

*Navigating the
Landscape of Rural
Land Development
for Solar and Wind*



F. John Hay 2026

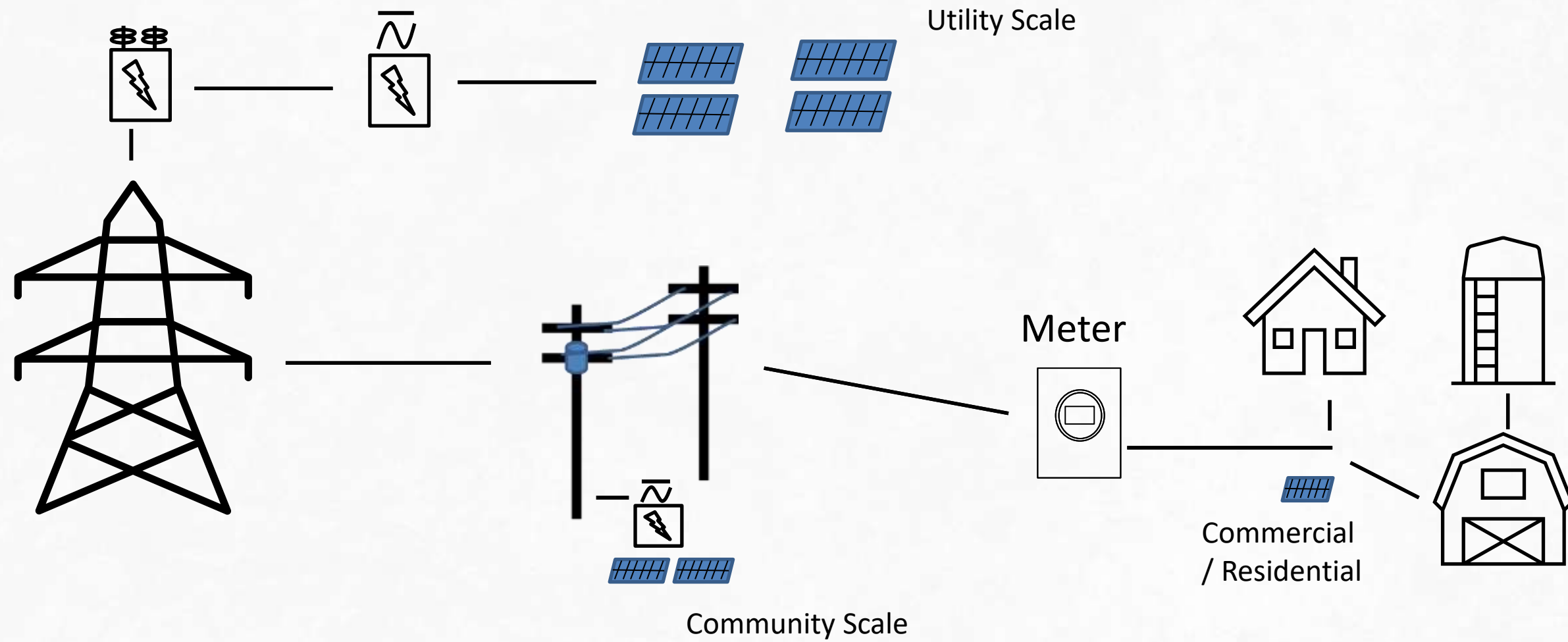
IN OUR GRIT, OUR GLORY™

Solar Array Sizing Terminology

	Residential	Commercial /Industrial	Community	Utility
Electric Grid Connection	Customer Side of meter	Customer side of meter	Sub-transmission level (distribution)	Transmission level
Common Size	< 25 kW	25 kW – 1 MW	< 10 MW (~50 acres)	> 10 MW
Market Value	Savings to customer electricity bill by offsetting purchases from the utility	Savings to customer electricity bill by offsetting purchases from the utility	Electricity sales to subscribers or a cooperative under a published rate	Electricity sales via a power purchase agreement or other bulk generation mechanism
Ownership	Homeowner (most common) Leasing company (less common not allowed everywhere)	Business, Farm/Ranch	Utility, independent power producer, customer group, municipality	Utility, independent power producer
Placement	Roof, or ground (usually fixed tilt)	Roof or ground (usually fixed tilt)	Ground (fixed tilt or 1-axis tracking)	Ground usually 1-axis tracking



Utility, Community, Commercial, Residential Scale Solar





- **Renewable Energy Drivers**
 - Trends
 - Subsidies (OBBBA)
- **Community Topics**
 - Socioeconomic (taxes, property values, distributional justice) (sound, health, visual impacts, place attachment)
 - Environmental (wildlife, climate change)
 - Planning process and trust
 - Water
- **Agrivoltaics**



- **Costs**
 - Levelized cost of energy
 - Federal Incentives
 - State Incentives
- **Renewable Energy Standards**
 - States
 - Utilities
- **Private Companies**
 - Private citizens



Estimated levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2030

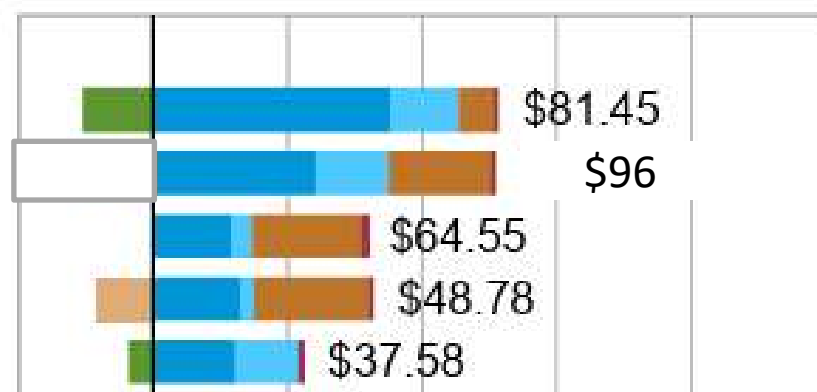
2024 dollars per megawatthour



dispatchable technologies

- advanced nuclear
- biomass
- combined-cycle
- combined-cycle with CCS
- geothermal

simple average

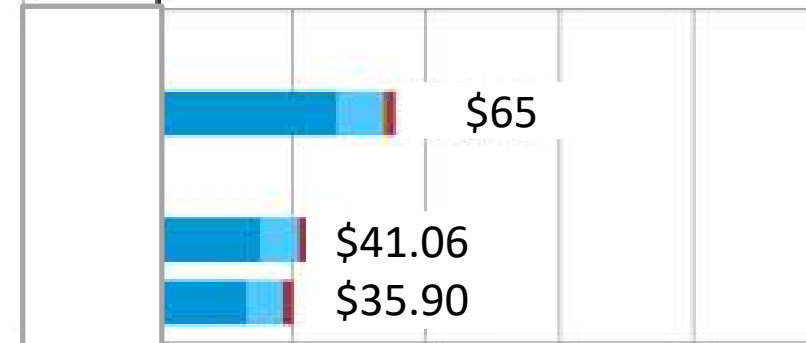
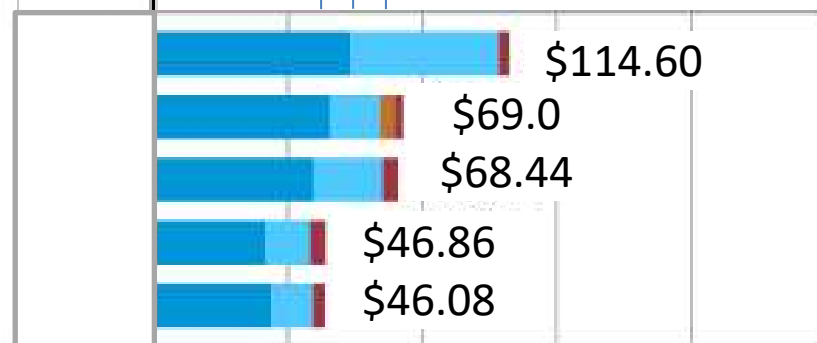


