

# DIVERSITY WITHIN COLLECTOR NETWORKS: ENHANCING GRID RESILIENCE THROUGH SUSTAINABLE INTEGRATION



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## 1 INTRODUCTION AND BACKGROUND

Energy is the lifeblood of South Africa's economy, powering industries, homes, and the everyday lives of millions. In recent years, however, the country has faced significant challenges, particularly with the persistent issue of loadshedding due to limited generation capacity to serve the ever-growing demand. This has not only disrupted businesses and households but has also underscored the critical role that a stable and sufficient energy supply plays in economic growth and social well-being.

Despite these struggles, there is a renewed sense of optimism. Recent developments have shown that the tunnel we've been navigating does indeed have light at the end. The absence of loadshedding in recent months, coupled with the availability of additional generation capacity from a diverse range of renewable energy (RE) sources, signals a turning point. This newfound stability offers a glimpse of a future where energy is not just a commodity, but a cornerstone for sustainable development and economic resilience.

In 2023 a RE grid survey was conducted by Eskom Holdings SOC in collaboration with SAPVIA and SAWEA [1]. The survey results in Figure 1 show the high RE interest in developing projects within the country. In the more recent 2024 grid survey, it was unveiled significant additional potential for RE projects across various regions. By mapping out these opportunities, the survey highlights areas where further development can be pursued to enhance grid capacity and support the transition to a more sustainable energy mix. These identified projects, ranging from solar and wind farms to innovative hybrid solutions, represent untapped resources that can be leveraged to meet growing energy demands. The data provided by the survey not only offers a roadmap for future investment but also emphasizes the strategic importance of aligning grid infrastructure with RE growth. This alignment is crucial for maximizing the efficiency and effectiveness of the grid, ensuring that South Africa can fully capitalize on its RE potential.

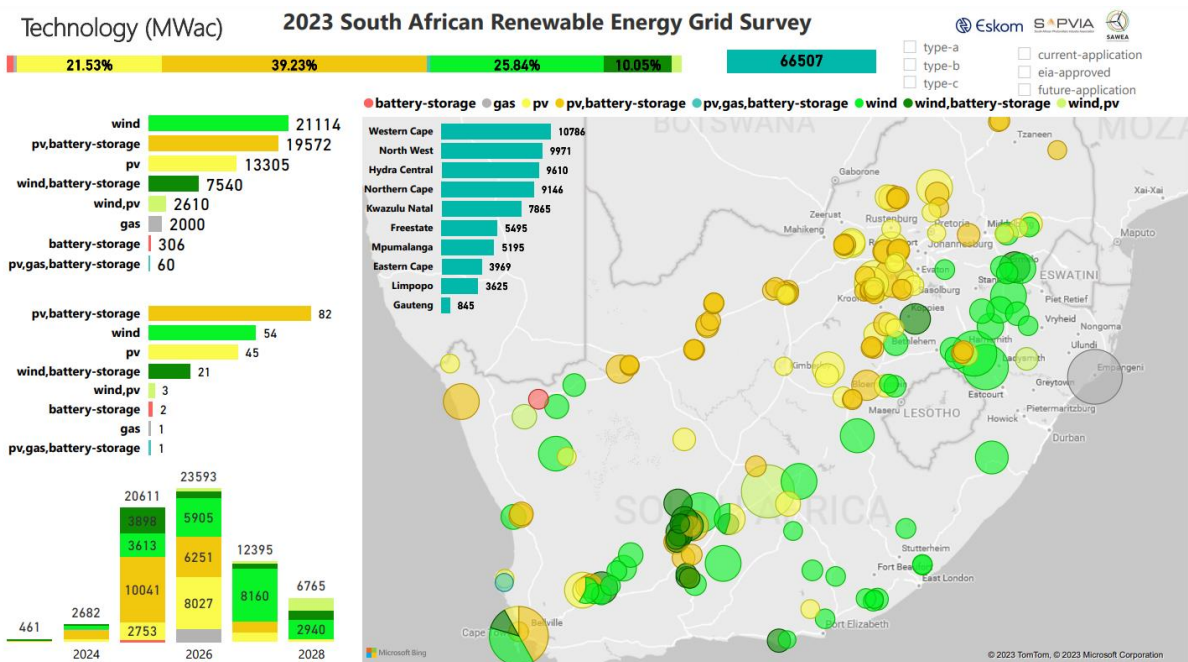


Figure 1: South African RE Grid Survey results [1]

The importance of energy cannot be overstated—it fuels our economy, drives innovation, and supports the quality of life for every South African. As we look ahead, the focus on enhancing our electrical infrastructure, diversifying our energy mix, and ensuring reliable supply will be pivotal in securing a prosperous and sustainable future for the nation.

## 1.1 Background

The Independent Power Producers Office (IPPO) is a critical entity in South Africa's energy landscape, established through a collaboration between the Department of Mineral Resources and Energy (DMRE), National Treasury (NT), and the Development Bank of Southern Africa (DBSA). Created specifically to deliver on the objectives of the Independent Power Producers Procurement Programme (IPPPP), the IPPO has been instrumental in securing electrical energy from private sector producers, encompassing both renewable and non-renewable sources.

IPPPP was initiated to reduce South Africa's dependency on fossil fuels, foster a local renewable energy industry, and contribute to socio-economic development and sustainable growth. Since its inception in November 2010, the IPPO has continuously evolved through successive Memoranda of Agreement (MoA) to extend its mandate, most recently until 2023. The programme not only focuses on energy procurement but also aligns with broader national goals such as job creation, social upliftment, and expanding economic ownership.

Within this framework, the current study on the implementation of Renewable Energy Development Zones (REDZs) and the facilitation of collector substations underscores the IPPO's vital role. These initiatives are central to integrating renewable energy independent power producers (RE IPPs) into the national grid. The transmission and sub-transmission networks, essential for connecting and collecting RE, presents several challenges that require meticulous planning and coordination.

The IPPO's expertise is crucial in addressing these challenges by providing professional advisory, procurement management, and comprehensive monitoring, evaluation, and contract management services. This ensures that the sub-transmission infrastructure is adequately developed or augmented to support the influx of RE. The study identified potential Renewable Energy Nodes (RE Nodes) within a 60 km radius of key substations in South Africa, necessitating a detailed examination of technical, regulatory, environmental, and stakeholder engagement aspects.

