

Levelized Costs of New Generation Resources in the Annual Energy Outlook 2023



Introduction

- This paper presents average values of levelized costs for new generation resources as represented in the National Energy Modeling System (NEMS) for our *Annual Energy Outlook 2023* (AEO2023) Reference case.
- Levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) represent the estimated cost required to build and operate a generator and diurnal storage, respectively, over a specified cost recovery period.
- Levelized avoided cost of electricity (LACE) is an estimate of the revenue available to that generator during the same period.
- Although LCOE, LCOS, and LACE do not fully capture all the factors contributing to the capacity expansion decisions as modeled, when used together as a value-cost ratio (the ratio of LACE-to-LCOE or LACE-to-LCOS), they provide a reasonable comparison of first-order economic competitiveness among a wider variety of technologies than is possible using LCOE, LCOS, or LACE individually.
- Both a capacity-weighted average reflecting as-built regional cost variation and a simple average (unweighted) of the regional values across the 25 U.S. supply regions of the NEMS Electricity Market Module (EMM) are included.

Note: U.S. supply regions of Electricity Market Module, https://www.eia.gov/outlooks/aeo/pdf/nerc_map.pdf

AEO2023 representation of tax incentives

Federal tax credits for qualified generation facilities can substantially reduce the realized cost of these facilities. Cost estimates in this report represent electric generators owned by the electric power sector but not for systems owned in the residential or commercial sectors.

Where applicable, we show LCOE both with and without tax credits that we assume would be available in the year in which the plant enters service.

The Production Tax Credit (PTC) is a per-kilowatthour tax credit on electricity sold for a 10-year period after the facility has been placed in service. The Investment Tax Credit (ITC) is a tax credit applied, on a percentage basis, to the cost of building certain generating assets. The ITC and PTC are exclusive of one another, meaning the same facility cannot claim both.

The Inflation Reduction Act (IRA) of 2022 modifies and extends the tax credits that were previously scheduled to reduce or expire for certain technologies. Furthermore, the IRA creates technology-neutral tax credits for facilities with zero-carbon emissions placed in service starting in 2025.

AEO2023 includes these extensions and modifications to the PTC and ITC. In addition, the Reference case assumes the prevailing wage and apprenticeship requirements are met by all eligible technologies, increasing by five times both the base tax credits of 6% for the clean energy ITC and 0.3 cents per kilowatthour (kWh) for the clean energy PTC. We also assume some technologies are eligible for the domestic content bonus credits. We currently lack sufficient information on potential implementation of bonus credits for the energy communities and therefore do not include it in our analysis.

Technology-specific implementation of tax incentives

The provisions of the IRA allow for eligible technologies to claim either the PTC or the ITC. We choose the credit that is most economically beneficial to the technology.

We assume standalone solar photovoltaic (PV) facilities will claim the PTC; only the ITC was available previously. Without further guidance on the tax credit for solar PV-battery hybrid facilities, we assume that it also will be eligible for and will claim the PTC.

We assume that onshore wind projects will continue to claim the PTC, and they are assumed to also meet the domestic content requirements for higher tax credits.

Because of high capital costs, we assume offshore wind projects will claim the ITC. In addition, we assume offshore wind projects will satisfy the domestic content requirements starting in 2032 for additional tax credits.

In addition, for projects entering service beginning in 2025, we assume:

- Geothermal projects will claim the ITC.
- Biomass projects will claim the PTC for the first 10 years of operation.
- Hydroelectric projects will claim the ITC instead of the PTC as previously allowed.

Advanced nuclear and small modular reactor facilities placed in service after December 31, 2024, are eligible to take either the ITC or PTC. For AEO2023, we assume new nuclear facilities will opt to take the PTC.

New battery storage technologies are eligible for the clean electricity ITC, and AEO2023 assumes that the wage and apprenticeship requirements are met, resulting in a 30% ITC level.

General assumptions

The costs presented in the report are for generation facilities entering service in 2028, which is the first feasible online year for all technologies given the long construction lead time for some technologies.

The levelized costs are calculated based on a 30-year cost recovery period, using an after-tax weighted average cost of capital (WACC) of 6.54% for the 2028 online year.

The capacity-weighted average is the average levelized cost per technology, weighted by the new capacity coming online in each region in 2028, excluding planned capacity additions. Technologies for which no capacity additions are projected do not have a capacity-weighted average.