capacity-weighted average



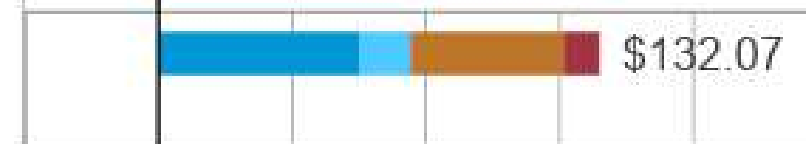
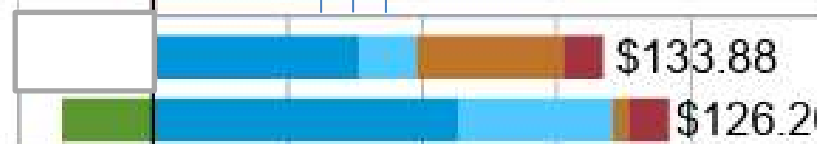
resource-constrained technologies

- wind, offshore
- hydroelectric
- PV-battery hybrid
- solar PV
- wind, onshore



capacity resource technologies

- combustion turbine
- battery storage



- levelized capital cost
- levelized fixed O&M
- levelized variable O&M
- levelized transmission cost
- levelized tax credit
- levelized captured carbon credit

-\$40 \$0 \$40 \$80 \$120 \$160 \$200

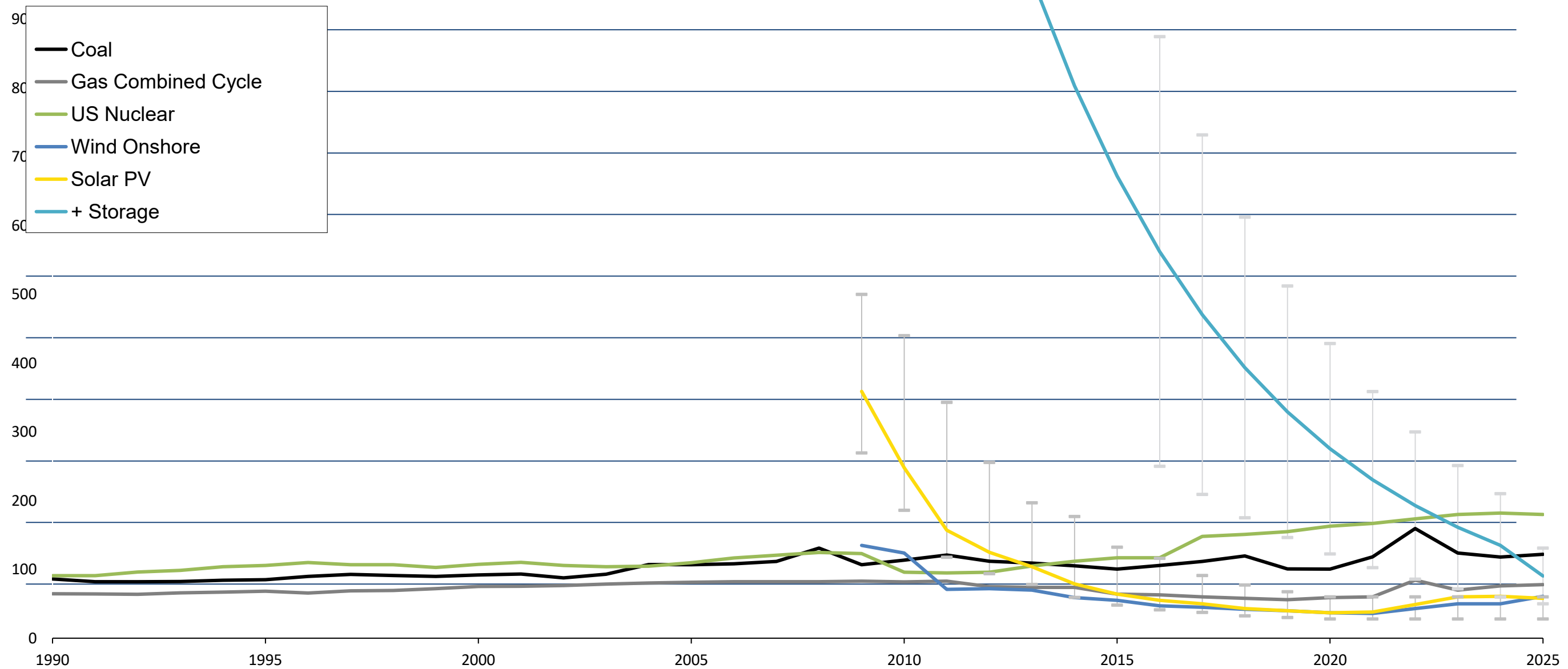
Data source: U.S. Energy Information Administration, Annual Energy Outlook 2025

Note: Technologies with no additions in 2030 do not have a capacity-weighted average. The stated LCOE values include the levelized tax credit component for eligible technologies. CCS=carbon capture & sequestration, PV=photovoltaic, O&M=operations and maintenance



