

RED CAP IMPOFU WIND FARMS – ASSESSMENT OF WAKE EFFECT ON YIELD OF NEIGHBOURING WIND FARMS

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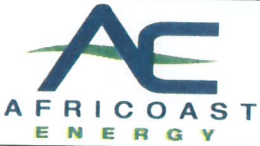
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DEFINITIONS/ABBREVIATIONS

AE	Africoast Energy (Pty) Ltd
KWF	Kouga Wind Farm (Pty) Ltd
TCWF	Tsitsikamma Community Wind Farm
OBWF	Oyster Bay Wind Farm
GBWF	Gibson Bay Wind Farm

1. INTRODUCTION

Africoast Energy (Pty) Ltd (Africoast) is a leading project management and engineering consultancy specializing in renewable energy projects. Africoast played a prominent role in various successful renewable energy projects in the REIPPP program in the role of owners technical advisors, site identification, turbine layout design, yield modelling, permitting, detail design, construction, operation and management.

Red Cap is proposing to develop 3 wind farms in the Kouga area of the Eastern Cape, as well as a \pm 140 km 132 kV grid connection between the project area and Port Elizabeth. The wind farms will be called the Impofu North Wind Farm, Impofu East Wind Farm and Impofu West Wind Farm.

Africoast Energy were commissioned by Red Cap Energy to assess the potential yield impact through wake effect that the proposed Impofu wind turbines could have on the existing neighbouring operating wind farms. The aim is for this study to be used in the technical and commercial discussions that Red Cap is currently having with these adjoining wind farms regarding the potential wake effect of the proposed Impofu windfarm development.

2. PROJECT DETAIL

Red Cap was involved in the successful development of the 80 MW Kouga Wind Farm and the 111 MW Gibson Bay Wind Farm in the Kouga Local Municipality, Eastern Cape, South Africa and has signed option agreements with new landowners in the same area for the new proposed Impofu development.

The \pm 15 500 ha consolidated site where the three wind farms are proposed to be developed is centred on 34° 5'14.81"S latitude and 24°34'35.47"E longitude, lying directly to the west and north west of the small coastal village of Oyster Bay. It is bounded by the operational Gibson Bay & Tsitsikamma Community Wind Farms in the West and the Kouga Wind Farm in the East. The Oyster Bay Wind Farm on its eastern boundary has reached financial close and should start construction in 2019.

The proposed Impofu Wind Farms are shown in Figure 1 below:



Figure 1: Proposed Impofu North Wind Farm, Impofu East Wind Farm and Impofu West Wind Farm- Current proposed layout for the Draft Environmental Impact Assessment

3. METHODOLOGY

The following wind farms in the Kouga and Koukamma Local Municipalities are considered in this report:

- The proposed Impofu Wind Farms (a worst case scenario was assessed in this report assuming all three wind farms are constructed and thus the assessment was done using all potential 95 turbines)
- Existing Kouga Wind Farm (KWF)
- Existing Tsitsikamma Community Wind Farm (TCWF)
- Approved Oyster Bay Wind Farm (OBWF) – Construction to start 2019
- Existing Gibson Bay Wind Farm (GBWF)

The next closest potential wind farms would be 10km away and is the Banna Ba Pifhu Wind Farm which has an approved EA but is not yet a preferred bidder. Beyond that is the operational Jeffreys Bay Wind Farm which is 20km away. These and any wind farms further away were not considered due to their distance from the Impofu Wind Farms.

The Wind Turbine configurations for the considered wind farm are listed in Table 1

Configuration	Proposed Impofu WF	Kouga Wind Farm	Tsitsikamma Community WF	Oyster Bay WF	Gibson Bay WF
Wind Turbine Manufacturer	Vestas	Nordex	Vestas	Vestas	Nordex
Wind Turbine Type	V150	N90	V112	V117	N117
Number of Wind Turbines	95	32	31	43	37
Rated Power Per Turbine	4 MW	2.5 MW	3.075 MW	3.3 MW	3 MW
Total Rated Power	380 MW	80 MW	95 MW	140 MW	110 MW
Rotor Diameter	150 m	90 m	112 m	117 m	117 m
Hub Height	105 m	80 m	94 m	91.5 m	91 m

Table 1: Wind Farm configurations for the considered wind farms in the Kouga & Koukamma Local Municipalities.

The turbine selection for the Impofu Wind Farms is not yet finalised, so the Vestas V150 was used during the simulations (using Wasp 10 and Windfarmer 4.2) as it has the maximum rotor diameter of 150m that is being assessed in the environmental process being undertaken for the Impofu Wind Farms.

The area covered by the listed wind farms is situated in a high wind resource area and this has attracted many developers to the area. The proposed Impofu Wind Farms are surrounded by the other wind farms in the area, as shown in Figure 2 below, and this report will assess the potential impact that the new development may have on these existing wind farms.

