Team 27 Energy of Wind Report

Felipe Gastaldi, Changhong Guan, Andrew McAlister, Swathi Mohandas Naik, Kerri Robinson

Overview of Project

Background Information

Due to various reasons including changes in energy cost dynamics, advancements in new technologies, response to climate change, and geopolitical pressures, there has been a steady push for developed nations to shift from heavy reliance on fossil fuels to more alternative sources of energy. While this push is continuing and growing every day, there is still heavy reliance by European nations (as with most nations) on oil.

Traditionally, Russia has been the primary supplier of oil to its European neighbors. In response to the Russian invasion of Ukraine in 2022, nations in the EU have systemically imposed economic sanctions on Russia and as a result are facing a reality of being cut off from the Russian oil supply. While short-term arrangements with alternative suppliers are in the works, it's clear this global trade shift will add increased pressure on the adoption of alternative energy.

Some European nations like Germany and France have had more advanced developments in the search for alternative energy sources and have largely mapped out their future progressions. However, there are still countries in a less- advanced state of alternative energy adoption. It will be critical for energy suppliers to project where those countries are headed and capitalize on these growth opportunities while the added pressures are in place for adoption of their technologies.

Large energy companies are some of the most heavily analyzed publicly traded companies. Models are routinely built to project future energy growth forecasts along with any outside factors that could alter those forecasts like climate data or changes in public policy. What is less likely to be included in most models is sudden and large shifts in policy due to less predictable events like pandemics or wars.

Russia's invasion of Ukraine and the resulting geopolitical reactions have caused a massive shift in the economics of the energy markets on top of the changes already being felt by the COVID-19 pandemic. These shifts can provide massive opportunities for changes in energy policy and for new market dynamics to benefit key market players that are positioned for growth.

This analysis will allow us to predict one potential shift in this market and the resulting opportunities key companies will have to take advantage of it. The result will be data that those companies could use to set their corporate strategy or for outside investors to predict those moves in hopes of investing before that growth occurs.

Problem Overview

Analyzing historical alternative energy trends with the most advanced European countries, how can we project future alternative energy adoption for less-sophisticated European nations and how can key energy companies financially benefit from increased adoption?

Initial Hypothesis

Due to the pressures created by the Ukraine-Russia conflict and newly enacted sanctions that will likely push European nations to seek alternative forms of energy, we hypothesize the wind turbine market will experience accelerated growth in the coming years. This accelerated growth will present the opportunity for leading companies in the wind turbine market to capture emerging markets and increase annual revenues.

Overview of Data

Datasets

We focused on two themes of data for this topic, energy related (electricity production/consumption, wind energy and weather conditions) and historical stock data for the companies under consideration (VESTAS and SIEMENS GAMESA) and their key performance indicators from the financial reports. The energy dataset came from Our World in Data on GitHub. Wind turbine market share data was pulled from Statista. Vestas and Gamesa Financial Reports came from their respective websites, and we pulled their stock prices from Yahoo Finance and FinanceCharts.com.

Data Cleaning

Regarding the energy related datasets, we found annual data containing figures for energy production, capacity installed, and climate data for Germany and Poland. However, the biggest challenge we faced with the data was that it was highly correlated. We continued to analyze capacity installed and energy produced separately. However, the behavior was similar, so we decided to clean up by one factor and go with electricity produced.

Next, we spent a considerable amount of time searching for monthly available wind energy with historical data for Germany and Poland. Our rationale was to run a Holt Winters model to see the behavior. We could find annual data, but we had a tough time finding monthly data. We were able to find a site with energy generated in the same format that we expected, but the data was only for Belgium.

The biggest hurdle that we faced during the collection of stock and financial datasets was that the numbers from various websites were not synchronized. We then had to verify numbers from the company website and then decide on one site as our source of truth for all the numbers.

The process of searching for KPIs was tedious since we had to dig into each of the annual reports for the two companies. We did this so we could take the numbers and use them in our model. VESTAS was a concise report, however, we had to perform extensive data profiling for SIEMENS GAMESA to determine what we needed to retain and what needed to be removed from the analysis.

Determining Onshore Wind Capacity

When creating future wind energy projections for our target countries it is critical that we consider the maximum amount of wind energy each country can produce. Without understanding the maximum capabilities of each country our projections could pass beyond what is realistically possible and thus render their estimates, and any resulting analysis from them, useless.

Like any existing energy source there is a limit to how much can be built out and deployed based on available resources. With wind energy this can be simplified down to available land. For the purposes of this analysis, we will limit our scope to onshore wind and ignore offshore wind capacity limits.

Just as it has been the primary basis for our other analyses in this project, we will use Germany as the baseline for our projections into the emerging Poland market. Based on a study “Potenzial der Windenergienutzung an Land” (2011) by the German Wind Energy Association (BWE) and further analyzed by Beckius and Magnusson (2013) it has been estimated that a realistic target for the total wind energy output of Germany would utilize a footprint equivalent to about 2% of German land area.

