Planning and Analysis for Wind Energy in Libya

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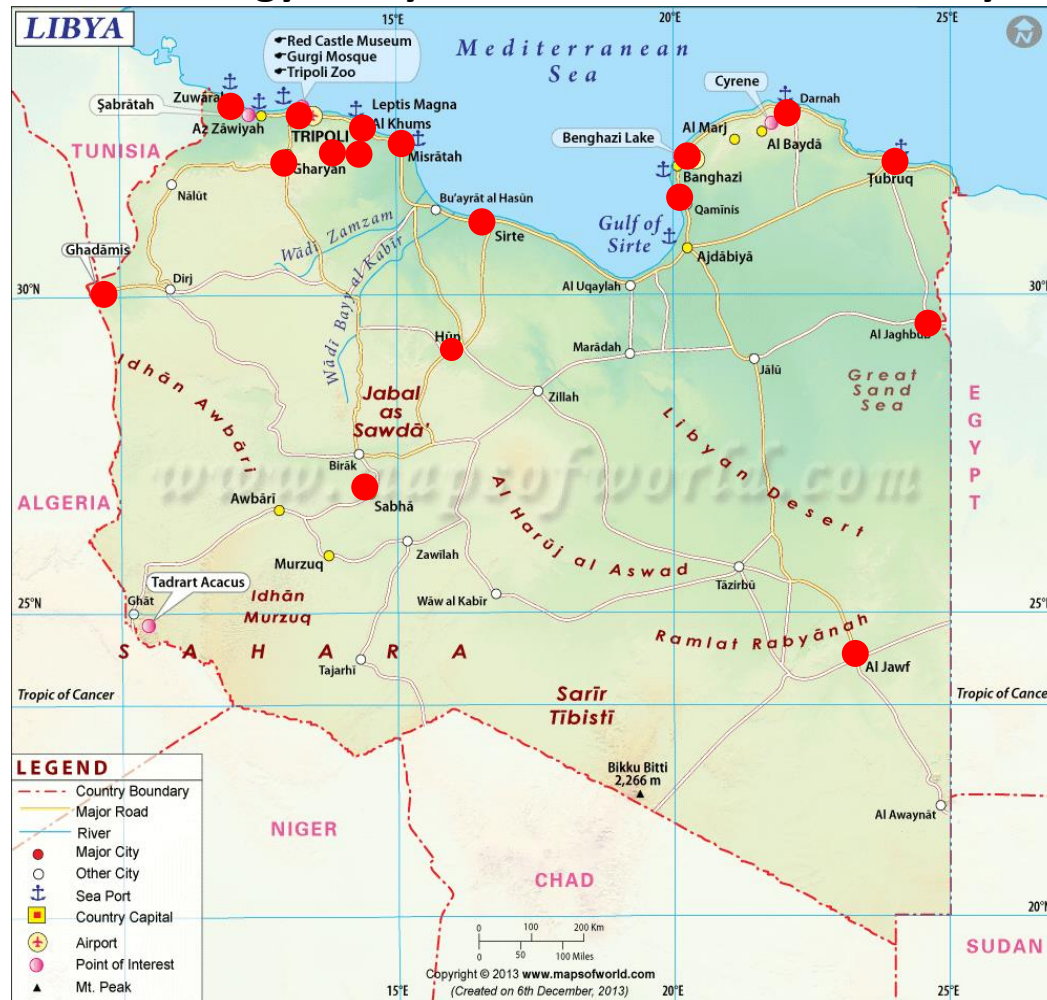
Presentation Outline

- **Wind Energy Modeling**
- **Capacity Factor of Wind Energy Resources**
- **Variability of Wind Energy Resources**
- **Aggregation of Wind Energy Resources**

Wind Energy Analysis for Some Locations in Libya

9 Locations for Comparison of Wind Energy Modeling and Analysis:
Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Benghazi,Magrun, Derna, Houn, Gadamis, Sabha, Kufra, Tobruk, Jaghbub

Typical Meteorological Year (TMY) data represents the weather for a "median year".
Data are retrieved from NREL's Developer Network: https://developer.nrel.gov/

Comparison of Monthly Average Wind Speed (m/s) at Height of 10m

Berlin in Germany has been added just for sake of comparison.
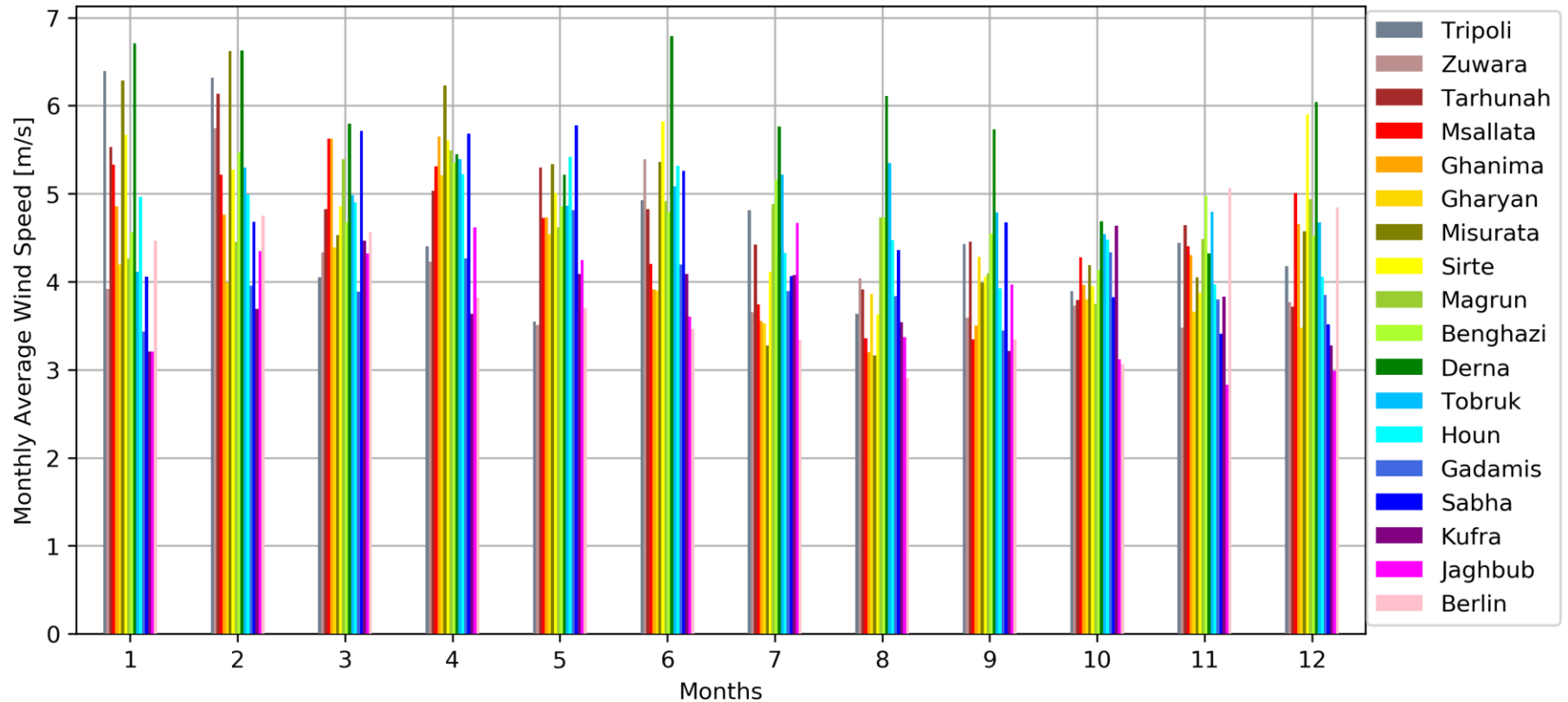
Comparison of Wind Roses (m/s) at Height of 10m

