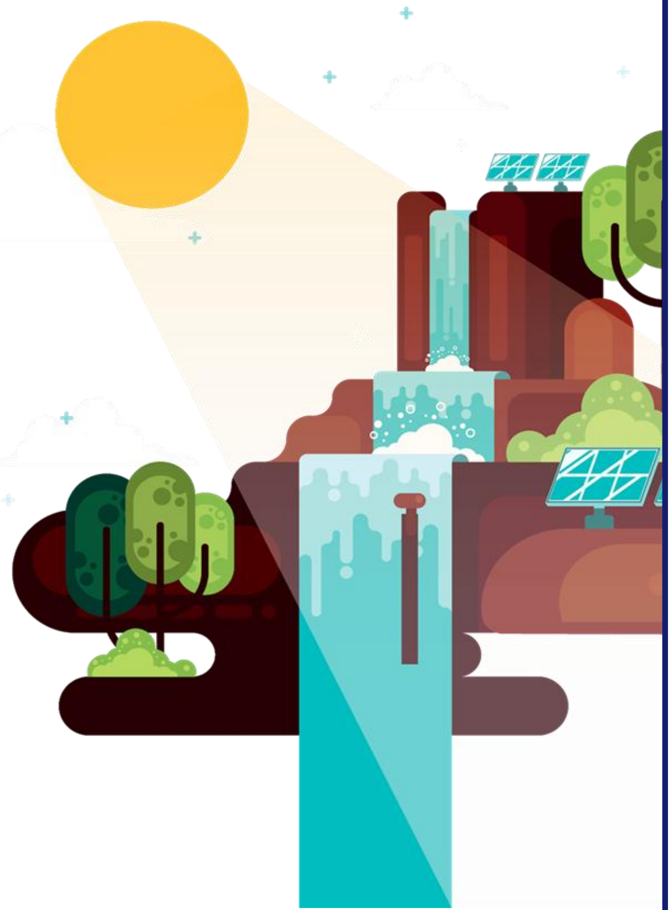

Climate Power Forecast

