SAWEA
South African Wind Energy Association

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BREAK THE GRIDLOCK! WIRE FOR GROWTH!

21 - 23 OCTOBER 2025
8:00 am – 5:00 pm

CAPE TOWN, SA
CTICC 2

2025 PRESENTATION

Impact of Climate Change on Long-Term Wind Forecasting

Mr. Mandla Albert Masoga

23 October 2025

SPEAKER **OVERVIEW**

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Area of focus: Renewable Energy Solutions

PRESENTATION **OVERVIEW**

1. Introduction

What is Climate Change?

- It is the long-term shift in the average weather patterns.
- The 2015 Paris agreement was established as a mitigation strategy to limit the average global temperature from reaching a level of 2 degrees Celsius.

How will climate change affect energy generation.?

- Yuchen Yang et al. [1] projected a varying wind production over time.
- Weber et al [2] projected wind energy generation to decrease.
- Reyes et al. [3] Forecasted wind energy generation to increase.

Why is long term wind forecasting and Climate modelling important ?

- It is critical for **renewable energy planning, financial investment, and infrastructure design.**
- Adequate **awareness** of the possibility of imminent threat caused by climate change is essential to **mitigate disruption.**
- Climate change will have an impact on wind speeds, and this wind speed will affect the power production.

1. Introduction

- To project the impacts of climate change on wind energy generation, the output from various global climate models running the RCP 8.5 scenario were used.

What is RCP 8.5 and Why is it important?

- RCP 8.5 is a high emission climate scenario. It projects a future where:

1. There is more reliance on fossil fuel.
2. No effort taken to reduce carbon emission.
3. A rapid growth in green house gas emission.

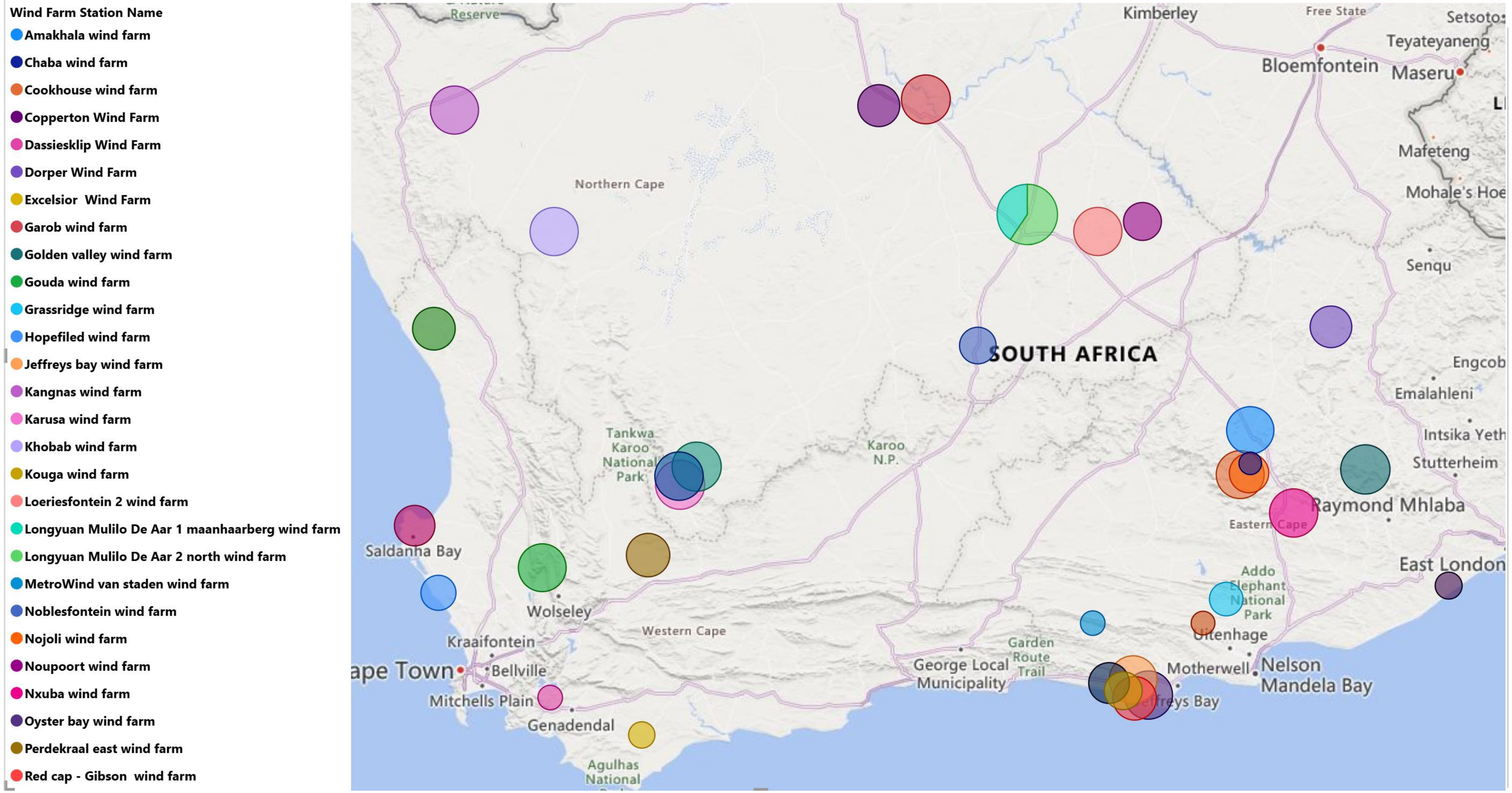
Why is it essential for this study?

