bid windows.
ii. Project dispatch rules

The rule that projects were to be fully dispatchable in the RFP-designated 05h00 to 21h30 time window was extremely easy to adhere to for gas-only projects, such as the Karpowerships, or gas-dominated projects, such as the Total Mulilo Coega project, where the declared dispatchable facility was gas-only. The dispatch rules were able to be met by renewable-dominated projects by the addition of suitably-sized energy storage systems (ESS). We will see however, that the combination of rules vi and vii result in the need to unnecessarily oversized storage systems, increasing the costs for renewable projects and thus increasing the tariffs that were bid.

"Dispatch" means the right of the Buyer, subject to the Codes and the standards of a Reasonable and Prudent Operator, to issue a Dispatch Instruction to the Seller in order to schedule, coordinate and manage the flow of Energy Output of a Dispatchable Facility including to Start-Up, commence, increase, decrease, shut-down or cease delivery of the Energy Output of a Dispatchable Facility;

"Dispatchable Facility" means a Facility or a Project that is capable of being Dispatched and is operated on such basis and can be used or called upon on demand and Dispatched at the request of System Operator for one hundred percent (100%) of the Contracted Capacity over the full duration of the Dispatchable Period while meeting all the technical performance requirements stipulated in Schedule 11 (Performance Requirements) for normal operation and for the provision of the Ancillary Services.

iii. Multiple facility rules

Projects were allowed to comprise multiple facilities, grouped together as a single project, and contracting for a single MW amount. A single project could comprise multiple facilities, that when grouped together, could constitute a single dispatchable project, although none of the individual facilities would be considered dispatchable.

The Omoyilanga project is the only example of such a project, comprising a wind-storage diesel ICE facility, and a separate PV, storage and diesel ICE facility, neither of which is individually dispatchable. Facilities grouped together to constitute a single dispatchable project, are then subject to the system operator rules regarding dispatch instructions (see for example iv, Mingen rules).

In the case of a project comprising a dispatchable facility, and a separate non-dispatchable facility, such as the Total Mulilo Coega project, the fully dispatchable LNG facility is subject to system operator dispatch instructions, whereas the solar PV non-dispatchable facility is not subject to system operator dispatch instructions.

"Non-Dispatchable Facility" means a Facility that the Buyer or its delegated alternative has no contractual right to influence the Dispatch of under normal operating conditions or a Facility which has no or limited ability to respond to a Dispatch Instruction;
iv. Project minimum generation (Mingen) rules

For dispatchable facilities or projects, the system operator can issue dispatch instructions at any time, to suit system needs. The instruction may be to supply the full contracted capacity for the entire duration of the dispatch window, or, as per the Mingen rules, to supply only 25% of contracted capacity on instruction. This is clearly easily complied to by gas-engine projects, when units can easily be shut down or fired up to meet dispatch instructions.

However, for storage-supported renewable dominated projects that are deemed dispatchable, a Mingen instruction is literally an instruction to curtail output. Given that the sunshine and wind cannot be switched off at will, if all on-site storage systems were already fully charged, then the surplus wind and solar would need to be curtailed in order not to exceed the 25% output instruction. This is easily accomplished via inverter instruction, and excess wind and or solar output is then simply wasted. All of the renewable-dominated project owners will have taken a view (different from project-to-project) on the likely curtailment that would be requested, and increased their bid tariffs accordingly.

It should be noted that all of the renewable dominated projects would be curtailing output even when called upon to dispatch at the maximum contracted capacity (Maxgen). This would mainly be in the summer months, as systems will have been sized to provide contracted capacity during the winter months, and would therefore generate excess for much of the year. Any Mingen dispatch instruction would significantly add to the amount that would need to be curtailed.

v. Minimum annual contracted capacity

The RFP stipulates that a minimum annual amount of energy will be purchased, or deemed to have been purchased, from each project, irrespective of the actual dispatch instructions from the system operator. This minimum quantity of annual energy is calculated at an annual capacity factor of 50% of the full contracted amount. This in turn translates to the buyer (Eskom) contracting to purchase at least 72.73% of the theoretical maximum output possible in the 16.5 hour dispatch window.