Levelized Cost of Electricity for New Generation

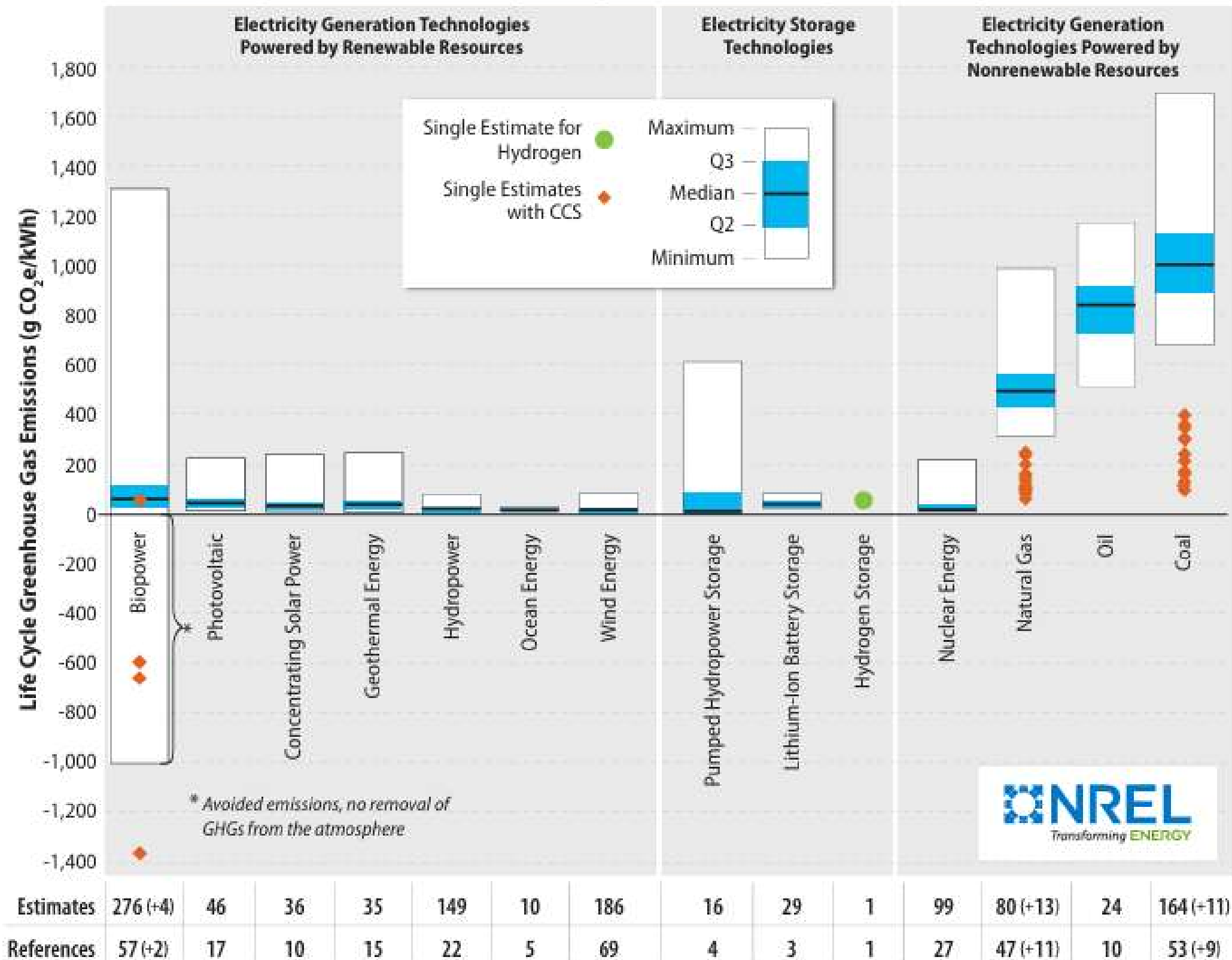
1,000
Levelized cost of electricity (LCOE) & storage (LCOS) (\$USD/MWh)



Sources: Lazard, [LCOE+](#) (2025); Our World in Data, [Our World in Data](#) (2024); Energy Institute, [Statistical Review of World Energy](#) (2024); BNEF, [Battery Price Survey](#) (2024); Kavlak *et al.*, [Evaluating the Causes of Cost Reduction in Photovoltaic Modules](#) (2018).
Credit: Hyae Ryung Kim, Xiaodan Zhu, and [Gernot Wagner](#). [Share with attribution](#): Kim *et al.*, "[Scaling Solar](#)" (10 July 2025).

Renewable Energy Drivers - Emissions

Figure 2. Life cycle greenhouse gas emission estimates for selected electricity generation and storage technologies, and some technologies integrated with carbon capture and storage (CCS).

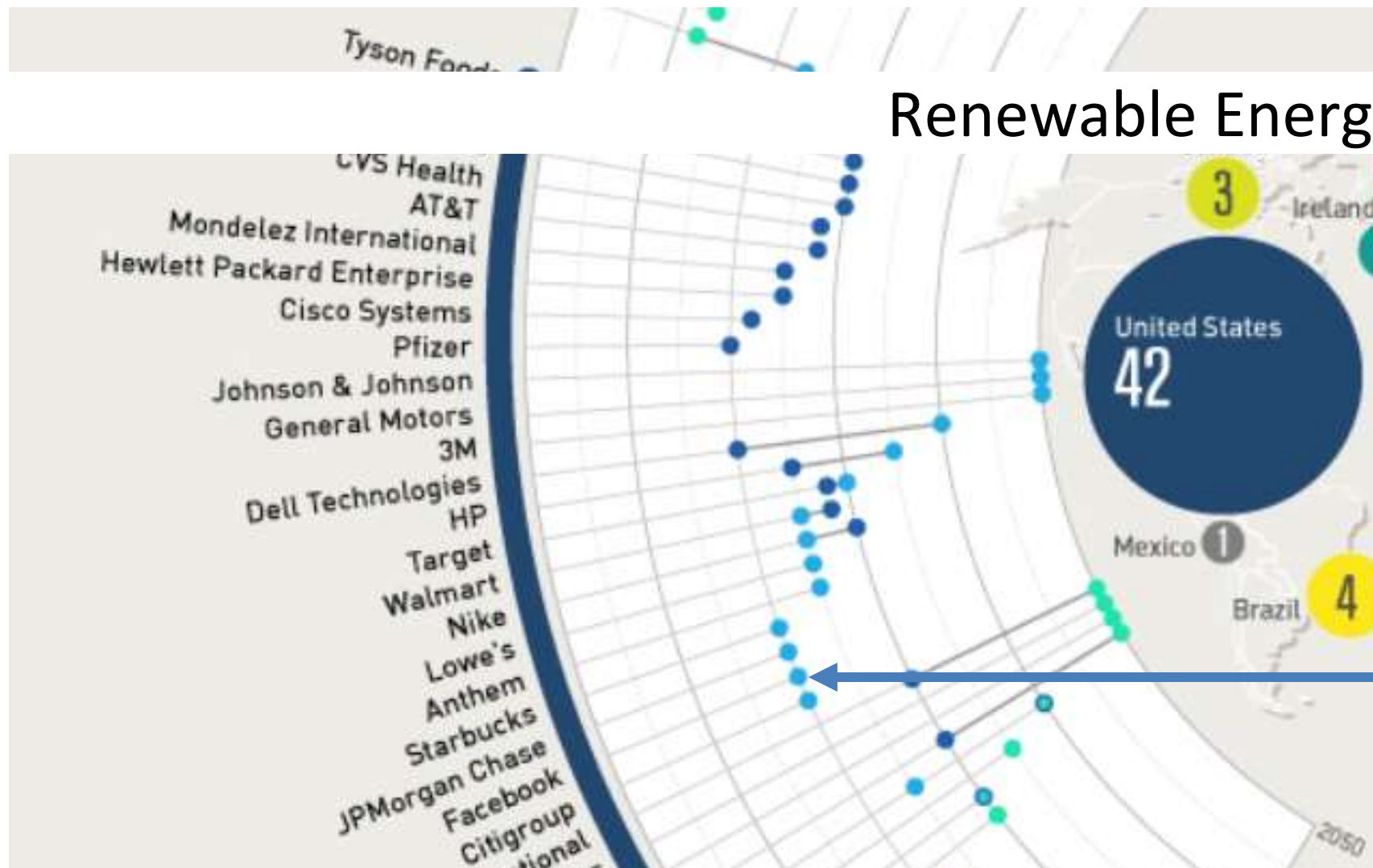


Notes for Figure 2: The number of estimates is greater than the number of references





