Forecasting California Electric Power Jobs to 2040

Motivation, modeling approach, and preliminary employment projections

PREPARED FOR

The California Independent System Operator

PREPARED BY

Berkeley Economic Advising and Research LLC

BEAR
BERKELEY ECONOMIC
ADVISING AND RESEARCH

Why This Study? — Statutory Mandate & Policy Context

INTRODUCTION

- AB 825 authorizes CAISO to transfer regional market governance to an independent Regional Organization for Western Energy (ROWE).
- Section 4.(f) of the statute mandates an independent assessment of employment impacts — specifically jobs constructing and maintaining powerplants in California.
- The study must be completed by December 31, 2026, delivered to the Legislature, and incorporated into the ISO's findings and resolution.

Apr 2026

BEAR LLC commissioned for the study.

Dec 2026

Statutory deadline for final report

23 yrs

BEAR’s economic assessment experience in California

Key Results - Jobs in Power Generation

- AB 825 would add over 6,800 FTE jobs to long-term (O&M) power sector employment by 2040, 27% above Baseline. Construction job growth would be 36% higher.
- This growth is due to mainly to market enlargement and SB100 compliance and Renewable Portfolio Standard (RPS) balancing needs for in-state renewable energy (RE).
- Results could vary dramatically in magnitude (but not direction), depending on the response of energy system investors.

O&M	Change from Baseline (FTE/yr)			
Year	Baseline	AB 825	Difference	Percent
2025	11,370	11370	0	0%
2030	15,034	16,409	1,375	9%
2035	20,245	23,946	3,701	18%
2040	25,950	32,825	6,876	26%

Construction	Change from Baseline (FTE job years)			
Year	Baseline	AB 825	Difference	Percent
2025	21,798	21,798	0	0%
2030	31,925	40,321	8,396	26%
2035	48,053	63,414	15,361	32%
2040	67,898	92,546	24,648	36%

Notes on Baseline load growth

The BEAR/CREPS model baseline case for 40% state load growth by 2040 is consistent with the CEC's newest adopted demand outlook, incorporated into their 2025 Integrated Energy Policy Report (IEPR). This Baseline is a background structural trend.

AB 825 impact results are strictly incremental, estimated independently by modeling the authorization with stated commitments and (importantly) their interactions with SB100 and the RPS.

California power sector job changes result from four AB825 drivers:

- accelerated in-state renewable production and export growth
- curtailment reduction
- improved investor returns
- average electricity cost reductions

AB 825 Sections 345.6(f) and 399.16.5 govern the counterfactual. Delta estimates feed into CGE model for economy-wide employment impacts.

How AB 825 improves returns to both investors and customers

INTRODUCTION

1. Load Growth

New electrification (EVs, heat pumps, data centers, hydrogen production) drives demand +40% to 2040 (Reference 2.3%/yr Baseline). This load growth increases in-state RPS obligations under SB100.

2. RPS / PCC1 Balancing

Section 399.16.5 freezes Portfolio Compliance Category 1 (PCC1) renewable eligibility to Dec 31, 2025. In-state resources retain premium compliance value; out-of-state IRO resources cannot qualify as PCC1 by default.

3. Improving the RE Investment Climate with Curtailment Reduction & IRO Export

Using the "Baseline Case" EDAM footprint described by Brattle (2024), we find that access to the broader Integrated Resource Outlook (IRO) market reduces solar curtailment losses, improving realized returns to in-state renewable investors.

4. Benefits for Consumers

Significant average energy cost reductions from economies of scale, assuming these are passed on.

AB 825 Sections 345.6(f) and 399.16.5 govern the counterfactual. Delta estimates feed into CGE model for economy-wide employment impacts.

A Market Model of Competition Between Technologies

Economic Model

The California Regional Electric Power Supply (CREPS) framework is a market-based model of competition in California electricity generation, adapted from the gravity model of the trade economics literature.

It treats each pair of generation technologies as competing for generation share, with market outcomes determined by relative installed capacities and relative costs. Gravity coefficients and their covariance then serve as stochastic inputs to the Monte Carlo risk framework.

136,066 MW

total installed capacity in California as of 2025Q1 — the base from which every forecast in the CREPS pipeline is projected forward.

THE EIGHT TECHNOLOGIES MODELED

- Natural Gas
- Hydro
- Nuclear
- Solar PV
- Wind
- Geothermal
- Biomass
- Battery / Other Storage

8 technologies → 28 competing pairs

28 pairs × 141 quarters (1990Q1–2025Q1) = 3,948 observations.

