Discovery

DISCOVERY GREEN

RENEWABLE ENERGY STRATEGIES FOR BUSINESSES IN SOUTH AFRICA: A TECHNICAL REVIEW

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FOREWORD FROM **ANDRE NEPGEN, HEAD OF DISCOVERY GREEN**

Businesses are increasingly prioritising the procurement of renewable energy. This trend has been catalysed by a year marked by unprecedented loadshedding, a surge in electricity costs that were double the rate of inflation, and looming global penalties on imports with high carbon footprints. The urgency for businesses to secure renewable energy from the market is notable, especially as South Africa possesses some of the finest renewable energy resources globally. However, it is imperative to question whether the current approaches are appropriate and whether these strategies are scalable. Our analysis suggests they are not.

As an organisation entrenched in actuarial problem-solving and critical thinking, and driven by our core purpose to "make people healthier", we approach this issue with a rigorous quantitative methodology. In September last year, we launched Discovery Green. This business has analysed data from hundreds of companies and tens of generation facilities, leading to an energy-as-a-product design informed by in-depth analytics. This paper outlines our findings and highlights critical oversights that businesses risk to their detriment.

It is often the case that decision-makers must navigate inherent behavioural biases when considering solutions with long-term consequences. For instance, there is currently a pronounced bias towards solar energy. While the immediate financial benefits of solar energy are clear, there is a tendency to overlook the long-term value, opting instead for short-term gains. Typically, after replacing 45% of their energy needs with solar, businesses face a 1.8x premium to fulfill the remaining 55% with renewable sources. Such long-term costs are frequently omitted during the sales process and decision makers are not yet equipped to understand all these dynamics.

Moreover, renewable energy generation is inherently variable, as is a business's electricity consumption. Many businesses base their decision-making on historical averages without accounting for the risk of extreme events that could impact generation or consumption. Our findings indicate that, even if the sun were to shine and wind was to blow as expected, output from a single solar facility can fluctuate by more than 14% between consecutive months, and by more than 33% for a single wind plant. Failing to consider this variability means that the perceived value of renewable energy may not materialise as expected.

We hope this paper will guide businesses in navigating the complex landscape of renewable energy procurement with a clear, analytical approach. With the current pause in loadshedding, there is an opportunity for businesses to reassess their strategies and to view renewable energy procurement through a new lens.

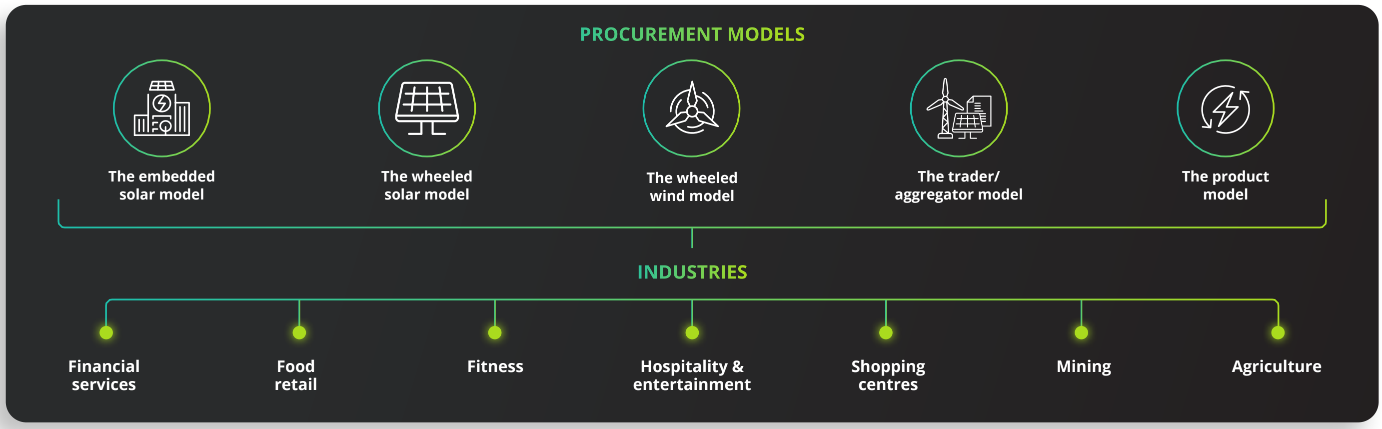
EXECUTIVE SUMMARY

The procurement of renewable energy, whether using embedded generation or wheeling energy through the national grid, presents a number of significant benefits to businesses. With renewable energy available at significant discounts to current utility prices, there is a strong financial incentive to make the transition to renewables. Additionally, businesses procuring renewable energy benefit from price security in their future energy costs, as annual price increases are typically fixed at CPI. In an environment where electricity costs have been increasing at CPI + 8% over the past five years, this price security provides a welcome relief. South African businesses are also consuming the dirtiest electricity in the world, and with impending local and international carbon taxes and import duties, renewable energy provides businesses with an effective way to substantially reduce their emissions and avoid operational and financial interruptions to their usual business processes.

However, there is a fundamental difference between the procurement of utility-supplied electricity and electricity that is generated from renewable sources. Unlike utility-supplied electricity where businesses pay for the quantity of electricity they consume, payment for renewable energy occurs at the point of generation. This is termed 'take-or-pay' and requires a business's commitment to procure a minimum number of kilowatt-hours each month, regardless of whether the business consumes such energy. The business faces the risk of incurring wasted energy costs, eroding its financial savings and detracting from the financial benefits that come with independence from utility prices.

With this dynamic in mind, this paper evaluates five different renewable energy procurement models against the single criterion of achieving the highest financial savings today, and in the long term. The total savings available to a business when procuring renewable energy is a function of two factors: the **price** and level of renewable energy **coverage.** However, their interdependence needs to be appreciated as price should not be evaluated only as the price of renewables, but as a weighted average of the cost of renewables, the cost of wasted renewable energy generation, and the cost of consumption not covered by renewables.

The analysis is carried out for the following five renewable energy procurement models, and investigates the savings (or cost) impact of each on typical business electricity consumption profiles from a number of different industries:



To demonstrate the complexity of accurately assessing the impact of different procurement models on long-term financial scenarios, the financial savings available under each model are analysed at three distinct stages in the implementation journey:

Stage 1: The point of declining marginal gains

Depending on generation technology, each business will reach a unique coverage level beyond which any additional energy generated begins to be wasted. The embedded solar model consistently provides the lowest coverage level across all industries due to the inability to 'bank' renewable energy generation and consumption on a monthly basis. Most industries achieve higher coverage levels using the wheeled wind model compared to the wheeled solar model due to having off-peak heavy consumption profiles. The combined generation profile used by the trader/aggregator model does not always offer a higher coverage level than the wheeled solar or wind models in isolation. At the point of declining marginal gains, the product model consistently offers the highest coverage level and financial savings across all industries.

Stage 2: Rate of declining marginal gains and when gains turn to losses

Businesses will experience an exponential price increase at coverage levels beyond the point of declining marginal gains where generation becomes wasted. Total savings from renewable energy begin to diminish at the point where the effective cost of renewable energy exceeds the business's prevailing utility price.

EXECUTIVE SUMMARY

Due to the cheaper price of renewable energy, businesses are able to increase their coverage level beyond the point of declining marginal gains, incur limited wasted generation costs, and continue to benefit from a lower weighted energy price compared to the price of utility-supplied electricity. For all businesses with standard-heavy consumption profiles, the wheeled solar model consistently yields the highest financial savings when implemented at a coverage level of 75%. The product model remains the optimal savings strategy for all businesses that consume energy predominantly during off-peak hours. Much like other regions around the world, South Africa is likely to experience a time-of-use tariff rebalancing due to excessive amounts of solar energy being generated in the future. This is expected to reduce the price of standard hours and increase the price of off-peak hours. The rebalancing scenario in this paper shows that the high coverage of the product model immunises businesses against the impact of tariff rebalancing and becomes the optimal strategy for all but one industry.

Stage 3: Robustness of the model

Once the true cost of high coverage has been quantified, it is necessary to account for the variable nature of energy generation and consumption, which can exacerbate financial losses significantly. In terms of generation volatility, solar production can vary by as much as 31% within a single billing reconciliation period, and wind by as much as 72%. Additionally, business consumption is variable and the financial risk to the business is compounded when generation and consumption volatility occur simultaneously. After accounting for such volatility, the product model remains the optimal renewable energy procurement model for all but one industry.

Results summary

Table 1 below shows the optimal procurement model for a business in each industry at different stages of the implementation journey, on a 10-year basis.

Table 1: Optimal procurement model for maximum savings

Industry	Zero generation and consumption variability	After accounting for generation variability	After accounting for consumption variability
Financial services	Wheeled solar model	Product model	Product model
Food retail	Product model	Product model	Product model
Fitness	Wheeled solar model	Wheeled solar model	Product model
Hospitality and entertainment	Product model	Product model	Product model
Shopping centres	Wheeled solar model	Wheeled solar model	Wheeled solar model
Mining	Product model	Product model	Product model
Agriculture	Product model	Product model	Product model

Energy as a product

The ability to meet the unique energy requirements of diverse businesses at an attractive price point requires significant scale and a strong risk-taking position. This, together with the platform dynamics relating to risk pooling and diversification of both generation and consumption, fundamentally shifts the risk profile of renewable energy procurement and delivery. For example, analysis shows that if one business experiences its point of declining marginal gains at a coverage level of 49%, a portfolio of five businesses from different industries can increase this coverage level to 78%. The benefits of a more stable consumption profile are enhanced by the platform's unique ability to create a diversified energy generation portfolio that is more resilient to fluctuations in generation. Businesses that implement the platform model can expect savings on their generation costs of up to 35% in future years, without the risk of wasted generation or consumption variability.

INTRODUCTION

Businesses in South Africa are grappling with a number of pain points when it comes to electricity procurement and consumption. The energy environment is one characterised by a lack of security, price increases consistently exceeding CPI inflation, and the threat of impending carbon taxes and global import duties interrupting established business processes. With the necessary regulatory frameworks now in place, businesses are increasingly looking to transition to renewable energy sources to not only immunise themselves against these risks, but also to unlock significant financial savings that are available through South Africa's rich solar and wind resources.

In this context, this paper explores the renewable energy procurement models and strategies available to South African businesses and assesses the long-term viability of each. The analysis aims to shed light on whether the current models are optimally structured to unlock the full long-term potential of renewable energy procurement in South Africa.

CURRENT MODELS FOR RENEWABLE ENERGY PROCUREMENT IN SOUTH AFRICA

When looking to purchase renewable energy (or simply reduce emissions), businesses in South Africa have the following procurement models available.

The embedded solar model

On-site installations that are typically small-scale, using either rooftop solar panels or, if land allows, a solar plant alongside a business's operating premises. This model is done either as an outright purchase upfront, or through a power purchase agreement (PPA) on a take-or-pay structure.

The wheeled solar model

A renewable energy wheeling contract with an independent power producer (IPP) for solar photovoltaic (PV). Renewable energy wheeling involves the purchase of privately generated electricity connected to the national grid. Large, utility-scale renewable power plants are constructed in areas of the country with attractive solar resources. The renewable energy that is generated is fed into the national grid at the point of generation. The business (or offtaker) enters into a purchasing agreement with the private power generator to be credited for the consumption of this power. The contract could be for the entire generation facility or for a share of the plant in a multilateral agreement, most commonly on a take-or pay structure.

The wheeled wind model

Similar to the wheeled solar model, a renewable energy wheeling contract with an IPP for wind energy, most commonly on a take-or pay structure.

The trader/ aggregator model

A wheeling contract with a renewable energy trader acting as an intermediary in the market. Traders contract to purchase renewable solar and wind energy from IPPs and sell this energy to businesses at a trading margin. The key feature of the trader business model is a complete, or near complete, pass through of IPP contract terms and risks to the business as the offtaker and the contracts on both sides are finalised at the same time. While a trader may contract with a variety of plants and offtakers, each offtaker is assigned a specific plant or a portion of a specific plant. It is not uncommon for IPPs to have vertically integrated trader functions. An aggregator is similar to the trader model but where the aggregator absorbs marginally more risk and provides offtakers with a packaged energy profile from a number of generation assets. Both traders and aggregators offer a take-or-pay structure with limits.

The product model

A wheeling contract with a renewable energy product platform. Much like traders or aggregators, renewable energy platforms purchase renewable energy en masse from IPPs. Platforms, however, have a supporting balance sheet of their own, and leverage scale and diversification to take on a fundamentally different risk position to aggregators. Energy is purchased and productised to be sold to businesses as a percentage replacement of almost all existing consumption. The platform often holds two significantly different procurement contracts, one with the IPP and the other with the business as the offtaker. The balance of risk is often shared equitably among the IPP, platform and offtaker. The product model offers a take-and-pay structure with limits.

A note on certificates and credits.

It is possible for a business to reduce its electricity-related emissions without having to procure renewable energy. This can be achieved by purchasing carbon credits or renewable energy certificates (RECs) on voluntary or formal markets to offset emissions. When one compares the cost of these tradeable instruments to the 'true' cost of electricity-related emissions reduction (arguably the construction and connection of a wind or solar facility), the credibility of these credits is concerning. Furthermore, the adoption of these credits or certificates is under question in international export markets. Therefore, RECs are not considered a viable comparison for the purposes of this paper.

DISCOVERY GREEN'S FRAMEWORK FOR ASSESSING RENEWABLE ENERGY PROCUREMENT MODELS

Discovery Green has developed a framework for assessing renewable energy procurement models to understand their impact on price and coverage. This framework is grounded in two key principles:

Principle 1: Renewable energy is a custom solution, not a commodity

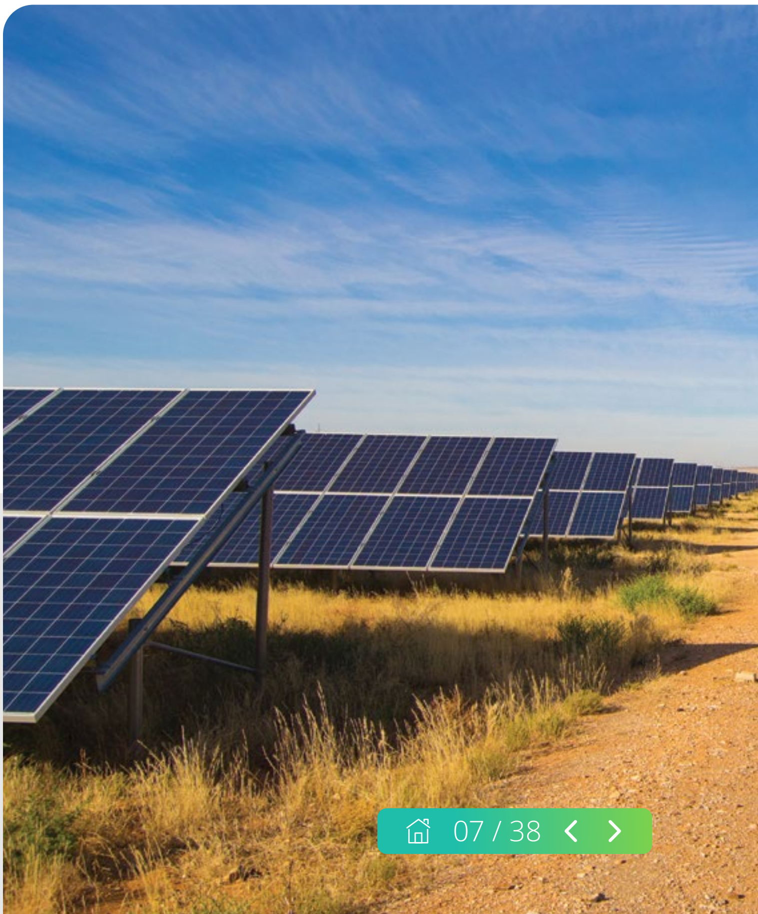
Price and risk must be considered together. With the market for privately procured renewable energy in its infancy in South Africa, it is important to appreciate the nature of the product being procured and the terms on which it is procured. Unlike in many developed economies around the world, the primary financiers of renewable energy projects in South Africa remain risk averse to funding renewable energy power plants without having secured a creditworthy offtaker on a long term procurement basis. As such, each project has a predefined client in place well before plant construction begins, and the nature of the purchasing agreements differ according to the risk appetite of the power producer, offtaker and lender to the project. Because of this, renewable energy does not exist as a commodity in South Africa. Instead, it is supplied and procured on a custom basis.

