INVESTING IN U.S. WIND POWER

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WOW!

ABOUT US

We are **Team JADEN** from WOW!, a Chicago-based private equity firm specialising in clean energy investments.

Currently, our portfolio includes U.S. hydropower projects, and we are exploring potential investments in U.S. wind power.

OBJECTIVE

The objective of this project is to evaluate the potential for WOW! to **invest in the U.S. wind turbine market**. The research will explore current and future growth outlook, investment opportunities and potential partner(s) to inform the decision of whether WOW! should enter this market.

AGENDA

1
US Power Generation Market Overview

2
Growth Outlook for Wind in U.S.

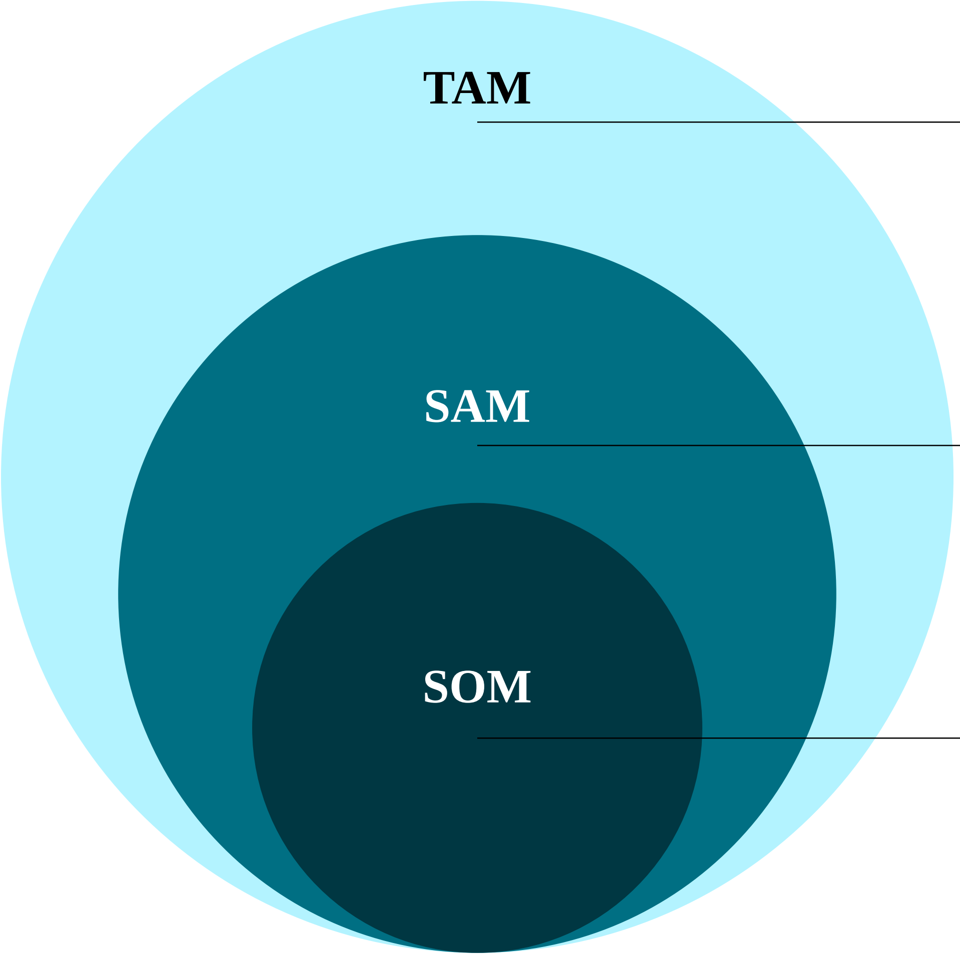
3
Identifying Investment Opportunities

4
Partner Selection & Investment Plan

5
Project Reflection

U.S. Power Generation Market Overview

The U.S. wind energy market is forecasted to grow almost 4x as fast as U.S. real GDP growth of 1.6 % in the next 5 years.



Total Addressable Market
Global renewable energy market size: US$1,031b (2022)
CAGR: 8.6% (2022-2030)

Serviceable Available Market
Global wind energy market size: US$78b (2021)
CAGR: 9.4% (2021-2030)

Serviceable Obtainable Market
U.S. wind energy market size: US$19b (2020)
CAGR: 5.9% (2022-2027)

Globally, U.S. ranked 2nd in annual and cumulative total wind power capacity additions in 2021.

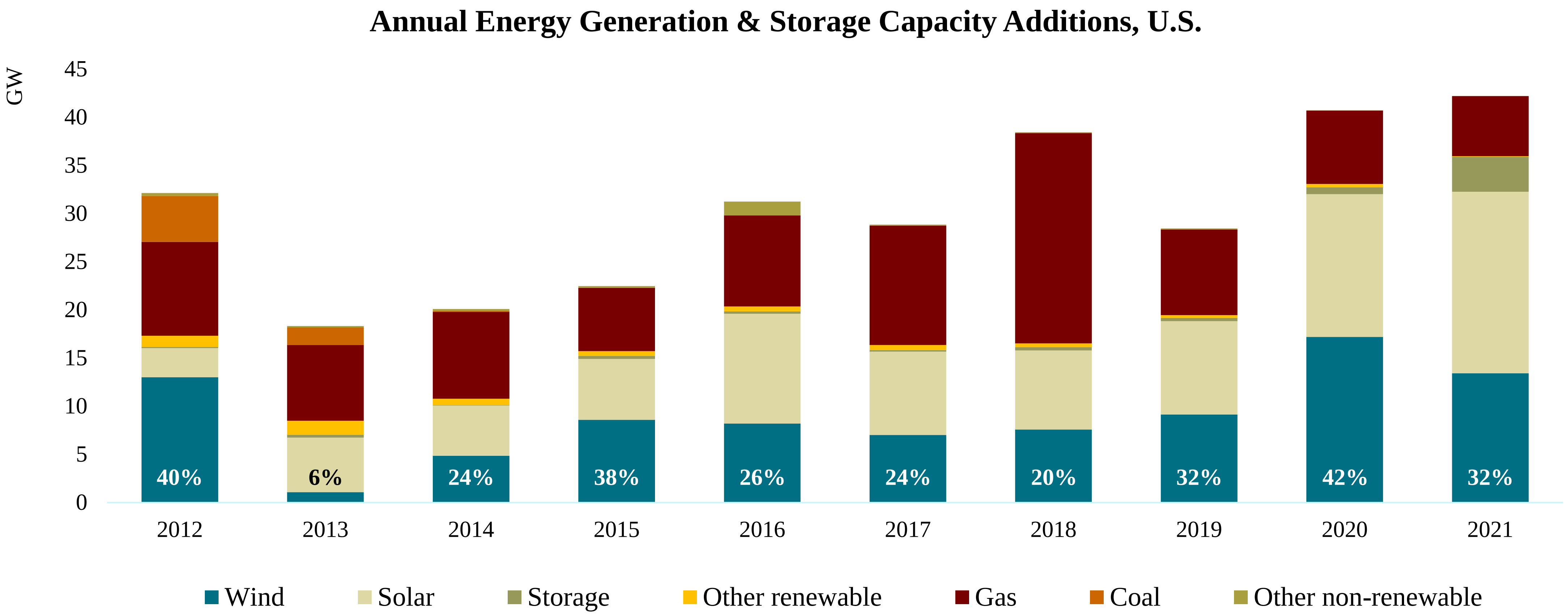
Annual Capacity (2021, GW)	
China	47.6
United States	13.4
Brazil	3.8
Vietnam	3.5
United Kingdom	2.6
Sweden	2.1
Germany	1.9
Australia	1.7
India	1.5
Turkey	1.4
Rest of World	14.7
Total	**94.3**

