

E3 Market Price Forecasting Service

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About E3





Technical & Strategic Consulting for the Clean Energy Transition





E3's expertise across our 5 practice areas gives us a unique perspective on the energy industry

- + E3's project scope and breadth is unmatched for a firm of its size. We complete over 250 projects a year across the energy sector, emphasizing electricity
- + E3's 30-year track record and extensive expertise across our 5 practice areas has informed the creation of the market price forecasting tool

Asset Valuation & Strategy

Determines asset values and strategies from multiple perspectives

Uses proprietary in-house models and in-depth knowledge of public policy, regulation and market institutions



E3 has five working groups which foster continual innovation in cutting-edge projects and best practices across the firm

Clean Energy

Provides market and policy analysis on clean energy technologies and climate change issues

Includes comprehensive and long-term GHG analysis



DERs & Rates

Analyzes distributed energy resources, emphasizing their costs and benefits now and in the future

Supports rate design and distribution system planning



Resource Planning

Develops and deploys proprietary tools to aid resource planners

Informs longer-term system planning and forecasting



Market Analysis

Models wholesale energy markets both in isolation and as part of broader, more regional markets

Key insights to inform system operators and market participants





Industry Trends: Uncertainty + Transformational Change



Key trends are changing the U.S. electricity sector, with uncertain results





The future electric system will be defined by widespread deployment of low-cost renewables

 Widespread deployment of variable renewable resources requires fundamental shifts in system planning and operations. System operators must answer two critical questions:

How many MW of <u>dispatchable</u> resources are needed to (a) meet load and (b) meet flexibility requirements at various time scales What is the <u>optimal mix</u> of new resources (renewables, storage, thermal) to (a) achieve policy goals and (b) meet reliability requirements at least cost?

+ However, this will create challenges at high penetrations due to

- Renewable oversupply during low load periods
- Inflexible conventional generation such as must-run resources; technical constraints on ramping, stable levels, up and down time; and high costs associated with frequent cycling
- Small balancing areas or constrained interactions with neighboring regions
- Research and industry attention has shifted to focus on grid integration solutions such as storage, flexible loads, and more interconnected markets



We have seen California's markets begin this evolution in the last 7 years

The impact of lower gas prices and renewables build out in recent years has already resulted in negative prices







Source: CAISO, E3 Analysis; note that solar generation does not include rooftop solar

Increasing solar and renewables penetration creates mid-day overgeneration and curtailment, leading to \$0 or negative prices during many daytime hours in recent years

This increases the spread of energy prices and calls for generation with fastramping capability

Thermal generation has been falling, pointing to the importance of capacity payments for many existing resources



- Market prices that are zero or negative are not outliers, but a daily occurrence in most seasons
 - Different generator classes have different economic propositions and incentives
- + Electricity system costs are dominated by fixed costs; resources are likely to recover costs outside of energy markets
 - Capacity payments, <u>especially for emissions intensive reliability resources</u>, become more important
- + The rules around regional interactions may completely change what market prices look like
 - What do prices look like in linked markets with different policy mechanisms in place? How does price formation occur with Washington's CES, CA SB100 + carbon price and Oregon TBD policy?
- + The disconnect between wholesale market prices and current retail rate regimes may become starker
 - How can <u>DER and wholesale resources be co-optimized</u>?



Our Approach to Building Better Price Forecasts





We Believe in Unrivaled Transparency and Flexibility.

Transformational change across North America's electricity markets is making traditional forecasts increasingly irrelevant.

Traditional Forecasting Paradigm

- + Gas prices are primary driver
- + "Black Box" Forecasting:
 - Multi-variate regressions force short-term relationships to predict long-term trends
 - No clear narrative or predictability for systemic step-changes in grid operations and prices from high renewable integration

+ Static Predictions:

• Focus on commodity trends and near-term market impacts

E3 Methodology

+ <u>Policies</u> are the primary driver of investments, loads, and future prices

+ Transparent Forecasting:

- All inputs/outputs available on as granular basis as necessary, i.e. hourly or sub-hourly, pre/post E3 processing steps, etc.
- Fundamentals-based production cost modeling connects the dots between policies, retirements, builds, and prices
 → clear narrative of causes + effects

+ Flexible Scenarios:

 Integrated policy + market scenarios capture interrelated dynamics of policy attainment or failures

Forecasts Built from 30 Years of 360° Experience

Reliability, Resource Costs and Renewables Megalion

Low Carbon Fuels

Technologies

Climate

E3 has been creating customized Person of the second se electricity price forecasts for clients for many years...

We now offer a standalone market outlook and price forecast built on:

- **30-year track record**
- 360° industry view
- **Deep knowledge and leading** + insights from all E3 practices:
 - Asset Valuation
 - **Resource Planning**
 - **Climate Pathways**
 - Markets + Regulation
 - **Distributed Energy Resources**

Asset Valuation

Transaction Support for **Billions in Deployed Capital** **Narkets**

Oistributed Energy

Solar and Storage

Electric Vehicles

360-view ensures forecasts are balanced. data-driven, and realistic



augmented by proprietary E3 data and tools from all practice areas

Economy-Wide GHG Policies + Pathways

Pathways



+ Based on E3's vast internal expertise and industry-leading IP

 E3's market price forecasting tools were developed in-house and lean on our expertise in the electricity industry, such as highly renewable energy systems, market design, electrification, storage and DERs.

