

The background of the slide is a photograph of a dense forest of tall, dark evergreen trees. A thick layer of mist or fog hangs in the air, partially obscuring the trees in the distance. The lighting is soft and diffused, creating a serene and somewhat somber atmosphere. The colors are muted, with various shades of green, brown, and grey.

Environmental Analysis: Brazil 2001-2021

Agenda

01	General Overview
02	Conditions for Wind Power Generation
03	Conditions for Solar Power Generation
04	Irrigation Investigation
05	Summary

1. General Overview

Across the whole of Brazil between 2001-2021:

Temperatures have risen by 1.1°C
on average

Rainfall has remained at about
6,700mm per year

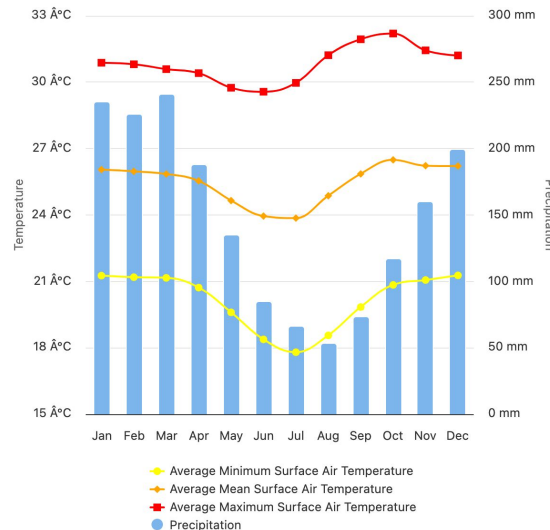
Wind speed has dropped by
0.2m/s across the years

Air relative humidity has increased
by 9%

Comparison with other countries

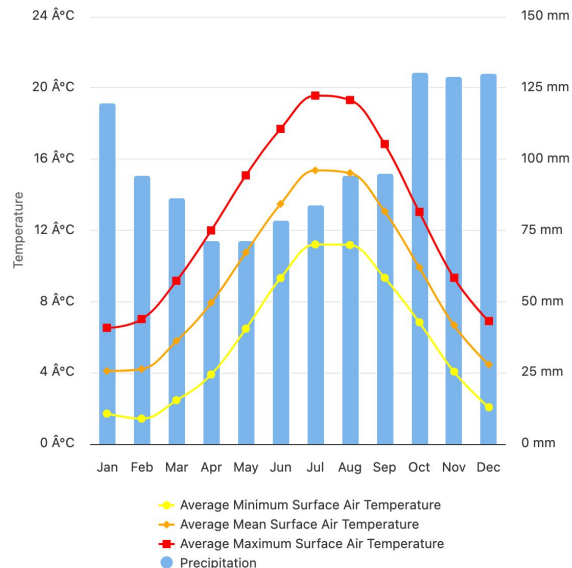
Southern Western Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; Brazil



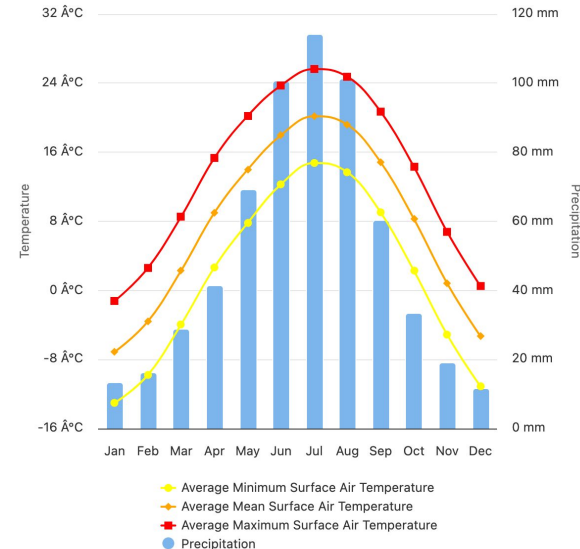
Northern Western Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; United Kingdom



Northern Eastern Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; China

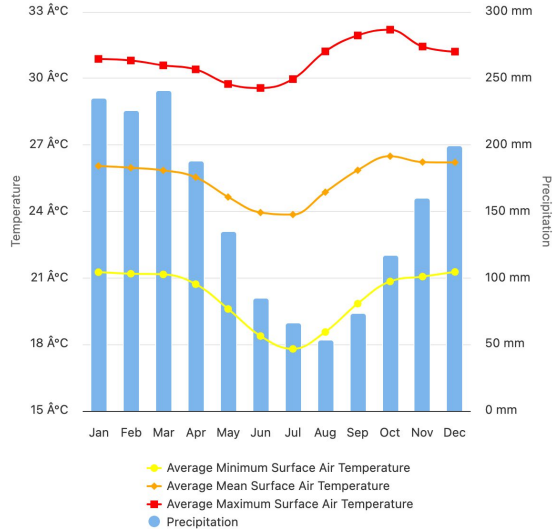


- Brazil has higher temperatures, likely due to the increased proximity to the equator and experiences peaks in opposite times of the year to northern hemisphere countries.

