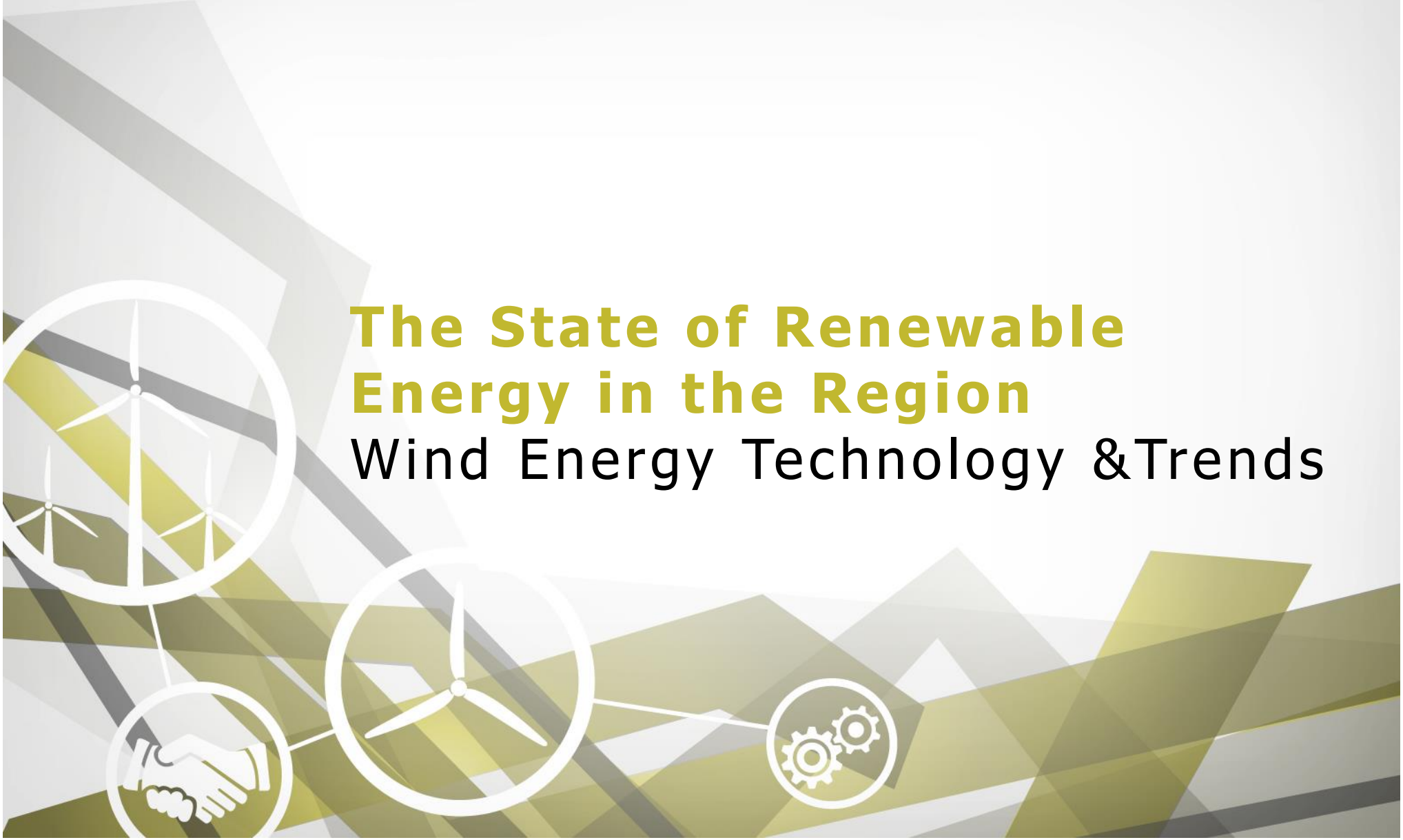
The State of Renewable Energy in the Region