+ Used by a wide variety of clients across the industry for many different uses

• E3 market price forecasts have been used by some of the biggest players in the industry for things as diverse as renewables purchasing strategy to asset valuation.

+ Built with transparency at the core

• E3 does not believe in the "black box" mentality and we are transparent and open when it comes to explaining our analyses. We are happy to provide inside-the-box explanations of drivers and results and work with you to answer your questions and explain our process.

+ Are the only price forecasts that are policy-driven

- U.S. electricity markets currently exhibit a historically high degree of uncertainty, driven by fundamental policy and technology changes that are rapidly evolving and hold the potential to transform price formation and push the limits of existing market constructs.
- E3 is the only one to take this into account by building policy scenarios as the cornerstone of our price forecasts.



Forecasts are designed to be a robust standard for fundamental asset value and a trusted tool to guide strategy, planning, and investment

Developers

- + Prioritize development opportunities
- + Define market entry strategies
- + Identify contracting strategies
- + Secure third-party funding

Investors + Lenders

- + Clearly identify risks & revenue drivers
- Define floor-toceiling value with integrated market & revenue scenarios
- Investment-grade analysis with a track record of financed projects

Utilities + Offtakers

- + Evaluate procurement & contracting options
- Inform planning & strategy with E3's IRP and regulatory expertise
- + Leverage E3's insights for DER, electrification, and system reliability

Policy-driven Scenarios Capture Different Trajectories for Systemic Change

- + US electric markets currently have a historically high degree of uncertainty, with fundamental policy and technology factors that are rapidly evolving and interacting in ways that affect prices
- + E3 is the only one to offer market price forecasts that are policy-driven
- + E3's approach combines
 - E3's market insight from detailed analysis of long-term fundamentals and cutting-edge research
 - Scenario-based approach that is essential for understanding the impact of these uncertainties.
- + Scenario-driven analysis allows for rapid testing of price sensitivity to a range of futures

	Low Policy Achievement	Base Policies	High Policy Achievement
Policy	Intermediate policy targets are met, but decarbonization and RPS deployment does not achieve long-term goals on schedule.	Existing intermediate and long- term policy targets are met on schedule.	Higher RPS or GHG-reduction policies are implemented with greater regional coordination.
Load Growth	Load growth is driven only by existing trends.	Loads reflect economically realistic levels of energy efficiency and electrification given policy.	Loads reflect more ambitious levels of energy efficiency and electrification given decarbonization policies.
Regional Alignment	Jurisdictions pursue policies independently without much coordination.	Similar jurisdictions align carbon policy (e.g. coordinated carbon policy for CA, WA and OR).	Similar jurisdictions align carbon policy (e.g. coordinated carbon policy for CA, WA and OR).

 Sensitivities can be constructed from each core scenario by changing gas and carbon price trajectories, technology cost and capacity credit assumptions, or policy enforcement mechanisms (RPS vs. GHG)

Scenario-based Production Cost Simulation for Hourly Day-Ahead Energy Prices



RECs, Capacity Prices, AS Prices, and RT Prices are all generated using DA energy prices as an input to ensure alignment with fundamentals.

In-House Electrification Load Modeling Using E3's Proprietary RESHAPE Tool

- Load growth is driven by electrification of buildings and vehicles and varies by scenario
- + Building loads based on
 - Building profiles
 - Weather
 - Growth and efficiency
 - Heat pump attributes and adoption rates
- + EV load models flexible and inflexible EV charging load in all scenarios
 - Heavy and medium-duty vehicles (HDV and MDV) modeled as inflexible throughout the run horizon
 - Light-duty vehicles (LDV) charging flexibility grows over time with technology and EV penetration



Policy Scenario

Renewables Scenarios



Load flexibility (TWh)





E3 Post Processing



Our Forecasts vs. Competitors (Illustrative)

Comparing against other market forecasts, divergence is apparent

- Many other forecasts projects higher energy prices with similar historical patterns
- E3's higher renewable scenarios shows potential for significantly lower average prices ^{\$40} which could be offset with higher electrification loads and other fundamental system changes ^{\$35}
- Even if averages converge, daily and hourly shapes are very different where volatility increases with increasing renewables





E3 Energy Price Forecast, 2019-2030 (\$/MWh)





Our Partnership with cQuant.io



- Production cost modeling reflects systemic changes in generation mix
- Integrated policy scenarios include RPS/GHG trajectories, distributed resources, electrification, and EVs
- Energy, AS, and capacity forecasts reflect evolving market rules and price formation dynamics

Best-in-class stochastic modeling and simulation

cQuant.io

- Advanced, layered modeling approach captures real-world, nonstandard distributions in intra-day, monthly, and seasonal dynamics
- Cloud-based platform provides easy, flexible access to models and results

cQuant Nodal Price Simulations





cQuant Simulation Results

- + Capture seasonal, hourly, and sub-hourly trends in expected price and uncertainty.
- + Account for hub-to-node basis spreads.
- + Accurately reflect negative price dynamics.
- + Expected price by month and peak period with sub-monthly spot price dynamics.
- Probability-weighted scenarios to support distributions of value and risk.