Energy price is as important as when it is generated. Most businesses understand the time-of-use (TOU) charging structure where a different tariff is charged for electricity depending on when it is consumed. However, an additional layer of complexity is added for renewable energy take-or-pay contracts where a single price of generation is charged for all times of the day, referred to as a blended tariff. Under wheeled energy contracts, the business receives a wheeling credit from its utility provider that is applied on a time-of-use basis while the cost of wheeled energy is fixed across all time-of-use periods. This results in starkly different savings at different times of generation and the benefit of renewable energy wheeling is completely dependent on when the energy is generated and consumed.

Principle 2: Selecting a model with the highest financial savings and renewable energy coverage today, and in the long term, should be a key underpin of an organisation's procurement strategy.

Each of the five renewable energy procurement strategies are assessed against the primary criterion – the total financial savings yielded for businesses, today and in the long term.

The total savings available to a business when procuring renewable energy is a function of two factors: the **price** and level of renewable energy **coverage.** However, their interdependence needs to be appreciated as price should not be evaluated only as the price of renewables, but as a weighted average of the cost of renewables, the cost of wasted renewable energy generation, and the cost of consumption not covered by renewables. Furthermore, this calculation must consider different time-of-use periods and seasons, as well as the marginal cost to the business should it be required to increase its renewable energy coverage.



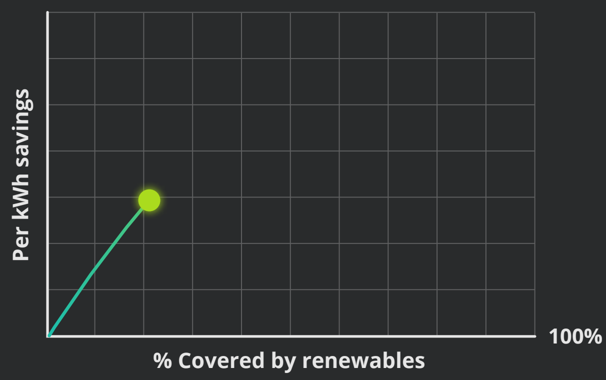
ASSESSING PROCUREMENT MODELS AT KEY STAGES IN RENEWABLE ENERGY IMPLEMENTATION

To demonstrate the complexity of accurately assessing the impact of different procurement models on long-term financial scenarios, the financial savings available under each model are analysed at three distinct stages in the implementation journey:

Stage 1: The point of declining marginal gains

Unlike utility-supplied electricity, renewable energy is most often paid for based on the amount generated. Businesses are at risk of paying for energy that is not consumed. Depending on generation technology, each business will reach a unique coverage level beyond which any additional energy generated begins to be wasted. This has cost implications for the quoted renewable energy price.

STAGE 1: POINT OF DECLINING MARGINAL GAINS

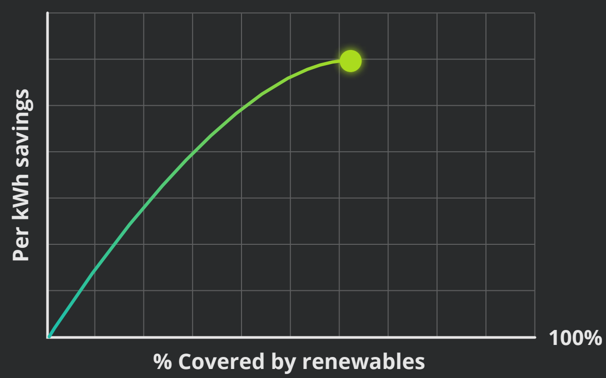


Energy first becomes wasted, and marginal gains begin to diminish

Stage 2: Rate of declining marginal gains and when gains turn to losses

Businesses will experience an exponential price increase at coverage levels beyond the point of declining marginal gains where generation becomes wasted. Total savings from renewable energy begin to diminish at the point when the effective cost of renewable energy exceeds the business's prevailing utility price. A layered procurement approach is often considered to be a workaround for this, but the implications of layering are arguably more severe.

STAGE 2: RATE OF DECLINING MARGINAL GAINS AND WHEN GAINS TURN TO LOSSES



Per kWh savings reach their peak

Stage 3: Robustness of the model

Once the true cost of high coverage has been quantified, it is necessary to account for the variable nature of energy generation and consumption, which can exacerbate financial losses significantly.

At each stage, a comparison is made between the financial savings from each model in today's terms and in year 10. The penalty for additional renewable energy coverage is also shown.

This paper considers each of these stages in the context of each procurement model available to businesses and offers insights on their impact on renewable energy price and coverage. This is done for different business consumption profiles across a wide range of industries with the view of quantifying the financial savings available to different businesses under each model. Each section includes a view of the savings results, followed by a commentary piece discussing the results observed.

UNDERLYING DATA AND ASSUMPTIONS

This paper has been produced using energy generation and consumption data from Discovery Green's renewable energy platform as well as from market data related to renewable energy generation projects that are either operational or have reached financial close. Generation projects that do not meet this criteria for the stage of development are not considered. This is because of the long term nature of the contract negotiation process and the variability in prices resulting from foreign currency movements, interest rate changes, and other macroeconomic variables between the date of contract signing and the date of the project's commercial operation.

Discovery Green platform

Discovery Green has access to verified electricity consumption data in 30-minute intervals, spanning a three-year period, for all businesses on its platform. The size of the platform's dataset is summarised below:

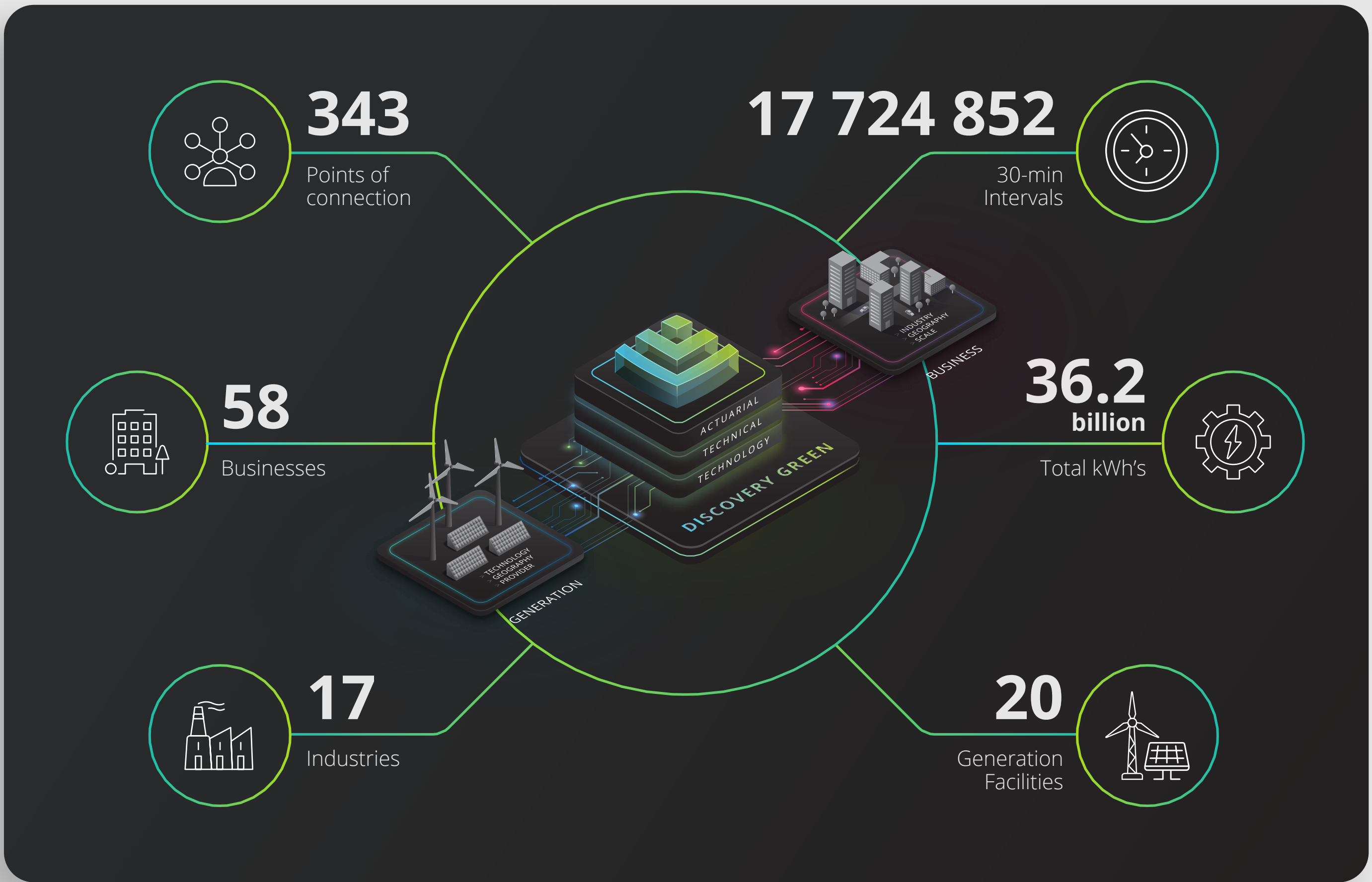


Table 2: Market assumptions

Condition	Assumption	Flexes tested
Utility price	Eskom WEPS active energy charges (excluding losses) and including Eskom's Affordability Subsidy Charge. As defined in Eskom's 2023/24 Schedule of Standard Prices; VAT exclusive.	**National excess solar event (TOU rebalancing)**
Utility price annual increases	Unless otherwise stated, constant annual increases at CPI + 3%.	**CPI + 1.5%; CPI + 5%**
Time-of-use periods	As defined in Eskom's 2023/24 Schedule of Standard Prices.	
CPI inflation	Constant 6% per annum	

Table 3: Procurement models

Condition	Assumption	Flexes tested
Embedded solar model	Effective price of R0.75 per kWh. Effective price derived by adjusting quoted price for additional utility cost savings: Transmission losses (13c) *Assuming transmission zone '<300km' and voltage '>500V & < 66kV'* Ancillary Service Charge (0.70c) Reactive Energy Charge (1.6c) Electrification and Rural Network Subsidy Charge (13.80c) No additional allowance made for Affordability Subsidy Charge as this charge is avoided under all five procurement strategies. Inclusive of all renewable credentials. All future price increases fixed at CPI.	**p50; p10**
Wheeled solar model	Quoted price of R0.80 per kWh; inclusive of all use-of-system charges and renewable credentials. All future price increases fixed at CPI.	**p50; p10**
Wheeled wind model	Quoted price of R1.05 per kWh; inclusive of all use-of-system charges and renewable credentials. All future price increases fixed at CPI.	**p50; p10** **Scenario of procuring wind after solar**
Trader/aggregator model	Generation profile that is 50% solar and 50% wind. Quoted price of R1.00 inclusive of all use-of-system charges and renewable credentials. Quoted price includes trading margin of R0.075 per kWh as indicated by prices of 5+ market participants, extrapolated to reflect a 50/50 generation profile. All future price increases fixed at CPI.	**p50; p10**
Product model	No fixed generation profile; platform provides 90% renewable energy replacement across all TOU periods regardless of business consumption profile. Quoted discount of R0.25 to business's weighted average utility price; based on single market participant. Price inclusive of all use-of-system charges and renewable credentials. All future price increases fixed at CPI.	**p50; p10**

INDUSTRIES REPRESENTED
AND AVERAGE CONSUMPTION PROFILES

The nature of a business's operations and energy consumption profile will have a material impact on the savings available under each renewable energy procurement model. This paper considers the impact of each procurement model on typical business consumption profiles across a wide range of industries.

INDUSTRY	ANNUAL DISTRIBUTION			AVERAGE UTILITY PRICE
	Off-peak	Standard	Peak	
Financial services	40%	43%	17%	R1.30
Food retail	47%	35%	18%	R1.27
Fitness	37%	44%	19%	R1.33
Hospitality & entertainment	45%	39%	16%	R1.25
Shopping centres	34%	49%	17%	R1.27
Mining	45%	39%	16%	R1.24
Agriculture	44%	38%	18%	R1.28

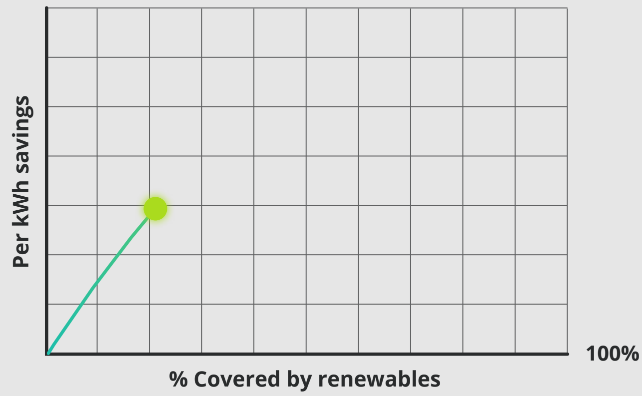
MONTHLY DISTRIBUTION

STAGE 1: POINT OF DECLINING **MARGINAL GAINS**

To understand the development of total financial savings for each renewable energy procurement model, the point of declining marginal gains must be found.

The requirement to reconcile renewable energy generation with a business's consumption by time-of-use and by month creates the risk of energy being generated but not consumed. The point of declining marginal gains is the point where, within any single time-of-use period in any month, any additional generation procured would result in wasted generation and the marginal financial gains of the model will begin to decrease.

STAGE 1: POINT OF DECLINING MARGINAL GAINS



Energy first becomes wasted, and marginal gains begin to diminish

Results

Table 4 below shows the maximum renewable energy coverage level that a typical business in each industry can achieve under each procurement model before generation is wasted. Noting that savings is a function of both price and coverage, the savings available to businesses in each industry at the point of declining marginal gains are quantified as a percentage of their expected utility charges. Assuming that utility prices will continue to increase at CPI + 3% each year, and that renewable energy prices follow annual CPI increases, the annual savings in year 10 of each model are also provided.

TABLE 4: RENEWABLE ENERGY COVERAGE LEVEL AND FINANCIAL SAVINGS AT THE POINT OF DECLINING MARGINAL GAINS:

Industry	Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model		
	Coverage	Savings (Yr 1)	Savings (Yr 10)	Coverage	Savings (Yr 1)	Savings (Yr 10)	Coverage	Savings (Yr 1)	Savings (Yr 10)	Coverage	Savings (Yr 1)	Savings (Yr 10)	Coverage	Savings (Yr 1)	Savings (Yr 10)
Financial services	27%	11%	15%	57%	22%	30%	66%	7%	19%	73%	13%	26%	90%	17%	33%
Food retail	8%	3%	4%	41%	16%	22%	73%	8%	21%	54%	10%	19%	90%	18%	34%
Fitness	28%	10%	13%	64%	24%	32%	49%	5%	14%	67%	12%	23%	90%	17%	33%
Hospitality and entertainment	24%	9%	12%	56%	22%	30%	73%	8%	22%	69%	13%	25%	90%	18%	34%
Shopping centres	39%	14%	19%	63%	25%	33%	55%	6%	16%	72%	13%	26%	90%	18%	34%
Mining	27%	10%	14%	51%	20%	28%	68%	8%	20%	64%	12%	24%	90%	18%	34%
Agriculture	14%	6%	8%	50%	19%	26%	67%	7%	19%	63%	12%	23%	90%	18%	34%

INSIGHTS
STAGE 1

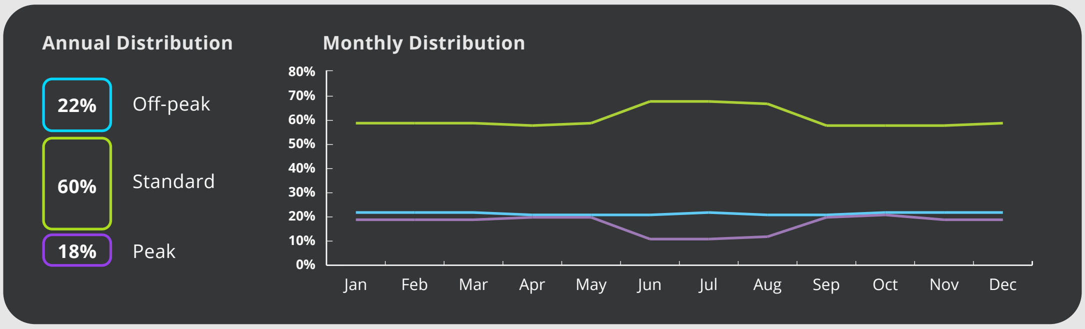
In analysing savings from each model, the paper looks at the difference between each business's utility price and that of the new weighted average cost of energy after executing each model. When procuring renewable energy, a business will pay the generator a certain price per kWh for energy produced, but will continue to pay its utility provider the prevailing utility tariff for consumption not serviced by renewables. The business's effective per kWh cost of energy can be calculated as the weighted average price of these two tariffs. The greater the level of renewable energy coverage, the less reliance on utility tariffs and the closer the business's weighted kWh price becomes to the price of renewable energy.

