

California ISO Market Price Forecast E3 Core Case

2023 edition



Energy+Environmental Economics

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Disclaimer

E3 created the following forecasts and analyses using the best available public information and our expertise and knowledge of the relevant markets, along with commercially available 3rd party software models and proprietary in-house energy market price forecasting tools. However, the future is uncertain, and these forecasts (along with underlying market expectations) may change due to many factors, including unforeseen events, new technology adoption or inventions, new market structures, regulatory actions, and changes in both state and federal government policies. E3 makes no guarantees related to these forecasts or the information presented herein and should not be held liable for any economic damages associated with independent investment decisions.



+ Executive Summary

+ Market Overview

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- Historical AS Prices
- Resource Adequacy
- Future Market Changes

+ E3 Forecasting Approach

+ E3 Modeling Assumptions

+ E3 Forecast Results: 2024-2050

+ Appendices

- Inflation Reduction Act (IRA)
- September 2022 Recent Reliability Events in CA
- Modeling Electrification Loads



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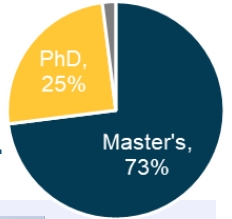
Executive Summary



Who is E3?

Thought Leadership, Fact Based, Trusted.

110+ full-time consultants | 30 years of deep expertise | Engineering, Economics, Mathematics, Public Policy...



San Francisco



New York



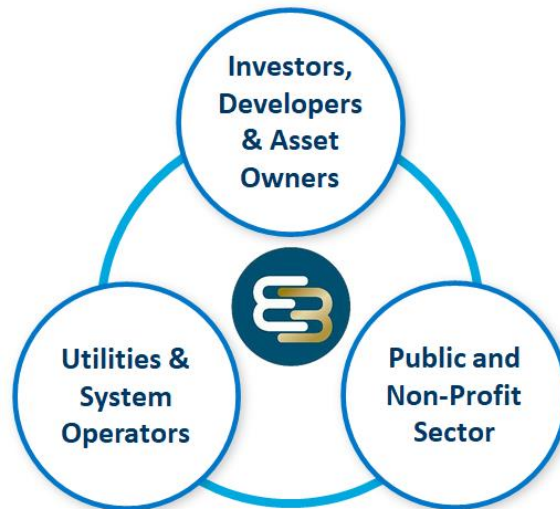
Boston



Calgary

E3 Clients

350+ projects per year across our diverse client base



Recent Examples of Relevant E3 Projects

Buy-side diligence support on several successful investments in **electric utilities** (~\$15B in total)

Supporting investment in several **stand-alone energy storage** platforms and individual assets across North America (15+ GW | ~\$5B)

Acquisition support for several portfolios and individual **gas-fired and renewable generation assets** (20+ GW | ~\$5B)

Acquisition support of several **electric vehicle infrastructure companies** (~\$500M)

Strategic advisory support for a SPAC offering of a **distributed energy resource aggregation software company** (~\$1.3B)

Supporting an investment into an **electric vehicle V2G software company** (~\$750M)

Buy-side diligence support to acquire several **residential and C&I solar portfolios** (~1+ GW | 200,000+ customers)

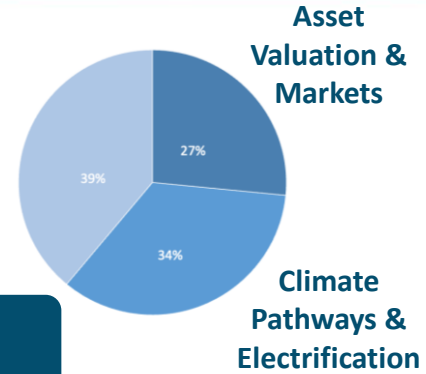
Supporting investment in over 5+ GW of **community solar and distributed energy resource projects**



E3's 3 Practice Areas

+ E3 has organized itself across three main practice areas to maximize its impact through the diversity of clients, project work, and technical innovation to support the energy transition across North America in a holistic, transparent, and intellectually honest manner.

