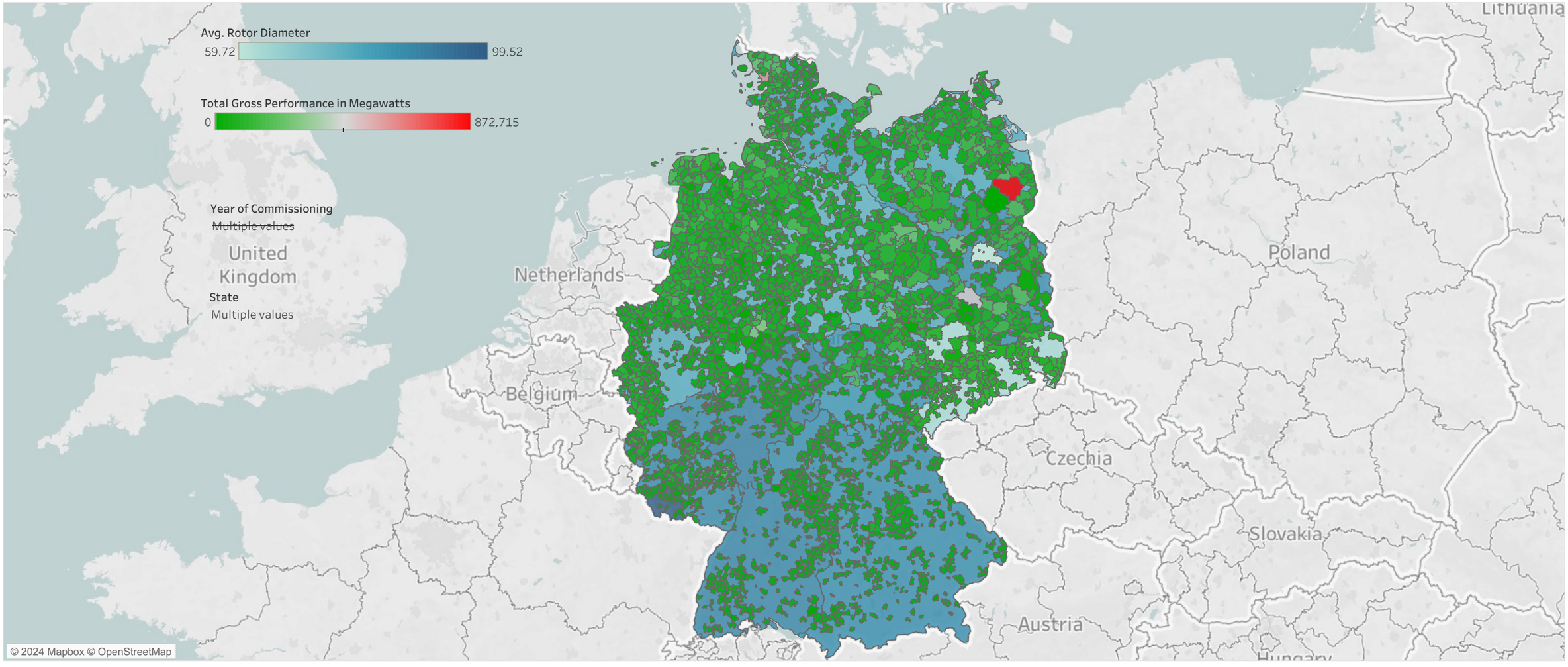
Wind Turbine Growth in Germany

Scope: Analysing the growth of the Wind Energy Sector

Key Questions

Where has the growth taken place in Germany?
What kind of growth have we seen in Germany?
Is the growth sustainable?