Our Offerings: Market Forecasts + Support Services



E3 offers the following as part of the market price forecasting service:

Outputs for three core scenarios (2020-2050)	 Day Ahead energy prices Real-time energy prices Ancillary services prices 	 Capacity / RA prices (includes resource specific ELCC curves) Hourly zonal curtailment 	
Sensitivities	 Gas, carbon, and load growth scenarios Resource costs and performance, transmission or model topology 	•Other custom sensitivities available on demand	
Market Report	 Detailed assumptions and modeling approach Analysis and commentary on long-term trends and market dynamics 		
Optional Support	 Expert support from our senior staff to defend forecasts General analysis, consulting and engagement support Revenue forecasting on an individual asset or portfolio level 		
Bi-Annual Updates	 Comprehensive global refresh in January Semi-annual update in June/July 		

National Coverage, from West to East

Now Available:

+ WECC

- CAISO
- Pacific NW
- AZ, NV, CO, NM, UT, WY

+ ERCOT

 All four zones (Houston, North, South, West)

Coming Fall 2020: + PJM, NYISO, ISO-NE



Source: FERC

For other markets (SPP, MISO, AESO, IESO) and vertically integrated regions such as TVA and Florida, we provide customized forecasts upon request



Additional Services

Strategy

- Market Entry + Go-to-Market
- Investment Strategy
- M&A, Partnerships, and Corporate Strategy
- Business Case / Competition
 Landscape
- Regulatory Strategy

Project Development

- Project Screening
- Site Selection
- Design + Technology Selection
- Offtake / Contracting
- RFP / Bid Support

Asset Value

- Asset operations
- Revenue projections
- Terminal value assessment
- Policy and regulatory analysis
- Contracting analysis
- Curtailment analysis
- Risk analysis

Expert support,

from Big Picture to Bottom Line.



Forecast packages starting at \$20k. Please contact us for details.

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Appendix: Illustrative Outputs



Illustrative Near-Term California Prices











Illustrative Near-Term New York City Prices





Fast forward to 20XX in New York City



Energy+Environmental Economics

Changing Resource Mix in Texas

- As solar economics drive increasing penetration, storage additions will likely follow
- Storage economics will be driven by opportunity to charge during lower-priced midday hours and discharge to meet evening peaks

350.0 ■ Coal ■ Gas ■ Nuclear ■ Oil ■ Other 300.0 Hydro Wind Solar Storage 250.0 200.0 NS S 150.0 100.0 50.0 0.0 2025 2030 2035 2040 2045 2050

ERCOT Nameplate Capacity, 2025-2050 Illustrative E3 Scenario



Modeled Storage Charge-Discharge Patterns in ERCOT

Illustrative Storage Revenues in CAISO

- + Revenue trajectories can vary significantly based on policies, prices, operating profile, siting, and market dynamics
- We create detailed revenue scenarios to present the envelope of value based on assetspecific inputs under a range of outcomes



Example Battery Operations



Example Revenue Trajectories



 Example projected annual revenue for CCGTs, CTs, and large CHPs based on E3 market price forecasts and its in-house generation asset dispatch model

Average Energy Margins by Plant Technology: E3 Modeled Backcast and Forecast \$/kW-yr



Illustrative solar- and wind-weighted price outputs and REC price implications

- Solar value changes rapidly in future, increasing/declining from \$XX/MWh today to \$XX/MWh in the 20XX-20XX timeframe
 - Future value driven increasingly by generation in xxx hours and seasonally in the xxx months
- Wind value increases/declines from \$XX/MWh today to \$XX/MWh in the 20XX-20XX timeframe
 - Load growth and large baseload thermal retirements changes wind's value over time along with carbon pricing (if applicable)

Solar-Weighted Energy Value vs. LCOE

	2018	2025	2030	2035
Solar LCOE (34% CF)	\$27.75	\$27.83	\$25.34	\$24.41
Solar-weighted energy value	\$XX.XX	\$XX.XX	\$XX.XX	\$XX.XX
Residual cost	\$XX.XX	\$XX.XX	\$XX.XX	\$XX.XX

Wind-Weighted Energy Value vs. LCOE

	2018	2025	2030	2035
Wind LCOE (38% CF)	\$27.38	\$37.98	\$35.57	\$34.57
Wind-weighted energy value	\$XX.XX	\$XX.XX	\$XX.XX	\$XX.XX
Residual cost	\$XX.XX	\$XX.XX	\$XX.XX	\$XX.XX