Optimal Renewable Energy for Los Angeles

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Abstract

As Los Angeles sets its sights on achieving 100% renewable electricity by 2035, the city finds itself at a critical crossroads. Surging energy demands and an imperative for sustainable development have converged, necessitating a comprehensive reevaluation of LA's energy landscape. This study takes a deep dive into the city's unique urban and coastal characteristics, meticulously analyzing pathways for integrating renewable sources like solar, wind, and bioenergy into the power mix.

With the current infrastructure straining under the weight of traditional fossil fuel reliance, a strategic overhaul tailored to Los Angeles' distinct challenges is no longer a luxury but a necessity. The study makes a compelling case for a decentralized energy management system that harnesses local renewable resources. Such an approach not only enhances resilience and reduces costly transmission losses but also democratizes energy access for all Angelenos. Through a granular synthesis of data on present-day energy consumption patterns and rigorous forecasting for 2035 and beyond, this research offers strategic recommendations for Los Angeles to realize its ambitious carbon neutrality goals. By prioritizing decentralized solar installations, wind farms, and bioenergy facilities, the proposed solutions directly confront grid limitations while charting a scalable course for renewable energy sourcing that aligns with broader environmental objectives.

While the study acknowledges that LA is unlikely to meet its 2035 or even 2045 targets, projections indicate the city is firmly on track to become carbon-free by 2049 – offering policymakers a pragmatic blueprint for cost-effective energy transitions that can be adopted globally. This research stands as a clarion call for sustainable urban development, paving the way for Los Angeles to lead by example in the fight against climate change.

Introduction

As the City of Los Angeles strides toward its ambitious goal of achieving carbon-neutral electricity by 2035, the urgent need to refine its energy portfolio becomes increasingly clear. This study delves into the intricate tapestry of Los Angeles' current energy landscape, focusing on optimizing its mix in the face of escalating demands and the imperative for sustainable development. Los Angeles, a sprawling urban expanse with unique geographical and environmental characteristics, presents a distinctive challenge in the integration of renewable energy sources.

Central to this endeavor is the city's existing electrical infrastructure, which, while robust, is challenged by the growing need for energy and the shift towards renewable sources. The study posits that a strategic overhaul of the energy supply chain, specifically tailored to the urban and coastal characteristics of Los Angeles, is not just beneficial but necessary. This involves a detailed analysis of the city's energy consumption patterns, its current reliance on traditional energy sources, and the potential for incorporating renewable energy like solar, wind, and bioenergy derived from urban organic waste. The economic and ecological sustainability of Los Angeles hinges on this transition. By leveraging the city's natural and infrastructural assets—such as its abundant sunshine and coastal winds[3]—this study explores the feasibility of scaling up renewable energy sources that are not only cost-effective but also environmentally prudent. This approach not only addresses the limitations of the existing grid but also aligns with the broader goals of reducing urban carbon footprints and enhancing energy security. Furthermore, this research advocates for a decentralized energy management system that harnesses local resources to meet local needs, thereby reducing transmission losses and associated costs. Such a system would not only fortify the city's energy resilience but also democratize energy access, ensuring that all communities within Los Angeles benefit from reliable and affordable power.

By synthesizing data on current energy usage with geographic and economic analyses, the study aims to present strategic recommendations that would facilitate Los Angeles' transition to a renewable-led energy portfolio. These recommendations are intended to serve as a cornerstone for future energy policies, providing a blueprint for other cities with similar ambitions[2]. This research endeavor is bound to offer insightful arguments on the multifaceted benefits of such an approach, setting a benchmark for sustainable urban development that harmonizes economic progress with environmental stewardship.

As America's aging electrical infrastructure groans under escalating energy demands, the integration of renewable sources emerges as a critical pathway toward sustainable development[1]. This study recognizes that the nation's three primary electrical grids face inherent limitations and an incapacity to adapt swiftly to rising power needs, underscoring an urgent call for a strategic overhaul of our energy supply chain. Tailoring renewable energy deployment to the specific landscapes of a region presents a compelling solution.

The pressing imperatives of climate change and environmental sustainability further amplify this necessity. Traditional overreliance on fossil fuels and large-scale, centralized energy systems has proven unsustainable, both ecologically and economically. Against this backdrop, the exploration of renewable energy solutions that harmonize with the geographical and ecological characteristics of a locality is not merely an option but an obligation.