Integrated System Planning



Climate Pathways & Electrification

- Climate pathways studies
- Future of gas
- Low carbon fuels
- Building electrification
- Transportation electrification
- Load forecasting



Integrated System Planning

- Integrated system planning for electricity: G, T, & D & non-wires alternatives
- Utility procurement
- Rate design
- Grid modernization
- Avoided costs
- Distributed resource planning



Asset Valuation & Markets

- Asset valuation and due diligence
- Strategic advisory for commercial clients
- Energy market price forecasting
- Market design & analysis
- DER dispatch & asset optimization

Policy

Integrated Energy Planning

Commercial Interests



E3 Work in California

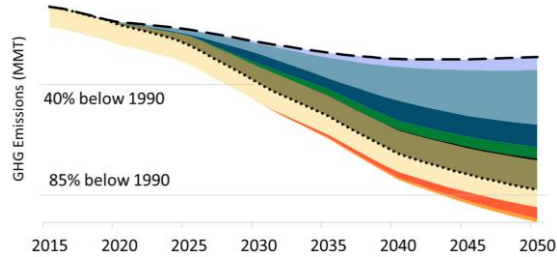
- + E3's experience with such a broad range of industry participants in California gives us an unparalleled understanding of policies, regulations, stakeholder interests, market dynamics, contract structures, and the competitive landscape
- + E3's work originated in California over 30 years ago and has covered a wide range of topics and clients. We not only understand the current market but have thought extensively how the market may change over the short, medium, and long-term from a holistic, transparent, and intellectually honest perspective
- + Previous versions of this forecast has been used by a wide range of market participants and stakeholders to support market strategy, project development, and major capital investment decisions valued in the many tens of billions of dollars across a diverse set of energy asset classes and mandates
- + **Specific examples of E3's recent work in the region include:**
 - California Public Utility Commission IRP, and specifically the development of the Preferred System Plan, which directs near-term new resource procurement in the state
 - Work with utilities across WECC on performing a benefit-cost analysis for expanding CAISO's extended day-ahead energy market, influencing the evolution of not only CAISO but also the broader WECC region's electricity markets
 - Revenue forecasts for the long-term value of battery storage assets in CAISO for project financing and tax equity investments
 - Revenue forecasting and offtake assessment for offshore wind in CAISO for a leading offshore wind developer
- + **E3 has actively supported dozens of developers, investors (infrastructure funds, private equity, lenders, and tax equity), and technology companies on storage, renewables, hydrogen production, and transmission**



E3's Comprehensive and Best-in-Class Modeling Toolkit is Designed to Analyze a Decarbonized Energy System

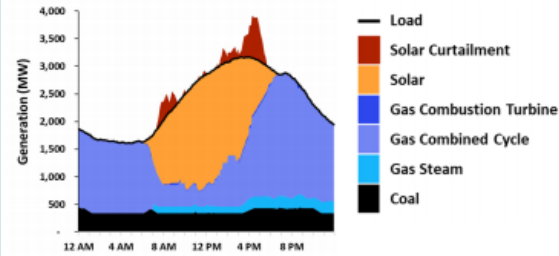
PATHWAYS

Economy-wide accounting of energy supplies and demands under deep decarbonization scenarios



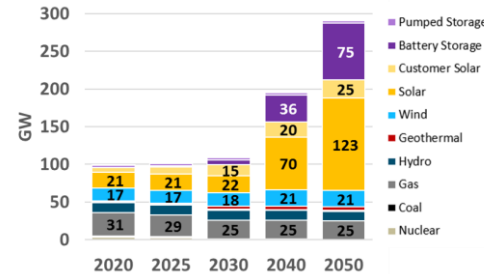
Production Simulation (PLEXOS)