Introduction



Trends in Wind Turbine Dimensions and Power

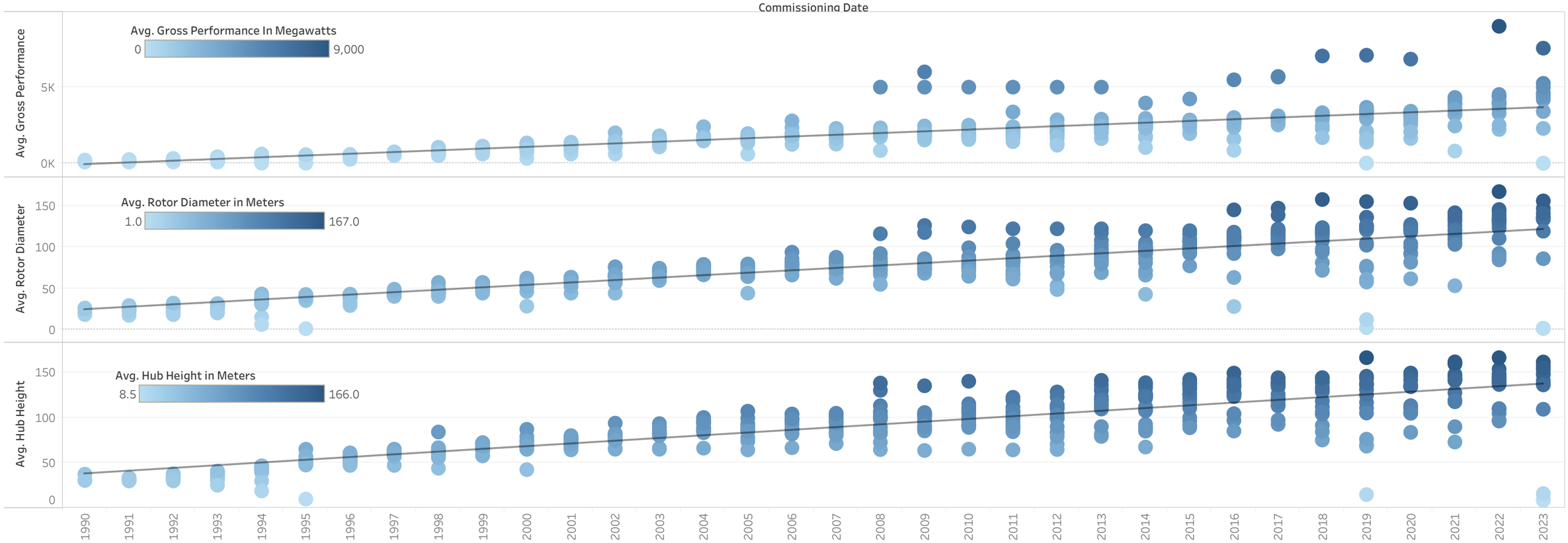
From the scatter plots, we can see that over time almost all dimensions of the wind turbines have increased in a linear fashion.

Gross Performance has followed a general trend, the outliers at the top represent large offshore projects.

The Rotor Diameter has increased over time making it possible to increase the power production potential.

The Hub Height or the height of the machine housing at the top of the tower has also increased making it possible to build larger blades and access higher altitudes of wind.