Wind Roses: Pie charts of wind speed and direction at each locations

Wind Rose of Tripoli

Wind Rose of Zuwara

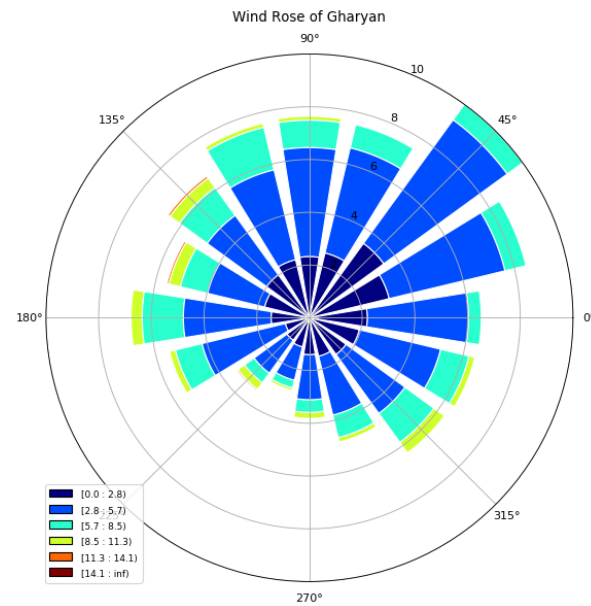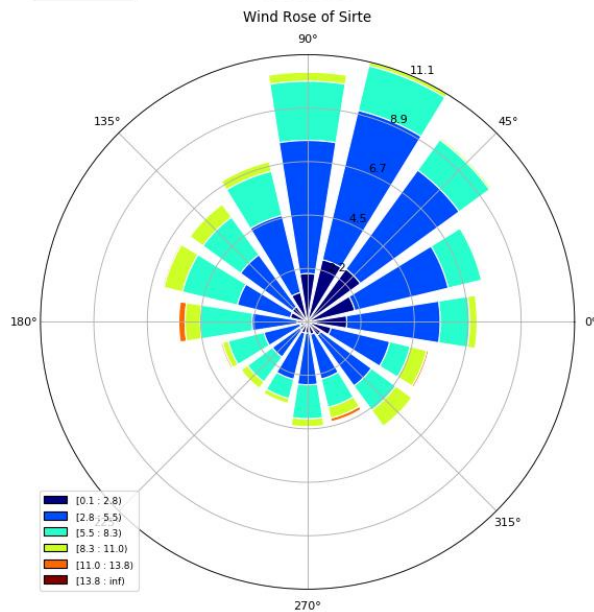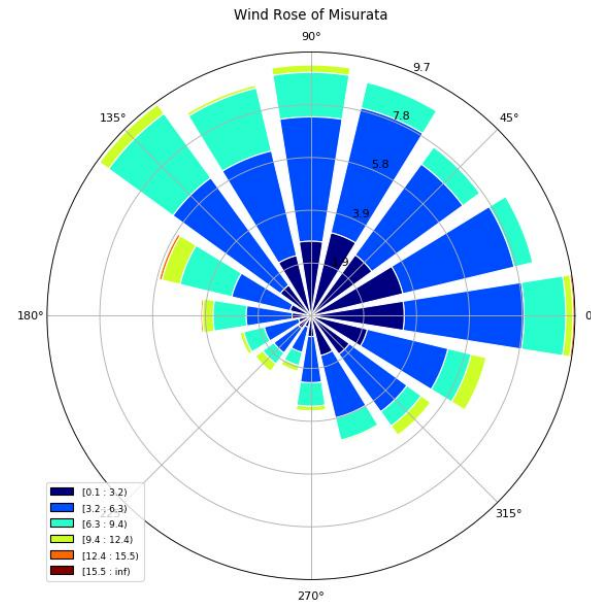Wind Rose of Tarhunah
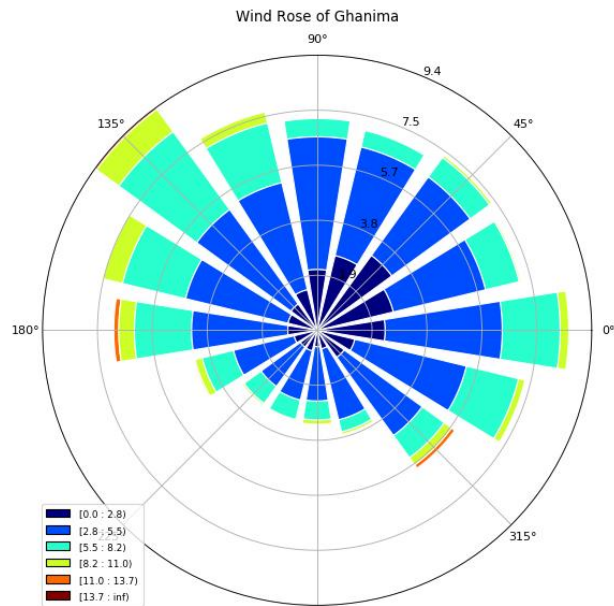

Wind Rose of Msallata

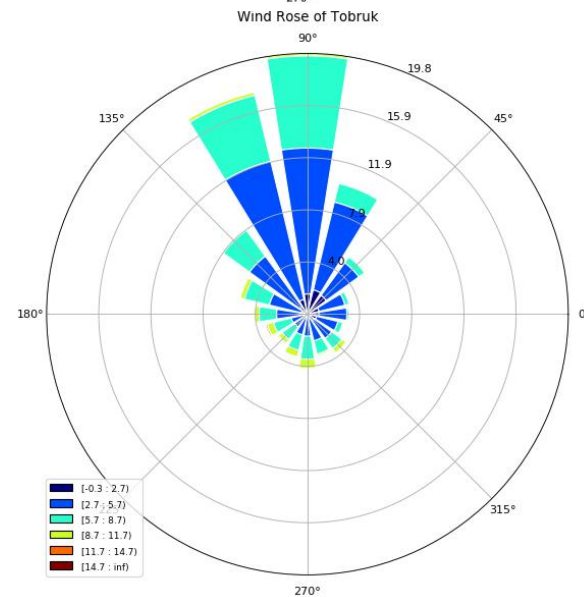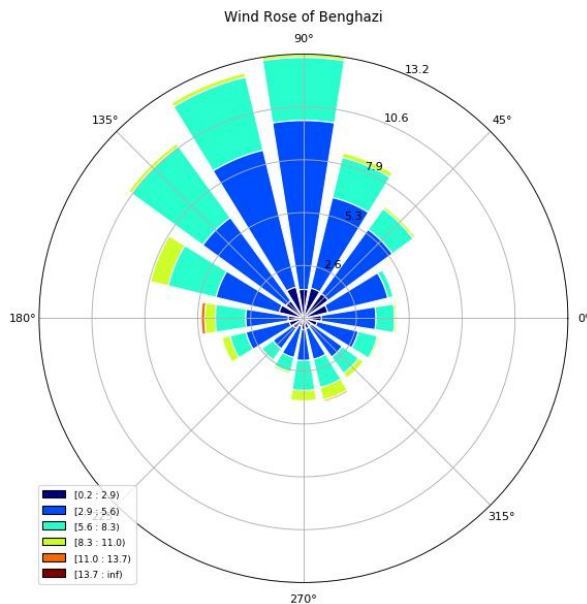# Comparison of Wind Roses (m/s) at Height of 10m

