E3 RECOST

Q1 2025 Update

February 2025

Energy+Environmental Economics

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Executive Summary

Q1 2025

Gas, Inflating

Costs for building new gas plants have increased materially from mostly stable averages from the 2010s, but in line with recent macro cost trends, in E3's latest forecasts. These increases are not just due to inflation –supply chain and labor constraints mean that critical equipment is now more difficult to obtain and deploy, which is flowing from OEMs to purchasers and beginning to become more widely known.

Solar, Eclipsed

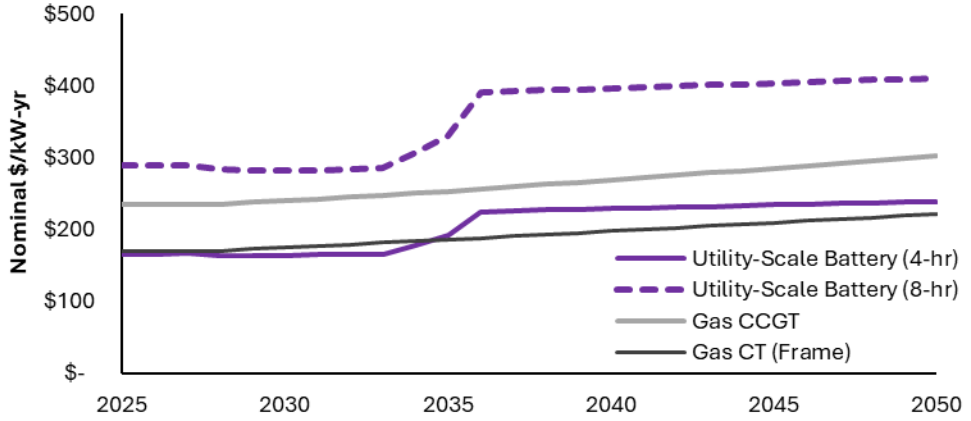
Solar tariffs appear likely to remain a critical component of this resource's cost profile, at least under the current administration. E3 updates our forecasts to reflect a conservative estimate: the broad application of recent anti-dumping / counter-vailing duty penalties across the sector, instead of only to select import sources.

Policy, Shocked

The acceleration of the phase-out or cessation of the Inflation Reduction Act's tax incentive components now appears to be a real possibility. E3 updates our prior assumption that the phase-out of these incentives will be triggered in 2045 to 2032, the earliest possible year under current legislation.

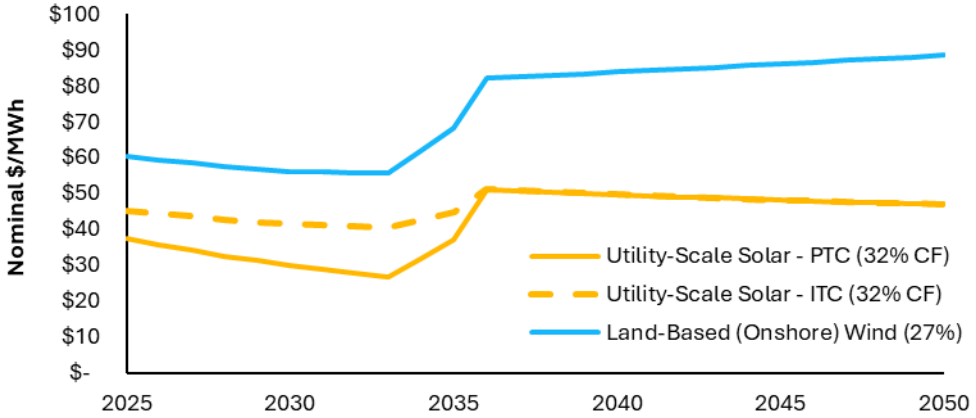
RECOST LFC Estimates for Selected Resources (Inclusive of PTC)

Q1 2025, Mid Cost Trajectory, Generic U.S. Location



RECOST LCOE Estimates for Selected Resources

Q1 2025, Mid Cost Trajectory, Generic U.S. Location



In a world where costs and benefits are more complicated, E3's RECOST forecasts aim to provide transparency and rigor

Who is E3?

Thought Leadership, Fact Based, Trusted.

130+ full-time consultants

30+ years of deep expertise

Engineering, Economics, Mathematics, and Public Policy Degrees


San Francisco


New York

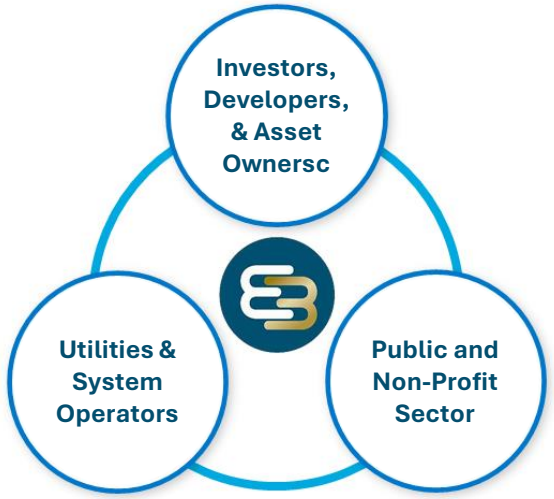

Boston


Calgary


Denver

E3 Clients

300+ projects per year across our diverse client base



Asset Classes Supported by E3

- Utilities
- Thermal Resources
- Transmission
- New and Emerging Technologies
- Electric Vehicles and Infrastructure
- Software and IoT
- Decarbonized Fuels
- Energy Storage
- On/Off-Shore Renewables
- Distributed Generation and Flexible Loads

Who is E3?

Our Practice Areas

+ **E3 is the largest consulting firm focused on the clean energy transition in North America**
+ **E3 is a recognized thought leader on decarbonization and clean energy transition topics**
+ **E3 has three major practice areas covering energy systems from bulk grid to behind the meter**

Climate Pathways & Electrification

- Long-term energy & climate scenarios
- Electrification and low-carbon fuels analysis
- Future of gas

Asset Valuation & Markets

- Energy market price forecasting
- Strategic advisory
- Due diligence
- Market design
- Transmission planning

Integrated System Planning

- Electric system planning: reliability and resource analysis
- Planning for utility and state RPS + GHG targets
- Utility planning and procurement decisions

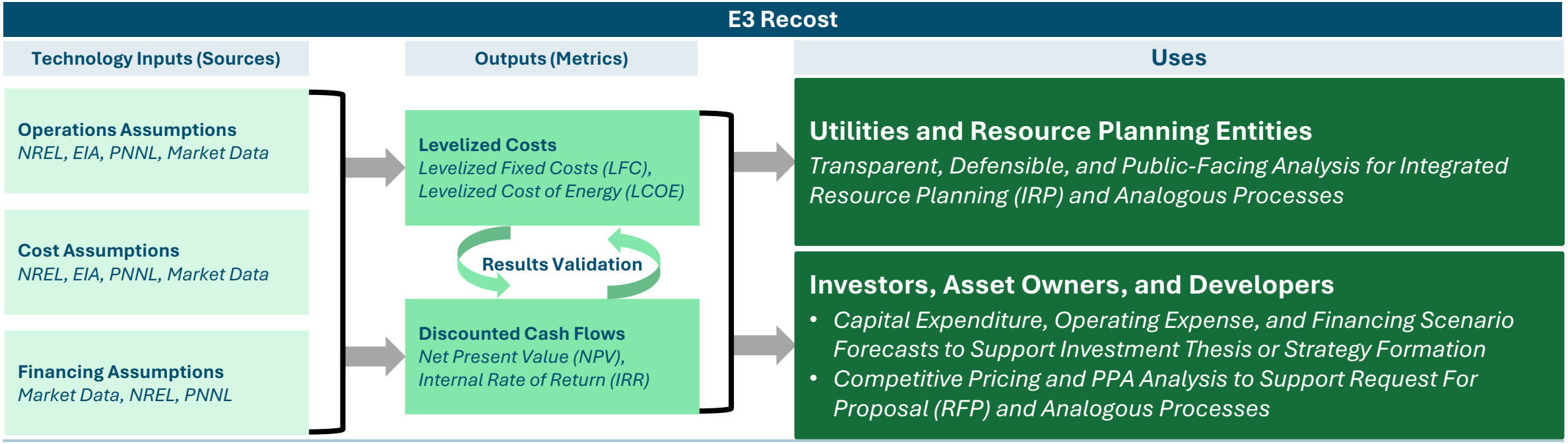
Economy-Wide Energy Systems — Bulk Grid Power Systems — Grid Edge / Behind-The-Meter

What is E3 RECOST?