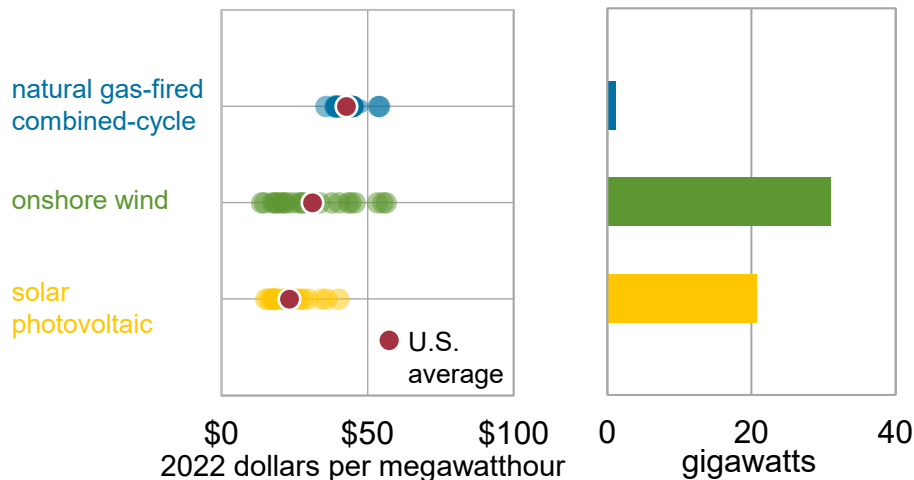
We assume solar technology is photovoltaic (PV) with single-axis tracking. A solar PV-battery (PV-battery) hybrid system is a single-axis PV system coupled with a four-hour battery storage system. Costs are expressed in terms of net AC (alternating current) power available to the grid for the installed capacity.

As modeled, we assume that hydroelectric generating assets are seasonal in that generation is a function of seasonal rainfall. Similarly, PV-battery hybrid generating assets are used at specific times of the day depending on the number of daylight hours.

Direct comparisons of LCOE or LCOS across technologies are misleading as a method to assess the economic competitiveness

Regional and U.S. average levelized cost of electricity,^a AEO2023 Reference case

Capacity additions, AEO2023 Reference case



LCOE does not capture all of the factors that contribute to actual investment decisions. The inherent uncertainty about future fuel prices, changing policies, or local considerations to ensure system reliability can place a value on portfolio diversification or other risk-related concerns.

In AEO2023, we project natural gas-fired combined-cycle (CC) capacity additions in 2028 even though their LCOE, on average, is higher than either onshore wind or solar PV. In this case, adding CC capacity to the system can add value in certain regions that LCOE may not fully capture.

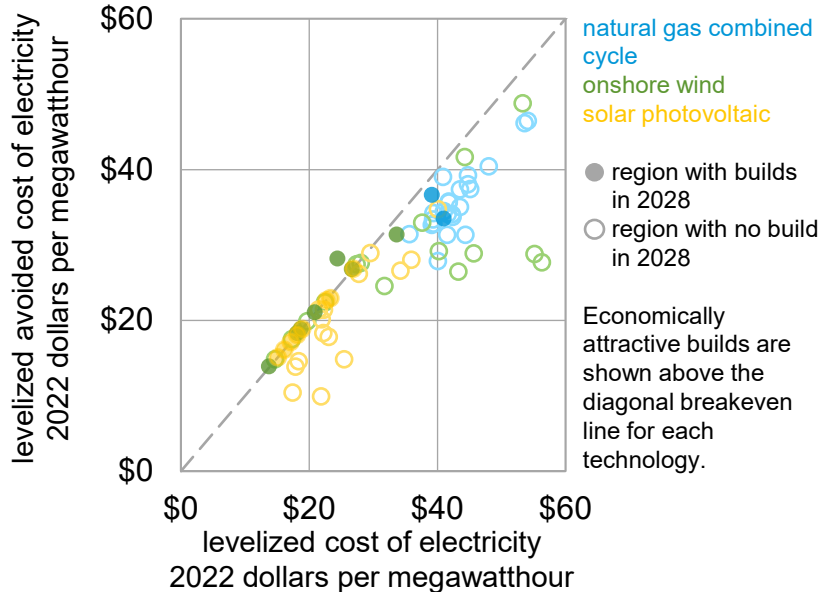
Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Note: Each solid circle on the figure represents an electricity market region as modeled.

^aLevelized cost includes tax credits available for plants entering service during the projection period.