The 2% target equates to an estimated 189 GW capacity potential. While this capacity target may end up smaller than reality due to advancements in turbine technology or other factors, for the purposes of this project we will set the 189 GW capacity estimate as our cap for future energy potential.

Next, we need to estimate the realistic wind capacity for Poland. To do this, further research was done to determine if previous studies had been done to estimate a Polish wind energy cap. In a study by Ember Coal to Clean (Czyzak 2022) they determined that Poland currently could use only 0.3% of their total land for wind turbines due to current policies around turbine distancing. They estimated this capped their max capacity at 10 GW.

Since the 0.3% cap is largely due to legal frameworks, and not technical or landscape constraints, for the purposes of our analysis we will assume that Poland will adopt a similar policy to other European countries and can reach a similar 2% target we set for Germany. If we extrapolate from the 10GW estimate for .3% land use for Poland a 2% land use would place Poland total capacity target at ~67 GW.

Key Variables

Our key variables include company revenue for both Vestas and Gamesa, wind capacity for Poland and Germany, historical wind energy adoption rates, historical energy consumption and Year for time series.

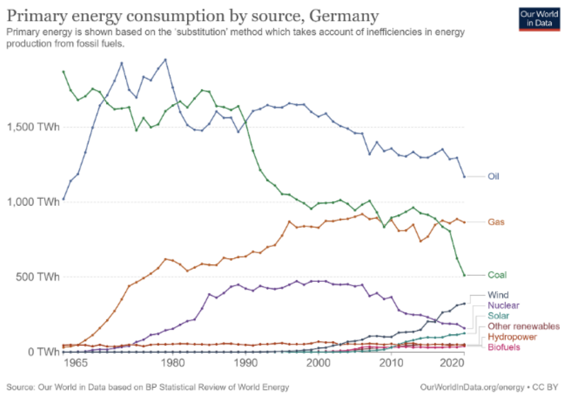
Overview of Modeling

Methodology and Approach

We began our analysis by reviewing the state of renewable energy growth in Germany and Poland by using Our World in Data Org data. Observe from Figure 1 and Figure 2, wind is the fastest growing renewable energy source in both countries, in both volume and percentage.

Energy consumption in Germany

Energy Consumption in Poland



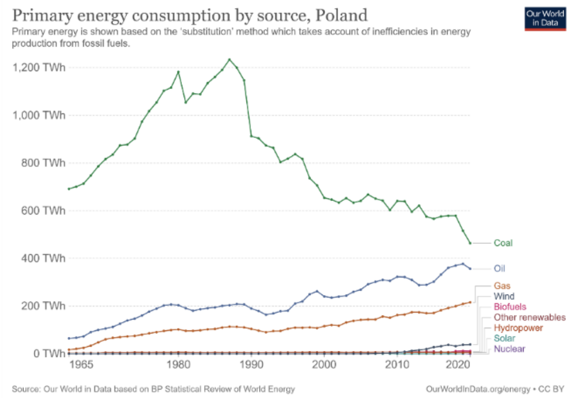


Figure 1 Energy consumption in Germany   Figure 2 Energy Consumption in Poland

Next, we zoomed in on the wind installed capacity. From Figure 3 we can see that installed capacity for wind in Germany has experienced parabolic growth since 1990. Poland has lagged Germany on wind installation for 12 years and their adoption rate is slower than Germany. In Figure 3 we can also see that China experienced exponential growth compared to Germany and Poland experiencing parabolic growth.

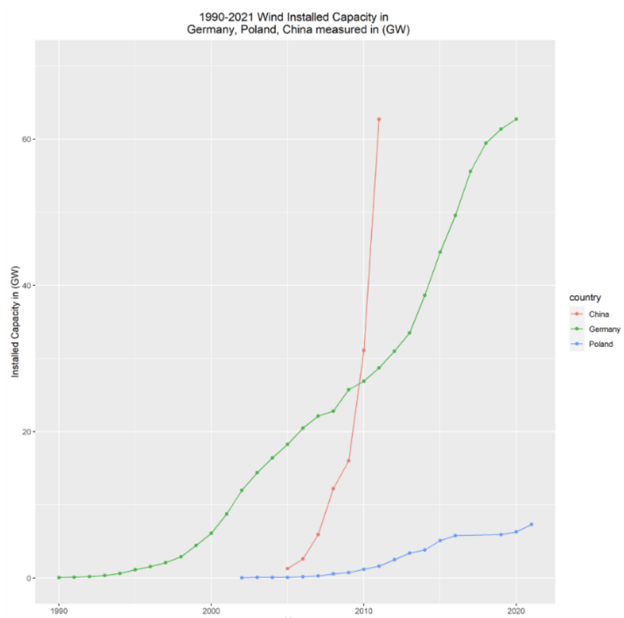
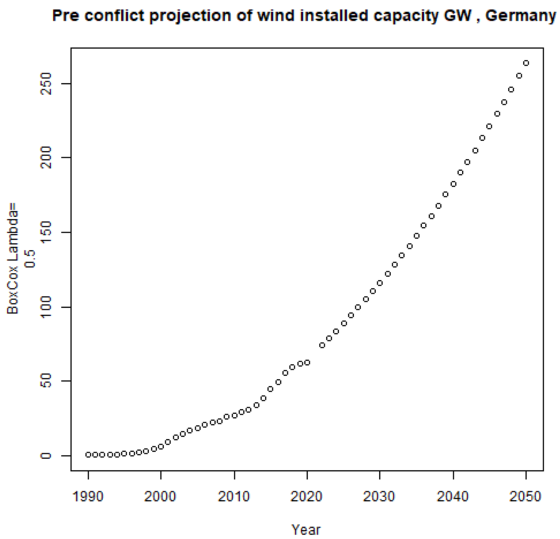