Comparison with other countries

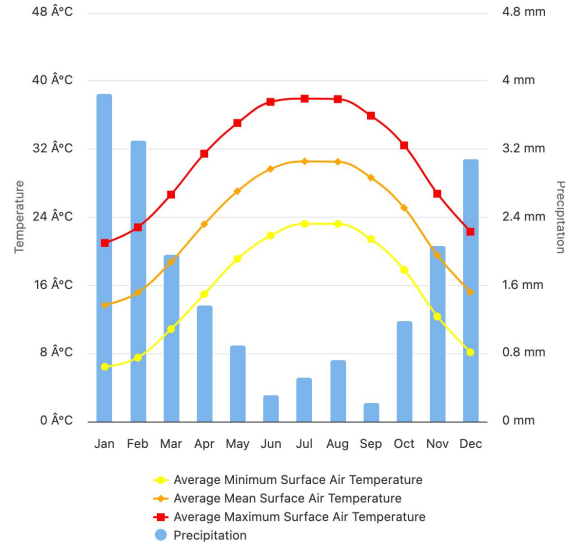
Southern Western Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; Brazil



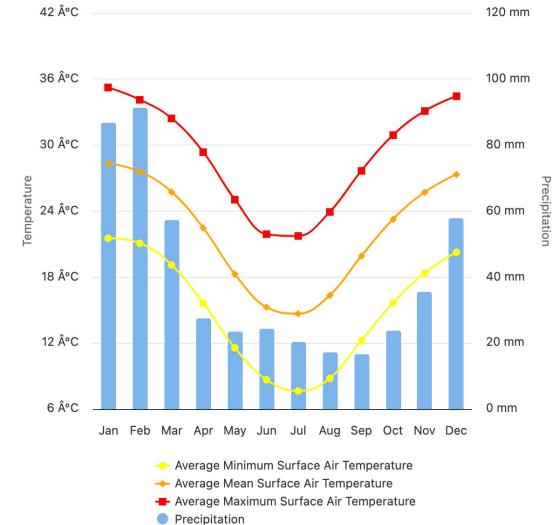
Mixed Central Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; Arab Republic of Egypt



Southern Eastern Hemisphere

Monthly Climatology of Average Minimum Surface Air Temperature, Average Mean Surface Air Temperature, Average Maximum Surface Air Temperature & Precipitation 1991-2023; Australia



- Brazil resembles temperature and precipitation patterns with countries close to the equator, but with much higher precipitation rates. Temperatures in Brazil remain more consistent throughout an average year.

2. Conditions Required for Wind Power Generation

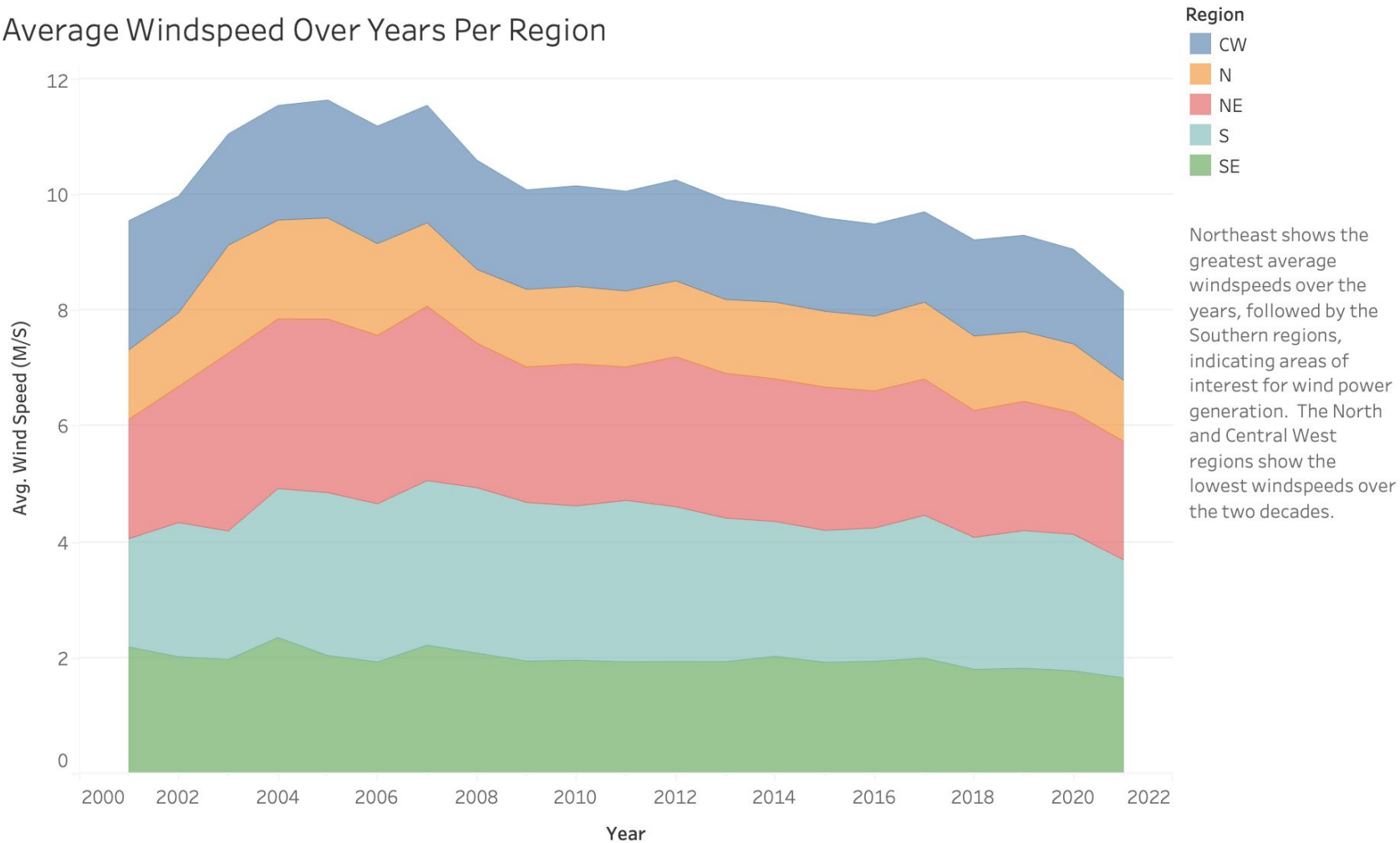
1. **High wind speed** - strongest predictor of wind power with a Shapely value* of 30.
2. **Consistent wind speed and direction** - wind direction has a Shapely value of 0.44.
3. **Low humidity, temperature and precipitation** - these factors can damage wind turbine machinery and its action.²

