

Los Angeles 100% Renewable Energy Study: Economic Impacts and Jobs

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Overview

- Background of the study
- LA100 Electricity Modernization Scenarios
- Models Used
 - Computable General Equilibrium (CGE) Model
 - NREL Jobs and Economic Development Impact (JEDI) Model
- Input Data
- Aggregate Economic Impacts
- Income Distribution Impacts
- Workforce Impacts
- Conclusion

Background

- City of LA plans to modernize its electricity infrastructure by 2045:
 - 100% renewable electricity
 - Aggressive electricity targets for buildings and vehicles
- Consistent with California Senate Bill 100: zero-carbon resource supply of retail electricity sales by 2045
- Considering nine major electricity modernization scenarios
- Large-scale study with many areas of analysis:
 - engineering
 - economic impact
 - environmental impact
 - stakeholder impact

LA 100 Scenarios

		LA100 Scenarios								
		Moderate Load Electrification				High Load Electrification (Load Modernization)				High Load Stress
		SB100	Early and No Biofuels	Transmission Focus	Limited New Transmission	SB100	Early and No Biofuels	Transmission Focus	Limited New Transmission	SB100
RE Target in 2030 with RECS		60%	100%	100%	100%	60%	100%	100%	100%	60%
Compliance Year for 100% RE		2045	2035	2045	2045	2045	2035	2045	2045	2045
Technologies that <u>do not</u> vary in eligibility across scenarios	Solid Biomass	N	N	N	N	N	N	N	N	N
	Fuel Cells	Y	Y	Y	Y	Y	Y	Y	Y	Y
	RE-derived Hydrogen Combustion	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - Existing	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Hydro - New	N	N	N	N	N	N	N	N	N
	Hydro - Upgrades	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Nuclear - New	N	N	N	N	N	N	N	N	N
	Wind, Solar, Geothermal Storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Technologies that <u>do</u> vary	Biofuel Combustion	Y	No	Y	Y	Y	No	Y	Y	Y
	Natural Gas	Y	No	No	No	Y	No	No	No	Y
	Nuclear - Existing	Y	Y	No	No	Y	Y	No	No	Y
RECS	Financial Mechanisms (RECS/Allowances)	Yes	N	N	N	Yes	N	N	N	Yes
DG	Distributed Adoption	Moderate	High	Moderate	High	Moderate	High	Moderate	High	Moderate
Load	Energy Efficiency	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Demand Response	Moderate	Moderate	Moderate	Moderate	High	High	High	High	Reference
	Electrification	Moderate	Moderate	Moderate	Moderate	High	High	High	High	High
Transmission	New or Upgraded Transmission Allowed?	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors	Only Along Existing or Planned Corridors	New Corridors Allowed	No New Transmission	Only Along Existing or Planned Corridors

Models Used

- Two types of models: Computable General Equilibrium (CGE) and the NREL Jobs and Economic Development Impacts (JEDI) suite of input-output models
- Both share sets of underlying data
- Both needed: **CGE** to estimate a broad set of overall economic impacts within LA and **JEDI** to estimate detailed impacts that are solely associated with the power sector

CGE Model *Economy-wide*

- Used to estimate **net** impacts within the City of LA
- **Net** impacts consider potentially positive impacts from investment, operation & price decreases and negative impacts from price increases & electricity displacement elsewhere in the economy.

JEDI Model *Workforce*

- Used to estimate in- and out-basin **gross** impacts from increased activities in power sector
- **Gross** impacts only account for positive changes such as jobs created and supported by LA 100 scenarios
- Captures workforce needs and associated economic activity