Renewable Energy Drivers - Emissions



SUSTAINABLE ENERGY

Facebook data center to be powered by \$430 million wind farm in Nebraska

PUBLISHED WED, NOV 15 2017 7:41 AM EST | UPDATED WED, NOV 15 2017 8:08 AM EST

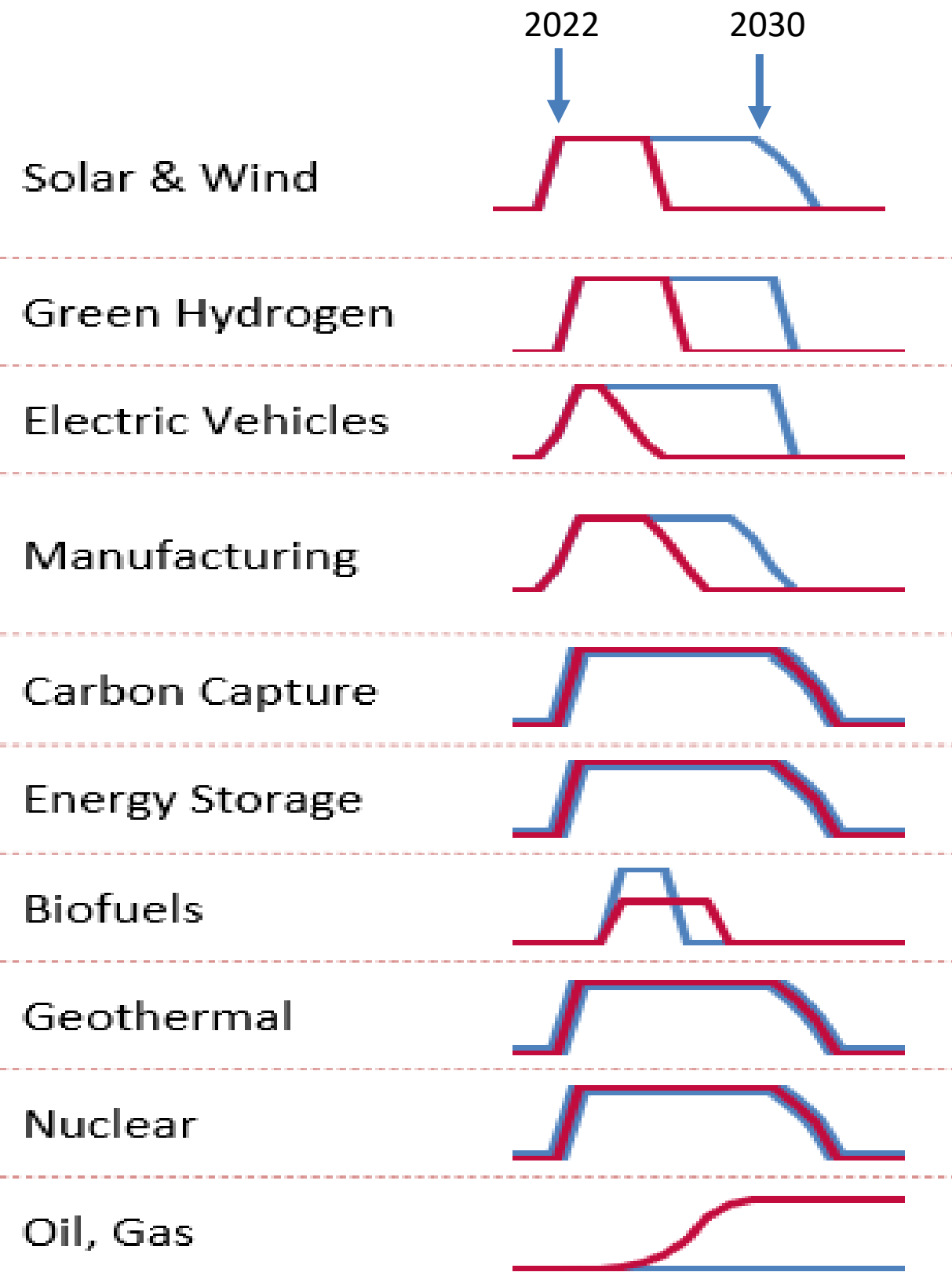
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One Big Beautiful Bill Act phases out incentives for solar & wind, biggest impacts on EV adoption and US manufacturing

Technology	IRA Incentives (2022-2025) vs OBBBA Policy Changes (2025 onward)	Industry Outlook ² in the U.S. with OBBBA
Solar & Wind	<p>48E and 45Y credits available until 2033 • Phased out after 2027¹; sourcing rules tightened (FEOC)</p>	<p>Continued growth trend through 2030, significant slow-down by 2035³ Overall higher electricity end-user prices</p>
Green Hydrogen	<p>45V credit available until 2033 Phased out by 2028</p>	<p>Deployment undermined by weak demand, loss of incentives, and sourcing restrictions</p>
Electric Vehicles	<p>30D, 25E, and 45W credits for EVs; 30C for charging infrastructure Phased out by 2026 (30D/25E/45W by Oct 2025, 30C by Jul 2026)</p>	<p>Consumer adoption hit by loss of credits and policy uncertainty</p>
Manufacturing	<p>45X and 28C credits support clean tech supply chain 45X phased out after 2027 (wind) and 2028 (solar/storage); 48C compromised by sourcing rules</p>	<p>• Clean energy manufacturing hit by loss of credits and supply chain constraints Subsidy loss threatens existing investments</p>
Carbon Capture	<p>45Q credit available until 2033 • Preserved; EOR provisions enhanced</p>	<p>Growth in oil and gas CCS, challenged by foreign entity restrictions</p>
Energy Storage	<p>48E credit available until 2033 Preserved in full</p>	<p>Preserved credits support growth, challenged by foreign entity restrictions</p>
Biofuels	<p>45Z credit available until 2027 Extended to 2029; feedstock sourcing rules tightened; capped SAF</p>	<p>Slow adoption, challenged by foreign entity restrictions</p>
Geothermal	<p>48E and 45Y credits available until 2033 Preserved in full</p>	<p>Moderate growth from low baseline R&D support for superhot geothermal</p>
Nuclear	<p>ITC/PTC for new, 45U for existing plants available until 2033 Preserved in full; fuel sourcing rules apply after 2028</p>	<p>Challenges remain for large ~1GW reactors More optimistic outlook for SMRs, XMRs</p>
Oil, Gas	<p>No support Gains tax breaks, public land access, and regulatory rollbacks</p>	<p>Stable or rising share, as renewables face disadvantage</p>

(1) Construction by 4 July 2026 = 4 years to completion, after = in service before 2028. (2) EV, Carbon Capture, Energy Storage, Biofuels, Hydrogen and Oil, Gas & Coal's Outlook use EIA's reference case and alternative transportation case. (3) Outlook expectations for solar and wind based on EIA's 2025 AEO, using "Reference" Case and "High Zero-Carbon Technology Cost" Case. Sources: Congress, [One Big Beautiful Bill Act](#) (2025); DOE, [Inflation Reduction Act](#) (2022); Norton Rose Fulbright, [Effects of "One Big Beautiful Bill" On Projects](#) (2025); CKI Analysis (2025). Credit: Mariana Castaño, Ariela Farchi, Nicolas Herrera Isaza, Isabel Hoyos, Hyae Ryung Kim, and [Gernot Wagner](#). [Share with attribution](#): Castaño *et al*, "Climate Impact of One Big Beautiful Bill Act" (15 July 2025).