*The Shapely value of an environmental factor value is its contribution to the wind power output based on the wind power model, weighted and summed over all possible environmental factor combinations.¹

¹Pang C., Yu J., Liu Y. Correlation analysis of factors affecting wind power based on machine learning and Shapley value. IET Energy Syst. Integr. 2021;3:227–237. doi: 10.1049/esi2.12022.

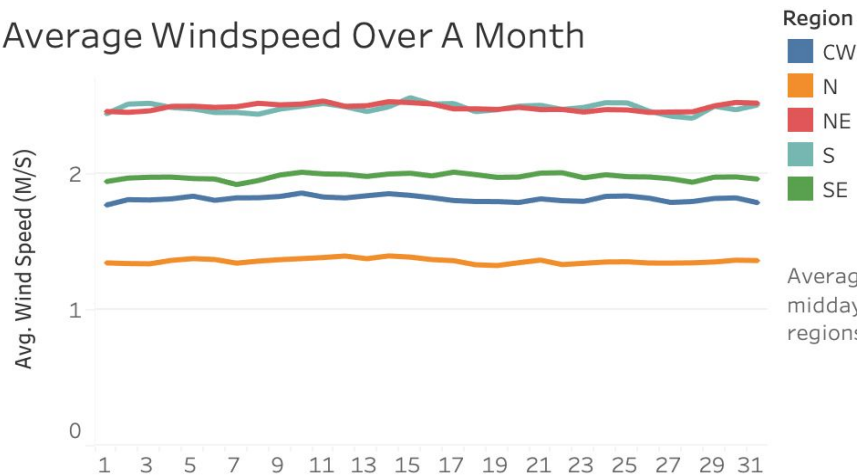
²Windurance. Weather Factors Affecting Wind Turbine Efficiency (+ Their Solutions). 2020. URL: <https://blog.windurance.com/weather-factors-affecting-wind-turbine-efficiency-solutions>

Average Windspeed Over Years Per Region



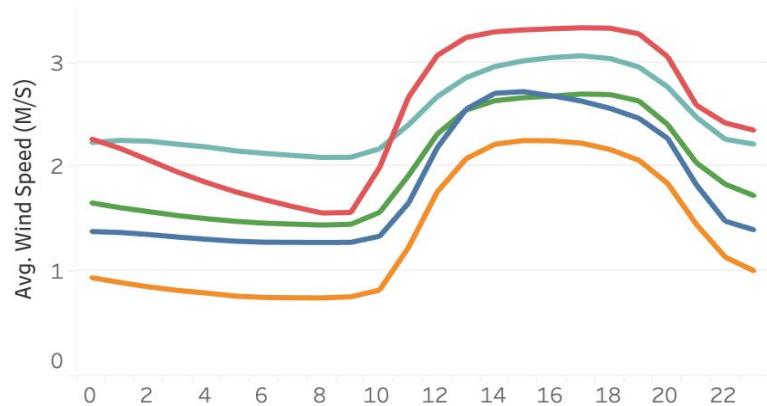
Factors Affecting Wind Generation: Fluctuations in Wind Speed and Wind Direction