Figure 3 Wind Installed Capacity

The first model we used was Simple Linear Regression (SLR). Electricity from wind was the dependent variable and year was the independent variable to find lambda for BoxCox transformation. Germany Lambda = 0.5. We then applied a BoxCox transformation on the dependent variable (wind_electricity) and re-trained the SLR model and analyzed the model's assumptions. After BoxCox transformation, the dependent variable presents a good linear relationship with year and the residual assumptions hold. We end up with a prediction for the next 15 years for Germany as shown in Figure 4. Figure 5 shows the residuals vs fitted, which shows an "S" shape system error.



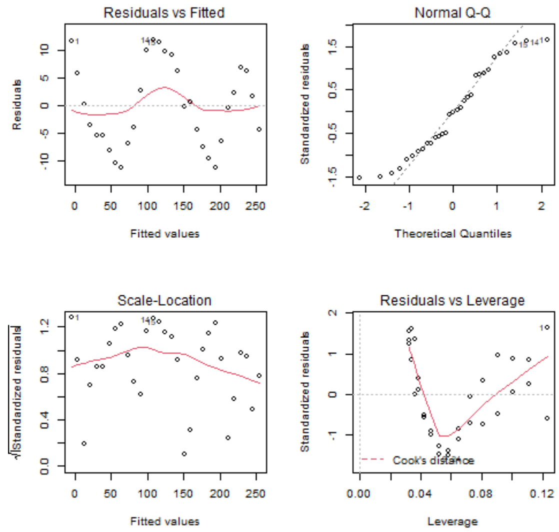
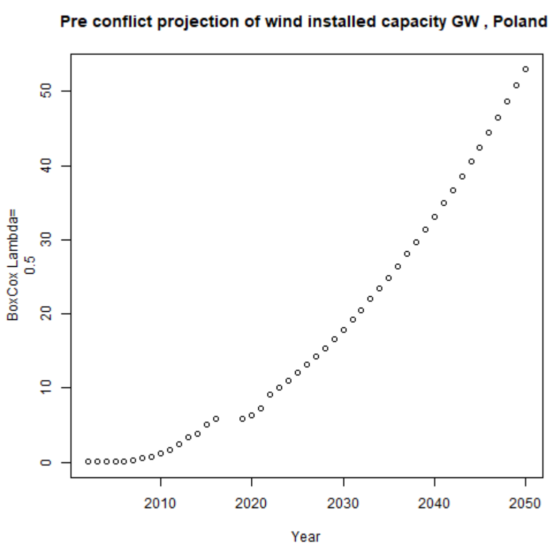


Figure 4 Germany Projection of Capacity

Figure 5 Residuals vs Fitted

For Poland we followed the same SLR model procedure as with Germany and we find Poland Lambda = 0.38. After the same BoxCox transformation, we predicted the next 15 years for Poland as shown in Figure 6. If we plot Electricity generation from wind, measured in terawatt-hours, vs year on Germany and Poland, and move Poland year ahead 15 years, both countries follow similar parabolic trajectories and Poland's wind electricity adoption rate is slightly faster. Figure 8 shows the residual vs fitted for Poland, as with Germany there is an "S" shape system error.



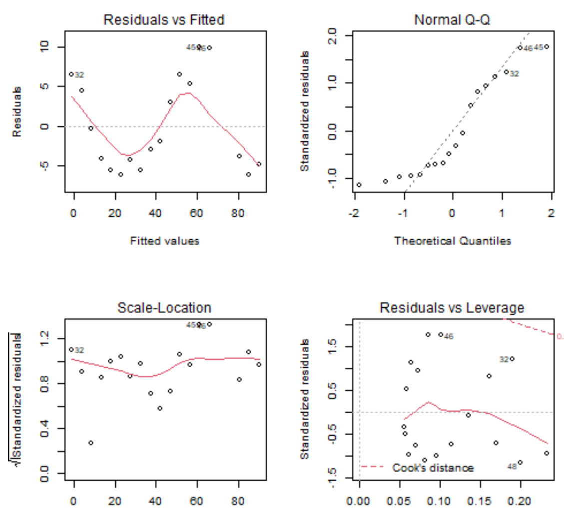


Figure 6 Poland Projection of Capacity

Figure 7 Residuals vs Fitted

The SLR model's assumptions do not hold for Germany and Poland due to residual analysis, residuals vs fitted as shown in Figure 5 and Figure 7. Also, the parabolic growth does not have a capping effect.