This multifaceted approach not only seeks to match renewable energy types to specific landscapes but also addresses the critical issue of grid limitations. The current grid infrastructure in the United States is a patchwork system that struggles with the integration of decentralized energy inputs, particularly from intermittent renewable sources such as wind and solar. By advocating for a decentralized approach, where regions harness and manage their own renewable resources, this study proposes a solution that can alleviate strain on the grid while reducing transmission losses and associated costs.

Decentralization of energy resources is not just a technical adjustment but a transformative approach that can democratize energy access, ensuring that remote and underserved communities have reliable and affordable access to power[6]. This paradigm shift can lead to a reduction in energy costs for consumers, increased resilience of systems through distributed generation, and enhanced local economic benefits through the creation of new employment opportunities in burgeoning renewable energy sectors.

The implications of this study, however, are not confined to the borders of the United States. The global energy crisis necessitates a diversified approach to renewable energy implementation, and the lessons learned and best practices gleaned from this research can be adapted and adopted worldwide. Developing nations, in particular, can leapfrog traditional phases of energy development by implementing decentralized, landscape-appropriate energy solutions from the outset, thus avoiding the environmental pitfalls and unsustainable practices experienced by industrialized nations[7].

This research endeavor aims to forge a new path toward a more sustainable, equitable, and resilient energy future for all. By tailoring renewable energy solutions to the specific regional characteristics of diverse landscapes, we can not only overcome the existing limitations of our national grid but also set a global benchmark for sustainable development that harmonizes economic progress with environmental sustainability. Bound to offer insightful arguments on the multifaceted benefits of such an approach, this study stands as a cornerstone for future energy policies, technological innovations, and a paradigm shift in our relationship with the planet

Methods

Research

The first step in conducting this case study is to find reliable database sources with data that covers the recent measurements of renewable energy in areas of production capacity, cost per watt, city demands for electricity, and plans for renewable energy production expansion in Los Angeles. LA was the city our group chose because of the immediate access to an abundance of data that is already provided in various reports on government websites. In addition, Los Angeles recently decided in 2021 to set a sustainability goal to operate on a hundred percent renewable energy by at least 2035. One report constructed by The Studio City Senior Living Center Project wrote an environmental impact analysis detailing the recent electricity demand and how it is generated throughout Los Angeles. The website Statistics.com contains forecasted data on the amount predicted to increase until the year 2050. The predicted amount of percentage increase in energy demand can then be used to calculate the future electricity demand for Los Angeles. The Department of Energy's website lists an Executive Summary Report for each renewable energy source used in the United States. This database contains an abundance of information that will help our team to gather specific, recent statistics on locations in the main regions for which each renewable energy source is abundantly used to generate electricity. Also, information regarding costs per wattage, the maximum capacity of certain sources, and future predictions are available through annual reports on the Department of Energy's government website.

Data Organization

Once this information is collected, two matrix charts will be created on Excel, one labeled "current" and the other labeled "2035". Both graphs will contain data on the renewable energy types used, their cost per watt, and their maximum capacity for generating electricity. The "current" table uses recent data gathered within the past few years from government backed database websites. The "2035" chart will use forecasted predictions regarding the future costs of electricity from various renewable energy sources, the projected increase or decrease in production of those energy generation sources, and the total projected electricity demand for Los Angeles in 2035.

We decided to use Excel to organize our work because the spreadsheet editor provides a large array of data management options. This application has a wide array of calculation capabilities that allows the user to compute complex calculations using built in functions or custom formulas. In addition, Excel further provides a broad selection of charts, graphs, and visual representations of data to analyze trends and patterns. These created informational pieces can be fully customized with options to change the font, size, color, and style of the graph or table. Pivot tables allow users to summarize, analyze and manipulate large datasets easily. Excel files are able to be exported easily in formats including an Excel Workbook, webpage, pdf, xml, and many others. The ability to share an excel workbook so that multiple people can work on it at the same time. This is useful since we are working in teams and need to make sure that everyone has access to the information being created for the research project.

Research Question: What combination of renewable energy sources is the most economically feasible in Las Angeles?