Linear Regression



Clustering by Gross Performance

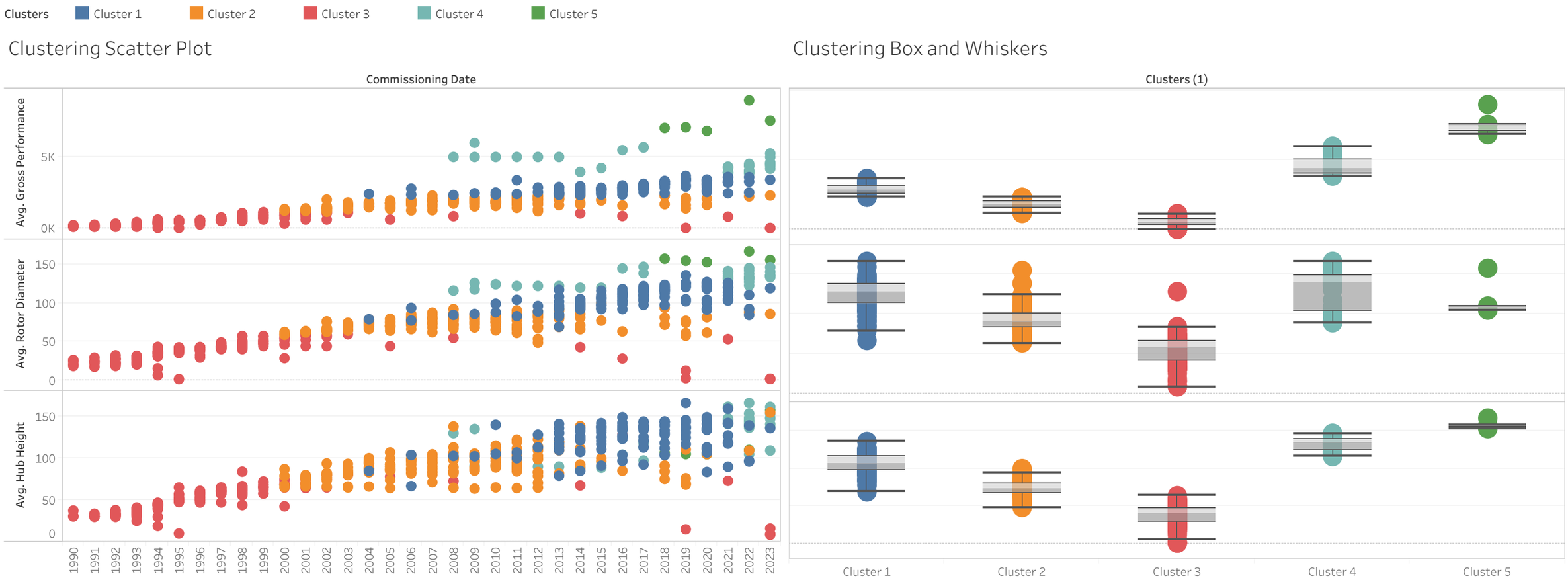
Scatter Plot Clustering

From the scatter plot, we can see that the **Gross Performance** is nicely segmeted. this also shows a clear trend towards more powerful turbines

The clustering on the **Rotor Diameter** is still well-segmented but we do see some overlapping. However, the longer blades and larger **Rotor Diameter** are related to more powerful turbines.

The **Hub Height** is fairly well segmented but there is more overlapping. This is due to environmental factors. Turbines in areas where there is nothing to obstruct the wind such as forests, buildings, and mountains means that the towers can be shorter. the turbines in the ocean don’t have any obstructions and generally have much shorter towers but also tend to be more powerful.

Box and Whisker Plots..