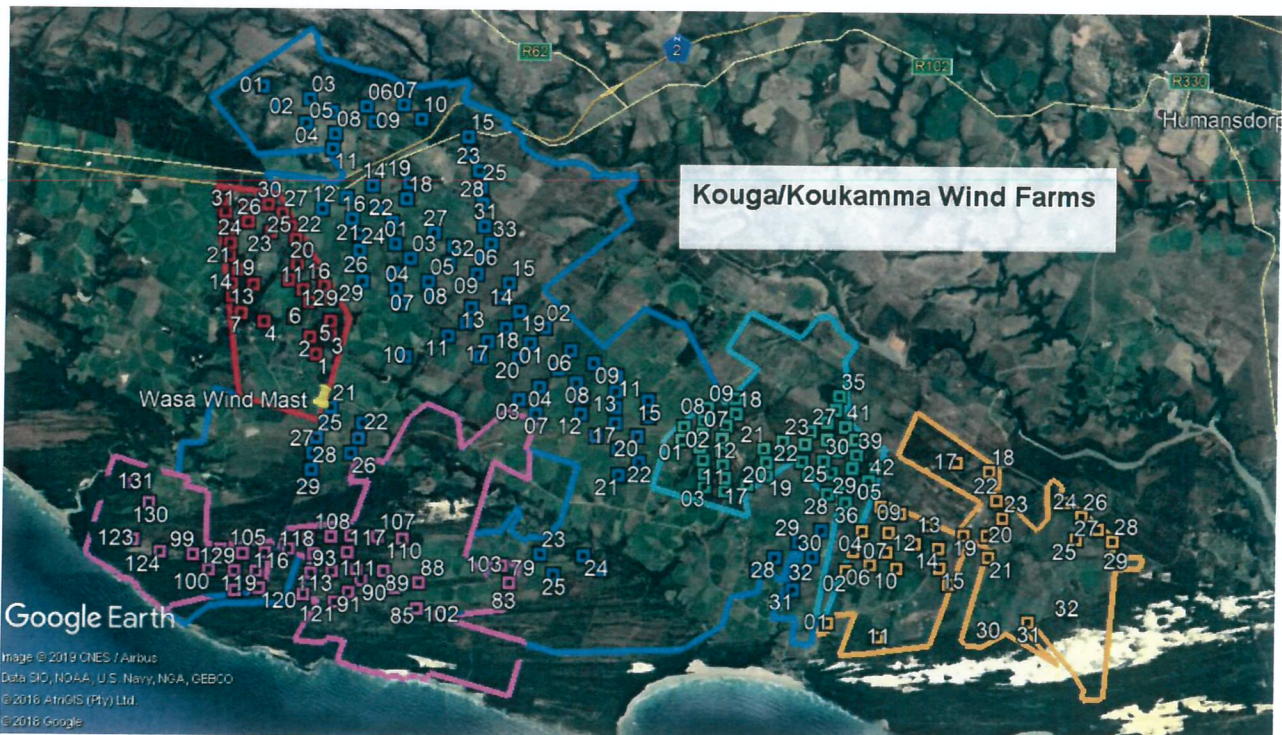


Figure 2: Layout showing Proposed Impofu Wind Farms in **BLUE**, Kouga Wind Farm in **Orange**, Tsitsikamma Community Wind Farm in **Red**, Oyster Bay Wind Farm in **Light Blue** and Gibson Bay Wind Farm in **Purple**

Due to the sensitivity around privately owned wind data, varying installation dates, anemometer heights and data discrepancies, it was agreed that only the wind data from the public Wasa wind mast that is situated next to the site would be used. The distance from the Wasa wind mast to existing and proposed turbines varies from 5km to 20km, which exceeds the recommended maximum distance of 5km. Although this is not ideal, the purpose of this study is to assess the **RELATIVE** impact the Impofu Wind Farms could have on existing windfarms, and thus one consistent wind data set was used for all scenarios modelled. The mast position is indicated in yellow in Figure 2 above and 6 years' worth of wind data were used in the model (2011 – 2016).

Ideally the results from the modelling for the existing wind farms should be compared with actual production data to increase the accuracy of this study.

Enel Green Power currently owns GBWF, OBWF and is developing the Impofu Wind Farms in partnership with Red Cap. Africoast Energy has been informed by Red Cap that Enel Green Power decided to address the wake impact from the proposed project on GBWF & OBWF internally. Therefore only the wake effect from the proposed wind farm on KWF and TCWF are addressed in this report.

Discussions have taken place between Red Cap and KWF and TCWF. Both KWF and TCWF have confirmed that they are happy with AE completing the initial wake impact modelling as a basis for further discussions.

4. ASSESMENT & RESULTS

In order to study the impact of the proposed Impofu Wind Farms on KWF & TCWF, AE first modelled the energy yield of the sites without the proposed Impofu Wind Farms and then compare it with the energy yield modelled with the proposed wind farms. This comparison enables an estimate of the loss in production by the KWF and TCWF due to the Impofu Wind Farms and the results are shown in Table 2 below. This is for the current layout being assessed in the Draft Environmental Impact Report (DEIR) for the Impofu Wind Farms.

Proposed Impofu WF Layout	Kouga Wind Farm	Tsitsikamma Community WF
Impofu WF Wake Effect %	0.93%	1.60%

Table 2: Loss in production due to the Wake Effect of proposed Impofu Wind Farms on Kouga Wind Farm and Tsitsikamma Community Wind Farm.