Detailed operational simulations of system dispatch and flexibility needs



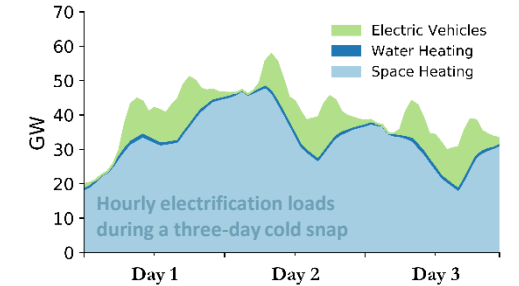
RESOLVE

Optimal capacity expansion model for electric systems



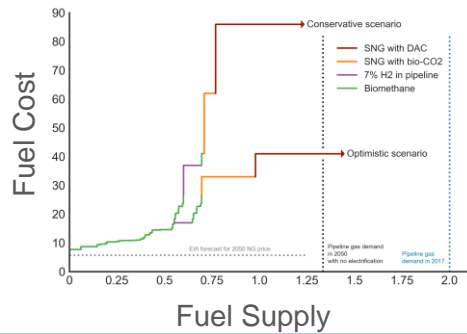
RESHAPE & EVGrid

Hourly simulations of electric loads for specific end uses



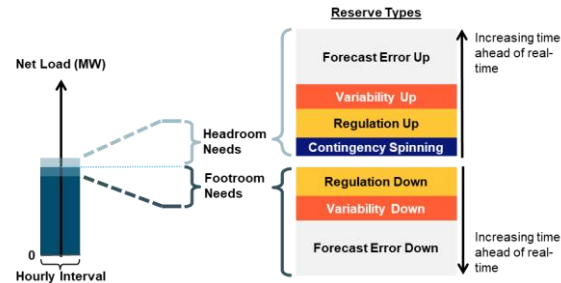
Low-Carbon Fuels and Future of Gas

Role of fuels in deep decarbonization



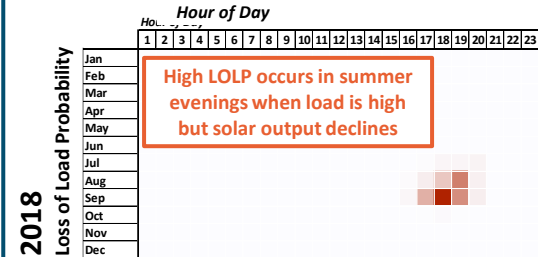
RESERVE

Dynamic operating reserves for renewable integration



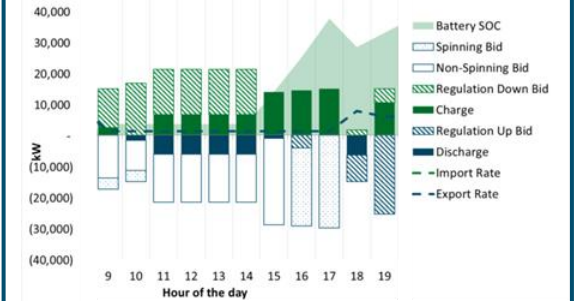
RECAP

Loss of load probability simulation to measure resource adequacy



RESTORE & IDSM

DER Toolkit for optimizing DER value stacking opportunities and adoption



Economy-wide energy systems

Bulk grid power systems

Grid edge & behind-the-meter



Asset Valuation & Markets Practice Area

+ The Asset Valuation & Markets practice area works primarily with project developers, asset owners, and investors

+ Insights informed by work being done across the firm that provides a unique 360-degree perspective of rapidly evolving markets

- Clean Energy Policy → how will policy change the playing field for different resources?
- Planning → what resources will power the grid in 2025? 2030? 2050?
- Market Analysis → how will market prices evolve in the grid of the future?

+ The E3 Asset Valuation & Markets team provides a variety of analytical support tailored to client needs.

+ Typical services include:

- Transaction support and due diligence on both the buy side and sell side
- Strategy formulation and market entry
- Board-level reports on market outlook and asset performance
- Customized forward-market price projections incorporating impacts of policy and technology changes
- Revenue stream/benefits analysis, either on an individual asset or portfolio basis
- Production simulation cost modeling using in-house proprietary tools or customized commercial software
- Project site evaluation
- Off-taker assessments
- Basis spread assessment
- Wholesale market rules and bidding strategies



Asset Valuation & Markets

- Analyze asset value from multiple perspectives in vertical, bilateral, and wholesale markets
- Strategic support for project development, acquisition, and operation, including market entry
- Proprietary in-house models and in-depth knowledge of public policy, regulation and markets



E3 Model Ecosystem for Market Price Forecasts: Built on Decades of Experience and 360° Analysis