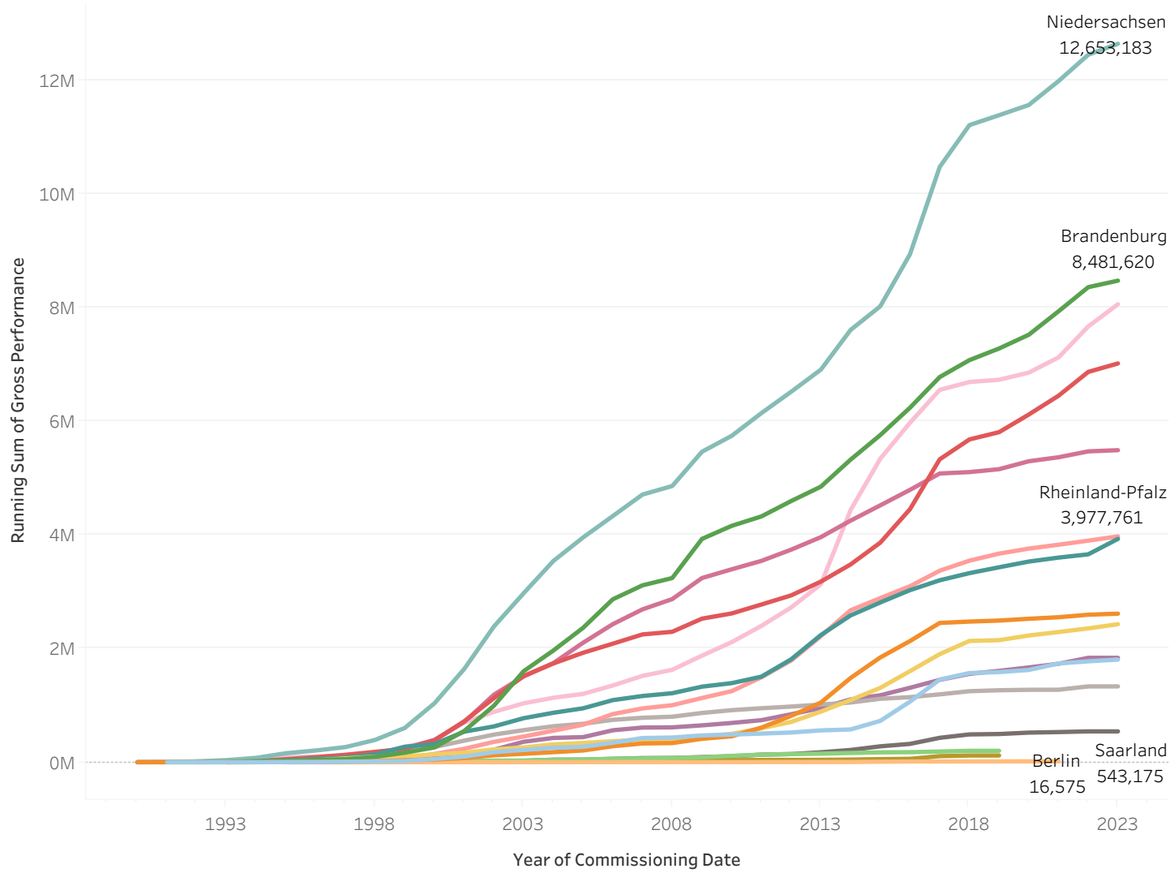
Growth in Production Capacity of Wind Turbines

We can see that some states have built much more capacity over time than others. Niedersachsen has really shown the way when it comes to building capacity.