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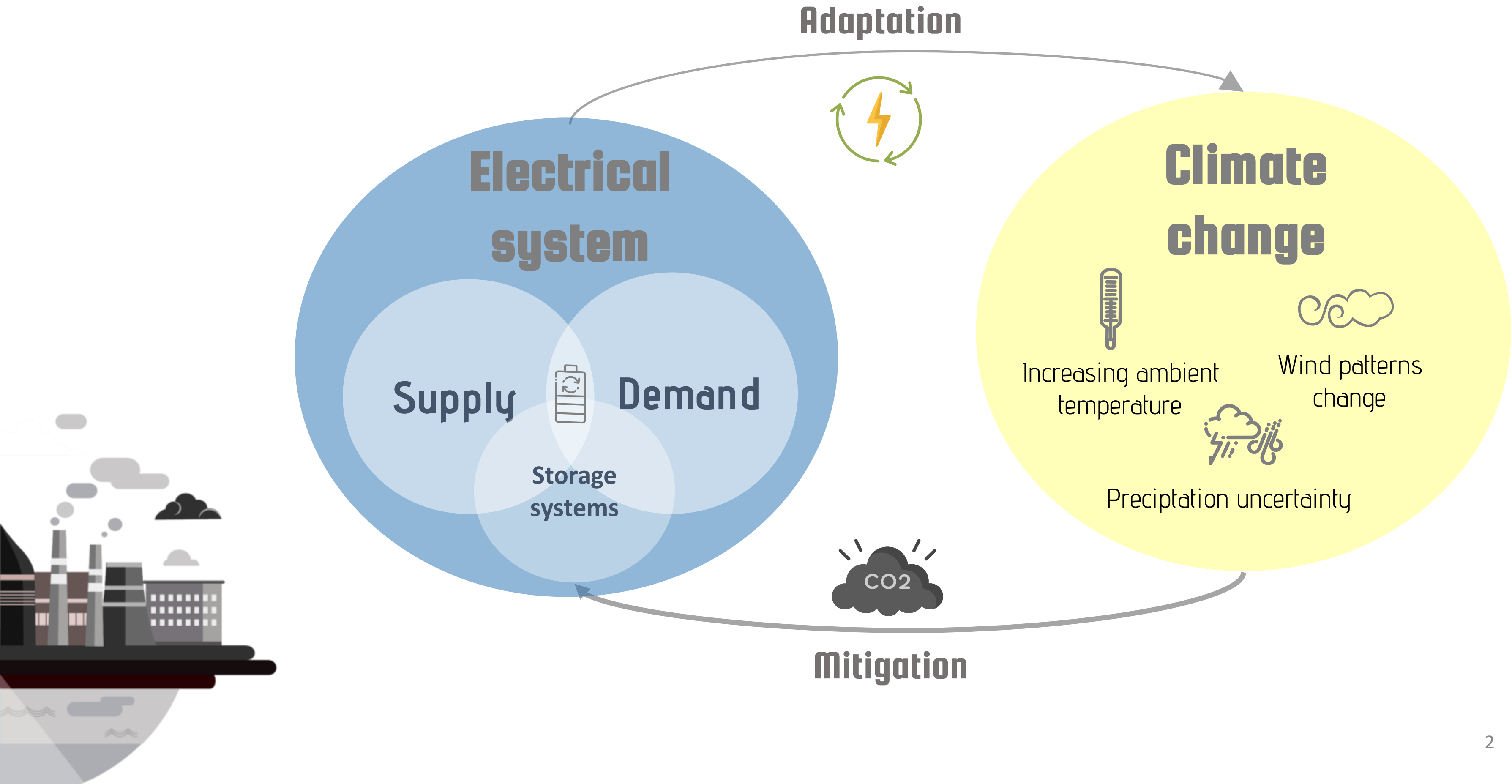
Natália de A. B. Weber