The IPPO's integral role in the development of REDZs and the facilitation of collector substations exemplifies its commitment to advancing South Africa's RE infrastructure. By effectively integrating RE

IPPs into the national grid, the IPPO supports the country's transition to a sustainable energy future while meeting its socio-economic and environmental goals.

The Implementation of the REDZ and Collector Substation Enablement study identified key recommendations to enhance South Africa's renewable energy integration to the grid and thus promoting greater renewable energy penetration. As part of this initiative, we proposed the further development and use of a Renewable Energy (RE) Diversity Calculation Tool. This tool will assist the Eskom and IPPO in optimizing the integration of renewable energy to the grid through the collector networks, maximizing energy yield, and ensuring cost-effective energy procurement.

## 1.2 Challenges with Grid Integration

The distribution / sub-transmission network plays a crucial role in connecting (collecting) RE IPPs to the grid, for this energy to be delivered to the load centres via transmission grid. However, integrating RE IPPs into the distribution network can present several challenges.

Thus, careful planning and coordination is required to develop or in some cases augment the sub-transmission network to effectively connect and collect RE generation. There are potential RE Nodes which are 60km radius of the identified substations as illustrated in figure below. The assignment involved technical, regulatory, environmental and stakeholder engagement services over the period of the project.

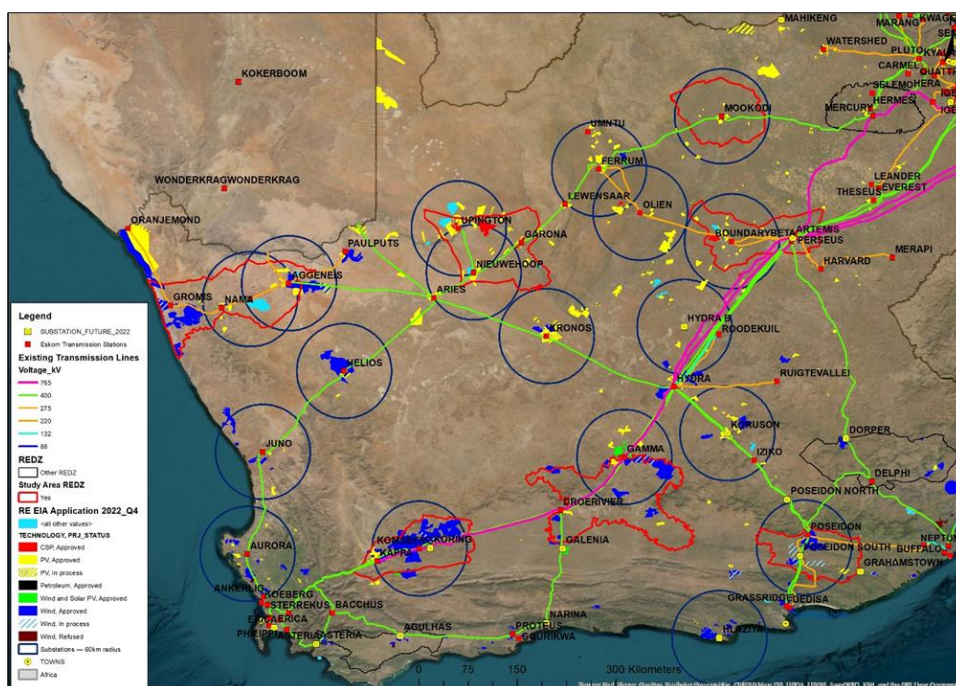


Figure 2: Potential RE Nodes identified for technical, regulatory, environmental assessments and stakeholder engagement services

The objective of this assignment is to provide an updated and appropriate collector network guideline and associated enablers to alleviate challenges with grid connection of IPPs. These challenges can be summarised as follows:

- After the REIPPP bid windows 1 to 6, the grid evacuation capacity in the high RE resource areas has been depleted. Thus, the transmission corridor evacuation capacity in the Greater Cape (Northern Cape, Eastern Cape and Western Cape Provinces) is 0 MW as per the Generation Connection Capacity Assessment (GCCA2025) [2]. Network extensions and upgrades are required to unlock additional network capacity to connect the least cost IPP development in the high RE resource areas.

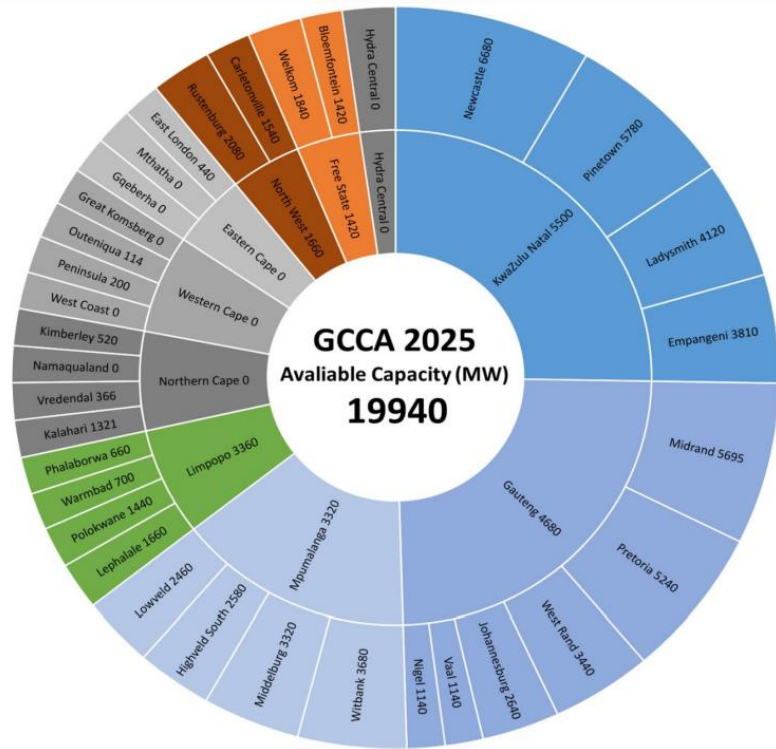


Figure 3: Summary of the GCCA 2025 results [2]

- RE-IPP plants have a 1 to 2 year post financial close construction period, whereas transmission line projects typically have a 6-to-8-year project life cycle. Thus, if transmission line projects are only initiated at the Budget Quote acceptance stage, then the IPP projects risk being delayed by approximately 4-6 years. This will critically impact on the viability of the IPP projects. Approximately 3 to 5 years of the transmission line project timeframe is the preparation time to perform the EIAs, servitude acquisition and designs. This stresses the need for the early initiation of the necessary grid project development works.
- Given Eskom's current financial constraints, there is a need for effective strategic planning and engagement that will not only enable the integration of RE onto the grid, but also alleviate some of the constraints experienced by the grid operator.
- Due to the individual project approach and timelines of the current generation procurement process, grid economy of scale is difficult to obtain without comprehensive and integrated strategic grid plans, with timely grid investment and project release.