Next, we used a Time Series Model to compare our finding with a Simple Linear Regression Model. However, we do not have enough data to be comfortable with the results of the model. We need to be able to add a cap for wind electricity due to a limited supply for each country. We need to analyze and compare Gompertz and Logistic Regression, to pick one model in order to further explore business cases.

The third model we used was Gompertz. This is a time series growth model that is mainly used to describe the growth of animals and plants as well as the number or volume of bacteria and cancer cells. In our case, we do not have data for the full cycle of growth. We could only insert hypothetical future steady state number aka cap number for both countries at an estimated future time Germany is 2055, Poland is 2070. Without enough data at the end of the cycle, the model tends to go over capping value. First, we ran the nlsfit(model=10) but there is a singular gradient error. Below is the original Gompertz equation.

$$y = ae^{-be^{-cx}}$$

To fix this error we used the modified Gompertz equation shown below, to reduce double exponential terms to one.

$$y = ae^{-bc^{x}}$$

Once we fit the model, we can see that the model goes beyond the capping value for both Germany and Poland in Figure 8 and Figure 9.

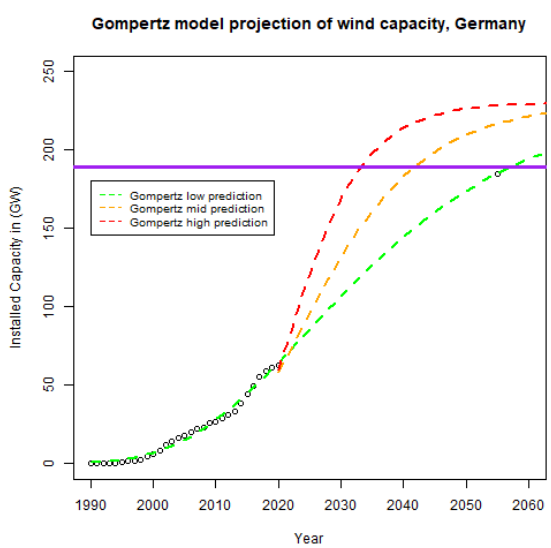


Figure 8 Germany Gompertz Model

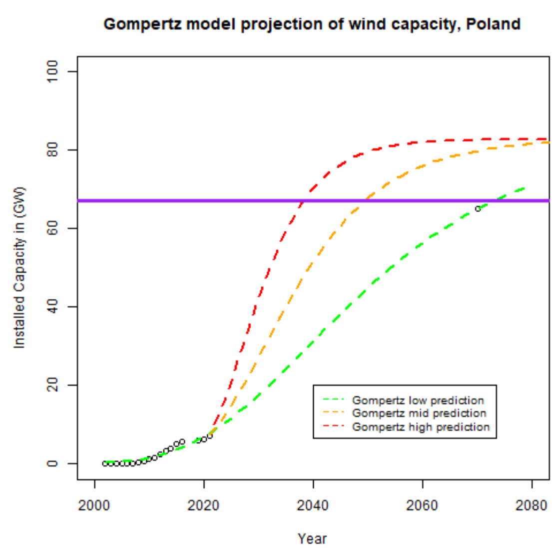


Figure 9 Poland Gompertz Model

The last model we explored was Logistic Regression. This model can also be used for time series data as well. Unlike the previous models, Logistic Regression allows for a cap number to be set. The equation is below.

$$y = \frac{Asym}{1 + e^{\frac{xmid - x}{scal}}}$$

We can adjust the scale to accommodate different growth rates. From Figure 10 and Figure 11, the model caps nicely for both countries.

