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U.S Wind Power Market: Investment decision

WOW! Investment Committee

September 2023

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US Wind Turbine Industry | focus and objectives

Wind Turbine Market

- Global market of wind energy
- Current State of the energy and renewable energy market
- Current State of the wind turbine market
- Evolution of the wind turbine market

Operators Analysis

- Understanding current players
- Geographical presence of key players
- Profitability of operators

Understanding Turbines

- Geographical distribution of plants in the US
- Attributes of plants
  - Size
  - Capacity
  - Location
- Trends in attributes of wind turbine:
  - Manufacturers
  - Capacity
  - Electricity Generation
  - Maintenance requirements
  - Dimensions

Future Outlook

- COP27
- US National Renewable Energy Targets
- Other policies and reforms

Recommendation & Funding

- Recommendation of operators, dimensions and locations
- Potential financier

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Wind Turbine Market

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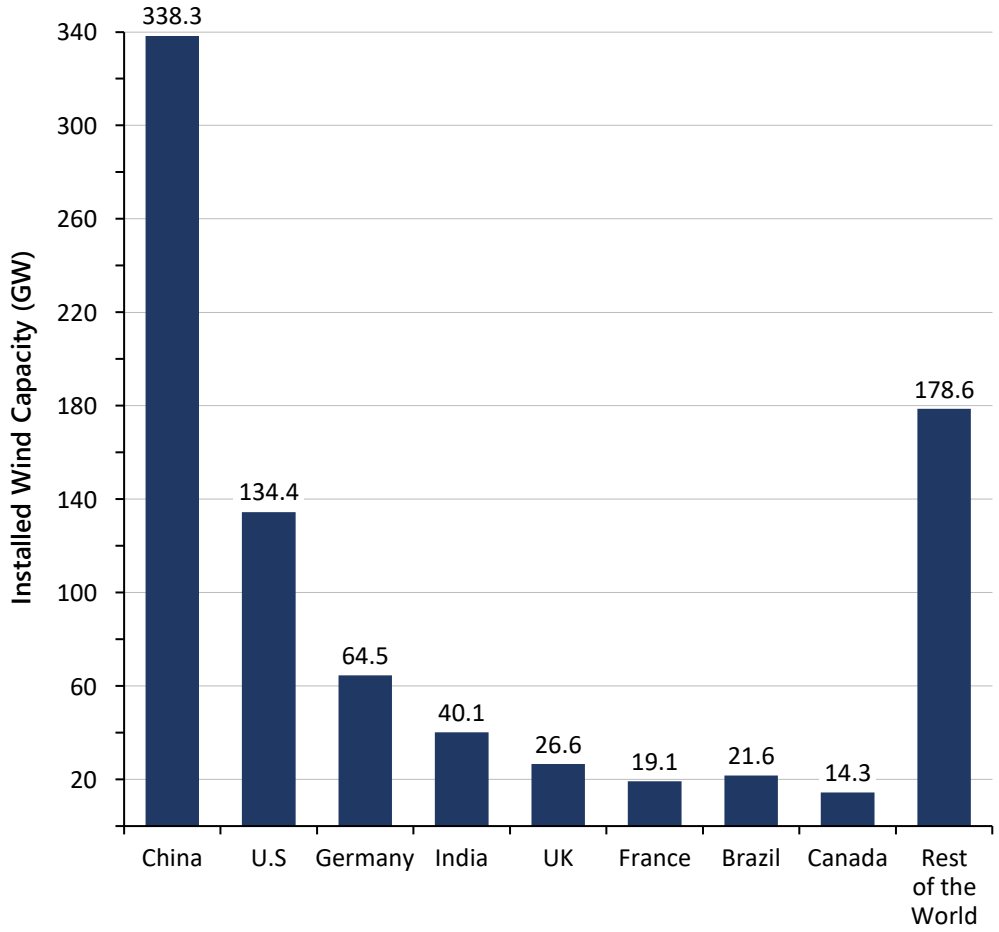
Wind Turbine Market | Global Market

Global Wind Turbine Market

- The global renewable energy market size was valued at $1.1 trillion (USD) in 2022 and has been projected to grow at 16.9% per year from 2023 to 2030.
- The global wind energy market was valued at over $99.28 billion in 2021, behind the solar power and hydropower segments.
- The US is the second largest generator of wind energy of installed wind turbine capacity in the world in 2021 at 132.7GW, behind China who are market leaders globally.
- The US's capacity is greater than the total of Germany, India and the UK.
- More than 60,000 turbines are installed in the U.S., with cumulative capacity of 134.2 GW.

Top Wind Producing Companies in 2021 | By Installed Wind Capacity (GW)



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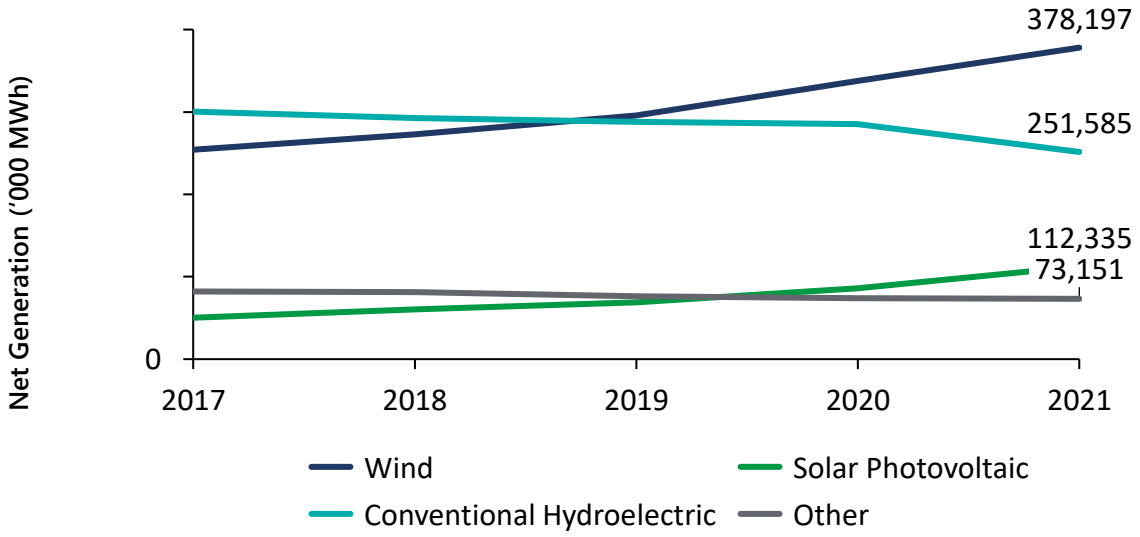
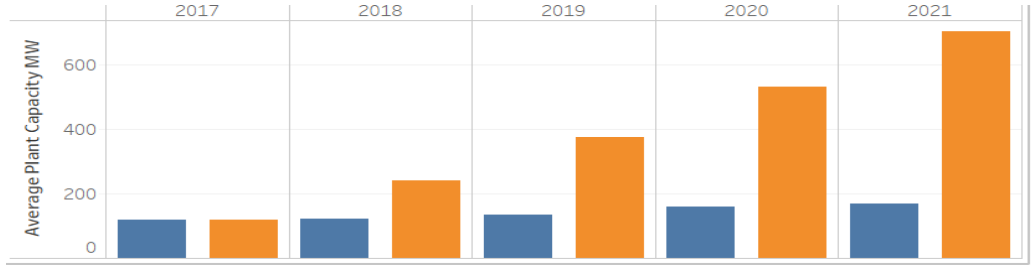
US Wind Turbine Market | US Market

US Wind Turbine Market

- As a result of current government policies and lower wind costs, the US has grown its wind capacity by an average growth rate of 11.3% from 2011 to 2021.
- Wind energy currently generates over 9% of national electricity, and more than 50% in states such as Iowa and South Dakota.
- In the US, Wind energy surpassed Conventional Hydroelectric as the leader in renewable energy source of energy generation in 2019 and has continued to increase year on year whilst Conventional Hydroelectric has gone on a decline in output.

Renewable Energy Sources | Net Generation ('000 MWh)





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Wind Turbine Market | US Market