Wind Roses: Pie charts of wind speed and direction at each locations

Wind Roses: Pie charts of wind speed and direction at each locations

Wind Roses: Pie charts of wind speed and direction at each locations

Wind Rose of Sabha

Wind Rose of Gadamis

Wind Rose of Houn

Wind Rose of Kufra
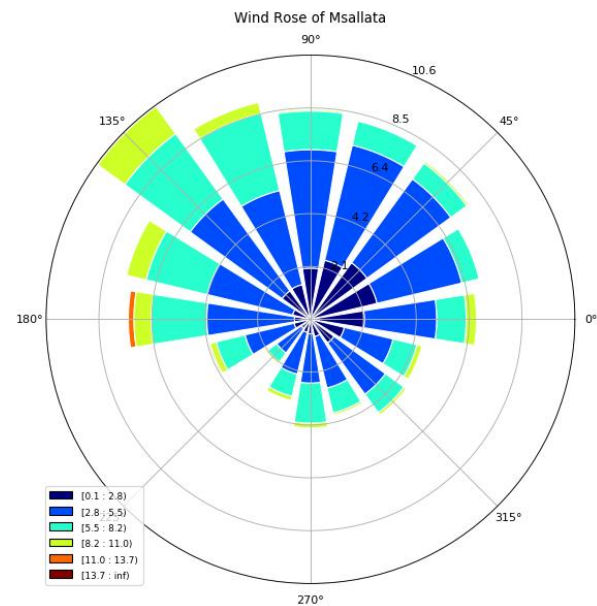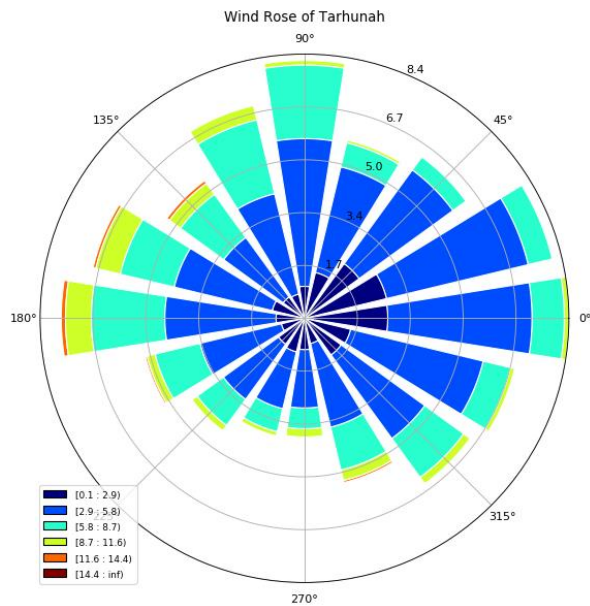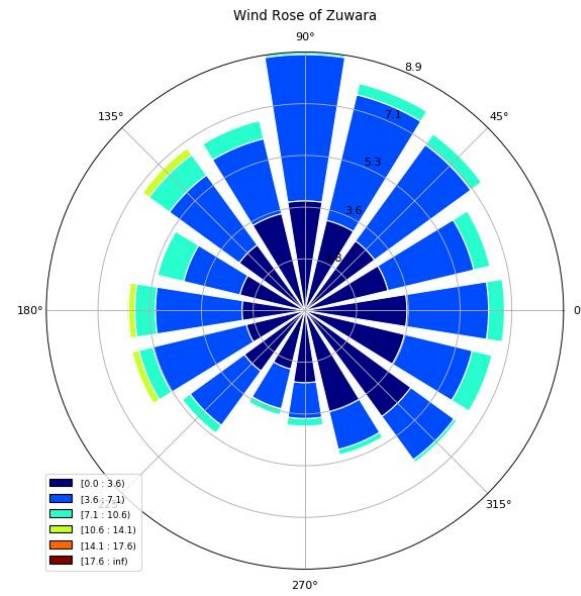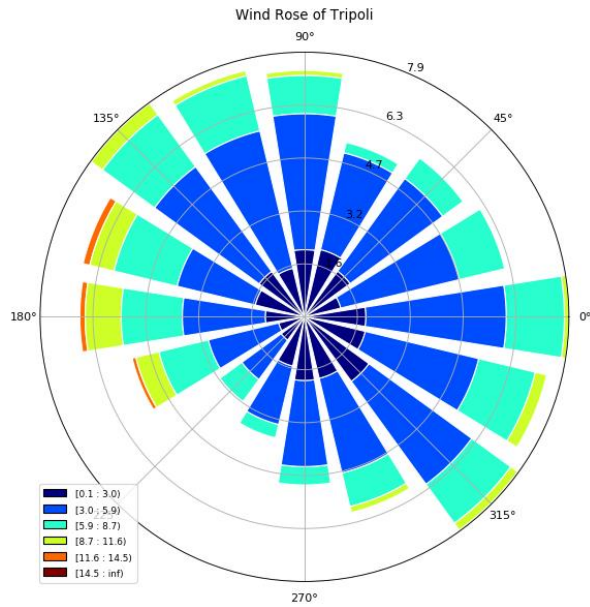
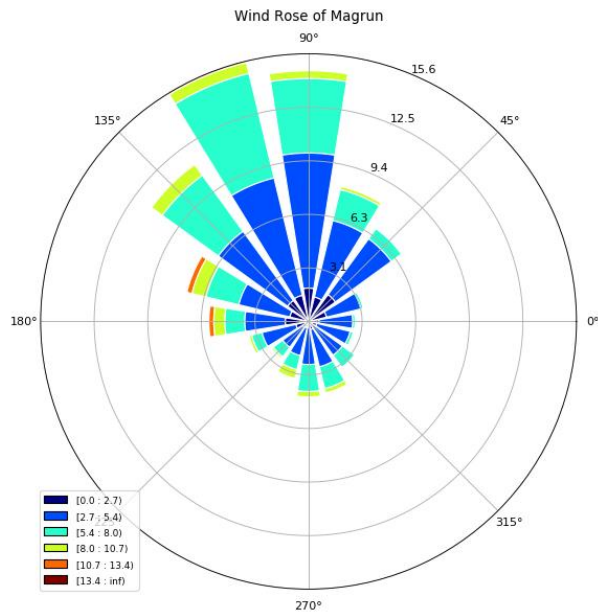Wind Roses: Pie charts of wind speed and direction at each locations

Comparison of Wind Roses (m/s) at Height of 10m
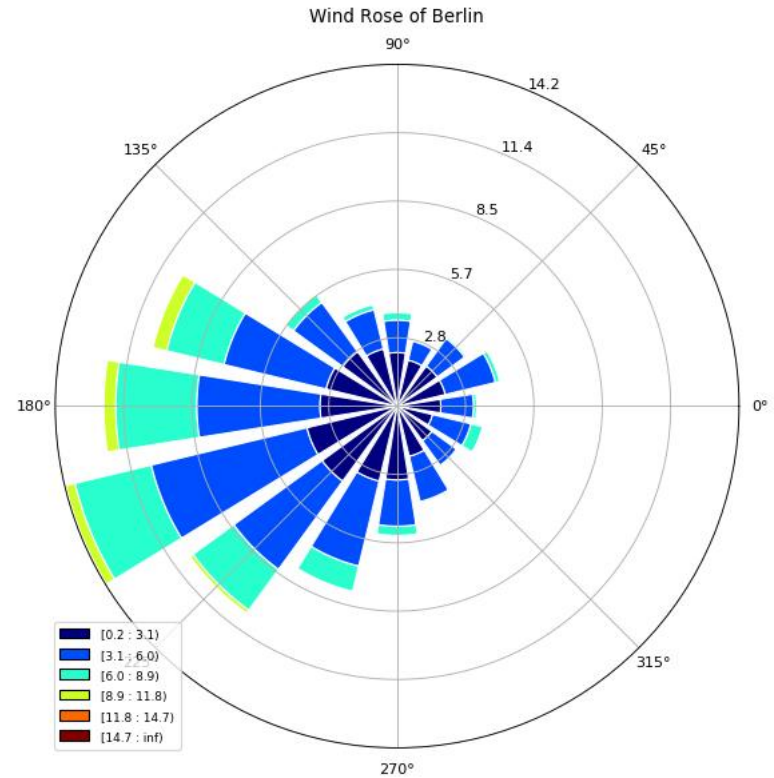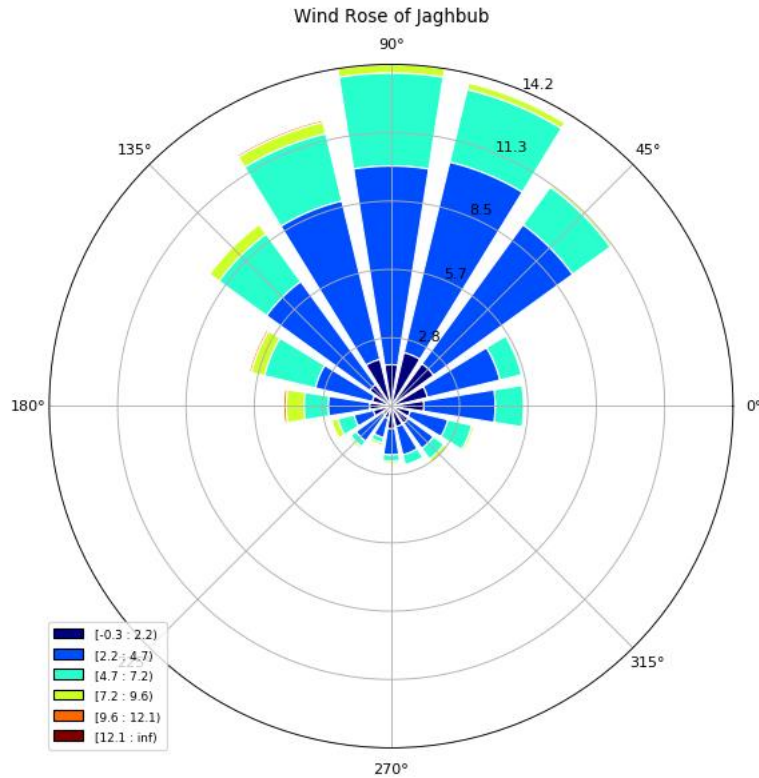
Correlation of wind speeds