Overview of Model and Use(s)

- **Recost** is E3's in-house discounted cash flow model used to calculate levelized fixed costs and levelized cost of electricity for mature and emerging technology resources, inclusive of financing costs
- **Recost** is optimized for two goals:
  1) Evaluate the fundamental economic costs of building new resources to inform energy system modeling, validate investment theses, and shape resource strategy for public and private sector stakeholders
  2) Estimate the expected cost to contract these resources under Power Purchase Agreements (PPAs), and support the calculation of Levelized Cost of Capacity (LCOC) using each resource's Effective Load Carrying Capability (ELCC)

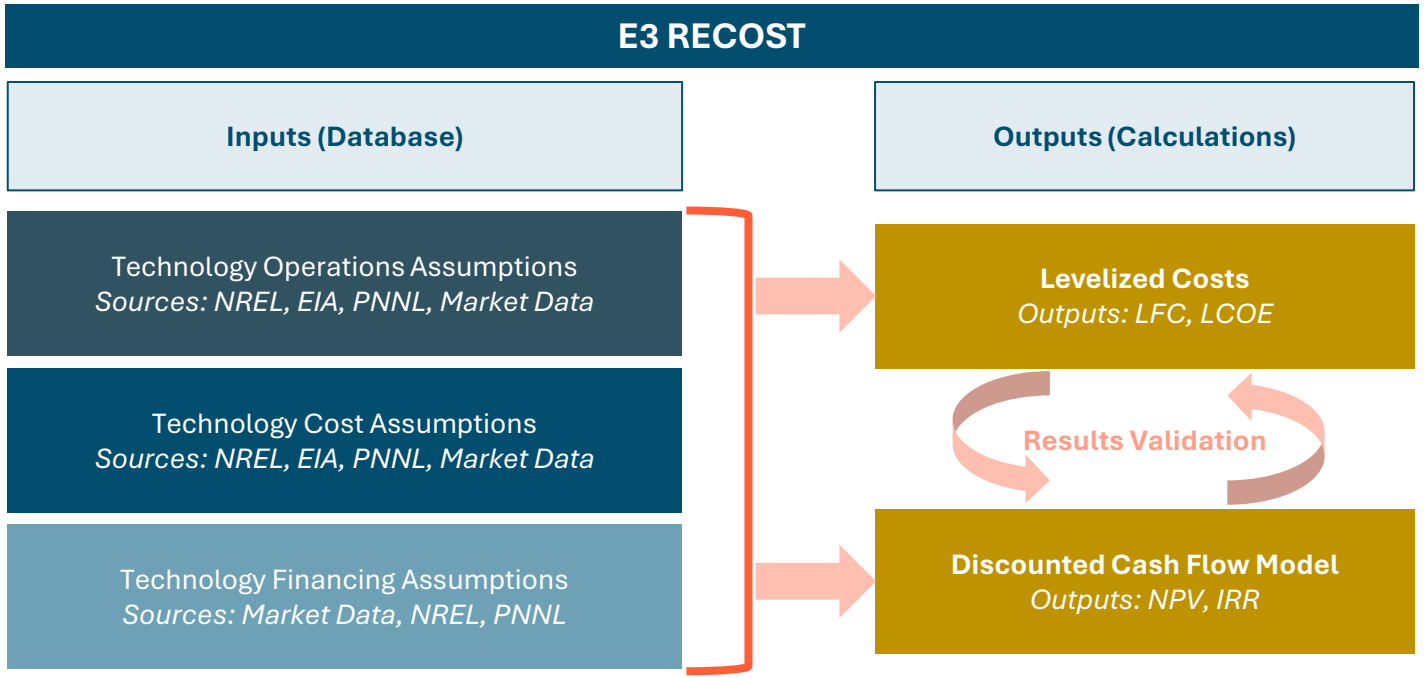
Recost is built to inform the ongoing debate around how to finance and build the resources necessary for the energy transition by leveraging E3's expertise on this topic



E3 Resource Cost Estimates

RECOST Model Overview

+ **E3's RECOST model calculates levelized fixed costs (LFC) and the levelized cost of electricity (LCOE) for a range of conventional and emerging technologies**
  - LFC is reported in $/kW-yr, and LCOE is reported in $/MWh
+ **LFC and LCOE are calculated by initial commercial operations date (COD), from 2025 through 2050**
+ **RECOST estimates are calculated using inputs from various sources:**



Calculation of Levelized Costs

RECOST Model Overview

+ **Levelized Fixed Cost (LFC) ($/kW-yr):** the levelized ***capacity*** payment that a system would need every operating year over its useful life to cover fixed costs, including amortized capital costs (capex), fixed operations and maintenance (O&M) costs, property taxes, and investment tax credits (if applicable)
  - This output is used to calculate Levelized Cost of Capacity (LCOC) by adjusting for Effective Load Carrying Capability
+ **Levelized Cost of Electricity (LCOE) ($/MWh):** the levelized ***energy*** payments that a system would need for every operating hour over its useful life to cover all costs, including fixed cost components as well as fuel costs, variable O&M, and the federal production tax credit (if applicable)
  - An electricity generator that collects revenue over its useful life at the LCOE will have an NPV of $0

$$\mathbf{LFC} = \frac{\mathrm{NPV}(\text{Fixed Costs}, \$)}{\mathrm{NPV}(\text{Capacity}, \mathrm{kW})}$$

Fixed Costs =
+ Capital Expenditures and Interconnection Costs
+ Investment Tax Credit
+ Fixed O&M
+ Property Taxes
+ Warranty
+ Repowering & Augmentation

$$\mathbf{LCOE} = \frac{\mathrm{NPV}(\text{Total Costs}, \$)}{\mathrm{NPV}(\text{Energy}, \mathrm{MWh})}$$

Total Costs =
+ LFC
+ Variable O&M
+ Fuel
+ Production Tax Credit

What is E3 RECOST?

Technologies Evaluated in RECOST

***RECOST** currently evaluates the following technologies, with the ability to modify any cost or operating parameter as appropriate:*

Biomass	Dedicated Biopower
Energy Storage*	1) Utility-scale lithium-ion battery storage 2) BTM lithium-ion battery storage 3) Pumped storage hydro (PSH) 4) Vanadium flow battery storage 5) Long-duration energy storage (LDES) technologies*
Geothermal	1) Hydrothermal (Flash, Binary) 2) Enhanced (Flash, Binary)*
Hydropower	1) New Non-Powered Dams (NPD) 2) Existing Non-Powered Dams
Hydrogen*	1) Production (electrolysis) 2) Storage 3) Transport 4) Conversion and combustion, including CCGTs, CTs, and fuel cells*
Natural Gas*	1) Natural gas combustion turbines (CT) 2) Combined cycle gas turbines (CCGT) 3) Reciprocating internal combustion engines (RICE) 4) CCGT new build and retrofit units equipped with carbon capture and storage (CCS)*
Nuclear*	1) Small modular reactor (SMR) units 2) Pressurized water reactor (PWR) units
Solar	1) Utility-scale solar photovoltaic (PV) systems 2) Commercial behind-the-meter (BTM) solar PV 3) Residential behind-the-meter (BTM) solar PV 4) Solar thermal systems
Wind*	1) Onshore wind 2) Offshore wind (fixed-bottom) 3) Offshore wind (floating)