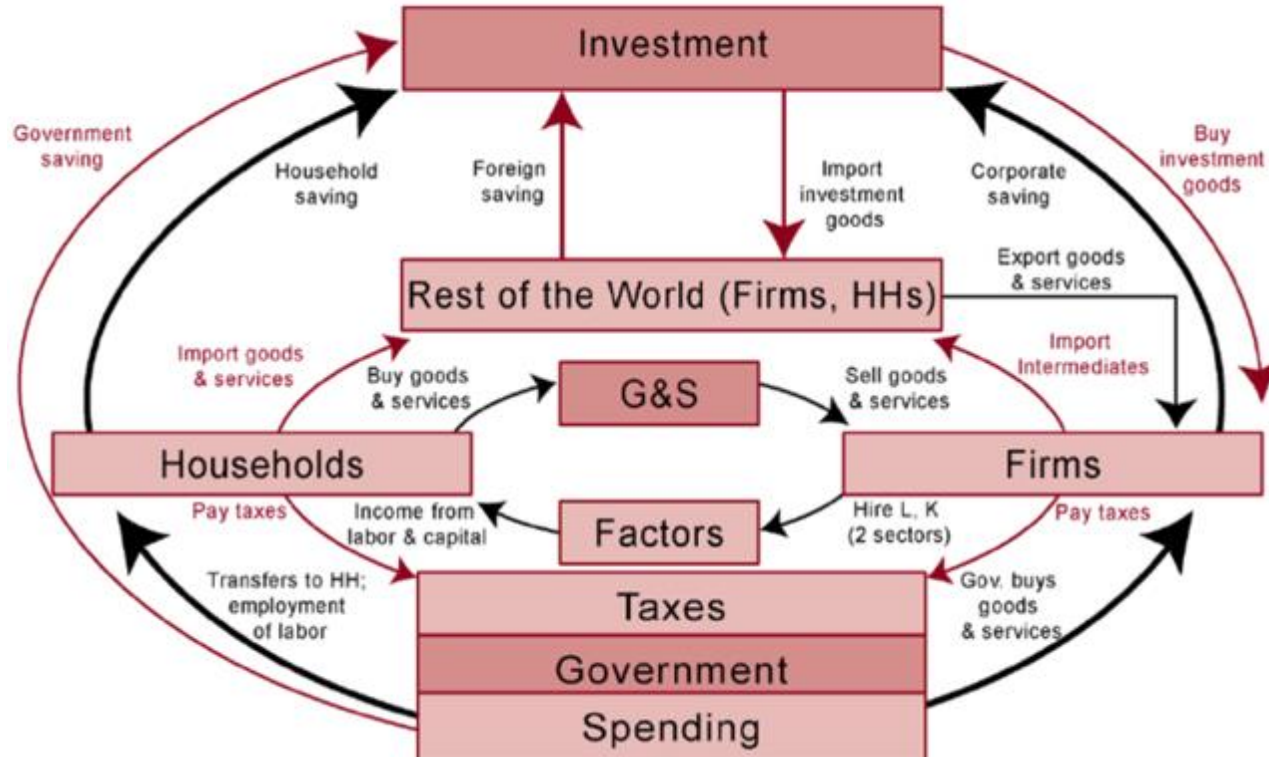
Input data

JEDI Model
Workforce

CGE Model
Economy-wide

- Both models are parameterized with capital and operations & maintenance (O&M) expenditures from rooftop solar and capacity planning models
- CGE additionally uses estimated cost data (translated to changes in electricity prices), which includes existing debt

CGE model flow diagram



- Models the economy as a set of interrelated supply chains
- Mimics role of markets & prices

CGE model specifics

- **Commercial Producing sectors** – generate output using labor, capital and intermediate inputs purchased from other industries
 - Labor
 - Physical capital (buildings, equipment)
 - Intermediate inputs, including electricity (inputs used in production)
- **Households earn income** - wages and capital income
 - Purchase goods and services
 - Purchase or rent housing
 - Purchase electricity
- **Electricity expenditures increase with household income**
- Impacts are **in addition** to changes that would otherwise occur

Absolute and relative analysis

- **Scenario Analysis Decisions**

- Electricity infrastructure and prices will not stagnate in the future
- Basic changes already set in motion
- Holding prices constant at Year 2020 levels would be misleading