- To observe the effects of climate change on wind energy generation, should minimal effort be placed in mitigating climate change.

1. Introduction

Operational Capacity: ~3.55GW

Wind Farm Locations in South Africa: Bubble size indicates installed Capacity



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2. Methodology

The model creates a virtual wind farm to which we can observe climate change impacts on the farms under the RCP 8.5 scenario.

To create the virtual wind farm, a four-step process can be followed:

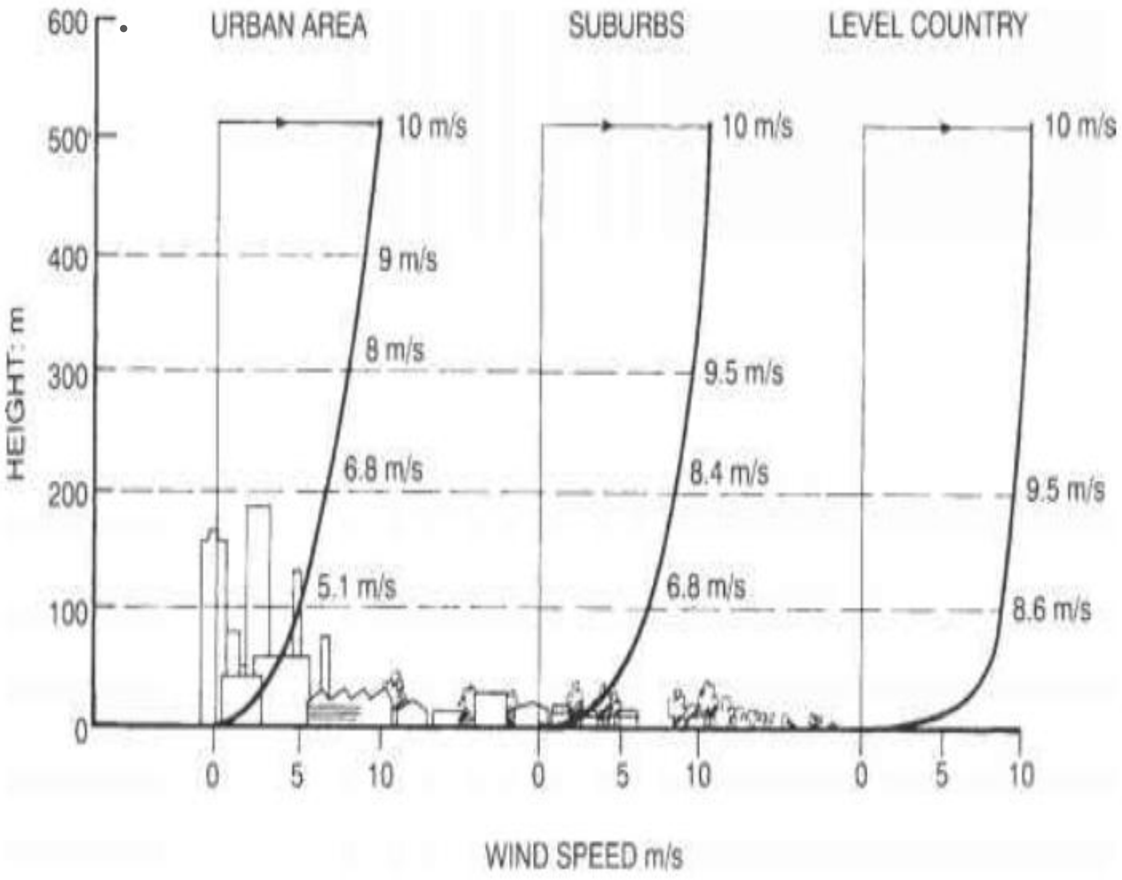
1. Wind Speed Correction to Hub Height.
2. Turbine Power output modelling and Power calculation.
3. Density Correction.
4. Virtual Farm Aggregation.