One of the outcomes of the rules of the RFP is thus that what are to all intents and purposes emergency supply gas peaking plants, such as the Karpowerships, will be operating at a minimum capacity factor of 50%, which is more in line with combined cycle gas turbines. Open cycle gas turbines (OCGTs), or reciprocating gas engines, are typically operated at no more than 10% annual capacity factors.

The three Karpowership projects represent 62% of the total RM4PP contracted capacity, and will generate a similar percentage of the total output of the combined projects. This is totally out of kilter with normal operating specifications of OCGTs or reciprocating gas engines. Although the Karpowerships make use of some heat recovery from the reciprocating engines, they are by no means fully comparable to combined cycle gas turbine plants.

Take for example the Eskom fleet. The Eskom OCGT fleet, together with private IPP OCGTs, constitute 3GW, or about 7 percent of total installed generation capacity in South Africa. In 2019, the OCGT fleet operated at an 8% capacity factor, and supplied
less than 1% of the annual output, at just over 2 TWh. This represents one third of the minimum contracted annual output of 6 TWh attributable to the three Karpowership projects.

vi. Grid integration rules

The question of being allowed to charge energy storage systems from the grid outside of the dispatch window was one of the most frequently asked clarification questions, and the answer was always, no, with the following stock answer:

“The supply of electrical energy to the Seller by the Buyer or from the system is prohibited for the purposes of storing energy in an electrical energy storage facility.”

This rule has no impact whatsoever on gas-engine projects, but results in storage-backed renewable projects needing to increase the installed storage duration hours, and therefore unnecessarily increases costs as reflected by bid tariffs.

The buyer in this case, Eskom, generally has surplus electricity available at night, and would benefit from the sale of this surplus. In addition this would significantly lower the tariffs bid by the project. The rule is therefore doubly irrational.

vii. Placement of energy storage systems

RFP rules dictate that any energy storage systems (ESS) must be co-located with either wind or solar generation capacity. However, if ESS are placed at key locations on the transmission or distribution grids, they are able to perform additional services over and above simply acting as storage devices. For example, at peak times of day, electricity transmission volumes are often constrained at bottleneck points, and insufficient electricity is able to be fed to certain areas. Storage devices correctly located can allow for charging of the devices at off-peak times, and then discharging to those areas at peak times to overcome upstream flow constraints.

vi. Local content rules

Local content rules for PV plants for instance dictate that a certain percentage of local content must be used. Local manufacture of PV panels, and inverters has declined over the past few years due to policy uncertainty negatively affecting local demand. Many potential RFP respondents chose not to bid, as the remaining local manufacturing capacity placed an effective cap on the number of solar bidders that stood a chance to be compliant with respect to local content requirements.

In the case of Karpowership, there was no chance of any of the three projects achieving local content requirements. The local content requirements were then waived for Karpowership on the grounds that South Africa didn’t have any local manufacturing capacity to build gas reciprocating engines.
b. Effects of the procurement rules

From the modelling undertaken as the core of this techno-economic evaluation, the cumulative effect of the RFP gas-oriented rules and regulations has resulted in substantial inefficiencies in the winning renewable-dominated projects. This has resulted in bid tariffs that are much higher than they need to be. These tariffs decrease substantially as the layers of unnecessary rules and regulations are stripped away.

The details of the impact of the procurement rules will be covered in section 4 that deals with the results of the modelling.

c. Risks specific to gas (LNG) generated electricity

It is notable that many of the rules and restrictions of the RFP that so negatively impact and increase the tariffs of renewable-dominated projects, have little to no effect on gas-dominated projects, rendering these projects as seemingly competitive.

There are however, certain rules to the RFP that have no effect on renewable-dominated projects, and no effect on gas-dominated projects, and yet expose the buyer, Eskom, and thus the South African electricity consumer, to unacceptable levels of risk and uncertainty.