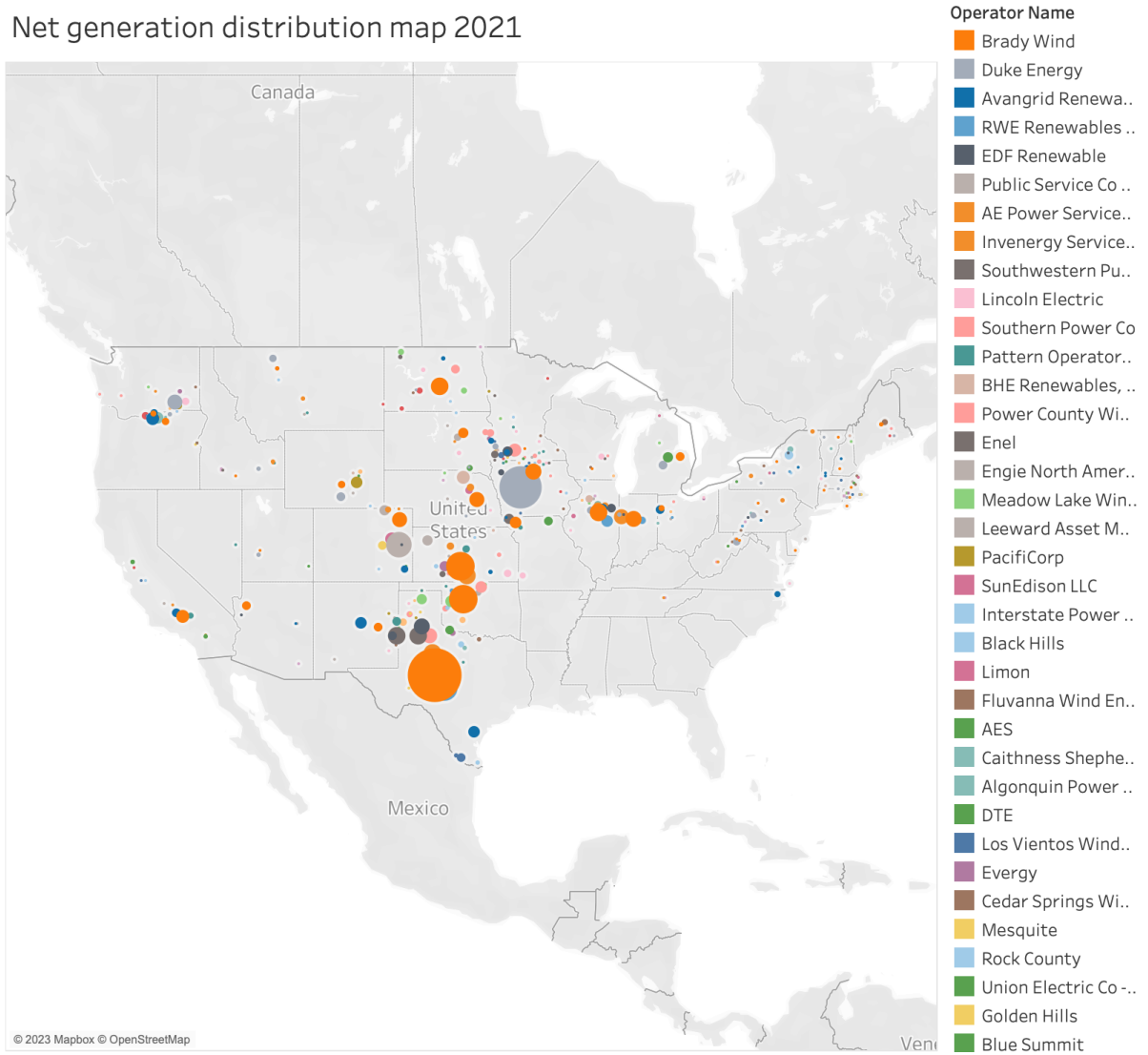
Number of plants: **1,160**

Total number of turbines: **73,009**

Number of operators: **213**

Total rated capacity: **129,944k MW**

Total net generation in 2021: **36,688m MW**



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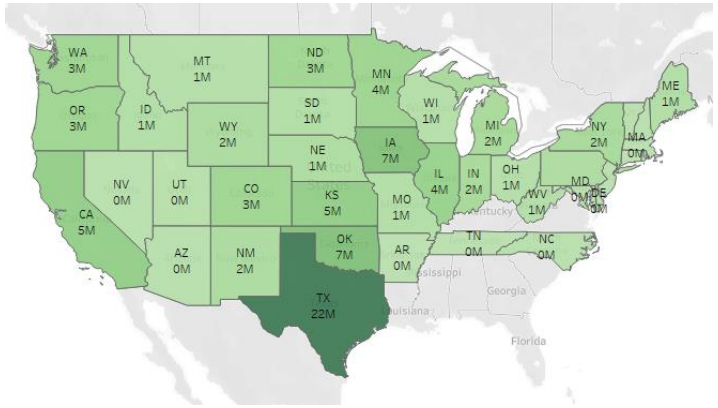
Wind Turbine Market | US Market

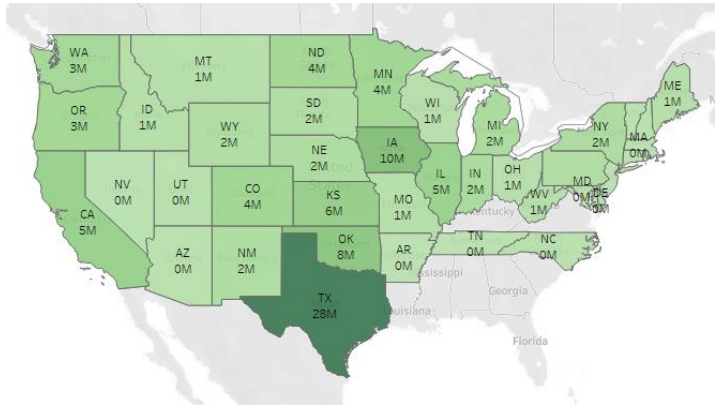
US Wind Turbine Market | Turbine Capacity over time (kW)

- Within the US, Texas has the highest electricity capacity by a significant margin out of all US states in 2021, this is approximately c. 34.6m kilowatts (kW).This is followed by Iowa at 12m kW
- Texas has remained the state with the greatest additional electricity capacity for all years from 2017 to 2021.
- It is also worth noting that the Midwest has the highest number of turbines. Texas has approx. 17,000 wind turbines and Oklahoma has approx. 4,900 wind turbines.

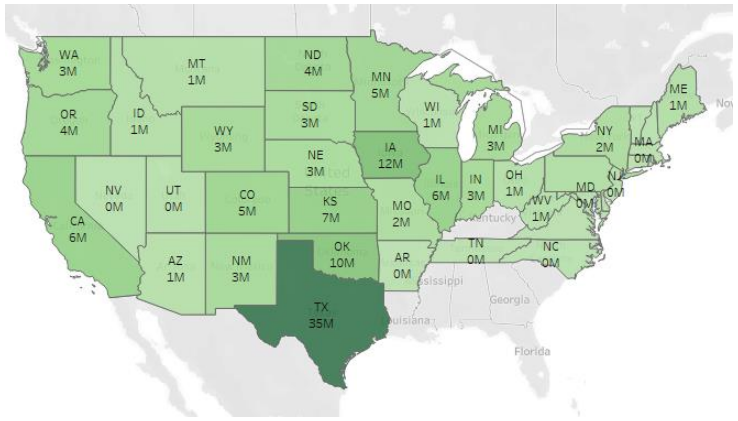
2017



2019



2021



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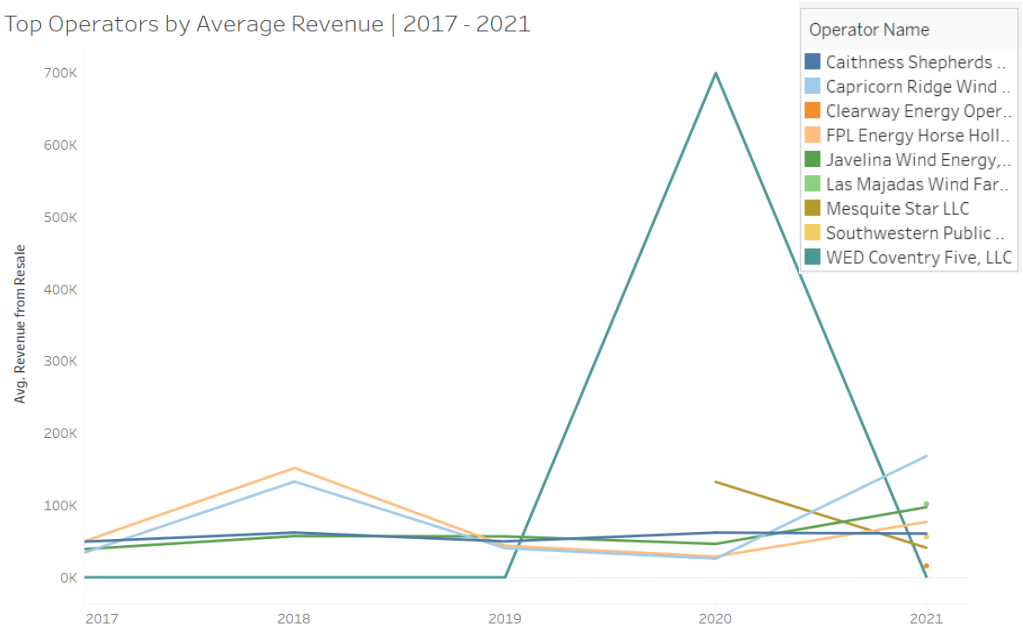
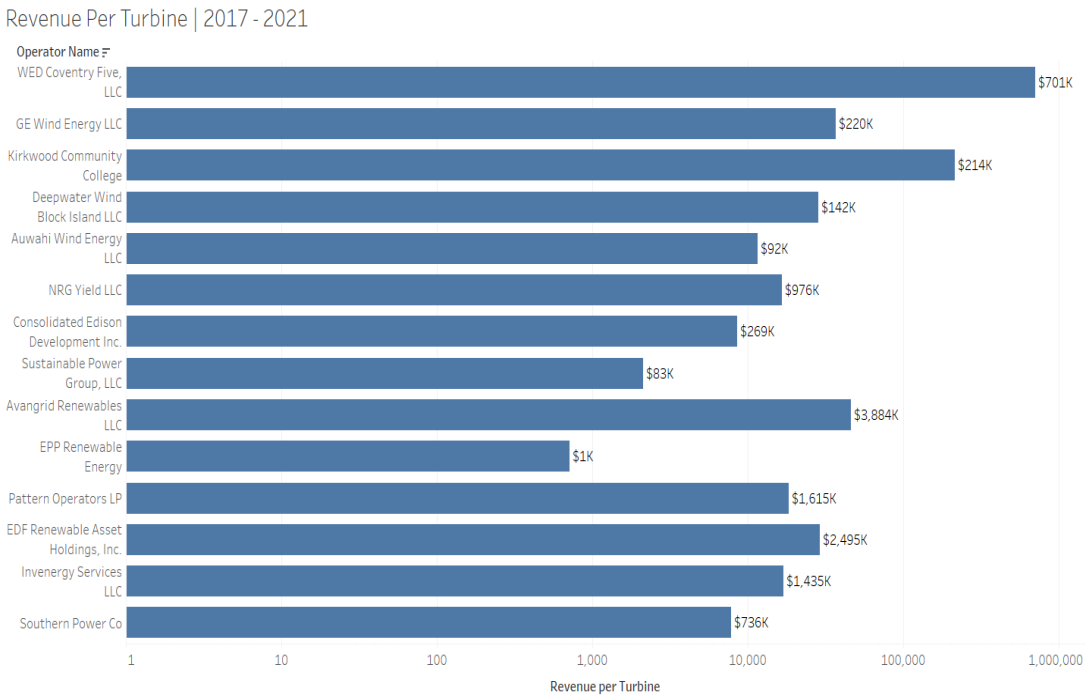
Wind Turbine Market | Revenue

Revenue Trend of the Turbine industry



- Most operators saw an increase in Revenues in 2018, followed by decline through 2019 and 2020, and increasing trends in 2021. Exception to this trend are for WED and Caithness shepherds.