Heat map of correlations of wind speeds
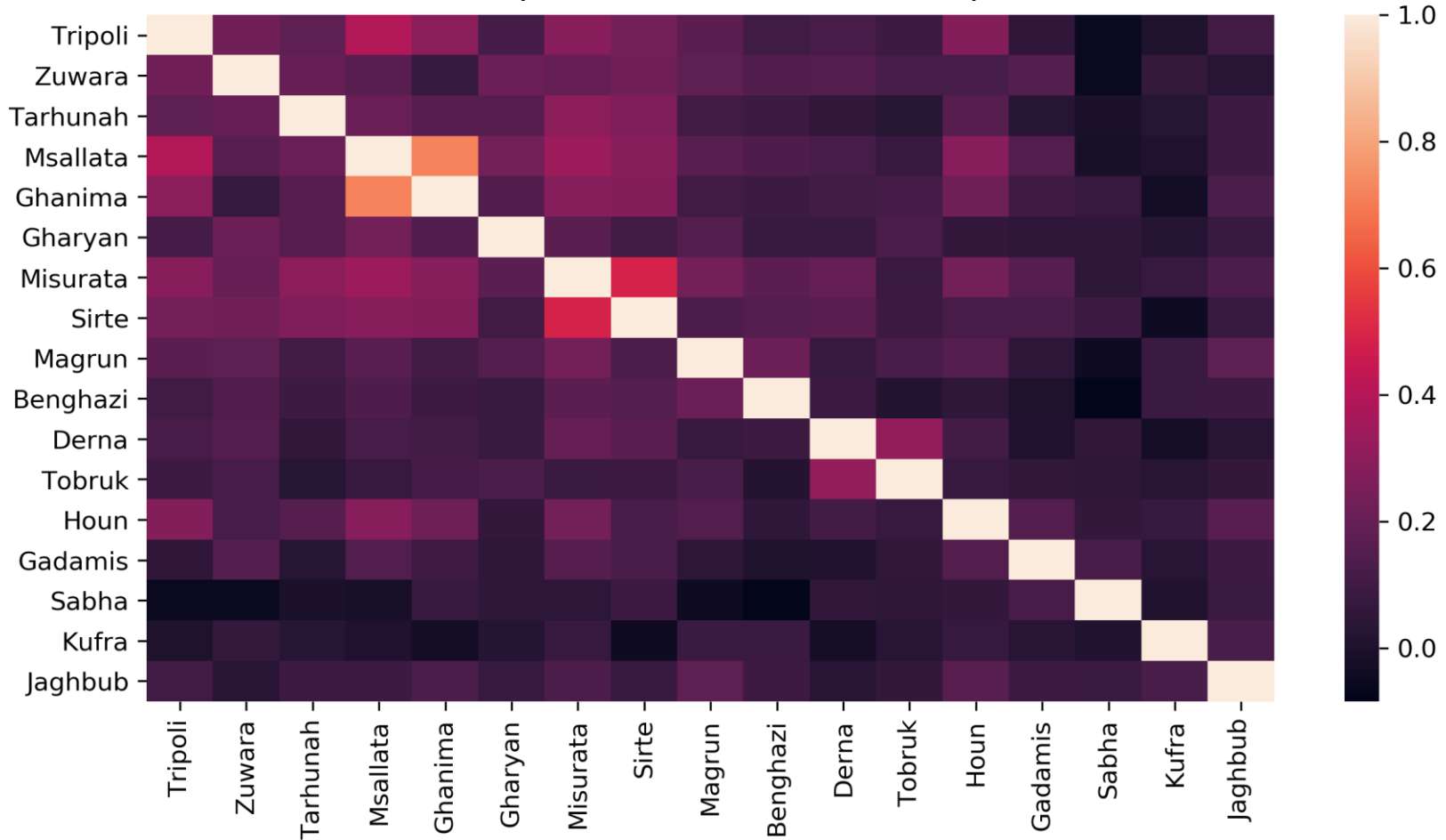
Comparison of Wind Roses (m/s) at Height of 10m

Correlation of wind speeds with solar global horizontal irradiance (GHI)
Wind speed variables as (location_x)
Solar irradiance variables as (location_y)

Heat map of correlations between wind speed and GHI
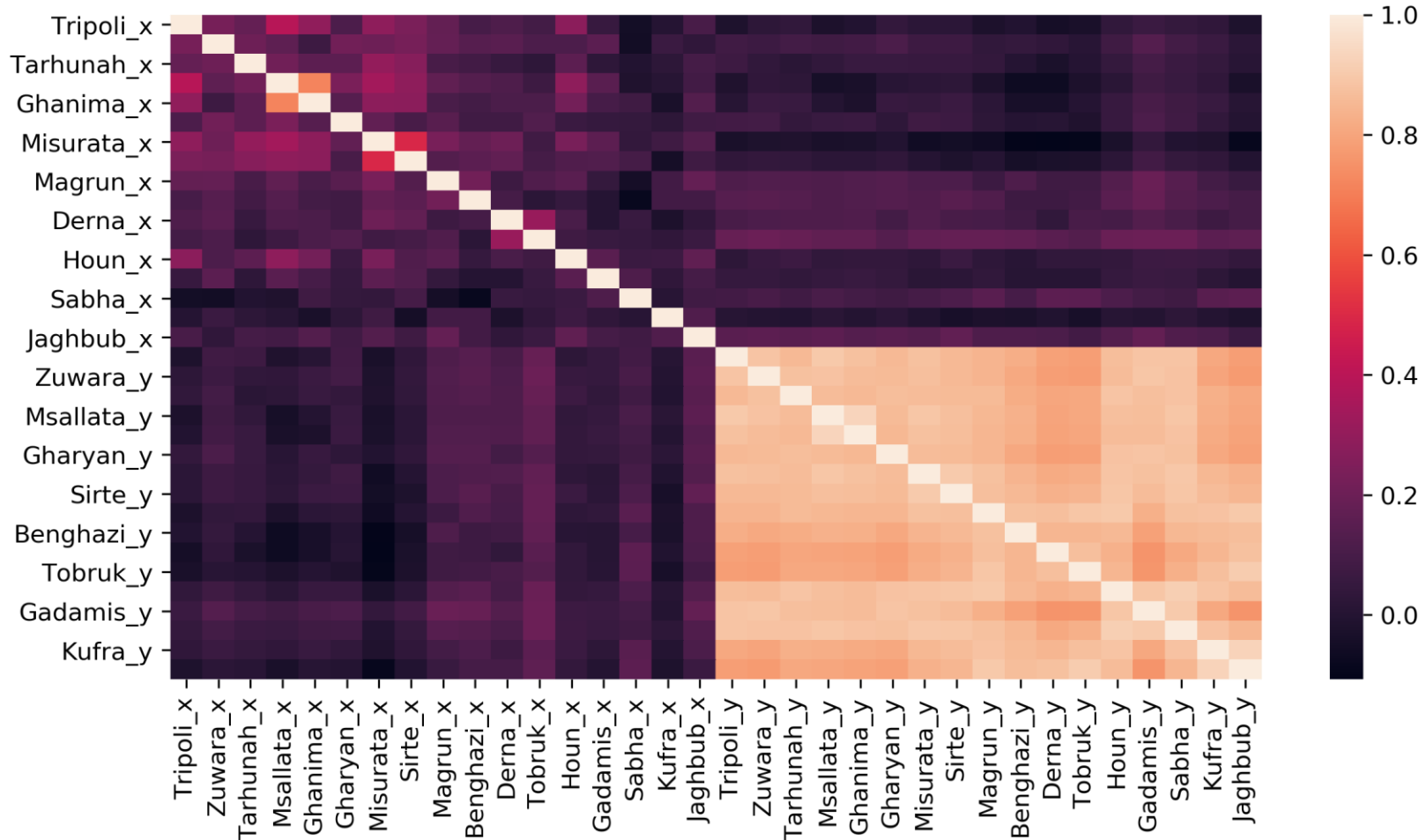
Modeling of Wind Energy

The wind power modeled from the wind speed at each location with a turbine at height of 100m. Using a wind turbine is GM120/2.5 https://www.thewindpower.net/turbine_en_592_ge-energy_2.5-120.php

