***LOS ANGELES 100% RENEWABLE ENERGY STUDY:
AGGREGATE AND DISTRIBUTIONAL ECONOMIC IMPACTS***

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## Overview

The City of Los Angeles has commissioned a multi-dimensional study to evaluate a range of technology pathways to transition the Los Angeles Department of Water and Power (LADWP) system to total reliance on electricity generated from renewable sources while maintaining a high degree of reliability. Analysis of system costs and local economic impacts are essential elements of the study. Achieving a 100% renewable electricity system involves capital investment and changes in operations and maintenance (O&M) outlays. These expenditures will have both immediate and ongoing impacts on the Los Angeles economy, as will any changes in electricity prices. In this analysis, we use a computable general equilibrium (CGE) model to estimate the economic and distributional impacts of nine separate potential LA100 technology pathways.  Overall, the differences in the economic impacts across scenarios are small, but some results stand out.  Compared to the SB100 – Moderate reference scenario, the SB 100 – High Load Stress case is projected to result in the largest expansion in LA City economic activity over the entire period, while Early & No Biofuels – Moderate is projected to result in the largest contraction. The analysis of the distributional impacts of the scenarios indicates that lower-income households have greater percent reductions in income resulting from increased electricity expenditures, as such expenditures make up a greater portion of total income of those households. When compared with SB100 – Moderate, increases in income inequality are projected for scenarios that result in decrease of earnings, while more equal income distribution is projected for scenarios with increased earnings.

## Methods

A computable general equilibrium (CGE) model built specifically for the City of Los Angeles is used to analyze the economic impacts of the LA100 scenarios. CGE models represent economy-wide relationships between the households, businesses and other organizations, government in the study region and the rest of the world (see Hannum et al., 2017 and Sue Wing and Rose, 2020, for examples applied to analyzing the impacts of energy policy). We estimate economic impacts through two basic channels: 1) changes in the average price of electricity, and 2) increases in expenditures to transition to larger reliance on renewable energy. The latter is decomposed into investments in renewable electricity technologies and operations and maintenance costs. Changes in electricity prices would result in changes in household purchasing power and consequently changes in the demand for electricity and other goods and services in the regional economy. Electricity price changes would also affect production costs because utility expenses are an important cost of doing business. Such changes will also generate multiplier effects up and down the supply chain. Overall, the magnitude of the impacts due to the price change will depend largely on: 1) the sensitivity of electricity demand by various user groups to price changes, including their ability to change behavior (for households) and the production process (for businesses) under higher or lower prices, 2) the magnitude of the price change and 3) the interdependence among businesses, which influences the size of the multipliers beyond the direct effects. The combination of quantity and price responses by business and households are referred to as the “general equilibrium effects”.

The CGE results on personal income changes across 9 household income brackets are used to evaluate the distributional impacts of the LA100 scenarios. We first compare and evaluate the absoluate and percentage changes of income across the income groups. For some of the scenarios, the results are easy to interpret, as they skew toward either upper- or lower-income brackets. In other instances, however, this is not the case. Therefore, we further calculate the Gini coefficient of income changes for each scenario in comparison to the reference scenario to evaluate whether the alternative LA100 scenarios increase or decrease income inequality of the City of LA (Keyser et al., 2021).

## Results

Our results indicate that achieving LA100 scenarios will not affect the LA economy, on net, in any meaningful manner. While there may be slight positive or negative impacts, these changes are small relative to the economy as a whole. Using SB100 – Moderate as a reference scenario, these net economic impacts within LA range from annual averages from 2026 to 2045 of -3,600 jobs under the Early & No Biofuels – Moderate scenario to 4,700 jobs under the SB100 – Stress scenario. As a percentage of the 3.9 million employed in Los Angeles in 2019, these reflect changes of -0.09% and 0.12%, respectively.

Assuming same electricity price changes for all customer classes and income brackets, lower-income households tend to be the most affected regardless of whether results are positive or negative. Under the Early & No Biofuels – Moderate scenario, where impacts are the most negative relative to SB100 – Moderate, average household income changes -0.51% annually for households earning less than $10,000 from 2026 to 2045 compared to changes of -0.10% for households earning more than $150,000 annually. Under SB100 – Stress, where impacts are the most positive, income for households earning below $10,000 increases an annual average of 0.37% while households earning over $150,000 annually increases 0.09%.

These trends affect the distributional impacts of income. For scenarios that project increased earnings relative to SB100 – Moderate scenario, a higher proportion of increased earnings is distributed to the lower-income groups.  Therefore, these scenarios would result in a more equal income distribution. However, for scenarios that project decreased earnings relative to SB100 – Moderate, a higher proportion of the income losses is distributed to the lower-income groups, and thus, these scenarios increase income inequality.

## Conclusions

In this study we estimate the economic and distributional impacts of nine scenarios of alternative technology pathways for the City of Los Angeles to transition to 100% renewable electricity supply by 2045. Compared to the SB100 – Moderate reference scenario, the average annual job-year impacts range from about 3,600 average annual job-year losses in the Early & No Biofuels – Moderate scenario to about 4,700 average annual job-year gains in the SB100 – Stress scenario over the study period of 2026 to 2045. The time-paths of the changes in economic impacts are affected by changes in electricity prices, capital investment in renewable energy, and O&M costs. The results indicate that changes in capital investments over time is the most variable factor across the scenarios. Although some of the aggregate impacts are large in terms of the absolute levels, the economic impacts to the city from changes in electricity costs and renewable energy investments are projected to be small relative to the overall size of LA’s economy. The analysis of the distributional impacts of the scenarios indicate that lower income households have greater percent reductions in income resulting from increased electricity expenditures. When income impacts are positive relative to SB100 – Moderate scenario, the positive accruals to lower-income households tend to make income distribution more even within LA, but when the income impacts are negative the opposite is true. It is essential to recognize that our analysis only considers a limited set of impacts and is limited to the LA basin. While our results show that some pathways have larger positive or negative economic impacts than others, all should be evaluated in context with the environmental- and health-related economic benefits accruing under various scenarios.

## References

Hannum, C., H. Cutler, T. Iverson, and D. Keyser. 2017. “Estimating the Implied Cost of Carbon in Future Scenarios Using a CGE model: The Case of Colorado,” *Energy and Policy* 102: 500-11. <https://doi.org/10.1016/j.enpol.2016.12.046>.

Keyser, D., H. Cutler, A. Rose, D. Wei, and M. Shields. 2021. “Chapter 11: Economic Impacts and Jobs.” In *The Los Angeles 100% Renewable Energy Study*, edited by Jaquelin Cochran and Paul Denholm. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-79444-11. <https://www.nrel.gov/docs/fy21osti/79444-11.pdf>.

Sue Wing, I. and A. Rose. 2020. “Economic Consequence Analysis of Electric Power Infrastructure Disruptions: An Analytical General Equilibrium Approach,” *Energy Economics* 89: 104756. [doi.org/10.1016/j.eneco.2020.104756](https://doi.org/10.1016/j.eneco.2020.104756).