Specifically, the fuel cost for projects requiring fuel, such as LNG, LPG, or diesel, is treated in the tariff calculations as a pass-through cost to the buyer. The buyer, in this case Eskom, is therefore fully exposed to the risk and price volatility of the global oil and gas markets. In addition, these products are all dollar denominated, so there is additional currency exchange risk on top of commodity price risk. One need only reflect on the recent fuel price increases to understand that the tariffs for the gas-dominated projects, as reflected at the time of the winning bidder announcement, have in all likelihood already increased, based on global LNG price increases.

One could argue that prices and exchange rates may in fact move in favour of lowering the tariffs of gas-dominated projects. Although this may conceivably happen, why take the risk when there are alternatives that are not exposed to price and exchange rate fluctuations?

3. Modelling methodology

A self-built, tested and robust model that makes use of 2019 South African hourly generation and demand data was modified and used to evaluate each of the projects with respect to energy mix make up and contracted amount. The demand profile was set up to reflect the fully contracted demand for each project, for the dispatch window from 05h00 to 21h30 for each day of the year. The data set includes all wind and solar output from existing projects connected to the grid as of 2019. Output data for wind and solar is normalised to 1MW, and then scaled appropriately for each of the projects.

In projects with storage, excess wind and/or solar is used to charge up the storage, limited to the specific charging capacity of the storage system. Once the storage device is fully charged, based on the hours of storage available, any additional excess requires curtailment, and is effectively wasted.
Visual output showing the full demand profile, and well as how the projects meet the demand profile, is generated for the full year. A subset of this full output is shown for each of the projects for a typical week in March, in Figure 1. Any portion of output above the contracted demand dispatch window that is coloured brown, depicts storage charging. Generation above the dispatch window that is not brown, depicts “wasted excess” and would require curtailment.

The model is used to verify the ability of projects to meet the 05h00 to 21h30 dispatch window at the necessary level of reliability. It automatically calculates the contributions from each energy generation source, how much if any excess is produced, and estimates an indicative average tariff, based on a weighted average modified form of levelised cost for each of the technologies.

Input assumptions for the model for capital costs, operating costs, and weighted average cost of capital, and debt tenor terms are recorded in Appendix A. Importantly, all of the same input assumptions are used for all of the projects. Although actual details for each project will clearly differ, the model allows for a robust high-level ranking of the projects, and also allows for ascertaining the effects of different RFP rules on each of the projects. These relative effects are due only to rule changes, and not to any of the other assumptions, which remain unchanged. As such, focus should be on the range of tariffs under different rule scenarios, more so than the actual tariff values.

In addition to modelling all of the winning projects, an additional four scenarios were modelled, and the model demand and energy mix profiles are shown in Figure 2.

- All of the winning projects grouped together as one large project;
- All of the winning projects grouped together as before as one large project, but with all of the storage capacity removed;
- All of the projects with a renewable component grouped together. This included all of the projects other than the three Karpower projects; and
- An illustrative full system approach large project, effectively replacing the Karpowership projects, and capable of delivering 2000 MW as per the RFP dispatch rules.

4. Results of modelling

a. Summary of key findings

The key findings from the results of the techno-economic modelling are as follows:

- Small changes to the rules and regulations of the RFP, such as allowing full system integration and night-time storage charging, result in a 35% decrease in the weighted average tariffs of all of the projects with a renewable component. The weighted average tariff drops from R1.70/kWh to R1.10/kWh;
The same changes have a minimal effect of the weighted average tariff for the three Karpowership projects. The tariff drops from R1.54/kWh, to R1.45/kWh, a decrease of 6%.

The weighted average tariff of all of projects, excluding the Karpowership projects, is thus 25% less expensive than the Karpowership weighted average tariff, or R0.35/kWh less expensive.

If the RFP was designed using a full systems approach, and projects were fully integrated with existing Eskom storage assets, the tariff for an optimal system procurement programme would be as low as R0.72/kWh, or less than one half of the current Karpowership tariffs.