I. INTRODUCTION

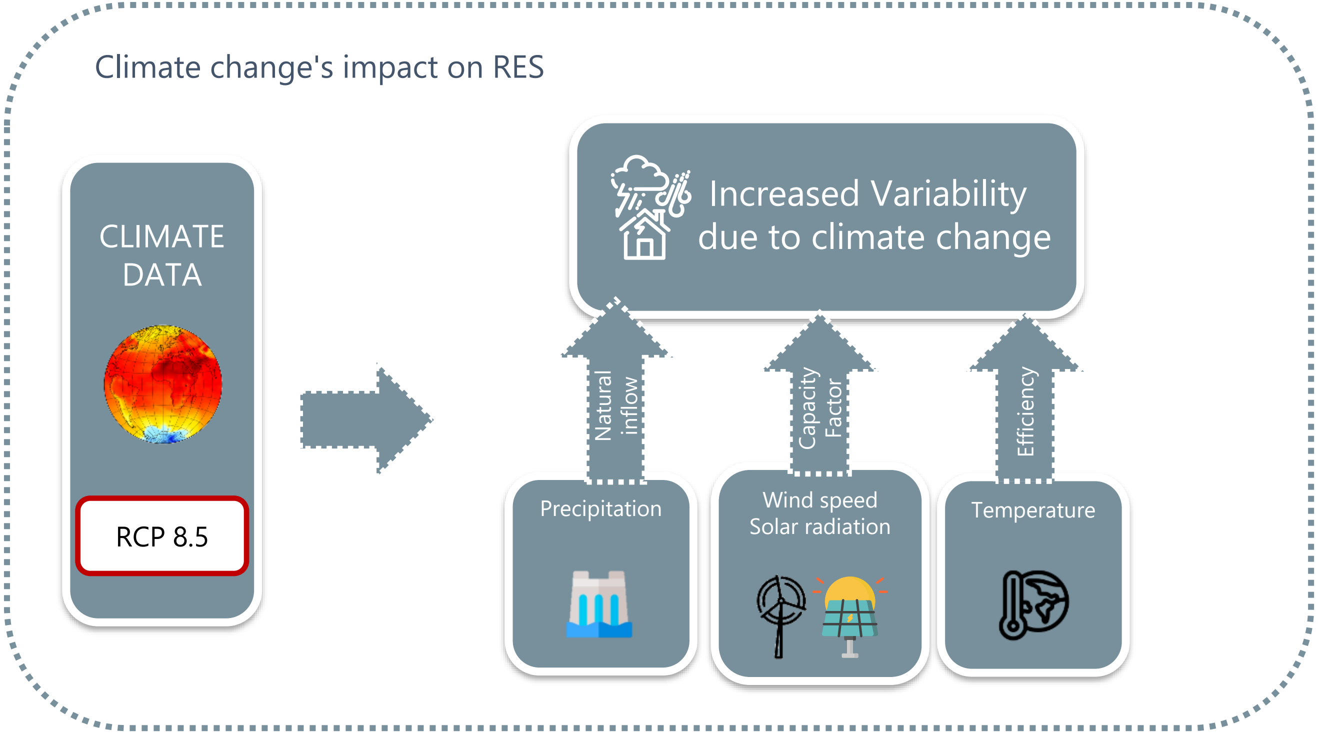


2. METHODOLOGY

"Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer)."

—World Meteorological Organization

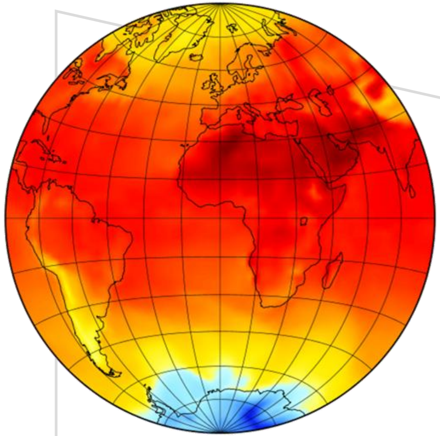
METHODOLOGY



STEP 1: CORDEX

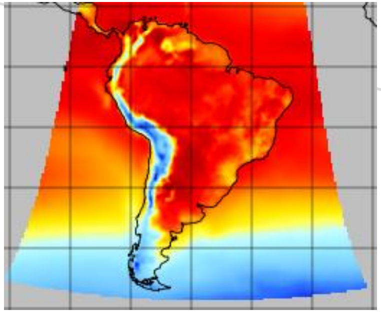
PERIOD:
1971-2005 – historical
2006-2099 – future