** Includes emerging technologies evaluated by E3.*

Resource Cost Forecasts

RECOST: Q1 2025 Update

Energy+Environmental Economics

Rationale for Q1 2025 Update

E3 has updated our Resource Cost (RECOST) forecasts for selected resources to reflect material shifts in market data and policy environment:

- **Market data on resource costs continues to evolve rapidly, especially so for natural gas facilities, reflecting a variety of development constraints**
- **New federal government policy priorities and motivations require sensitivity analysis to require potential implications**
- **To reflect these changes, E3 is updating our resource cost forecasts to reflect the following:**
  - For natural gas plants (CT and CCGT): increase capital cost requirements to reflect more recent market estimates (see following slide)
  - Acceleration of Inflation Reduction Act (IRA) tax credit phase-out trigger year to 2032, shown in these materials as an impact on solar, onshore wind, and BESS technologies
  - Increase in utility-scale solar cost levels to reflect tariff impacts

Natural Gas Plant Cost Data

+ **Data used for the update of new gas plant costs shown here is drawn from a variety of utility, developer, market analyst, and market data aggregator sources, for plants both completed and approved or planned**
  - Utilities referenced below are NV Energy, NextEra Energy (FPL), and Wisconsin Electric Power Company
  - Independent Power Producers referenced below are Panda Power and CPV
  - Additional market data is shown for Morgan Stanley market research (via New York Times), and was validated by E3 in further discussions
  - Years for source data range significantly: earlier years are included to show how inflation has impacted historical costs, but more weight is given to more recent years of data
  - All data shown here is used to update E3's generic (i.e., USA-wide, national average) estimate of capital cost for gas plants; these costs are adjusted by RECOST for state-specific labor and land cost scalars
+ **This data is further supported by recent transactions that imply new build cost expectations greater than $2000/kW**
  - Historically (i.e., during the pre-Covid decade), acquisition costs for existing gas plants tended to aggregate around $500/kW while new build plants tended to represent costs of $1000/kW based on estimates at the time, implying a 2x ratio of acquisition costs to new build requirements
  - Constellation's acquisition of Calpine reflects an implied value of $1100/kW; a haircut of 50% from new build costs implies expectations of $2200/kW for new plants(1)
  - Blackstone's acquisition of Potomac Energy Center (VA) for roughly $1 billion implies a transaction value of $1300/kW, translating to implied new build costs of $2600/kW

New Gas Plant Market Data for 2025 Q1 Update

Item	*Units*	1	2	3	4	5	6	7	8	9	10	11
Owner / Dev	*name*	Panda	Panda	CPV	WEPCo	WEPCo	NVE	NEE	MS	WEPCo	S&P	S&P
Plant	*name*	Patriot	Liberty	Fairview	"Common"	"Common"	Valmy	Generic	Generic	Oak Creek	Various	Various
Capacity	*MW*	829	850	1,050			400			1775		
Tech		CC	CC	CC	CC	CT	CT	CC	CC	CT	CT	CC
Source Year		2013	2013	2017	2023	2023	2024	2024	2024	2024	2024	2024
Capex (2024$/kW)		$1,764	$1,655	$1,422	$1,496	$1,625	$1,433	$1,500	$2,000	$1,217	$1,025	$1,052

Average Capital Cost (2024$)	
CT	$1,325
CC	$1,556

Historical plants included to show impact of inflation
Group Average: $1,614/kW

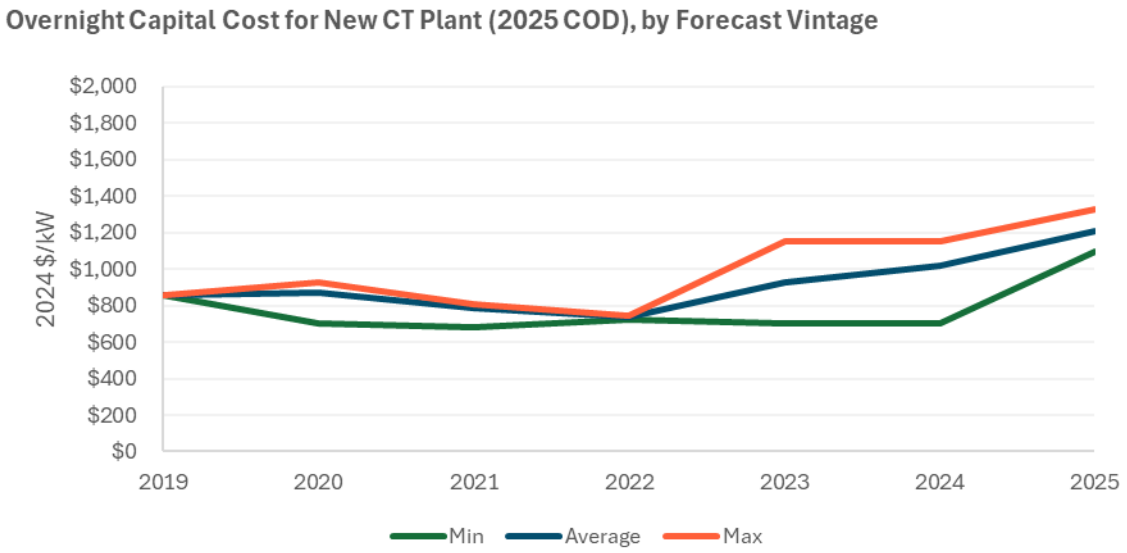
Plants completed in last 12 – 24 months, to show impact of recent non-inflationary cost drivers across examples; we would not expect plant costs to increase uniformly, and CC costs may not be increasing as much as CT costs
Group Average: $1,665 (CC) / $1,425 (CT)

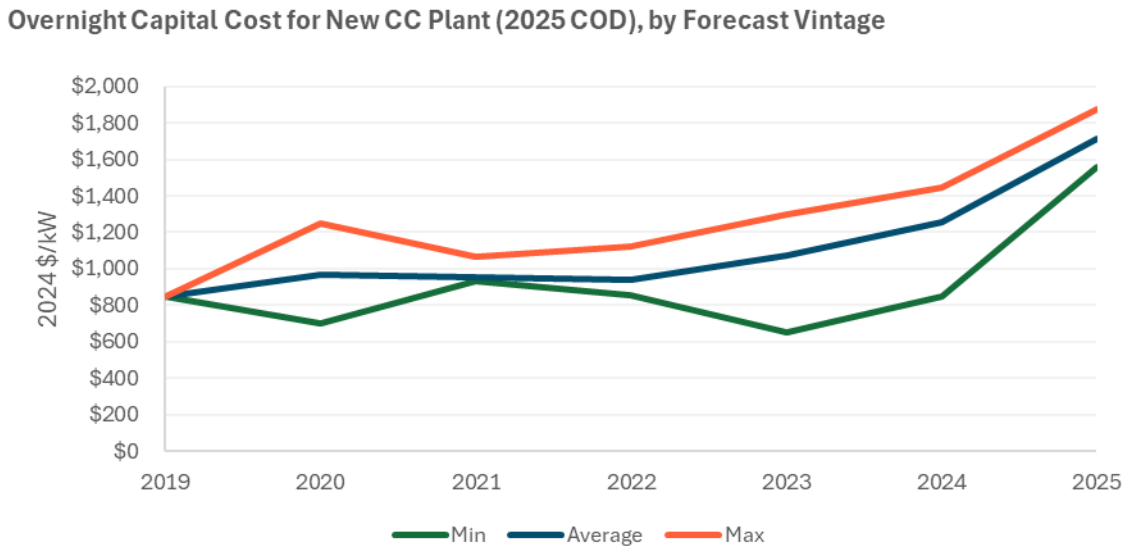
S&P plant cost dataset, reviewed to exclude duplicate data