An optimal full system integrated RFP would have no gas, and thus zero carbon emissions, as opposed to the current winning bidders that will produce in excess of 4 million tonnes of greenhouse gas emission per year (not including methane emissions from the production and transport of the gas), of which 90% will come from the three Karpowership projects.

A particularly interesting albeit bizarre result was found when all of the projects were grouped together as one single large project, as depicted in the top image in Figure 2. It was found that the grouped projects would not be able to meet the maximum dispatch instruction for 1996 MW unless the storage systems were regularly partially charged at night with output from the gas-generated electricity.
Figure 1. Dispatch window load profiles and contracted amounts in MW for winning bidder projects in the RM4P. The plots show the contributions from the energy mix make up for each project. Actual normalised solar and wind data is used, and a week in March 2019 is depicted as an example. Note that Y-axis scales differ.

- Omoyilanga 75 MW
- Oya 128 MW
- Combined Scatec Projects 150 MW
- All projects grouped together 1996 MW
- All projects grouped together, storage removed 1996 MW
- All renewable projects grouped together, 776 MW
Figure 2. Dispatch window load profiles and contracted amounts in MW for the four additional scenarios that were modelled. The plots show the contributions from the energy mix make up for each project. Actual normalised data is used, and a week in March 2019 is depicted as an example.

This inability to meet the full dispatch requirement in the early morning, and evening, shows as white gaps in Figure 2. Only a very small percentage of the combined storage capacity would thus ever be used. The reason for this is that the maximum combined solar and wind output from the grouped projects never exceeds 1996 MW. As we all know, one can only store if you have an excess. For this reason, a grouped model without any storage was modelled for a comparison, and the calculated tariff dropped from R1.81/kWh, to R1.18/kWh, with little impact on system reliability.

b. Details of key findings

1. Cost

The impact of relaxing rules and restrictions to the RFP that are clearly designed for gas projects is dramatic. The results are recorded in Table 1, and shown in Figure 3. The different tariffs are shown based on different output assumptions (Mingen, Maxgen and Avegen), as well as when all excess generation is allowed to be sold, and not curtailed.

Weighted average tariffs as bid for the Karpowership projects, as well as the estimated tariff possible in a full system integrated procurement process are circled in red in Table 1.

Table 1. Modelling results for each of the winning RM4P winning bids. The Karpowership and Scatec projects are grouped together as single bids. In addition, results are shown of all bids grouped together, with and without storage components, as well as for all renewable bids, and for an optimal system scenario. Winning bid tariffs are only shown for actual projects, not the different combination scenarios.
Figure 3. Estimated and actual bid tariffs for the winning RM4P projects. The black outlined small white squares are the actual bid tariffs. The bars depict the range of modelled tariffs, with increasing RFP restrictions. The left edge of each bar indicates the lowest estimated tariff, and the right hand side the maximum estimated tariff.

All of the estimated project tariffs from the modelling show a range of possible tariff rates that include the actual bid tariffs, except for The Mulilo Coega project.

The Mulilo Hydra project, is the only project with a bid tariff to the left of the centre of the estimated range. The Acwa project bid tariff is located in the centre of the range, and all of the other project bid tariffs are close to the top of the range, indicating the expectation from the project owners that average annual output requested by the system operator would be close to the minimum allowable quantum (Mingen rules).

Further analysis of the winning project bid tariffs appears warranted, but is beyond the scope of this report, and not material to the conclusions that are drawn from an analysis of the trends that are so apparent in the results.

It is however worth drawing attention to the “all bids’ and “all bids no storage” results, mentioned in the results summary, shown clearly in Figure 3, and once again illustrating
the imbalance in the collective makeup of the winning bids, exemplified by the Karpowerships providing 62% of the total capacity and output.

2. Reliability

Using the generation mixes from the actual winning projects, it was possible during the modelling to estimate reliability, albeit using generic wind and solar output data, as actual data for the individual projects was not available.