E3 Model Toolkit

Input Models

E3 PATHWAYS

Least-cost decarbonization pathways across sectors to meet GHG targets

E3 RESHAPE

Load simulation for building electrification & EVs

E3 Pro Forma Model

Levelized costs of new resources including financing and tax incentives

E3 RECAP

Stochastic reliability modeling for ELCCs of renewables and storage

Output Models

E3 RESTORE

Optimized battery operations and revenues

E3 Scarcity + RT Price Model

Forecasts scarcity and real-time energy prices with regression analysis

E3 Nodal Price Model

Node-zone basis forecast for nodal prices

E3 Ancillary Services Model

Forecasts AS prices with regression analysis and market saturation

E3 Capacity Market Models

Capacity price formation by market, aligned with unique market dynamics

E3 REC Market Models

Renewable Energy Credit prices aligned with unique market dynamics

Market Price Forecasting Approach

Key Scenario Variables

1 Load Forecasts
Regional load growth, energy efficiency, building electrification, and EVs

2 Policies
RPS, CES, GHG, other mandates

3 Regional Coordination
Transmission, Trading, and policy alignment

4 Costs:
• New resource costs
• Gas prices
• Carbon prices

PLEXOS Model Outputs

5 Long-Term Capacity Expansion (Annual)
New Resource Additions

- Economics
- Policies and mandates (RPS, CES, GHGs)
- System reliability needs
- Retirements

6 Production Cost Simulation (Hourly)
Energy Market Forecasts

- Hourly day-ahead energy prices by zone
- Dispatch, renewable curtailment, and transmission flows

E3 Forecasts

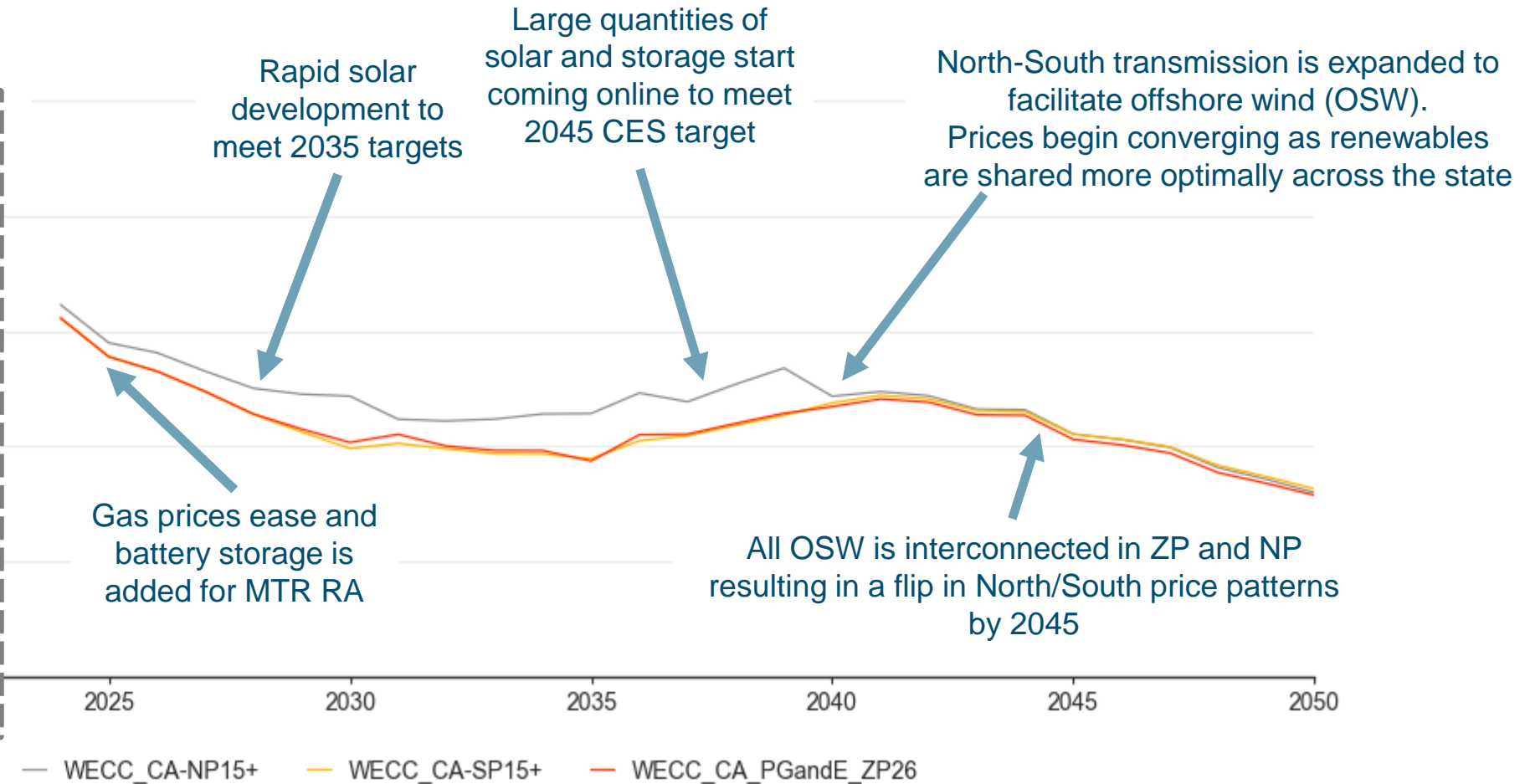
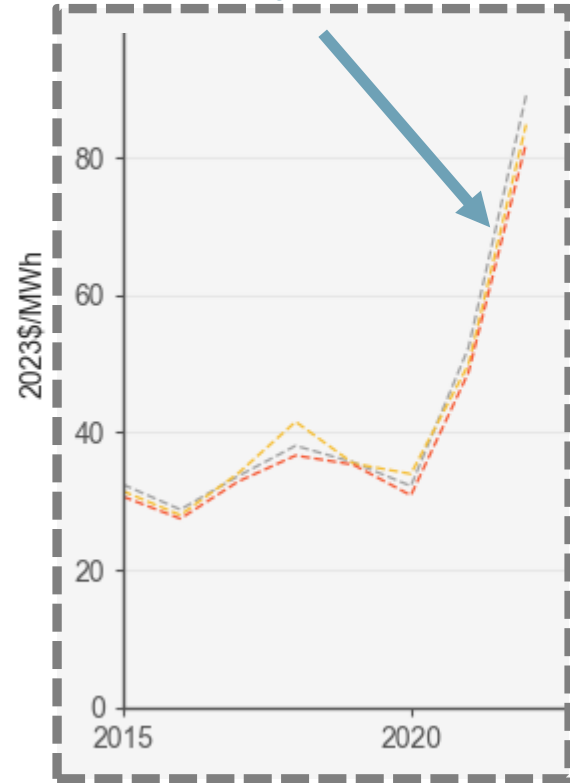
Market Product	Geographic Granularity	Temporal Granularity
Energy (Day-Ahead and Real-Time)	Zonal	Hourly
Capacity (low, medium, high forecasts)	System / Local	Annual
Ancillary Services (Reg, Spin, Non-Spin)	ISO	Hourly
ELCC Curves	Regional	Annual
RECs	State / ISO	Annual
System Operations	System / Local	Hourly / Monthly