General data
- Manufacturer: GE Energy (Etats-Unis)
- Model: 2.5-120
- Rated power: 2,500 kW
- Rotor diameter: 120 m
- No more available
- Wind class: IEC TC IIIs (DiBT WZII)
- Offshore model: no
- Swept area: 11,310 m²
- Specific area: 4.53 m²/kW
- Number of blades: 3
- Power control: Pitch
- Commissioning: 2014
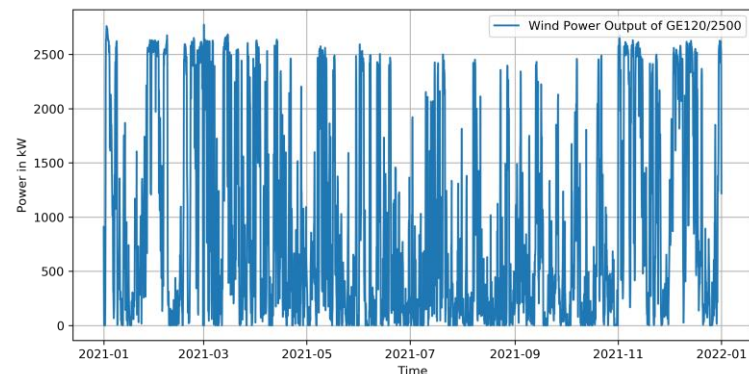
Rotor
- Cut-in wind speed: 3 m/s
- Rated wind speed: 12 m/s
- Cut-off wind speed: 20 m/s

Generator
- Type: DFIG

Tower
- Minimum hub height: 85 m
- Maximum hub height: 139 m

GE120 power coefficient curve

GE120 power curve

Wind Power Output of GE120/2500
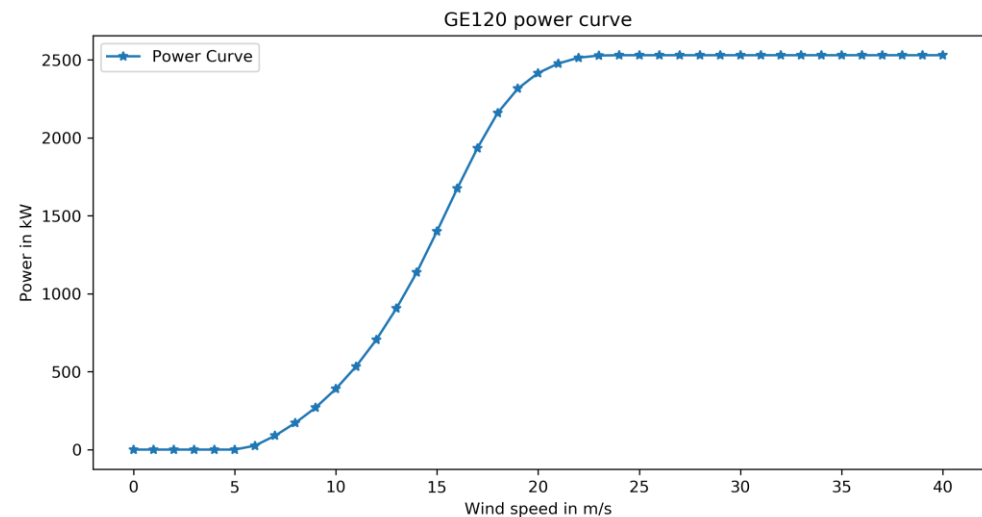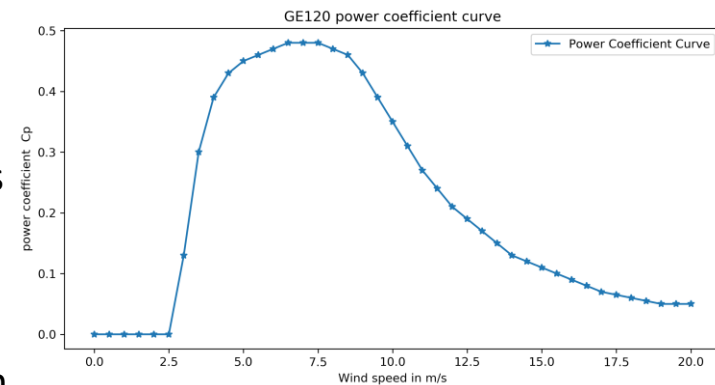
Comparison of Accumulated Wind Energy (MWh) at Height of 100m

Berlin in Germany has been added just for sake of comparison.
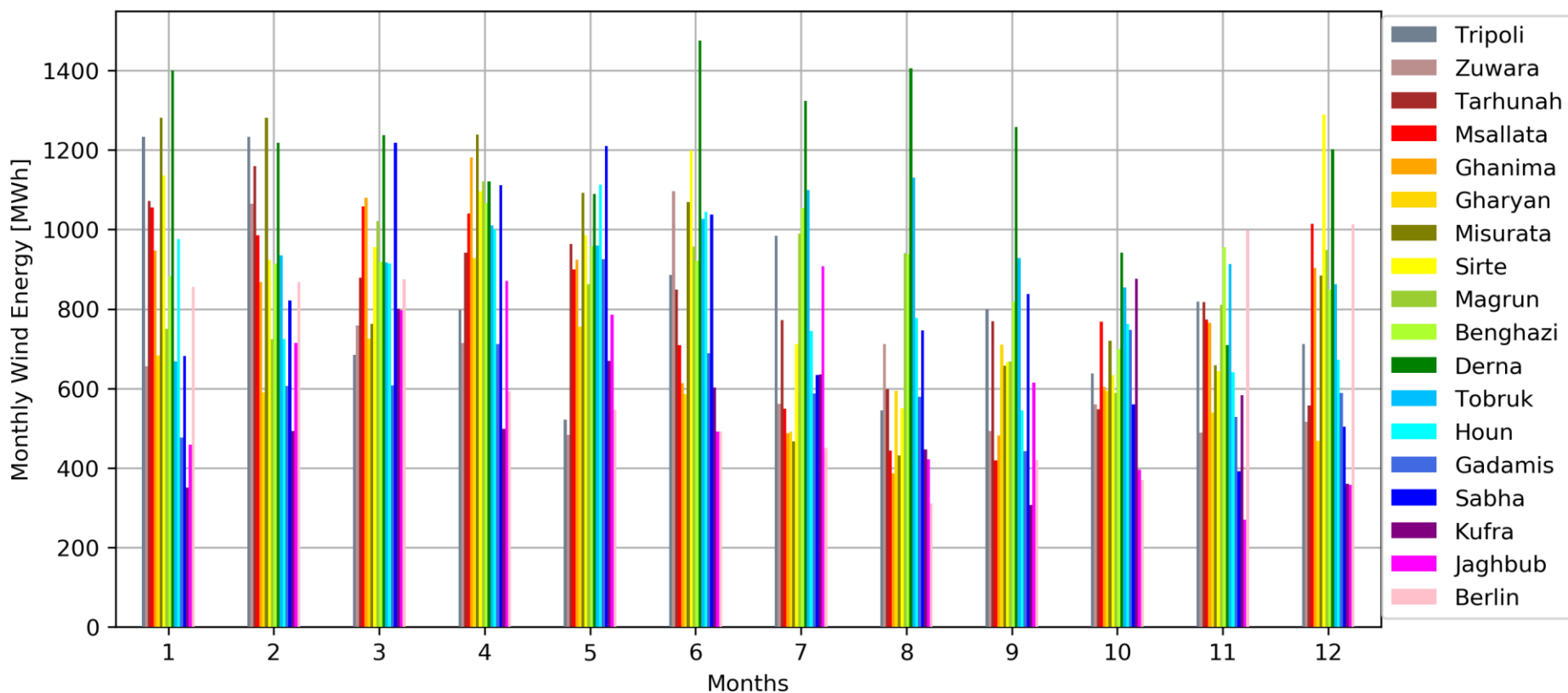
Comparison of Net Capacity Factors (NFC)