Based on this data used, the projects modelled all indicated that they would be able to reliably meet system operator dispatch instructions for at least 95% of the time, well within acceptable limits.

Figure 4 shows the installed capacity mix as a percentage of total capacity for each of the projects, and for the four modelled scenarios. It also shows the generation output ratios for each of projects, and the four scenarios. Notice how the All Bids scenario has a fairly large installed storage capacity, but the modelled output results show almost no contribution from storage, for reasons previously discussed.

Figure 4. Installed generation capacity ratios for different technologies, and modelled output ratios for each technology for the winning projects, as well as the four scenarios including the optimal system scenario.

3. Flexibility

The modelling results confirm that all of the projects provide the requisite flexibility to be able to meet the rules and regulations of the RFP. However, modelling also shows conclusively that a relaxation of the gas-orientated rules and regulations would have a significant impact on the renewable-dominated projects. If they were allowed to interface with each other, and integrate with underutilised Eskom storage assets, the flexibility of the whole system would increase, and with it, there would be a significant reduction in tariffs, potentially by as much as 50% in a fully integrated systems approach to an alternative, amended RFP.

On the matter of flexibility, we should be increasing flexibility in our procurement approach, especially for so-called emergency procurement. More than 600 days have already passed since the initial launch of the risk mitigation procurement programme,
back in December 2019, and not one project has reached financial close, let alone started actual construction.

Nothing highlights this lack of procurement flexibility more so than the fact that a minimum of 25%, and as much as 50% of all solar- and wind-generated electricity, in the RM4P stands to be curtailed (Figure 5), increasing tariffs by as much as 50%. At the same time, bid window 5 of the REIPPPP closed just this week, and the aim is to procure wind and solar on a take-or-pay basis. Not only is the approach inflexible, but it is demonstrably irrational.

4. Energy independence

As things stand, if the projects go ahead in their current form, and at the current tariffs, 62% of the total output, and a similar amount of the total payments will accrue to the three Karpowership projects. This is the current reality, no modelling required. This means that a disproportionately high level of energy dependence will rest with the three Karpowership projects. This high ratio of gas to renewable projects is totally unbalanced. For example, when compared to the ratio of gas to renewables in the integrated resource plan (IRP_2019), where gas represents less than 15% of wind and solar PV combined. This is once again a reflection of the RFP rules and regulations written to accommodate large gas projects, at seemingly competitive prices.

![Figure 5. Percentage output requiring curtailment under Maxgen and Mingen operational assumptions](image)

In addition, the bulk of the payments made will flow out of the country, and impact negatively on the sovereign trade balance. It will have the effect of increasing our energy dependence on fuel imports.

Maximum energy independence can be achieved by an efficient and optimal utilisation of our abundant natural resources of wind and sunshine.
5. Greenhouse gas emissions (excluding upstream production and transportation methane leaks)

Greenhouse gas emissions were estimated from the model outputs that reflect the contribution of each technology to the annual output for each project. CO₂ emission intensity per kWh, as well as annual CO₂ emissions for each of the projects and scenarios are shown in Figure 6.

![CO₂ emissions intensity and modelled annual output](Figure 6)

Combined annual emissions of just over 4 million tonnes of CO₂ are dominated by the three Karpowership projects, making up more than 90% of the total. No estimate has been made of additional emissions linked to the LNG supply chain, although recent information gathered by satellite indicate that methane emissions have been systematically underestimated and under-declared by oil and gas companies.