LCOE is limited because it only reflects the *cost* to build and operate a plant, but not the *value* of the plant to the grid

Levelized cost of electricity and levelized avoided cost of electricity by region for online year 2028, AEO2023 Reference case



We use the levelized avoided cost of electricity (LACE) as a companion metric to LCOE to improve comparisons of different generation technologies by providing the value of the plant in serving the electric grid.

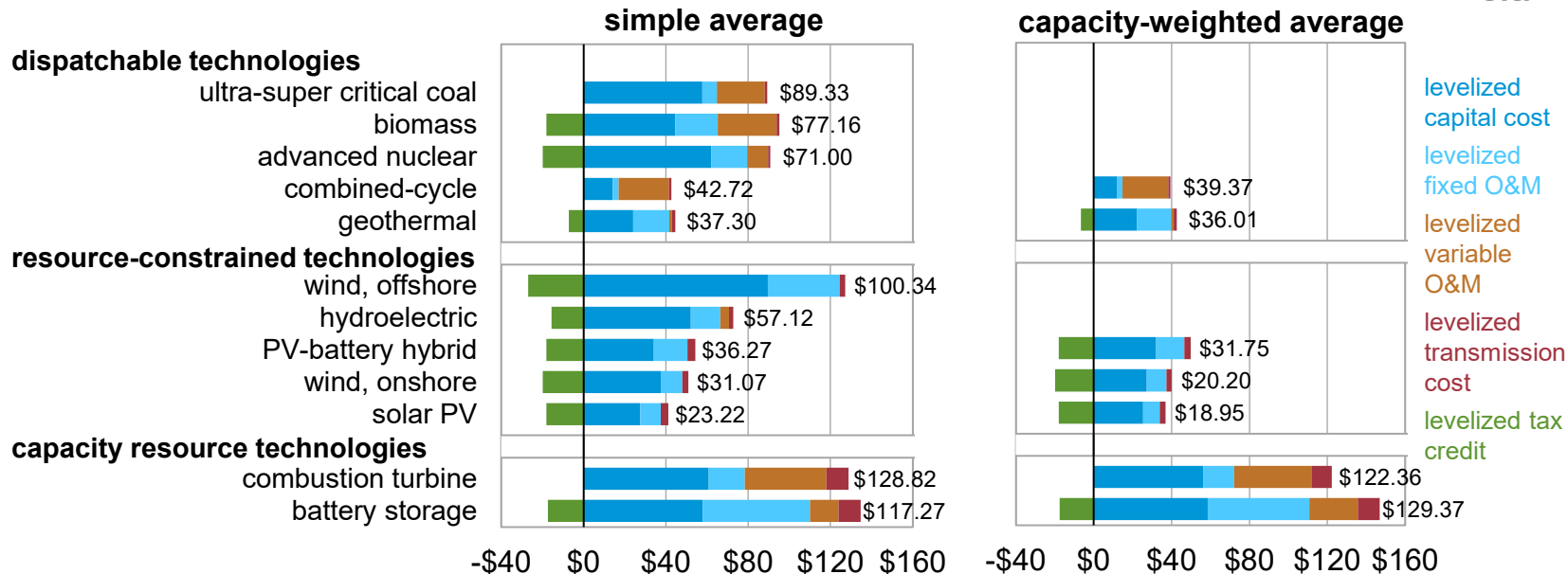
The LACE (value) provides a proxy measure for potential revenues (or avoided costs) from the sales of electricity generated or other ancillary services produced from a candidate project displacing another marginal asset.

Projects with LACE (value) greater than LCOE or LCOS (cost) are more economically attractive to build than those with a value-cost ratio less than one (that is, LACE is less than LCOE or LCOS).

Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Estimated levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2028