Incentives: IRA (Blue) vs OBBBA (Red)



- Phase out after 2027
- Phase out by 2028
- Phase out by 2026
- Phase out after 2027-2028
- Extended to 2029
- Gains tax breaks, public land access and regulator rollbacks

1 MW(AC) = ~5-7 acres

Single Axis Tracking

Utility Scale Solar



https://www.linkedin.com/posts/ely-valdez-2448b014b_perfect-combination-solarandsheep-ugcPost-7104532918538051584-7bYP?utm_source=share&utm_medium=member_desktop





**1 MW(AC) = 30-60 acres
Horizontal Axis Turbine**



Utility Scale Wind: Physics and Function



Utility Scale Wind: Physics and Function



$$\text{Power in the wind (W)} = \frac{1}{2} \rho A v^3$$

N



Community Issues Wind and Solar



Energy Return on Energy Investment

- **WIND:**

Energy for building, transporting and erecting wind turbines is substantial

- It takes wind turbines about 3.4 to 8.5 months to generate this same amount of energy

- **SOLAR:**

Energy for building, transporting and erecting solar farms is substantial

- It takes solar PV systems about 2-3 years to generate this same amount of energy



Environmental - Water Use

Technology	Water consumption Gal/MWh Range	Water Withdrawal Gal/MWh Range
Photovoltaic (utility scale)	0 – 31	0 – 50
Wind (utility scale)	0	0
Concentrated Solar (thermal)	31 – 739	50 – 829
Geothermal	52 – 4,000	5,440
Hydroelectric	105 – 3,700	19,000 – 55,000
Nuclear	100 – 800	800 – 59,000
Natural Gas (Combined Cycle)	5 – 306	412 – 60,000
Coal	100 – 317	734 – 50,000



Wind and Solar

- **Construction related erosion control**

Wind

- **Italy – Spring water quality research did not link wind turbine construction to water quality**



Federal Aviation Administration (FAA) has determined that glare from solar PV arrays could result in ocular impact to pilots and/or air traffic controllers; therefore, a glare analysis is required for all proposed PV system installations within FAA-controlled boundaries.

(National Lab of the Rockies 2016)



- **Solar Impact on wildlife**
 - Habitat fragmentation
 - Greater impact if land was good habitat before
- **Wind Impact on Wildlife**
 - Some bird and small mammals keep their distance
 - Birds and bats can be killed
 - Most concerning if in high numbers or endangered species
 - Up to 1 million birds killed by wind turbines
 - Up to 1 million birds killed by oil pits
 - Buildings, vehicles, power lines, cats combine to kill over 3 billion

Wind: Conkling et al., 2023, Nebel et al., 2024, Choi et al., 2020, Zwart et al., 2015, Windor 2015, Sander et al., 2024, May et al., 2020
Opuchi et al., 2017, Opucki and Mroz 2016, Arnett and May 2016, Smallwood and Bell 2020, US fish and Wildlife 2017,

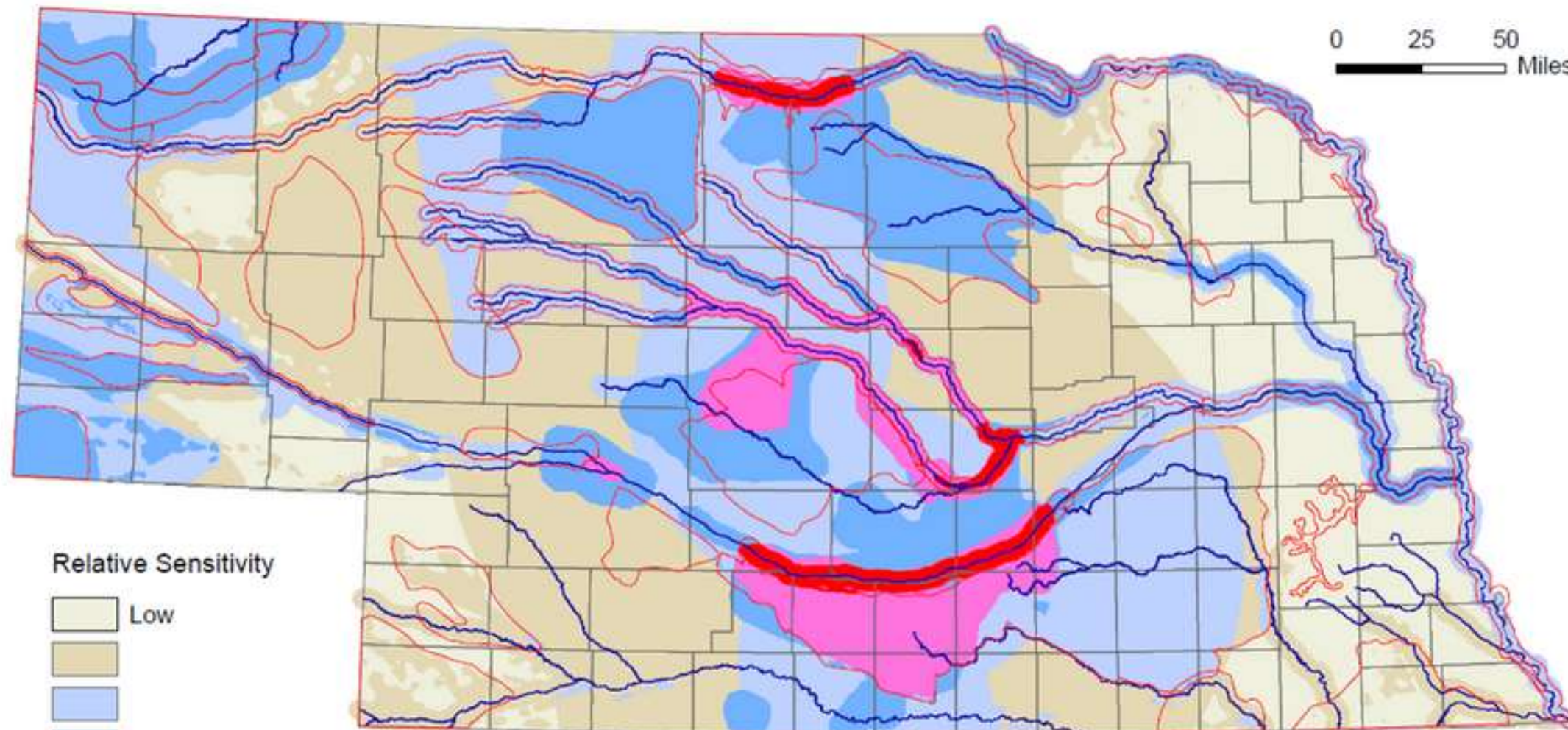
Solar: Rewi 2023



Environmental

Community Issues Wind

Wind Energy and Nebraska's Wildlife:
An index of the sensitivity of wildlife habitats to wind energy development,
based on selected at-risk species



This map was designed to aid in planning for wind energy development by identifying areas that are considered relatively more sensitive or less sensitive to such development, with respect to species of concern. This map is not designed to evaluate wind farm siting at specific locations. Even in "low sensitivity" areas shown, there will be specific locations where siting of wind power infrastructure can negatively impact significant biological resources (e.g. remnant tallgrass prairie, listed plant species, etc.). Contact the Nebraska Game and Parks Commission and the U.S. Fish and Wildlife Service for potential site-specific impacts and potential conservation measures to avoid "take" under the state Nongame and Endangered Species Conservation Act and the federal Endangered Species Act.

See attached document for a description of the information used to develop this map.

Map version date: October 4, 2011

The interaction between wind turbines and wildlife

- collision risks
- habitat displacement
- behavioral changes.

These impacts vary across species and are influenced by factors such as turbine size, location, and noise.

Understanding these dynamics is essential for developing strategies to mitigate negative effects on wildlife.