To help address these challenges, the development of the proposed REvGrid Diversity Calculation Tool aims to:

- **Optimize Capacity:** Enable Eskom planners to maximize the use of the grid capacity to integrate more RE plants using diversity. This will be achieved by potentially unlocking additional capacity that can be integrated onto the grid through RE source diversity between RE plants using geographical diversity and or different resources.
- **Cost-Effective Mix:** Assist procurement teams (IPPO) in determining the most economical RE projects combinations based on generation profile data, energy time of use, and generation tariffs. This will allow for determining the appropriate energy mix to serve the country's demand based on plant generation capability (energy yield per time of use). Through the bid windows released by the Department of Mineral Resources and Energy (DMRE), generation capacities are detailed with total MW per technology type. With the potential use of the tool, an appropriate energy mix that will yield an optimized generation profile to inform energy procurement by optimizing the cost of energy and overall system generation profile, producing a high energy yield at appropriate times of use.

- **Enhance Reliability:** Improve the security of supply by diversifying energy sources within specific regions and portions of the national grid. This diversification ensures a more resilient energy system capable of withstanding resource fluctuations and disruptions.

Thus, careful planning and coordination is required to develop or in some cases augment the sub-transmission network to effectively connect and collect RE generation. The objective of this assignment is to develop a tool that will provide a coordinated and efficient RE generation network integration.

The REvGrid Diversity Tool stemmed from the study's recommendation to further develop a tool for use by Eskom planners and the IPPO. This tool will assist the Eskom planners to determine spare grid capacity for generation plants through RE plant's generation diversity. Additionally, determine the most appropriate RE sites from independent power producers (IPPs) to maximize energy yield while optimizing the use of the grid capacity and considering the cost of generation. By implementing this recommendation, the IPPO and Eskom desire in achieving South Africa's RE goals, ensuring a sustainable and cost-effective energy future can be supported.

## 2 METHODOLOGY

In the pursuit of sustainable energy solutions, the swift integration of renewable energy sources into existing power grids has become a necessity. The integration of RE technologies into the grid can be challenging due to technical constraints associated with these technologies and the designs of the collector networks. In this regard, the Tool is intended to optimise the use of the collector networks capacity by considering diversity between the RE plants within those collector networks. By recognizing the unique resource and generation attributes of each RE plant and incorporating them into the design framework, it becomes possible to optimally select the RE with specific resource characteristics to increase the utilization of the grid by connecting more RE MW.

As part of this study, the technical team worked to develop a basic RE diversity calculation tool. It's important to clarify that while the enhancement of accounting for RE plant diversity within collector networks was not a predetermined deliverable of the study, it emerged as a valuable addition through ongoing conversations with the Eskom team. This collaborative effort aimed to not only enrich the study but also provide practical support and organization for Eskom's needs. The development of the REvGrid Diversity Calculation Tool follows a structured approach to ensure it effectively unlocks the identified opportunities and meets the objectives. The REvGrid Diversity tool is currently designed to maximize the integration of RE sources into the existing grid through RE diversity. The linkage of the tool to the grid planning is that the Collector Grid Approach promotes sharing of grid infrastructure and the REvGrid Tool adds optimization the integration of the RE resource onto the grid. Below is an outline of the methodology employed to enhance the tool for use by Eskom and the IPPO.

The tool was developed to not only determine the spatial and technology diversity within the same collector networks using existing RE plant performance information, but to see the overall generation at MTS level that may present additional generation capacity to be added onto the grid. This will eventually result in the optimization of both distribution and transmission infrastructure.

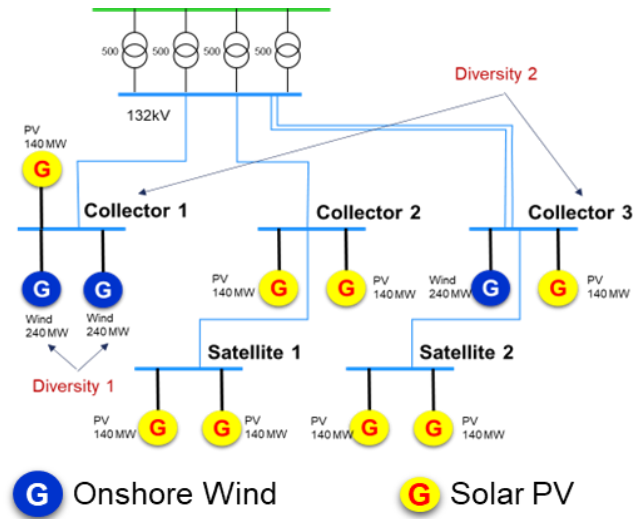


Figure 4: RE Diversity within an MTS or Collector Network

## 2.1 Initial Development and Capabilities

### 2.1.1 Data Inputs

**Data Provided:** IPP applications, RE plant generation profiles, geographic locations, RE project types, and per unit generation data spanning over five years, supplied by IPPs to Eskom.

**Data Processing:** The raw profile information is stored and utilised by the tool. Users can select up to five (5) sites within a specific MTS or collector network to conduct diversity calculations.

Currently, the tool allows the user to select sites based on RE technology type and MTS the proposed projects are located within. The raw generation profile information provided is based on the measured existing RE plant generation over a period of 5 years. Sites located within less than 60km radius of the Main Transmission System (MTS) substation or fall within the same proposed collector network radial geographic area can be selected for assessment. For each site the location (coordinates) for spatial correlation, hourly per unit generation profile for diversity calculation and the plant technology type providing resource capabilities is analysed.

### 2.1.2 Technology and Resource Diversity Analysis

**Objective:** To assess and leverage the diverse generation profiles of different RE sources such as solar and wind across the country based on data inputs from existing operational RE plants.

**Current Capabilities:** The tool evaluates the diversity between RE technologies within the same MTS substation or collector network using existing RE plant performance data to identify potential additional generation capacity.

The tool uses the hourly per unit generation of each selected site to subsequently calculate the hourly diversity between these sites. Inserted contracted capacity allow the user to estimate the generation per selected site, and overall generation taking into diversity per hour.