(1) https://www.capitaliq.spglobal.com/apisv3/spg-webplatform-core/news/article?Id=87198138&KeyProductLinkType=2
(2) https://www.capitaliq.spglobal.com/apisv3/spg-webplatform-core/news/article?id=87251410&redirected=1

Historical Natural Gas Plant Costs

- **Overnight capital costs for new gas plants of various configurations have increased on average since 2022 across available resource cost estimates from NREL and EIA**
  - There is considerable variation across plant configuration, but the charts below illustrate data available for configurations identified as CT Frame; CC technology descriptions were less consistent across sources, and may therefore reflect more variation in configuration
- **Viewed from the perspective of a new gas plant reaching COD in 2025, E3's updated forecasts reflect the continuation of recent trends**





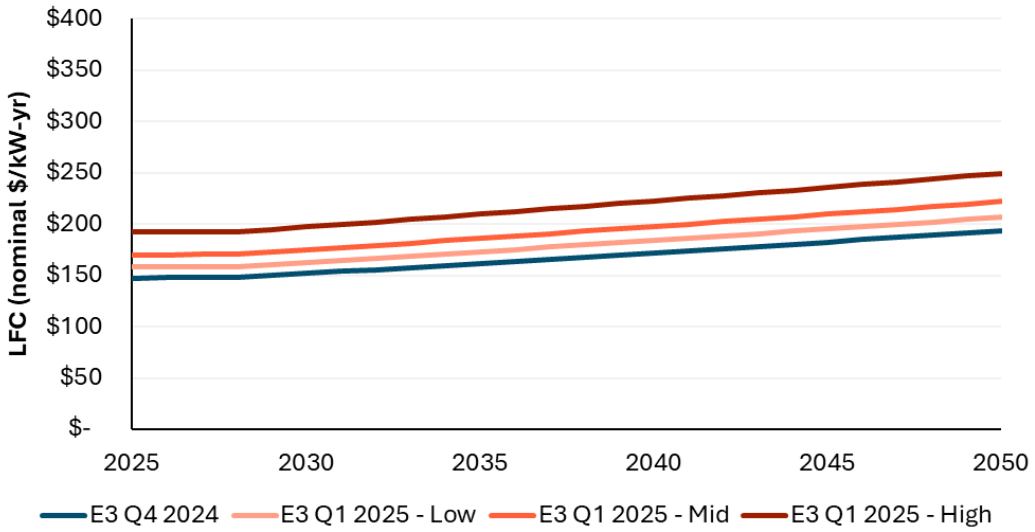
Note: Data from EIA AEO and NREL ATB reports collected for calendar years 2019 - 2024. Lazard references were consulted but not applied here because LCOE reports did not include forecast values.

Gas Plant Cost Details and Forecasts

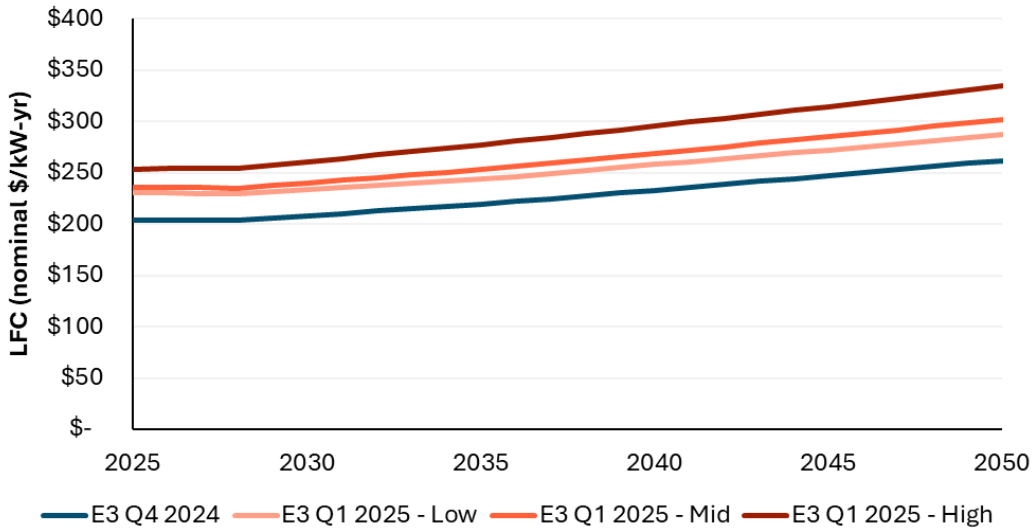
- Recent market evidence shows capital cost requirements for gas turbines increasing significantly
- E3 has adjusted forecasts to reflect more recent market estimates
- Gas CT and CCGT capital costs are increased by 30% relative to Q4 2024 estimates in E3's new "Mid" forecast, by 18% in the "Low" forecast, and by 43% in the "High" forecast; this reflects ranges across CT and CCGT plant capital costs obtained by E3, adjusted for inflation

Gas Capital Cost *2024 $/kW*	CT - Frame – F Class	CCGT – F Class
E3_Q42024 (Mid)	$929	$1,312
EIA	$929	$1,343
NREL	$1,172	$1,312
E3_Q12025 (Low)	$1,097	$1,556
E3_Q12025 (Mid)	$1,211	$1,710
E3_Q12025 (High)	$1,325	$1,878