The embedded solar model

In the absence of battery storage, embedded generation suffers from the inability to 'bank' renewable energy generation on a monthly basis. Energy must be consumed as soon as it is generated, or it is wasted and the business incurs an effective cost on every kWh actually consumed. The concept of monthly energy reconciliation (or 'banking') is further explained under wheeling of wind and solar energy. This is typically the biggest driving factor behind the relatively low penetration level offered by embedded generation, along with a business's available roof space or adjacent land in fortunate circumstances.

Since solar panels will exclusively produce energy during the day, businesses will first exhaust their quota of standard hours. Beyond this point, any additional generation capacity added will result in wasted generation. Note how the standard-heavy solar PV generation profile below compares to the typically off-peak-heavy business consumption profiles.

GRAPH 1: TYPICAL SOLAR PV GENERATION PROFILE



It is inevitable that a business will experience at least one medium to large reduction in its consumption sometime throughout the year, even if for a few seconds. Without monthly banking, these events cause generation to be temporarily wasted, leading to a significant reduction in a business's coverage level where generation first becomes wasted. To account for such anomalous events and to not be overly restrictive towards the embedded solar model, this paper allows for 5% of generation to be wasted before the point of declining marginal gains is triggered. This margin is not considered for other procurement models.

Embedded generation not only decreases the utility-based consumption of a business in kWh, but it can have the added benefit of avoiding a number of key utility-added levies such as transmission losses and subsidies on the amount of energy consumed. This paper assumes an adjusted price of embedded solar to take account of these efficiencies. While embedded generation may not be as cost effective as large-scale wheeling projects, the added cost can be offset or eliminated by these additional savings.

It is important to note that the results assume each business has sufficient roof space to install the generation capacity required to achieve these coverage levels. This is often not the case. For example, analysis indicates that for multi-story non-industrial businesses, embedded generation without storage is estimated to meet less than 10% of a business's electricity demand in a given year on average. A business's theoretical point of declining marginal gains may never be achievable due to the structural layout of the business.

INSIGHTS
STAGE 1

The wheeled solar model

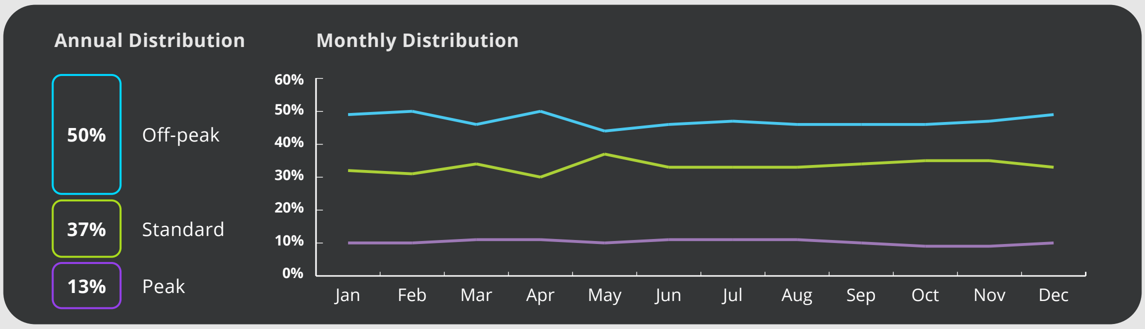
The key distinction between embedded solar and wheeled solar is the ability to reconcile energy generation and consumption on a monthly basis. This means that if a solar farm produces energy on the first day of the month and a business consumes energy on the last day of the same month, the network operator will recognise such consumption as a validly consumed unit of renewable energy (provided generation and consumption occur in the same time-of-use period within the month). This makes the mathematics of production and consumption matching a lot more favourable when compared to an embedded facility where monthly banking is not available, and energy must be consumed as soon as it is generated to avoid wasted costs.

Notwithstanding the ability to reconcile generation and consumption on a monthly basis, the same dynamics regarding renewable energy coverage for embedded generation are largely applicable with wheeled solar energy. Typically, not more than 40%-60% of a business's consumption can be met with a pure solar solution before generation becomes wasted. It can be argued that while solar offers attractive short-term savings, a low coverage level has long-term financial implications as businesses remain heavily exposed to future increases in the utility price of electricity.

The wheeled wind model

Given the size of wind turbines, the scale of land needed to ensure adequate distance between turbines to prevent wake losses, and the localised availability of constant wind resources, it is rare for wind energy to be delivered by an embedded facility. Unlike solar which is limited to daytime generation, wind usually presents a 24-hour generation profile. For industries that operate 24/7, this typically means that the point of declining marginal gains is higher with wind than with solar.

GRAPH 2: TYPICAL WIND GENERATION PROFILE



In cases where wind offers a greater coverage level than solar, the premium paid by the business for such coverage is the higher cost of wind energy.

INSIGHTS
STAGE 1

The trader/ aggregator model

Renewable energy traders (or 'aggregators') typically adopt a 'share-of-plant' approach. That is to sell businesses a fixed proportion of the total kilowatt-hours generated by a specific plant each month, noting that generation is variable from month to month. In essence, the business has effectively contracted directly with the IPPs to purchase the energy they produce. As a result of this, the renewable energy coverage level businesses can achieve with either solar or wind are identical to those presented under traditional bilateral PPAs with IPPs. However, the results assume the trader is providing the business with a renewable energy supply that is 50% solar and 50% wind, while charging a R0.075 per kWh trading margin. The crude blend of generation technologies can, but does not always, create a better matching proposition for some consumption profiles.

The product model

By taking on a fundamentally different risk position to energy traders, renewable energy platforms are able to offer energy to businesses in a more productised form. The platform will typically seek to absorb the risk of variable generation and consumption itself by offering businesses a relatively constant supply of renewable energy from month to month based on a set of product parameters. Platforms will typically target a specific renewable energy coverage level to offer to businesses, regardless of the generation technology used to produce such energy. By introducing scale and diversification of generation and consumption, platforms are able to increase businesses's renewable energy coverage levels beyond their theoretical maximums.

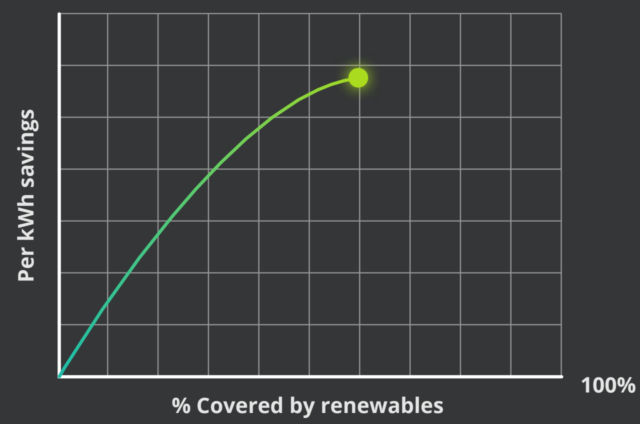
The results represent a renewable energy platform offering a product which provides businesses with a 90% renewable energy coverage level, regardless of the consumption profile of the business or the performance of generation assets. The platform offers every business a discount on its utility price, regardless of the business's unique consumption profile. Note how even though the initial price offered by the platform is higher than the market price of solar, the 90% coverage level provides greater protection against inflation in utility prices and results in a higher level of future savings than solar across all industries. This demonstrates the importance of considering both price and level of coverage in any renewable energy procurement decision.

STAGE 2: RATE OF DECLINING MARGINAL GAINS **AND WHEN GAINS TURN TO LOSSES**

Since renewable energy is paid for based on generation rather than consumption, there is a critical relationship that arises between price and level of renewable energy coverage, regardless of generation technology. As a business scales up its supply of renewable energy beyond the point of wasted generation, generation begins to exceed consumption in at least one of the 36 monthly time-of-use periods in a year. The result is the business paying for generation that is not consumed, increasing the effective per kWh price of consumed renewable energy and eliminating the financial benefit that comes with independence from utility prices. Importantly, beyond the point when generation begins to be wasted, the rate at which wastage occurs and hence the effective price per kWh consumed increases exponentially as coverage levels rise further.

The total cost of kWh's consumed is based on the combination between renewable and utility-based consumption. Hence, at this point, for every additional renewable kWh procured, utility-based consumption does not decrease by the same amount. Energy is wasted and the business's marginal gains begin to decrease.

STAGE 2: RATE OF DECLINING MARGINAL GAINS AND WHEN GAINS TURN TO LOSSES



(Cost of kWh's consumed + Cost of kWh's wasted)

÷

Sum of kWh's consumed

=

Effective price per kWh

Results

Table 5 below shows, for each industry and procurement model, the percentage of generation that is wasted and the resultant [effective price] of renewable energy at coverage levels beyond the point of declining marginal gains.

TABLE 5: PERCENTAGE OF GENERATION WASTED AND EFFECTIVE RENEWABLE ENERGY PRICE AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS.

Industry	Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model
Coverage	30%	45%	60%	60%	75%	90%	60%	75%	90%	60%	75%	90%	90%
Financial services	8% [R0.81]	55% [R1.67]	NA	0% [R0.80]	11% [R0.90]	38% [R1.29]	0% [R1.05]	1% [R1.06]	11% [R1.18]	0% [R1.00]	0% [R1.00]	3% [R1.03]	0% [R1.05]
Food retail	59% [R1.83]	97% [R27.31]	NA	10% [R0.89]	33% [R1.20]	49% [R1.55]	0% [R1.05]	0% [R1.05]	6% [R1.12]	1% [R1.01]	6% [R1.06]	16% [R1.19]	0% [R1.02]
Fitness	7% [R0.80]	39% [R1.22]	93% [R11.01]	0% [R0.80]	5% [R0.85]	33% [R1.20]	1% [R1.06]	5% [R1.11]	16% [R1.25]	0% [R1.00]	0% [R1.00]	3% [R1.04]	0% [R1.08]
Hospitality and entertainment	13% [R0.86]	72% [R2.64]	NA	2% [R0.81]	26% [R1.08]	45% [R1.46]	0% [R1.05]	0% [R1.05]	3% [R1.08]	0% [R1.00]	1% [R1.01]	9% [R1.10]	0% [R1.00]
Shopping centres	3% [R0.77]	11% [R0.84]	53% [R1.59]	0% [R0.80]	2% [R0.82]	22% [R1.02]	1% [R1.06]	9% [R1.15]	23% [R1.37]	0% [R1.00]	0% [R1.00]	3% [R1.03]	0% [R1.02]
Mining	11% [R0.84]	75% [R3.01]	NA	4% [R0.83]	26% [R1.09]	47% [R1.50]	0% [R1.05]	1% [R1.06]	5% [R1.11]	0% [R1.00]	2% [R1.02]	10% [R1.12]	0% [R0.99]
Agriculture	45% [R1.36]	94% [R13.20]	NA	5% [R0.84]	25% [R1.07]	46% [R1.48]	0% [R1.05]	1% [R1.06]	8% [R1.14]	0% [R1.00]	2% [R1.02]	12% [R1.14]	0% [R1.03]

STAGE 2: RATE OF DECLINING MARGINAL GAINS **AND WHEN GAINS TURN TO LOSSES**

Now accounting for this financial impact of wasted generation, the present and future savings can be quantified per industry:

TABLE 6: PRESENT AND FUTURE SAVINGS AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS.

☐ Indicates highest savings scenario per industry

Industry	Embedded solar model						Wheeled solar model					
Coverage	30%		45%		60%		60%		75%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	12%	16%	-11%	1%	NA	NA	23%	31%	23%	35%	0%	19%
Food retail	-13%	-3%	-917%	-702%	NA	NA	19%	29%	6%	22%	-19%	5%
Fitness	10%	14%	2%	11%	-434%	-324%	22%	30%	26%	36%	7%	25%
Hospitality and entertainment	10%	14%	-48%	-27%	NA	NA	23%	32%	13%	28%	-13%	10%
Shopping centres	11%	15%	14%	20%	-16%	1%	23%	32%	28%	39%	19%	35%
Mining	10%	15%	-61%	-37%	NA	NA	23%	32%	13%	27%	-17%	7%
Agriculture	-1%	6%	-414%	-311%	NA	NA	22%	30%	13%	27%	-14%	9%

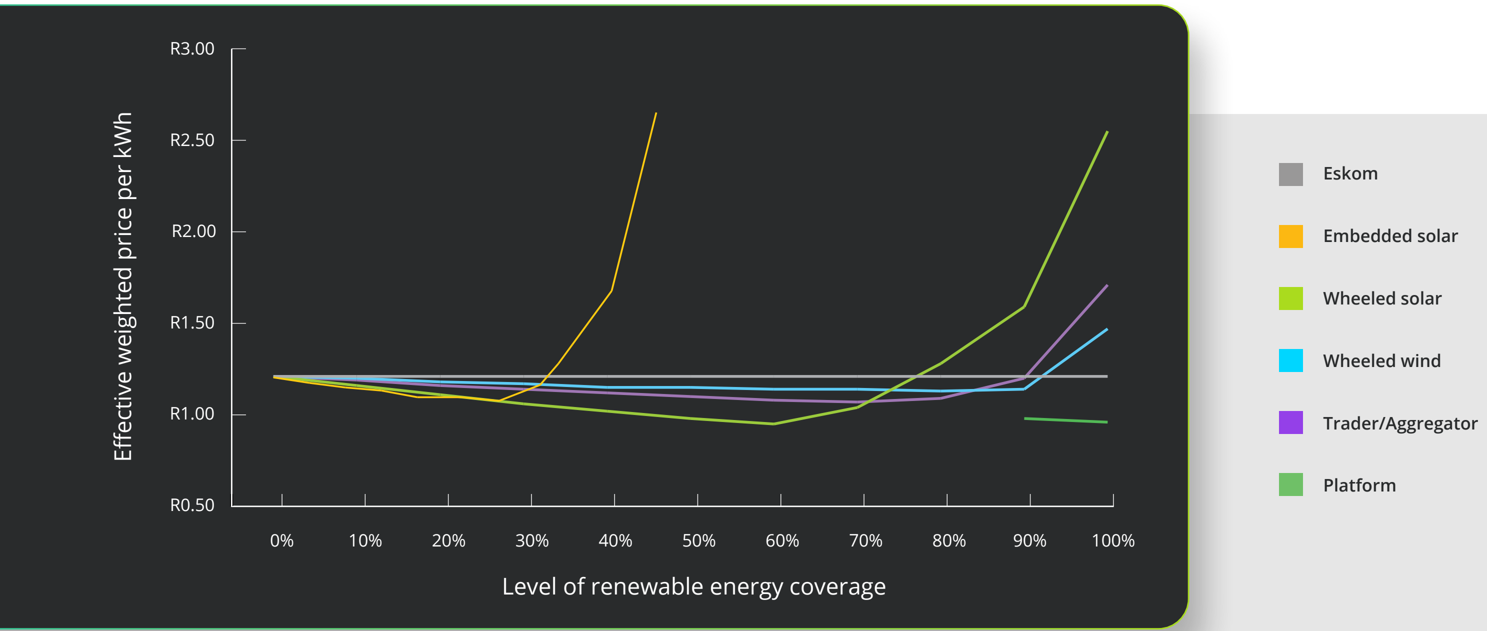
Industry	Wheeled wind model						Trader/aggregator model						Product model	
Coverage	60%		75%		90%		60%		75%		90%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	6%	17%	8%	21%	4%	22%	11%	21%	14%	27%	15%	31%	17%	33%
Food retail	7%	17%	8%	22%	6%	23%	11%	21%	10%	24%	3%	22%	18%	34%
Fitness	6%	17%	6%	20%	1%	20%	11%	21%	13%	26%	14%	30%	17%	33%
Hospitality and entertainment	7%	18%	8%	22%	8%	26%	11%	22%	14%	27%	10%	27%	18%	34%
Shopping centres	6%	17%	4%	19%	-7%	14%	11%	22%	14%	27%	15%	31%	18%	34%
Mining	7%	18%	8%	22%	7%	25%	12%	22%	13%	27%	9%	27%	18%	34%
Agriculture	6%	17%	8%	22%	5%	23%	11%	22%	13%	26%	7%	25%	18%	34%

It is useful to represent this coverage and pricing dynamic graphically. The pricing pathways below show the effective weighted price per kWh that a typical business would be required to pay under each of the five renewable energy procurement models. The weighted price is calculated using the effective price of renewable energy (after considering wastage) as well as the prevailing utility price for consumption not served by renewable energy. Businesses maximise their total savings at the lowest effective weighted price. Graphs 3 and 4 below do not yet consider the impact of generation or consumption variability.