### 2.1.3 Analysis and Outputs

**Diversity Calculation:** Assesses the diversity between selected sites on an hourly basis.

**Generation Estimates:** Provides hourly total generation estimates in both per unit and MW, per time of use.

**Average Profiles:** Charts the average hourly per unit and MW generation for each site and for consolidated sites.

**Histogram Analysis:** Displays the distribution and frequency of system peak generation using the diversity values.

Generation profiles of the selected sites are also visually represented on the tool to better understand the profile behaviour for the different sites.

Using the calculated hourly diversities, analysis is conducted on the proposed study area. The maximum per unit generation for each selected site is displayed with its respective date and time to provide an understanding of when peak generation occurred for the selected site. The combined sites maximum diversity is also highlighted to show the system peak with its time and date for comparison. The tool allows the user to input their own contracted capacity in megawatt (MW) for each site selected to simulate the contracted capacities presented by potential RE projects on the horizon.

The peak generation based on the inputted contracted capacity and the per unit generation at combined sites maximum diversity time and date is shown to present the estimated generation of each plant at that stage.

Another current feature of the tool is displaying the calculated hourly diversity on a histogram and pareto to understand the frequency of occurrences of the calculated hourly total generation of the sites based on the input data. Using the complementary cumulative distribution function (CCDF) of the histogram that provides insights to the probability that a data point is greater than a certain value. This is particularly useful in displaying whether dates and time of high diversities are indeed anomalies or regular occurrences. This information can potentially assist network planners with determining appropriate shut down periods for maintenance during low generation and low demand periods, and potentially necessary generation curtailment.

## 2.2 Application of the REvGrid Tool

For this application, the planning framework for future MTS substation is used based on a 4x500MVA transformer design. When applying N-1 Grid Code reliability criteria, the transformer switching the MTS substation needs to be able to sustain a power evacuation of 1 500-1 600MW of the load connected to the substation. This therefore limits the amount of RE generation in MW allocated to a MTS.

As mentioned previously and displayed in Figure 3, there is little to no capacity available for the Western Cape to pick up additional RE potential. Droerivier MTS substation is located near Beaufort West as seen in Figure 5 and would connect RE potential within the Western Cape (part of the Greater Cape region) that lacks sufficient capacity to collect additional generation capacity.

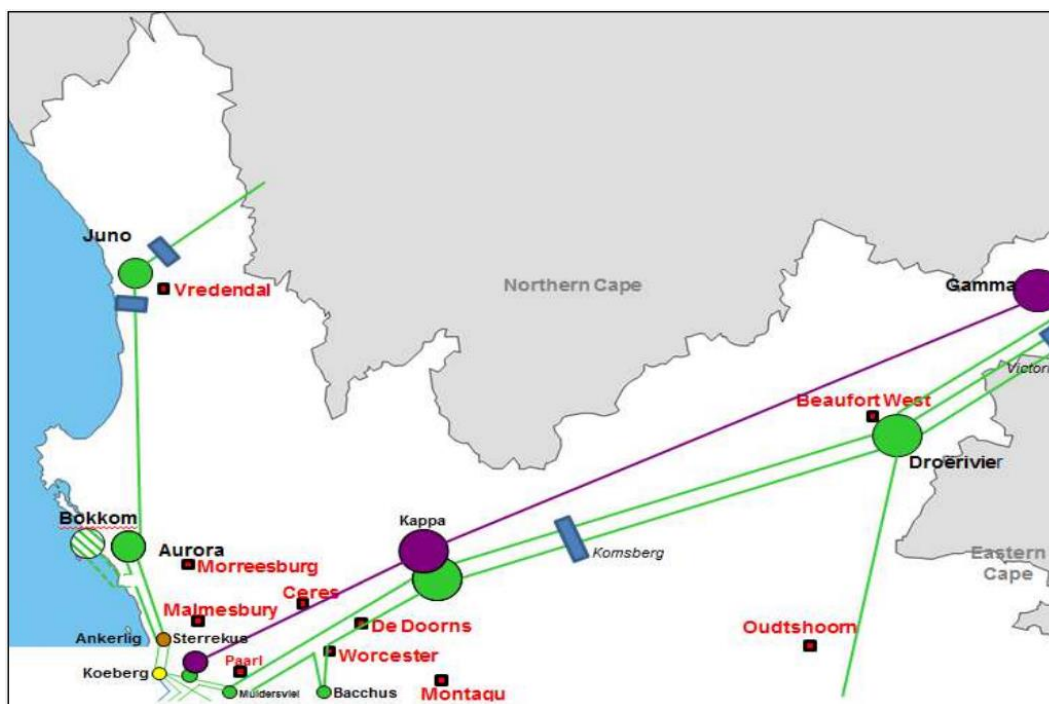


Figure 5: Single Line Diagram of the existing Western Cape network [3]

Droerivier is selected as the test MTS and the RE potential surrounding the substation that adheres the planning framework will be assessed.