Wind Energy Technology &Trends



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01

Technology Trends and Future Challenges

02

Market Trends and Policy Drivers

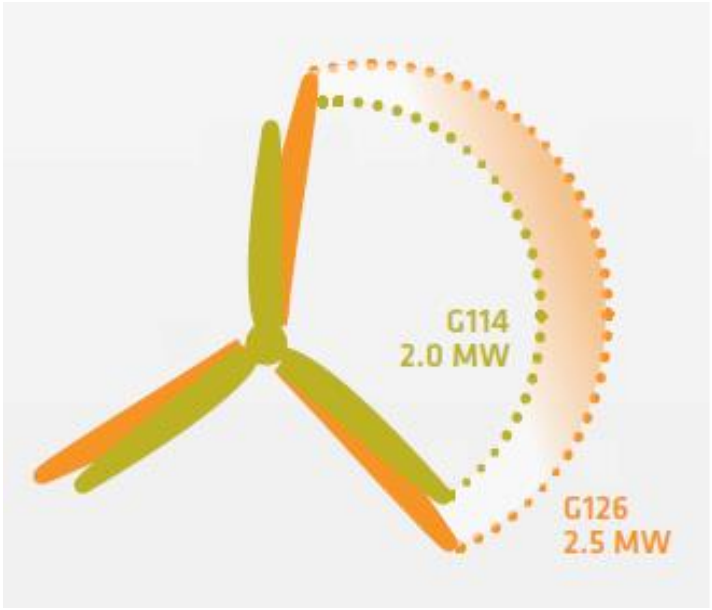
03

Wind Energy in Pennsylvania

01 · **Technology** trends and future challenges

Higher Towers, Bigger Rotors

Taking advantage of lower wind resources



SWEPT AREA INCREASE

+22%

AEP INCREASE

>20%

Most high wind areas with good transmission access have been developed

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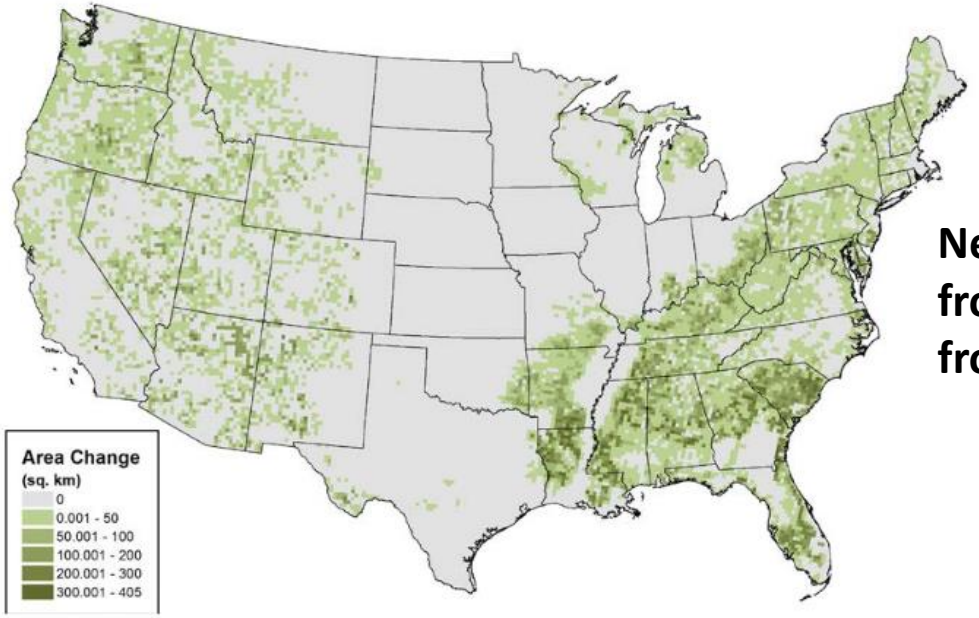
Higher Towers, Bigger Rotors

Taking advantage of lower wind resources



New deployable land resulting from increasing hub height from 96m to 110m[1]

Most high wind areas with good transmission access have been developed

1. Cotrell et al. "Analysis of Transportation and Logistics Challenges Affecting Deployment of Larger Wind Turbines: Summary of Results," NREL, January 2014.

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Infrastructure Limitations

Transportation and Transmission

Navigating curves, bridge underpasses, and tunnels becomes more challenging as components grow in size

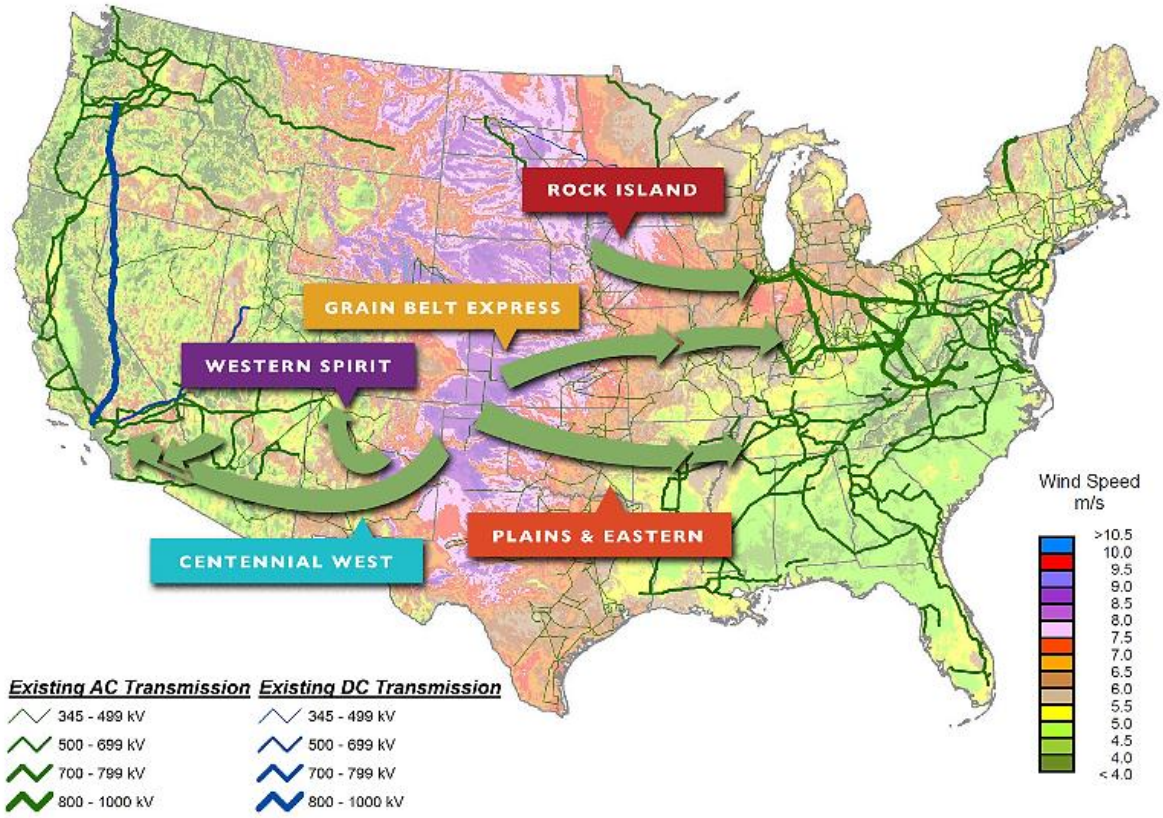
Infrastructure limits blade and tower size due to transportation needs

Infrastructure Limitations

Transportation and Transmission

Proposed Clean Line Energy transmission projects

Source: cleanlineenergy.com



Recent transmission investments for RE produced up to a 3.9 benefit to cost ratio[2]

2. Trabish, Herman K. "3 transmission projects that illustrate the importance in modernizing the grid," Utility Dive Online, 24 June 2016.