Average Windspeed Over A Month

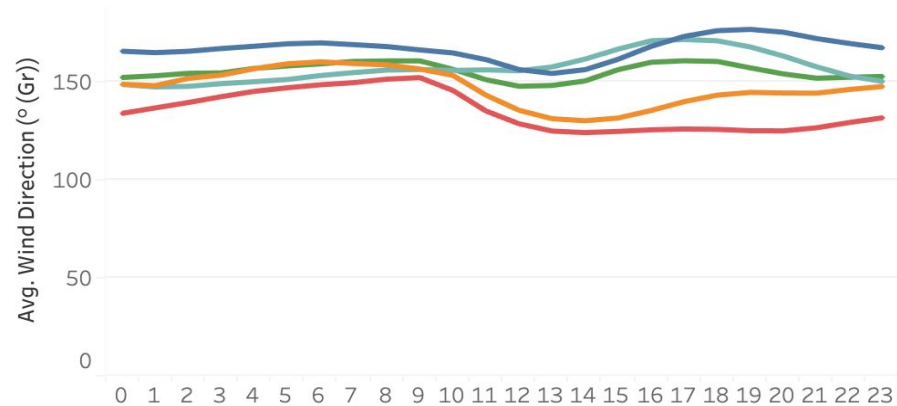


Average Windspeed remains consistent over each day of the month, and peaks after midday (around 12:00-20:00). Wind direction also remains consistent across all regions, averaging at around 150 degrees.

Windspeed Over a Day

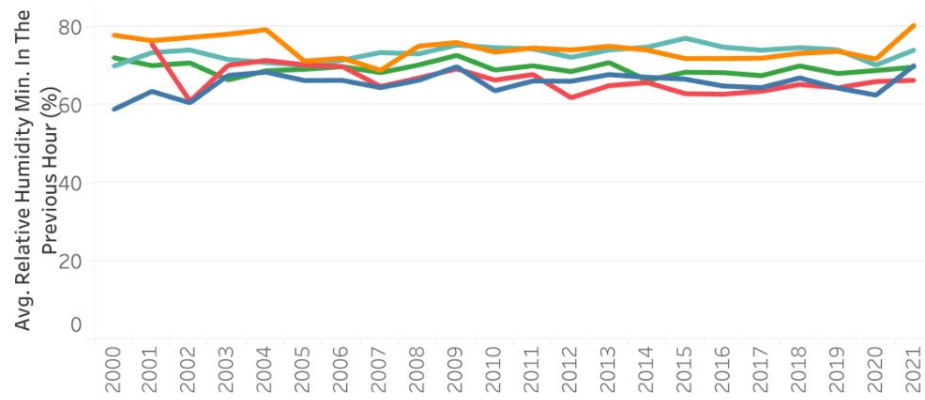


Wind Direction Over a Day



Environmental Conditions for Wind Power Generation

Average Humidity Per Year

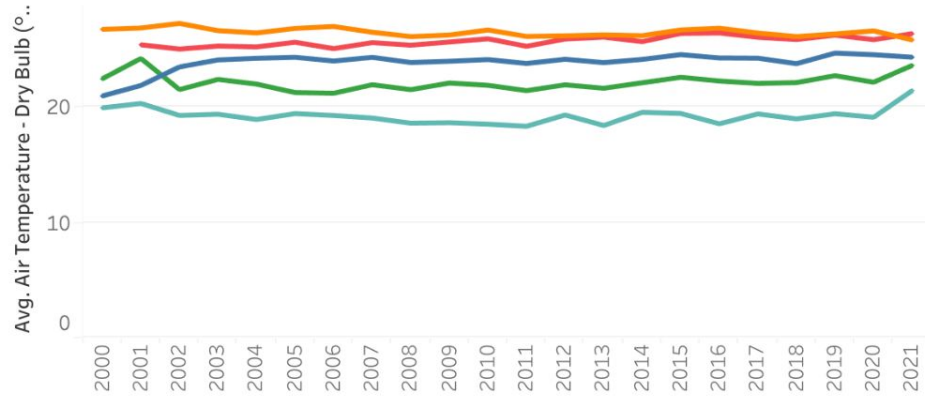


Ideal conditions for wind power generation are low temperatures, low humidity and limited precipitation. The areas of interest North East, South and South East (NE, S, SE) will be discussed.

