

Wind-Powered Electricity Generation

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WIND GENERATION TRADEOFFS

ADVANTAGES

Clean

- ▶ zero marginal emissions

Cheap

- ▶ zero marginal cost

Secure

- ▶ domestic, predictable generation

DISADVANTAGES

Intermittent

- ▶ not always available

Dispersed (Not dense)







- ▶ large footprint, industrial landscape

Distant

- ▶ best resources far from load centers

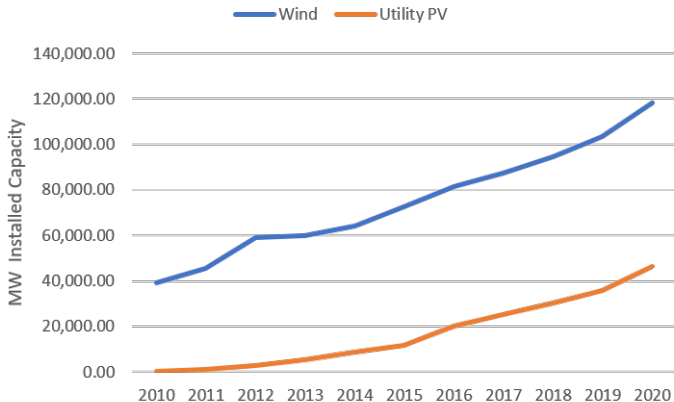
TRADEOFFS

COMPARING GENERATION TECHNOLOGIES

	 Wind	 Solar	 Hydro	 Natural Gas	 Coal	 Nuclear
Build Cost	Medium	Medium	High	Low	Low	High
Marginal Cost	~0	~0	~0	Medium (CC) High (OC)	Low (Base) Medium (Ramp)	Low/medium
Marginal Emissions	0	0	0	Medium	High (CO2 + criteria)	0
Density	Low	Low	High	High	High	Highest
Dispatchable	No	No	Limited	Yes	Yes	Yes

U.S. RENEWABLE GENERATION DEPLOYMENT

2010–2020



Source: EIA

AS THE WIND BLOWS...

$$\text{Capacity factor} = \frac{\text{Total generation}}{\text{Total capacity}}$$

There are about 134 GW installed wind capacity in U.S. (ACPA)

In March 2022, wind generated 43 TWh of power. (EIA)

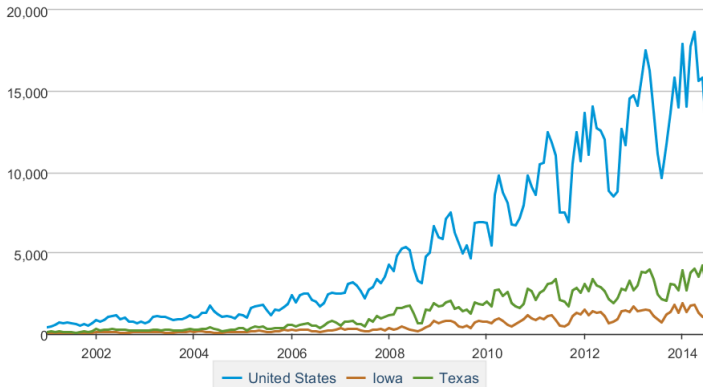
There were 744 hours in March 2022, or 99.7 TWh of potential wind generation. The monthly capacity factor in March 2022 was 43.5%.

In July 2021, generation was 21 TWh (EIA) – a monthly capacity factor of 22.3%.

U.S. WIND GENERATION

Net generation, wind, all sectors, monthly

thousand megawatthours



Data source: U.S. Energy Information Administration

FEDERAL INCENTIVES

14 ACTIVE PROGRAMS

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Programs

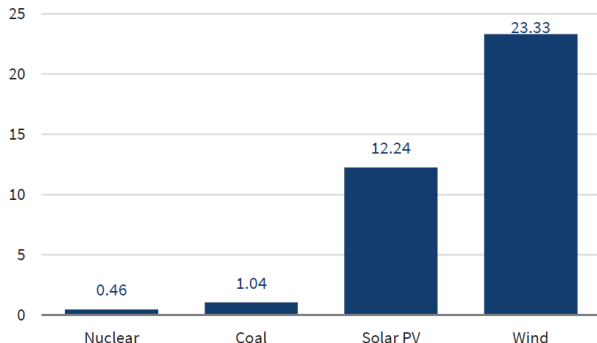
[Overview](#) [Summary Maps](#) [Summary Tables](#) [News](#)

Name	State/ Territory	Category	Policy/Incentive Type	Created	Last Updated
Green Power Purchasing Goal for Federal Government	US	Regulatory Policy	Green Power Purchasing	02/19/2004	08/27/2021
Residential Renewable Energy Tax Credit	US	Financial Incentive	Personal Tax Credit	08/10/2005	03/15/2021
Business Energy Investment Tax Credit (ITC)	US	Financial Incentive	Corporate Tax Credit	03/15/2002	02/24/2021
Renewable Electricity Production Tax Credit (PTC)	US	Financial Incentive	Corporate Tax Credit	03/11/2002	01/27/2021
Office of Indian Energy Policy and Programs - Funding Opportunities	US	Financial Incentive	Grant Program	05/01/2003	02/26/2020
Qualified Energy Conservation Bonds (QEGBs)	US	Financial Incentive	Loan Program	10/23/2008	08/22/2018
USDA - Rural Energy for America Program (REAP) Loan Guarantees	US	Financial Incentive	Loan Program	04/09/2003	08/21/2018
USDA - Rural Energy for America Program (REAP) Grants	US	Financial Incentive	Grant Program	04/09/2003	08/21/2018
Modified Accelerated Cost-Recovery System (MACRS)	US	Financial Incentive	Corporate Depreciation	03/15/2002	08/21/2018

Federal PTC is \$15/MWh

Figure 5-18. CEA Estimates of Federal Electricity Generation Subsidies by Fuel Type for Fiscal Year 2016

Subsidy (dollars per megawatt-hour, 2016)



Sources: Energy Information Administration; Internal Revenue Service; CEA calculations.
Note: PV = photovoltaic. Subsidy levels from the Investment Tax Credit for solar generation were unavailable for 2016. Estimates are from the EIA's 2018 *Annual Energy Outlook* for new generation deflated to 2016. These estimates may understate the level of subsidy in 2016 due to the falling price of solar photovoltaic technology over time.

WHAT HAPPENS AS WIND FARMS AGE?

Wind fleet is aging

- ▶ like any other type of capital equipment, turbines eventually wear out and break down
- ▶ this is more pronounced after 10 years, though newer vintages of turbines show slower decay

Studying repowering (uprating) in TX, we find

- ▶ limited but increasing repowering – still only a fraction of 1% of capacity additions
- ▶ policy incentives have been important in Europe
- ▶ U.S. will need to expand dramatically to meet wind generation targets

ENERGY TRANSITION TARGETS

Variety of ambitious targets for energy transition

- ▶ 2022 AEO contemplates almost no retirements and about 435 GW new renewables
- ▶ NREL (2009) estimated 1–8 MW/km²
- ▶ At 8MW/km², each 100 GW of wind requires over 3 million acres

Generation assets are only one aspect

- ▶ transmission, grid infrastructure

THANK YOU

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