STAGE 2: RATE OF DECLINING MARGINAL GAINS **AND WHEN GAINS TURN TO LOSSES**

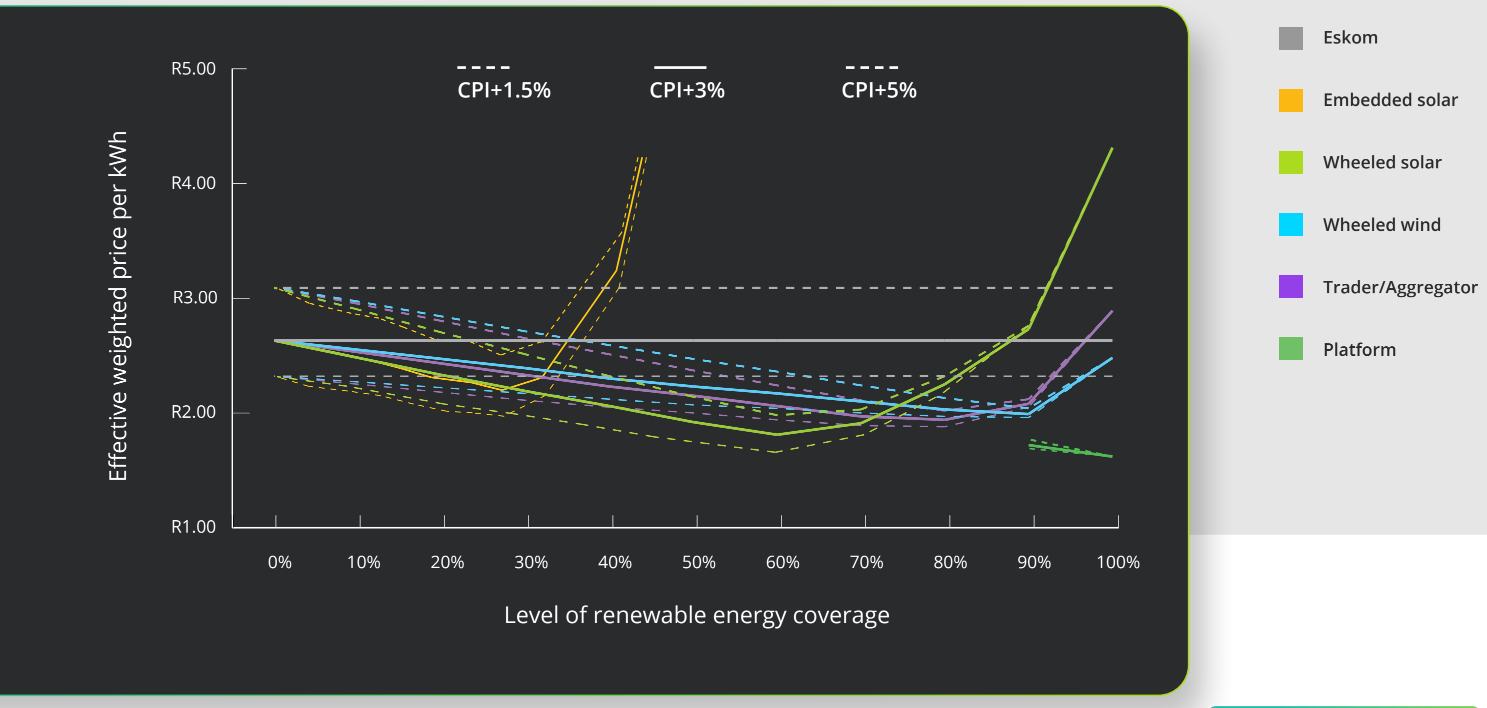
The business in this example has a consumption profile that is 14% peak, 38% standard and 48% off-peak, and is charged a utility price of R1.21.

GRAPH 3: EFFECTIVE WEIGHTED PRICE PER KWH ACCORDING TO COVERAGE LEVEL.



The higher the level of renewable energy coverage, the less exposed a business is to unknown utility price increases in future. Using the same example, the below shows the set of results in year 10 of each procurement strategy, and under different assumptions for future utility price increases. It is evident that the lower the coverage, the greater the sensitivity to price changes from the utility.

GRAPH 4: EFFECTIVE WEIGHTED PRICE PER KWH ACCOUNTING FOR PRICE INFLATION.



INSIGHTS
STAGE 2

It is critical to note that the point of declining marginal gains, as described in stage 1, does not imply the point of maximum savings. As soon as generation becomes wasted, the pricing pathway begins to decrease at a slower rate. This is because the business must compensate the renewable energy supplier for generation that is not needed, increasing the effective price of consumed energy. The point of maximum savings, as highlighted in the results tables, is the point where the pricing pathway reaches its turning point. However, provided that the effective weighted price of consumed energy never exceeds the utility price of electricity, the business will continue to make some financial savings.

The embedded solar model

At a cost well below the prevailing utility price, the financial benefits of embedded solar generation at low levels of coverage are significant. There is minimal risk of any generation being wasted as the business's consumption comfortably exceeds the number of kilowatt-hours generated by the embedded solar facility at any point in time. However, because embedded generation does not benefit from monthly energy reconciliation (monthly banking), a coverage level is soon reached where generation is wasted (approximately 12% in the diagram above). Note how the point of maximum savings to the business occurs at a coverage level of 30%. The consequence to the business seeking to increase its coverage level beyond this point is an exponentially increasing level of wasted generation and hence an exorbitant effective price paid. Importantly, for businesses with a consumption profile that is skewed more towards off-peak hours than for the consumption profile assumed above, the turning point of the graph occurs at a coverage level lower than 30% as standard consumption hours are exhausted at a quicker rate. The opposite holds true for standard heavy consumption profiles.

Importantly, the pricing pathway does not extend to high levels of renewable energy coverage as the absence of monthly banking means the business will never be able to service its nighttime consumption. The theoretical maximum coverage level that each business can achieve using only embedded solar is provided below. These results assume that each business is not constrained structurally by the size of its roof space, and that each has an unlimited amount of capital to spend on the exorbitant number of solar panels required:

Industry	Financial services	Food retail	Fitness	Hospitality and entertainment	Shopping centres	Mining	Agriculture
Theoretical maximum coverage	59%	49%	65%	55%	74%	54%	50%

**It is, however, possible for a business to achieve a 100% renewable energy coverage level using wheeled solar and monthly banking, albeit at an exorbitant cost. This is because daytime hours during weekends and public holidays are classified as off-peak. Renewable energy generated during these times can be used to offset a business's off-peak nighttime consumption. However, the business must over-subscribe significantly to solar energy in order to achieve this, resulting in excessively high effective prices.*

INSIGHTS
STAGE 2

The wheeled solar model

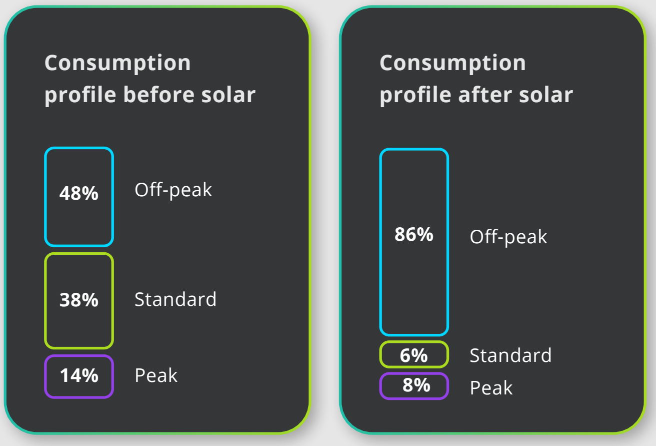
Although not as pronounced as for embedded generation, the same pricing dynamic plays out for wheeled solar energy. Wheeled solar energy is often slightly more expensive than embedded solar generation due to use-of-system charges that are incurred under a wheeling agreement, and it does not benefit from the avoided transmission losses and subsidies. The key feature behind the delayed rise in the effective price when compared to embedded generation is the ability to bank energy monthly. As a result, the point where generation first becomes wasted in the graphical example shifts from a 12% coverage level under the embedded generation scenario to a 26% coverage level. Beyond the point of wasted generation, higher coverage levels result in a similarly exponential price increase. Beyond the point of wasted generation, the business enjoys a further 33% of coverage before the pricing pathway reaches its minimum and total savings fall.

The wheeled wind model

Compared to solar, the key features of the pricing pathway for wind are the less aggressive fall in price for lower levels of coverage, but a delayed turning point where the effective price begins to increase because of wasted generation. This is purely driven by the higher cost of wind (although still lower than the prevailing utility price), but the better consumption matching proposition offered by wind for this business in particular. As shown by the industries represented in this paper, most businesses tend to have off-peak heavy consumption profiles. Generally, such consumption profiles will benefit from a higher level of coverage with wind energy before the effective price begins to increase. This tends to hold true up to the point where 50% of a business's consumption is attributable to off-peak hours, beyond which wasted generation occurs at a quicker rate.

Implications of procuring solar followed by wind

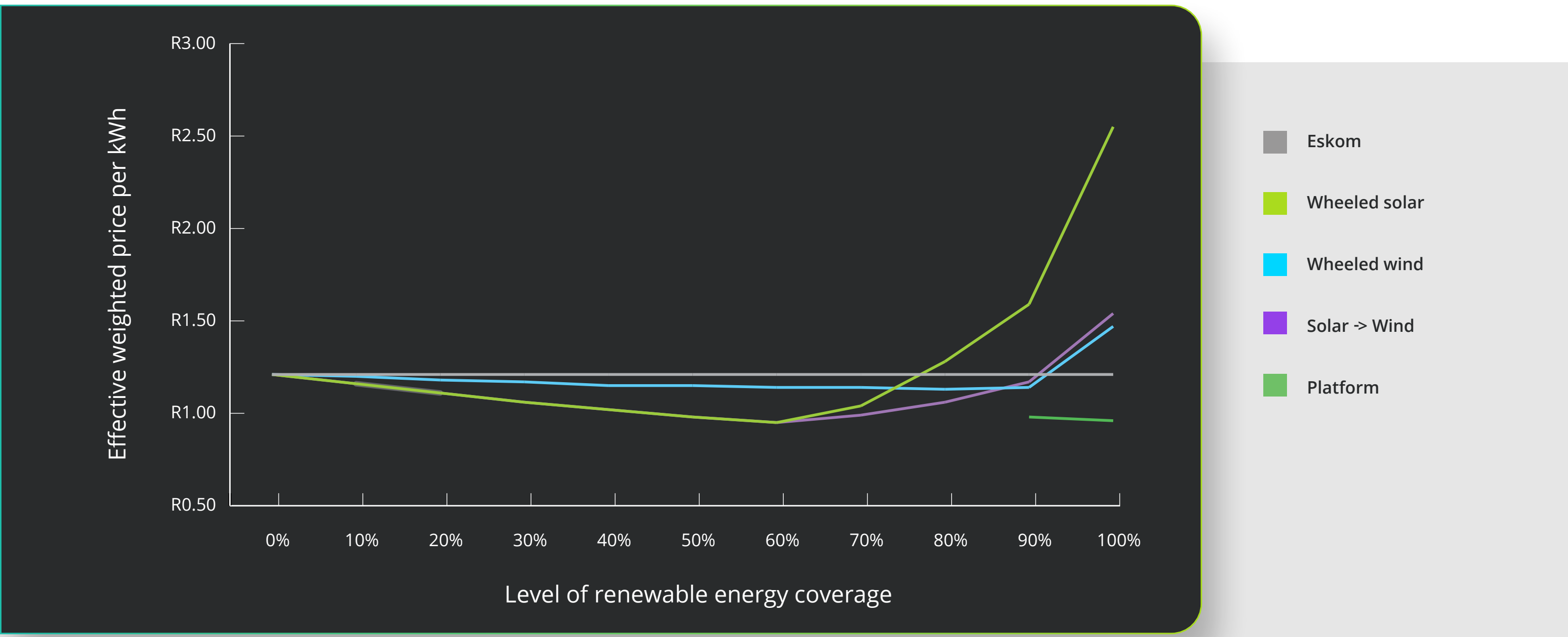
At this point, it may appear that a logical strategy to achieve a high renewable energy coverage level while avoiding wasted generation is to first procure solar energy at a low level of coverage, benefit from the cheaper price, and then meet the remaining demand with wind. While solar is typically quick to install and provides tangible coverage in the short term, the fundamental issue is that businesses are left with a severely skewed residual consumption profile after procuring solar energy, particularly towards off-peak hours. Consider the scenario where the business in the graphical illustration above wheels solar energy. Assuming the business can service 60% of its existing demand with solar, its share of off-peak consumption increases from 48% to 86%.



Intuitively, to source additional renewable energy to meet such a profile, wind must be procured. However, the typical wind generation profile contains a healthy share of peak and standard hours. As a result, businesses seeking off-peak hours must necessarily over-contract for a substantial amount of wind energy. This can lead to the wastage of standard and peak time supply, and a subsequent increase in the effective cost of renewable energy once this wastage is accounted for.