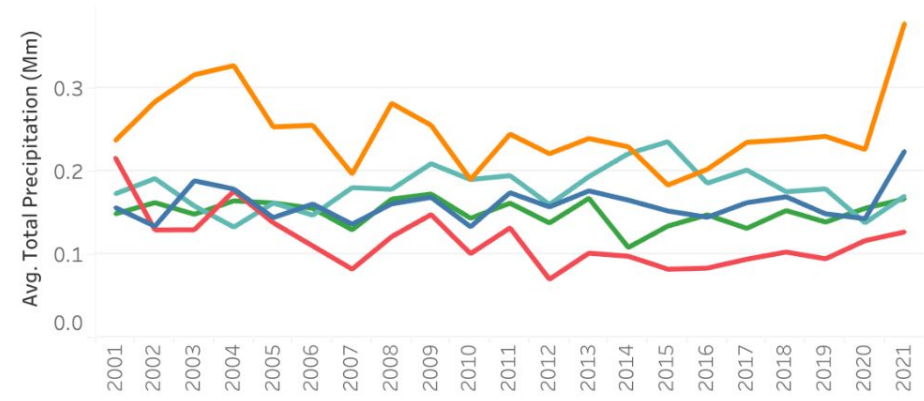
- NE shows the lowest humidity of all the regions, with S having the highest and SE a middling humidity.
- NE shows the second to highest average temperature, with S the lowest and SE second to lowest.
- NE shows the lowest precipitation, followed by S and SE being second to highest.

Conclusion: SE shows the most compromise between all three factors, indicating good conditions for wind turbine action/power generation.