Global climate model
HadGEM



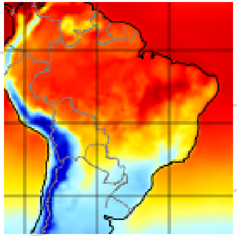
Resolution: 1000km

Regional climate model
SAM-Cordex



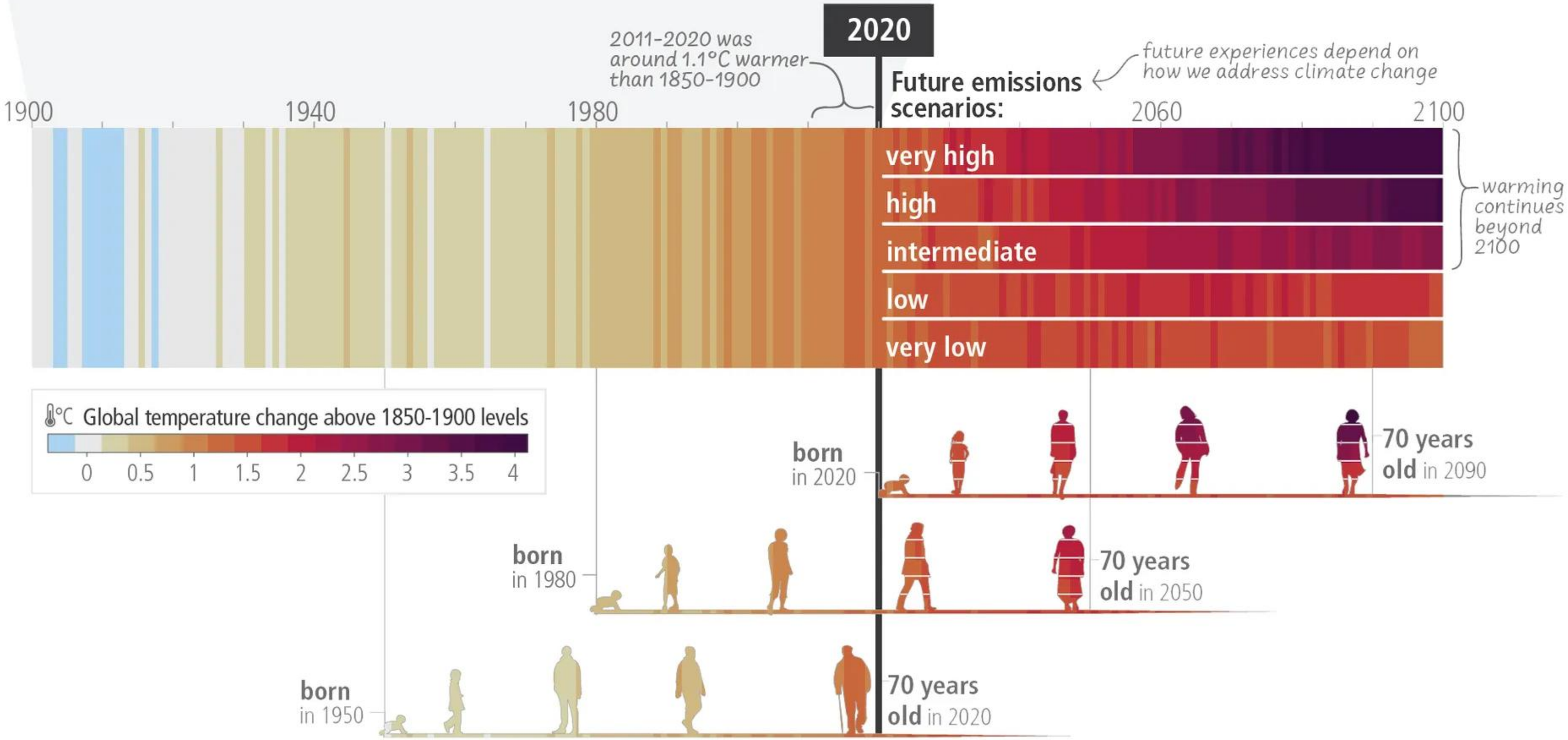
Resolution: 50km

Brazil delimitation



Resolution: 50km

c) The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near-term



Source: https://www.ipcc.ch/report/ar6/syr/downloads/figures/IPCC_AR6_SYR_SPM_Figure1.png