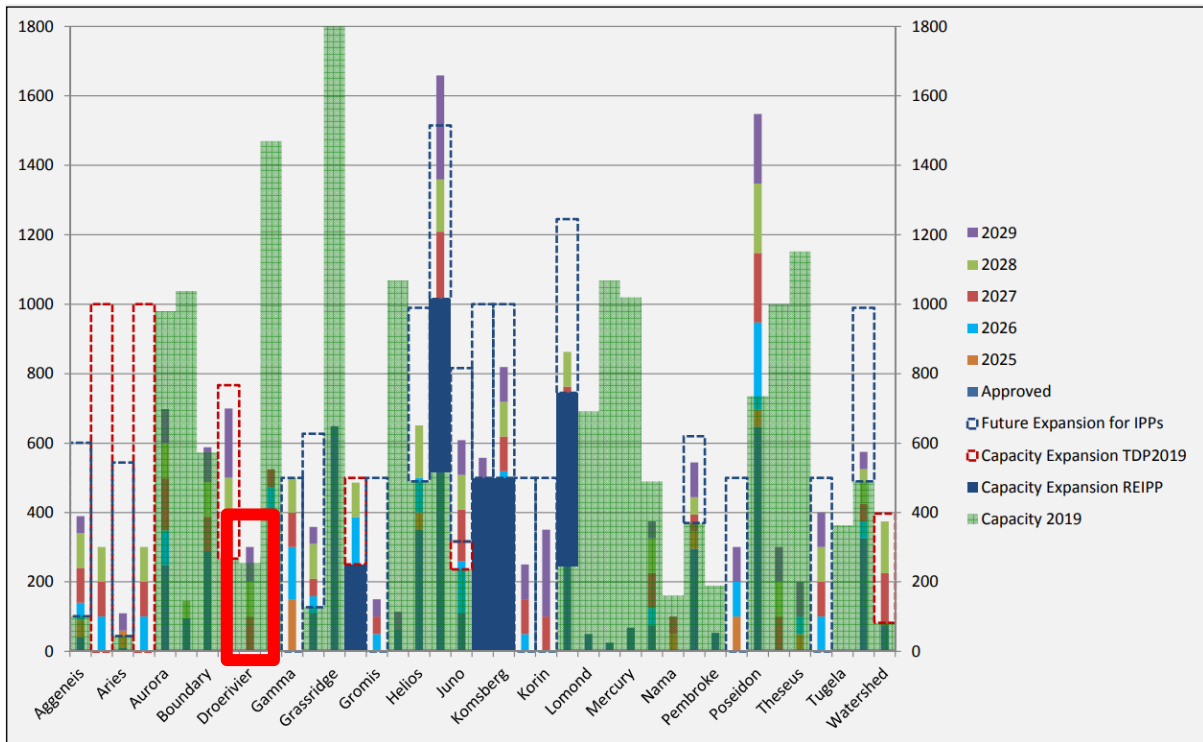


Figure 6: Transmission capacity enhancement for IPP integration – TDP 2020-2029 [3]

Figure 6 displays the anticipated RE generation to be allocated to the different MTS substation between 2025 and 2029, the graph also displays the available capacity of these substations in 2019. When we zoom into Droerivier substation, we see that the substation allocated capacity will be exceeded with all the RE potential by 2029.

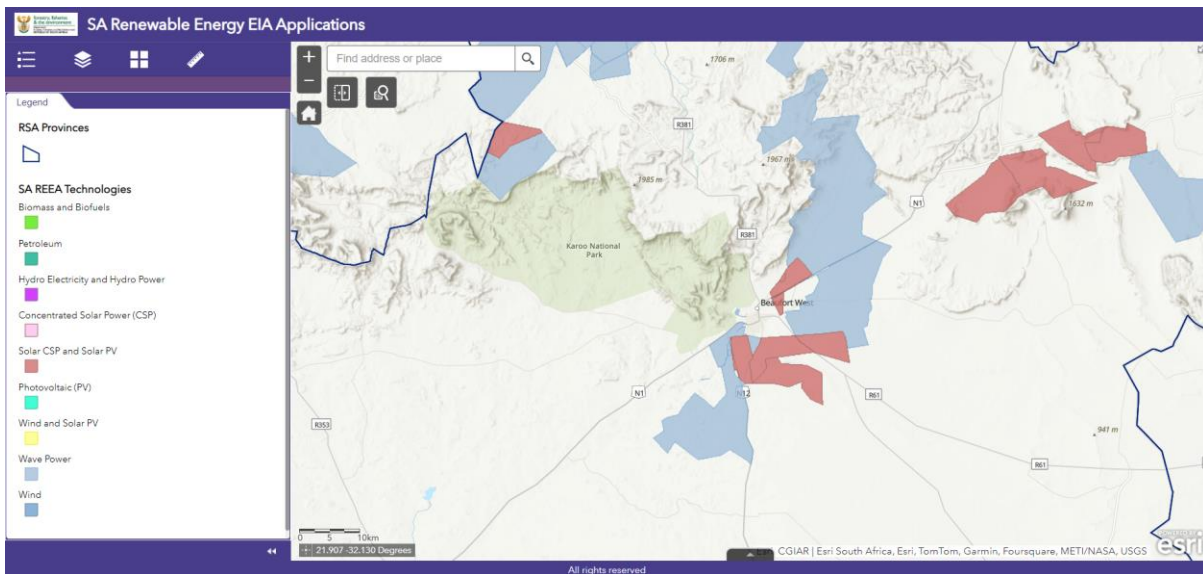


Figure 7: RE potential from the EIA dataset surrounding Droerivier MTS substation [4]

The RE potential surrounding the MTS substation is displayed in part on Figure 7 and detailed in Table 1, this information is obtained from the EIA Q1 2023 dataset [4]. The estimated total contracted capacity of the RE potential that is likely to be connected to Droerivier substation according to the dataset provided is 2 318MW. This total exceeds the planning framework by over 800MW.

Table 1: RE Potential surrounding Droerivier Substation

Project Technology Type	Contracted Capacity (MW)	MTS
PV	694	Droerivier
PV	300	Droerivier

Project Technology Type	Contracted Capacity (MW)	MTS
PV	600	Droerivier
Wind	424	Droerivier
Wind	300	Droerivier
<b>Contracted Capacity Sum (MW)</b>	<b>2,318</b>	

It is possible that one or more future projects may not be accommodated within the collector networks connected to the MTS and will need to be allocated to other surrounding MTS. Note that the total contracted capacity of the RE potential was aggregated without considering the diversity of RE sources when assigning generation capacity to the MTS substation.

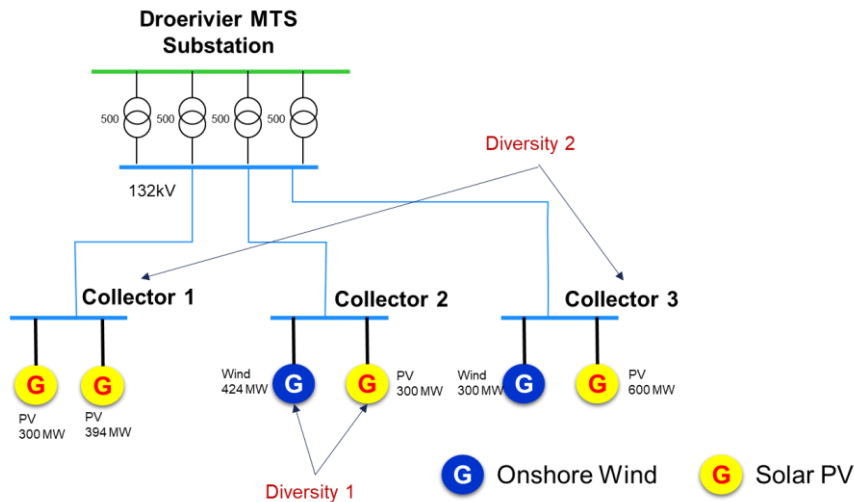


Figure 8: Droerivier MTS Substation collector network

Figure 8 displays the potential network configuration of the collector network connected to Droerivier MTS substation. The diversity between the RE potential will be assessed using the REvGrid Tool to see if there is any additional generation capacity unlocked due to diversity. Five sites were selected within the Droerivier MTS, three PV sites, and two Wind sites to simulate the RE generation based on existing RE plant information within the MTS.