The Capacity Factor is calculated based on GE120/2500 Turbine at height of 100m
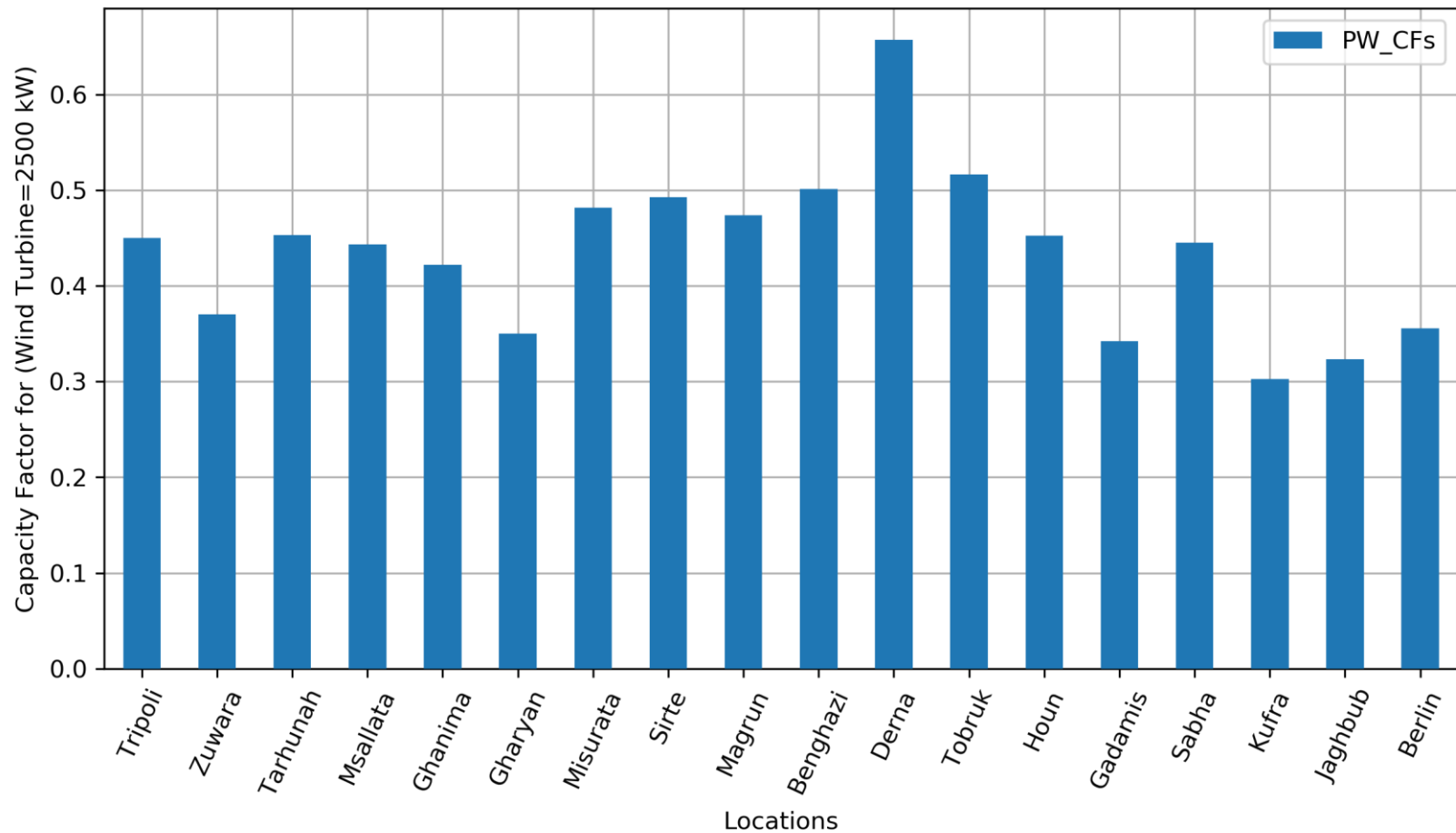
Comparison of Wind Power Variability

The variability of wind energy at a given location which is deviated from the wind power at rating power of the turbine 2500kW
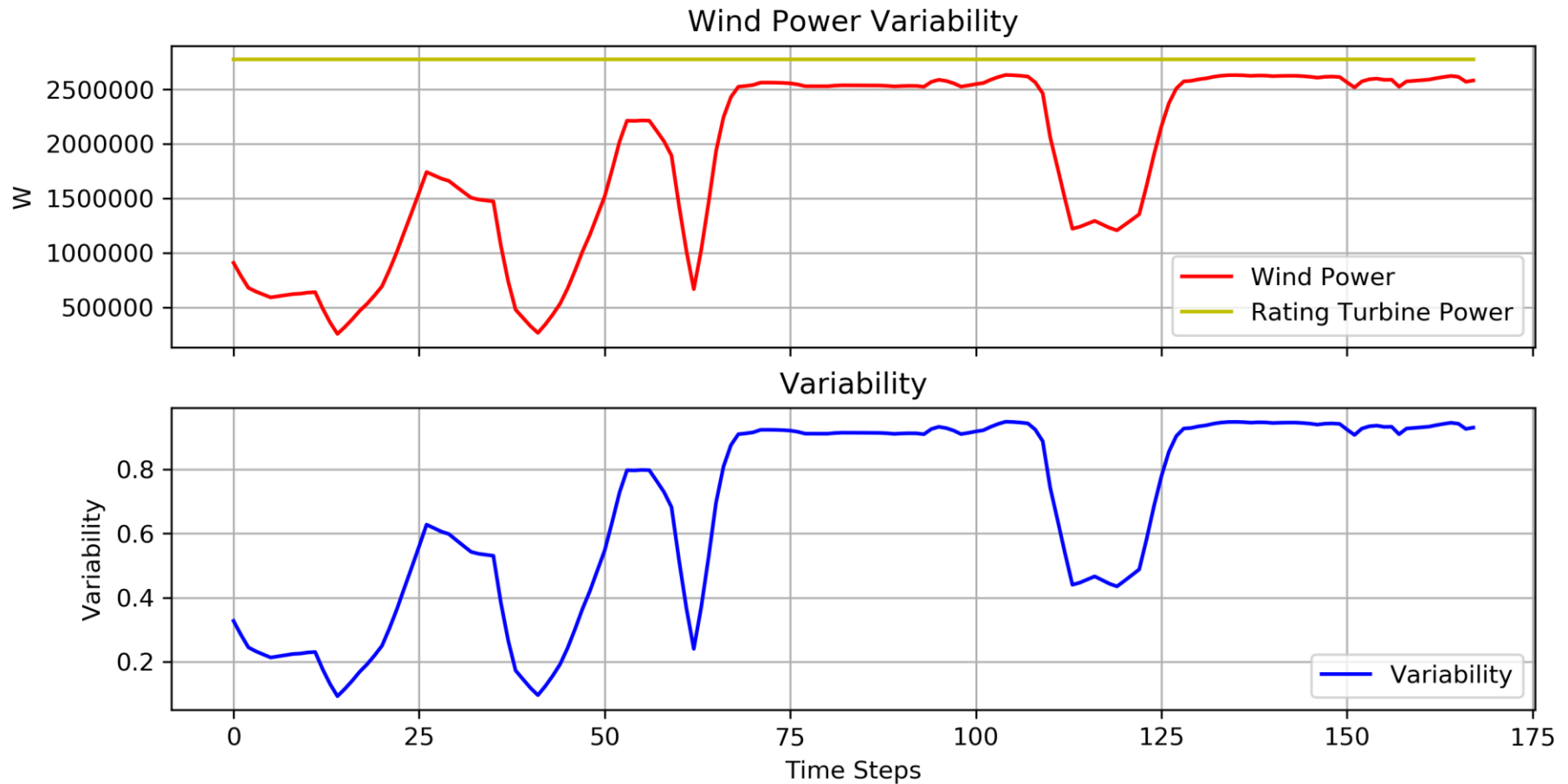
Comparison of Wind Power Variability