Model Accuracy — Coefficient Estimates & Stability

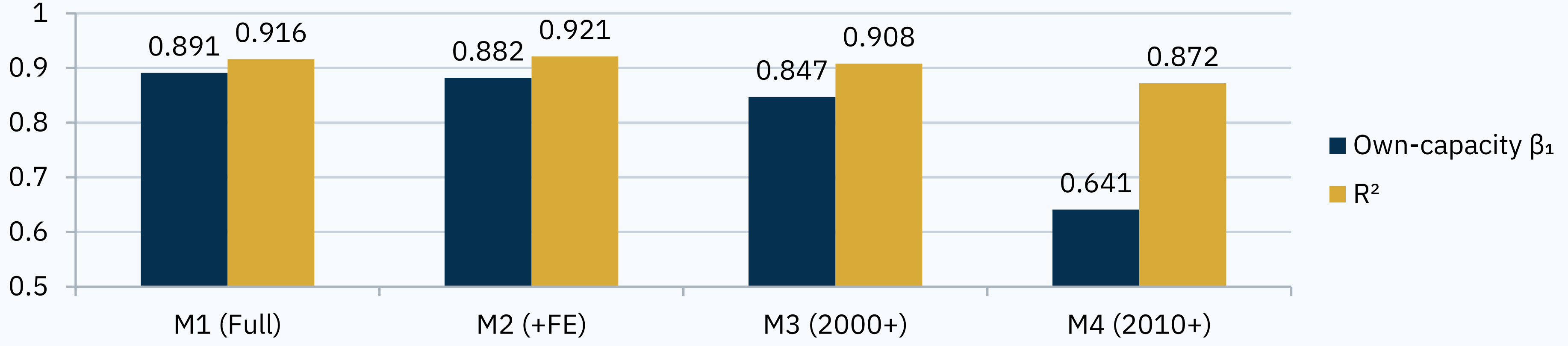
R^2

0.92

Full sample
HC3 robust SEs

Parameter	Estimate	Interpretation
α (intercept)	2.7034***	Baseline generation advantage
β_1 own-capacity	0.8911 ***	Sub-unitary: diminishing returns in constrained dispatch
β_2 rival-capacity	−1.2582 ***	Displacement > own-capacity — consistent with solar curtailment
β_3 cost-ratio	−0.3252***	Lower-cost technologies gain share; capacity dominates short-run
γ_2 Q2 summer	0.0986 ***	Summer generation premium
γ_3 Q3 autumn	0.0764**	Autumn premium

Coefficient Stability Across Model Variants



- *** |t| > 82 · ** t = 2.61 · HC3 heteroskedasticity-robust standard errors*

Why a parsimonious model?

METHODOLOGICAL POSITION

Models built by energy system experts are usually far more complex, detailing grid and other interactions between hundreds or even thousands of system elements. Those data- and computation-intensive approaches may be appropriate to shorter-term system modeling.

For long-term forecasting of the generation portfolio, the more parsimonious log-linear model offers excellent transparency and goodness of fit — explaining 92% of quarterly historical variation in California's power portfolio shares over the last two and a half decades.

> *“If you are right over 90% of the time, you may not be infallible, but things should work out very well for you.”*
>
> **David Blackwell**

THE GRAVITY MODEL'S PEDIGREE

Jan Tinbergen 1969
Gravity models central to his work

Wassily Leontief 1973
Standards underpinning industry data

Bertil Ohlin 1977
Gravity models in trade theory

Paul Samuelson 1970
Iceberg transport costs

Sir Richard Stone 1984
SNA / ISIC accounting standards

Paul Krugman 2008
Gravity models in economic geography

Even relatively simple models, rigorously applied, can yield lasting and useful insights for decision makers.

SECTION THREE · EMPLOYMENT FORECASTING

Forecasting Jobs to 2040

Two-stage pipeline:

Time series capacity projection → Gravity-model allocation of generation shares

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The Two-Stage Forecasting Pipeline

FORECASTING

STAGE 1 — ECONOMETRIC CAPACITY PROJECTION

- Auto-Regressive Distributed Lag model projects MW by technology from 2025Q1 base (136,066 MW total)
- Three growth scenarios (geometric structure): Low 1.0% · Reference 2.0% · High 4.0% p.a.
- Per-technology capacity bounds: floors at 80–85% of 2025Q1; ceilings cap runaway growth
- Nuclear floor in Low Scenario: Diablo Canyon held online through 2035
- AR sum rescaled for stationarity

STAGE 2 — GRAVITY-MODEL SHARE ALLOCATION

- Gravity model converts econometric capacity + cost-ratio inputs into bilateral log-generation scores for all 28 pairs
- Scores assembled into an antisymmetric 8×8 matrix
- Thurstone row-mean scoring + softmax normalization → portfolio generation shares
- Scale-invariance property: technology mix converges similarly across scenarios
- Employment intensities (jobs/MW, jobs/TWh) applied → quarterly trajectories to 2039Q4