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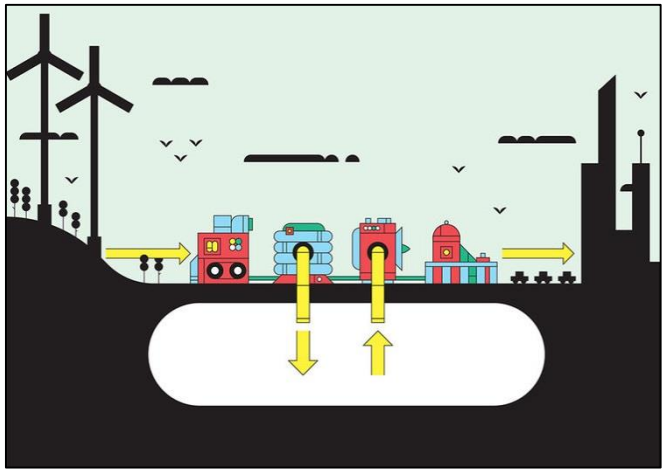
Storage Innovation

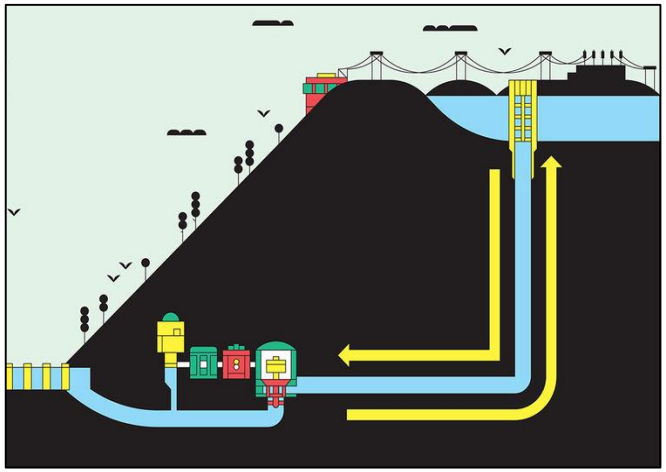
Key to higher RE penetration

Compressed Air



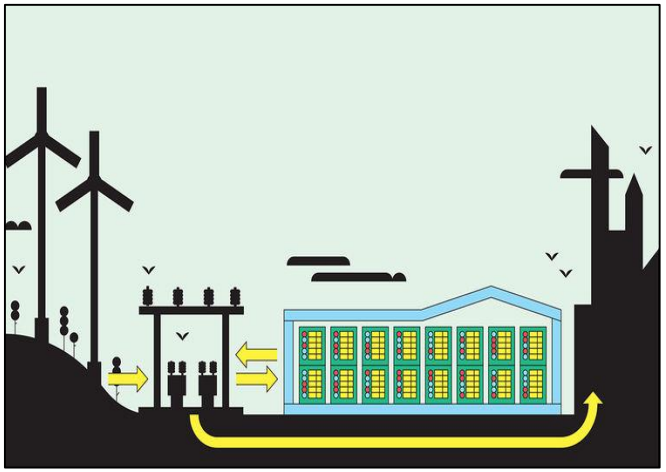
Source: dwell.com

Pumped Water



Source: dwell.com

Battery Storage



Source: dwell.com

A Different Approach: Chemical Processes

Electricity + Water (H_20) = 2 Hydrogen Gas (H_2) + Oxygen (O_2)

Penetration rates in the 50% and higher range will require storage solutions

Offshore Wind in the US

Challenges and Incentives

Challenges:

- Siting
- Transmission
- Capital costs and land availability

Incentives:

- East Coast Metropolis
- Energy intensity
- Growth internationally will reduce costs
- New policy initiatives (HI, MA, NY)

The Block Island Wind Farm, the 1st offshore project in the US, is under construction.