Revenue Per Turbine, per Operator



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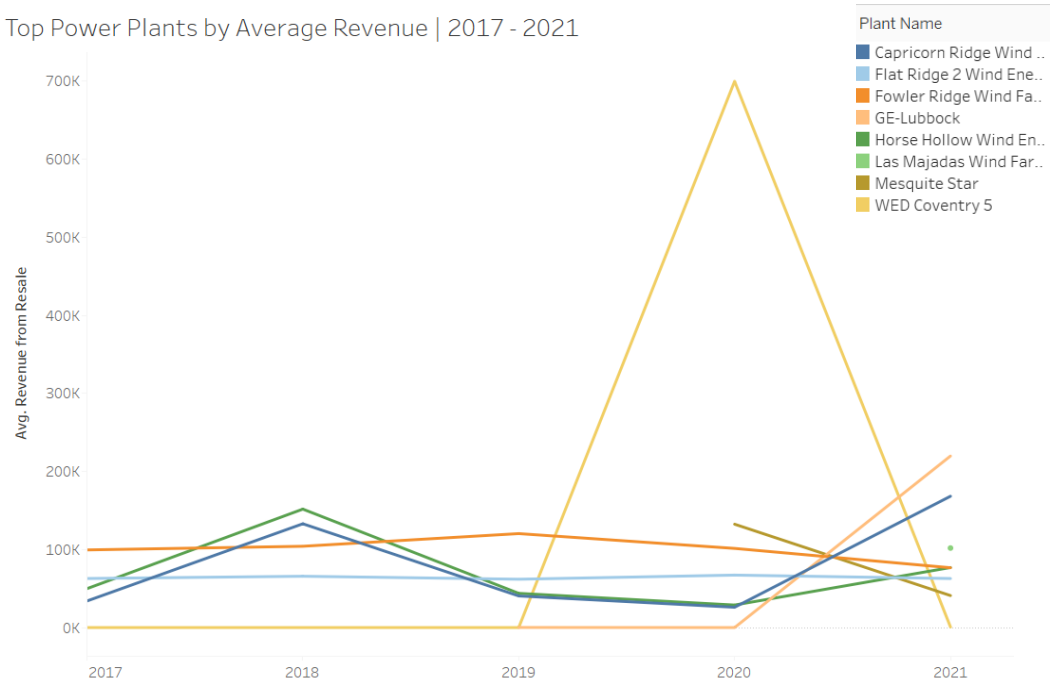
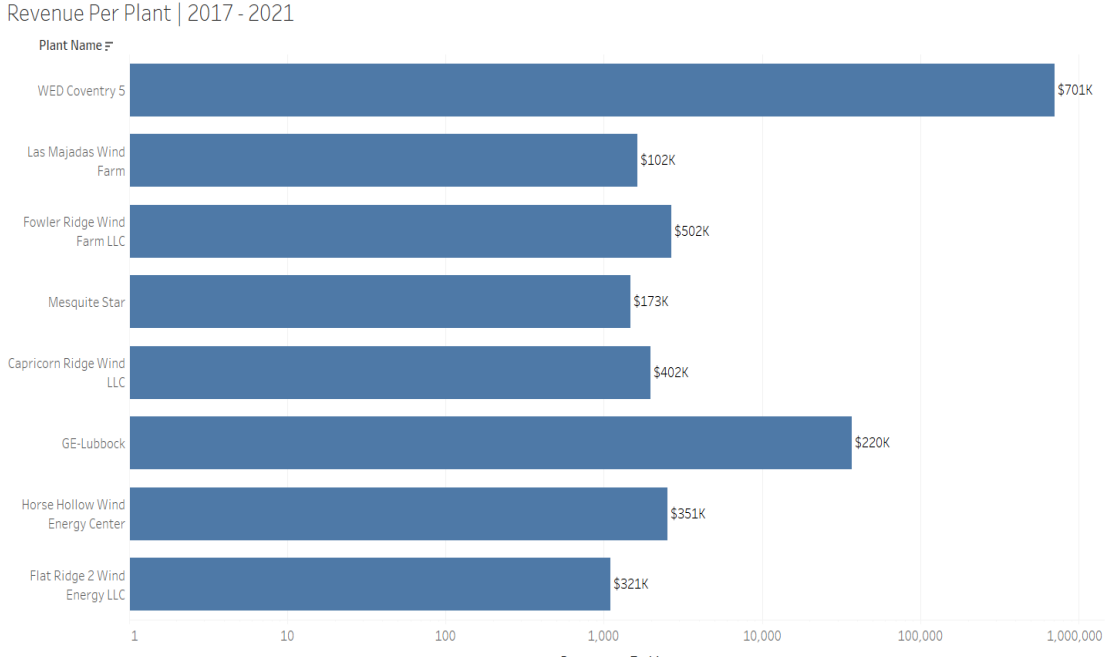
Power Plant | Revenue

Plant Revenue Trend





Operators Analysis

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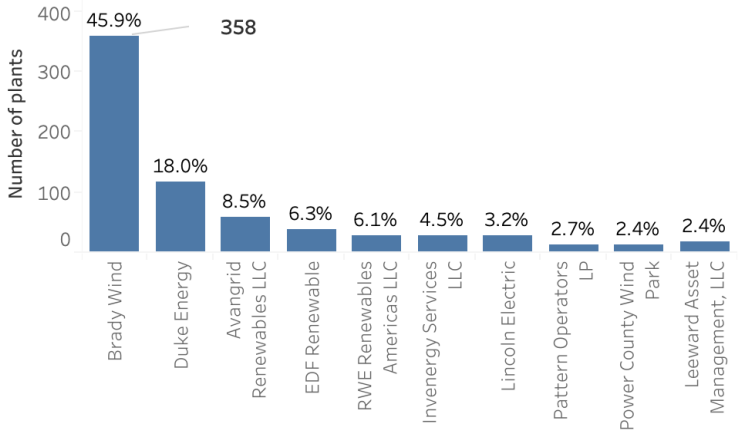
Operators Analysis | Key players in the market

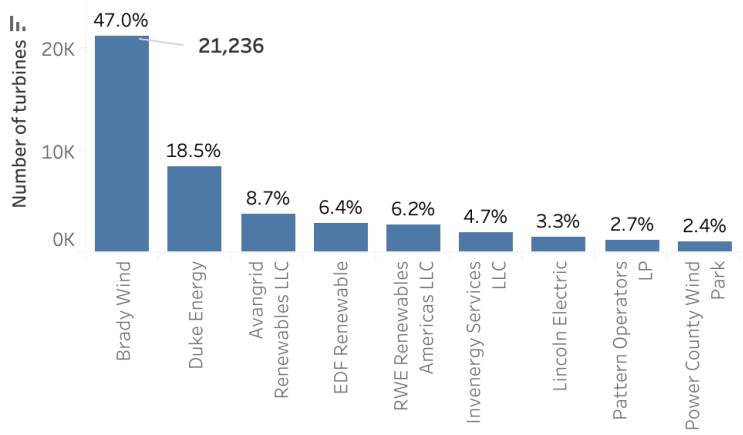
Top operators at a snapshot

- Number of operators: 213
- Top 10 operators collectively command more than 90% of the market share.
- Top 3 operators maintain their positions across various metrics, including plant count, turbine count, rated capacity, and total net generation in 2021.

Number of plants

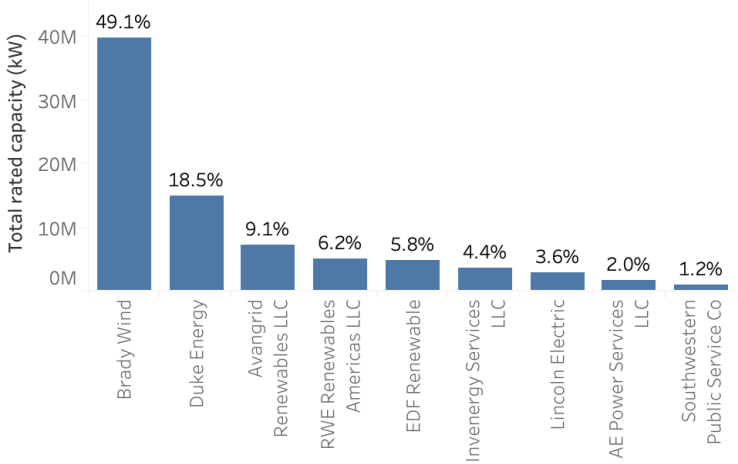


Number of wind turbines

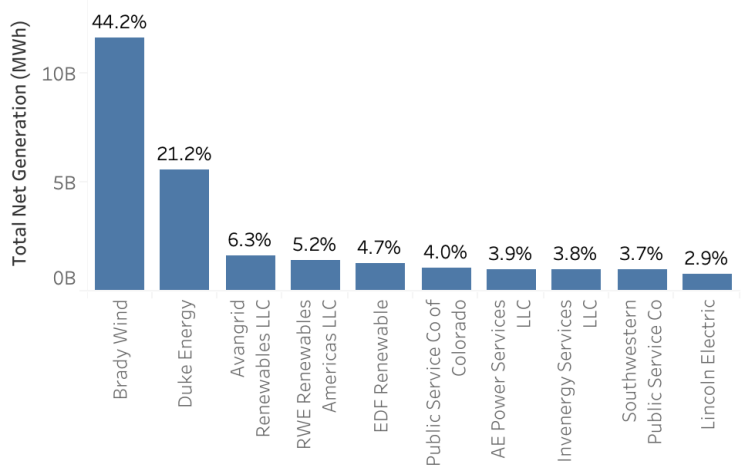


Among the 200+ operators in the US, the top 10 leading ones collectively hold over 90% of the wind energy market share. The top 3 maintain their positions across plant count, turbine count, rated capacity and total net generation in 2021.