Three Capacity Growth Scenarios

FORECASTING

LOW

1.0% per year

Constrained build environment

Diablo Canyon nuclear floor held online through 2035

REFERENCE

2.0% per year

Central case — current policy

Reference = √(Low × High)
Geometric mean by design

HIGH

4.0% per year

Accelerated clean energy deployment

Offshore wind, deep electrification, longer nuclear operation

2025Q1 Base (136,066 MW) → **Econometric Capacity Forecast** → **Gravity Model Share Allocation** → **Employment Trajectories → 2040**

Modeling the Investment Climate – SB100 Compliance Arithmetic

FORECASTING

THREE AB 825 Impact CHANNELS

1. Load Growth

Electrification (EVs, heat pumps, data centers, hydrogen production) drives demand +40% to 2040 (Reference 2%/yr Baseline). Higher total load compounds RPS obligation under SB100.

2. RPS / PCC1 Balancing

Section 399.16.5 freezes Portfolio Compliance Category 1 (PCC1) renewable eligibility to Dec 31, 2025. In-state resources retain premium compliance value; out-of-state IRO resources cannot qualify as PCC1 by default.

3. Curtailment Reduction & IRO Export

Access to the broader IRO market reduces midday solar curtailment losses, improving realized returns to in-state renewable investors.

HOW THE DELTAS ARE MODELED

The baseline Econometric scenarios (Section 4.1) establish reference capacity trajectories. The counterfactual represents a “delta” — AB 825 implementation changes in-state generation investment and jobs relative to the baseline.

The CREPS power portfolio model enforces RPS balancing constraints: as load grows, the SB100 compliance obligation grows faster than the energy market. In-state resources are allocated preferentially to that compliance growth; the residual is distributed to in-state nonrenewable and out-of-state resources in trade- and price-weighted shares.

Curtailment reduction is driven by an improvement in exports of in-state RE, increasing returns and accelerating investment.

AB 825 Sections 345.6(f) and 399.16.5 govern the counterfactual. Delta estimates feed into CGE model for economy-wide employment impacts.

In-State Solar & Wind: Path of Least Resistance & Price Signals

FORECASTING

ONLY THREE PCC1 SUPPLY SOURCES

√ California-sited generation — always PCC1, no added transmission cost

⚠ Out-of-state with dedicated P2P certification — bottlenecked by FERC filings, permitting, and capital costs

→ Legacy contracts w/ deliverability — fixed pool, not scalable for new demand

For rapid load growth, in-state development sidesteps every bottleneck. A solar project in the Mojave or Carrizo Plain is PCC1 by construction. While the IRO allows cheaper out-of-state energy for real-time balancing, the RPS compliance market — where investor premium value lies — remains structurally biased toward in-state resources.

PRICE SIGNAL AND INVESTMENT EFFECTS

PCC1 premium rises with demand pressure

Higher PCC1 demand against a constrained supply class widens the spread between a bundled California-deliverable renewable MWh and a generic energy MWh, improving revenue stacks for CA solar/wind.

Marginal RE projects become viable

Higher PCC1 prices improve long-term contract attractiveness for offtakers, reducing financing costs for new development and bringing previously marginal projects into the money.

Offshore wind business case strengthens

California offshore wind (583,000 leased acres off Morro Bay and Humboldt) is unambiguously in-state and PCC1. Growing scarcity value justifies pressing through permitting costs, and CAISO's unchanged transmission planning mandate supports in-state grid expansion.

Section 4 Forecasting Pipeline

FORECASTING

4.1 Baseline Capacity Projection

Econometric model projects MW by technology from 2025Q1 base (136,066 MW)

Three scenarios: Low 1% · Ref 2% · High 4% p.a.

Outputs: quarterly MW by technology to 2040

Key inputs:

Historical capacity data (EIA-860)

Median case at 40% load growth by 2040

4.2 Scenario Counterfactuals

Applies delta adjustments to baseline: load growth, PCC1/RPS balancing, curtailment reduction

Outputs: adjusted capacity & cost inputs reflecting AB 825 market structure

Delta adjustments :

Load growth (+40% Ref; +High for IRO)

PCC1 / SB100 compliance constraint (§399.16.5)

Curtailment improvement → cap. factor uplift

In-state / out-of-state allocation split

4.3 Generation Share Allocation

Gravity model converts capacity + cost inputs → 28 bilateral log-scores → 8×8 matrix → Thurstone/softmax shares

Outputs: quarterly generation share by technology

Scale-invariance :

Tech portfolio wants to follow relative costs across scenarios, but with AB825 the

RPS mandate induces portfolio shifts from Baseline shares

4.4 Employment Estimates

Jobs/MW & jobs/TWh intensities applied to capacity & generation shares

Feeds CGE model for economy-wide impacts

Final output:

Quarterly job trajectory 2025Q2–2039Q4 forecast with the BEAR model → economy-wide impacts & occupation breakdown

THANK YOU

Questions:

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APPENDIX: Background Slides

Bilateral Gravity Model — Specification & Intuition

GRAVITY MODEL

$$\ln\left(\frac{G_i}{G_j}\right)_t = \alpha + \beta_1 \ln(Cap_i)_t + \beta_2 \ln(Cap_j)_t + \beta_3 \ln\left(\frac{Cost_i}{Cost_j}\right)_t + \gamma_1 Q1_t + \gamma_2 Q2_t + \gamma_3 Q3_t + \varepsilon_{ijt}$$

$\ln(G_i/G_j)$

Log-ratio of quarterly generation — technology i vs rival j

$\beta_1 \cdot \ln(Cap_i)$

Own-capacity: more installed MW → greater generation share

$\beta_2 \cdot \ln(Cap_j)$

Rival displacement — merit-order effect (consistent with solar curtailment)

$\beta_3 \cdot \ln(\text{Cost ratio})$

Relative cost: lower-cost technology gains dispatch share

$\gamma_1, \gamma_2, \gamma_3$

Seasonal effects — Q2 summer premium largest ($\gamma_2 = 0.099$)

3,948	28	141	8	4
Observations	Technology pairs	Quarters (1990Q1–2025Q1)	Technologies	Model variants

Preliminary Results – Other Economic Benefits of AB825

FORECASTING

This analysis supports the main benefit results found by Brattle in 2024. Our scenarios use the “Baseline Case” EDAM footprint from the Brattle and we identify the same beneficial AB 825 effects in terms of :

- **Investment Climate for Renewable Energy (RE)**
  - Obligations for the Renewable Portfolio Standard (RPS) favor in-state RE procurement
  - Reduced curtailment driven by expanding RE exports to regional markets
- **Benefits to Consumers**
  - Potentially dramatic RE average cost reductions from economies of scale, assuming these are passed on

The Monte Carlo estimation process flow

FORECASTING

How a scenario specification and six stochastic layers become P10 / P50 / P90 bands

1 INPUTS

Scenario specification

Table 2.1 — load-growth μ and σ, capacity multipliers by technology, intensity improvement rates.

Reference + S1 · S2 · S3 · S4

ARDL load growth

Reference trajectory 2.27%/yr; the model's residual variance sets σ for layer 1.

sets μ,σ

2025 base system

Installed fleet by technology; CEC baseline retail load of 285,000 GWh (2024).

25,000

simulated paths

5,000 draws × 5 scenarios

outputs at 2025 · 2030 · 2035 · 2040

2 ONE DRAW — SIX SHOCKS

1. **Load growth g**
   TruncNormal(μ_g, σ_g)
   scenario-specific
2. **Capacity factor**
   × Normal(0, 1.5%)
   CAISO / NREL CF variability
3. **Import volume**
   × Normal(0, 5.0%)
   gravity-model residual SE
4. **Emission intensity**
   × Normal(0, 2.5%)
5. **LCOE surprise**
   × Normal(0, 3.0%)
   NREL ATB 2024 range
6. **Employment multiplier**
   × Normal(0, 5.0%)
   DOE JEDI / BLS OEWS mix

All draws: NumPy default_rng(seed = 20260101)

one sampled parameter set

3 PROPAGATE ONE PATH

Load path, 2025–2040

the sampled g compounds from the base year

Generation by technology

portfolio shares across the eight technologies

Imports and exports close the balance

in-state generation + imports = retail load + exports

RPS % and PCC1 gap

compliance against the SB 100 milestones

CO_2e emissions

generation × the sampled emission intensity

System LCOE

resource cost with the sampled surprise

Employment

by technology and 5-digit SOC occupation

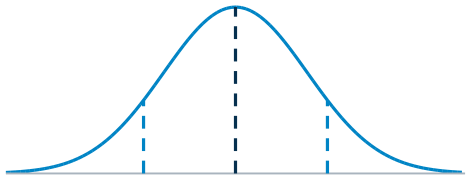
REPEAT · 5,000 times per scenario

one path's outcomes

4 SUMMARIZE

Order the 5,000 outcomes

For every scenario-year cell, take the 10th, 50th and 90th percentile of the draws.



one scenario-year cell, 5,000 outcomes

Reported for every scenario

- Retail load served
- Generation by technology
- Gross imports and gross exports
- RPS achievement and PCC1 gap
- CO_2e emissions
- System LCOE
- Employment by technology and SOC
- Expected unserved energy

Every path satisfies the balance identity, so uncertainty in one quantity is never resolved by silently breaking another. Reported bands are per cell — they are not a single coherent path.