Average Temperature Per Year



Average Precipitation Per Year

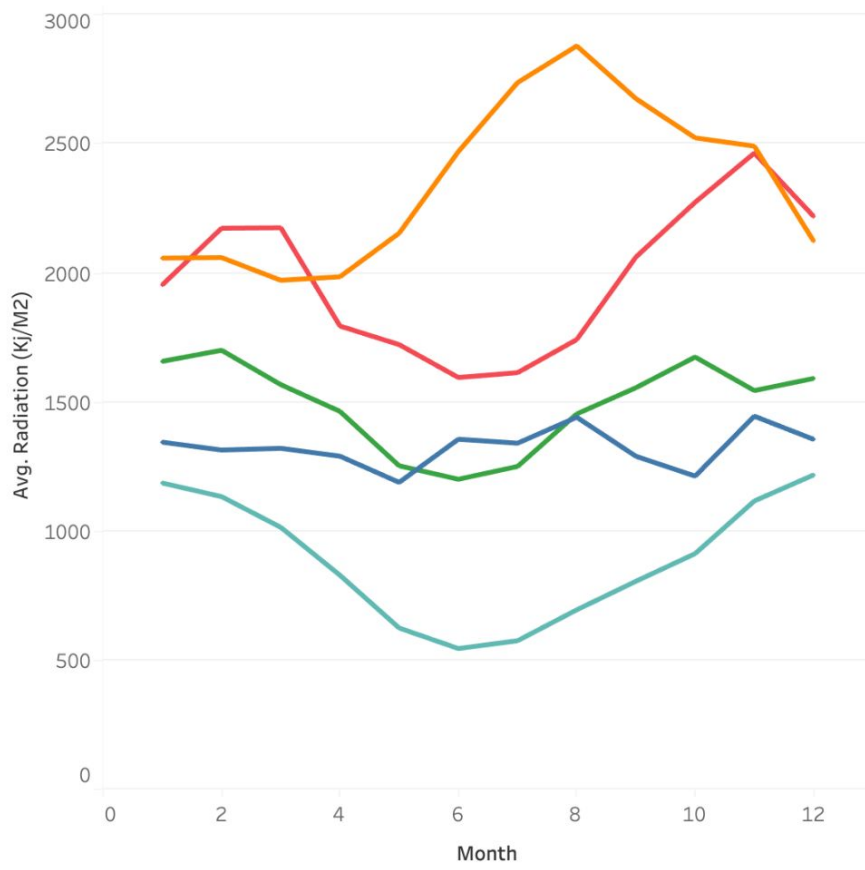


Conditions Required for Solar Power Generation

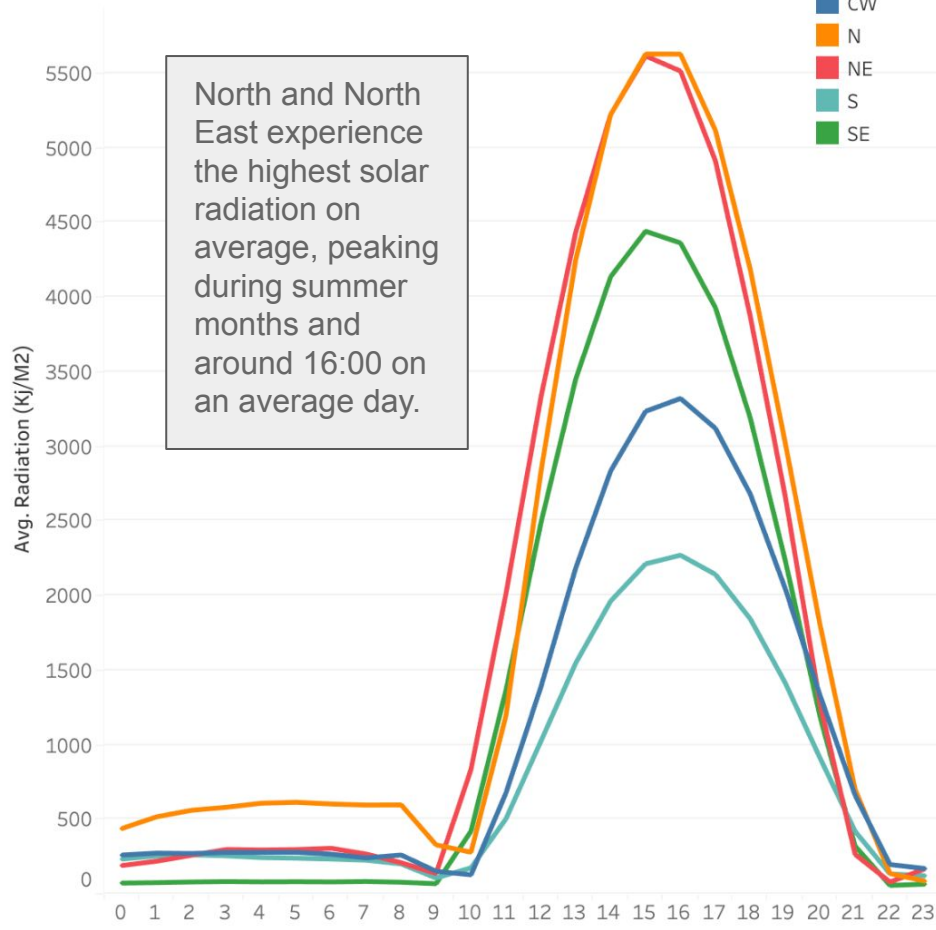
1. **High solar radiation** - Solar panels generate more electricity when they receive higher levels of irradiance.
2. **Temperatures below 25°C** - Solar panel efficiency decreases as temperature increases. Most silicon-based solar panels will lose between 0.25%-0.5% efficiency per 1°C increase.
3. **Weather:** Cloud cover, rainfall, and wind can affect solar panel performance.³

³Eze, Val & Richard, Kiiza & K.J, Ukagwu & Okafor, Wisdom. (2024). Factors Influencing the Efficiency of Solar Energy Systems. 6. 119-131. 10.36079/lamintang.jetas-0603.748.