Total rated capacity



Total net energy generation in 2021



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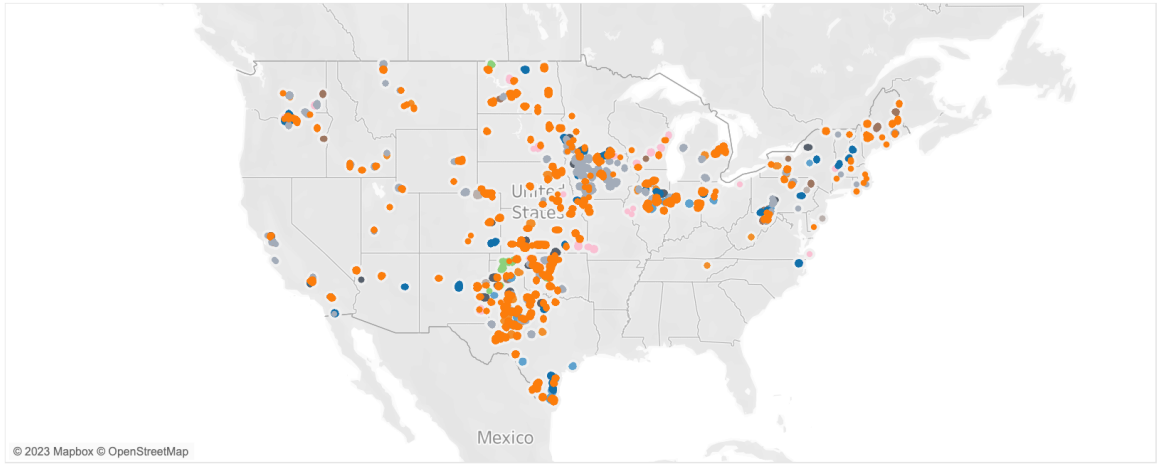
Operators Analysis | Key players in the market

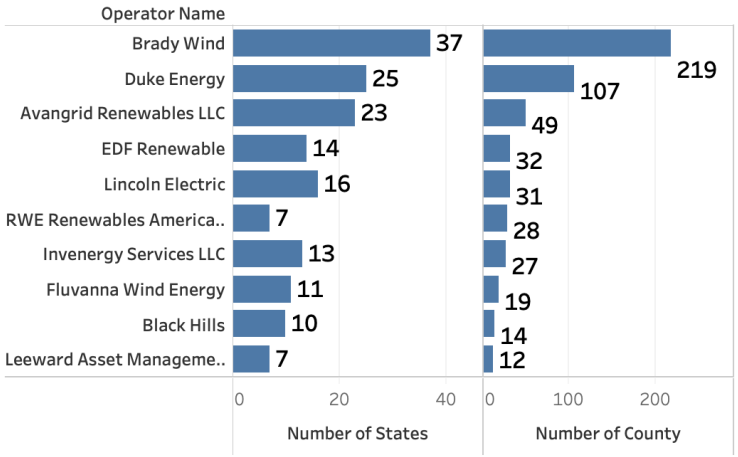
Top operators by plant presence

- Brady Wind dominates the US market by number of plants and presence in state – present in 37 states, 219 counties.
- Duke Energy are second market leaders and have a more diverse portfolio than Brady Wind – operates plants in all fuel types (e.g. Wind, Natural Gas, Solar PV, thermal and distillate petroleum)

Plant Count Map



Number of States and County with Wind-Energy Plants



Number of plant by fuel types

Operator Name	AER Fuel Type Code WND	SUN	OTH	NG	DFO
Brady Wind	358		6		
Duke Energy	118	1	1	1	1
Avangrid Renewables ..	58				
RWE Renewables Ame..	28		2		
EDF Renewable	38	1			
Invenergy Services LLC	27				
Lincoln Electric	28	1	1		1
Leeward Asset Manag..	17				
Meadow Lake Wind Fa..	16				
Fluvanna Wind Energy	18			1	

Note for fuel type
DFO: Distillate Petroleum
SUN: Solar PV and thermal
OTH: other
WND: Wind
NG: Natural GAs

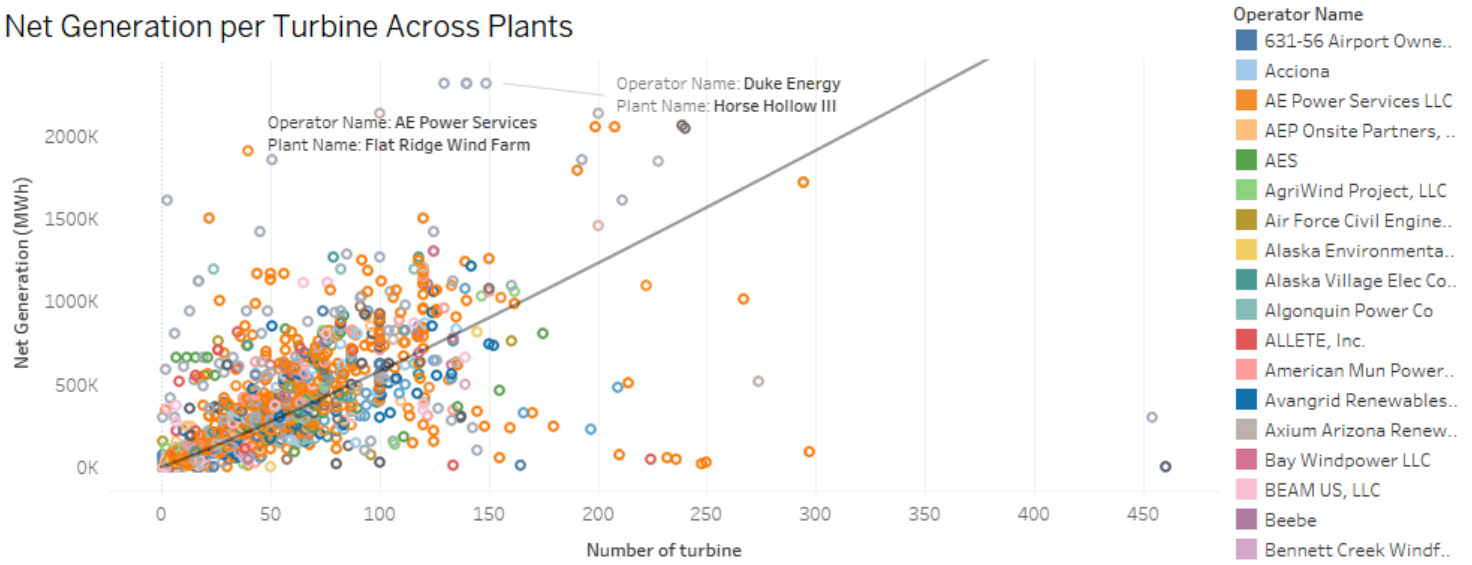
Operators Analysis | Key players in the market (cont.)

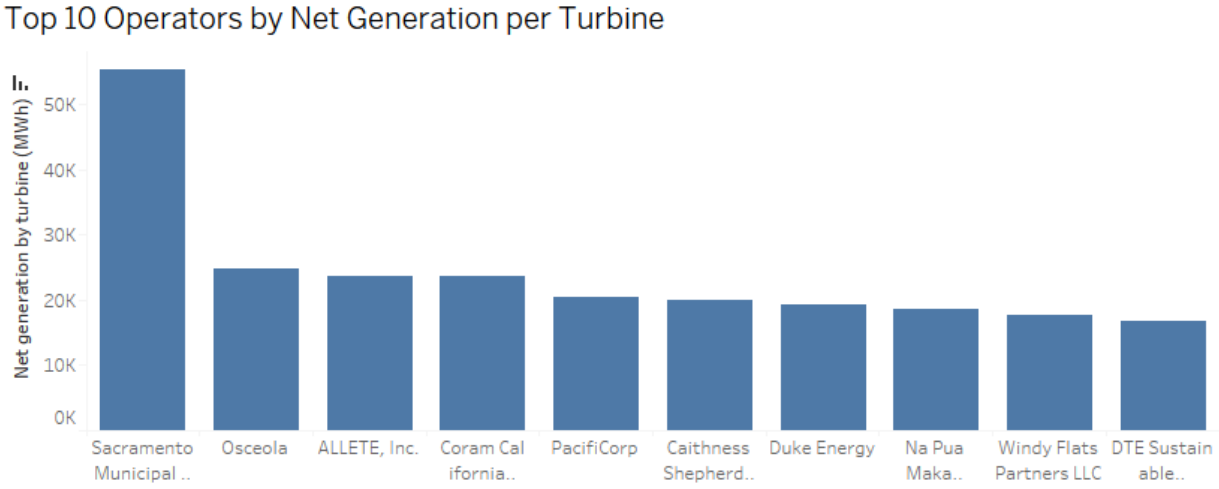
Top operator – highest net generation to no. of turbines by project

