# 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



- 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



## 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

GRAVITY MODEL

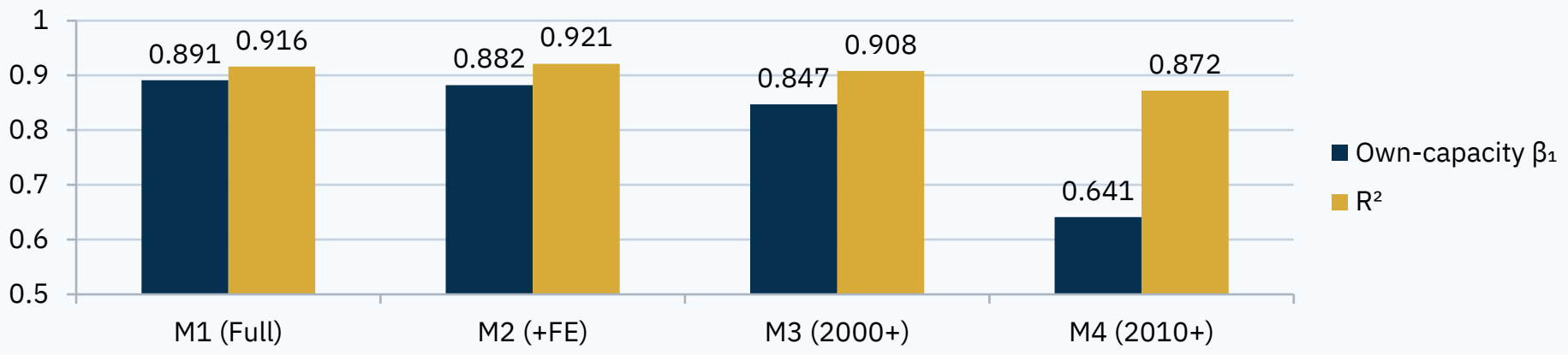
**$R^2$**

**0.92**

*Full sample*
*HC3 robust SEs*

| Parameter | Estimate | Interpretation |
|---|---|---|
| α (intercept) | 2.7034*** | Baseline generation advantage |
| $\beta_1$ own-capacity | 0.8911 *** | Sub-unitary: diminishing returns in constrained dispatch |
| $\beta_2$ rival-capacity | −1.2582 *** | Displacement > own-capacity — consistent with solar curtailment |
| $\beta_3$ cost-ratio | −0.3252*** | Lower-cost technologies gain share; capacity dominates short-run |
| $\gamma_2$ Q2 summer | 0.0986 *** | Summer generation premium |
| $\gamma_3$ 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** | Gravity models central to his work | **1969** |
| **Wassily Leontief** | Standards underpinning industry data | **1973** |
| **Bertil Ohlin** | Gravity models in trade theory | **1977** |
| **Paul Samuelson** | Iceberg transport costs | **1970** |
| **Sir Richard Stone** | SNA / ISIC accounting standards | **1984** |
| **Paul Krugman** | Gravity models in economic geography | **2008** |

*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

## 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

## 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

## 4.4 Employment Estimates

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

Feeds CGE model for economy-wide impacts

### Key inputs:

Historical capacity data (EIA-860)

Median case at 40% load growth by 2040

### 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

### Scale-invariance :

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

RPS mandate induces portfolio shifts from Baseline shares

### 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.

### 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

*sets μ,σ*

## 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

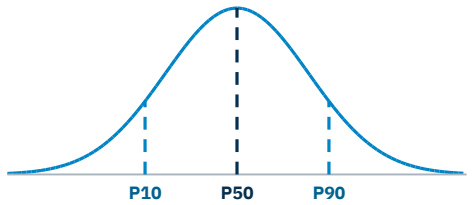
**Employment**
by technology and 5-digit SOC occupation

*one path's outcomes*

**REPEAT · 5,000 times per scenario**

## 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.

Monte Carlo Comparative Scenario Analysis, Berkeley Economic Advising and Research LLC, 2026 — §3 and Table 3.1. The gravity/portfolio model is documented separately and runs its own Monte Carlo (mc_framework.py, seed 42); this figure describes mc_comparative.py.