Cumulative Capacity (2021, GW)	
China	338.3
United States	135.9
Germany	64.5
India	40.1
Spain	28.3
United Kingdom	26.6
Brazil	21.6
France	19.1
Canada	14.3
Sweden	12.1
Rest of World	138.1
Total	**838.9**

- Global wind additions totalled over 94 GW of newly added capacity
- U.S. remains a distant second to China in annual and cumulative capacity.

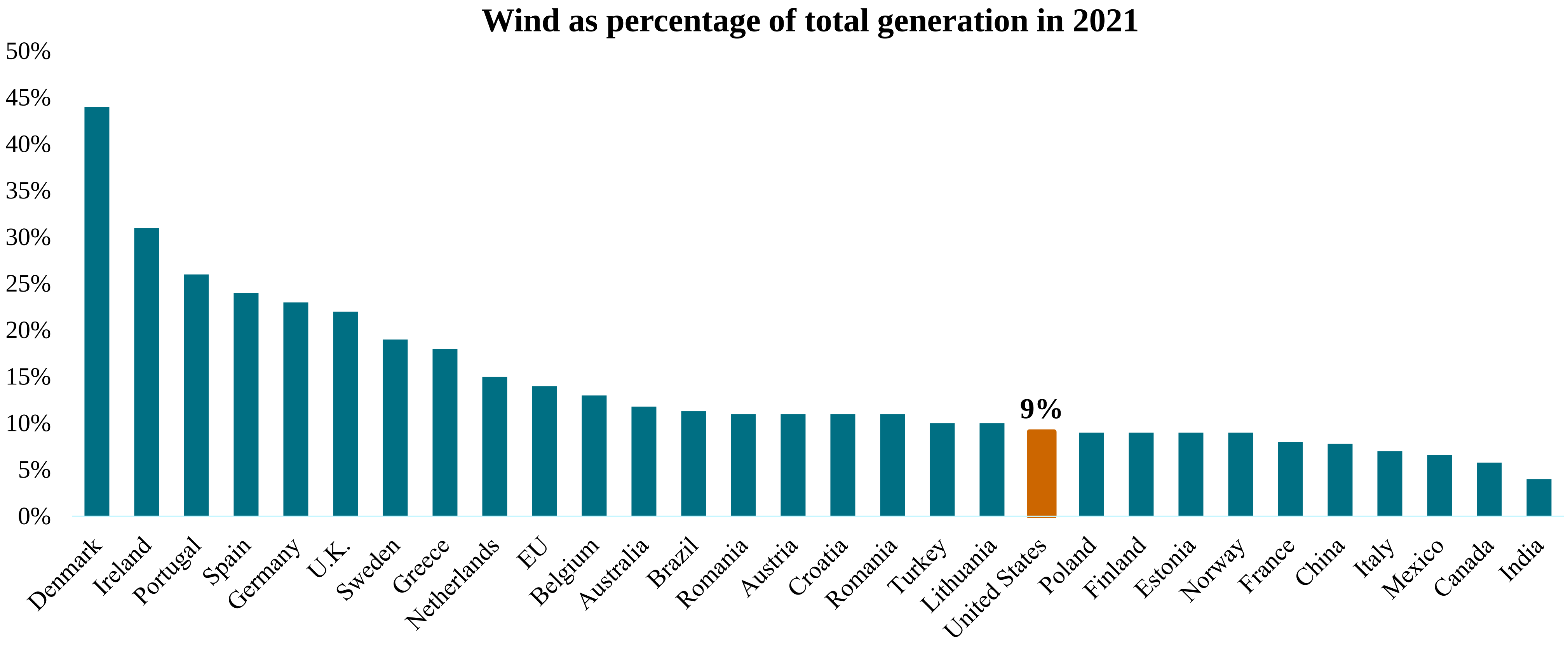
Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

Wind power makes up 30% of total capacity additions in U.S. over the last decade, second only to solar power in 2021.



Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

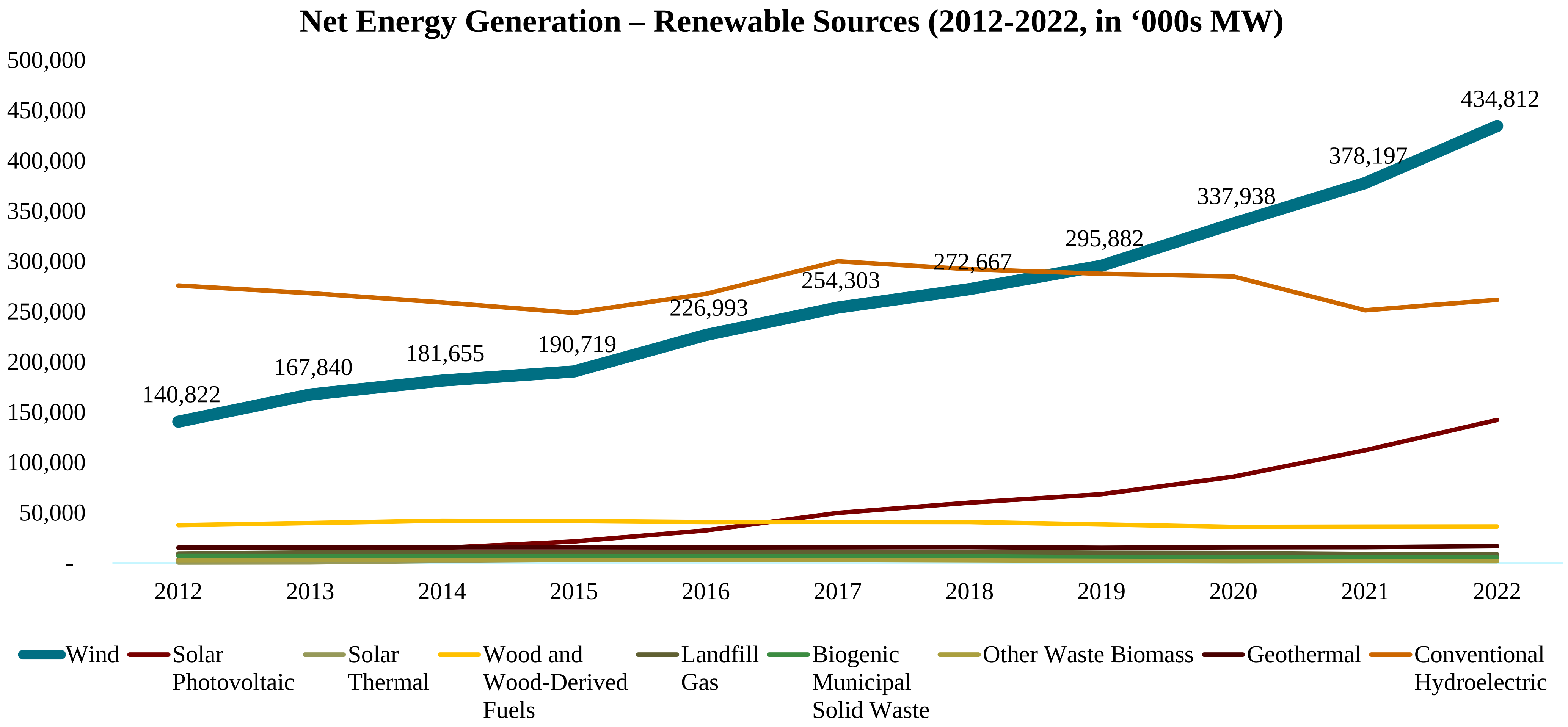
U.S. ranks lower than many other countries in terms of wind energy as a share of total generation at only 9%



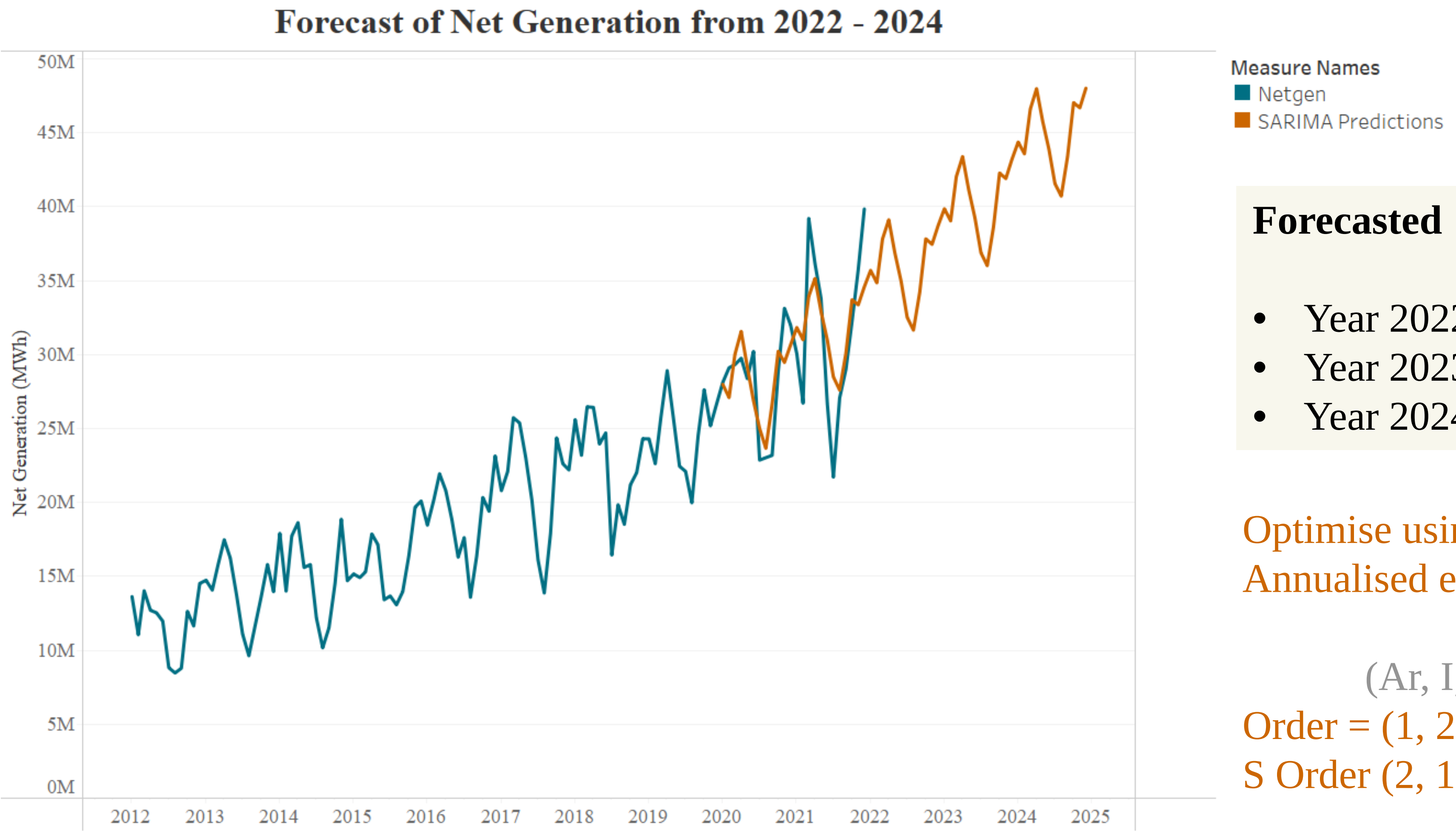
Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy

Growth Outlook for Wind in U.S.

Among renewable sources of energy, Wind is growing the fastest at a CAGR of 11% from 2012 to 2022.



Consistent with historical trend, our SARIMA prediction shows positive growth for the wind power market at least for the next 3 years.



Forecasted % growth

- Year 2022 – 14.1%
- Year 2023 – 12.0%
- Year 2024 – 11.6%

Optimise using RMSE
Annualised error < 1%

(Ar, I, Ma)
Order = (1, 2, 2)
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Growth Drivers of Wind Energy in U.S.

Cost competitiveness	Federal clean energy policies	State clean energy policies
Fuel costs for conventional generation rising faster than renewable costs.	Inflation Reduction Act (IRA) - tax credits for wind and solar projects built before 2025 and technology-neutral credits through 2032.	More than 22 states targeting 100% renewable energy or 100% carbon-free electricity by 2050.