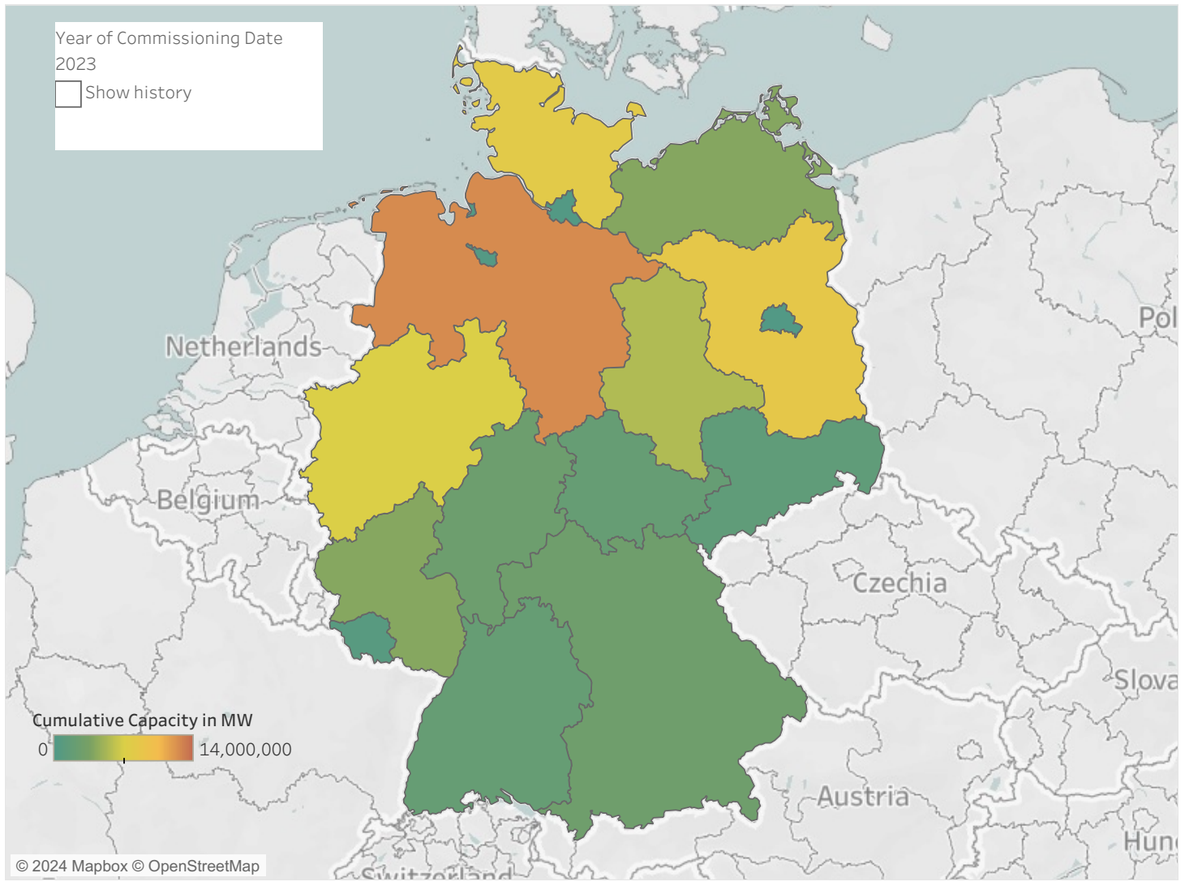
From around 2000 we can see a massive boom in the Industry. for each states having less than 1 000 000 megawatts production capacity to almost 13 000 000 for the top state in 2023.

From the map we can see that the northern states have increased thier production capacity far more than the southern states.

Growth of Potential Capacity in Megawatts by State



Cumulative Capacity in German States



Industry Growth and Manufacturer Contribution

Industry Growth Capacity

From the industry growth, we can see that there have been some real ups and downs.

From **1990 - 2001** we saw almost exponential growth with almost **300,000 MW** of production coming online in **2001.**

There was a large drop in production between **2001 -2010** followed by a boom in production capacity from **2010 - 2018**

From **2019** we see a massive drop in new production capacity.