- The operators with the highest level of net generation and lowest number of turbines by projects are :
  - Duke Energy (Hollow II and Horse Hollow Wind Energy Project)
  - Brady Wind
  - Public Services Co of Colorado (Rush Creek II project)
  - AE Power Services (Flat Ridge Wind Farm)

Top 10 operators – net generation by no. of turbines

- The operators with the highest level of net generation per turbine are:
  - Sacramento Municipal
  - Osceoia
  - Allete





Understanding Wind Turbines

Understanding Turbines | Geographical Location

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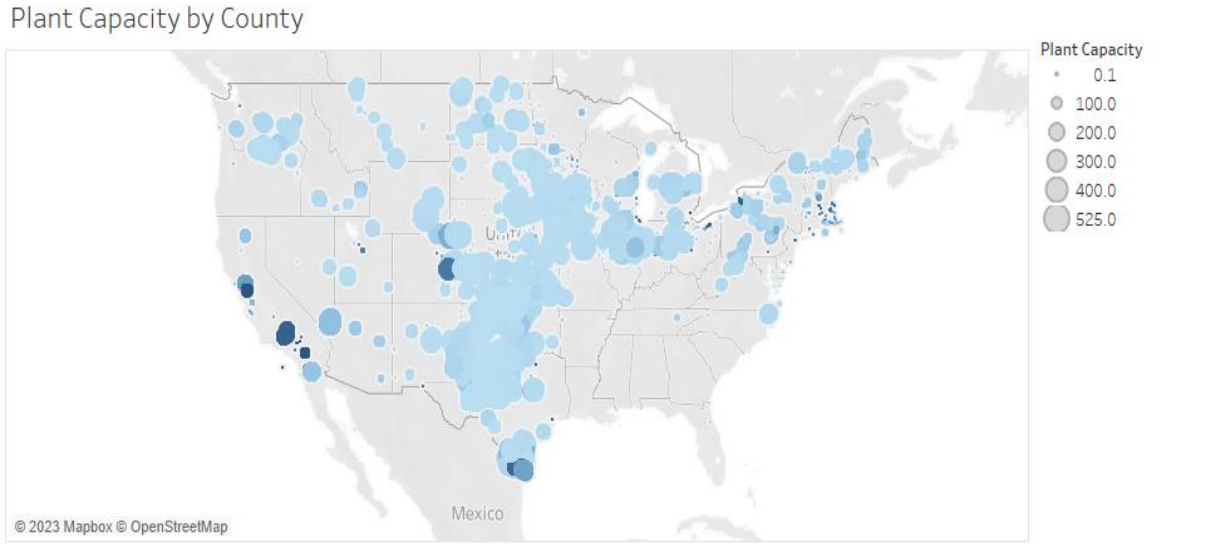
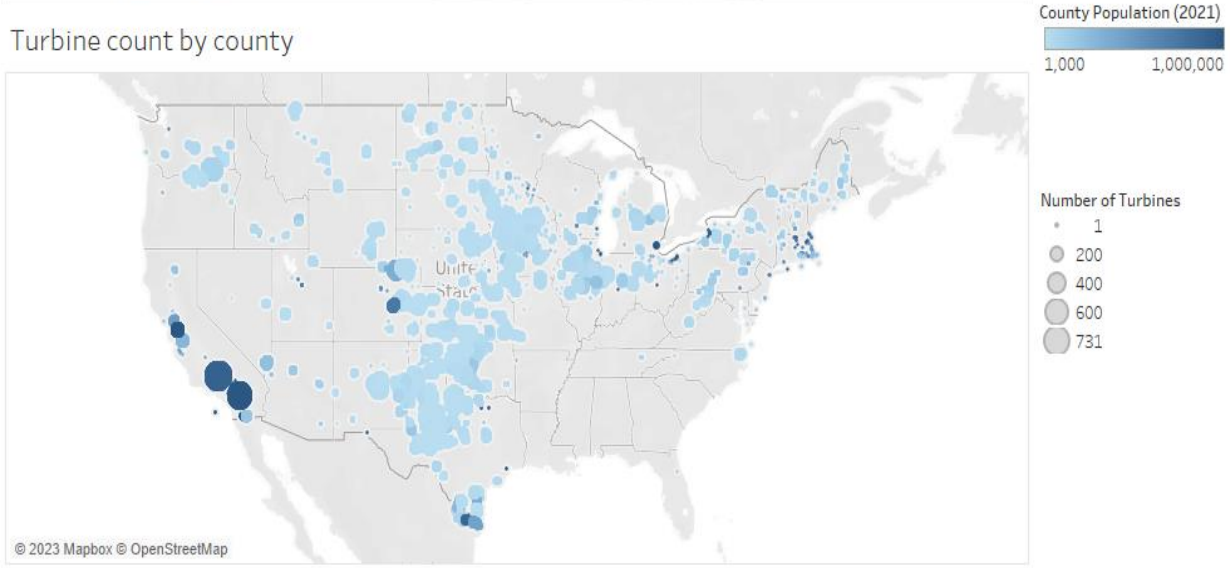
Turbine Locations

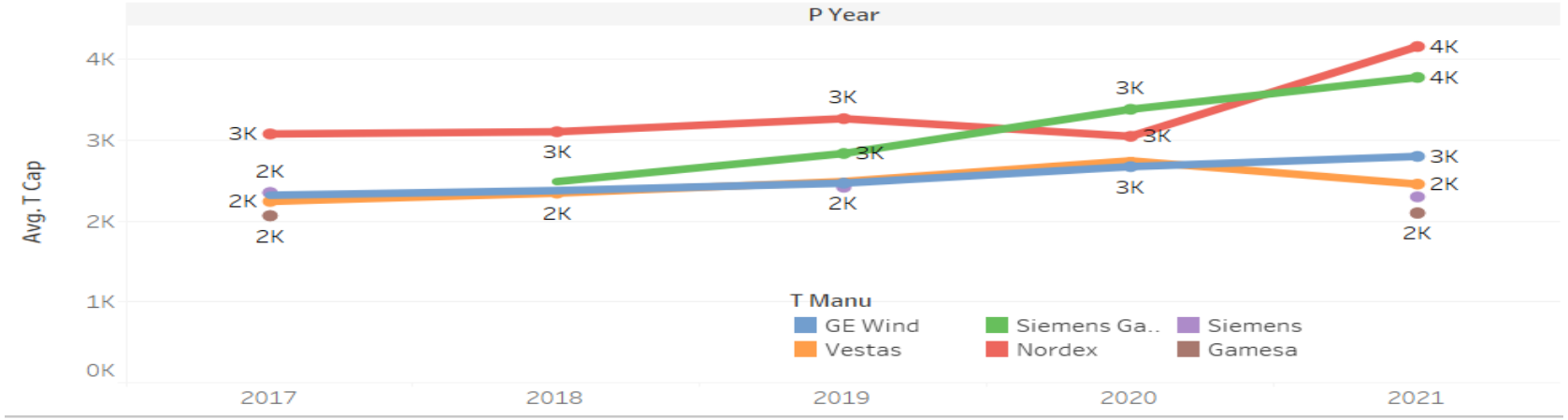
- Most large plants are not close by to largely populated counties.
- Typical for there to be many plants in an area/county
- Would like to ascertain if there is a drop off in energy if it travels large distances, but beyond our scope.