2. Methodology

Wind Speed Conversion to Hub Height:

Step 1.

- $U_{hub} = U_{anem}(\frac{Z_{hub}}{Z_{anem}})^{\alpha}$
- U_{hub} – Wind speed at hub height (m/s)
- U_{anem} – Wind speed at anemometer height (m/s)
- Z_{hub} – Hub height of wind turbine (m)
- Z_{anem} – Anemometer height (m)
- α - Power law exponent
- When using the power law, the equation becomes as follows, where Z_o is the surface roughness.
- $U_{hub} = U_{anem} \times \left(\frac{ln\left(Z_{hub} / Z_o\right)}{ln\left(Z_{anem} / Z_o\right)} \right)$



https://forum.dcs.world/topic/275852-wrong-average-wind-speed-gradient-with-increasing-altitude/

2. Methodology

Step 2.

Calculating **Wind Power Output Using Wind Turbine Power Curve**. At standard temperature and atmospheric pressure.

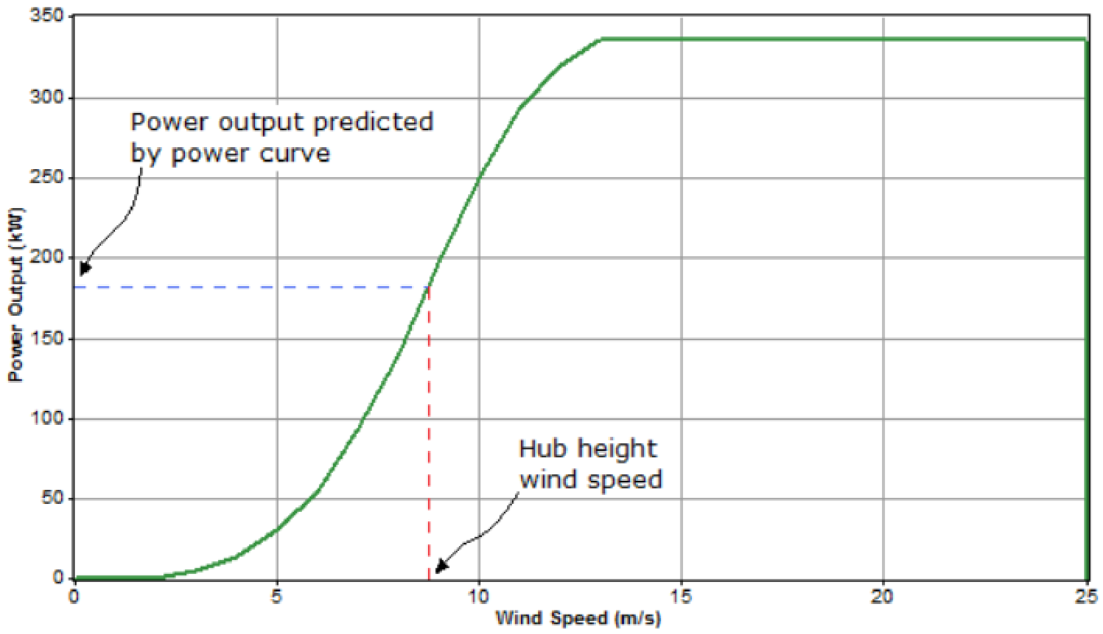
The Power Curve is represented by the following equations.