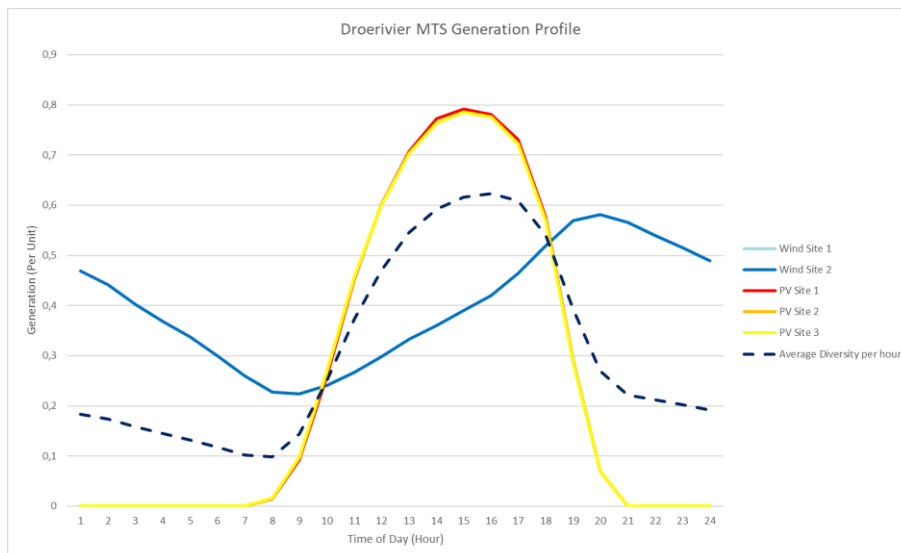


Figure 9: Generation profiles extracted by the REvGrid Tool for the Wind and PV sites within Droerivier MTS

The generation profiles for PV plants do not match those of Wind plants. Figure 9 shows the average daily generation profile from the tool based on the existing plant data. It is obvious to see the differences in the PV and wind generation profile.

Hour	Wind Site 1 (MW)	Wind Site 2 (MW)	PV Site 1 (MW)	PV Site (MW)	PV Site 3 (MW)	MTS Total (MW)	Max Generation Day	Total Gen Power (MW)
0	198,6000841	140,5189275		0	0	339,1190116	2011/12/14 00:00	371,5389513
1	187,1476818	132,4158126		0	0	319,5634944	2011/12/14 01:00	113,2497432
2	170,5604526	120,6795656		0	0	291,2400182	2011/12/14 02:00	3,185255419
3	156,1909112	110,5124371		0	0	266,7033483	2011/12/14 03:00	0
4	143,1506561	101,2858416		0	0	244,4364977	2011/12/14 04:00	0,18504816
5	126,8220378	89,73257393		0	0	216,5546117	2011/12/14 05:00	0
6	110,2996771	78,04222434		0	0	188,3419014	2011/12/14 06:00	22,95899776
7	96,54011317	68,30668384	9,212096329	4,877760297	11,26803428	190,2046879	2011/12/14 07:00	409,3745972
8	84,77302268	67,05638397	55,16996709	29,2186718	67,53798794	313,7560335	2011/12/14 08:00	1187,069588
9	102,0475683	72,20346816	155,4331425	80,3312794	185,7201256	595,735584	2011/12/14 09:00	1463,981477
10	113,3107244	80,17268235	272,0433001	137,2044348	317,2757825	920,0069241	2011/12/14 10:00	1672,89916
11	126,6013278	89,57641118	360,9624573	180,1233018	416,5953534	1173,858852	2011/12/14 11:00	1929,709109
12	141,1292193	99,85557971	423,8765	211,0666949	488,2322555	1364,160249	2011/12/14 12:00	2042,978836
13	152,6070649	107,9766969	463,261274	229,3478751	530,5605043	1483,753415	2011/12/14 13:00	2245,018829
14	165,3028428	116,9595586	474,8334812	235,6133335	545,0668822	1537,776098	2011/12/14 14:00	2284,647772
15	178,2767068	126,1391793	468,7458098	232,9696845	538,944152	1545,075532	2011/12/14 15:00	2284,972763
16	196,8202024	139,2595772	438,24631	216,6367521	501,1398554	1492,102697	2011/12/14 16:00	2245,11579
17	220,1820163	155,7891625	345,9711331	171,2706885	396,0760406	1289,289041	2011/12/14 17:00	2116,065151
18	241,1976064	170,6586837	173,9526826	86,34002237	199,6568486	871,8058437	2011/12/14 18:00	1782,257696
19	246,5528845	174,4477956	41,90043816	21,05849156	48,67788537	532,6374952	2011/12/14 19:00	1103,098871
20	239,7896341	169,662477		0	0	409,4521111	2011/12/14 20:00	445,9035978
21	228,9544826	161,9960962		0	0	390,9505788	2011/12/14 21:00	286,0765336
22	218,6236578	154,6865504		0	0	373,3102082	2011/12/14 22:00	133,7890638
23	207,4745862	146,7980563		0	0	354,2726424	2011/12/14 23:00	

Figure 10: REvGrid Tool average per hour site generation and max day generation calculation result

The result displayed in Figure 10 from the tool shows the average generation in MW per hour for each site based on the existing average profile in per unit for the respective sites. The MTS total generation takes into consideration this diversity between the sites and accumulates each site's estimated generation. The tool also displays the estimated generation at the maximum generation day from the dataset, this is the day which presented the highest generation and had low diversity between the sites. In this application, there are hours, namely, 03:00, 05:00 and 23:00 when there was no generation.

The estimated generation and diversity are calculated for each hour of the 5 years profile data recorded of each existing site. The calculated peak generation based on this total is at 15:00 in the afternoon at 2 284MW for the sites, this generation is about 700MW above the planning framework limits, and about 33MW less than the sum of total contracted capacity of the sites. This estimated peak generation considering diversity does not seem to unlock sufficient amount of capacity, however, further data analysis on the results present some interesting insights.