The following mitigations were undertaken to reduce the Wake effect impact on KWF and TCWF:

- Red Cap refrained from placing wind turbines within 1km from existing neighbouring wind turbines
- Altering the layout during the EIA process
- Varying the turbine hub heights

Further potential mitigation investigated was the removal of the worst impacting turbines.

The model showed that varying the hub heights of the turbines on the proposed Impofu Wind farms (within the limits between 80m and 120m as set by the environmental process currently underway for the Impofu Wind Farms) did not make any significant impact and therefore we believe that this is not a viable mitigation.

The results of the model are shown below in Table 3.

Modelled Impofu WF Layout	KWF - Wake Effect [%]	TCWF - Wake Effect [%]
Hub Height - 105m	0.93%	1.60%
Hub Height - 120m	0.93%	1.62%
Hub Height - 80m	0.91%	1.55%

Table 3: Reduction in Wake Effect due to changes in Hub Height of the turbines used for the proposed Impofu Wind Farms.

Attempts were made during the iterative Environmental Impact Assessment (EIA) process to ensure the least environmentally damaging practicable alternative is currently being undertaken by Red Cap for the Impofu Wind Farms while reducing the potential wake effect on the KWF and TCWF. Previous layouts (from September 2017 and January 2018) were modelled and the results are presented in Table 4. Table 4 also then shows the reduction in the wake effect of the current layout if the highest impacting turbines were to be removed.

Modelled Impofu WF Layout	KWF – Yield Impact [%]	TCWF – Yield Impact [%]
August 2017 Layout	1.07%	1.85%
January 2018 Layout	1.00%	1.69%
Current Proposed Layout (DEIR)	0.93%	1.60%
Removing Turbine East 30	0.74%	n/a*
Removing Turbine North 26 & 29	n/a*	1.41%
Removing Turbine North 12,13,16,21,24,26&29	n/a*	1.08%

* n/a is shown as removing the indicated turbines has no impact on reducing the wake effect on the relevant wind farm as they are too far away

Table 4: Reduction in Wake Effect due to changes in Layout during the EIA process and if further turbines are dropped from the current DEIR layout.

The results in Table 4 above show the following for the two wind farms assessed:

- *Kouga Wind Farm:*
 1. The yield impact was reduced from 1.07% to 0.93% due to the changes in layouts during the EIA Process.
 2. By reducing the worst impacting turbine (East 30), the yield impact from the Impofu Wind Farms was reduced from 0.93% to 0.74% which is a significant reduction achieved by removing only one turbine. The impact on Impofu East Wind Farm by removing 1 turbine will be the reduction in its potential MW size by 3% and this could have an impact on its viability.

- *Tsitsikamma Wind Farm:*
 1. The yield impact was reduced from 1.85% to 1.6% due to the changes in layouts during the EIA Process.
 2. By removing the two worst impacting turbines (North 26 & 29) a reduction from 1.6% to 1.41% is achieved. The impact on Impofu North Wind Farm by removing 2 turbines is the reduction in its potential MW size by 6% and this could have an impact on its viability.
 3. In the event that the seven worst impacting turbines close to TCWF are removed, the yield impact on TCWF reduces to 1.08%, while the impact on the Impofu Wind Farms viability would be significant, as it would reduce the potential wind farm MW size by 21%.

5. CONCLUSIONS AND RECOMMENDATIONS

This study is a technical study and it deals with relative impacts on adjacent windfarm production, to be used in further discussions between the developer of the Impofu Wind Farms and adjacent windfarms.

The report should be viewed within the limitations and accuracy of data and modelling software used.

Africoast recommends that the results from the modelling for the existing wind farms should be compared with actual production data to increase the accuracy of this study. Actual production data would be required from the owners of the windfarms.

Following the outcome from the wake impact assessment, Africoast Energy recommends the following mitigations/action to reduce the yield impact on KWF and TCWF due to wake effect from the proposed Impofu Wind Farms.

- *Kouga Wind Farm:*
As has been shown the current layout has a 0.93% impact on the production of the KWF and by removing the worst impacting turbine (East 30), the yield impact from the Impofu Wind Farms can be reduced to 0.74%. This is a significant reduction by removing only one turbine (the equivalent of 3% drop in the potential MW output of the Impofu East Wind Farm). AE therefore recommends that KWF and Red Cap discuss this further with the possibility of removing Turbine East 30 after both sides consider the impact of this on their respective wind farms.
- *Tsitsikamma Wind Farm:*
The study shows that the current impact is 1.6% on TCWF production from the Impofu Wind Farms. It also shows that by removing the two worst impacting Impofu Wind Farms turbines, the impact would be reduced to 1.41%. Removing 7 turbines would have a significant impact on the viability of the Impofu North Wind Farm, and only a minimal reduction (1.08% impact) in potential losses to Tsitsikamma Wind Farm.
It is therefore recommended that Red Cap rather engage TCWF to enter into a commercial agreement, which is fair to both parties, to reduce the loss of income to TCWF, due to the wake effect from the proposed project, to a fair level.