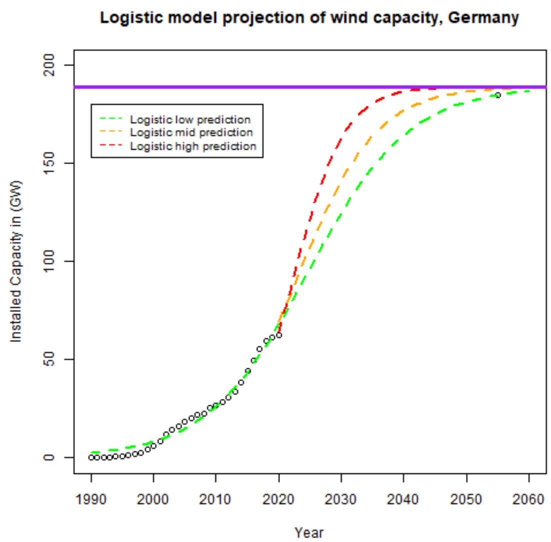


Figure 10 Germany Logistic Model

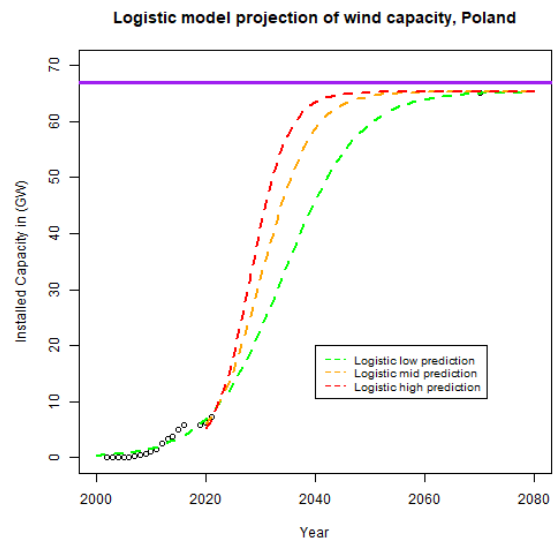
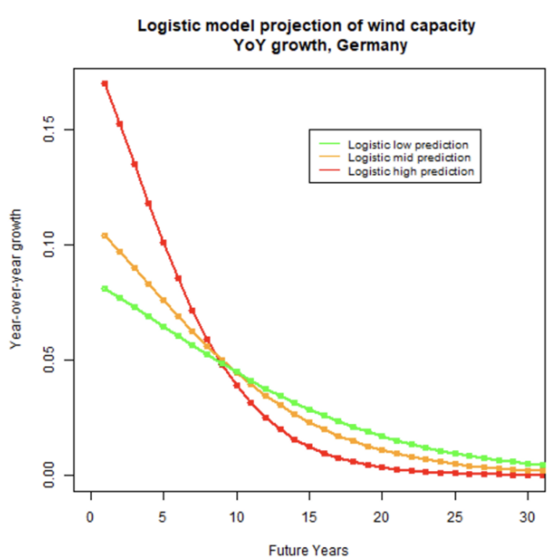


Figure 11 Poland Logistic Model

Next, we converted the total installed capacity to percentage of year over year growth, which can be used for business revenue. Germany will experience moderate growth in the next 7 years while Poland will experience 10%+ growth in the next 10 years as shown in Figure 12 and Figure 13.



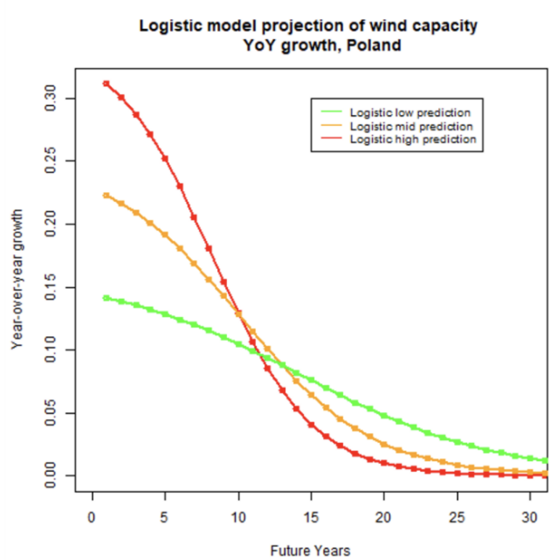


Figure 12 Germany YoY Growth

Figure 13 Poland YoY Growth

Challenges

There were several challenges that forced our team to make adjustments or assumptions to successfully execute our project. Among these challenges was the availability and type of data, external factors that impact financial measures, and differing operating practices for the companies and countries we analyzed.

Our first obstacle was the general availability of data to support our hypothesis. While certainly the focal point of modern-day research and innovation in the energy space, renewable energy is a relatively new concept. With most significant advancements arriving in the 21st century, most data dates back no further than the early 2000s. Though our original intention was to analyze the upward trend of energy production and consumption in the wind energy space, those intentions were quickly halted due to the limited data at our disposal. In turn, we decided to shift to forecast based models which allowed us to analyze future potential scenarios.

In addition to limited availability, the type of data we were dealing with introduced another limitation – modeling techniques. Given we were working with time series data, our original simple linear regression was not well suited given SLR is best for interpolation. The decision to shift to a time series model introduced an additional concern in that it demonstrated exponential forecasted growth. With this in mind, we shifted to models which would allow us to introduce energy production caps to demonstrate growth to a certain previously identified capacity constraint.

In addition to data and modeling-related challenges, we encountered other financial and economic challenges as well. Our initial idea was to use forecasted wind energy production growth to predict increased demand which in turn would impact stock price. Given there are several external factors that come into play when calculating stock price, we made the decision to shift to revenue growth predictions as revenue is less likely to experience similar levels of irrational volatility when compared to stock price. Additionally, Vestas and Gamesa follow different reporting methodologies for their business sectors. While Vestas reports on MW delivered, Gamesa reports total MW capacity, which required our team to use percentages of revenue figures for each company to accurately draw comparisons between the two.