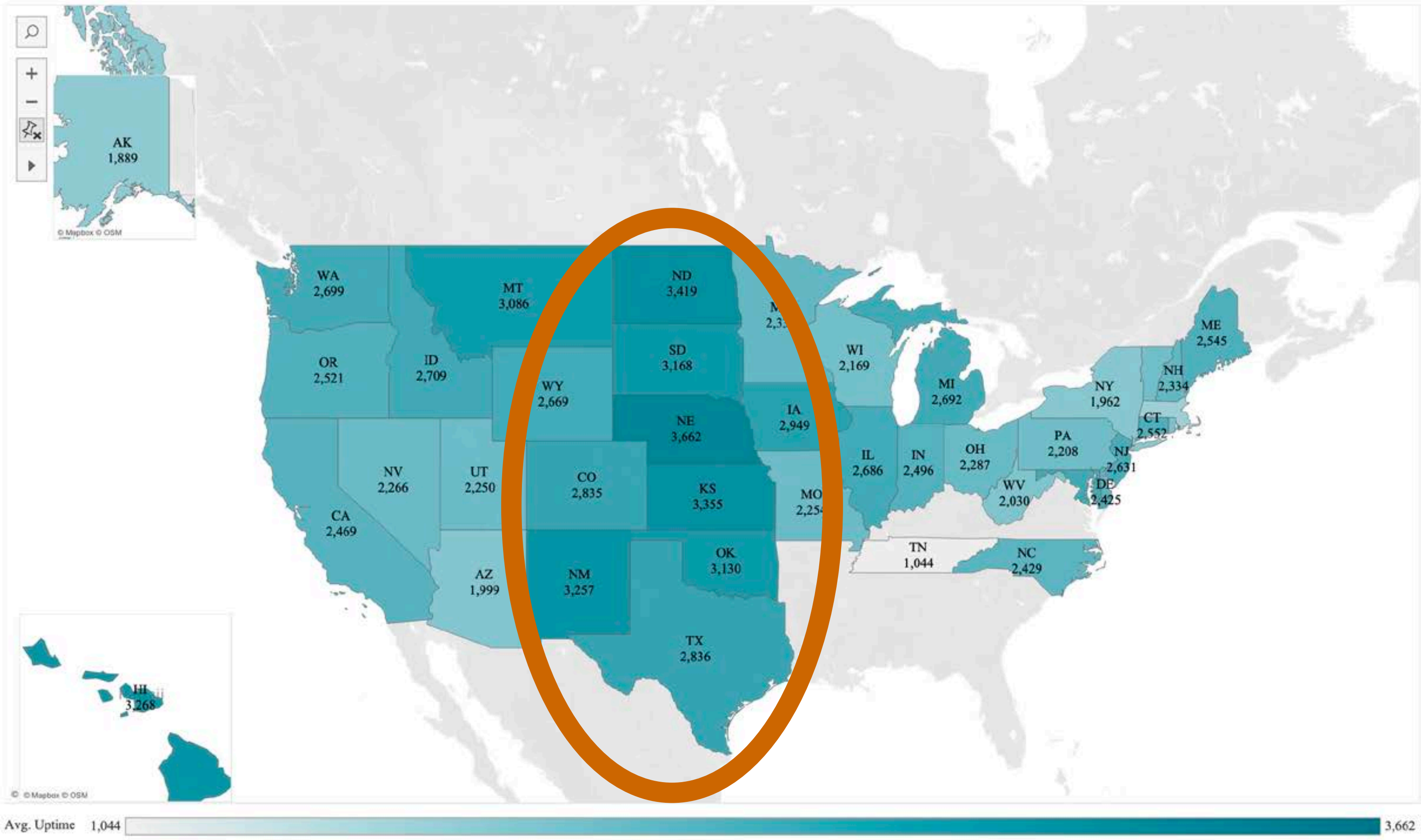
Utility decarbonisation	Corporate procurement	Rising private investment
96% of the largest US investor-owned utilities committed to reducing carbon emissions by boosting renewables	RE100 renewable electricity initiative – more than 380 global businesses committed to 100% clean electricity	Investors attracted by transparent returns on mature technologies backed by 10-year tax credits with direct pay options.

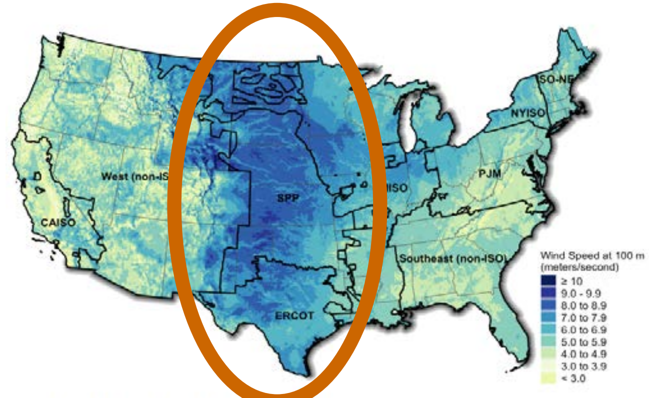
Identifying Investment Opportunities

Key Evaluation Metrics

Output	Uptime	Net Generation / Total Capacity ⬆
	Uptime Growth Rate	Uptime CAGR ⬆
Efficiency	Fuel Consumption %	Total Consumption / Net Generation ⬇
	Fuel Consumption% Growth Rate	Fuel Consumption % CAGR ⬇
Turbine features	Average turbine performance	• Net generation per turbine • Fuel consumption per turbine • Capacity per turbine