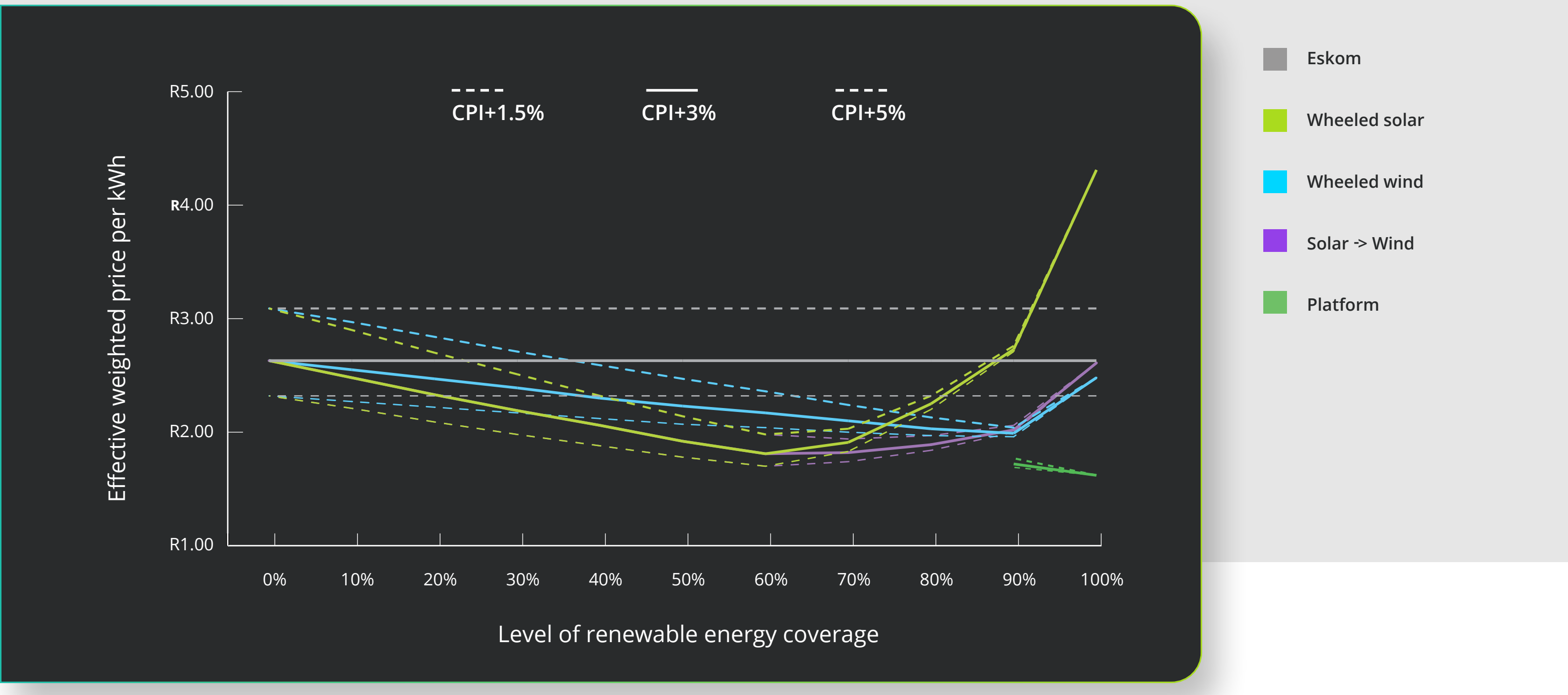
INSIGHTS
STAGE 2

GRAPH 5: EFFECTIVE WEIGHTED PRICE PER KWH ACCORDING TO COVERAGE LEVEL.



The higher the level of renewable energy coverage, the less exposed a business is to unknown utility price increases in future. Using the same example, the below shows the set of results in year 10 of each procurement strategy, and under different assumptions for future utility price increases:

GRAPH 6: EFFECTIVE WEIGHTED PRICE PER KWH ACCOUNTING FOR PRICE INFLATION.



Additionally, battery storage and green hydrogen, though promising, remain economically impractical for large-scale implementation.

The data reveals a trend. Initially, after installing enough solar capacity to cover approximately 45% of total demand, businesses aiming to cover the remaining 55% with wind would have to purchase more than 80% of the wind energy needed to fulfil all their consumption needs in the first place. This indicates that the perceived cost efficiency of starting with solar is misleading. Compared to a wind-only strategy, this approach has increased the cost of wind energy by 35% in pursuit of the ultimate goal to achieve a 100% renewable energy coverage level.

INSIGHTS
STAGE 2

Furthermore, the lack of a liquid market for off-peak prices complicates the procurement process. Wind producers are reluctant to sell off-peak energy at lower prices in isolation as it disrupts the balance of their energy profile. Such a strategy would result in the generator having predominantly standard hours left to sell, an offering which is easily replicable by a solar facility. The generator faces a crippling price disadvantage as wind is the more expensive technology (a wind generator's prized asset is the ability to provide a balanced profile). As a result, this optionality is unlikely to exist in the renewable energy market unless consumers are willing to pay an exorbitant premium for off-peak hours. There is thus the fundamental question of whether the business's remaining energy needs can ever be met by renewables at all.

The trader/ aggregator model

As a result of the 'share-of-plant' approach adopted by traders, the pricing pathway suffers from the same exponential price increase beyond the point of wasted generation. To avoid this risk, businesses often settle for a lower coverage level at a cheaper price, notwithstanding the argument of a skewed residual consumption profile hindering their long-term renewable energy strategy. Because this risk is also prevalent when wheeling wind or solar energy through an IPP, it is rare in practice for any of the pricing pathways discussed to this point to extend beyond their respective turning points.

The combination of a 50% solar and 50% wind strategy creates a better matching proposition than for a pure solar solution, at a slightly cheaper rate than for a pure wind solution. The aggregator's trading margin reduces the total savings potential from the solar and wind combination. As can be seen in the results table for different industries, a 50/50 split is not always the optimal savings solution as the level of savings may fall below that what is achievable using only solar or only wind.

The product model

Renewable energy platforms compete on product design just as much as they do on price. Because of this, it is misleading to present a pricing pathway applicable to all platforms. However, the pricing pathway illustrated above represents the same product structure where an energy platform aims to replace a constant 90% of a business's demand for each time-of-use period, at a fixed price that does not vary by coverage level. The fixed price implies that the platform absorbs the risk of wasted generation at higher coverage levels and results in the linearity of the pricing pathway. The greater the level of coverage, the less reliance on the prevailing utility price and the lower the effective cost of energy consumed.

In the absence of a product model, the ability to achieve high coverage levels without incurring significant wasted generation costs is rare. Calculations show that a business procuring renewable energy from IPPs or traders can never achieve a *guaranteed* 100% renewable energy coverage level (after accounting for variations in generation and consumption) using wheeled wind or solar without paying at least double the prevailing utility price. This can be exacerbated further with a short-term procurement strategy that leaves a business with a skewed residual consumption profile.

INSIGHTS
STAGE 2

Implications of a national excess solar scenario

The rapid adoption of solar PV globally has had significant implications for time-of-use tariffs in many major economies. Australia, for example, generates the most solar energy per capita in the world and has seen a significant reduction in daytime electricity prices because of the increased energy supply during the day. Price reductions have been so severe that wholesale electricity prices in Australia's National Electricity Market were negative or zero for approximately 20% of the time during Q4 of 2023[1]. This is to incentivise higher demand during times of the day when generation exceeds consumption at the national level.

The adoption of solar photovoltaic (PV) in South Africa, although not as advanced as Australia, has been equally rapid. Without considering utility-scale solar plants, the installed capacity of rooftop solar PV alone increased by 349% from March 2022 to June 2023[2]. Considering the long-term nature of traditional bilateral purchasing contracts, it is necessary to model the impact of rebalancing time of-use prices for South African businesses.

This paper models a rebalancing scenario where utility standard prices reduce by 40%, off-peak prices increase by 40%, and peak prices remain unchanged. The net effect is a reduction in the average tariff paid by businesses. The table below shows, for each procurement model, a business's weighted price of electricity after the rebalancing has occurred and in today's prices for ease of comparison. The results assume that the procurement strategies commence immediately before the rebalancing.

[1]AEMO 2024 | Quarterly Energy Dynamics Q4 2023 | [2]Professor Anton Eberhard, UCT Power Futures Lab

TABLE 7: WEIGHTED PRICE PER KWH AFTER TIME-OF-USE REBALANCING.

Industry	Utility price		Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model
Coverage	Old basis	New basis	30%	45%	60%	60%	75%	90%	60%	75%	90%	60%	75%	90%	90%
Financial services	R 1.30	R 1.21	R 1.16	R 1.53	NA	R 1.05	R 1.07	R 1.33	R1.14	R 1.13	R 1.21	R 1.14	R 1.12	R 1.12	R 1.06
Food retail	R 1.27	R 1.24	R 1.50	R 13.74	NA	R 1.12	R 1.27	R 1.54	R 1.18	R 1.16	R 1.19	R 1.18	R 1.19	R 1.26	R 1.05
Fitness	R 1.33	R 1.23	R 1.17	R 1.35	R 7.55	R 1.07	R 1.05	R 1.27	R 1.16	R 1.18	R 1.29	R 1.16	R 1.14	R 1.15	R 1.10
Hospitality and entertainment	R 1.25	R 1.19	R 1.16	R 1.97	NA	R 1.04	R 1.15	R 1.44	R 1.12	R 1.11	R 1.12	R 1.12	R 1.11	R 1.15	R 1.02
Shopping centres	R 1.27	R 1.14	R 1.08	R 1.09	R 1.54	R 0.98	R 0.95	R 1.06	R 1.07	R 1.12	R 1.33	R 1.07	R 1.05	R 1.06	R 1.03
Mining	R 1.24	R 1.19	R 1.15	R 2.14	NA	R 1.04	R 1.15	R 1.48	R 1.12	R 1.10	R 1.13	R 1.12	R 1.11	R 1.16	R 1.01
Agriculture	R 1.28	R 1.23	R 1.35	R 7.00	NA	R 1.09	R 1.18	R 1.49	R 1.16	R 1.15	R 1.20	R 1.16	R 1.15	R 1.21	R 1.05

After accounting for the impact of utility price inflation, the table below shows the weighted prices in year 10 of each strategy.

TABLE 8: WEIGHTED PRICE PER KWH AFTER TIME-OF-USE REBALANCING AND ACCOUNTING FOR PRICE INFLATION.

☐ Indicates highest savings scenario per industry

Industry	Utility price		Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model
Coverage	Old basis	New basis	30%	45%	60%	60%	75%	90%	60%	75%	90%	60%	75%	90%	90%
Financial services	R 2.81	R 2.62	R 2.39	R 2.95	NA	R 2.05	R 1.99	R 2.33	R 2.17	R 2.07	R 2.12	R 2.18	R 2.07	R 1.99	R 1.85
Food retail	R 2.76	R 2.70	R 2.99	R 23.54	NA	R 2.17	R 2.32	R 2.68	R 2.25	R 2.14	R 2.10	R 2.27	R 2.19	R 2.21	R 1.83
Fitness	R 2.89	R 2.66	R 2.43	R 2.65	R 13.02	R 2.09	R 1.97	R 2.24	R 2.22	R 2.16	R 2.26	R 2.22	R 2.11	R 2.04	R 1.91
Hospitality and entertainment	R 2.71	R 2.59	R 2.40	R 3.67	NA	R 2.02	R 2.12	R 2.50	R 2.14	R 2.03	R 1.95	R 2.15	R 2.04	R 2.02	R 1.77
Shopping centres	R 2.76	R 2.47	R 2.23	R 2.18	R 2.86	R 1.89	R 1.77	R 1.86	R 2.03	R 2.02	R 2.29	R 2.03	R 1.92	R 1.85	R 1.80
Mining	R 2.69	R 2.57	R 2.38	R 3.96	NA	R 2.02	R 2.12	R 2.56	R 2.12	R 2.02	R 1.97	R 2.13	R 2.03	R 2.03	R 1.76
Agriculture	R 2.78	R 2.67	R 2.72	R 12.17	NA	R 2.12	R 2.17	R 2.58	R 2.22	R 2.12	R 2.11	R 2.23	R 2.13	R 2.14	R 1.83

INSIGHTS
STAGE 2

Businesses may have contracted for wheeled solar energy at a price that is fixed across all time-of-use periods and non-reviewable during the contract term, only for the utility price of daytime power to fall below the contracted renewable energy price sometime in the future. The business would be in the position of paying a premium for its daytime energy, and because the generation profile of solar is weighted heavily towards standard daytime hours, the business faces a higher weighted energy cost relative to what it expected. Due to the off-peak heavy generation profile of wind, businesses procuring wind energy experience a relative savings advantage over businesses wheeling solar. With the platform model, businesses receive the same monetary discount per time-of-use as before the rebalancing occured. However, due to the high renewable energy penetration level offered by the platform model, the impact of utility price rebalancing has a minor impact on the business's weighted per kWh cost, particularly in the long term.

The reality of traditional bilateral solar procurement contracts with terms as high as 20 years and more is that South African businesses face a material risk of time-of-use tariff rebalancing causing an erosion in their financial savings.

STAGE 3: **ROBUSTNESS OF THE MODEL**

Variability of renewable energy generation

Arguably the greatest risk with relying on a single site for renewable energy generation is the inherent variability in energy output dictated by local weather conditions. Variability of generation is a significant risk factor that is often overlooked in renewable energy procurement. The risks discussed in this paper until now assumed the performance of a solar or wind plant to be stable and predictable annually, monthly, and on a time-of-use basis. Making this assumption is extremely problematic as businesses would be relying on predetermined and fixed averages without considering the natural variability in weather conditions creating financial and contractual risk.

The risk of wasted generation increases. Consider a solar plant that is expected to produce 100 MW of power on average throughout the year. Forecasters estimate, with 80% certainty, that the plant's total generation will not deviate by more than 7% in either direction throughout the year. In other words, instead of the expected 876,600 MWh over the year, the plant will produce between 815,238 and 937,962 MWh with 80% confidence. These numbers are typical deviations for solar generation. The variability associated with wind is higher at 13%. The generation spread would increase to between 762,642 and 990,558 MWh for a wind facility with an average generation output of 100 MW. These upper and lower bounds on generation, when referring to an 80% level of confidence, are commonly referred to in the industry as p10 and p90 profiles. The upper bound (p10) implies a 10% likelihood of generation exceeding this figure on an annual basis. The lower bound (p90) implies a 10% likelihood of generation falling below this figure on an annual basis (or equivalently, a 90% chance of generation exceeding this figure on an annual basis). Using this terminology, this paper assumes a p50 generation scenario up to this point.

However, from a billing reconciliation and financial savings perspective, the risk of variable generation ultimately applies at the monthly level.

Annual output figures benefit from months of poor generation being offset by months of better-than-expected generation. The result at the annual level remains relatively unchanged as long as both scenarios of under and over-generation occur in the same frequency and magnitude. The business, however, loses out on financial savings in months of poor generation, and these losses are not necessarily recouped in months of higher generation as the business's savings from renewable energy are limited to the number of kWh's that it consumes and that can be offset each month. Similarly, the businesses faces the risk of experiencing a wasted generation scenario in months of higher generation, the impact of which is arguably more severe. Therefore, it is necessary to understand the impact of a p10 and p90 generation scenario at the monthly level as this will ultimately drive the savings position of the business. Using hourly generation profiles for both solar and wind, Discovery Green has simulated the impact of generation volatility at the monthly level.

In terms of p10 and p90 variability at the monthly level, the 7% deviation from the expected number of MWhs generated *annually* by a single solar plant increases to as much as 14%. The 13% annual deviation from a single wind farm increases to as much as 49%.

However, because monthly billing reconciliation is further restricted by time-of-use, it is critical to understand generation variability within each time-of-use period within each month. This means that there are actually 36 different generation figures for which variability needs to be understood and appreciated as opposed to a single annual figure. The result is that the 7% annual deviation figure for solar typically used in forecasting can be as high as 31% within a single monthly time-of-use period. The 13% annual deviation figure for wind can be as high as 72%. It is almost always the case that, for businesses procuring renewable energy, the true financial implications of generation volatility are not fully appreciated.

Results

Taking account of production variability (at least to some extent), the table of results below shows the financial impact of increased wasted generation from a p10 generation scenario at the same coverage levels as before. Notwithstanding the analysis on monthly time-of-use variability, these results adopt a prudent approach by modelling a p10 generation scenario at the annual level. The [effective price] of renewable energy as a result of wasted generation is shown:

TABLE 9: PRESENT AND FUTURE SAVINGS AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS AND ACCOUNTING FOR GENERATION VOLATILITY.