$$P = \begin{cases} 0, & if\ 0 \leq v < v_{cut-in}, \\ \alpha v^6 + \beta v^5 + \gamma v^4 + \delta v^3 + \theta v^2 + \mu v + C & if\ v_{cut-in} \leq v < v_{rated}, \\ P_{rated} & if\ v_{rated} \leq v < v_{cut-off} \end{cases}$$

Where:

P – Power in [MWh]

v – wind speed at hub height



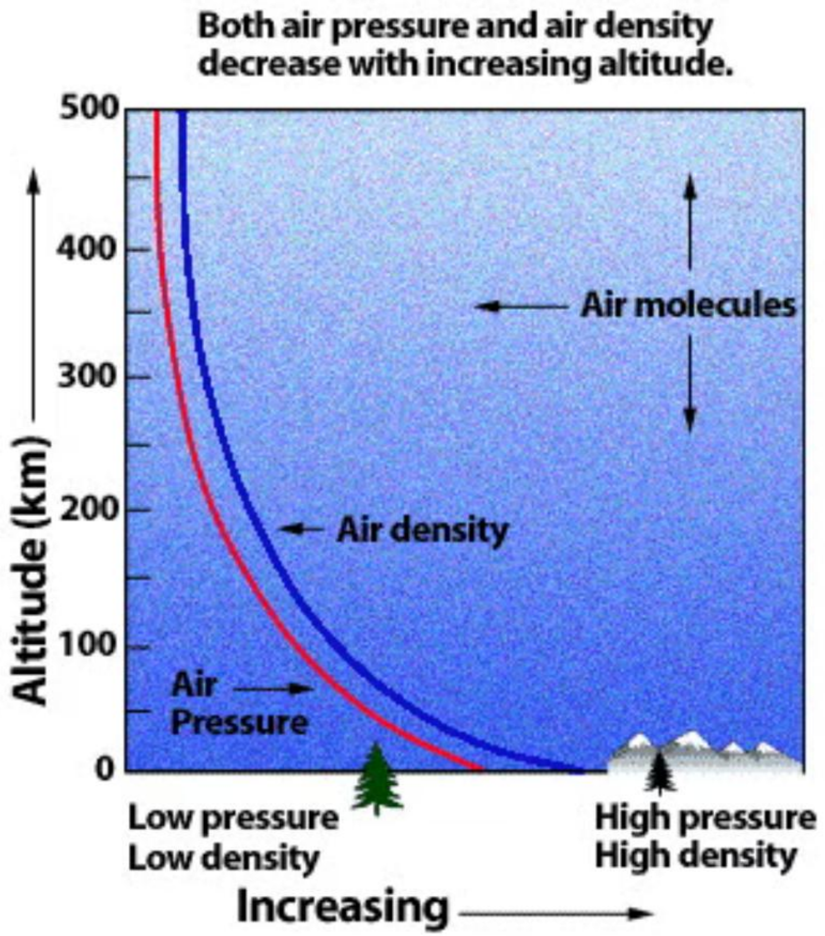
2. Methodology

Step 3.

- **Density Correction:**
- Adjust Power output to actual conditions at which the turbine operates.
- $P_{act} = \mathrm{P} \times \left(\frac{\rho}{\rho_o}\right)$
- $Where$:
- P_{act} – Turbine power at actual density [MW].
- ρ_o – Air Density at Standard Condition [1.225 $^{kg}/_{m^3}$].
- ρ – Actual Density [$^{kg}/_{m^3}$].

Step 4.

- **Wind Power Aggregation**
- Calculating the Power of the virtual farm, based on the number of wind turbines. This is done after following the mentioned steps, by multiplying the obtained power by the number of turbines.