Manufacturers

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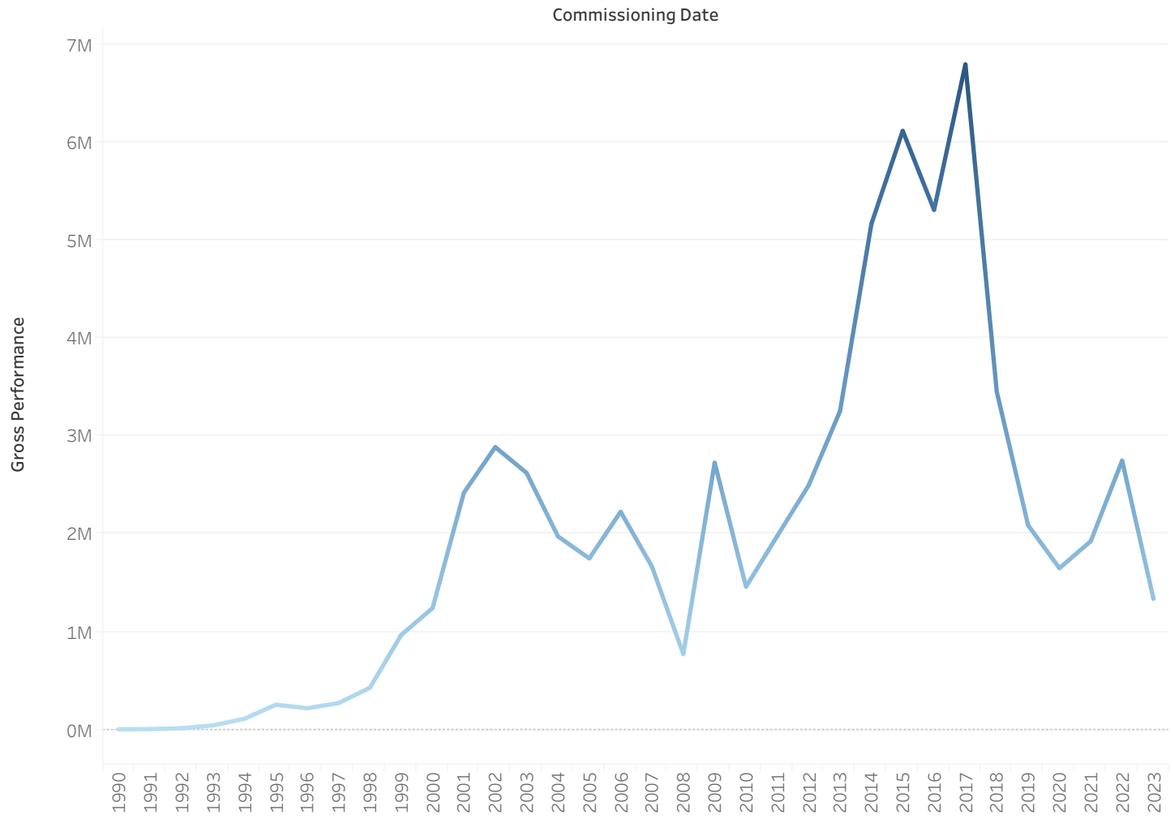
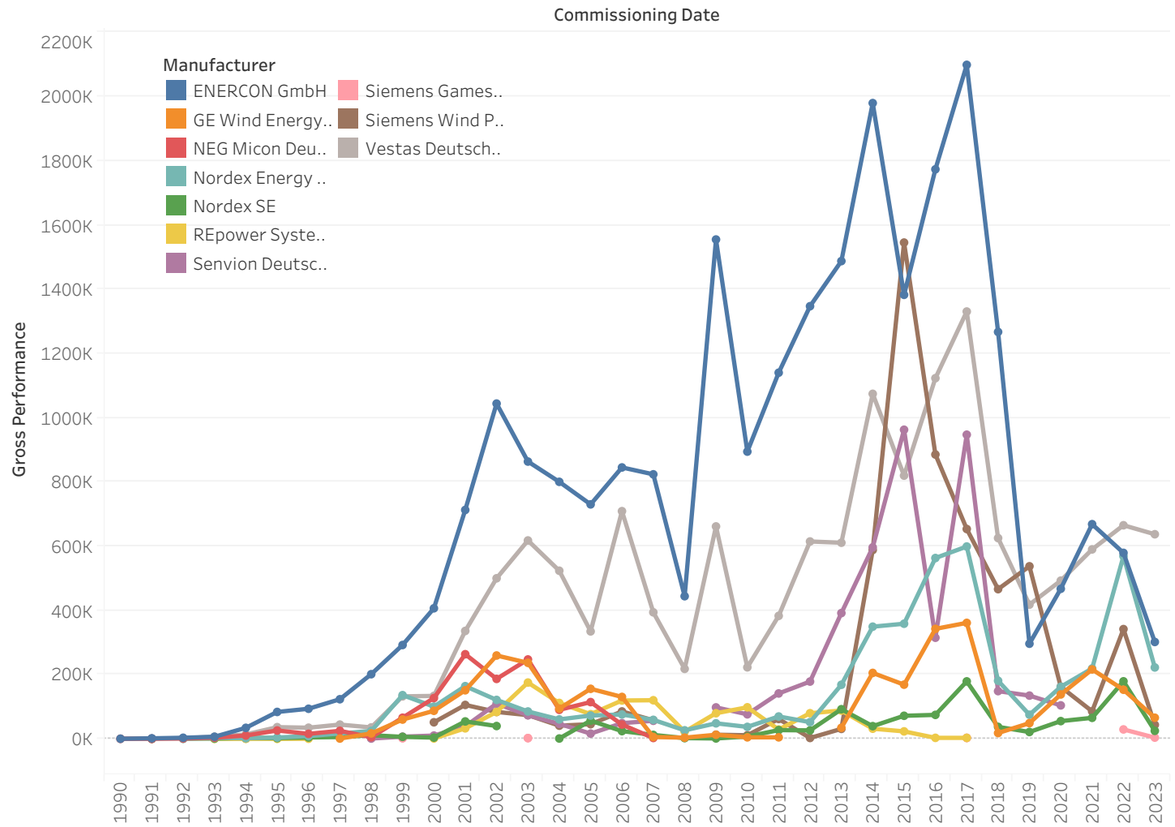
Industry Growth Capacity by Year