States with the highest wind speed also have the highest uptime*



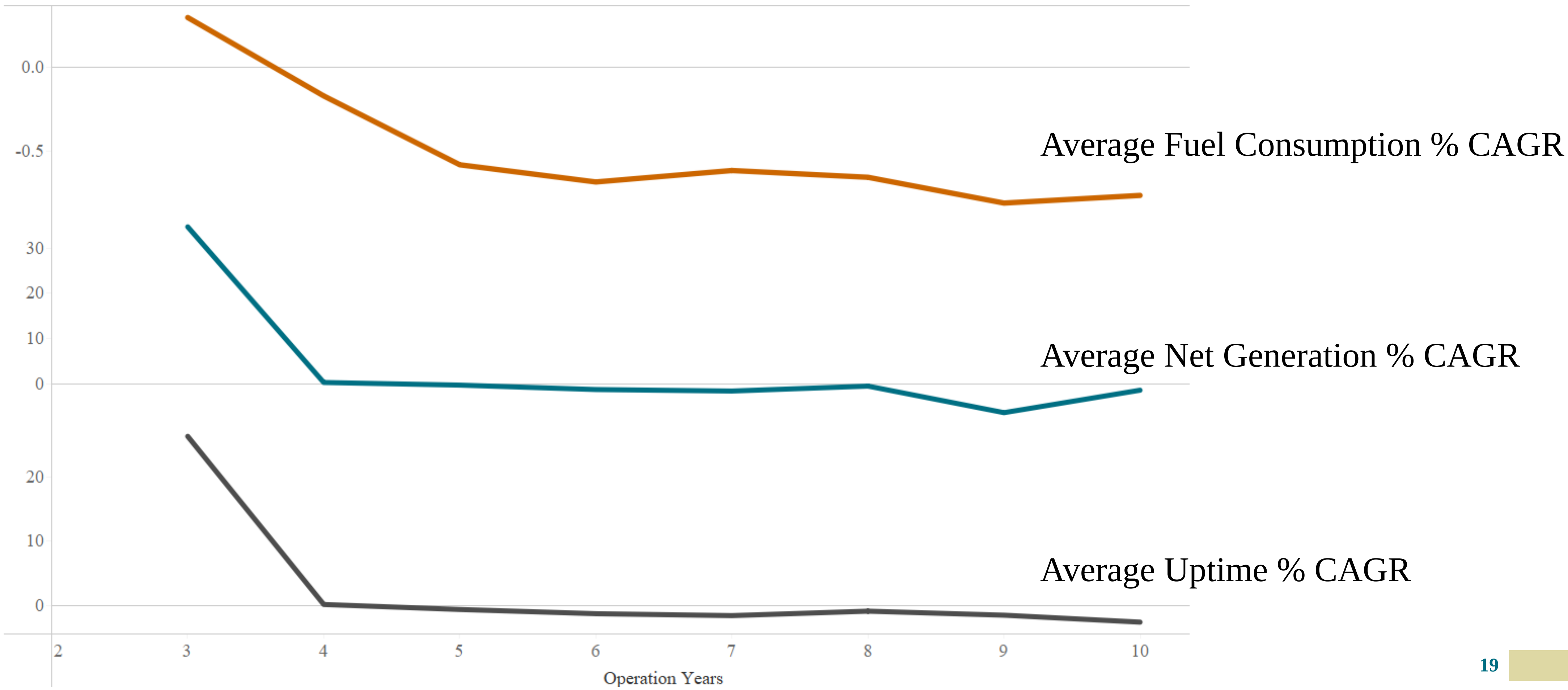


Sources: AWS Truepower, National Renewable Energy Laboratory (NREL)

Figure 1. Regional boundaries overlaid on a map of average annual wind speed at 100 meters

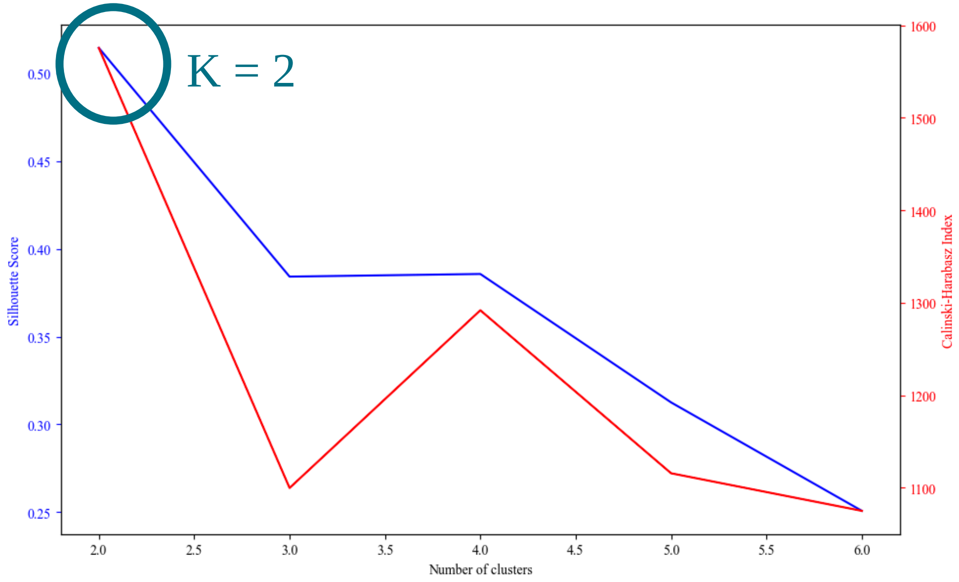
* Uptime = Net generation / Plant capacity

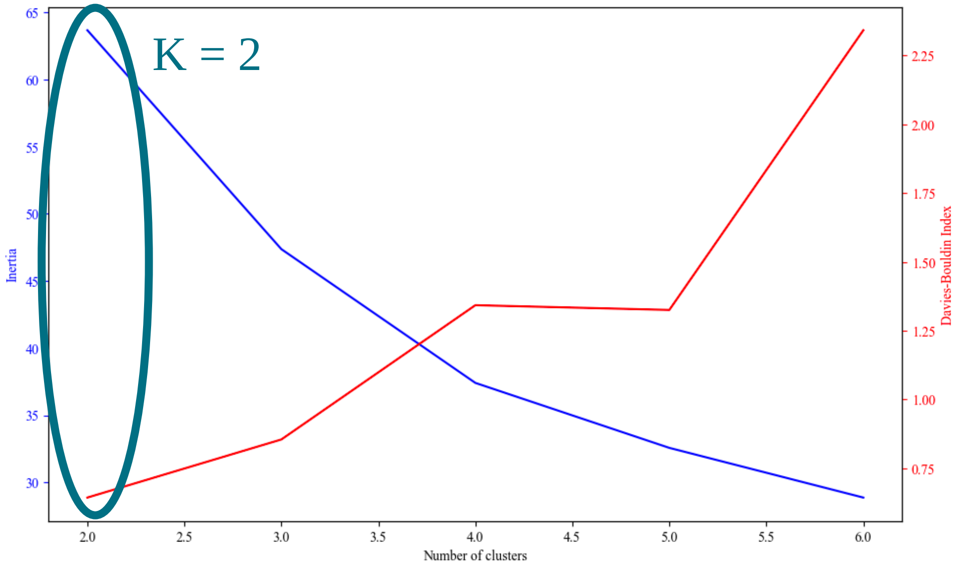
Older wind farms are more efficient but have lower net generation and uptime growth rate.



Using unsupervised learning on various metrics, 2 distinct clusters of plants were selected.

Energy plant metrics were grouped into ‘k’ clusters based on sklearn’s evaluation metrics for unknown labels.