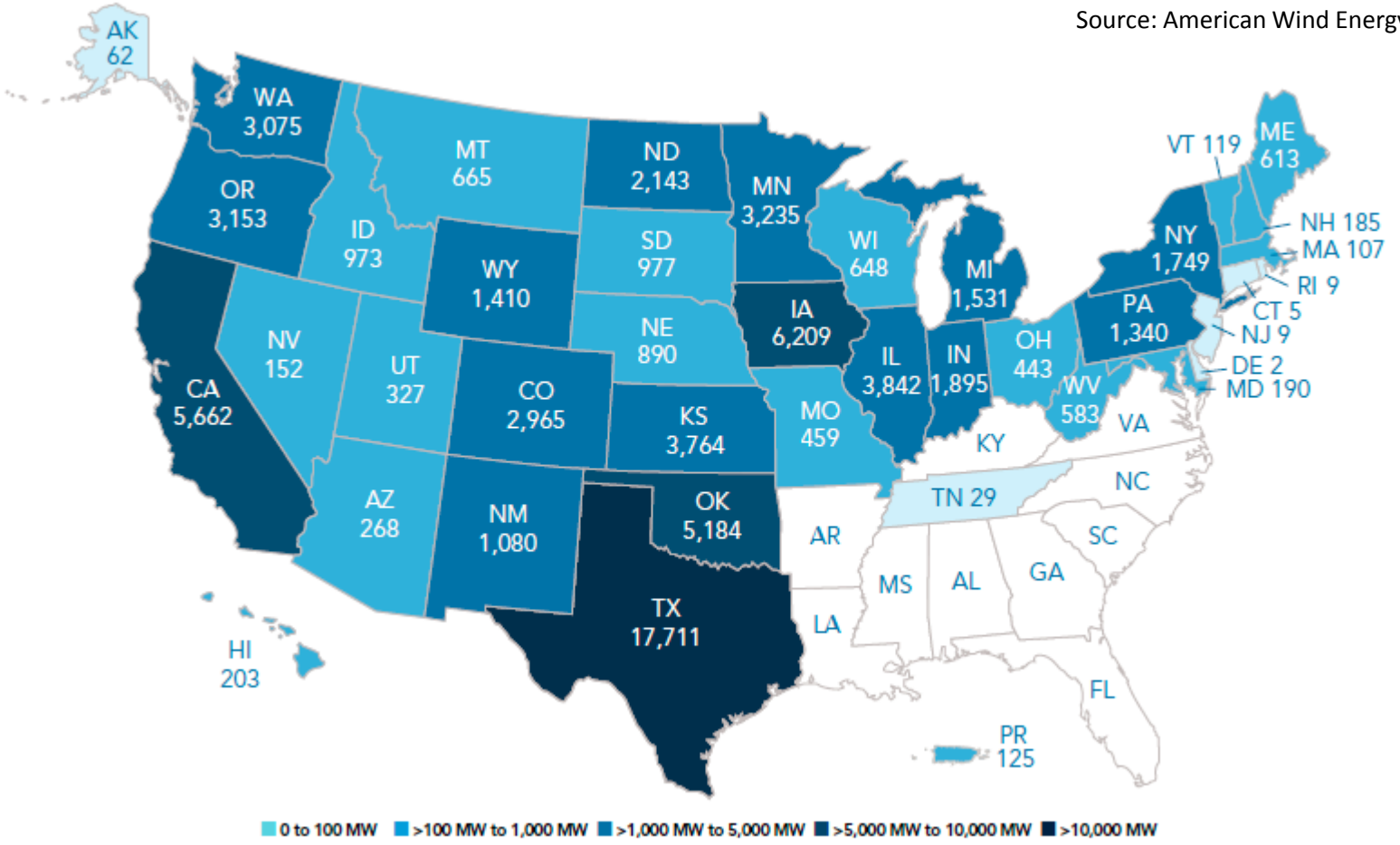
02 · **Market** trends and policy drivers

Installed Capacity

74.8 GW and Counting

Total Installed Capacity, Year End 2015

Source: American Wind Energy Association



Installed capacity has seen fourfold increase since 2008[3]

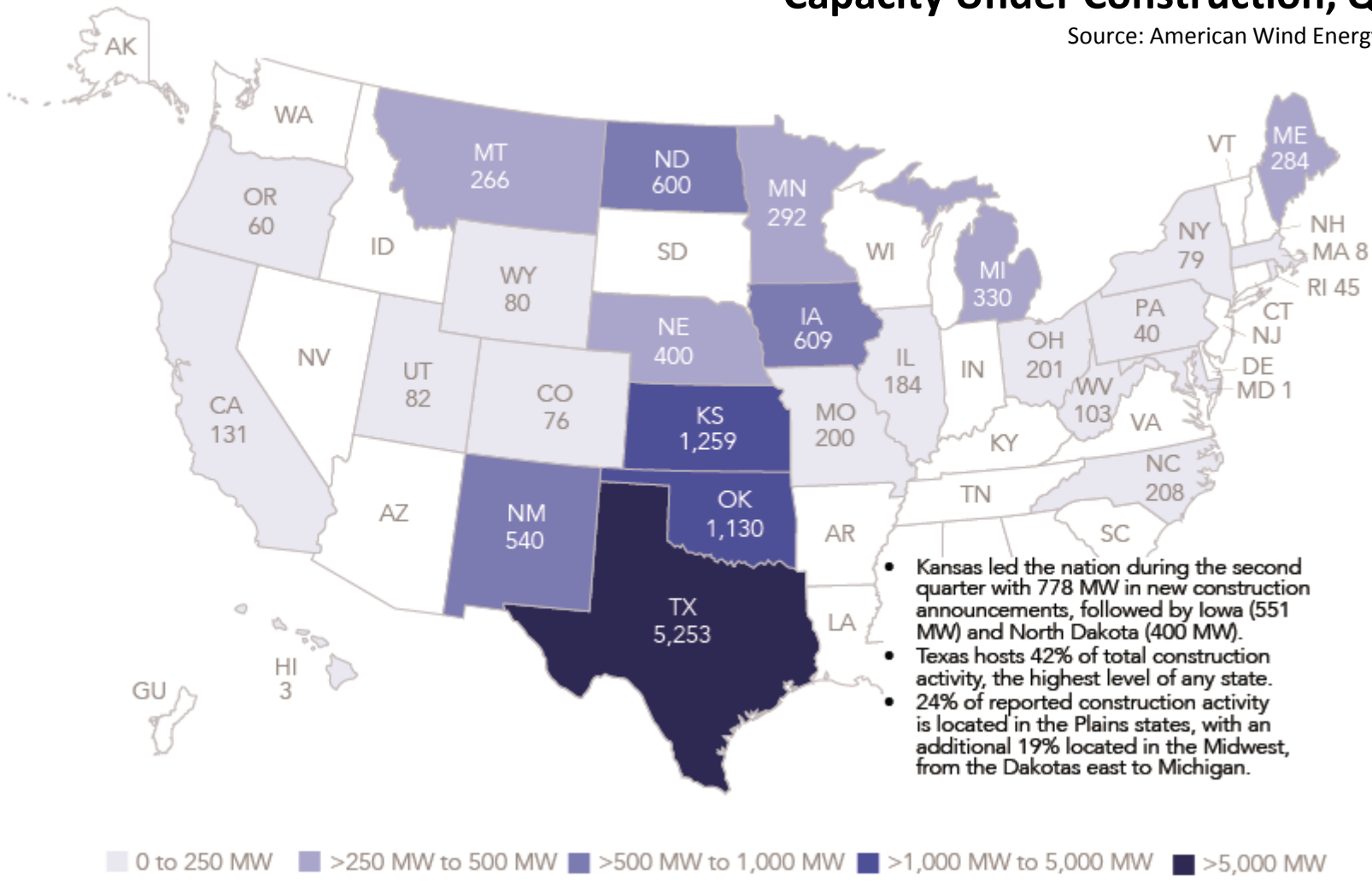
3. "U.S Wind Industry Annual Market Report: Year Ending 2015," American Wind Energy Association, 2016.