Levelized Fixed Costs (LFC): Gas CT



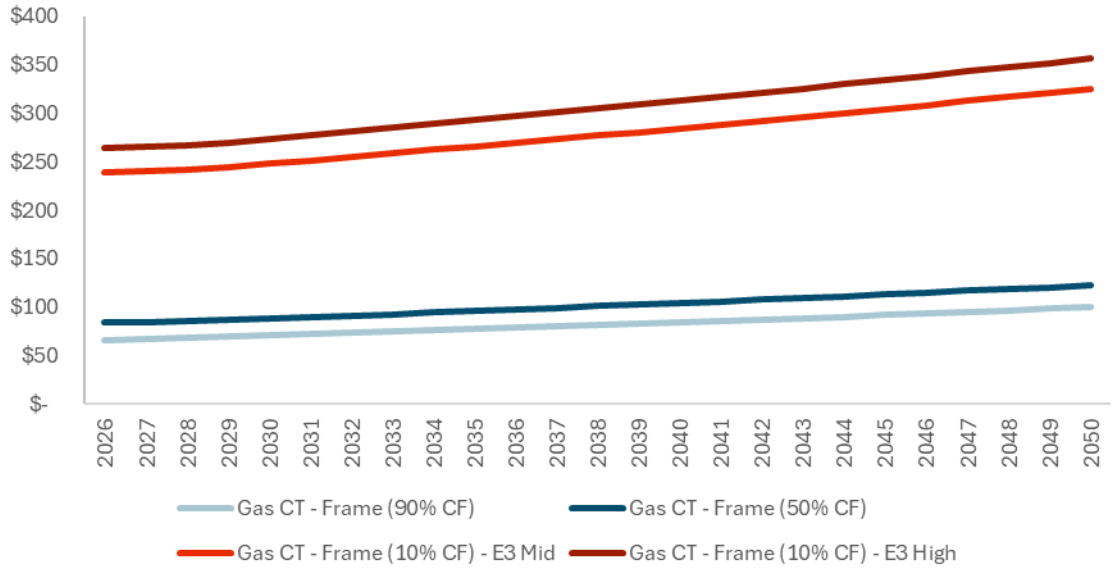
Levelized Fixed Costs (LFC): Gas CCGT



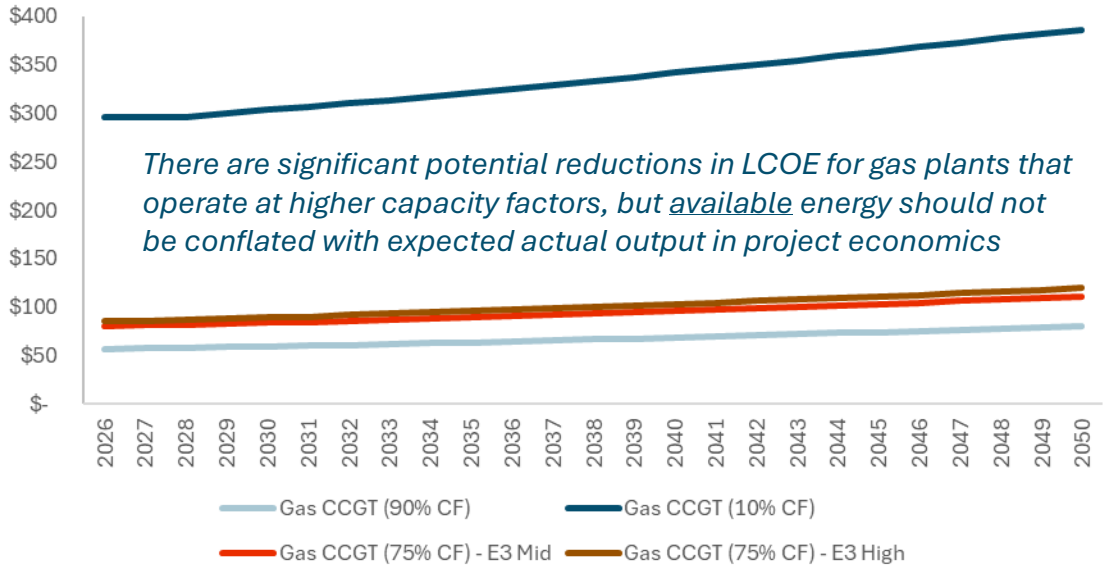
“Effective” LCOE for Gas Plants at Different Capacity Factors

+ **A common gap in understanding between resource planning entities and market participants is that the Levelized Cost of Energy should reflect the capacity factor at which a plant operates in reality**
  - For planning purposes, this mis-represents the available energy that a plant could provide in a least-cost portfolio that meets reliability standards
+ **While actual production is a critical metric for estimating and forecasting project cash flows, this distinction between available and actual production should not be lost in discussions of resource costs**
+ **Below is a comparison of gas plant LCOE using different potential capacity factors that a plant may realize in its actual operations, relative to a proxy availability factor of 90%**

RECOST LCOE Estimates for Gas CT (Frame)
Q1 2025, Mid Cost Trajectory, Generic U.S. Location



RECOST LCOE Estimates for Gas CCGT
Q1 2025, Mid Cost Trajectory, Generic U.S. Location



There are significant potential reductions in LCOE for gas plants that operate at higher capacity factors, but available energy should not be conflated with expected actual output in project economics

Solar Cost Details

- **E3 has updated RECOST to capture a likely but *conservative* increase in utility-scale solar cost levels due to tariffs**
- **This increase is reflected as 8% increase in module costs as a share of total capital costs for utility scale solar through 2028, based on AD/CVD analysis (CEA/ACORE, 2024)(1)**
- **In future RECOST updates, E3 will continue to explore potential tariff impacts on solar technology costs, as well as costs for other resources likely to be impacted (e.g., battery energy storage systems), as more information becomes available**

Solar Cost Impact From Tariffs

NREL ATB 2024 Cost Components, Utility PV Solar
https://atb.nrel.gov/electricity/2024/utility-scale_pv

		Base (2023)	Mod (2035)	Cons (2035)
Direct Capex	*$/Wac*			
	Inverter	0.06	0.06	0.06
	BOS Equip.	0.39	0.17	0.26
	Install Labor	0.30	0.09	0.14
	Installer Margin	0.13	0.10	0.13
	Module	0.50	0.33	0.41
	Subtotal	$ 1.38	$ 0.75	$ 1.00
Indirect Capex	*$/Wac*			
	Sales Tax	0.06	0.04	0.05
	Contingency	0.02	0.02	0.03
	Engineering / Dev Overhead	0.02	0.02	0.02
	Interconnection	0.04	0.03	0.03
	Land Prep / Transmission	0.02	0.01	0.01
	Permitting / Enviro Studies	0.02	0.00	0.00
	Subtotal	$ 0.18	$ 0.12	$ 0.14
Total	*$/Wac*	$ 1.56	$ 0.87	$ 1.14
	Module/Total	*32%*	*38%*	*36%*
Tariff Impact Sensitivity				
Tariff Increase	*c/W in module costs*	$ 0.13	$ 0.13	$ 0.13
Total w/ Tariffs	*$/Wac*	$ 1.69	$ 1.00	$ 1.27
	% change	***8.0%***	*14.4%*	*11.0%*

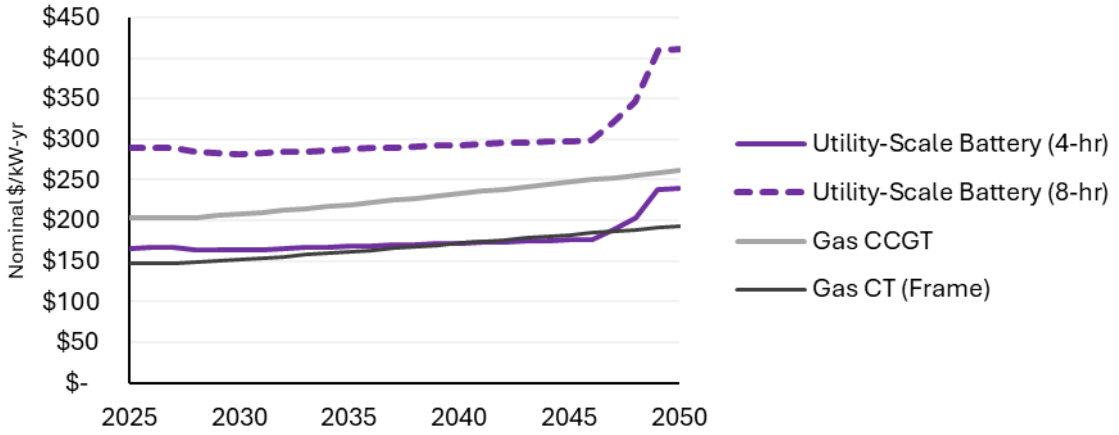
Sensitivity Value ↑

(1) https://acore.org/wp-content/uploads/2024/07/Potential-Impacts-of-2024-Antidumping-and-Countervailing-Duties-on-the-U.S.-Solar-Industry.pdf

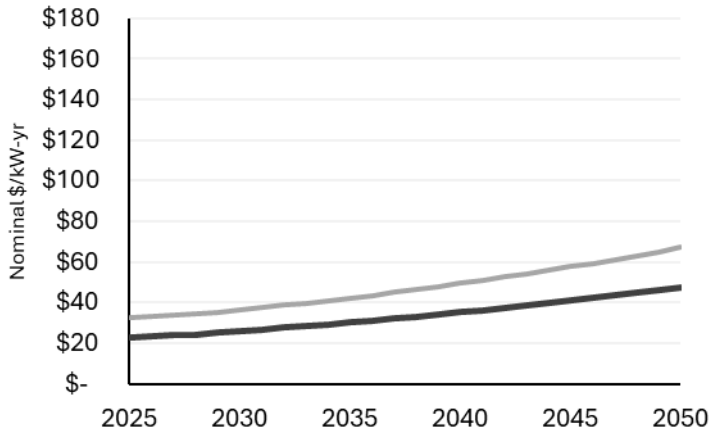
Q1 2025 Scenarios: Levelized Fixed Costs

- **Each scenario shown reflects only the *incremental impact* of the change identified in the chart title, relative to the E3 Q4 2024 estimate shown above**
- **Recent market data shows increases in capital costs for new gas plants, which drives LFC results higher for these technologies here**
- **IRA tax credit phase outs are critical to resource cost trajectories for all clean energy resources**
  - Assuming no tariffs apply specifically to battery storage, which has yet to be confirmed, IRA phase-out remains the most material risk to clean dispatchable energy storage