The variability of wind energy at a given location which is deviated from the wind power at rating power of the turbine 2500kW
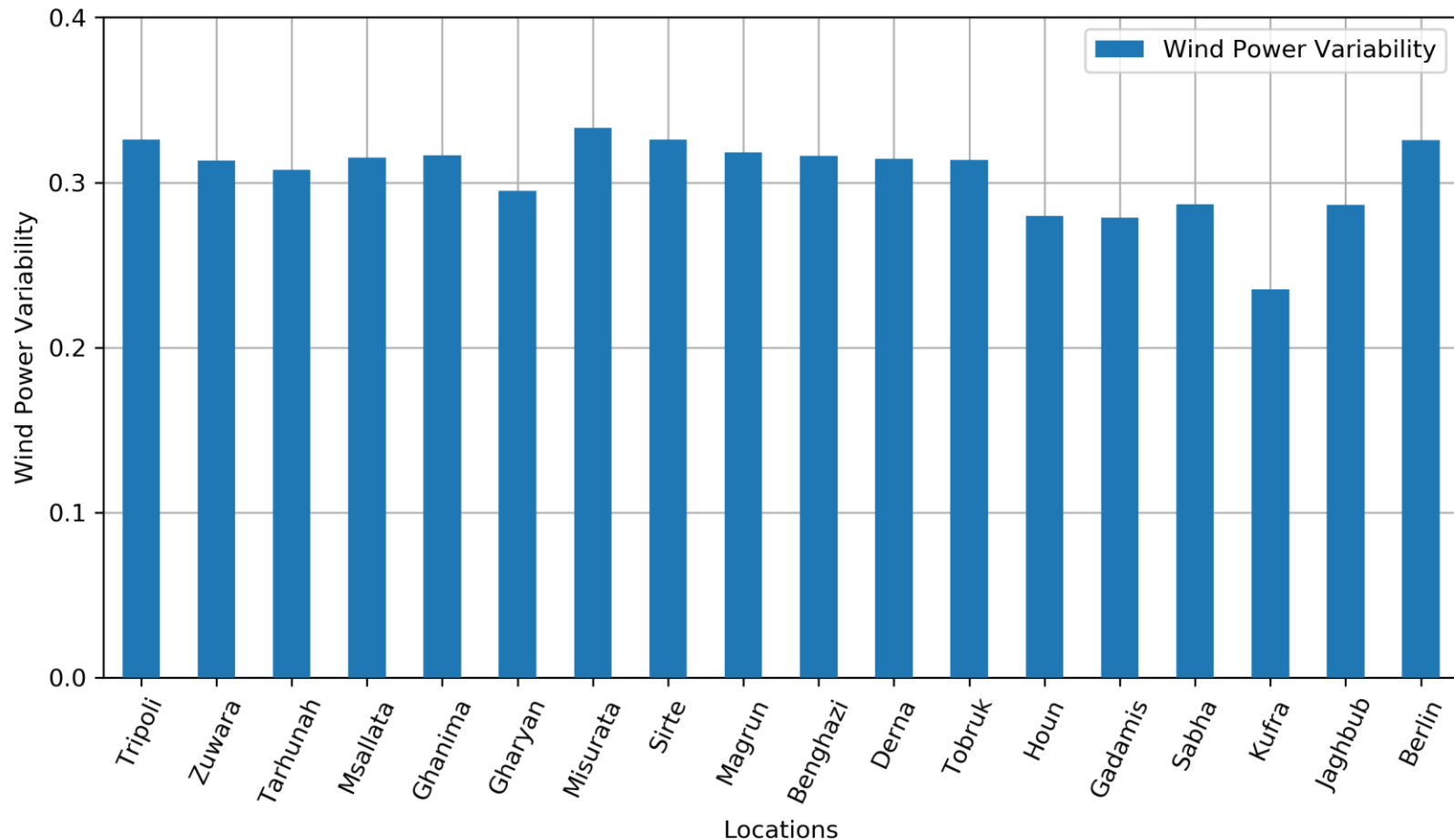
Comparison of Aggregated Wind Power Variability

The wind resources are aggregated based to their locations:

- West Region: Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Houn, Gadamis, Sabha.
- East Region: Benghazi,Magrun, Derna, Kufra, Tobruk, Jaghbub.
- All Locations: Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Benghazi,Magrun, Derna, Houn, Gadamis, Sabha, Kufra, Tobruk, Jaghbub.
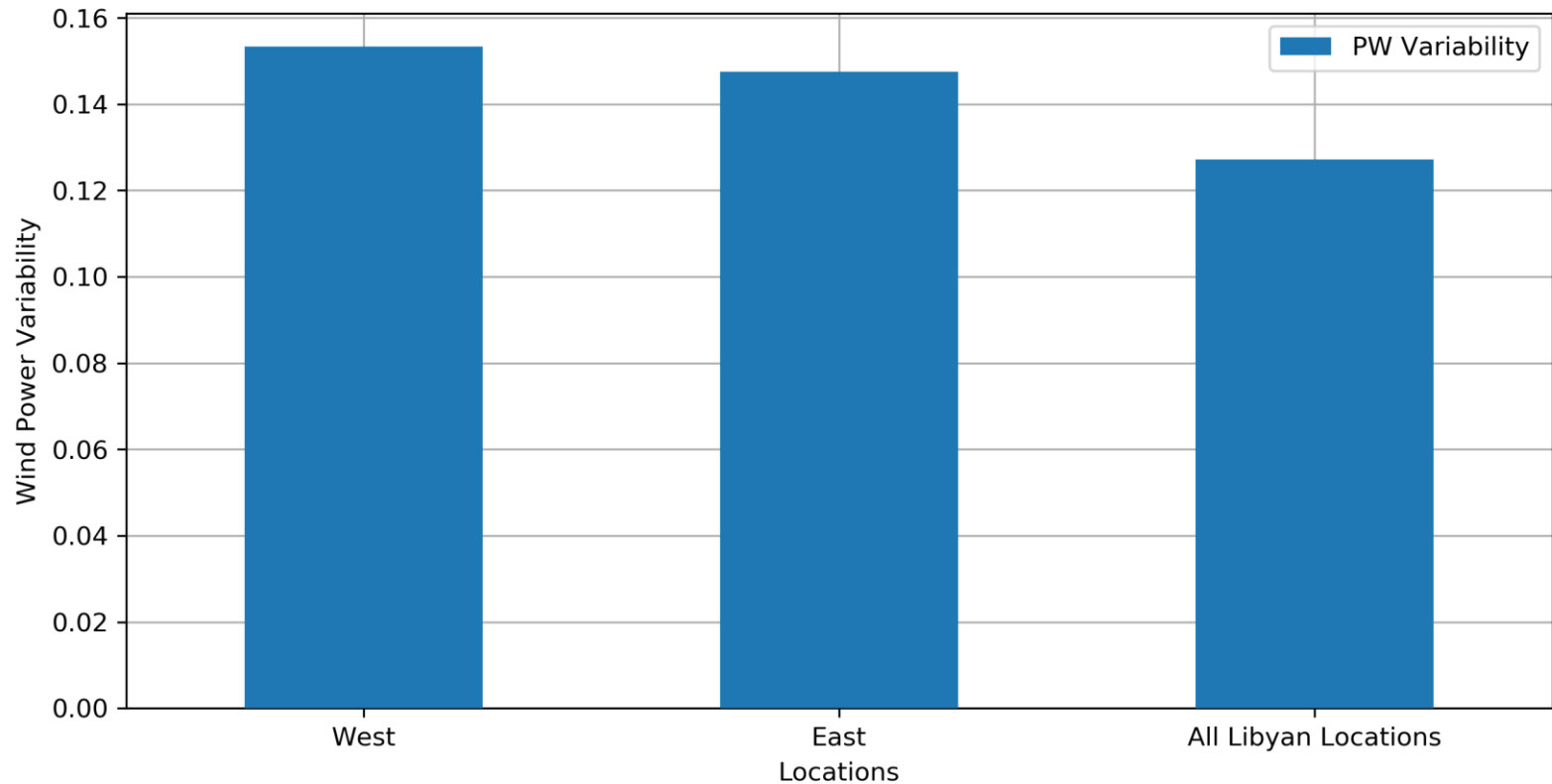
Improvement of Variability Due to Aggregated Wind Resources

The wind resources are aggregated based to their locations:

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- East Region: Benghazi,Magrun, Derna, Kufra, Tobruk, Jaghbub.
- All Locations: Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Benghazi,Magrun, Derna, Houn, Gadamis, Sabha, Kufra, Tobruk, Jaghbub.

Improvement at Aggregated Locs=(1 - (Agg_var/min_Agg_Var@Region))*100

Improvement (%)	Agg vs. Best West	Agg vs. Best East	Agg vs. Best All
West	44.93%	34.75%	34.75%
East	47.06%	37.27%	37.27%
All Libyan Locations	54.32%	45.88%	45.88%

Visualization of Aggregated Wind Power Variability

The wind resources are aggregated based to their locations:

- All Locations: Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Benghazi,Magrun, Derna, Houn, Gadamis, Sabha, Kufra, Tobruk, Jaghbub.