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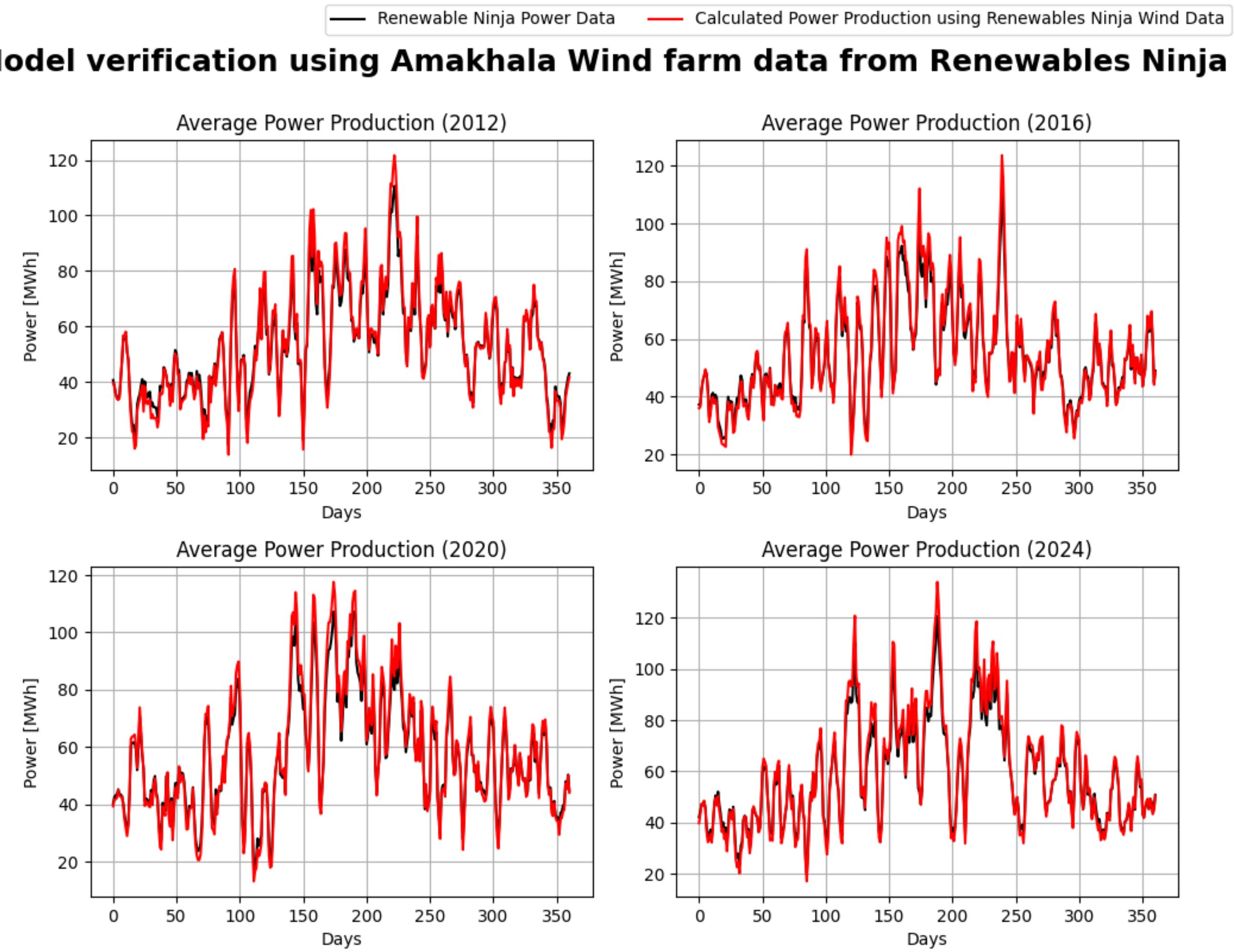
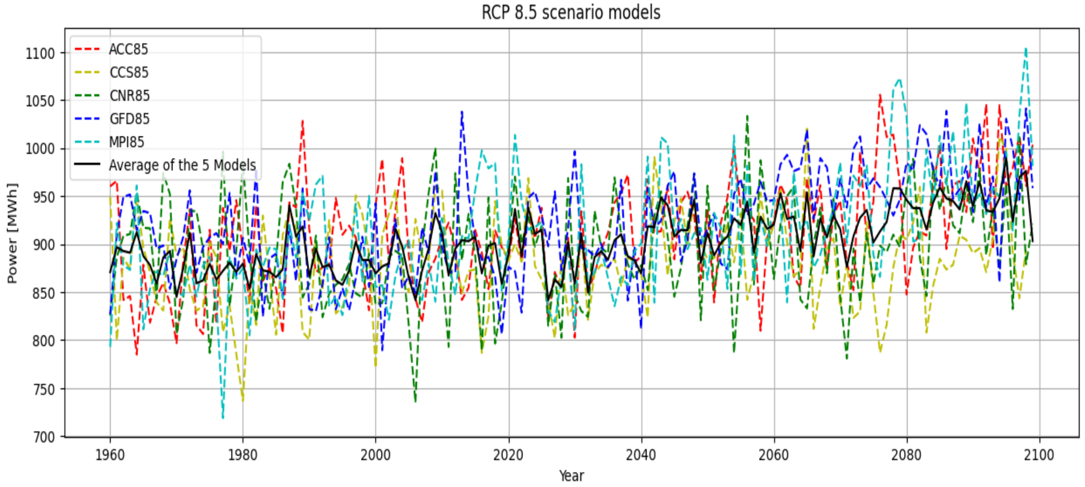
2. Methodology