Lastly, legal challenges came into play during our analysis. While Germany currently allows 2% of available land to be allocated for wind turbine installation, Poland is capped at .3% due to distancing regulations. With both countries having relatively similar land areas (Germany 138K mi^2 vs. Poland 124K mi^2), this meant Poland would be operating at a significant disadvantage with regards to wind energy production growth in the future. Given the Ukraine-Russia conflict and increasing demand for alternative energy sources however, we assumed that these regulations would likely change soon and thus implemented a 2% land cap to mirror the current German policy.

Future Expansion

There are several expansionary applications of our project that could render interesting results. Firstly, while our project focused on the thorough analysis of the German and Poland markets, a similar analysis could be done for other European nations if using Germany as the baseline, or even nations on other continents with emerging renewable energy markets. Additionally, there are several other renewable energy resources such as hydroelectric, geothermal, and solar which would need to be factored in an in-depth analysis to properly forecast what wind energy production growth could look like. A key consideration to support this claim is that it is likely most nations would adopt an optimal mix of renewable energy sources instead of relying heavily on one type. For example, opting for a mix of solar, hydroelectric, and wind could better suit a country's geographic, technological, or even legal constraints.

Lastly, macroeconomic factors have a large impact on market growth in general. Major events such as recessions, pandemics, natural disasters, and international conflicts all play a role in how domestic and international markets react, which in return either accelerates or decreases the naturally occurring growth of emerging markets. An extension of this project could see a simulation approach where we create different macroeconomic landscapes to understand how the current landscape (pandemic, looming recession, new international conflict) impacts the forecasted outlook, and best-case and worst-case scenarios entail for the wind energy market.

Financial Review of Gamesa and Vestas

Determining Vestas and Gamesa Market Position

Given the final step of our analysis is taking our wind energy growth models and applying them to our two companies (Vestas and Gamesa) we need to further understand their market positions. We need to answer two key questions. First, what percentage of each company's business is reflected by their existing supply of wind energy to Germany and Poland? Second, and more critically, what percentage of each country's onshore wind capacity is provided by each of our companies?

To analyze these questions, we turned to the public annual reports released by both of our companies. Annual reports from public companies can be extremely helpful in understanding the market position of companies. The challenge with using them for comparative performance is each company chooses how they wish to report their performance metrics. Outside of regulatory required metrics (usually focused on revenue and cost) companies will choose how to speak to their market performance. Since they control the message, they will often pick metrics that put their company in the best light to investors. In our research on Vestas and Gamesa it revealed that both companies report their wind markets in two different ways. Vestas choose to report their annual wind energy metrics in terms of deliveries, while Gamesa chose to report their total capacity each year.

To answer our first question on the percentage that current business in Germany and Poland represent of the total wind business of each of our companies, we had to take separate approaches. For Vestas we had to look at the percentage of deliveries each year compared to global deliveries. We could use percentage of deliveries to Germany and Poland to estimate the level each country currently plays in their total wind business.

Year	Company	Country	Estimated Non-Service Wind Revenue (mEUR)	Total Deliveries (MW)	% of Global Deliveries
2016	Vestas	Germany	1008	1119	11.60%
2017	Vestas	Germany	1282	1336	15.20%
2018	Vestas	Germany	1041	638	12.30%
2019	Vestas	Germany	360	445	3.50%
2020	Vestas	Germany	370	499	2.90%
2021	Vestas	Germany	388	598	3.60%
2016	Vestas	Poland	0	0	0.00%
2017	Vestas	Poland	0	0	0.00%
2018	Vestas	Poland	0	0	0.00%
2019	Vestas	Poland	62	76	0.60%
2020	Vestas	Poland	306	413	2.40%
2021	Vestas	Poland	484	739	4.50%
2017	Vestas	Total		8779	
2018	Vestas	Total		10847	
2019	Vestas	Total		12884	
2020	Vestas	Total		17212	
2021	Vestas	Total		16594	

Figure 14 Annual Deliveries in Germany and Poland

From the data above (manually pulled and compiled from their annual reports) we can see the total annual deliveries in Germany and Poland and what percentage that represents of their total global wind deliveries. This shows the dichotomy in these two markets. With Germany being a more mature wind producer Vestas is delivering less than in previous years while Poland, where they initially had no business, is starting to grow and surpass Germany.

For Gamesa, due to their different focus in reporting, we had to look at total installed capacity for each country relative to their global install base. While this will also give us a general sense of the importance within their business, we should be careful in comparing directly with Vestas as it’s not a directly comparative value.

Year	Company	Country	Total Wind Platforms Onshore and Offshore (MW)	Total Wind Platform % of Company Business
2017	Gamesa	Germany	6011	10.92%
2018	Gamesa	Germany	6785	11.96%
2019	Gamesa	Germany	7510	12.51%
2020	Gamesa	Germany	7393	9.96%
2021	Gamesa	Germany	7502	9.47%
2017	Gamesa	Poland	1045	1.90%
2018	Gamesa	Poland	1045	1.84%
2019	Gamesa	Poland	1053	1.75%
2020	Gamesa	Poland	1159	1.56%
2021	Gamesa	Poland	1297	1.64%
2017	Gamesa	Total	55023	
2018	Gamesa	Total	56725	
2019	Gamesa	Total	60028	
2020	Gamesa	Total	74240	
2021	Gamesa	Total	79199	

Figure 15 Growth in Germany and Poland

From the data above (again manually pulled and compiled from their annual reports) we can see that growth has also slowed for them in Germany while Poland has for the most part remained static or at best showing very minor growth.