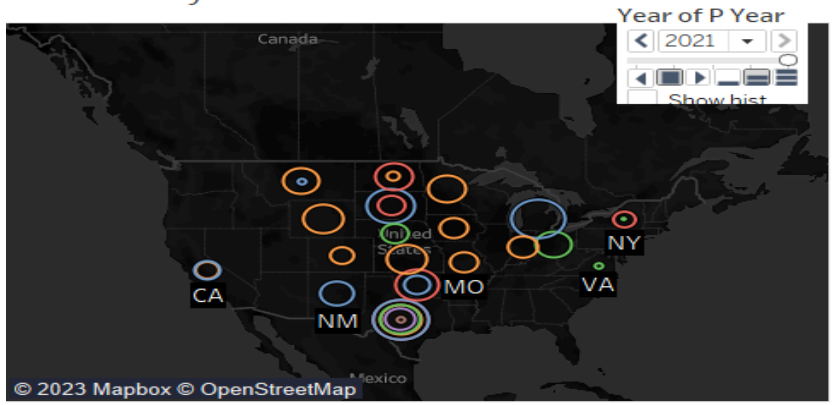


Turbine Manufacturer Analysis

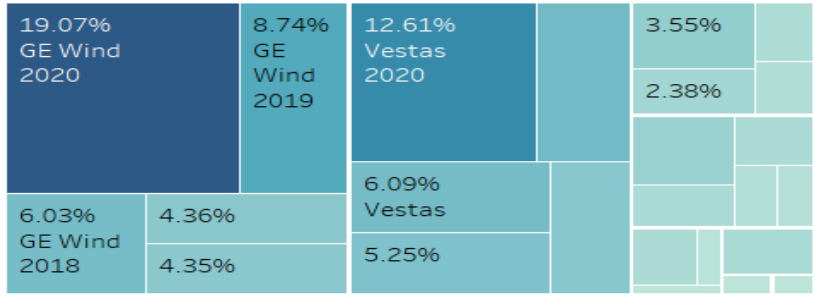
Total manufacturers by turbine capacity



t manu by location - 2021



Top Manufacurers for 2021



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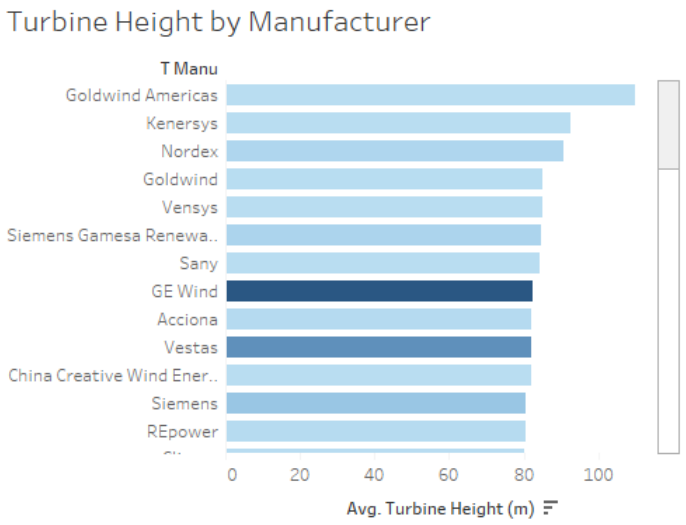
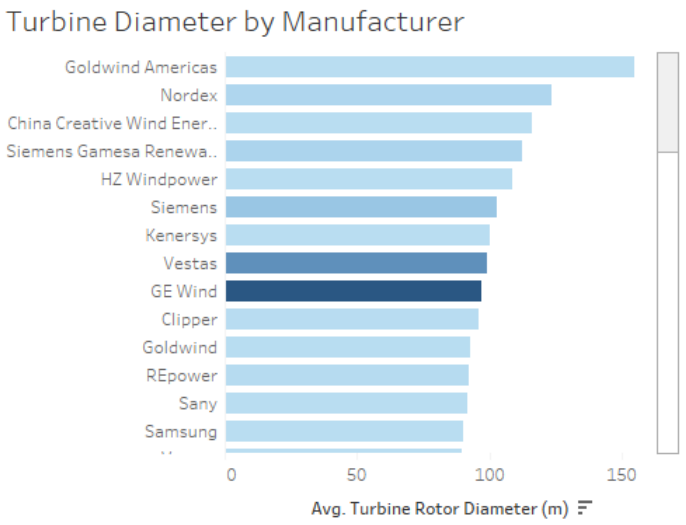
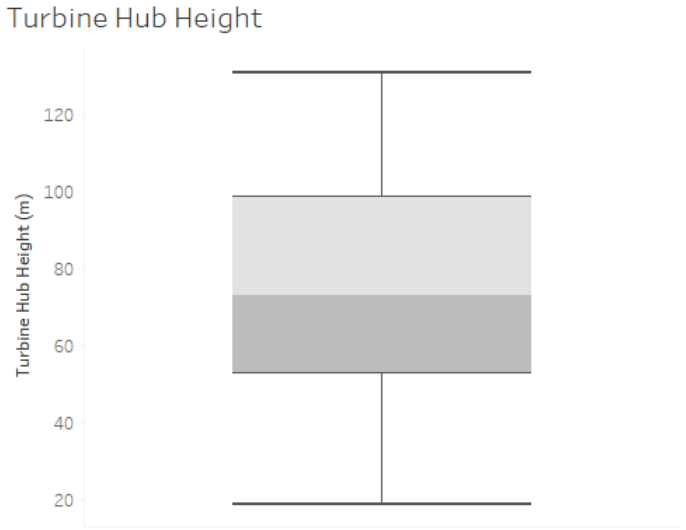
Understanding Turbines | Attributes (cont.)

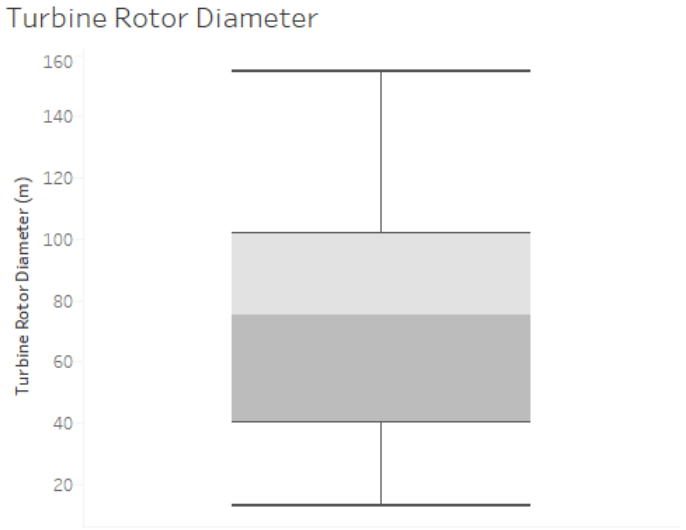
Turbine Attributes

- Turbines can differ wildly in the attributes, even across manufacturers.
- Turbine Hub Height and Rotor Diameter are evenly distributed over the ranges found, indicating that no individual height or Diameter is default better, and should be constructed based on the needs of the plant.
- GE Wind and Vestas are the manufacturers with the greatest share of turbines in the space by a large margin.
- On average turbines have a Hub Height of about 75m and Rotor Diameter of about 80m.
- Hub Height is used to catch more wind and a greater Rotor Diameter will generate more electricity.









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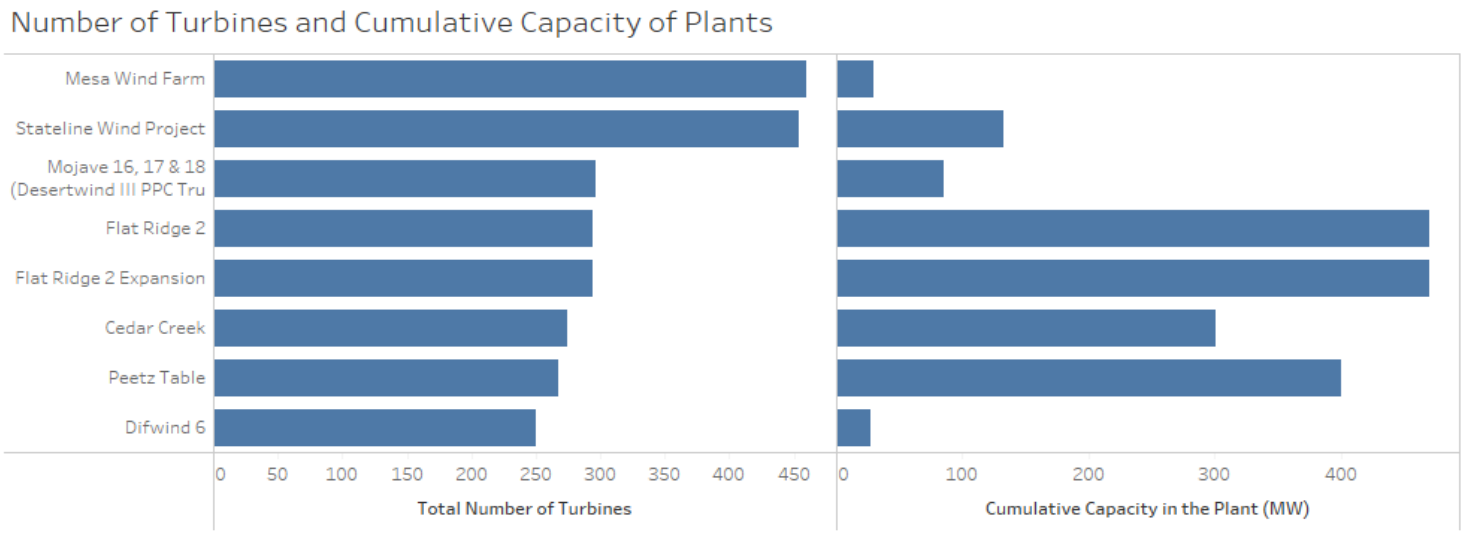
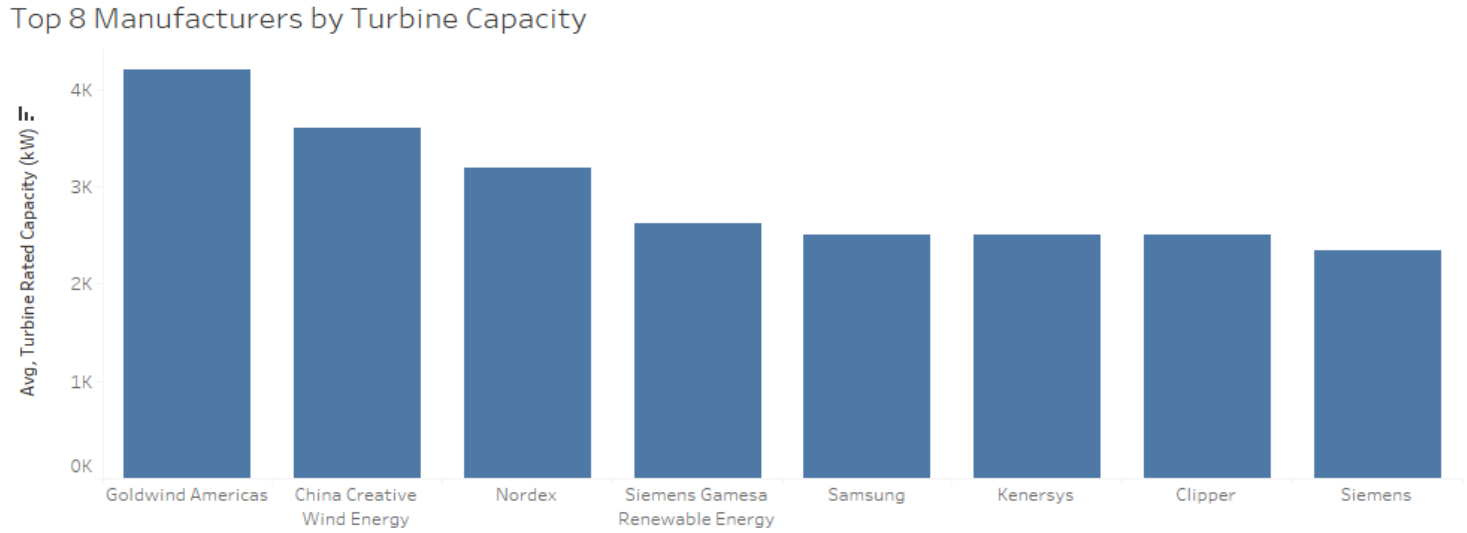
Understanding Turbines | Attributes of turbine plants

Turbine Attributes Capacity

- Largest plants have over 250 turbines generating electricity.
- Plant energy Capacity and number of turbines aren't necessarily correlated. Can't immediately expect a plant that has a large number of turbines to have a large Capacity.
- If looking at purchasing a plant by looking at avg Turbine Capacity, Goldwind Americas would be the first choice.