Current Activity

12.5 GW Under Construction

Capacity Under Construction, Q2 2016

Source: American Wind Energy Association



- Kansas led the nation during the second quarter with 778 MW in new construction announcements, followed by Iowa (551 MW) and North Dakota (400 MW).
- Texas hosts 42% of total construction activity, the highest level of any state.
- 24% of reported construction activity is located in the Plains states, with an additional 19% located in the Midwest, from the Dakotas east to Michigan.

Total new installed capacity YTD 830 MW[4]

4. "U.S Wind Industry Second Quarter 2016 Market Report," American Wind Energy Association, 21 July 2016.

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Supply Chain Strategies

Flexibility and Timing

"Just in time" Delivery

- Cash flow sensitivity and availability targets

Predictive Maintenance

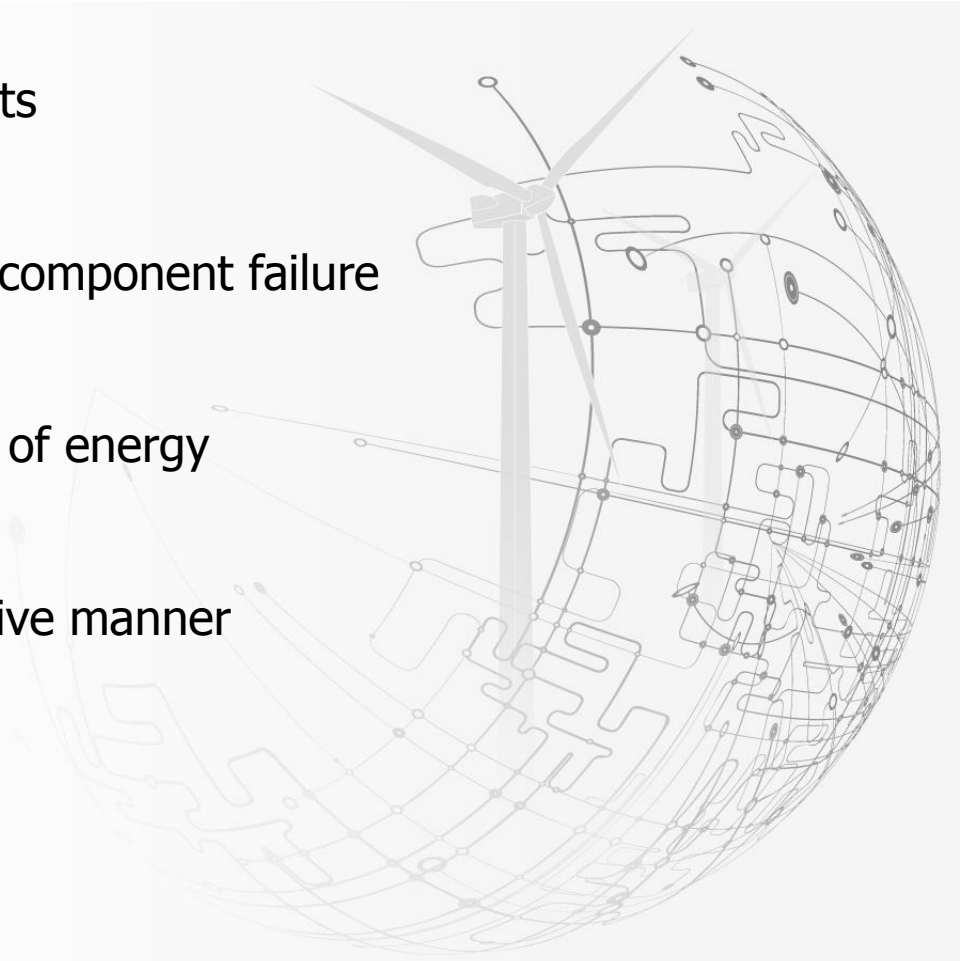
- Reducing risk of down time due to major component failure

Data & Analytics

- Reducing cost of O&M to drive down cost of energy

Repair and Reconditioning

- Maintaining an aging fleet in a cost effective manner



There are 48,500 operational wind turbines in the US[3]

3. "U.S Wind Industry Annual Market Report: Year Ending 2015," American Wind Energy Association, 2016.