Yearly contribution to Capacity by Manufacturer



Conclusion

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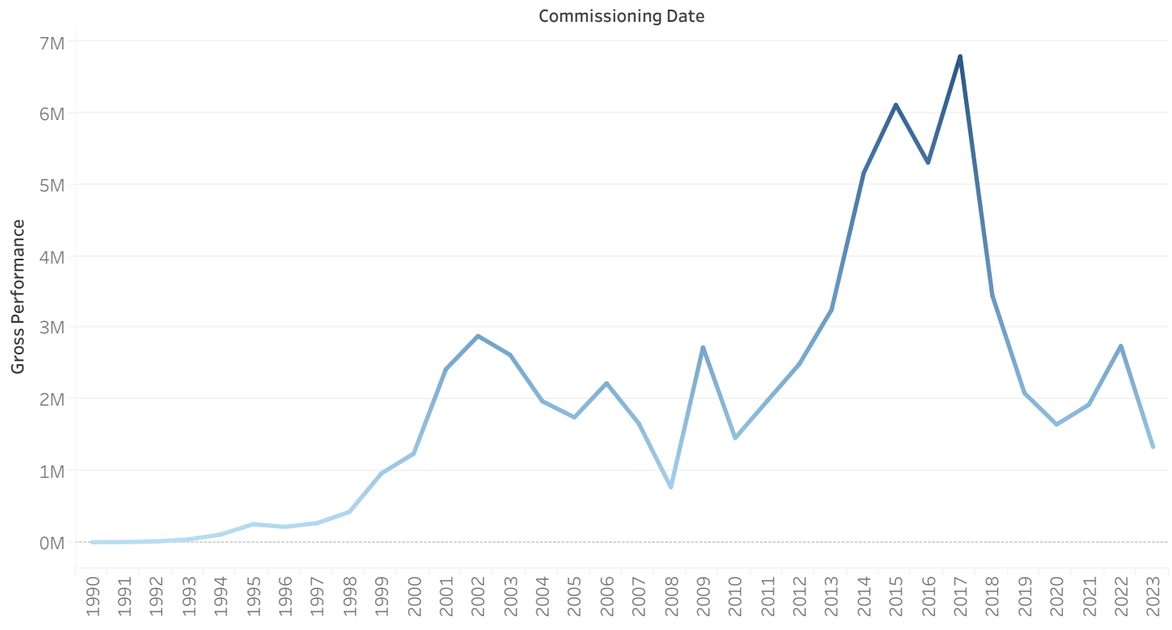
As wind turbines have become larger they have also become more powerful, there is huge potential for growth in the industry.

31% of Germany's energy production comes from wind.
Most of the wind turbines are in the north of the country.
There is the potential for large-scale production under the right conditions.