STEP I: Climate change scenarios

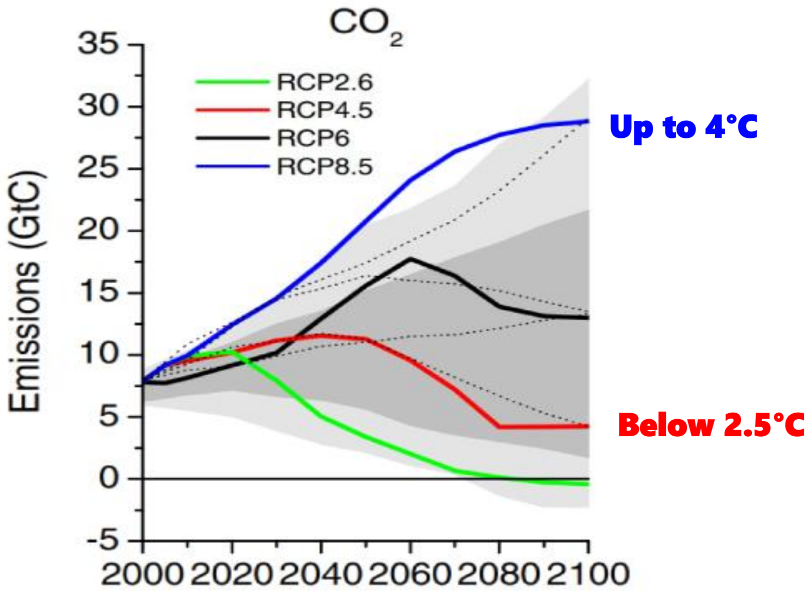


Fig. 9: Selected RCPs scenarios main assumptions and projected temperature increase above pre-industrial levels [Adapted from Van Vuuren et al., 2011]

RCP 4.5: stabilization scenario

- CO_2 emissions start declining by 2045;
- To keep global warming below 2.5°C.

RCP 8.5: no-policy scenario

- Does not include any specific purpose of mitigation
- By 2100 the global mean temperature can be 4 °C higher than the historical mean

STEP I: Conversion of climate variables to future energy production

Climate variable:
Near surface (10m) wind speed $(m\ s^{-1})$

1. Choose a representative wind turbine We chose a popular choice in Latin America: Vestas V110-2.MW
   - Rated power: 2.MW
   - Cut-in wind speed: 3 m/s
   - Rated wind speed: 12 m/s
   - Cut-out wind speed: 25 m/s
   - Hub height: 100 m

2. Extrapolated from 10m to the hub height 100m.

$$\frac{U(z)}{U(z_r)} = \left(\frac{z}{z_r}\right)^{\alpha} \qquad \text{Eq. 1}$$

where α is the roughness length

3. Calculate the power curve of the Vestas turbine in kW

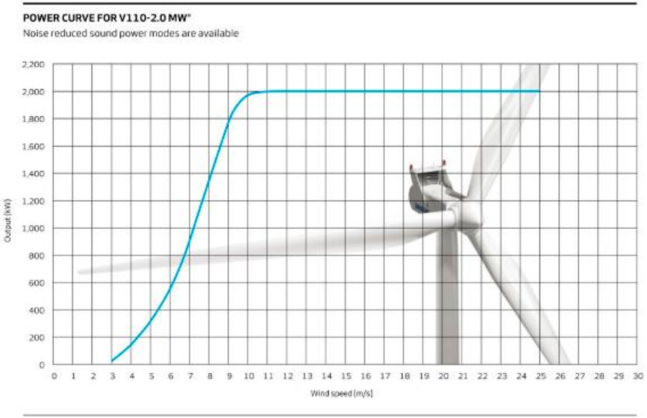
$$P_{flux} = \frac{1}{2}\,\rho_{air}\,U^3 \qquad \text{Eq. 2}$$