Policy Drivers

PTC, CPP, and RPS

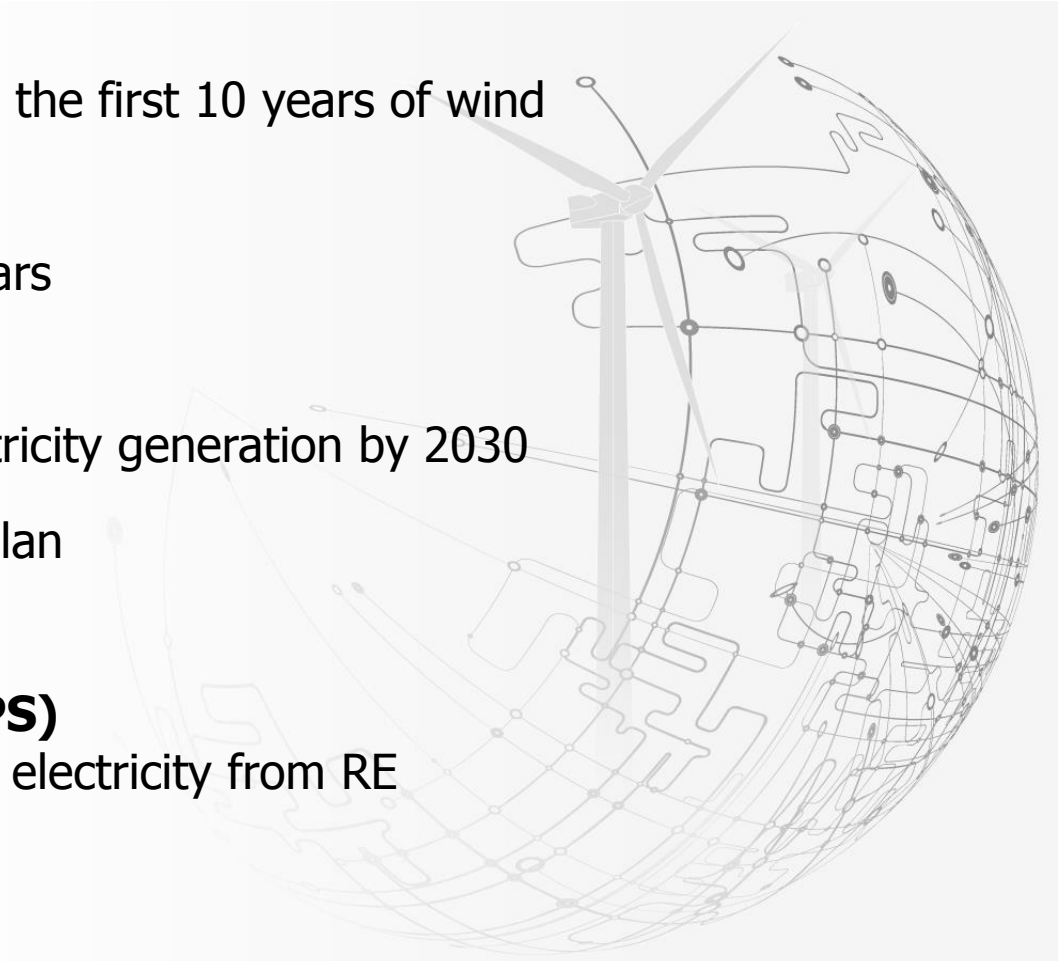
Production Tax Credit (PTC)
A federal tax credit for $23/MWh during the first 10 years of wind energy generation

- Phasing out over the next several years

Clean Power Plan (CPP)
EPA regulation to reduce CO_2 from electricity generation by 2030

- States create their own compliance plan
- On hold pending legal challenges

Renewable Portfolio Standards (RPS)
State-based mandates to supply a % of electricity from RE

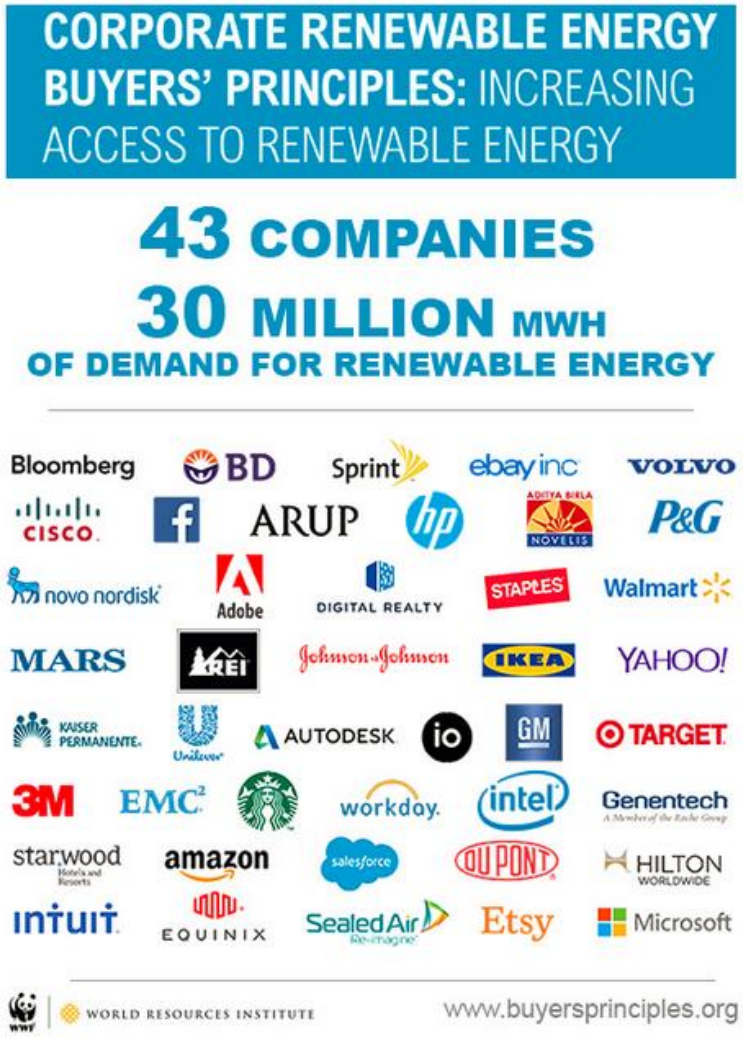


California, Oregon, and New York have moved to a 50% RPS

Corporate Power Purchasing

New Market Driver

According to a recent Ceres analysis, "Power Forward: Why the World's Largest Companies are Investing in Renewable Energy," **more than 2/3 of Global Fortune 100 companies have made a commitment to reduce their GHG emissions.**