2022 dollars per megawatthour



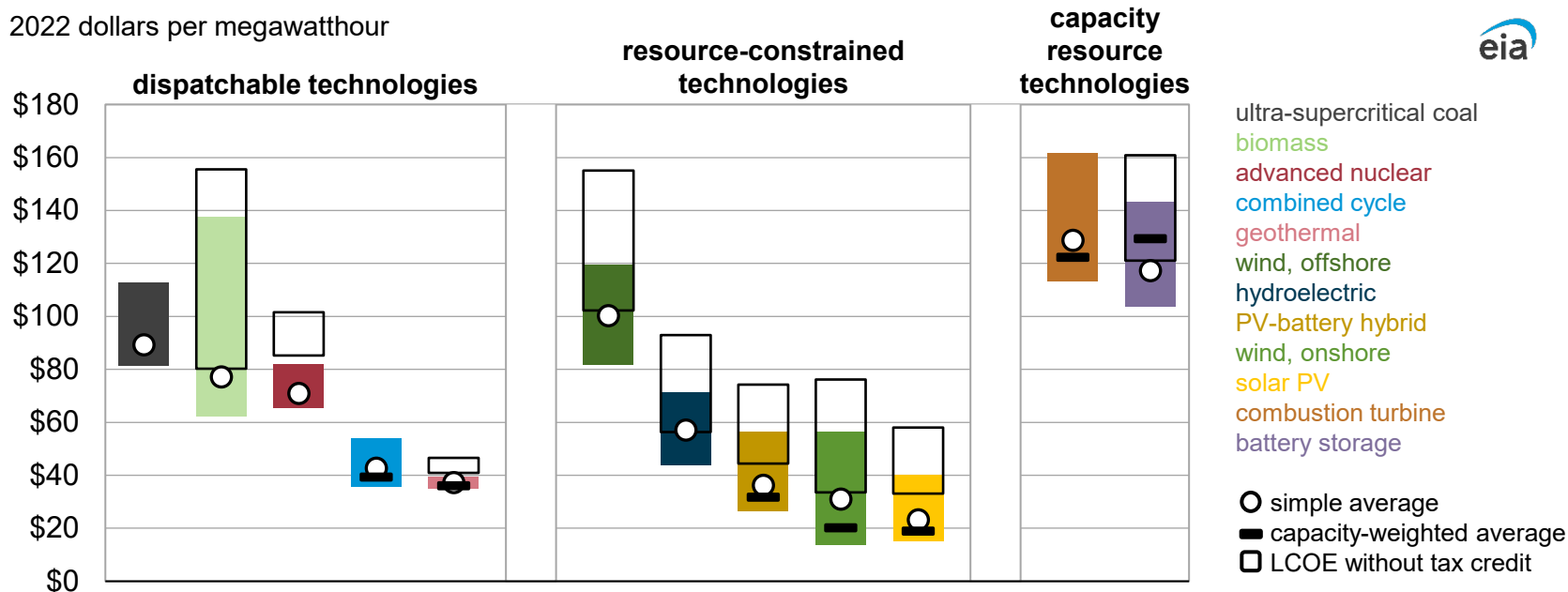
Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Note: PV = photovoltaic, O&M = operations and maintenance; technologies in which capacity additions are not expected in 2028 do not have a capacity-weighted average. The stated LCOE values include the levelized tax credit component for eligible technologies.

Combined cycle and solar have little variation in LCOE from region to region compared with other generation technologies

Regional variation in levelized cost of electricity (LCOE) and levelized cost of storage (LCOS) for new resources entering service in 2028 by technology, AEO2023 Reference case