Average Solar Radiation Per Region Over an Average Year

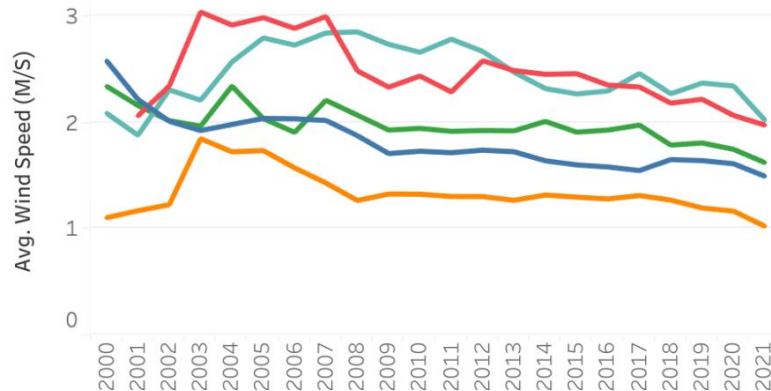


Average Solar Radiation Over a Average Day



Environmental Conditions for Solar Power Generation

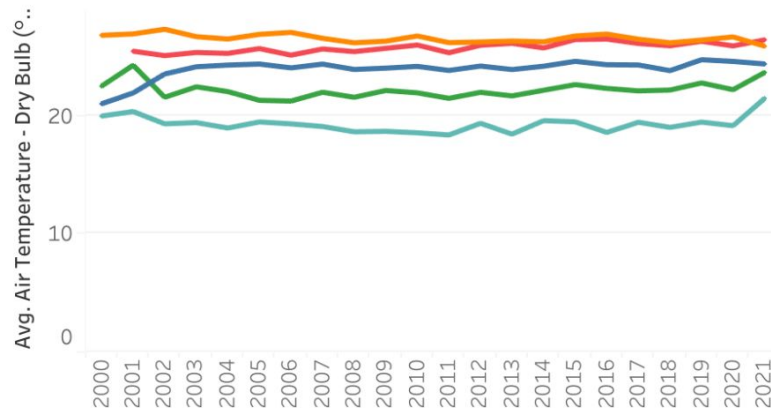
Average Wind Speed For Each Region



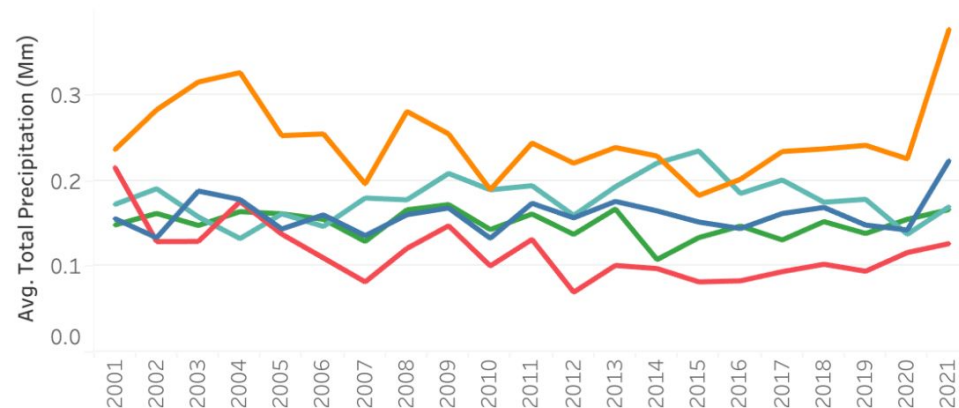
Region
CW
N
NE
S
SE

Wind speeds are high for the North East, which indicates problematic conditions for solar power generation despite high solar radiation. Average temperatures for N and NE exceed 25°C which could be problematic for solar power performance. However, their temperatures are not excessively high at around 26°C. Highest precipitation occurs in the North, while the lowest in the North East.

Average Temperature Per Year



Average Precipitation Per Year



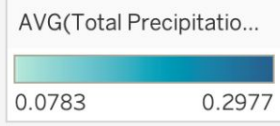
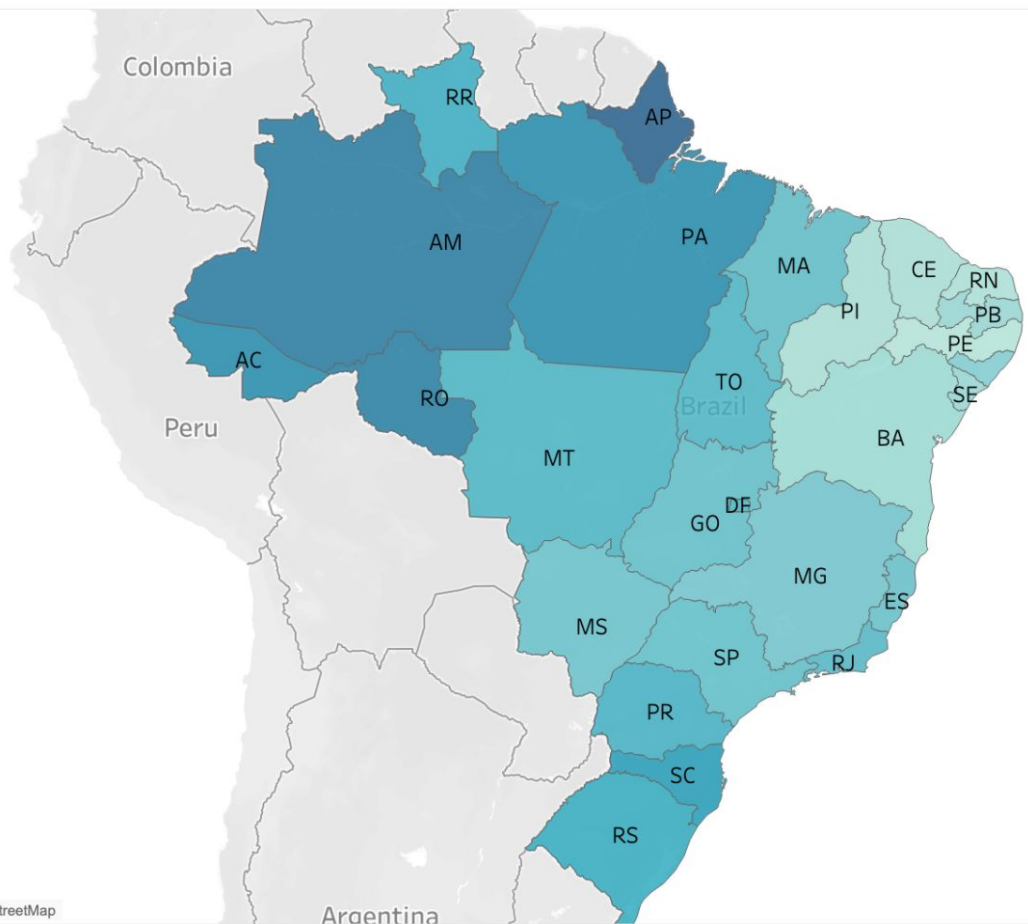
Conditions indicating need for irrigation

1. **Low water availability** - e.g. through low rainfall rates.
2. **High temperatures and solar radiation** - increase evapotranspiration rates* and increase water demand.
3. **High humidity and wind speed** also increase evapotranspiration.

*Evapotranspiration is the total water loss from a land area through both evaporation from the soil and water bodies and transpiration from plants.