During days from January 1st to January 15th

Individual and Aggregated Wind Power
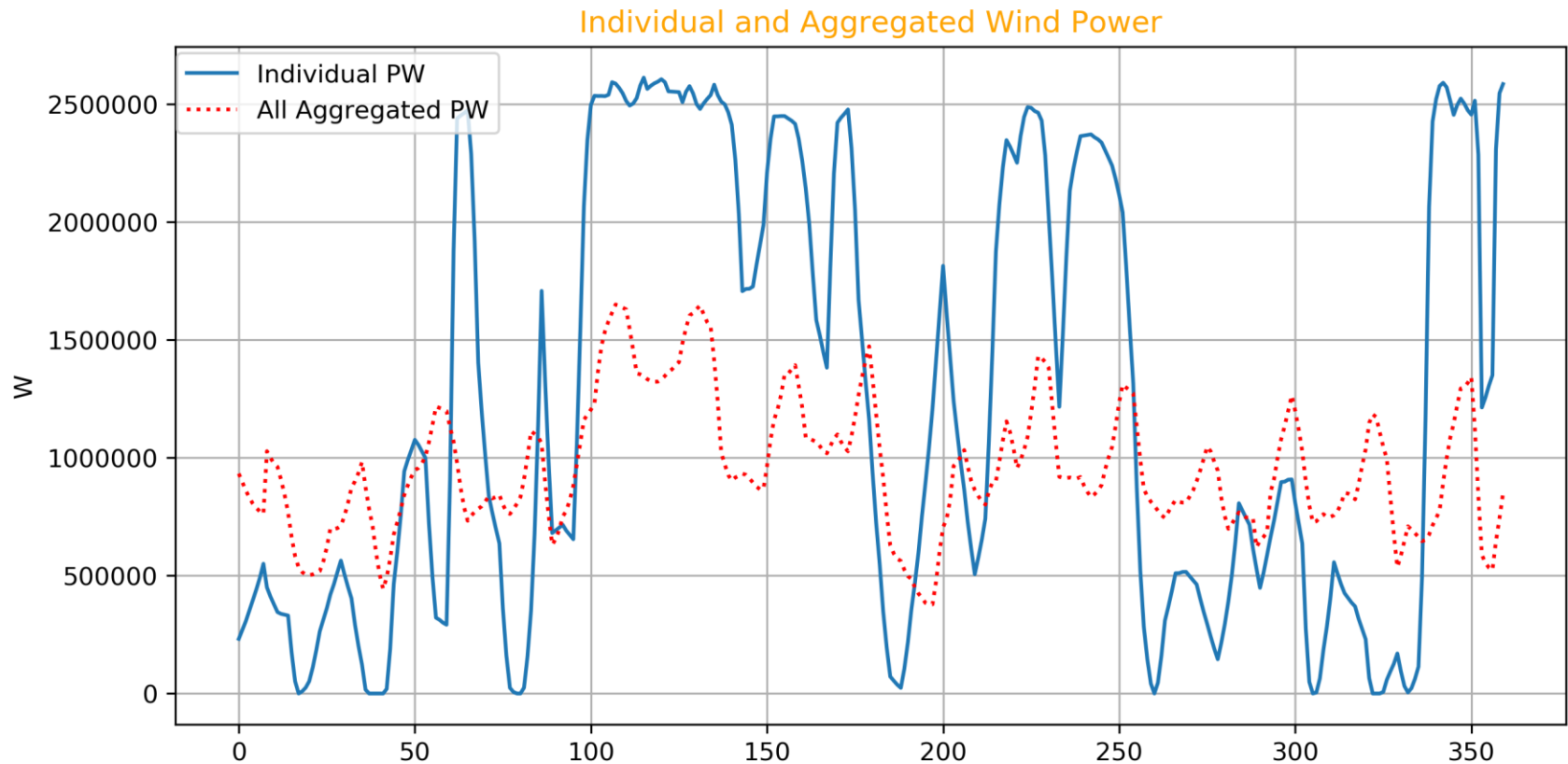
Net Capacity Factor for Aggregated Locations

The aggregated net capacity factor for all aggregated locations:
- All Locations: Tripoli, Misurata, Tarhunah, Ghanima, Msallata, Zuwara, Gharyan, Sirte, Benghazi,Magrun, Derna, Houn, Gadamis, Sabha, Kufra, Tobruk, Jaghbub.
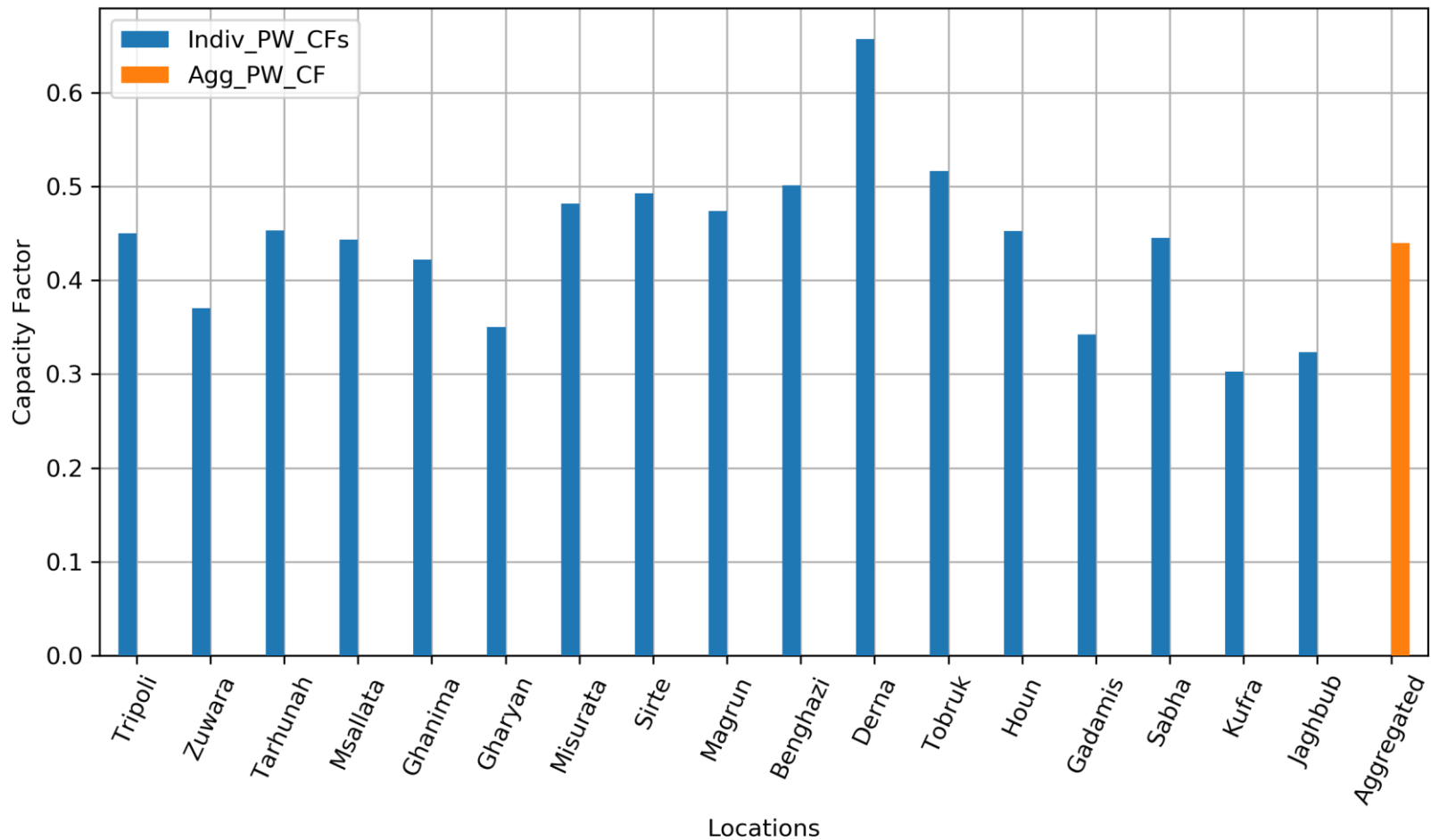
Conclusions

- In Libya, the eastern locations yield more wind energy, but the northern locations have a very good yielding compared to the southern locations.
- The average net capacity factor is about 0.43, and it can be considered realtively high for wind power plants.

- The variability of the northen locations is higher than the southern "Sahara" locations, which means a need for more auxiliary services at the northen region, such as more energy storage.

- The aggregation of West, East, and All locations leads to a reduction in the variability and averaging the capacity factor.

- Aggregation different wind plants from various regions can lead to more enhancement in wind power deployment.

Thanks for Listening

Any Question?

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https://mohamedabuella.github.io