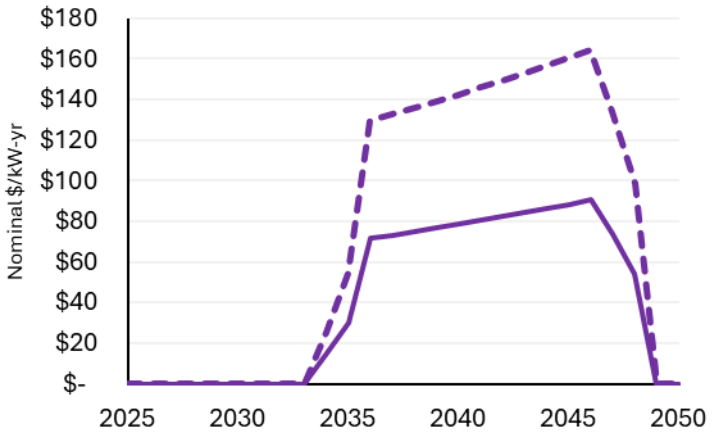
E3 RECOST: Q4 2024



Impact: Gas CT and CCGT Cost Increases



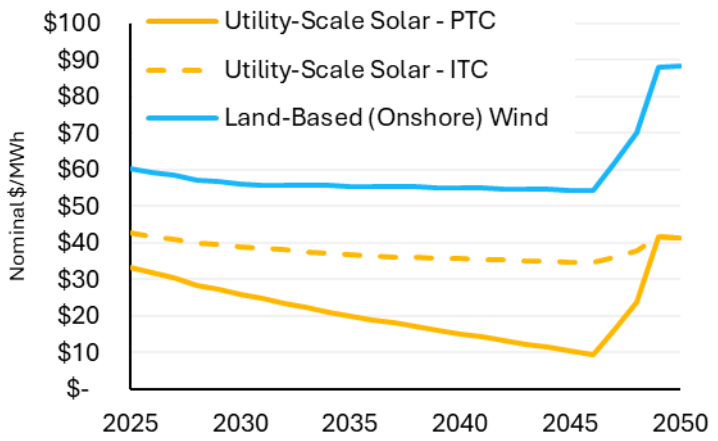
Impact: IRA Expiration Triggered in 2032



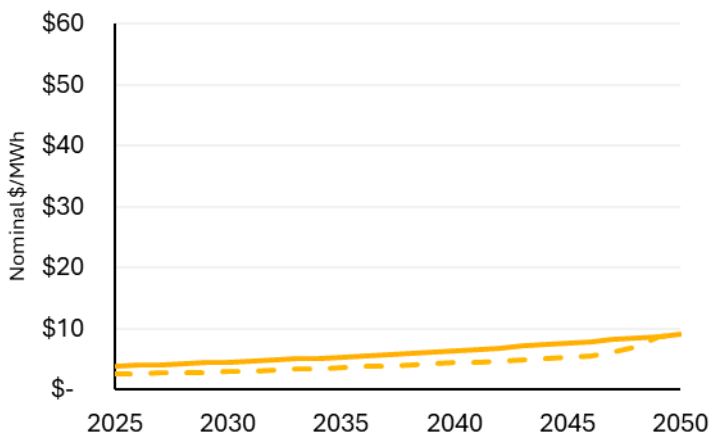
Sensitivity Scenarios: Levelized Cost of Energy

- **Each scenario shown reflects only the *incremental impact* of the change identified in the chart title, relative to the E3 Q4 2024 estimate shown above**
- **IRA tax credit phase outs are critical to resource cost trajectories for all clean energy generators, more so even than tariffs at assumed levels shown here**
  - While tariffs could increase levelized costs for new solar generators by ~8% immediately, IRA phase out would have a far larger impact on LCOE for new solar under current assumptions