Industry	Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model
Coverage	30%	45%	60%	60%	75%	90%	60%	75%	90%	60%	75%	90%	90%
Financial services	10% [R0.83]	57% [R1.76]	NA	1% [R0.81]	15% [R0.94]	40% [R1.34]	0% [R1.05]	4% [R1.10]	16% [R1.25]	0% [R1.00]	1% [R1.01]	7% [R1.07]	0% [R1.05]
Food retail	61% [R1.92]	97% [R29.01]	NA	13% [R0.92]	36% [R1.25]	50% [R1.61]	0% [R1.05]	2% [R1.07]	12% [R1.19]	2% [R1.02]	8% [R1.09]	20% [R1.25]	0% [R1.02]
Fitness	8% [R0.81]	42% [R1.28]	94% [R11.68]	0% [R0.80]	8% [R0.87]	36% [R1.26]	2% [R1.07]	10% [R1.16]	22% [R1.34]	0% [R1.00]	1% [R1.01]	8% [R1.09]	0% [R1.08]
Hospitality and entertainment	15% [R0.88]	73% [R2.79]	NA	4% [R0.83]	29% [R1.12]	47% [R1.51]	0% [R1.05]	1% [R1.06]	9% [R1.16]	0% [R1.00]	2% [R1.02]	14% [R1.16]	0% [R1.00]
Shopping centres	3% [R0.77]	14% [R0.87]	55% [R1.68]	0% [R0.80]	4% [R0.83]	25% [R1.07]	3% [R1.08]	14% [R1.22]	29% [R1.48]	0% [R1.00]	1% [R1.01]	7% [R1.08]	0% [R1.02]
Mining	13% [R0.86]	76% [R3.18]	NA	5% [R0.85]	29% [R1.13]	49% [R1.57]	0% [R1.05]	3% [R1.08]	11% [R1.18]	0% [R1.00]	3% [R1.03]	16% [R1.19]	0% [R0.99]
Agriculture	47% [R1.42]	95% [R14.01]	NA	6% [R0.85]	28% [R1.12]	48% [R1.55]	0% [R1.05]	3% [R1.08]	14% [R1.22]	0% [R1.00]	4% [R1.04]	17% [R1.20]	0% [R1.03]

Now accounting for this financial impact of additional wasted generation, the present and future savings can be quantified per industry:

TABLE 10: PRESENT AND FUTURE SAVINGS AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS AND ACCOUNTING FOR GENERATION VOLATILITY AND PRICE INFLATION.

Indicates highest savings scenario per industry

Industry	Embedded solar model						Wheeled solar model					
Coverage	30%		45%		60%		60%		75%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	11%	16%	-14%	-1%	NA	NA	24%	**33%**	21%	**33%**	-4%	17%
Food retail	-14%	-4%	-976%	-748%	NA	NA	19%	29%	3%	20%	-24%	2%
Fitness	10%	14%	0%	9%	-455%	-348%	24%	32%	25%	**36%**	3%	22%
Hospitality and entertainment	9%	14%	-53%	-31%	NA	NA	24%	33%	11%	26%	-18%	7%
Shopping centres	11%	15%	13%	20%	-20%	-3%	25%	34%	28%	**40%**	16%	33%
Mining	10%	14%	-67%	-42%	NA	NA	23%	33%	10%	26%	-22%	3%
Agriculture	-2%	5%	-442%	-333%	NA	NA	22%	31%	11%	26%	-19%	6%

Industry	Wheeled wind model						Trader/aggregator model						Product model	
Coverage	60%		75%		90%		60%		75%		90%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	7%	19%	7%	22%	0%	21%	12%	23%	15%	29%	12%	30%	17%	**33%**
Food retail	7%	20%	8%	23%	2%	21%	11%	23%	9%	25%	-1%	19%	18%	**34%**
Fitness	6%	18%	4%	20%	-4%	17%	12%	23%	14%	28%	12%	29%	17%	33%
Hospitality and entertainment	7%	20%	9%	25%	4%	24%	13%	24%	14%	29%	6%	25%	18%	**34%**
Shopping centres	6%	19%	1%	18%	-15%	9%	12%	24%	15%	29%	13%	31%	18%	34%
Mining	8%	20%	8%	24%	3%	23%	13%	24%	13%	28%	4%	24%	18%	**34%**
Agriculture	7%	20%	8%	23%	1%	21%	12%	24%	12%	27%	3%	22%	18%	**34%**

STAGE 3: **ROBUSTNESS OF THE MODEL**

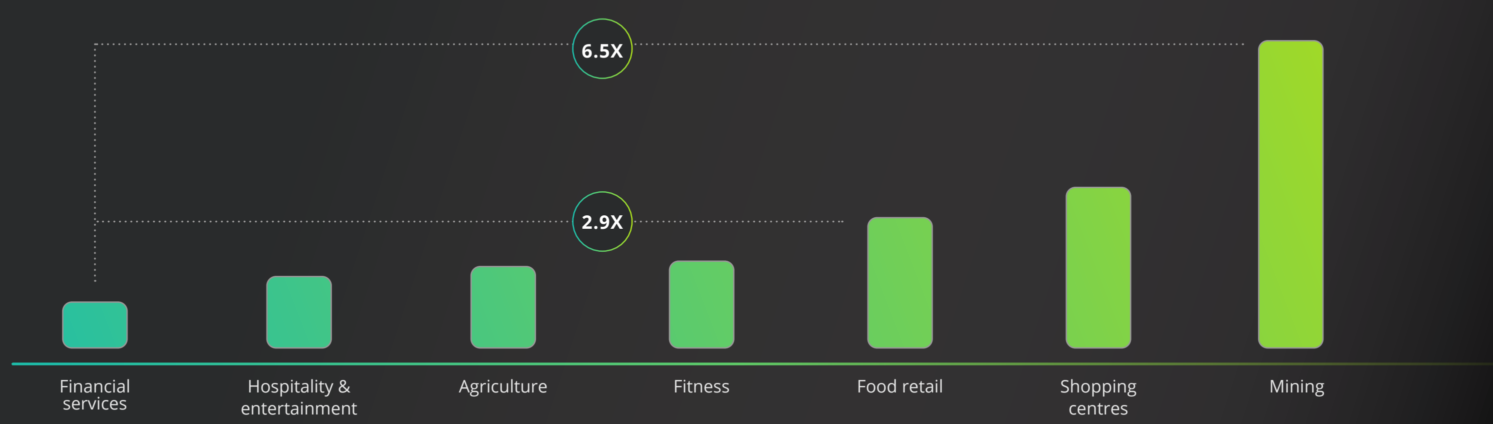
Variability of business consumption

There is another layer of variability that adds to the risk and contractual complexities in renewable energy procurement. It is equally important to consider the fluctuations in a business's energy demand, whether planned or unplanned. It is highly plausible that a business receives its expected generation from renewables, only to encounter a drop in its own demand for electricity. In such a situation, the business may find itself paying for energy that it does not consume. Conversely, if the business's energy needs were to grow, it may become unable to service enough of its demand with renewable energy, leading to additional costs and inefficiencies.

To better understand the challenges posed by variability of demand, this paper investigates historic consumption patterns across a wide range of businesses and industries. The results show a significant level of consumption volatility, not just between businesses in different industries but within industries too. For example, during the COVID 19 pandemic, electricity consumption dropped by as much as 40% during the first set of lockdowns, highlighting the extent of variability that businesses must contend with.

After analysing time-of-use consumption data over a three-year period, it was found that the financial services industry had the most stable energy consumption. The table below compares the consumption volatility of businesses from different industries relative to the financial services industry:

GRAPH 7: CONSUMPTION VOLATILITY RELATIVE TO THE FINANCIAL SERVICES INDUSTRY



STAGE 3: **ROBUSTNESS OF THE MODEL**

Results

To model the financial impact of consumption variability, this paper considers a plausible scenario where a business has a 90% reduction in energy consumption for the month of March, along with the same p10 generation scenario:

TABLE 11: PRESENT AND FUTURE SAVINGS AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS AND ACCOUNTING FOR GENERATION AND CONSUMPTION VOLATILITY.

Industry	Embedded solar model			Wheeled solar model			Wheeled wind model			Trader/aggregator model			Product model
Coverage	30%	45%	60%	60%	75%	90%	60%	75%	90%	60%	75%	90%	90%
Financial services	16% [R0.89]	61% [R1.91]	NA	8% [R0.87]	22% [R1.02]	45% [R1.46]	7% [R1.13]	11% [R1.19]	23% [R1.36]	7% [R1.08]	8% [R1.08]	14% [R1.16]	0% [R1.06]
Food retail	64% [R2.07]	98% [R31.50]	NA	20% [R1.00]	41% [R1.36]	54% [R1.76]	7% [R1.13]	9% [R1.15]	19% [R1.30]	9% [R1.10]	15% [R1.18]	26% [R1.36]	0% [R1.04]
Fitness	15% [R0.88]	46% [R1.39]	94% [R12.72]	7% [R0.86]	16% [R0.95]	41% [R1.37]	9% [R1.15]	16% [R1.26]	28% [R1.45]	7% [R1.08]	8% [R1.09]	15% [R1.18]	0% [R1.10]
Hospitality and entertainment	22% [R0.96]	75% [R3.05]	NA	10% [R0.89]	35% [R1.22]	51% [R1.65]	7% [R1.13]	8% [R1.14]	16% [R1.26]	7% [R1.07]	9% [R1.11]	21% [R1.26]	0% [R1.01]
Shopping centres	10% [R0.83]	20% [R0.94]	59% [R1.83]	7% [R0.86]	11% [R0.90]	31% [R1.17]	10% [R1.16]	20% [R1.32]	35% [R1.61]	7% [R1.07]	8% [R1.09]	14% [R1.17]	0% [R1.03]
Mining	19% [R0.93]	78% [R3.45]	NA	12% [R0.91]	35% [R1.22]	53% [R1.71]	7% [R1.13]	10% [R1.17]	18% [R1.28]	7% [R1.08]	11% [R1.12]	22% [R1.28]	0% [R1.00]
Agriculture	51% [R1.53]	95% [R15.12]	NA	13% [R0.92]	34% [R1.21]	52% [R1.68]	7% [R1.13]	10% [R1.17]	20% [R1.32]	7% [R1.08]	11% [R1.13]	23% [R1.30]	0% [R1.05]

Now accounting for the financial impact of this reduced consumption, the present and future savings can be quantified per industry:

TABLE 12: PRESENT AND FUTURE SAVINGS AT COVERAGE LEVELS BEYOND THE POINT OF DECLINING MARGINAL GAINS AND ACCOUNTING FOR GENERATION VOLATILITY, CONSUMPTION VOLATILITY AND PRICE INFLATION.

☐ Indicates highest savings scenario per industry

Industry	Embedded solar model						Wheeled solar model					
Coverage	30%		45%		60%		60%		75%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	9%	14%	-20%	-6%	NA	NA	21%	31%	17%	30%	-11%	11%
Food retail	-19%	-8%	-1065%	-818%	NA	NA	15%	26%	-3%	15%	-33%	-5%
Fitness	7%	12%	-5%	5%	-513%	-385%	21%	30%	21%	**33%**	-4%	17%
Hospitality and entertainment	6%	11%	-63%	-39%	NA	NA	21%	31%	5%	22%	-27%	0%
Shopping centres	9%	13%	9%	17%	-28%	-9%	23%	32%	25%	**37%**	9%	28%
Mining	7%	12%	-78%	-50%	NA	NA	20%	30%	5%	22%	-31%	-3%
Agriculture	-6%	2%	-482%	-364%	NA	NA	19%	29%	6%	22%	-27%	0%

Industry	Wheeled wind model						Trader/aggregator model						Product model	
Coverage	60%		75%		90%		60%		75%		90%		90%	
	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)	Saving (Year 1)	Saving (Year 10)
Financial services	4%	17%	2%	19%	-6%	16%	9%	21%	10%	25%	6%	25%	17%	**33%**
Food retail	4%	17%	3%	20%	-5%	16%	8%	20%	4%	21%	-8%	14%	17%	**34%**
Fitness	3%	16%	0%	16%	-10%	12%	9%	20%	10%	25%	6%	25%	17%	**33%**
Hospitality and entertainment	4%	18%	4%	21%	-2%	19%	9%	22%	9%	25%	-1%	20%	18%	**34%**
Shopping centres	3%	16%	-4%	14%	-24%	3%	9%	22%	10%	26%	7%	26%	18%	34%
Mining	4%	18%	3%	20%	-3%	18%	9%	22%	8%	25%	-2%	19%	18%	**34%**
Agriculture	4%	17%	3%	19%	-5%	16%	9%	21%	8%	23%	-4%	17%	17%	**34%**

RESULTS SUMMARY

The requirement to pay for energy generated, as opposed to energy consumed, means that a business must distinguish between the price quoted and the effective price paid for renewable energy. It is often the case that the cheapest quoted price does not in fact yield the maximum savings to businesses. Price must necessarily be considered in conjunction with the level of renewable energy coverage, particularly when protecting against future unknown price increases in utility-supplied electricity. Because the risk of wasted generation is low at low coverage levels, it should not come as a surprise that the cheapest quoted prices are often accompanied by low coverage levels.

Furthermore, in the absence of a renewable energy product model, the risks of variable generation and consumption are passed on to the business. The business's expected financial position can change according to the performance of the sun and wind. This makes achieving high renewable energy coverage levels, without incurring exorbitant wasted costs, materially more difficult. The risk is amplified after considering the possibility of a reduction in business consumption that also occurs in a month of high energy generation. Alternatively, a business's growth leading to higher energy requirements may reduce the level of savings on its utility bill if its supply of renewable energy is inflexible.

The summary table below shows the optimal procurement model for a business in each industry at the different stages of implementation, on a 10-year basis.

TABLE 13: OPTIMAL PROCUREMENT MODEL BY STAGE OF IMPLEMENTATION.

	Optimal procurement model for maximum savings		
Industry	Zero generation and consumption variability	After accounting for generation variability	After accounting for consumption variability
Financial services	Wheeled solar model	Product model	Product model
Food retail	Product model	Product model	Product model
Fitness	Wheeled solar model	Wheeled solar model	Product model
Hospitality and entertainment	Product model	Product model	Product model
Shopping centres	Wheeled solar model	Wheeled solar model	Wheeled solar model
Mining	Product model	Product model	Product model
Agriculture	Product model	Product model	Product model

Additionally, this paper highlights two critical procurement risks not often considered:

The belief that coverage limitations of solar can be solved with wind in future

Solar procurement leaves businesses with an awkward residual consumption profile skewed towards off-peak hours. Using either wind or battery storage, businesses must pay a significant premium to meet this residual demand and protect themselves against unknown utility-price increases in future. Businesses are often lured by the low price of solar and fail to recognise its long-term procurement risk.

The potential for a reduction in daytime electricity prices

As seen across the world, the influx of solar energy has the potential to flood the supply of daytime electricity. The national utility is forced to rebalance time-of-use pricing as a result. Businesses entering into long-term solar procurement contracts face the risk of the utility price of power falling below their contracted price for renewable energy.

THE CASE FOR RENEWABLE ENERGY PLATFORMS

This paper shows that the most economically optimal and low risk renewable energy procurement model is the product model offered by renewable energy platforms. The dynamics that enable this are shown below.

Generation

While a 50/50 generation blend between wind and solar generally creates an increase in the renewable energy coverage level businesses can achieve before generation is wasted, it is preferable to optimise this blend to meet the unique consumption profile of a business. An analysis across industries shows that the blend between solar and wind that would allow the business to achieve a 100% renewable coverage level in the most cost-effective way can vary significantly from a crude 50/50 split. The results consider both the amount of wasted generation and the cost of such wastage. See below how the optimal blend could differ according to the starting consumption profile of the business:

TABLE 14: OPTIMAL BLEND OF SOLAR AND WIND FOR DIFFERENT CONSUMPTION PROFILES

Business	Industry	Starting PSO profile	Optimal solar	Optimal wind
A	Commercial property	16%/45%/39%	39%	61%
B	Metal processing	14%/36%/50%	8%	92%
C	Chemical manufacturing	15%/36%/49%	23%	77%
C	Residual after 40% solar	13%/20%/67%	0%	100%

Any renewable energy supplier not using the product model is subject to the typical generation profiles of solar and wind energy to meet the unique consumption needs of offtakers. As shown in this paper, it is nearly impossible to find a business whose consumption profile perfectly matches the generation profile of either solar or wind. Solar and wind generation profiles can be manipulated to some extent through the aggregator model. However, this requires the selection of a specific portfolio of plants that meet the consumption needs of a single offtaker or group of offtakers according to their unique consumption profile. Any other business with a different consumption profile looking to procure renewable energy from the aggregator must wait until the aggregator has developed a new project more suitable to its consumption profile for it to secure the same economic benefits as the aggregator's initial offtakers. Despite this being a very difficult task, given the constraints on land availability, grid connection and the ability to develop plants rapidly, the offtakers remain exposed to the risk of generation and consumption variability eroding savings.