52% of wind energy PPAs in 2015 were signed by non-utility buyers[3]

3. "U.S Wind Industry Annual Market Report: Year Ending 2015," American Wind Energy Association, 2016.

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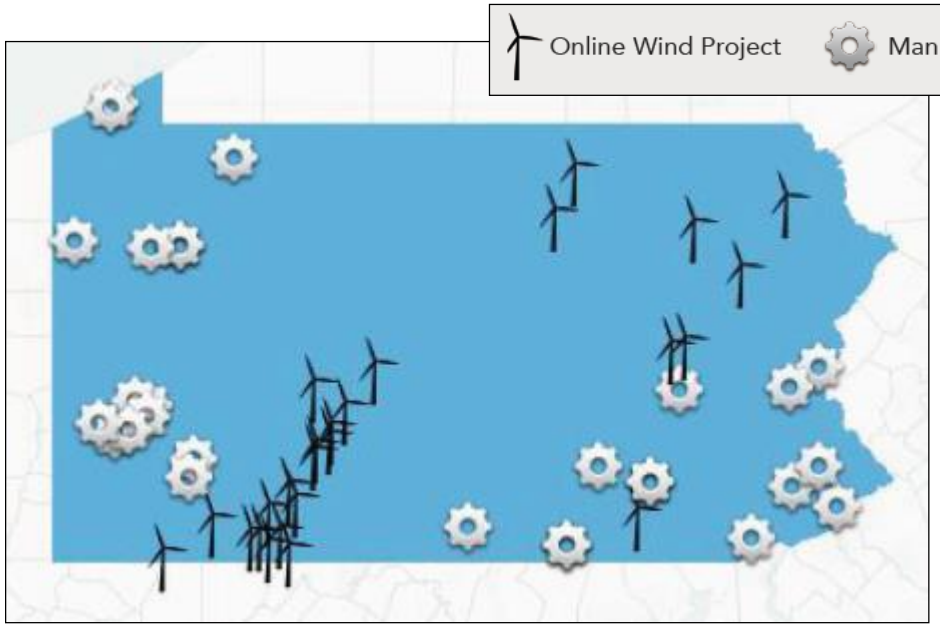
03 · Pennsylvania wind energy

PA Wind Industry

16th in Nation for Installed Capacity



Source: American Wind Energy Association

1,340 MW installed

$2.7 billion capital investment

Up to $5 million annual lease payments

Over 1,000 jobs

Only 40 MW under construction

Pennsylvania wind energy avoided 2.4 million metric tons of CO_2 in 2014[5]

5. "Pennsylvania Wind Energy," American Wind Energy Association, 2015.

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PA Alternative Energy Portfolio Standard