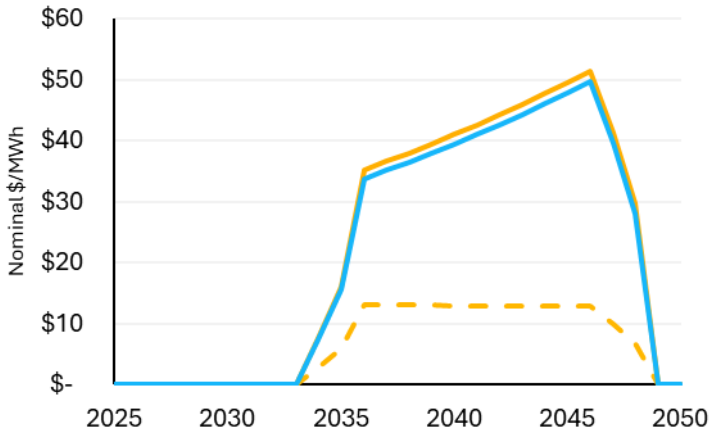
E3 RECOST: Q4 2024



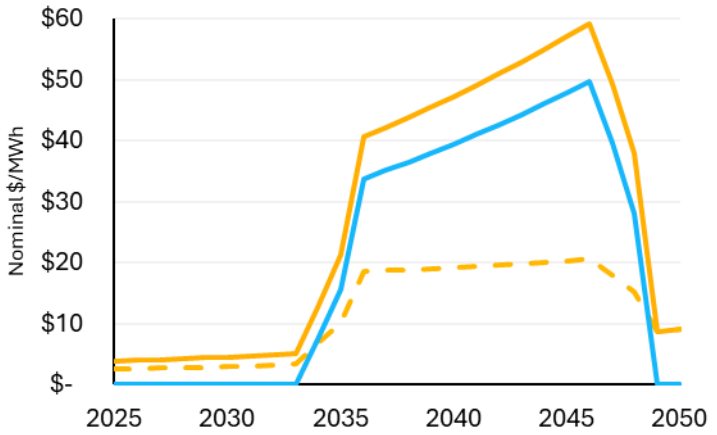
Solar Tariffs



IRA Expiration Triggered 2032

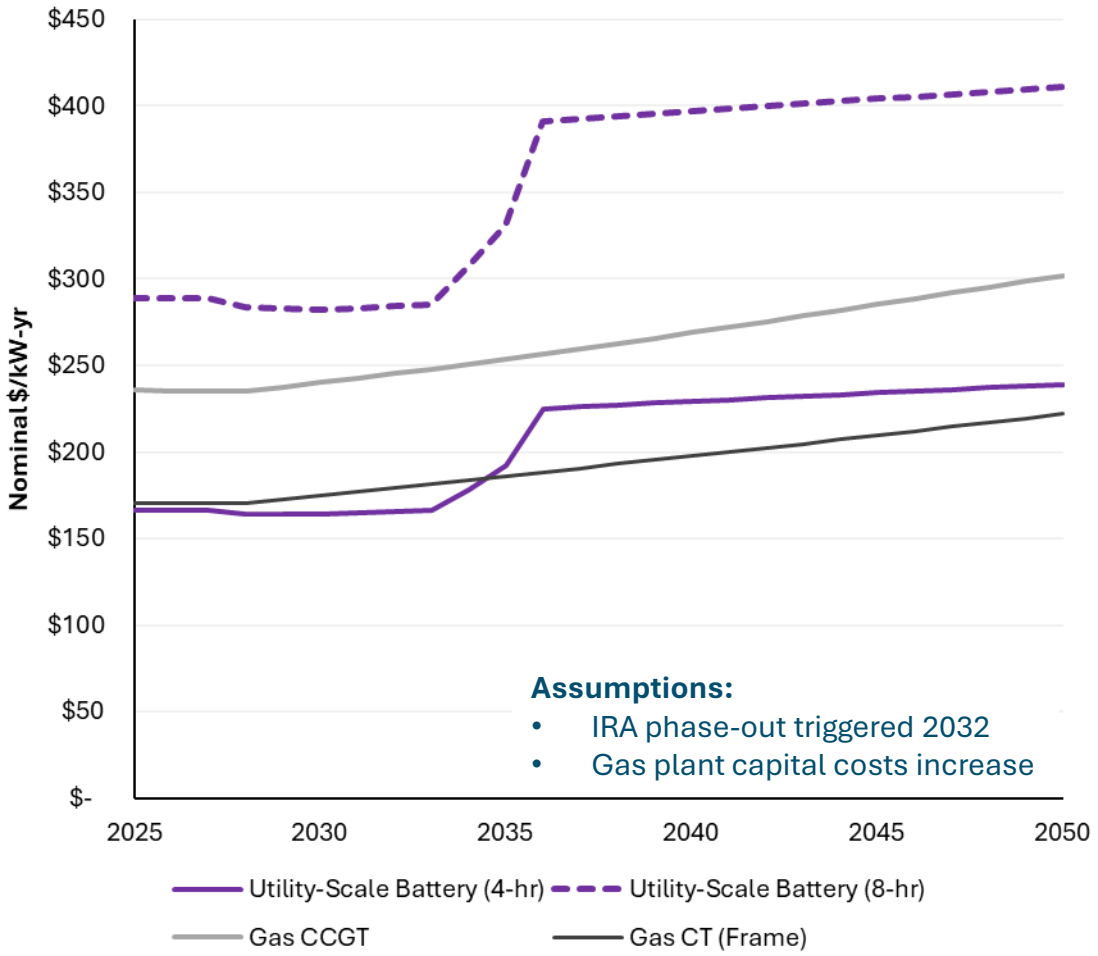


Solar Tariffs + IRA Expiration Triggered 2032

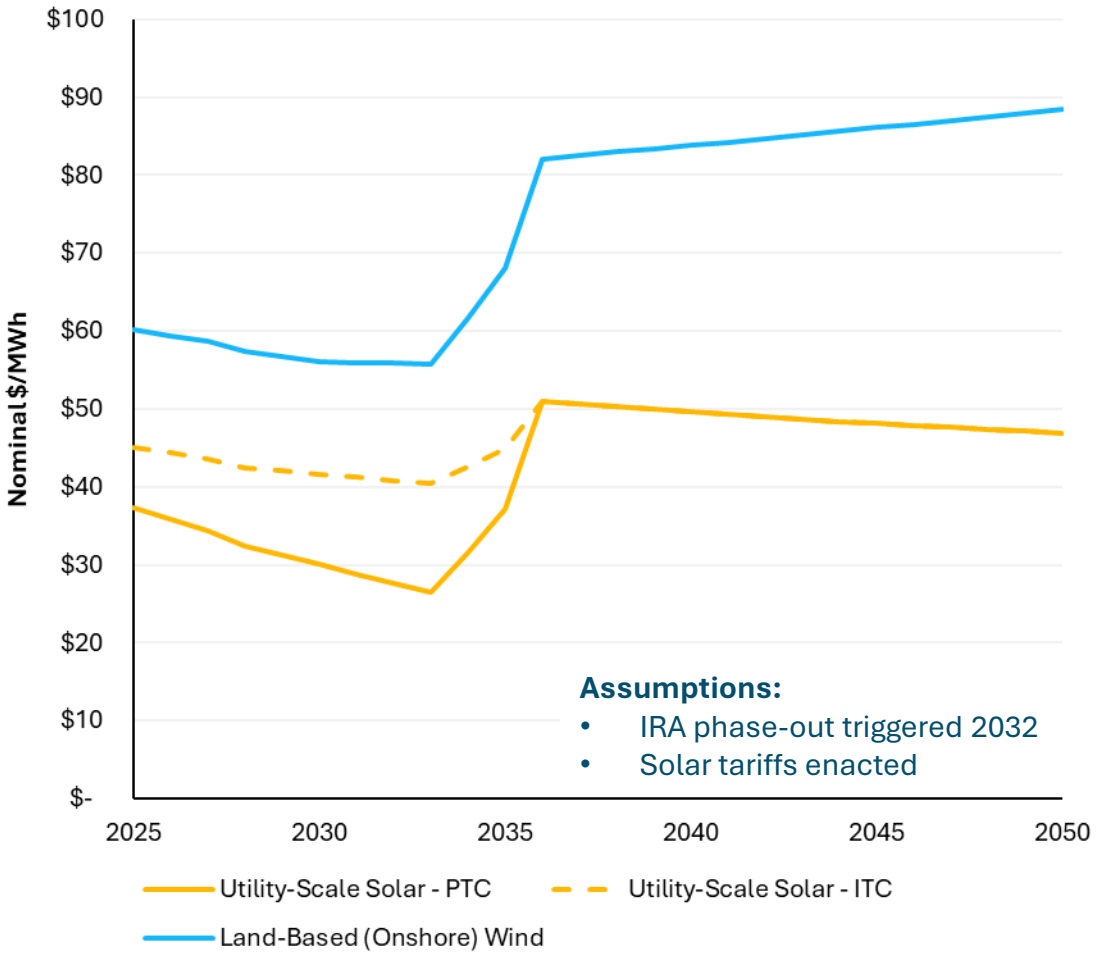


Final Results: Recost Estimates for Q1 2025

RECOST LFC Estimates for Selected Resources (Inclusive of PTC)
Q1 2025, Mid Cost Trajectory, Generic U.S. Location



RECOST LCOE Estimates for Selected Resources
Q1 2025, Mid Cost Trajectory, Generic U.S. Location



Effective Load Carrying Capability: RECOST Impacts

+ **RECOST forecasts the fundamental economic costs of a given resource, anywhere in North America**
  - These forecasts are agnostic to ELCC, and may be thought of as the price of 'perfect capacity' described earlier
+ **The capacity value of a resource as reflected under a capacity contract (e.g., Resource Adequacy in California) will be different for every system in North America**
  - ELCC reflects the capacity mix of the system to which the new resource is added as well as the load characteristics of the system, both of which will vary from market to market
+ **Therefore, E3 recommends calculating expected capacity payments for a given resource by applying an ELCC adjustment to the Levelized Fixed Costs shown in these materials**
  - Conversely, calculating the capacity cost in effective capacity term requires dividing the nameplate capacity by the ELCC input for comparability to other resources with higher and lower ELCC

For an energy storage resource where:
Nameplate Capacity = 100MW
State-Specific Levelized Fixed Cost (Recost Output) = 150 $/kW-yr
Resource- and Market-Specific ELCC = 80%

Expected Annual Capacity Payment = 100MW * 150$/kW-yr * 80% * 1000MW-per-kW = **$11.25mm, or 112.50 $/kW-yr**