For the second, and more critical financial question, we need to look at each company's market position in each country. Since Gamesa reports in total capacity, their half of this analysis was very easy as public data availability for the wind energy installed per country will be published as a total capacity number. We can simply look at the percentage of Gamesa's reported capacity per country against the country's total installed capacity overall.

Year	Company	Country	Total Wind Platforms Onshore and Offshore (MW)	Total Wind Platform % of Market
2017	Gamesa	Germany	6011	10.82%
2018	Gamesa	Germany	6785	11.53%
2019	Gamesa	Germany	7510	12.37%
2020	Gamesa	Germany	7393	11.81%
2021	Gamesa	Germany	7502	11.71%
2017	Gamesa	Poland	1045	16.34%
2018	Gamesa	Poland	1045	17.82%
2019	Gamesa	Poland	1053	17.80%
2020	Gamesa	Poland	1159	17.52%
2021	Gamesa	Poland	1297	18.23%
2016	Total	Germany	49430	
2017	Total	Germany	55580	
2018	Total	Germany	58850	
2019	Total	Germany	60720	
2020	Total	Germany	62580	
2021	Total	Germany	64040	
2016	Total	Poland	5782	
2017	Total	Poland	6397	
2018	Total	Poland	5864	
2019	Total	Poland	5917	
2020	Total	Poland	6614	
2021	Total	Poland	7116	

Figure 16 Market Presence in Germany and Poland

Above we can see that Gamesa has a stable market presence in Germany of about 11-12% while their presence in Poland is growing to a current 18%.

For Vestas, since they report largely from a delivery perspective, we were only able to find their current country install capacity from a recently reported track record document (separate from their annual report). No historical data was able to be found on this metric.

Year	Company	Country	Total Wind Platforms Onshore and Offshore (MW)	Total Wind Platform % of Market
2021	Vestas	Germany	16438	25.67%
2021	Vestas	Poland	3559	50.01%
2021	Total	Poland	7116	

Figure 17 Market Presence

While historical data would be helpful to see how things have grown in these markets, we do have their current market presence. As you can see, Vestas has about 26% of the Germany market and 50% of the Poland market. This is a key metric we can use to directly compare it to the Gamesa values since it's measuring the same metric.

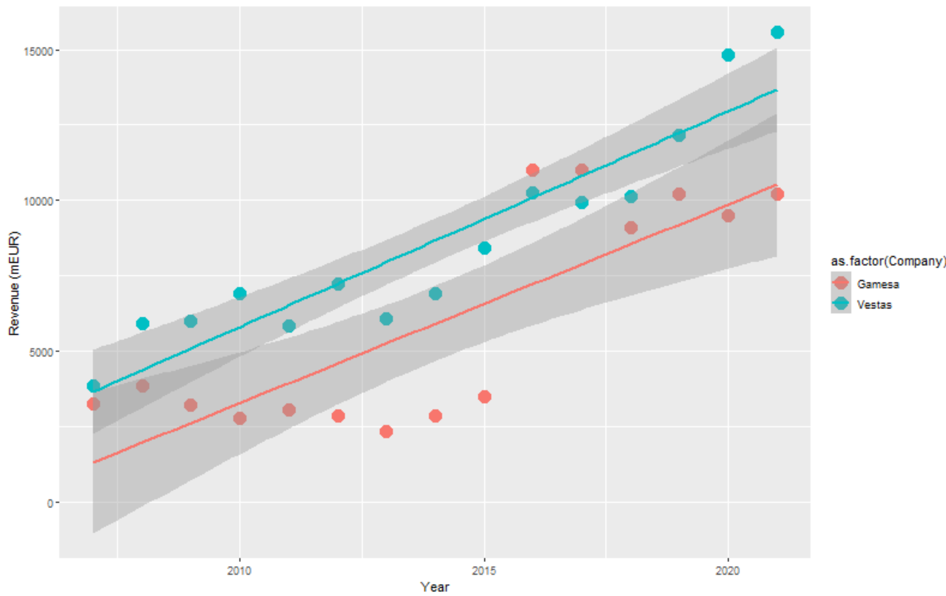


Figure 18 Gamesa and Vestas Revenue Plot

Figure 18 shows both Vestas and Gamesa have been steadily growing in the past decade. VESTAS is the overall leader in terms of installed capacity and annual revenue (Net Income), which is due to the good unit costs in its onshore turbine business. The key takes here is VESTAS has managed to grow revenue much more profitable relative to GAMESA, something investors would more like to see. GAMESA, the German-Spanish turbine maker had bigger problems like supply chain issues, covid-19 impact in the past two years which caused profit margins to briefly turn negative while Vestas navigated the pandemic much better.