- **Used SB100 – Moderate as a minimal compliance (reference) scenario**

- But also calculated impacts in relation to 2020 constant prices

Cost per kWh changes relative to SB100 – Moderate

Compare changes in per unit costs with cost changes (from 2020) in the SB100-Moderate Scenario

Higher-cost scenarios

- Early & No Biofuels (both)
- All Moderate electrification scenarios

Lower-cost scenarios

- SB100 – Stress
- All High electrification scenarios except Early & No Biofuels – High

Scenarios	2026 - 2030	2031 - 2035	2036 - 2040	2041 - 2045
SB100 - Moderate	n.a.	n.a.	n.a.	n.a.
SB100 - High	-5.2%	-8.2%	-10.7%	-12.9%
SB100 - Stress	-6.3%	-9.9%	-13.0%	-15.6%
Early & No Biofuels - Moderate	17.4%	27.5%	25.2%	16.4%
Early & No Biofuels - High	8.4%	13.3%	9.8%	2.1%
Transmission Focus - Moderate	2.5%	3.9%	5.1%	6.1%
Transmission Focus - High	-2.9%	-4.5%	-6.0%	-7.2%
Limited New Transmission - Moderate	3.1%	5.0%	6.5%	7.8%
Limited New Transmission - High	-2.3%	-3.6%	-4.7%	-5.7%

Net employment impacts of the LA100 scenarios relative to SB100 in a given year – Moderate

	Annual Average, 2026 to 2030		Annual Average, 2041 to 2045	
	Employment	Percent Change	Employment	Percent Change
SB100 - Moderate	n.a.	n.a.	n.a.	n.a.
SB100 – High	2,200	0.13%	3,500	0.19%
SB100 – Stress	3,000	0.17%	6,000	0.33%
Early & No Biofuels – Moderate	-2,500	-0.14%	-3,900	-0.22%
Early & No Biofuels – High	300	0.02%	-760	-0.04%
Transmission Focus – Moderate	1,700	0.09%	-800	-0.04%
Transmission Focus – High	1,700	0.10%	3,300	0.18%
Limited New Transmission – Moderate	5	0.00%	2,300	-0.13%
Limited New Transmission – High	2,200	0.12%	4,100	0.23%

- Largest projected **increase**: SB100-Stress
- Largest projected **decrease**: Early & No Biofuels – Moderate
- Time-paths of changes affected by a combination of three causal factors
- Percentage changes are relatively small

Income Distribution Impacts

SB100 – High example

- All numbers are positive, indicating increased aggregate income compared to SB100 – Moderate scenario
- Lower-income households receive a higher proportion of increased income
 - Relatively smaller absolute *levels* of income gains
 - But relatively larger *percentage* increases of total income

Household (HH) Income Bracket	2026-2030		2041-2045	
	Amount (mil of \$)	Percent Change	Amount (mil of \$)	Percent Change
HH1 < \$10,000	1.1	0.16%	2.7	0.38%
\$10,000 < HH2 < \$25,000	2.1	0.09%	7.2	0.32%
\$25,000 < HH3 < \$30,000	4.0	0.12%	11.4	0.35%
\$30,000 < HH4 < \$40,000	6.2	0.14%	16.8	0.39%
\$40,000 < HH5 < \$60,000	12.8	0.13%	35.5	0.37%
\$60,000 < HH6 < \$80,000	13.8	0.08%	32.9	0.19%
\$80,000 < HH7 < \$125,000	15.1	0.07%	42.0	0.20%
\$125,000 < HH8 < \$150,000	30.6	0.14%	64.6	0.30%
\$150,000 < HH9	31.5	0.06%	68.5	0.13%

Income Distribution Impacts

Early & No Biofuels – Moderate example

- All numbers are negative, indicating larger aggregate income losses compared to SB100 – Moderate scenario
- Lower-income households more adversely impacted
 - relatively smaller absolute *levels* of income losses
 - but relatively larger *percentage* decreases of total income
- Electricity expenditures account for a higher proportion of income for lower-income households