When assessing the bin analysis data from the histogram and pareto generated containing the estimate total generation incorporating this diversity for the MTS, we are able to see the number of occurrences for ranges of estimate generation of the MTS. When taking the instances when the combined generation is above 1 500MW, there are only 6 550 instances out of the total 43 824 that the peak generation of the sites combined, this is 15% of the time. What this means is, out of the 43 824 hours within the 5 year span, only 6 550 hours would see a total combined generation above 1 500MW. The bin analysis also shows us that the estimated total generation above 2 000MW is least likely to occur with a CCDF of 3% in total. These figures pale in comparison to occurrences of estimated total generation lower than 1 500MW which account for the remaining 85%.

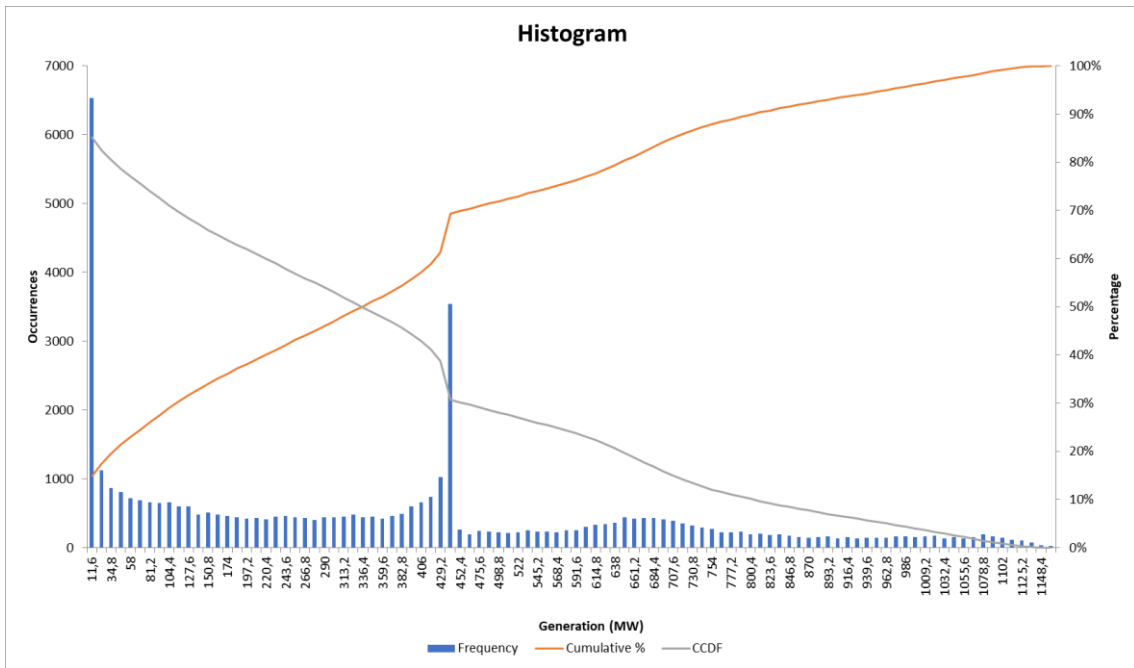


Figure 11: Histogram of the Droerivier MTS estimated total generation

When the bin analysis is organised in the form of a pareto, the estimated total generation at the MTS is now in order of likely occurrences. The chart in Figure 12, the highest occurrences of estimated total generation are below 1 500MW, while the lowest likely occurrences are those above 1 500MW.

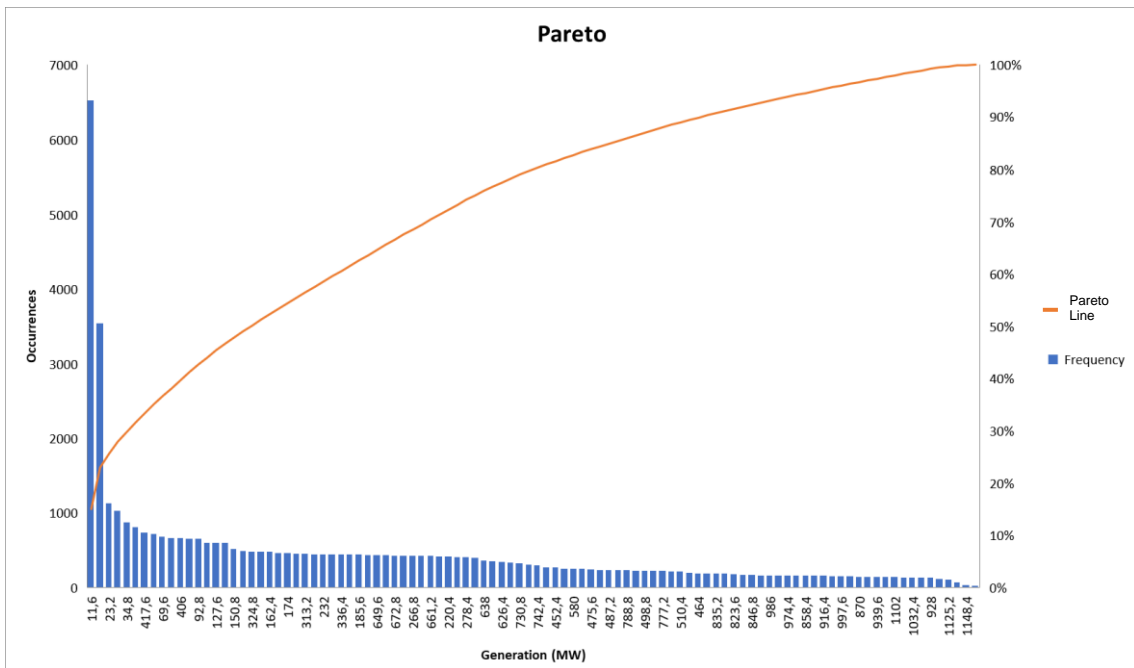


Figure 12: Pareto of the Droerivier MTS estimate total generation

As a planner, one starts to realise that the peak generation connected to the MTS, in this case Droerivier, will less likely be the initial 2 318MW that was anticipated when the RE potential was simply aggregated without considering diversity between the RE sources. When using existing RE plant data within the same MTS location, the estimated peak generation for the RE potential is less likely to reach 2 318MW, but instead peak at 2 284MW on five separate occasions (5 hours out of 43 824), while only being above 1 500MW, 15% of the time, which is about 6 550 instances out of 43 824 based on the five-year hourly data for this MTS study area. When planning infrastructure based on peak, there is 33MW less to plan for at peak, and when adhering to the 1 500MW limit for the power evacuation during N-1 condition, all these RE potential can be integrated onto the grid with some of the RE generation curtailed at certain days and hours to ensure the power evacuation limits are met.