• **Solar Impact on Property Values** Property Values

- Home values close to solar arrays change by +2 to -5 %
 - Distance, community acceptance
- Ag land values were not changed
- Non-monetary land value can change (how do you feel about your home after solar installation nearby)

• **Winds Impact on Property Values**

- Home values impacted as high as 11% reduction at the time of announcement
 - Distance, community acceptance, visibility
- Home values normalized after 3-7 years (multiple studies)
- Ag land values were not changed
- Non-monetary land value can change (how do you feel about your home after solar installation nearby)
- Communities before and after wind development see increase in property values by 2.7-2.9%
- Wind development increases school district revenue by ~\$800 per pupil

- **Solar**
 - Silicon, Glass, Aluminum, Cadmium, Lead, Copper, Steel
 - No toxic material risks during operation (exposed broken panels to rainwater in controlled environment)
 - Studies show improper disposal can lead to possible toxic metals leaching (exposed ground up panels to acidic leachate)
 - Electromagnetic fields (limited due to distance)
- **Wind**
 - Steel, Copper, Fiberglass, Resin
 - 90+% recyclable at end of life
 - Wind turbine blades are the portions with low recycling value
 - Oil used in gearbox
 - Electromagnetic fields (limited due to distance)



- **Solar Noise**
 - Minimal noise from inverters and power electronics located inside the fenced area
- **Wind Turbine Noise**
 - Subjective (perceptions impacted by attitude, acceptance, visual)
 - Linked to annoyance, sleep disturbance
 - Wind turbine noise linked to similar health outcomes as other sources of noise
- **Wind Turbine Infrasound**
 - Weakly linked to physiological response, annoyance in some studies
 - Annoyance associated with symptoms
 - No physiological response detected in lab studies

Solar: Cleveland 2017

Wind: Krogh et al., 2018, Turunen et al., 2021, vanKamp and van den Berg 2021, Botelho et al., 2017, Barry et al., 2018, Rosciszewska et al., 2025, Feder et al., 2015, Nissenbaum 2012, Radun et al., 2022, Dumbrille et al., 2021, NIH.gov, Marshall et al., 2023, Koch et al., 2025,





- **Property Tax (Wind and Solar)**
 - Nameplate capacity tax (replaces personal property tax)
 - \$3,518 per MW per year
 - Real property tax (buildings, roads, owned land)
- **Leased Land Solar**
 - \$800 to \$1,200 per acre per year + Inflation
 - All land controlled by developer (vegetation management)
- **Leased Land Wind**
 - ~\$5,000 per MW per year + inflation
 - All but ~1 acre is still in Ag production
- **Jobs**
 - 5-10 jobs per solar or wind farm



**Scottsbluff NE, 2023 100 mph Baseball Size Hail.
Panels removed and recycled. Replaced and
operating within ~6 months**



Northeast Nebraska turbine caught fire during construction

Not much data directly related to wind and solar from research, Similar to risks from debris from buildings in pastures after tornado

- **Solar:**
 - Glass from broken panels may be risk to grazing livestock
- **Wind:**
 - Fiberglass from broken blades may be risk to grazing livestock and in future hay



Decommissioning



- Wind/Solar company must follow State or Local Decommissioning rules.
- State law is followed when local does not have their own rules.
- State Law says decommissioning security must be in place in year 10 of the project.

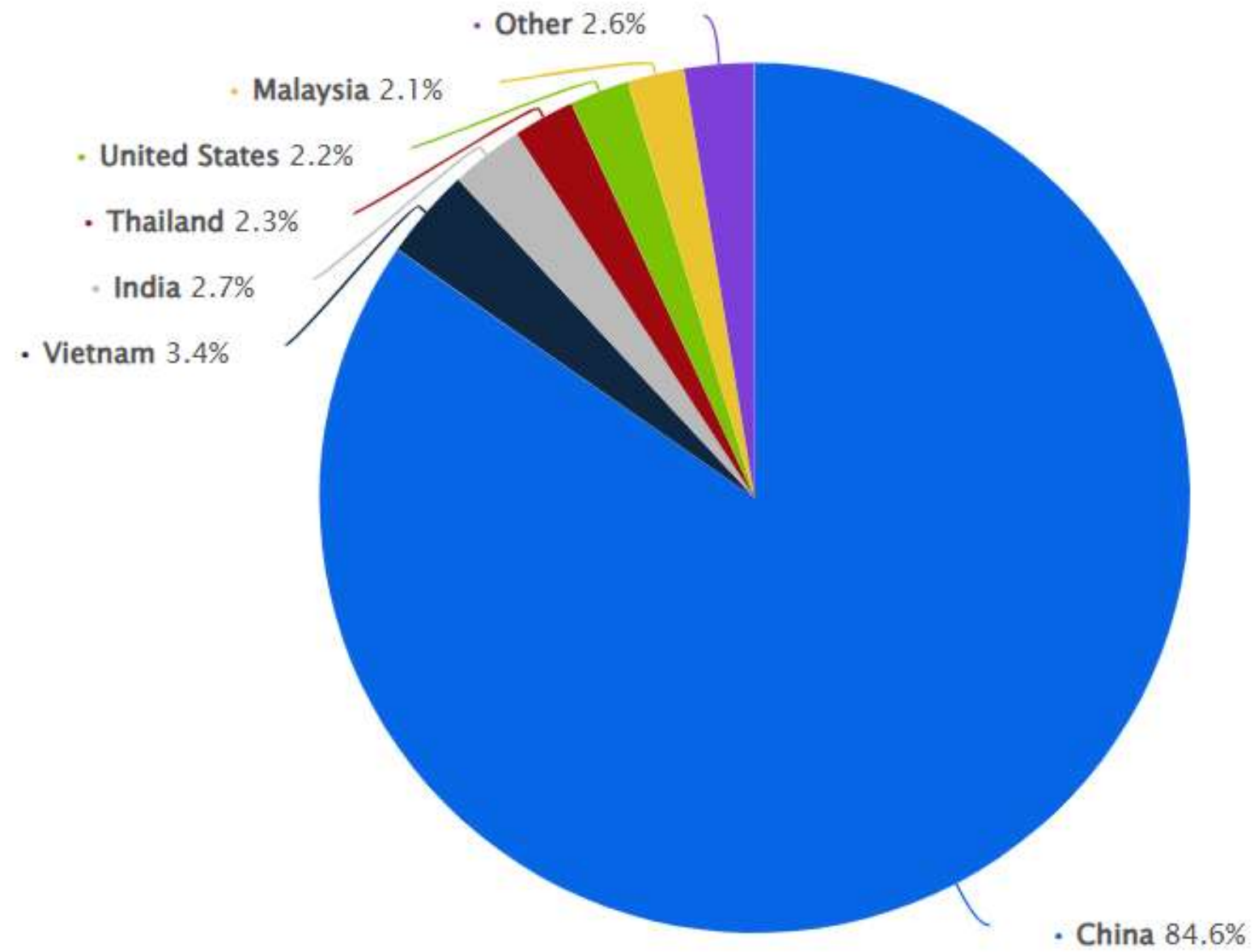
Decommissioning

Community Issues Wind



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Where are solar modules made?