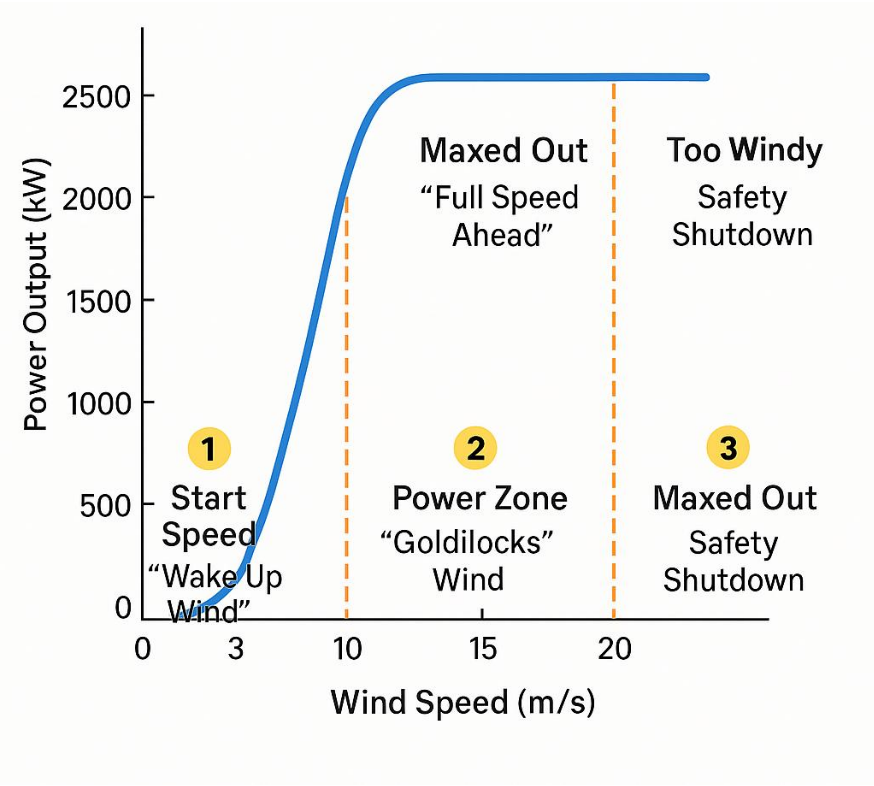
where ρ_{air} is the air density

4. Compute energy over 3-hour intervals kWh

$$Energy\_out = P_{flux} * 3 \qquad \text{Eq. 3}$$

How the Wind Power is Calculated





Limitations of Wind Power Curve Calculations

- **Simplified Assumptions**: The standard power curve assumes ideal conditions — constant air density, no turbulence, and perfect turbine performance — which may not reflect real-world variability.
- **Temporal Resolution**: Using coarse time resolution (e.g., 3-hourly wind data) can distort power estimates due to the nonlinear relationship between wind speed and power.
- **Fixed Technology Assumption**: We assume current wind turbine technology remains unchanged. For projections extending to 2099, this is a major limitation, as future turbines may be more efficient, larger, or optimized for different wind regimes.

3. FUTURE DEVELOPMENTS

STEP I: Conversion of climate variables to potential energy production

Climate variable:
Solar radiation measured as ($\mathrm{W}\ m^{-2}$)

1

Future solar energy production was calculated using a linear correlation between the monthly average solar energy production and the monthly average solar radiation measured as (W m−2)

Estimated the losses due to change in temperature (T_{loss})

$$T_{loss} = 0.05 * (tas - 25)$$

for

$$tas \geq 25$$

where tas is the temperature (ºC)

Comparison of renewable energy resources' average (2099) projections with the historical average

	North	Northeast	Southeast/ Midwest	South
Hydropower	↓ ↓ ↓	↓ ↓ ↓	↑ ↑ ↑	↑ ↑ ↑
Wind Power On-shore	-	= = ↑	-	↓ ↓ =
Wind Power Off-shore	-	↑ ↑ ↑	-	-
Solar Power	↑ ↑ ↑	↑ ↑ ↑	= = =	= = =

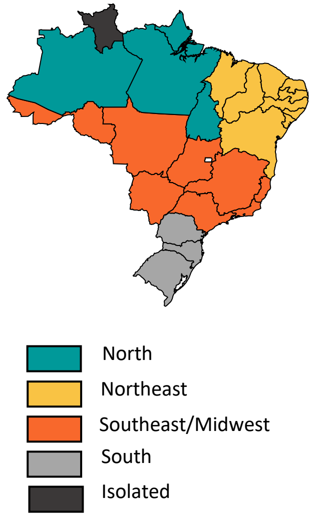
Legend:

- Change on average capacity factor for wind and solar power:
- Change on average water Inflow for hydropower:

lower | No change | higher

- Climate change scenarios: Historical | RCP 4.5 | RCP 8.5

- not accessed



Thank you

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