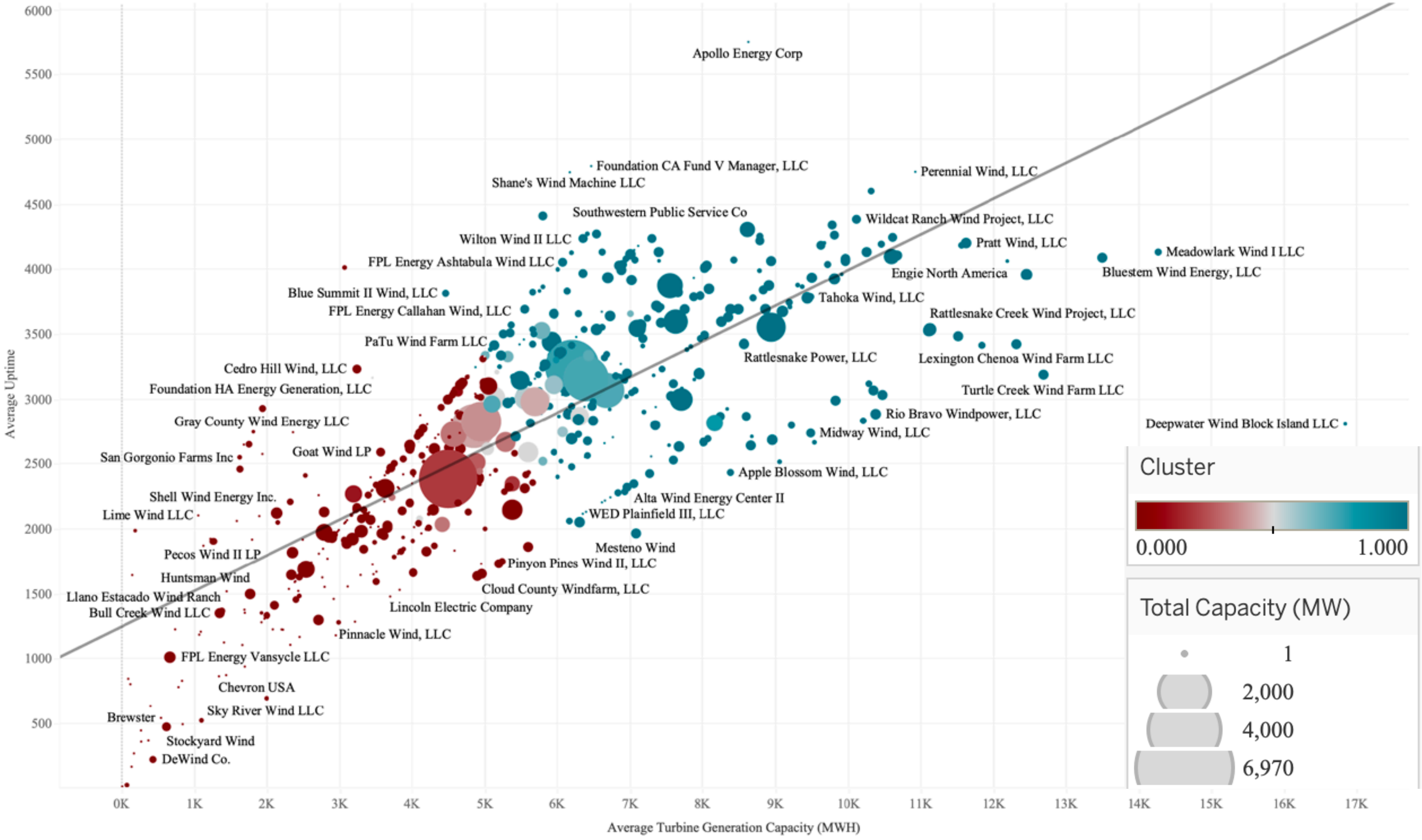




1. Silhouette Coefficient: A score between -1 to 1, where **the higher** the score the better the cluster.
1. Calinski-Harabasz index: **A higher Calinski-Harabasz score** relates to a model with better defined clusters.

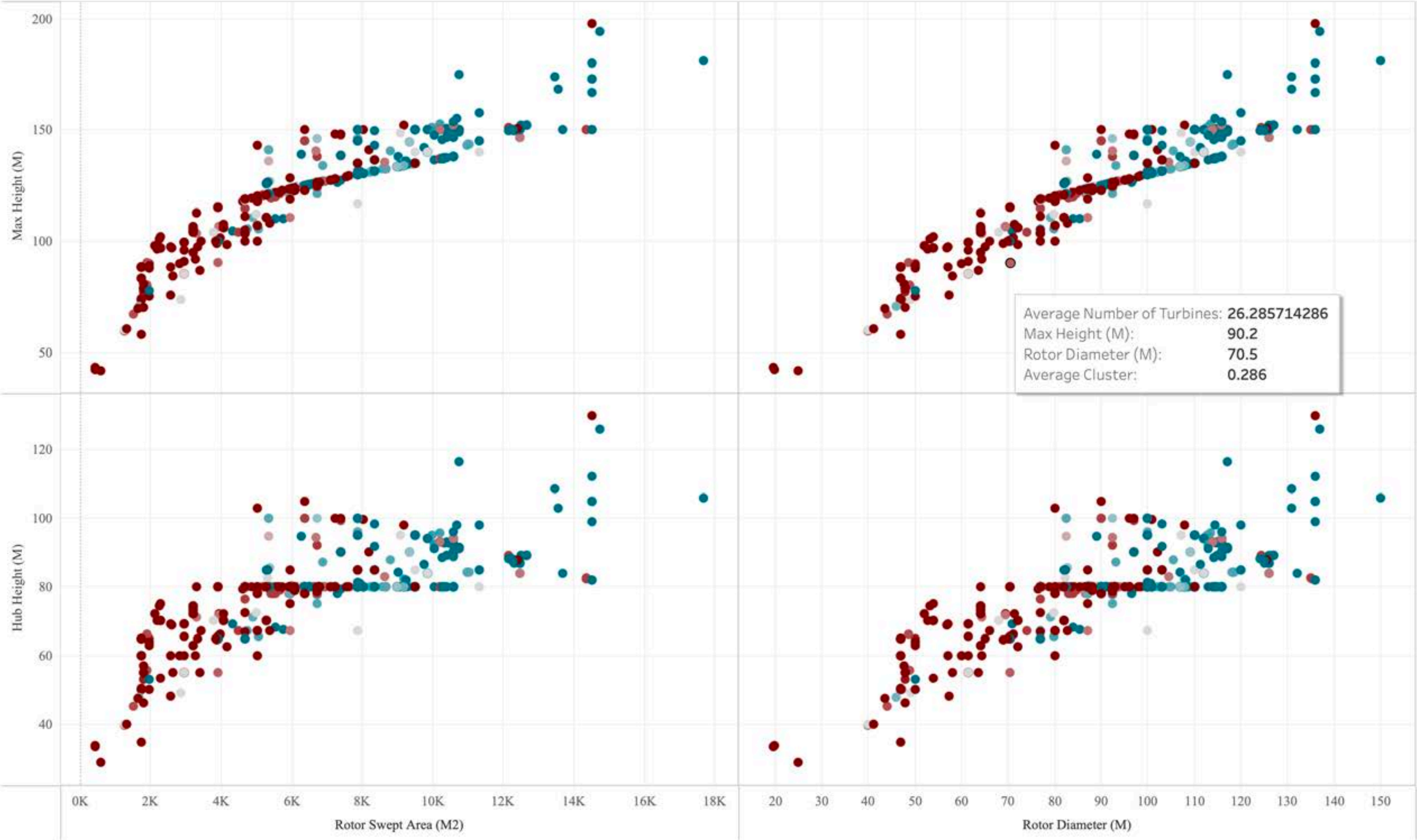
1. Inertia**: **A lower intertia, the better the cluster.**
2. Davies-Bouldin Index: **A lower Davies-Bouldin index** relates to a model with better separation between the clusters.