and Levelized Cost of Capacity = 150$/kW-yr ÷ 80% = **187.50$/kW-yr**

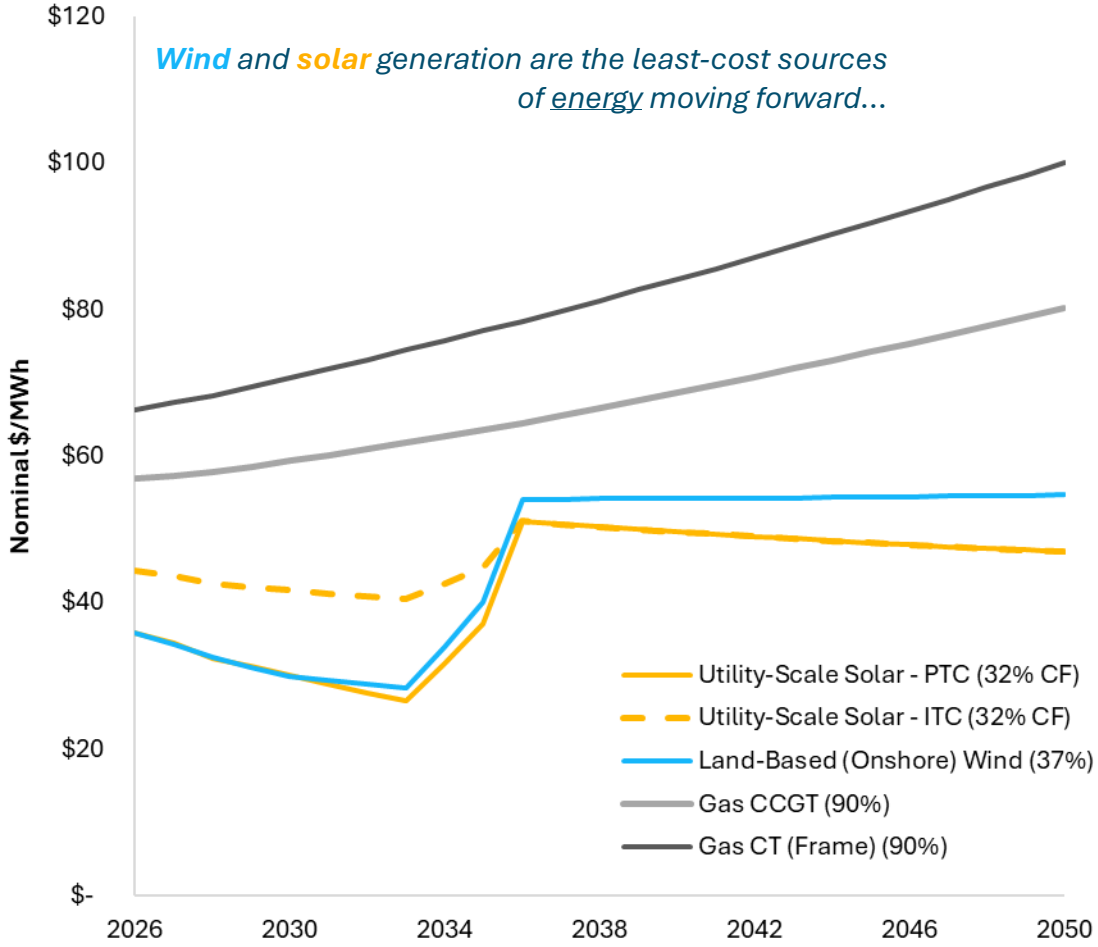
Note: Calculation above is simplified and excludes adjustments for additional contract terms (e.g., round-trip efficiency, operating deviation factors).

Resource Comparison: LCOE for Available Energy and LCOC

RECOST Forecasts: Q4 2024

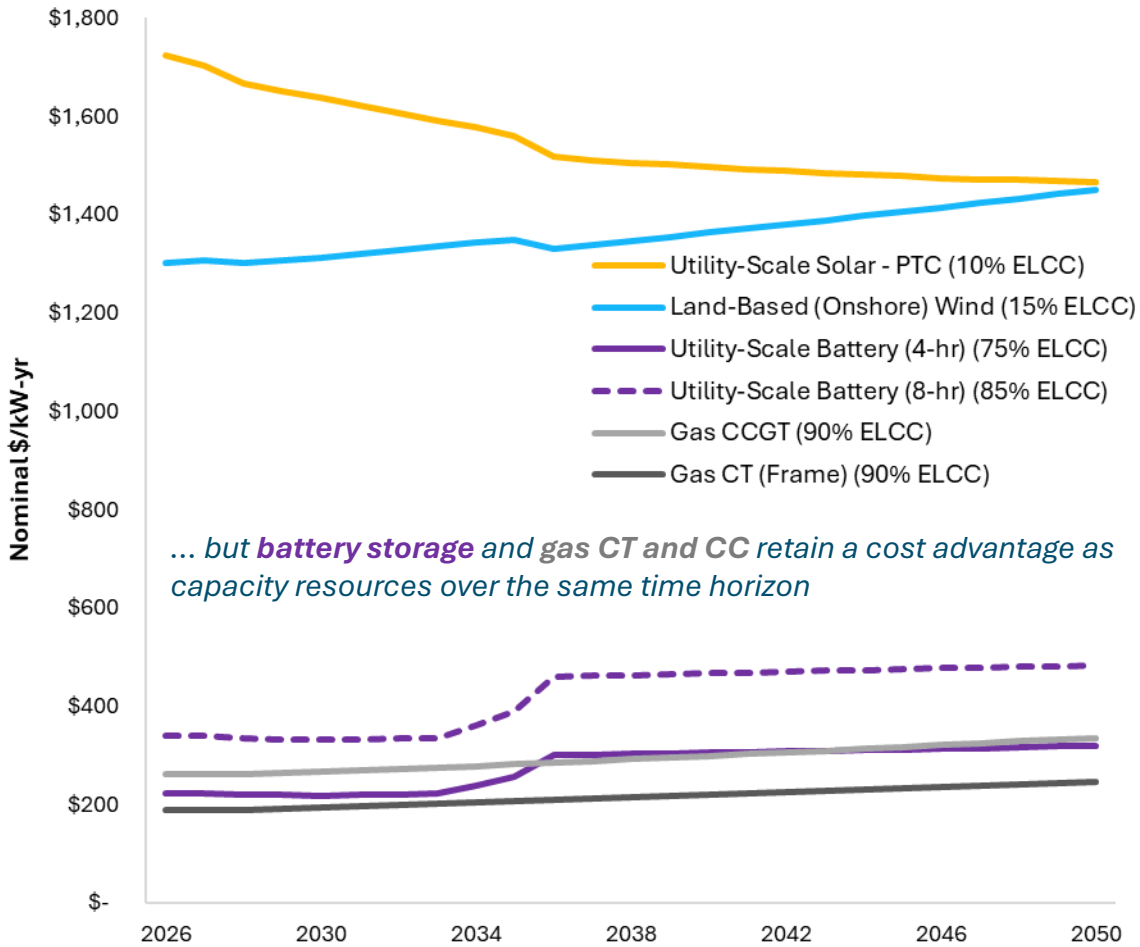
E3 LCOE Forecast

Nominal $/MWh of Available* Energy, Mid Cost Forecast



E3 LCOC Forecast

Nominal $/kW-yr of Effective Capacity, Mid Cost Forecast



* Available energy denotes the technical potential output of a project, without adjusting for congestion or curtailment (physical or economic). LCOC excludes energy revenues.

Stepping Back: What's in a Contract?

Levelized Costs Versus PPAs

+ **RECOST calculates the recovery of all project costs over the technical life of the project, discounted by a specified cost of capital and levelized over total project output (or capacity, for LFC)**
  - By default, IPP financing assumptions are used to calculate the cost of capital
  - Term (years) used for debt is always matched to PPA term, even though costs post-PPA are still captured in the final LCOE or LFC output
+ **It may not always be appropriate to compare levelized costs to PPA price offers, for a variety of reasons:**
  1) Market evidence is overwhelming that PPA term tends to fall below operating life over which levelized costs are calculated; LevelTen Energy estimates the average term length for solar and wind PPA offers in Q3 2024 at ~14 years
  2) PPAs typically recover less than 100% of project costs; the term for debt used to finance the project will not exceed the PPA term
  3) PPAs may be priced as an initial value that escalates over time, or as a flat nominal price for the contract term
  4) In any given year, for any given technology, a PPA will reflect the degree to which buyers versus sellers have greater pricing power, which are shaped in large part by factors exogenous to this analysis
     1) Supply chain cost shocks or improvements are typically not foreseeable in terms of exact timing
     2) Macroeconomic shocks such as inflation, and ensuing changes in the Federal Funds rate can lift or depress pricing dynamics
     3) Credit rating upgrades or downgrades can impact leverage potential and associated PPA pricing for reasons specific to the developer
+ **Even if we were to assume that economic life is equal to technical life, and the PPA will recover 100% of project costs, this does not mean that LCOE or LFC are equivalent to a PPA price: the quantity of energy or capacity guaranteed by a PPA does not need to be equal to technical (available) generation or capacity**
  - PPAs are often signed for a portion of plant output, either to facilitate multi-party contracting arrangements or because a developer is being conservative in their guarantees (or is forced into being conservative

Thank You

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Energy+Environmental Economics