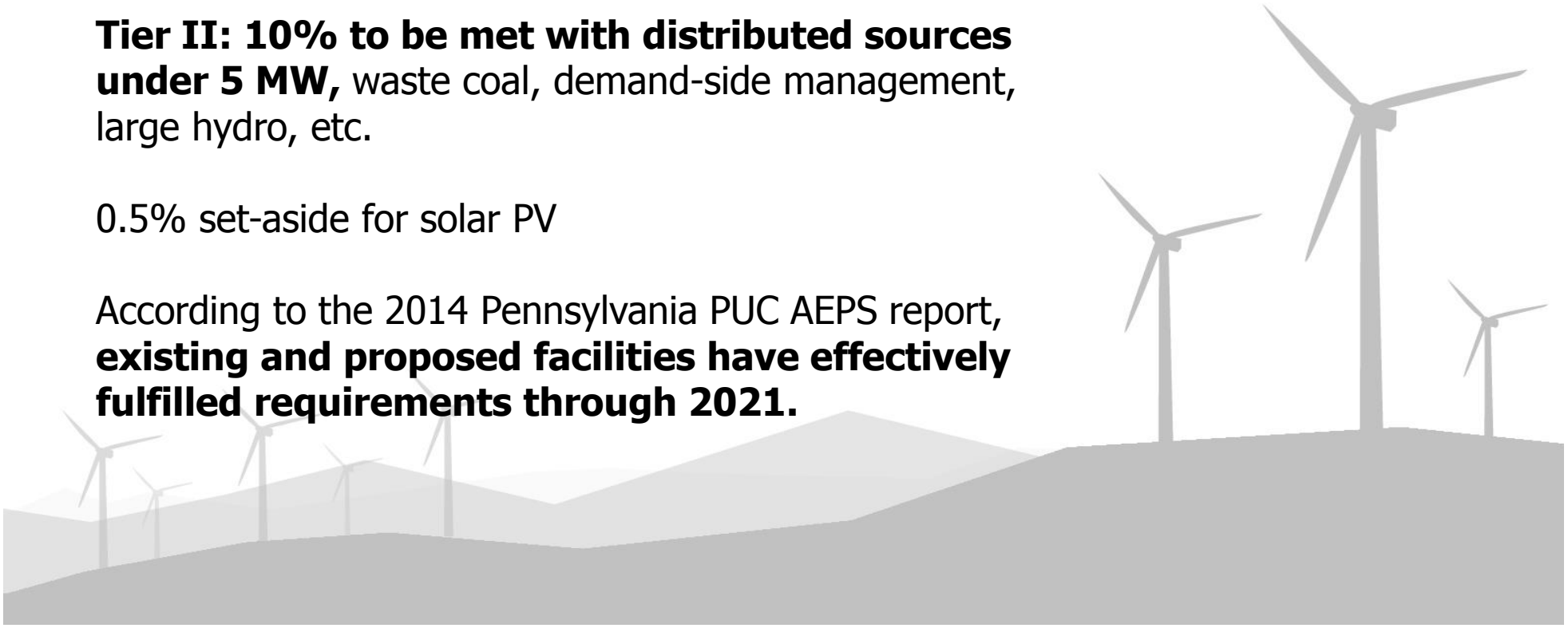
18% by 2021

Tier I: 8% of AEPS can be met with wind, solar, biomass, geothermal, methane, etc.

Tier II: 10% to be met with distributed sources under 5 MW, waste coal, demand-side management, large hydro, etc.

0.5% set-aside for solar PV

According to the 2014 Pennsylvania PUC AEPS report, **existing and proposed facilities have effectively fulfilled requirements through 2021.**



PA utilities may procure compliance credits from anywhere within PJM

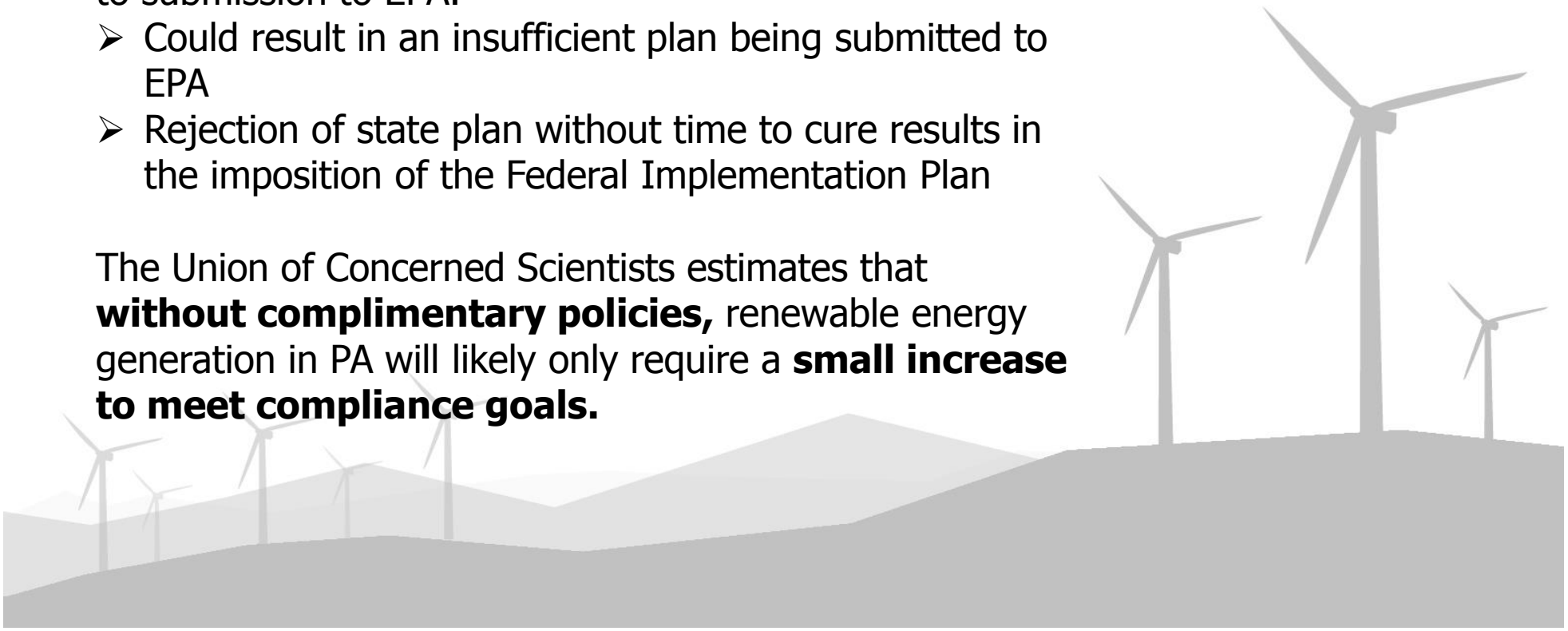
Clean Power Plan in PA

24% reduction in CO_2 by 2030

New bill, signed into law, makes CPP compliance plan subject to legislative and public review and approval prior to submission to EPA.

- Could result in an insufficient plan being submitted to EPA
- Rejection of state plan without time to cure results in the imposition of the Federal Implementation Plan

The Union of Concerned Scientists estimates that **without complimentary policies,** renewable energy generation in PA will likely only require a **small increase to meet compliance goals.**



If the UCS policy proposals are implemented, potential for 4,000 MW of new wind[6]

6. "Meeting the Clean Power Plan in Pennsylvania," Union of Concerned Scientists, February 2016.

CONCLUSIONS

Technology trends and storage innovation will help wind reach higher levels of grid penetration.

Private sector trends have the potential to overcome policy shortfalls to sustain growth.

National growth will help to nurture local supply chain businesses and manufacturing.

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Cutting-edge technology