Fundamentals-based market modeling built on day-ahead energy prices



Avg. Annual Historical and Forecast Prices (\$2023/MWh)

Avg 2021-2022 prices spiked due to elevated gas prices and unseasonal high temperatures



*Average annual prices for the historical years are shown in nominal unadjusted dollars




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CAISO Market Overview



Resource Adequacy



CA Resource Adequacy (RA) Reform: Slice of Day Framework





Historical AS Prices





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Market Changes in the Future



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E3 Forecasting Approach



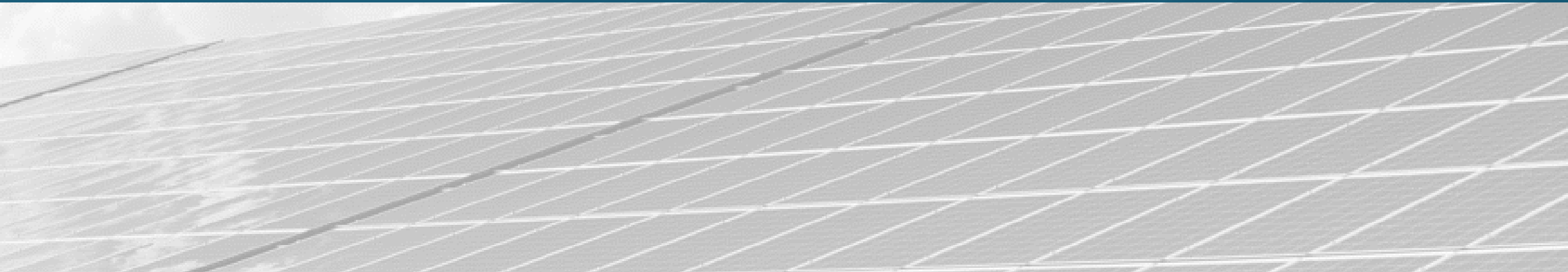
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E3 Modeling Assumptions



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E3 Forecast Results: 2024-2050





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Appendices



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Inflation Reduction Act (IRA)



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September 2022 Reliability Events in CA