5. Conclusions

Techno-economic evaluation of the results of RM4P, as per the RFP rules, clearly indicate that the procurement process was designed with gas-procurement in mind. Some of the conclusions that can be drawn are as follows:

- The strict regulations regarding grid or system usage/interfacing have no impact on gas-only projects, such as the Karpowerships. Gas-dominated projects have no need to draw electricity from the grid outside of the designated time window (05h00 - 21h30), and are thus unaffected by this restriction;

- The same regulations, when applied to renewable-dominated projects, have a disproportionate effect, and lead to average tariff increases of over 50%;

- The fact that projects with storage are not allowed to charge the storage at night from the grid, even when there is spare generation capacity, results in the oversizing of storage systems by a factor of almost two, significantly increasing tariff levels;
The minimum generation (Mingen) rule that can be imposed at any time by the system operator, has a minimal effect on gas projects, and a very large effect on renewable-dominated projects;

Gas-dominated projects are not negatively affected by operating in isolation. There are no differences if these projects operate individually, or in combinations with each other;

By contrast, renewable-dominated projects perform poorly in isolation, and far more effectively in concert. Operating in concert, via grid interaction, and full system integration, is however prohibited by the rules of the RFP;

The rules of the RFP lead to some absurd outcomes. For example, if one models the output of all of the projects grouped together as one large project, as in “All Bids”, only a tiny fraction of the 2 860MWh of combined storage duration - from the bids that include storage - is ever utilised, for storage of excess wind outside of the dispatch window. The reason for this is that the combined PV and wind in this hypothetical single large project never exceeds the 1996 MW output requirement. It only makes sense to store surplus PV and wind, and there isn’t any surplus during the dispatch window, unless of course Mingen restrictions are put in place;

Small changes in the RFP rules would significantly reduce the tariffs offered by renewable-denominated projects, thereby rendering gas-dominated projects non-competitive; and

The “Optimal System” that was modelled has zero gas, 4 000MW of PV, 1 500 MW of wind, and 1 000MWh of storage. It is fully integrated with existing underutilised Eskom System assets, such as the Eskom Pumped-hydro storage facilities. This quantum of PV, wind and storage is similar to the sum of the PV, wind and storage from the RM4P bids, and bid window 5 of the REIPPPP. These two separate procurement programmes could easily be combined as a single, two-stage procurement programme. A sensible grouping of these two procurement efforts would lower the average RM4P bid tariff from R1.60/kWh to R0.72/kWh. This presents a compelling case of value for money, in addition to having zero carbon emissions.

6. Recommendations: an alternate procurement process

It is recommended that the IPP office reassess the rules and regulations of the RM4P as embedded in the RFP. Recognising that speed to achieve commercial operation is of the essence, the following is but one possible new scheme for emergency power procurement:

Accept that the RM4P process should not be treated in isolation to new REIPPPP bid windows;

Ensure that full use is made of the utility of the grid, and the existing, yet underutilised Eskom storage assets;
- Allow night-time storage from the grid, when surplus generation capacity is available;

- Aim to procure PV, wind, and storage separately, and in the proportions indicated by the optimal system scenario: namely 4 units of PV, to 1.5 units of wind, to one unit of storage;

- Offer adjusted feed-in tariffs for wind and solar, based on location, and speed to commercial operation date (COD);

- Offer incentives for early COD, and apply penalties for late COD;

- Enter into long-term lease agreements with energy storage system suppliers, as they are not net generators, and PPAs based on kWh produced make little sense; and

- Allow energy storage systems to be located in the most strategic and beneficial locations, including within municipal distribution networks, where they can provide multiple or stacked services, especially when under full control of the system operator.

Appendix A: Model input assumptions

<table>
<thead>
<tr>
<th></th>
<th>Solar PV</th>
<th>Wind</th>
<th>Storage power</th>
<th>Storage Energy</th>
<th>Gas engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditure ($/kW)</td>
<td>625</td>
<td>1100</td>
<td>300</td>
<td>160/kWh</td>
<td>700</td>
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<tr>
<td>Operating expenditure (% of Capex)</td>
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<td>2.5%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
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<tr>
<td>Fuel costs ($/kWh)</td>
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<td>-</td>
<td>-</td>
<td>0.08</td>
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<tr>
<td>Debt %</td>
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<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Debt term (Years)</td>
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<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
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<td>Debt interest rate %</td>
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<td>Capacity factor</td>
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<td>41.10%</td>
<td>-</td>
<td>-</td>
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