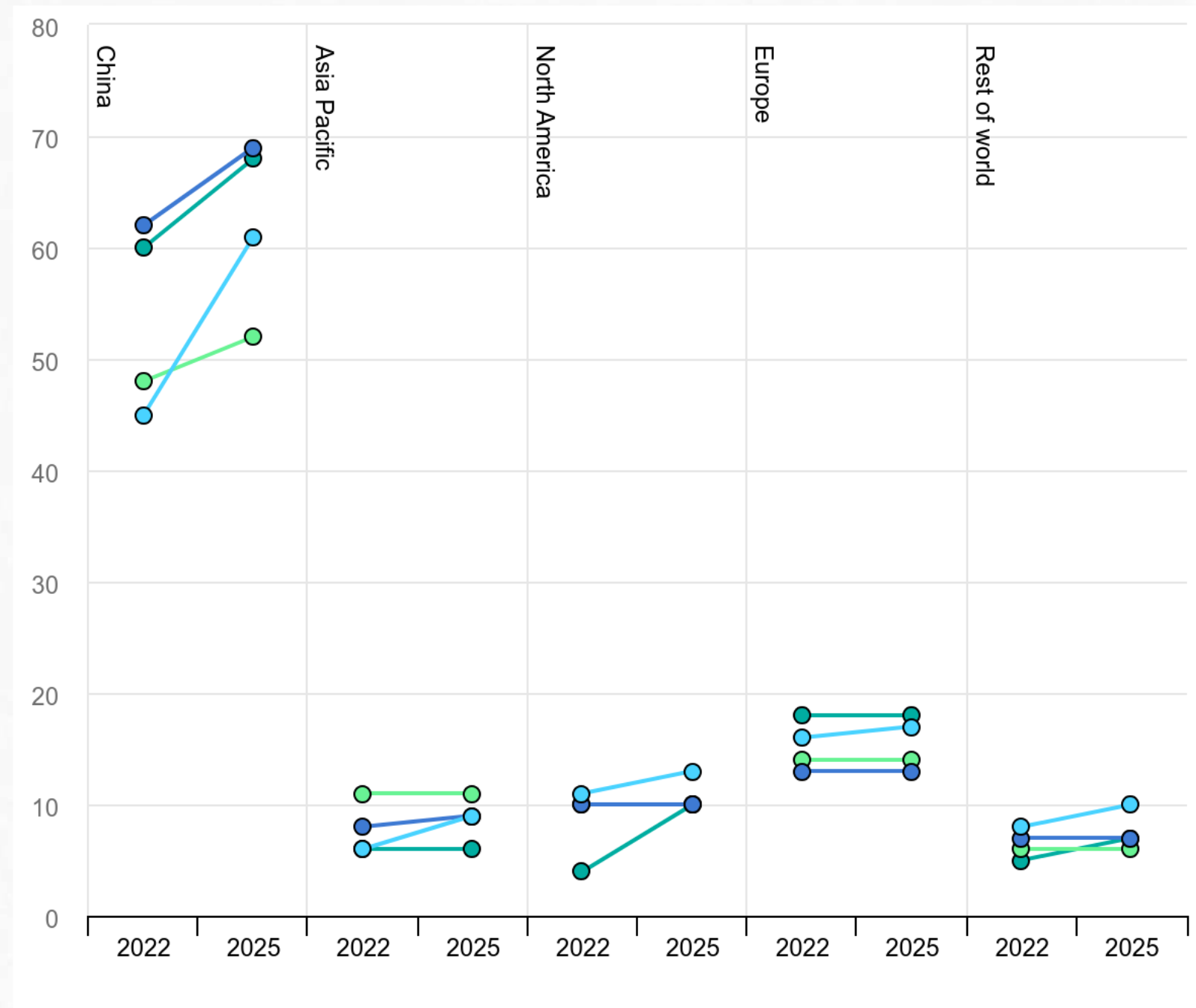


Details: Worldwide; RTS Corporation; PVPS; IEA; 2023

© Statista 2025



Where are wind turbines made?



IEA (2023), Onshore wind equipment manufacturing capacity by region and component, 2022-2025, IEA, Paris
<https://www.iea.org/data-and-statistics/charts/onshore-wind-equipment-manufacturing-capacity-by-region-and-component-2022-2025>, License: CC BY 4.0



Please Complete this Short Survey



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<https://bit.ly/3MNxnai>



Agrivoltaics – Solar Plus Agriculture



- **Agrivoltaics – Agriculture + Photovoltaics (PV)**
 - Generic term for all types of ag which may take place under PV
- **Ecovoltaics – Ecological practices + PV**
 - Native prairie plants – grasses, forbs, wildflowers etc. may combine with grazing or apiculture
 - Ecological services
- **Solar Grazing – grazing under solar panels**
 - Using Grazing as means of vegetation management usually with sheep
- **Solar Honey – Honeybees and solar PV**
 - Forbs, and wildflowers providing for honey production