2022 dollars per megawatthour



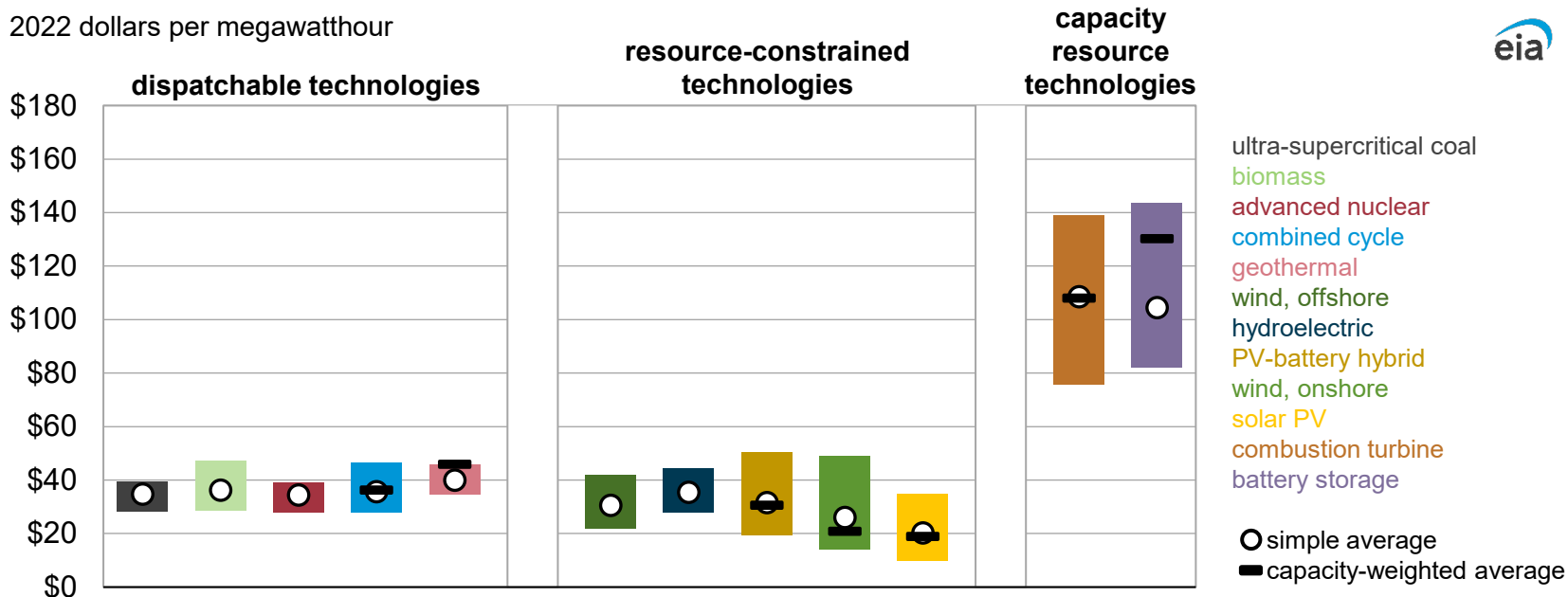
Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Note: PV = photovoltaic; technologies in which capacity additions are not expected in 2028 do not have a capacity-weighted average

LACE for resource-constrained technologies is generally lower because of their lower contribution for energy, capacity, and spinning reserve to the grid

Regional variation in levelized avoided cost of electricity (LACE) for new resources entering service in 2028 by technology, AEO2023 Reference case