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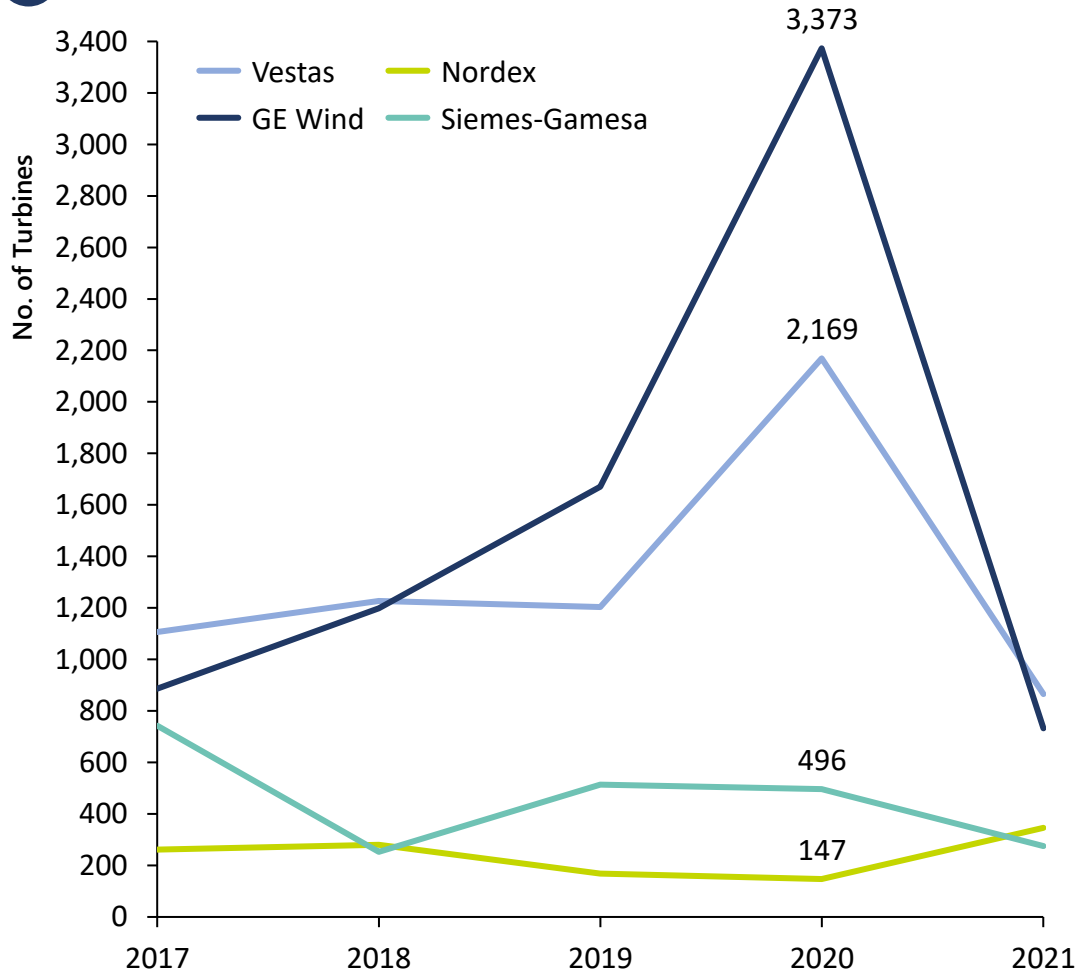
Manufacturer Analysis | Key players in the market (cont.)

Manufacturers on Wind Turbine in the US | 2017 - 2021

- There were 4 manufacturers of wind turbines in the US in 2017 - 2021. Vestas and GE Wind dominates the manufacturing market.
- Vestas and GE Wind are the top players respectively and together, they make up over 80% of the total manufacturing market share from 2017 – 2021. This also represents 14,434 units of turbine.
- In 2017 and 2018, Vestas was the market leader by a small margin, however, GE Wind overtook Vestas' position by a significant in 2019 and 2020.

Wind turbine manufacturer | No of turbines from 2017 – 2021



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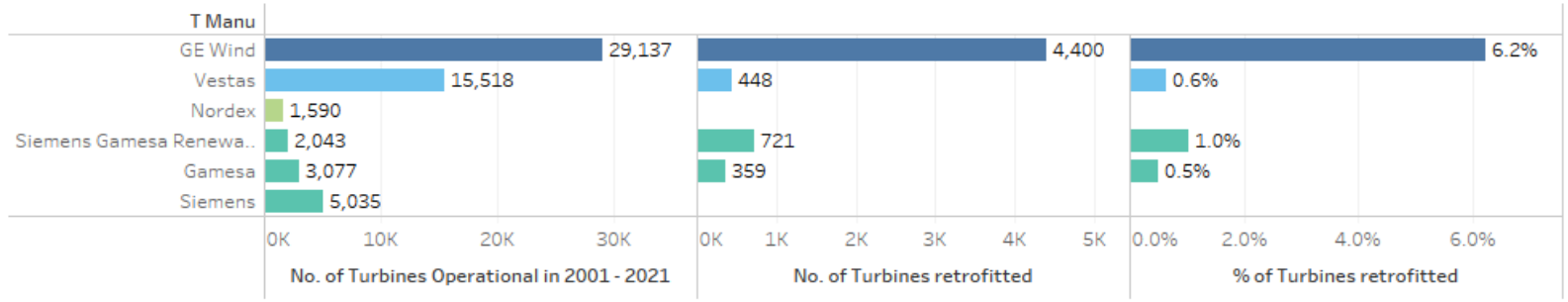
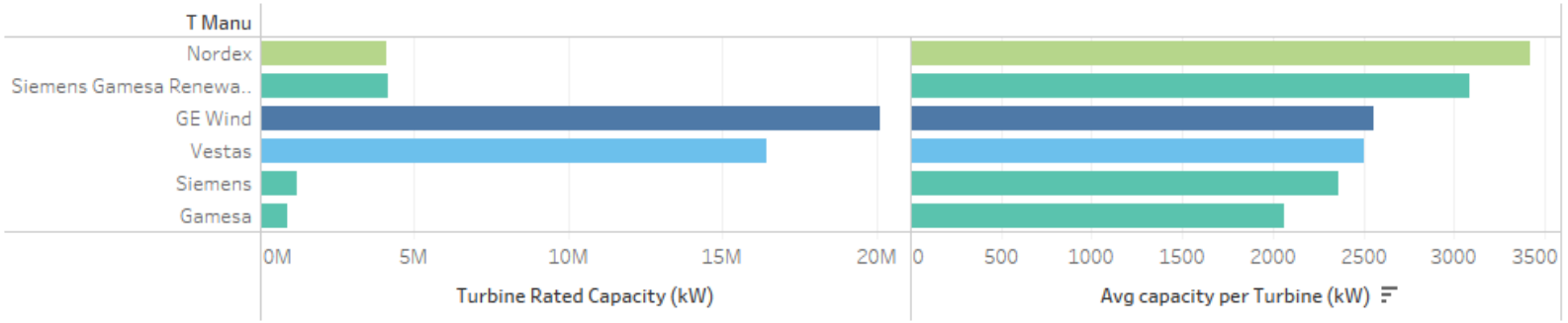
Manufacturer Analysis | Key players in the market (cont.)

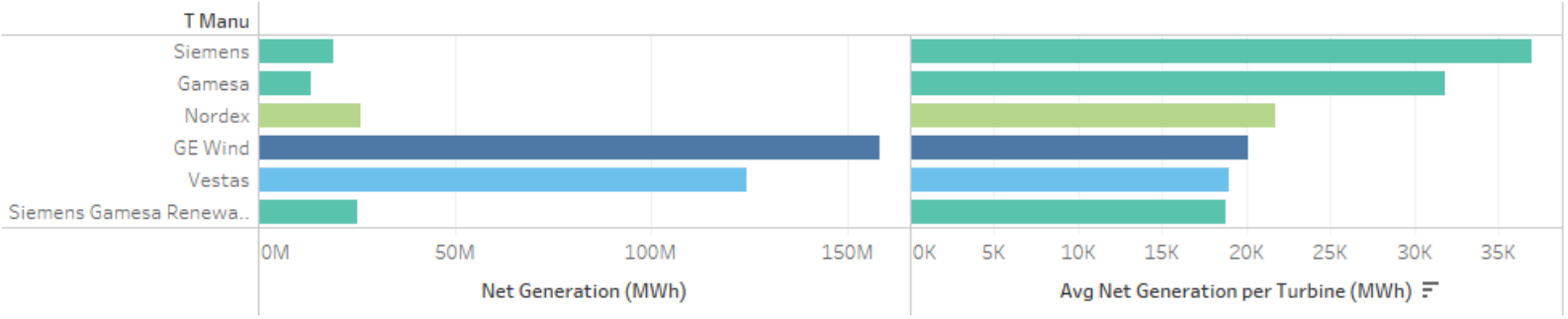
Retrofit by Manufacturer | Turbines Manufactured in 2001 - 2021



Turbine Capacity by Manufacturer | Turbines Manufactured in 2017 - 2021



Net Generation by Manufacturer| Turbines Manufactured in 2017 - 2021



Quality of Turbines by Manufacturer

- Several metrics for quality are explored:
  - Percentage of Retrofit
  - Average Capacity by Manufacturer
  - Average Net Generation by Manufacturer
- The typical useful life of a turbine is 20 years and we have therefore elected to analyse turbines operational from 2001 to 2021 with respect to retrofit.
  - Wind turbines manufactured by GE Wind have the highest percentage of retrofit.
- When looking at Capacity and Net Generation by Manufacturer
  - Turbines manufactured by Nordex, Siemens Gamesa and GE Wind have the highest average turbine capacity.
  - Turbines manufactured by Siemens Gamesa have the highest average net generation per turbine.