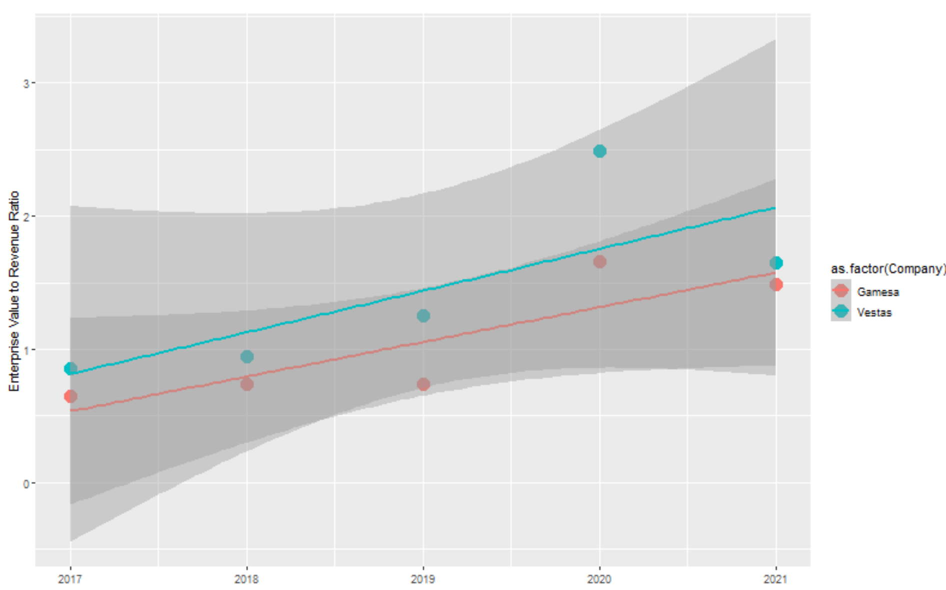


Figure 19 Gamesa and Vestas Enterprise Value/Revenue Ratio Plot

The EV/Sales ratio is a good estimate for how much expectation there is for growth (EV-to-sales multiples are usually found to be between 1x and 3x). By looking at the EV/Sales ratio in Figure 19, both companies are currently reasonably priced, with ratios at around 1.5x by the end of 2021. Vestas has a slightly higher ratio due to its better profitability and investors have higher expectations and valuation. The valuation premium has always existed because Vestas is the highest quality companies on operating metrics something that has happened in the wake of the company's near-death experience in 2012, which caused Vestas to transition into a much more disciplined company. Also, both companies' EV/Sales ratios are increasing because both have experienced steady growth and investors are growing in confidence in both companies.

Since Poland market is expected a much higher growth in next a few years, and as shown in Figure 16 and 17, Gamesa currently takes 18% Poland's market share while Vestas possesses 50%, we believe, due to conflicts in east Europe and accelerated transformation to renewable energy need in that region, Vestas will benefit a lot more compares to Gamesa.

Conclusion

As we conclude, we predict that Poland will outgrow Germany in year-over-year growth in the future though Poland may have operating disadvantages over Germany in the future due to legal challenges and other areas. This can be seen through our Logistic Regression Model that we drew which clearly depicts that Poland is a growing market over Germany, with a 10%+ growth.

Considering Vestas and Gamesa Financial reports over the past few years and looking at their performance, we deduce that Vestas is still and will be the overall leader in terms of installed capacity and annual revenue unless Gamesa overcomes all the Covid-19 effects and supply chain issues on its side.

Works Cited

Beckius, D., & Magnusson, D. (2013). The German wind energy market and its developers – a study of sourcing models, success factors and challenges. http://www.diva-portal.org/smash/get/diva2:644677/FULLTEXT01.pdf

Umwelt Bundes Amt (UBA) (2013), Potenzial der Windenergie an Land. https://www.wind-energie.de/fileadmin/redaktion/dokumente/publikationen-oeffentlich/themen/01-mensch-und- umwelt/03-naturschutz/bwe_potenzialstudie_kurzfassung_2012-03.pdf

Czyzak, P. (2022). Change is in the Wind. https://ember-climate.org/app/uploads/2022/03/Briefing_-Unlocking-onshore-wind-in-Poland.pdf

https://www.home.saxo/content/articles/equities/the-future-of-energy-a-look-into-vestas-and-siemens-gamesa-24082021

Rafael Lahoz-Beltra, Gompertz Function with R. https://encyclopedia.pub/entry/626

https://www.financecharts.com/stocks/GCTAY/income-statement/revenue

Vestas Annual Reports - https://www.vestas.com/en/investor/reports-and-presentations/vestas-reporting

Gamesa Annual Reports - https://www.siemensgamesa.com/en-int/investors-and-shareholders/financial-information/annual-reports

Vestas Global Track Record - https://us.vestas.com/en-us/products/track-record#accordion-562c3c810a-item-8880e4206a