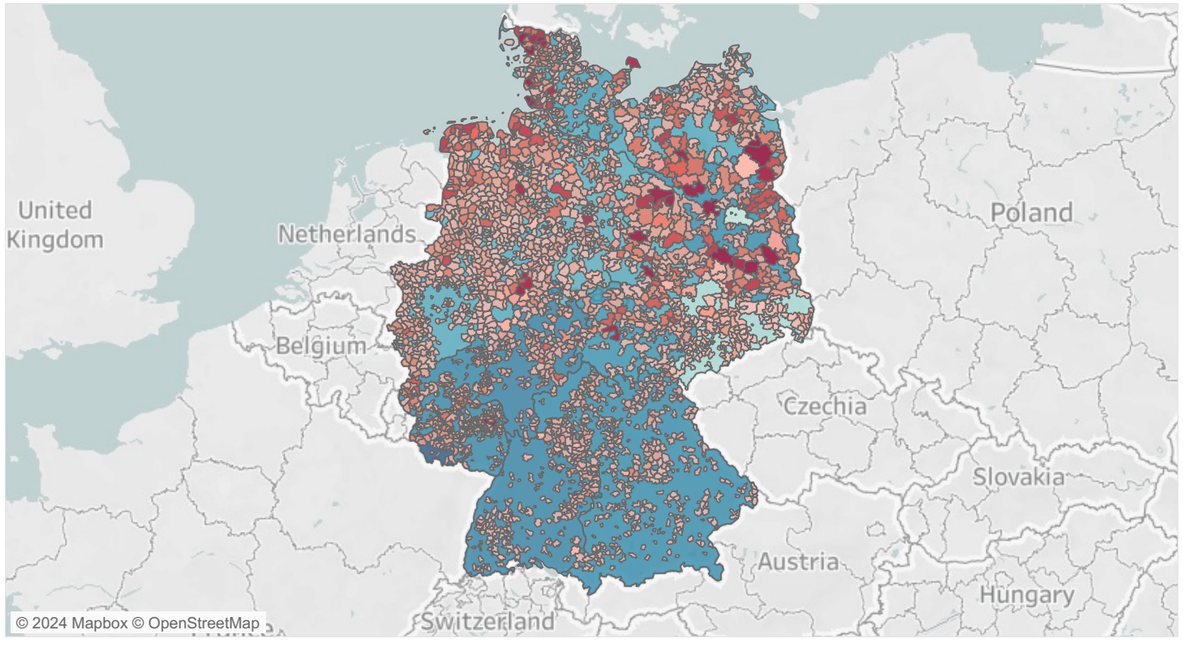
Challenges
Given the widespread Construction of turbines, Germany may be running out of suitable space to build a larger capacity.
Overproduction in high wind is an issue, without a good way to store the power many, many turbines are turned off on windy days to protect the grid from being over-energized.
There has been little study to find out how or if there are any effects on the climate, taking millions of megawatts out of the wind and atmosphere may not be a good idea.

Recommendations
Southern States should look at building more capacity.
New technologies should be developed to better store energy.
Ongoing and new analysis of environmental conditions should be conducted to better understand the relationship between wind and wind energy production.

Industry Growth Capacity by Year



Introduction



Summary Statistics

Summary stats

State	Avg. Hub Height	Avg. Rotor Diameter	Total Gross Performan..
Baden-Württemberg	109	88	1,807,727
Bayern	112	85	2,616,425
Berlin	122	60	16,575
Brandenburg	104	85	8,481,620
Bremen	89	77	201,314
Hamburg	90	78	118,700
Hessen	112	89	2,431,162
Mecklenburg-Vorpommern	92	78	3,933,795
Niedersachsen	90	76	12,653,183
Nordrhein-Westfalen	96	77	7,023,392
Rheinland-Pfalz	111	87	3,977,761
Saarland	120	100	543,175
Sachsen	77	63	1,335,587
Sachsen-Anhalt	96	78	5,495,757
Schleswig-Holstein	77	81	8,065,532
Thüringen	102	83	1,838,985

Citations

Data Sources

Wind Turbine Data
German government Data Registry (Marktstammdatenregister)
https://www.marktstammdatenregister.de/MaStR/Datendownload

JSON file
GitHub
https://github.com/isellsoap/deutschlandGeoJSON/blob/main/2_bundeslaender/1_sehr_hoch.geo.json