Future Outlook

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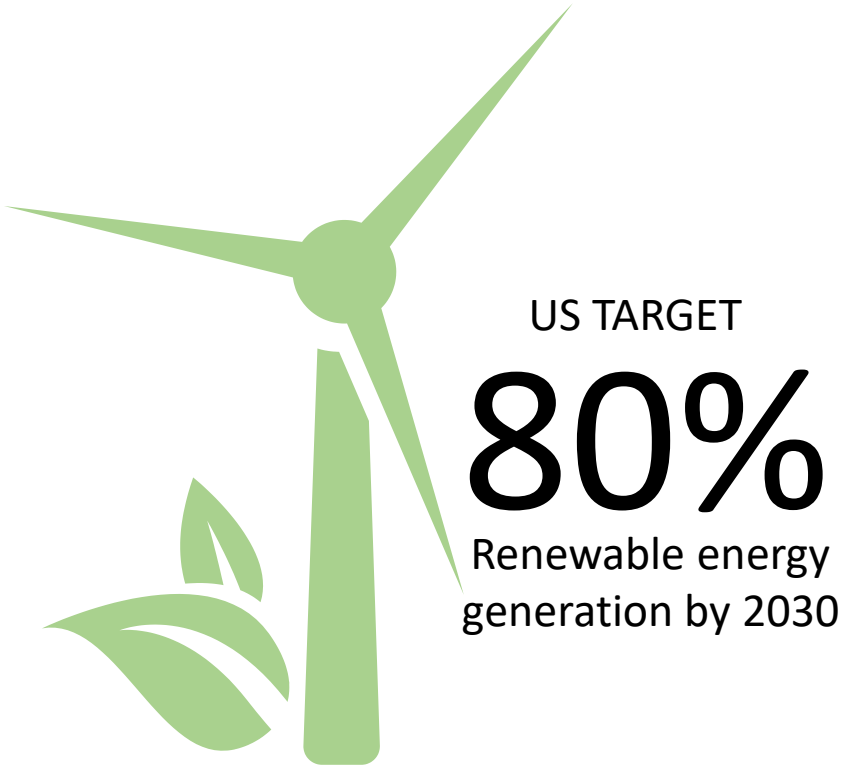
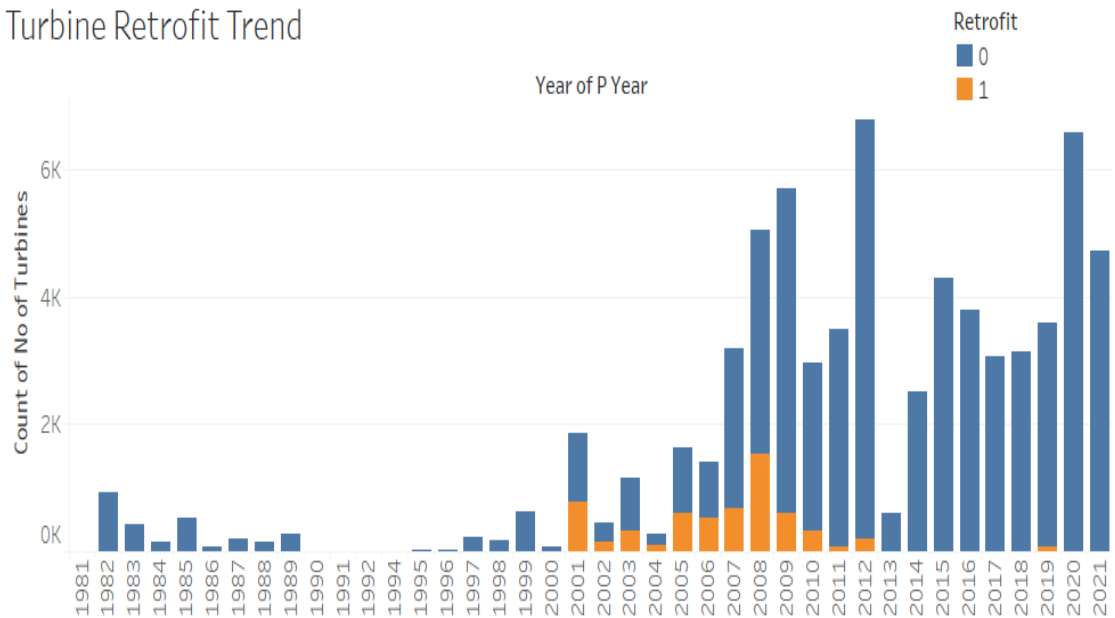
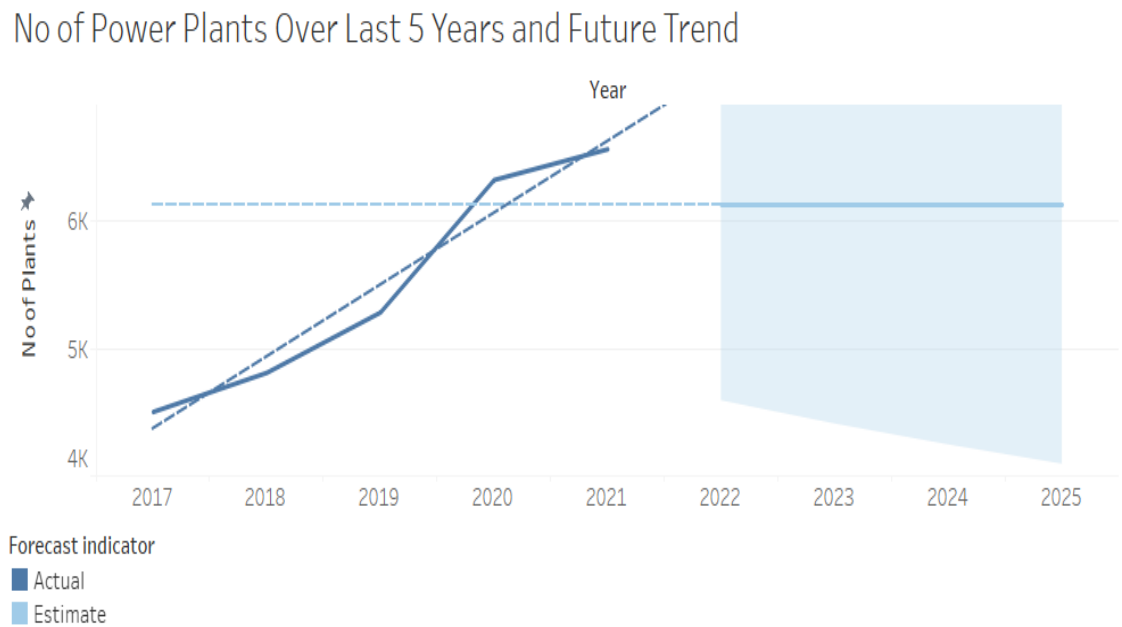
Future Outlook | policies and reforms

Targets for green energy in the US.

- There has been significant support by the US government for renewable energy and this has been a key factor in driving growth in the industry.
    - Federal tax credits for production and investment
    - Federal grants and loan programs including the Department of Agriculture and the Department of Energy
    - State and local government tax credits to help financing projects
- Renewed efforts by the federal government are in play and are projected to further expand the renewable energy market
    - Ambitious goals set by the Biden-Harris Administration: mandates to achieve 100% carbon pollution free electricity by 2023 and net zero emissions from federal procurement by 2050
    - Efforts to improve permitting and regulatory processes for renewable energy projects and investments in US supply chain and manufacturing
- At COP27, climate adaptation was a key focus area, with a particular push towards pledges from nations across the world to commit towards a renewable energy target.







The U.S. wind power industry has been experiencing consistent growth in terms of installed capacity. Wind power installations have been increasing, contributing significantly to the country's renewable energy generation capacity.

Retrofits indicating technological advancements have led to the development of larger and more efficient wind turbines.

Looking at the trend in Turbine retrofit, majority of the retrofits were done between 2001-2012.

Recommendation

Wise Data Analytics

Recommendations

Recommend approaching Duke Energy to invest in

- Operate in 25 states, 107 counties
- 2nd largest operator in term of size owns over 18% of the plants in the country
- One of the top ten leading operators by net generation per turbine
- Operating different fuel-type plants
- Very high average plant efficiency to turbine ratio

Recommend approaching Brady Wind to invest in

- He owns over 45% of the plants in the country, and 32% of the total capacity.
- Also largest net energy generator by a large margin, and more energy generated translates to a larger return.
- Good average plant efficiency, of over 7000 MWh per turbine
- Moderate-high plant efficiency to turbine ratio

Other small plants to acquire:

WED Conventry 5 ($701k in revenue per turbine) and GE Lubbock ($220k in revenue per turbine).