2022 dollars per megawatthour

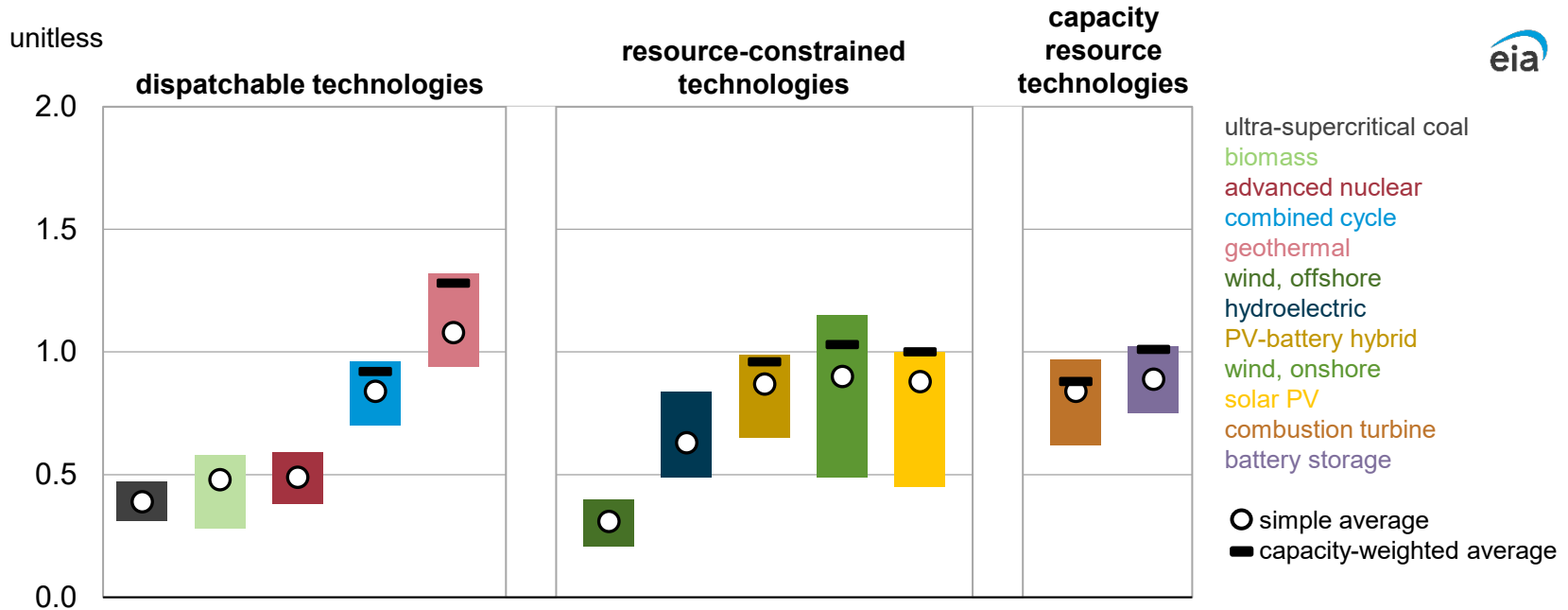


Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Note: PV = photovoltaic; technologies in which capacity additions are not expected in 2028 do not have a capacity-weighted average.

Capacity-weighted value-cost ratio stays above simple average value-cost ratio, indicating capacity is added in regions where it is most economical

Regional variation in value-cost ratio (VCR) for new resources entering service in 2028 by technology, AEO2023 Reference case

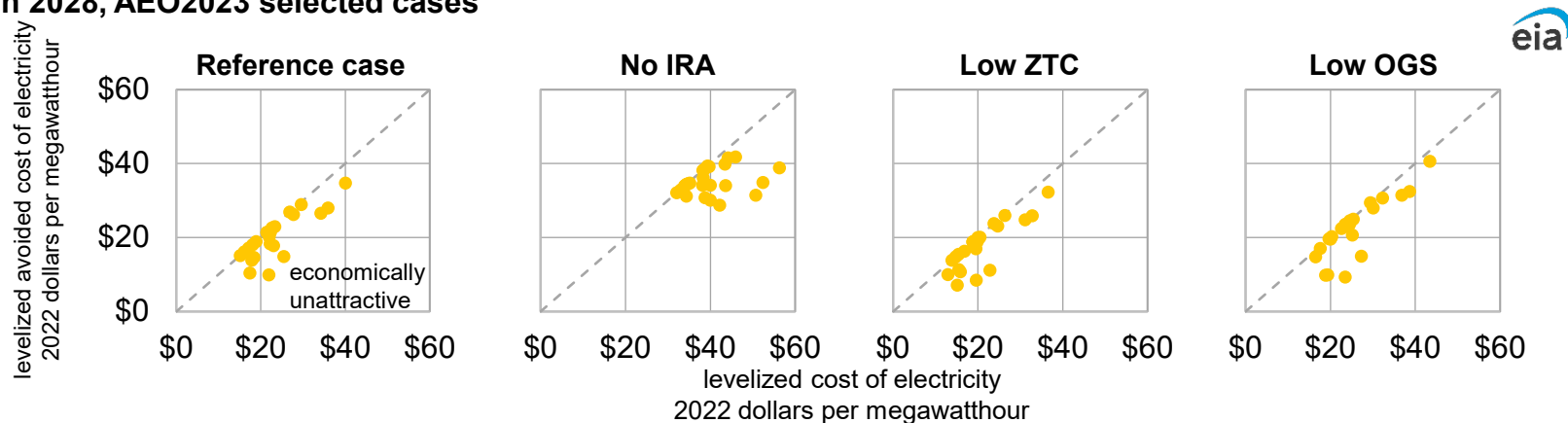


Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

Note: PV = photovoltaic; technologies in which capacity additions are not expected in 2028 do not have a capacity-weighted average.

Market factors affect LCOE, LACE and value-cost ratio differently at regional-level, making the context of projection scenarios important

Levelized cost of electricity and levelized avoided cost of electricity for solar photovoltaic entering service in 2028, AEO2023 selected cases



When the energy-related provisions of the Inflation Reduction Act of 2022 (IRA) that include tax credits for solar photovoltaic (PV) are excluded as in the No IRA case, LCOE increases but LACE is also higher.

Carbon Technology (ZTC) case, LCOE is lower but so is LACE, as higher solar penetration reduces its value.

Under the lower-cost assumption in the Low Zero-

With higher natural gas prices as in the Low Oil and Gas Supply (OGS) case, LACE increases compared with the Reference case but so is LCOE.

Data source: U.S. Energy Information Administration, Annual Energy Outlook 2023

For more information

U.S. Energy Information Administration home page | www.eia.gov

Annual Energy Outlook | www.eia.gov/aeo

Levelized Cost of New Generation Resources Methodology | https://www.eia.gov/outlooks/electricity_generation.php