Operators show a clear segregation based on their uptime performance.



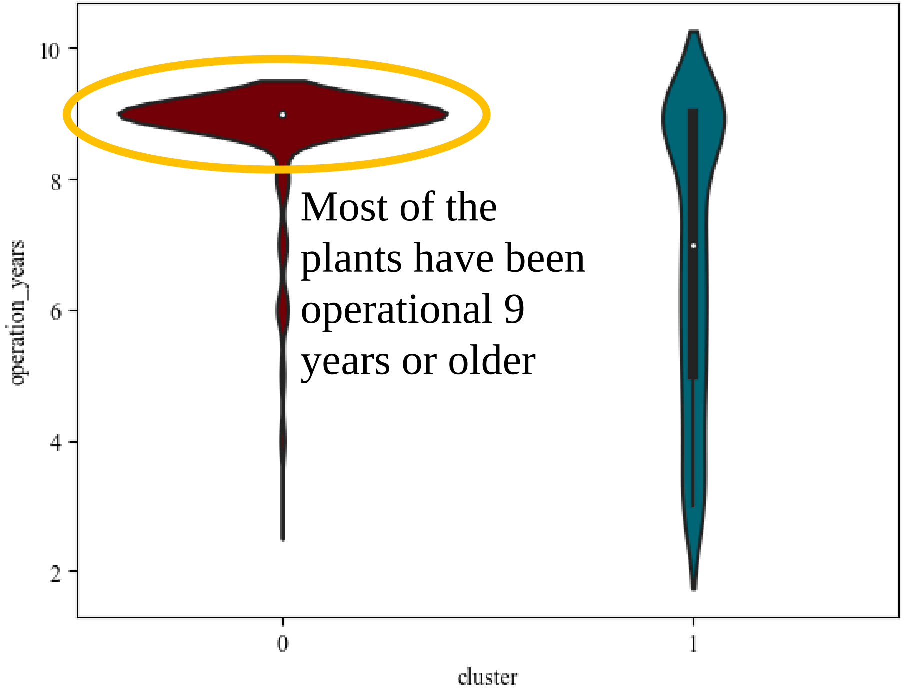
- **Bigger is better and also more productive.**
- **Both ends of the performance spectrum are dominated by small players.** Larger players are more diversified and hence produce stable results
- **Cluster 1 (in teal) is more favorable as an investment opportunity**
- Each company is made up of a portfolio of plants hence the color gradient

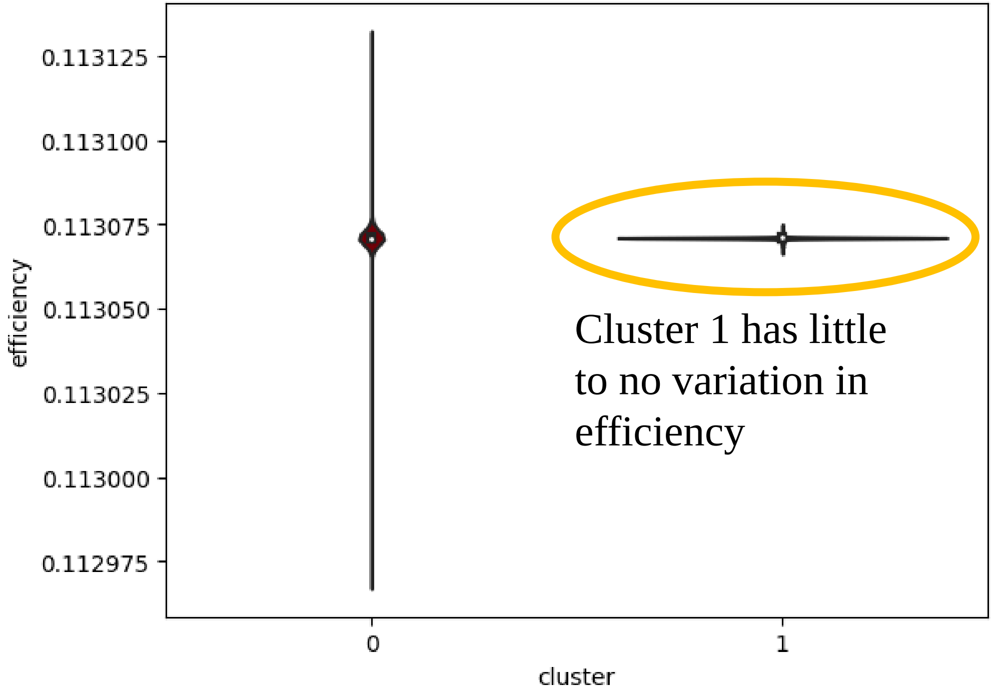
Operators with higher uptime use taller and bigger turbines.



- **Bigger turbines are better and more productive.** There is a clear correlation between turbine size and uptime.

The clustering can also be a proxy for an amalgamation of plant features.





- The weaker cluster (0) tends to have **more plants that have been operationally longer** and hence not running as often to its stated capacity
- The weaker cluster (0) also tends to have a **slight variation in efficiency**

Partner Selection & Investment Plan

Pitch Deck Tagline

Based on past M&A activities, deals ranged from US$250m to US$1.5b for wind farm capacity of 300-600 MW.

2019

April

USD773m

NextEra Energy Partners acquired **391MW** capacity wind farm from Brookfield Renewable.

2022

September

USD320m

Enbridge acquired wind and solar energy portfolio from Tri Global Energy.

October

USD277m

InfraRed Capital acquired 49% stake in **551MW** capacity wind farm from Algonquin.

November

USD1.5b

NextEra Energy Partners acquired wind and solar energy portfolio from NextEra Energy Resources.