The ability to meet the unique energy requirements of diverse businesses at an attractive price point requires significant scale and a strong risk-taking position. At the heart of the case for renewable energy platforms lies the concept of aggregation itself. The difference is that renewable energy platforms are not driven by offtaker consumption profiles when selecting generation facilities. By pooling together renewable energy from various sources, platforms can create a diversified energy portfolio that is more resilient to fluctuations in generation. This diversification helps to smooth out the variability inherent in renewable energy sources, such as solar and wind power, ensuring a more stable and reliable energy supply and a less risky product proposition to businesses. As a result, businesses that work with platforms enjoy a more consistent and predictable energy supply, reducing the risk of energy shortages or surpluses.

Consumption

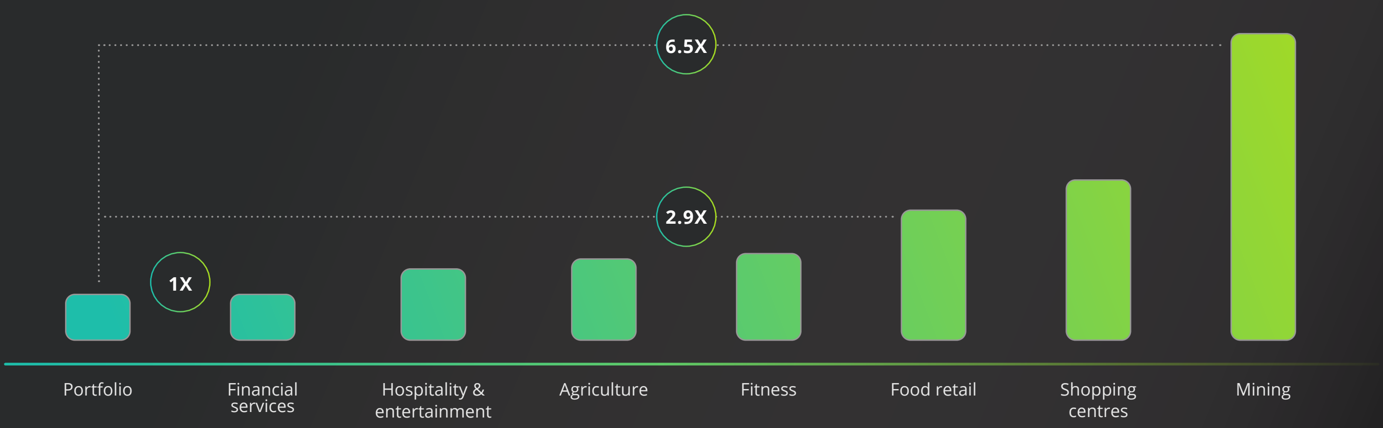
It is equally important to consider the financial and risk benefits of a diversified business consumption portfolio. Renewable energy platforms can match diverse generation types and locations with even more diverse business consumption profiles to create an eco-system that achieves a higher percentage of renewable coverage, with a negligible risk of wasted generation. The following table shows how aggregation and diversification of demand can increase the coverage level a portfolio of businesses (from different industries) can achieve before generation becomes wasted.

THE CASE FOR RENEWABLE ENERGY PLATFORMS

Number of industries (in equal share)	1	2	3	4	5
% renewable energy coverage for the portfolio before wastage	49%	64%	74%	77%	78%

The risk of wasted generation is significantly reduced as more businesses are included in the demand portfolio. Companies consume energy differently and this consumption can be subject to independent and unrelated market factors. For example, an increase in demand for certain mining materials for export and manufacturing that is impacted by local consumer spending pressures are independent and have opposite electricity demand effects. As a result, the platform ecosystem has an ability to better absorb any single industry's electricity demand volatility compared to a traditional bilateral PPA. This can be shown by comparing the consumption volatility of different industries over the last three years to the consumption volatility of a portfolio of these same industries over the same period.

GRAPH 8: CONSUMPTION VOLATILITY OF A PLATFORM PORTFOLIO RELATIVE TO INDIVIDUAL BUSINESSES



The result is that changes in consumption, whether specific to a company or industry, can be better absorbed by the platform as generation can be reallocated between businesses in the platform ecosystem. The result is a significantly reduced risk of wasted generation.

Energy as a product

These platform dynamics relating to both generation and consumption fundamentally shift the risk profile of renewable energy procurement and delivery. The proposition to offtakers is more similar to taking out a home loan or signing a mobile phone contract than it is to entering traditional renewable energy procurement contracts. A more commoditised product allows for greater consumer understanding and promotes increased competition amongst renewable energy suppliers. The notion of selling 'energy as a product' is crucial for the development and transformation of any renewable energy market.

THE COST OF SHORT-TERM OR DELAYED PROCUREMENT

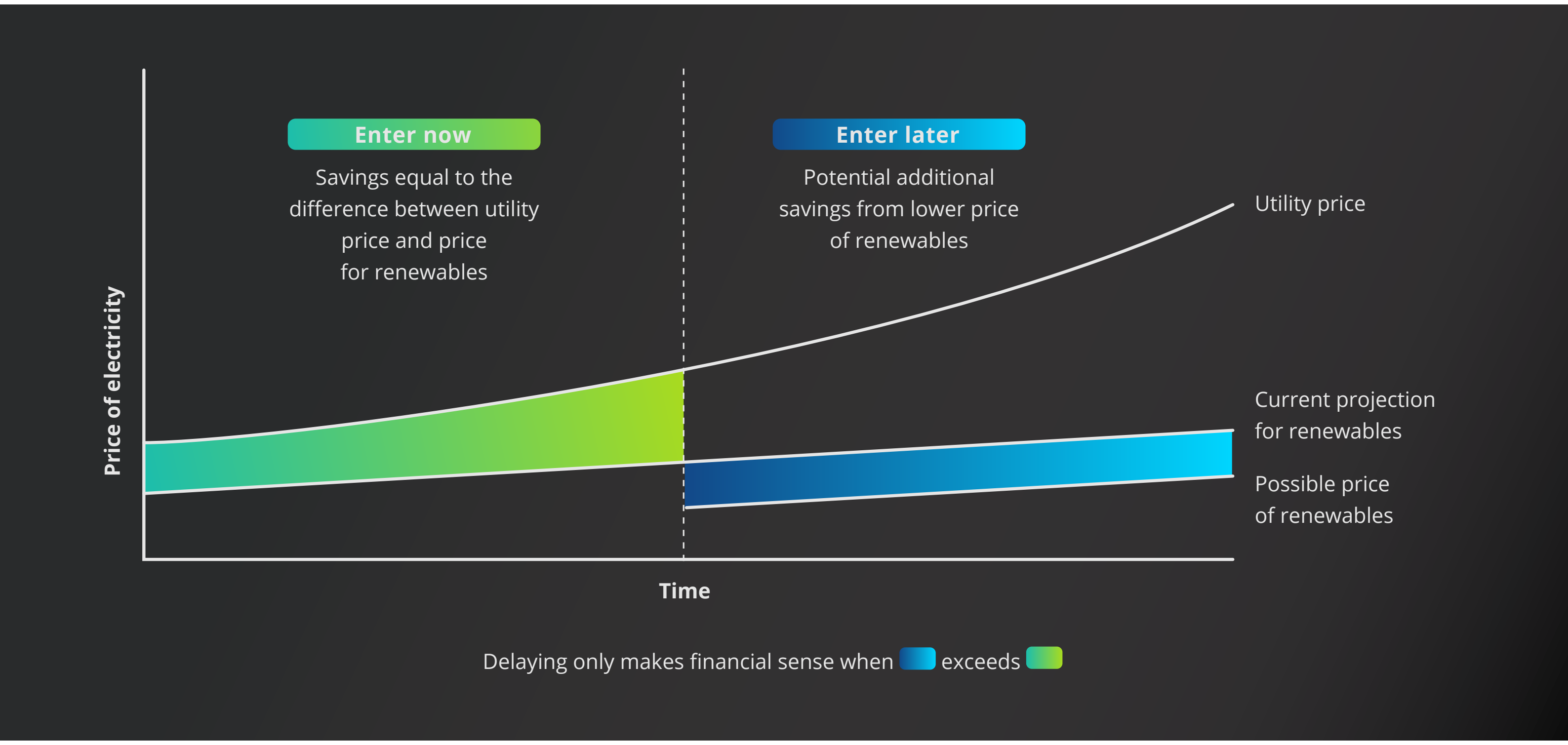
The world of renewable energy procurement can be complex, particularly in South Africa where the market for the private procurement of renewable energy is in its early stages of development. The variety of available renewable energy generation technologies, together with the large number of new entrants to the market, makes it difficult for businesses without the necessary expertise to commit to any strategy over the medium to long term. There is a multitude of considerations and the perceived fluidity of the market that key decision makers face. The conclusion made by corporate companies is often to defer their procurement, or at least adopt an incremental procurement strategy, until they have a firmer understanding of the market's trajectory.

While this approach is understandable, there is a strong mathematical and evidence-based argument against taking a short-term view or deferring the procurement of renewable energy.

Opportunity cost

Renewable energy is available at a discount on current utility prices in South Africa. This discount increases by the contract term. By deferring the procurement decision in anticipation of lower renewable energy prices in future, businesses incur an opportunity cost of the savings lost during the period of deferral. For a business to ever recover these lost savings, the price of renewable energy must fall significantly so that the additional savings are enough to account for this opportunity cost.

GRAPH 9: ILLUSTRATION OF OPPORTUNITY COST OF DELAYED PROCUREMENT



Similarly, by taking out a short-term contract at a lower discount, businesses incur an opportunity cost of the savings lost from a higher discount on a long-term contract.

Before considering the factors driving renewable energy prices, we must appreciate the extent of the reduction in prices required for any deferral, or short-term contract with a lower discount, to make economic sense. The table below shows the reduction in renewable energy prices that is required for a business to be in the same economic position if procurement had not been deferred.

THE COST OF SHORT-TERM OR DELAYED PROCUREMENT

TABLE 15: REDUCTION IN RENEWABLE ENERGY PRICES REQUIRED TO JUSTIFY A DELAY IN PROCUREMENT

Length of delay (years)	Contract length (years) 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2.4%	2.1%	1.9%	1.8%	1.7%	1.6%	1.6%	1.5%	1.5%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
2	5.6%	4.9%	4.4%	4.2%	3.9%	3.7%	3.5%	3.4%	3.3%	3.2%	3.1%	3.0%	3.0%	2.9%	2.9%	2.8%
3	9.6%	8.4%	7.6%	7.0%	6.5%	6.1%	5.9%	5.6%	5.4%	5.2%	5.1%	5.0%	4.9%	4.8%	4.7%	4.6%
4	14.3%	12.6%	11.3%	10.4%	9.6%	9.1%	8.6%	8.2%	7.9%	7.6%	7.4%	7.2%	7.0%	6.9%	6.8%	6.7%
5	20.2%	17.5%	15.7%	14.3%	13.3%	12.4%	11.8%	11.2%	10.7%	10.4%	10.1%	9.7%	9.5%	9.3%	9.1%	8.9%
6	26.7%	23.2%	20.7%	18.9%	17.4%	16.3%	15.4%	14.6%	14.0%	13.5%	13.0%	12.6%	12.3%	12.0%	11.7%	11.1%
7	34.2%	29.6%	26.4%	24.0%	22.2%	20.7%	19.4%	18.5%	17.7%	16.9%	16.3%	15.8%	15.4%	15.0%	14.2%	13.5%
8	42.7%	37.0%	32.8%	29.8%	27.4%	25.5%	24.0%	22.8%	21.7%	20.8%	20.0%	19.4%	18.8%	17.7%	16.8%	16.0%
9	52.3%	45.1%	40.0%	36.2%	33.2%	30.9%	29.1%	27.4%	26.2%	25.1%	24.1%	23.3%	21.9%	20.7%	19.6%	18.6%
10	62.8%	54.1%	47.9%	43.3%	39.7%	36.9%	34.5%	32.7%	31.1%	29.7%	28.6%	26.7%	25.2%	23.8%	22.5%	
11		64.0%	56.6%	51.1%	46.8%	43.4%	40.6%	38.4%	36.5%	34.8%	32.5%	30.4%	28.7%	27.1%		
12			66.1%	59.6%	54.5%	50.5%	47.3%	44.6%	42.3%	39.2%	36.6%	34.3%	32.3%			
13				68.8%	62.9%	58.2%	54.4%	51.2%	47.3%	43.9%	41.0%	38.4%				
14					72.0%	66.6%	62.1%	56.9%	52.6%	48.8%	45.6%					
15						75.6%	68.7%	63.0%	58.1%	54.0%						

Assumptions: utility price inflation of CPI+2%; renewable energy discount applied linearly across contract term; 10% for 5-year term and 23% for 25-year term

For example, a business may want to procure renewable energy over a five-year contract term. A decision may have been made to defer entry into the market by three years, either in anticipation of future price reductions or because of market uncertainty. Alternatively, the business could enter an eight-year contract for renewable energy today. For the deferral to make economic sense, ie, for the business to be in the same financial position over the eight-year period, the price of renewable energy must fall by 9.6% over the three-year deferral period. Furthermore, this calculation does not include the cost of emissions tax or import duties incurred by the business during the three-year deferral period.

To determine the likelihood of experiencing these required price reductions, this paper draws on evidence-based data from South Africa's public and private renewable energy markets and from the most developed renewable energy markets across the globe. Two key considerations are made:

01 | The trends in renewable energy technology prices over time

02 | The declining availability of grid capacity for renewable energy projects

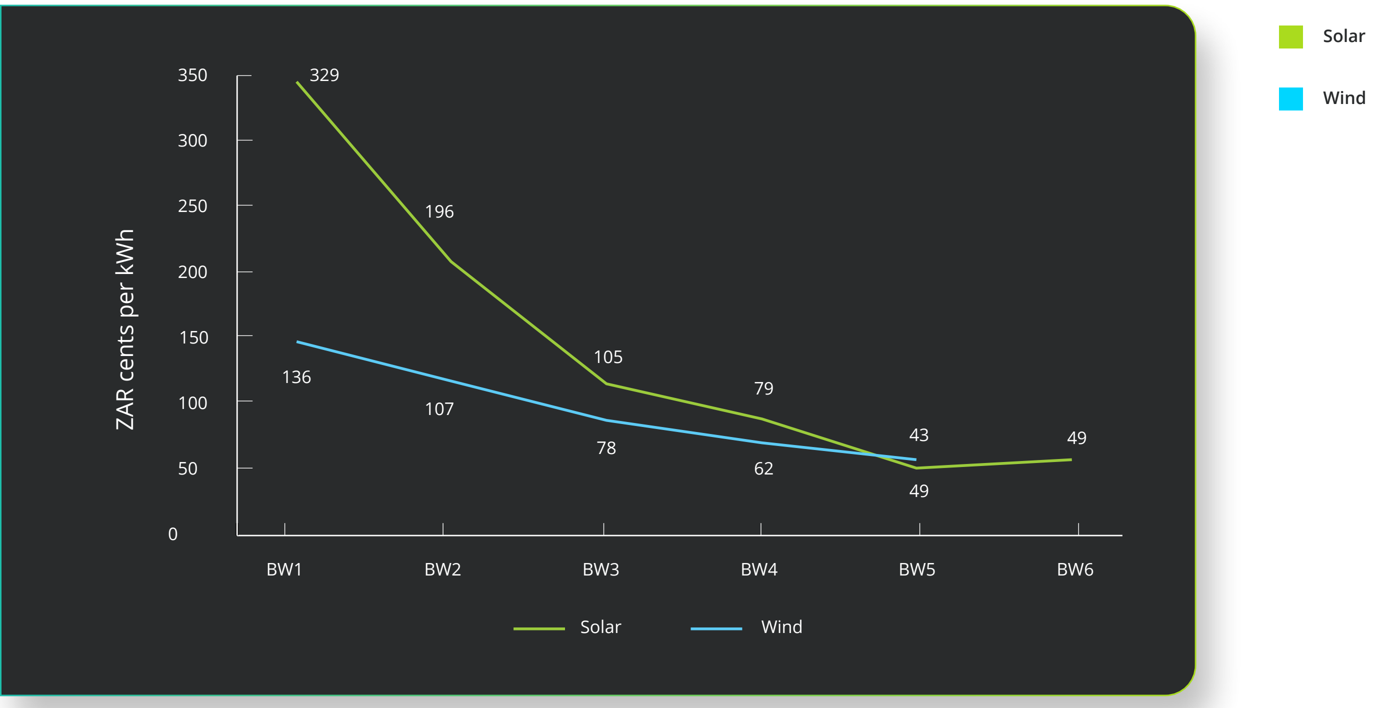
01 | Trends in technology prices

Before assessing the trend in the cost of solar and wind technologies over time, it is important to appreciate the breakdown of total project costs for a renewable energy generation facility. Typically, not more than 40% to 60% of the project's total cost is attributable to the cost of the actual generation technology (solar panels or wind turbines). The remaining 40% to 60% of the project costs are driven by expenditure for land procurement and contracts for engineering services, plant operation and maintenance. This implies that the scope for project cost reductions purely because of technology improvements is limited as technology typically accounts for less than 60% of the total cost of generating energy.