Daniel Hillel, Paul Vlek, The Sustainability of Irrigation, Advances in Agronomy, Academic Press, Volume 87, 2005, pages 55-84, ISSN 0065-2113, ISBN 9780120007851, [https://doi.org/10.1016/S0065-2113\(05\)87002-6](https://doi.org/10.1016/S0065-2113(05)87002-6).
(<https://www.sciencedirect.com/science/article/pii/S0065211305870026>)

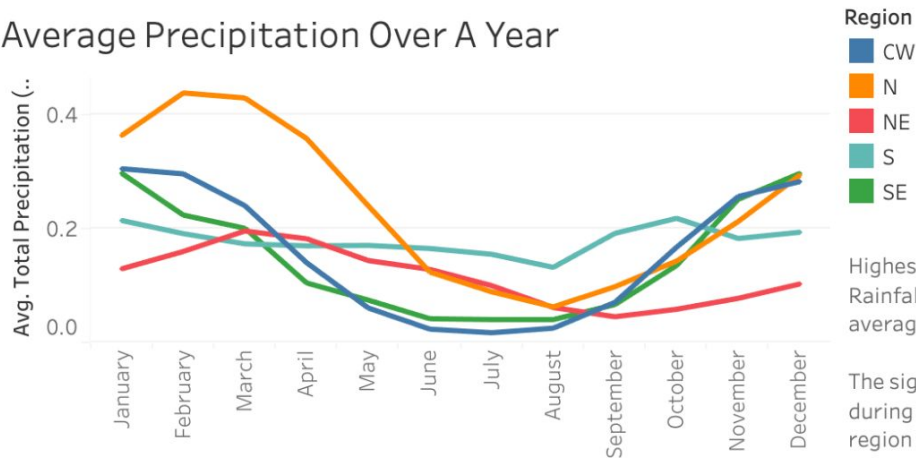
Average Rainfall Across Brazil



North region has the highest rainfall, followed by Southern regions. Northeast has the driest states including Pernambuco (PE), Piaui (PI) and Rio Grande do Norte (RN), likely due to high temperatures, wind speeds and humidity, and may benefit from irrigation.

Consistency of Rainfall Across Regions

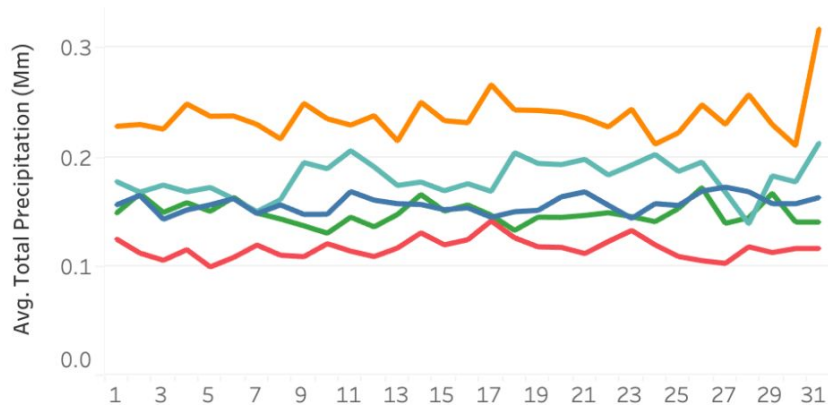
Average Precipitation Over A Year



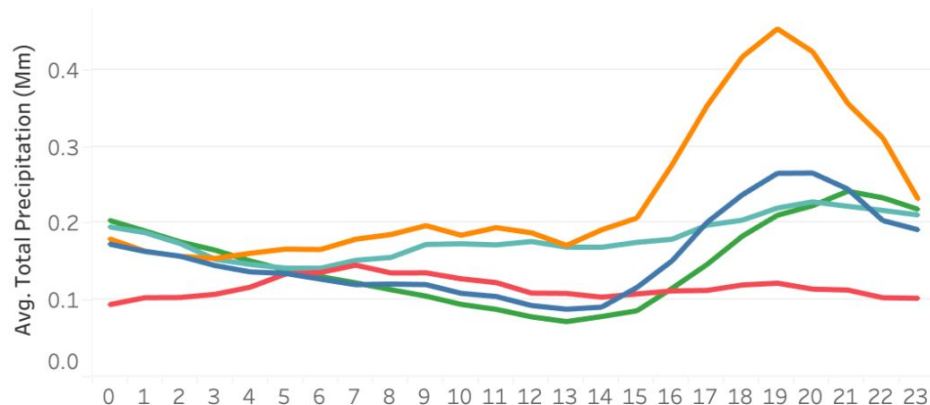
Highest rainfall is observed during spring, with a significant drop in the summer months. Rainfall remains consistent over an average month, and peaks towards the evening in an average day.

The significant drop in rainfall during the summer months may signal the need for irrigation during this time, particularly in the Central West and South East regions. The North East region has the most urgent need for irrigation as it consistently displays the lowest rainfall.

Average Precipitation Over a Month



Average Precipitation Over a Day



Summary

- ❖ Temperatures and humidity has increased across the two decades, likely due to climate change due to increased greenhouse gas emissions.
- ❖ South East has the best conditions for wind power generation (with the North East and South being contenders).
- ❖ The North and Northeast show the best conditions for solar power generation (high solar radiation).
- ❖ North East experiences the least rainfall on average and should be considered for irrigation.