December

USD250m

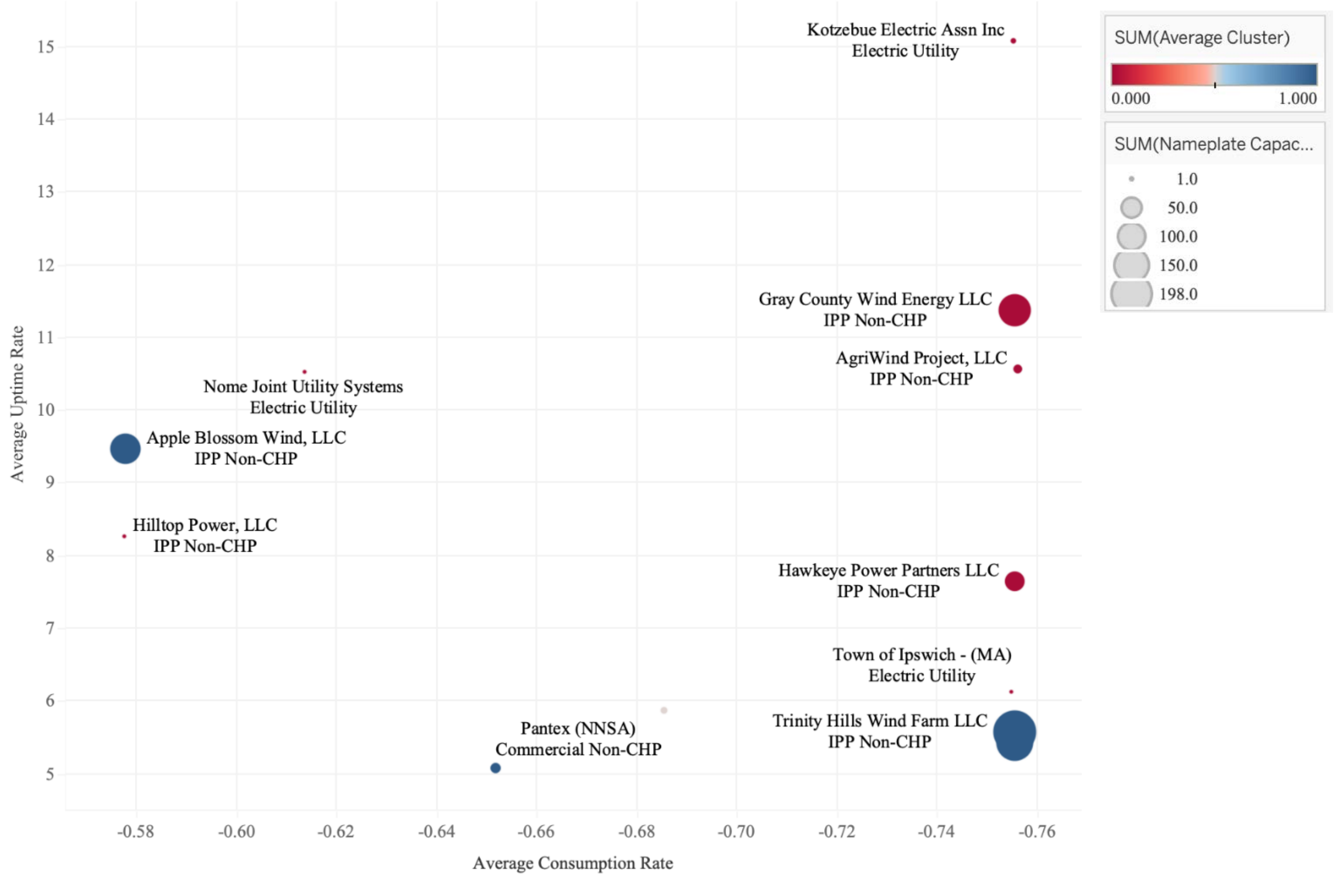
Boralex acquired 50% stake in **447MW** capacity wind farm from EDF Renewables North America

The following criteria are used to evaluate potential operators for acquisition.

- Plant capacity below 600 MW to keep within a more manageable investment budget
- Projects with 2 years of operation or less were excluded from analysis
- At least 5% compounded annual growth in uptime rate across plants
- No increase in compounded annual fuel consumption rate across plants

Partner companies are selected based on higher uptime rate and lower fuel consumption rate.

Targets based on Consumption Rate vs. Uptime Rate



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Top operators for acquisition include FPL Energy Weatherford, Trinity Hills Wind Farm, Pantex and Apple Blossom Wind.

Rank	Operator name	Total Farm Size (MW)	Average Uptime (MWh/MW) Average: 2,711	Average Uptime Rate Average: -2.06%	Start Year Average: 2013	Location
1	FPL Energy Weatherford, LLC	147	4,235	5.43%	2005	Oklahoma
2	Trinity Hills Wind Farm LLC	198	4,062	5.57%	2011	Texas
3	Pantex (NNSA)	12	3,773	5.06%	2014	Texas
4	Apple Blossom Wind, LLC	100	2,431	9.46%	2017	Michigan
5	Hawkeye Power Partners LLC	42	4,014	7.64%	1999	Iowa
6	Gray County Wind Energy LLC	112	2,932	11.37%	2001	Kansas
7	Agriwind Project, LLC	8	1,668	10.57%	2007	Illinois
8	Kotzebue Electric Assn Inc	3	803	15.08%	1997-2012	Alaska

Note: Shortlisted targets are ranked on average uptime

Hawkeye
Too old and prone to retrofitting, growth might keep up for long based on general statistics of the industry

Gray County
Too old and average uptime is slight above average only

Agriwind
Too small and uptime capacity is below average

Kotzebue
Too small of 3MW, uptime might be due to small scale and its staggered turbine upgrades

Our worst performing blue company might be below average on uptime but it shows the highest growth rate and only started in 2017 with room to catch up

With a long term horizon, steps can be taken to further develop plants after the acquisition of wind farm operator(s)

- Exit in 5-10 years as the market grows
- Repower older turbine through retrofitting which increases plant lifespan by another 5 to 10 years
- Further plant expansion to capitalise on good operating management
- Future establishment of hybrid farms

Project Reflection

Future Work

- Include more years of data into the historical performance analysis so that our dataset can be more robust
- Look into data on turbine manufacturers and explore investment opportunities with them
- Consider alternative case scenarios to analyse potential impact of state energy policies and population growth on the identified opportunities
- Explore wind energy data from other countries to consider overseas investment opportunities

Key Takeaways

- Data cleaning and validation with large volume of data
- Feature engineering
- Data gathering and understanding
- A data-driven approach in business decision-making
- In-dept market research
- Achieve synergy as a team

wow!

THANK YOU!

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