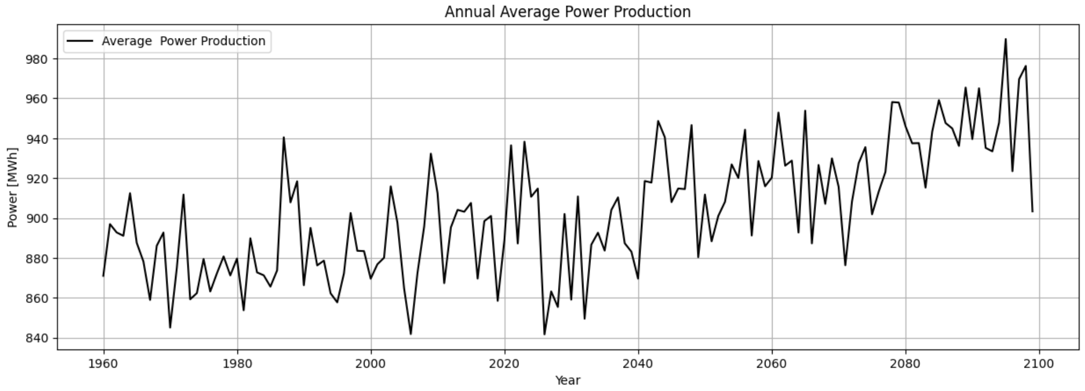


2012: Pearson Correlation = 99.83; 2016: Pearson Correlation = 99.8; 2020: Pearson Correlation = 99.78; 2024: Pearson Correlation = 99.79

3. Results



Climate change weather scenarios used in forecasting wind energy production [MWh] for all 35 sites.



Average of the climate change weather scenarios used in forecasting wind energy production [MWh] for all 35 sites.

Years	1960-2005	2005-2069	2070-2089
Average power	883.9MWh	918.4MWh	931.8MWh
Power Difference	-----	35.5MWh	13.5MWh

There is an increasing trend in the annual average power production with a slope magnitude of **0.536MWh/year.** This is due to increasing wind speeds.

4. Discussion

Remarks:

- A study was conducted on the effects of climate change on wind energy generation in south Africa under the RCP 8.5 climate scenario. Upon analysis of the average power production showed an increase of 0.536MWh/year.
- Although the findings indicate an increase in average power production, the average value is not evenly distributed.
- It may indicate some areas having high winds and other areas having low winds.
- Higher wind speeds my result in turbulence that is not effective for wind turbines thus having a negative financial impact and energy security.
- The produced power is dependent on the accuracy of the generated RCP 8.5 data.

Future outlook:

- Areas affected by High or Low wind speeds and how that will affect site energy generation and infrastructure.
- Comparing RCP2.6 with RCP8.5 scenarios.

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THANK YOU FOR LISTENING!

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