With this dynamic in mind, the cost of renewable energy has decreased significantly over the last decade. While the market for the private procurement of renewable energy is still in its infancy in South Africa, price trends can be drawn from the government's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). This programme was introduced to encourage and facilitate private sector investment into renewable energy generation connected to the national grid. With the South African government as the sole offtaker to REIPPPP generation projects, Independent Power Producers (IPPs) enjoy long-term national treasury-backed procurement contracts. The prices that IPPs bid are low to reflect such security. Bid Window 1 of the Government's REIPPPP programme in 2011 fetched prices of R3.29 per kWh for solar and R1.36 per kWh for wind. Improvements in both technologies meant that solar and wind prices reached their lowest point 10 years later in Bid Window 5 at R0.43 and R0.49 per kWh respectively. However, the price for solar projects in the latest Bid Window 6, which announced its preferred bidders in December 2022, increased for the first time in the programme's history to R0.49 per kWh. No onshore wind projects were awarded in Bid Window 6.

THE COST OF SHORT-TERM OR DELAYED PROCUREMENT

GRAPH 10: AVERAGE REIPPPP TARIFFS (ZAR c/kWh) FOR SOLAR PV AND WIND[1]



The levelling out of prices from both wind and solar projects, together with the limited potential for technology improvements to create further cost efficiencies, implies that further reductions in the price of renewable energy in South Africa are possible but difficult to achieve.

02 | Limited and reducing grid availability

In electricity markets across the globe, developed and emerging, private power generators are finding it increasingly difficult to obtain the necessary authorisation to connect their generation facilities to national electricity grids. This is largely the result of congested queues of project developers, network infrastructure needing to be upgraded and regulatory frameworks that do not always optimally allocate grid capacity to sufficiently developed projects. This issue is most prominent in some of the most developed global economies:

TABLE 16: AVERAGE WAIT TO CONNECT RENEWABLE ENERGY GENERATION FACILITIES TO NATIONAL ELECTRICITY GRID

Region	*Average wait for grid connection*
UK	10 to 15 years[2]
Europe	5 to 10 years[3]
USA	5 years[4]

[1]FinerGreen: Results of South Africa Renewable Energy Independent Power Producer Procurement Program ("REIPPPP")
[2]https://ratedpower.com/blog/UK-interconnection-delays/
[3]https://www.edie.net/report-eus-renewable-energy-rollout-at-risk-due-to-grid-connection-delays/
[4]Lawrence Berkeley National Laboratory

THE COST OF SHORT-TERM OR DELAYED PROCUREMENT

Importantly, these waiting periods have been increasing over time. In the USA, for example, waiting times have more than doubled since 2008. It is estimated that global grid infrastructure needs to more than double by 2050, requiring an investment of almost $550 billion a year by 2030[5] .

Although South Africa is lagging in terms of market development, we are already beginning to see a similar trend emerging, with no wind projects being awarded in Bid Window 6 of the REIPPPP programme due to grid constraints. The latest generation connection capacity assessment (GCCA) released by Eskom shows that none of the three cape provinces (which have the most abundant solar and wind resources in South Africa) have any available grid capacity. This closing window of opportunity means that IPPs and businesses looking to procure wheeled renewable energy simply cannot afford to delay their decision making at the risk of never receiving allocated grid capacity for decades.

While nothing is certain, it is highly unlikely that the opportunity cost of deferral, or taking shorter-term low discount contracts, ever outweighs the potential financial benefits of doing so. It is crucial that businesses appreciate the mathematical and evidence-based arguments against deferring the procurement of renewable energy or taking a short-term view as well as the high risks associated with deferring procurement.

[5]WITS; Grid capacity a significant obstacle to renewables transition and fixing load shedding

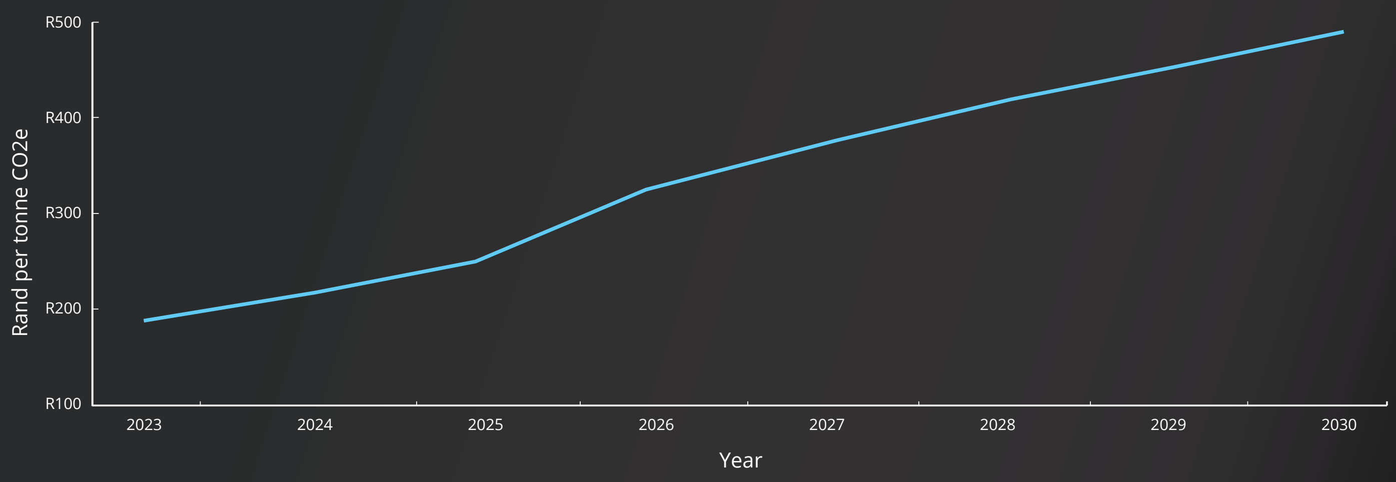
THE RISING COST OF BUSINESS EMISSIONS

Businesses across the globe are under increasing pressure to reduce emissions from their operations. This pressure comes in two forms. This first form is reputational pressure driven by the public demand for businesses to demonstrate a decreasing environmental impact and a clear goal to achieving carbon neutrality and, eventually, a net zero position. Businesses also face financial pressure driven by the impending introduction of local and international carbon taxes and import levies. For businesses in South Africa, the latter poses a significant threat to business continuity. There are two forms of such regulation on the horizon for South African businesses: the introduction of a more stringent South African carbon tax, and the implementation of the European Union's Carbon Border Adjustment Mechanism (CBAM).

South African carbon tax

At R190 per tonne of carbon dioxide equivalent (CO2e) emitted, the price of carbon in South Africa is low, relative to the policies of other economies around the world. Carbon prices in the European Union, for example, are eight times this. Prices in California are four times this amount. The South African government has adopted a three-phase approach to the introduction of a carbon tax, with the implementation currently in phase one. The second phase of South Africa's carbon tax mechanism is expected to be introduced in 2026, which will result in reductions to existing tax allowances. Additionally, the government has proposed increases to the South African carbon tax rate well above expected CPI inflation up until 2030. The potential impact on South African businesses is substantial. For example, a company emitting 100,000 tonnes of CO2e per year and paying approximately R3.82 million in carbon tax in 2023 could be paying as much as R34.2 million in carbon tax by 2030[1] .

GRAPH 11: SA CARBON TAX RATE



The European Union's Carbon Border Adjustment Mechanism (CBAM)

The European Union's Carbon Border Adjustment Mechanism (CBAM), expected to be online in 2026, is threatening the international competitiveness of exports from South African businesses. CBAM is a tariff levied on importers of carbon intensive products within the European Union (EU), with the intention to equalise the price of carbon between EU manufacturers and EU importers. This is particularly concerning given the significant differentials in the price of carbon between South Africa and the EU. Additionally, South Africa has the dirtiest electricity grid factor among any major global economy (0.87 kg CO2e per kWh[2]), which is twice the global median and, as a result, is the 12th largest emitter of greenhouse gases globally. This could have severe consequences for South African businesses once CBAM is extended to include scope 2 emissions from electricity use for all imports. It is currently envisaged that scope 2 penalties will, initially, only apply to imported cement and fertiliser. It is estimated that $2.8 billion of South African exports are under threat in the short term as a result of CBAM, particularly the iron, steel and aluminium industries. As the CBAM mechanism is developed to include more products, this number is expected to grow[3].

For businesses with low renewable energy coverage levels, the development of these policies to include scope 2 emissions from electricity use could erase all financial savings provided by renewable energy. This is particularly true for the embedded solar model and wheeled solar model where coverage levels are particularly low, leaving the business exposed to impending regulation.

[1]Deloitte. Available at https://www.deloitte.com/za/en/services/tax/perspectives/south-africas-carbon-tax-changes-and-implications-for-taxpayers.html
[2]Carbon Footprint Ltd. Available at https://www.carbonfootprint.com/international_electricity_factors.html
[3]Maimela S. 2023. Responding to the European Union's Carbon Border Adjustment Mechanism (CBAM): South Africa's vulnerability and responses.

GLOSSARY
OF TERMS

Coverage: The percentage or proportion of renewable energy which is supplied in relation to the offtaker's total energy requirements. This will typically vary greatly from month to month depending on how much renewable energy was produced by the renewable energy supplier and how the offtaker's electricity consumption varied during the month. The proportion of coverage that is not supplied by the renewable energy supplier is typically made up by Eskom-supplied energy.

Independent power producer (IPP): Also known colloquially as 'generators' or 'developers', IPPs are the organisations that own, build and operate renewable energy power plants. IPPs are responsible for identifying suitable land, getting the relevant permits, securing financing, constructing the plants (with contractors if necessary) as well as operating and maintaining the plants.

Offtaker: A party or entity that agrees to purchase the renewable energy of a particular renewable energy supplier, typically electricity or another form of energy. Offtakers are commonly involved in power purchase agreements (PPAs) for renewable energy projects, where they commit to buying the electricity generated by the project over a specified period. A renewable energy trader or aggregator can be an offtaker to an IPP and have offtakers of its own to whom it then sells the energy.

Photovoltaic (PV): This is one of the main forms of solar energy production. It is a type of renewable energy technology that converts sunlight directly into electricity. Most will know of this as 'solar panels'. This process occurs in solar cells, which are typically made of silicon or other materials. When sunlight strikes a solar cell, it excites electrons in the material, creating an electric current. Multiple solar cells are connected to form a solar panel and several panels can be combined to create a solar array or solar power system. Photovoltaic energy is clean, renewable and sustainable, making it an important part of the global transition to clean energy sources.

Power purchase agreement (PPA): This is the authoritative and legal contract that governs the relationship between an IPP and its customer (known also as an 'offtaker'). The PPA will stipulate measures such as how much energy is procured, the offtaker's obligation to pay for energy and the timelines for when energy should be delivered. The PPA will also outline the necessary legal codifications as to what should happen under various contract scenarios, such as force majeure.

Renewable energy certificates (RECs): A tradable, market-based instrument that represents the environmental attributes and benefits associated with generating electricity from renewable energy sources. When renewable energy is generated, it produces two main products: the electricity itself and the environmental attributes, which include reductions in greenhouse gas emissions and other pollutants. A REC certifies the legal and environmental benefits of one megawatt-hour (MWh) of renewable electricity generation. It provides proof that a certain amount of electricity was generated from a renewable source and allows the holder of the REC to make claims about using renewable energy. RECs are often bought and sold separately from the electricity itself, allowing individuals, organisations and governments to support renewable energy generation and claim the associated environmental benefits.

Take-or-pay: A contractual provision used in agreements between a seller and its offtakers (the buyers) to ensure a minimum level of commitment or revenue payable to the seller. In the context of renewable energy contracts, take-or-pay contracts are common.

In a take-or-pay contract, the offtaker agrees to either consume a minimum quantity of renewable energy from the seller (the 'take' part) or pay a specified amount as if they had consumed it (the 'pay' part), even if they do not actually use the energy. This ensures a minimum level of revenue for the seller, even if the offtaker does not fully use the contracted quantity of renewable energy.

Take-or-pay contracts are used to provide security to the seller to ensure a minimum level of revenue to support ongoing operations. However, they can also be seen as a risk for the buyer, as buyers may be required to pay for goods or services that they do not actually need or use.

GLOSSARY
OF TERMS

Take-and-pay: Unlike take-or-pay contracts, take-and-pay contracts only require payment for the amount of renewable energy supplied by a seller and actually consumed by the offtaker. This provides more flexibility for the offtaker, as they are not obligated to pay for unused or unneeded quantities of renewable energy.

Tariff: The charge per kilowatt hour (kWh) or megawatt hour (MWh). This can be levied by an independent power producer (IPP) to an offtaker for renewable energy supplied, or by Eskom to its customers for Eskom energy consumed. Eskom tariffs come in different tariff structures depending on the customer and the consumption behaviour of the customer. For wheeling to be enabled, an Eskom customer must currently be on a time-of-use tariff structure, where they are charged by Eskom according to the time-of-use periods during which electricity is consumed.

Time of use (TOU): The pricing structure implemented by Eskom or a local authority where electricity tariffs vary depending on the time of day. Under time-of-use pricing, electricity is divided into three different periods – peak, standard and off-peak periods. These periods are divided into two seasons – high demand and low demand, each with different pricing rates. Peak periods usually correspond to times of high electricity demand, such as weekday mornings and evenings when people return home from work. Standard periods typically cover times of moderate demand, such as daytime hours. Off-peak periods usually occur during times of low demand, such as late at night or early in the morning, large parts of Saturday and all of Sunday. High demand season consists of the winter months of June to August, and low demand season is all other months of the year.

Wheeling: This is the core financial mechanism that enables the private procurement of renewable energy. The process involves at least three parties – the IPP, the offtaker, and the third party responsible for the national grid (currently Eskom transmission). Wheeling is the process where an IPP supplies energy to an offtaker through the national grid. The charge or energy that gets supplied into the grid at a moment in time does not need to physically make its way through to the designated offtaker. Once the energy gets produced, it becomes part of a general 'pool' of energy flowing through the grid, which is then consumed by any potential user of energy on the grid at the same time. All that matters in practice is that the IPP supplies energy into the grid at the same relevant time that the offtaker is consuming the same amount of energy from the grid. The central network operator will then recognise this financial transaction as being 'wheeled' and charge relevant fees to each party for use of the national grid. Thus, the IPP has fulfilled its obligation of supplying a unit of renewable energy into the grid, and the offtaker fulfils the obligation of consuming one unit of energy from the grid at the same relevant time.

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