What people may think it looks like

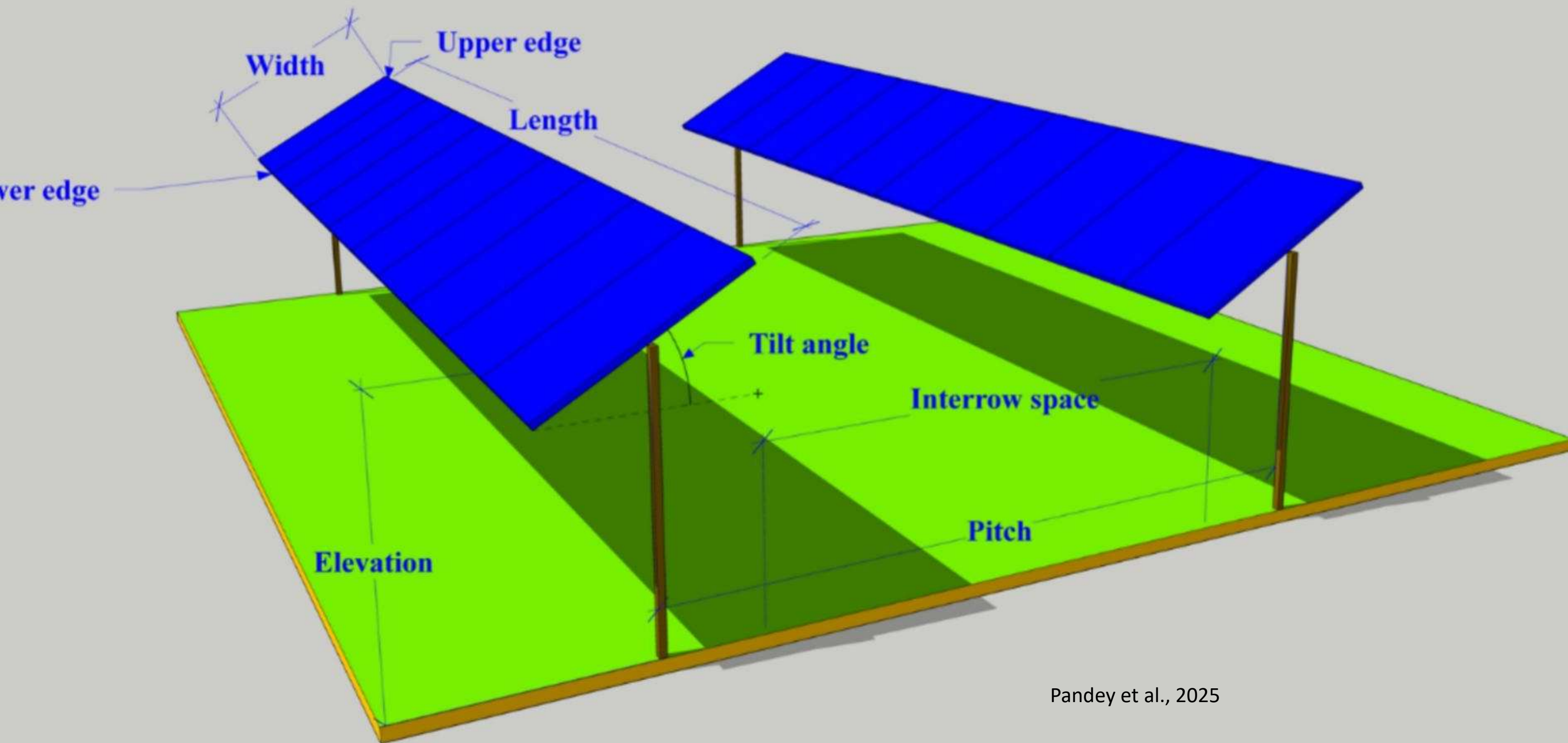


What I think it looks like



What I hope for: Cattle, High value crops, Hay, Robots,





- **Forage crops, soybeans, perform similarly to control (not under solar) (Ohio State University – prepublication data)**
- **Forage yield was 9-33% lower yet higher in quality under solar panels. Sheep rate of gain was similar to control (Oregon) (Andrew et al., 2021)**



Most Common:

- **Private company or Utility owns and operates solar array**
 - Sells the electricity to utilities or into electrical markets
 - Contracts for vegetation management

Less Common:

- **Landowner, farmer, or business owns solar array**
 - Uses electricity locally, or sells to other businesses, utilities, or markets
 - Plans for their own vegetation management
 - May have more flexibility



Vegetation Management

1. Mow and spray to keep vegetation from interfering with solar operations (maybe 2-4 times per year in Nebraska)

- Cool Season Grasses
- Native mix of grasses, forbs, and flowers

2. Mowing and Grazing (sheep), sheep do much of the work but mowing to clean up and to keep up in early season

- Cool Season Grasses
- Native mix



Agreement which defines how vegetation management is done

- **Maintain height of vegetation “24 inches below solar panels in the horizontal position for 1 axis tracking systems”**
- **Methods for management**
 - Mowing, spraying, grazing, haying, crops
- **Who can be inside the fence (PPE)**
- **Monetary terms**
- **Communication requirements**



- **Grazing Ready (Sheep)**
 - Seed mix for grazing
 - Perimeter fencing adequacy
 - Plan for water
 - Proper gates and areas for unloading and loading
 - Gates for moving sheep to other parcels
- **Cattle Ready?**
 - Similar to sheep except
 - Conduit is tight to posts
 - Armor sensitive equipment like inverters using fencing
 - WATER (cattle drink a lot more water than sheep)



Making A Site “Hay Ready”

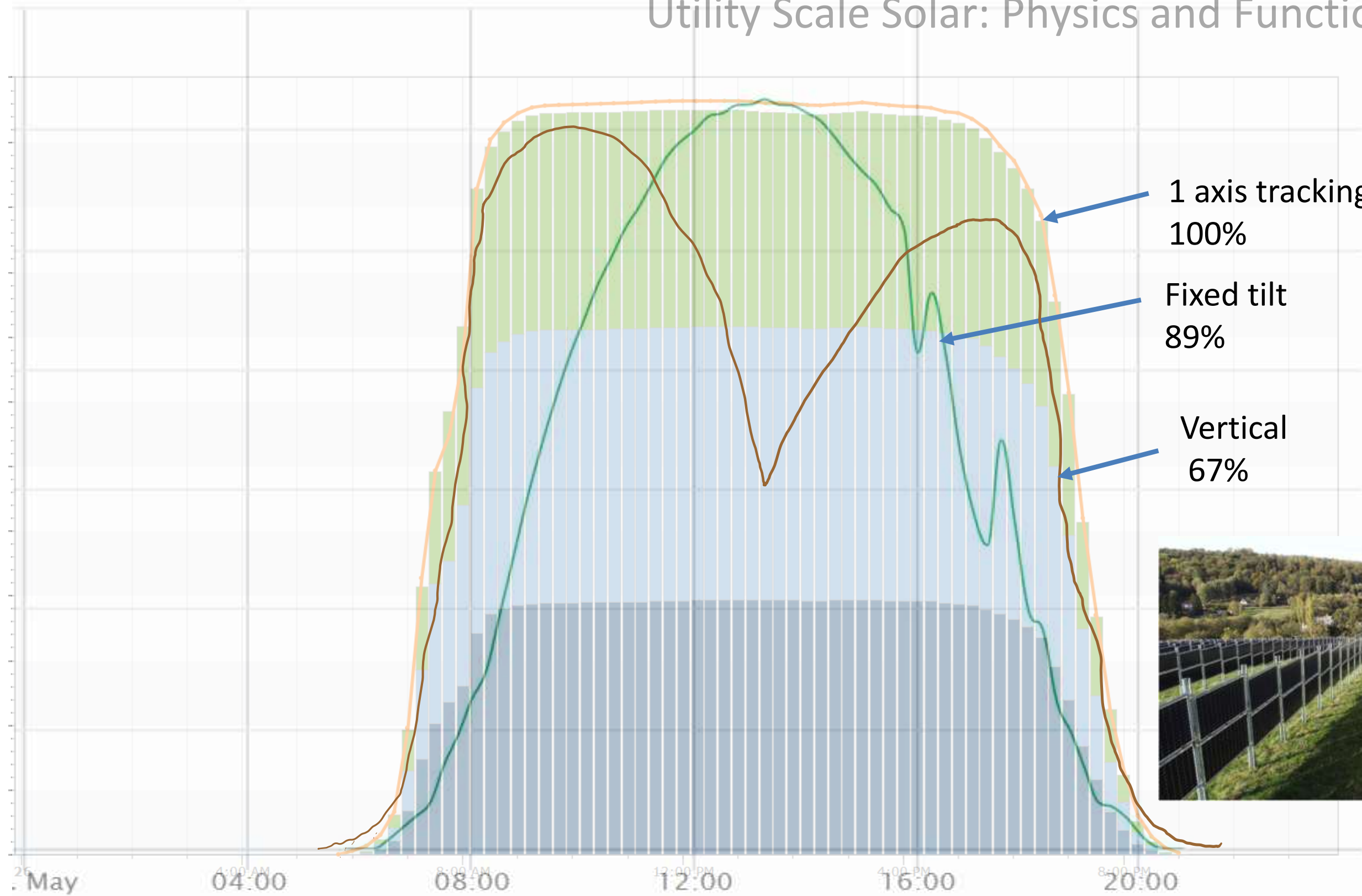
- Bury wires between rows so equipment does not have to back up
- Give appropriate space for tractor to turn around at end of rows
- Ensure if any land leveling was done topsoil was replaced
- Planting before installation is preferred



Vertical Bifacial Solar
Sometimes called solar
fences



Utility Scale Solar: Physics and Function



Same:

- Location
- Capacity
- Panel (bifacial)



Alternative Architecture to Accommodate Agriculture

**Taller to
accommodate
agriculture
activities**



- **Farmers (vegetation managers) working with solar developers to plan projects which minimize problems and maximize options for ag under solar**
- **Grazing cattle**
 - Possibly without changing architecture
 - Feeder cattle
 - Sort based on temperament
- **High value crops**
 - Grapes
 - Vegetables
- **Unique designs that focus on agriculture**
 - Solar shade for cattle
 - Raised solar
 - Vertical solar