Household (HH) Income Bracket	2026-2030		2041-2045	
	Amount (mil of \$)	Percent Change	Amount (mil of \$)	Percent Change
HH1 < \$10,000	-2.8	-0.39%	-3.1	-0.44%
\$10,000 < HH2 < \$25,000	-10.0	-0.44%	-7.5	-0.33%
\$25,000 < HH3 < \$30,000	-16.6	-0.51%	-10.3	-0.32%
\$30,000 < HH4 < \$40,000	-23.4	-0.54%	-15.4	-0.35%
\$40,000 < HH5 < \$60,000	-49.5	-0.52%	-33.3	-0.35%
\$60,000 < HH6 < \$80,000	-49.3	-0.29%	-27.0	-0.16%
\$80,000 < HH7 < \$125,000	-60.5	-0.28%	-38.1	-0.18%
\$125,000 < HH8 < \$150,000	-77.5	-0.36%	-60.2	-0.28%
\$150,000 < HH9	-104.4	-0.19%	-49.3	-0.09%

Income inequality: Gini coefficients

- For some scenarios, results are less easy to interpret
- Gini coefficient is a better way of determining welfare effects than looking at household income changes in levels
- Gini coefficient is a one-parameter estimate of income inequality (between 0 and 1; higher values indicating higher income inequality)
- Baseline Gini coefficient for Los Angeles: 0.4582
- Changes in Gini coefficients, i.e., inequality, are very small (ranging between 0.05% and 0.25%)

Income inequality: Gini coefficients

- All scenarios contribute towards greater income inequality in absolute terms but when compared with SB100 – Moderate there are increases and decreases
- Scenarios that project increased earnings relative to the SB100 – Moderate scenario result in a more equal income distribution
- Scenarios that project decreased earnings relative to SB100 – Moderate scenario increase income inequality
- However, **all impacts remain small in absolute and relative terms.**

Conclusions

- Compared to SB100 – Moderate, employment impacts of LA100 scenarios vary from:
 - Nearly **3,600 average annual job-year losses** in the Early & No Biofuels – Moderate scenario.
 - About **4,700 gains** in the SB100 – Stress scenario between 2026 and 2045.
- Time-paths of the changes in economic impacts are affected by three causal factors (capital, O&M, costs/prices), with changes in capital investments over time being most variable across scenarios
- Although many of the aggregate impacts are large in terms of absolute levels, they are relatively small compared to the overall Los Angeles economy.
- Almost all impacts are <0.5% compared with SB100 – Moderate.

Scenario Averages

- Average of 8,600 annual jobs supported by construction and installation, associated with \$856 million in value added or gross domestic product (GDP)
- Average of 2,000 O&M workers associated with \$201 million annually in value added
- 2,700 ongoing O&M jobs by 2045 with \$270 million in GDP
- \$67,000 average construction and installation annual earnings per worker; \$65,000 average O&M earnings

Average construction and installation supported impacts

Scenarios	2026 - 2030	2031 - 2035	2036 - 2040	2041 - 2045	Average
Jobs	10,600	9,700	7,400	6,800	8,600
Earnings	\$ 696	\$ 661	\$ 488	\$ 461	\$ 577
Output	\$ 1,705	\$ 1,541	\$ 1,126	\$ 1,042	\$ 1,353
Value Added	\$ 1,058	\$ 965	\$ 724	\$ 675	\$ 856