### 3 ENHANCEMENT AND DEVELOPMENT AREAS

As with any innovative tool, continuous improvement is key to ensuring its effectiveness and relevance. The enhancements proposed for the REvGrid diversity calculation tool are informed by valuable feedback and insights provided by key stakeholders. These enhancements are designed to address the specific needs and challenges identified during stakeholder consultations, ensuring that the tool remains a robust and adaptable resource for optimizing energy mix decisions in an ever-evolving landscape.

#### 3.1.1 Operationalization and Practical Use

In order to enhance the current REvGrid diversity calculation tool to be used by Eskom planners and IPPO, the tool will now incorporate practical applications for decision-making in distribution planning.

**Proposed Enhancement:** Expansion of the site selection limit to accommodate more RE projects, enabling comprehensive analysis of MTS substation and collector network study areas and maximizing energy output. This will now allow assessment of different combinations of actual RE applications to optimize energy output based on diversity, tailored to real-world scenarios.

#### 3.1.2 Planning and Capacity Design

Assist in planning future capacity requirements by analyzing combinations of RE profiles. It was acknowledged that different use cases, such as maximizing energy diversity versus optimizing capacity, may not always yield the same optimal choices. The tool should be flexible enough to accommodate various use cases and provide insights tailored to specific objectives.

**Proposed Enhancement:** Systematically assess combinations of RE projects to identify optimal solutions based on economic and technical factors.

#### 3.1.3 Selection Criteria for IPPs

Enabling selection of IPPs based on criteria that maximizes energy value derived from limited capacity.

**Proposed Enhancement:** Include evaluations of energy time of use, diversity of renewable sources, and market/tariff dynamics to optimize energy yield and value proposition. This involves assessing the energy value relative to the time-of-use, such as peak hours versus off-peak periods, to optimize selection criteria. Taking into consideration market and tariff dynamics. The Rand value of energy varies based on market dynamics, including time-varying and season-varying factors. The tool needs to incorporate these dynamics into its calculations to provide a comprehensive assessment of the energy's value at different times. The addition of this assessment that compares the energy generation cost vs the energy usage time-of-use cost to allow for determining the best RE technology mix for a study area taking into consideration the demand and overall load profile seen at the MTS substation or within collector network.

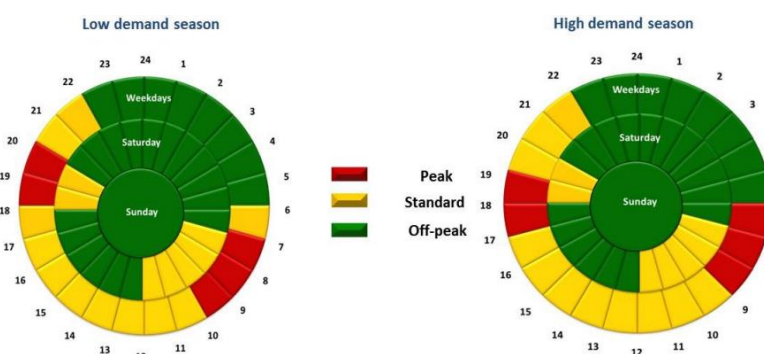


Figure 13: WEPS, Megaflex, Megaflex Gen, Miniflex, Transflex, Homeflex, Ruraflex and Ruraflex Gen: low and high demand seasons TOU periods [5]

#### 3.1.4 Extended Dataset for Analysis

Use a longer time series for data analysis to better evaluate wind energy projects.

**Proposed Enhancement:** Incorporate a longer dataset to accurately capture variations in wind patterns.

### 3.1.5 Enhanced Data Representation

Improve data visualization for better clarity.

**Proposed Enhancement:** Explore alternative user-friendly visualizations, such as Pareto charts, to enhance user interpretation.

### 3.1.6 Detailed Curtailment Analysis

Analyze the impact of curtailment percentages on capacity.

**Proposed Enhancement:** Evaluate the rate of change of capacity added versus energy lost to provide insights into curtailment value.

## 3.2 Continuous Improvement and Collaboration

The tool should be continuously refined based on user feedback and emerging needs.

**Stakeholder Engagement:** Regular collaboration with stakeholders like Eskom and IPPO ensures the tool remains relevant and effective.

**Innovation and Adaptation:** The long-term goal for the tool will be to make it a Web-Enabled tool that will be integrated with new technologies and methodologies to keep the tool at the forefront of RE planning and integration.

In essence, the journey towards a more sustainable energy future demands continuous innovation and refinement. Through ongoing collaboration and investment in development initiatives, we can harness the full power of technology to accelerate the transition towards a cleaner, more resilient energy ecosystem. The insights gained from our engagement with Eskom serve as a catalyst for further exploration and refinement, guiding us towards a future where renewable energy plays a central role in powering prosperity for generations to come.

## 4 CONCLUSION

The REvGrid Diversity Calculation Tool potentially represents a pivotal advancement in optimizing the planning for the integration of RE sources to the national grid. By assessing the unique generation profiles of different operating RE technologies (plants), this tool aids in optimizing the use of the distribution and transmission grid to integrate more RE capacity. Its development is rooted in the practical needs of Eskom and the procurement process at IPPO, ensuring it delivers real-world benefits.

Initially deployed as a standalone application, the tool will provide immediate support for planners and procurement process. It will enable them to maximize grid efficiency, determine cost-effective energy selection, and enhance the security of supply through diversified renewable sources. As the tool evolves, plans are in place to expand its capabilities into a web-enabled platform. This transition will offer greater accessibility, enhanced user experience, and robust data integration, ultimately driving more informed decision-making and strategic planning.

The continued refinement and enhancement of the tool, guided by ongoing feedback and collaboration with stakeholders like Eskom, will ensure it remains a valuable asset in South Africa's journey towards a sustainable energy future. By leveraging advanced analytics and innovative methodologies, the REvGrid Diversity Calculation Tool will play a critical role in optimizing renewable energy integration, supporting the nation's socio-economic and environmental goals, and contributing to a cleaner, more resilient energy ecosystem.

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