Average O&M supported impacts

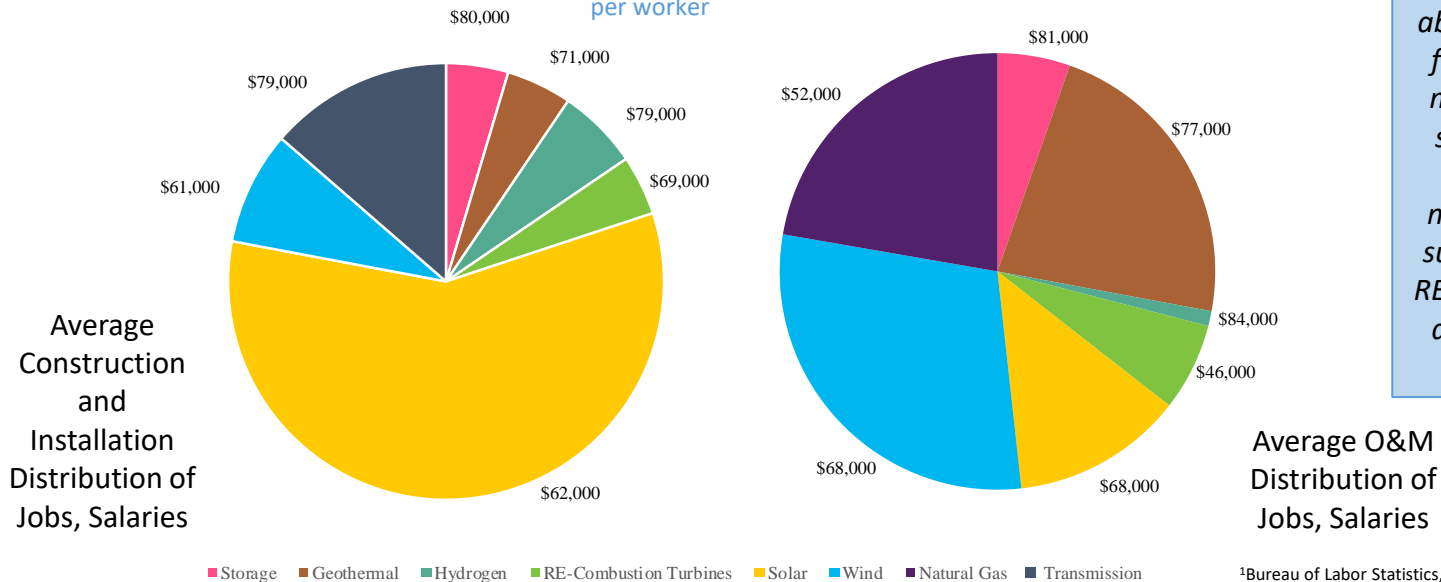
Scenarios	2026 - 2030	2031 - 2035	2036 - 2040	2041 - 2045	Average
Jobs	1,500	1,800	2,000	2,700	2,000
Earnings	\$ 96	\$ 117	\$ 131	\$ 172	\$ 129
Output	\$ 241	\$ 288	\$ 326	\$ 423	\$ 320
Value Added	\$ 148	\$ 180	\$ 204	\$ 270	\$ 201

All dollar figures are millions of 2019 dollars

Average Earnings Across LA100 Scenarios

- Are these good jobs? LA average earnings: \$60,000¹
- RE-CT, natural gas O&M, including ripple effects, are below this while others are above
- Earnings include all impacts: onsite, throughout the supply chain, and induced

Figure 11. Proportions of jobs supported by construction (left) and O&M (right) on average across all scenarios and annual earnings per worker



We have a good idea about what wages are for onsite workers in mature technologies such as wind. These were modeled for nascent technologies such as hydrogen and RE-CT; as these mature actual wages will be better known

¹Bureau of Labor Statistics, Occupational Employment Survey

Conclusions

- Scenarios with the highest expenditure levels tend to support the most jobs, although this is also affected by technologies deployed
- Across all scenarios:
 - 8,600 construction and installation workers are supported annually
 - 2,000 are supported annually due to O&M
- LA100 scenarios will have workforce needs. Generally, solar PV is among the largest drivers of construction and installation jobs but lower O&M jobs. Transmission can also be significant during the construction phase but not for O&M.
- Geothermal, wind, RE-CT support more O&M workers
- The average earnings for workers across all LA100 scenarios are higher than the average for LA as a whole for most technologies

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