	City	
RE Source	LA	
RE source 1	$	<-- cost per megawatt
RE source 2	$	
RE source 3	$	

	LA	*Total Used*	*Total Supply*
RE 1			
RE 2			
RE 3			
Total Fulfilled			
Total Demand			

Total cost	0

*graph showing timeline comparisoins of amounts, costs, etc. of renewable energy being used

An example model of the chart that we are going to create is inserted above. This matrix chart will contain the renewable energy sources in the rows portion and LA as the city for the main column. Next, the costs per watt and maximum capacity (total supply) for each renewable energy source will be put in. If LA currently relies on nonrenewable energy sources for power, then that information will also be put in. On the bottom row the total electricity demand will be inputted in the chart. Once all of these variables are put in, we will use the Solver function to calculate the most financially efficient way to manage the intake of these various points of production through the least cost method. When this is calculated, the total cost will be calculated measuring the amount of dollars it takes to support the electrical demand for LA and the percentages in which each source comes from. This process will be completed for both the "recent" and "2035" charts.

The ideal situation is when the total electricity demand for Los Angeles equals the production capacity generated by renewable energy sources thus leaving the reliance on nonrenewable energy sources to 0%.

After both of the matrix charts are filled out, the timeline function on excel will show how the reliance on certain renewable energy sources will increase while nonrenewable energy sources will greatly decline by 2035 to meet the city's goal. Pie graphs charts will also be used to provide a clear visualization in the comparison between the two matrix charts.

Results

Renewable Energy unit costs (per MW)

	LA
Land based Wind	$ 32.00
Solar	$ 1.92
Hydro Power	$ 45.00

Renewable Energy amounts (in MW)

	LA	*Total Used*	Max Capacity (MW per day in LA)
Land based Wind	881	881	881
Solar	1121	1121	1121
Hydro Power	481	481	481
Total Fulfilled	2483		
Total Demand (MW per day	8009		

Total Renewable Energy Produced (MW per day)	*2483*
*Energy created by nonrenewable sources * (MW per day)*	*5526*

Total cost (of energy production with renewables)	$ 51,989.32

*nonrenewables defined by the Department of Energy

The matrix chart above shows the current results of land based wind, solar, hydro power used in Los Angeles, its cost, and the amount of energy produced by those sources. The renewable energy cost chart shows the cost for each renewable energy source to produce a megawatt of energy. In the renewable energy amounts chart, the max capacity column provides the maximum production capacity of each renewable energy source in megawatts per day in Los Angeles. The LA column has the total demand listed in megawatts per day in the last column of its section. The row above this shows the total amount of renewable energy that has been produced to fulfill the overall energy demand. This was found by finding the sum of the renewable energy amounts produced from each source. The total cost of the energy produced by renewable sources (found at the bottom of the sheet) was calculated by multiplying the cost per megawatt produced with the amount produced for each source and then finding the sum of each of those products. The amount of energy created by nonrenewable sources was found by subtracting the total amount renewable energy produced from the total LA energy demand.

Renewable Energy unit costs (per MW)

	LA
Land based Wind	$ 32.00
Solar	$ 1.92
Hydro Power	$ 45.00

Renewable Energy amounts (in MW)

	LA	*Total Used*	Max Capacity (MW per day in LA)
Land based Wind	4709	4709	4709
Solar	3139	3139	3139
Hydro Power	1328	1328	1328
Total Fulfilled	9176		
Total Demand (MW per day)	12076		

Total Renewable Energy Produced (MW per day)	*9176*
Energy created by nonrenewable sources (MW per day)*	*2900*

Total cost (of energy production with renewables)	$216,474.88

*nonrenewables defined by the Department of Energy

The matrix chart above shows the results of the predicted amount of energy used from renewable sources in Los Angeles, its cost, and the amount of energy required produced by those sources in 2035. The 2035 predicted total demand for LA was found using the equation: $A = P(1 + \frac{r}{n})^{nt}$*. This equation calculates the compound interest rate where P = current energy demand, r = 2.6%, t = time (of goal which can be subjected to change), and A = compounding annual model. The same calculations were used in this matrix chart as the first one described above. The numbers changed in the 2035 chart are the maximum capacity limits for each renewable energy source in megawatts per day and the LA total demand.*

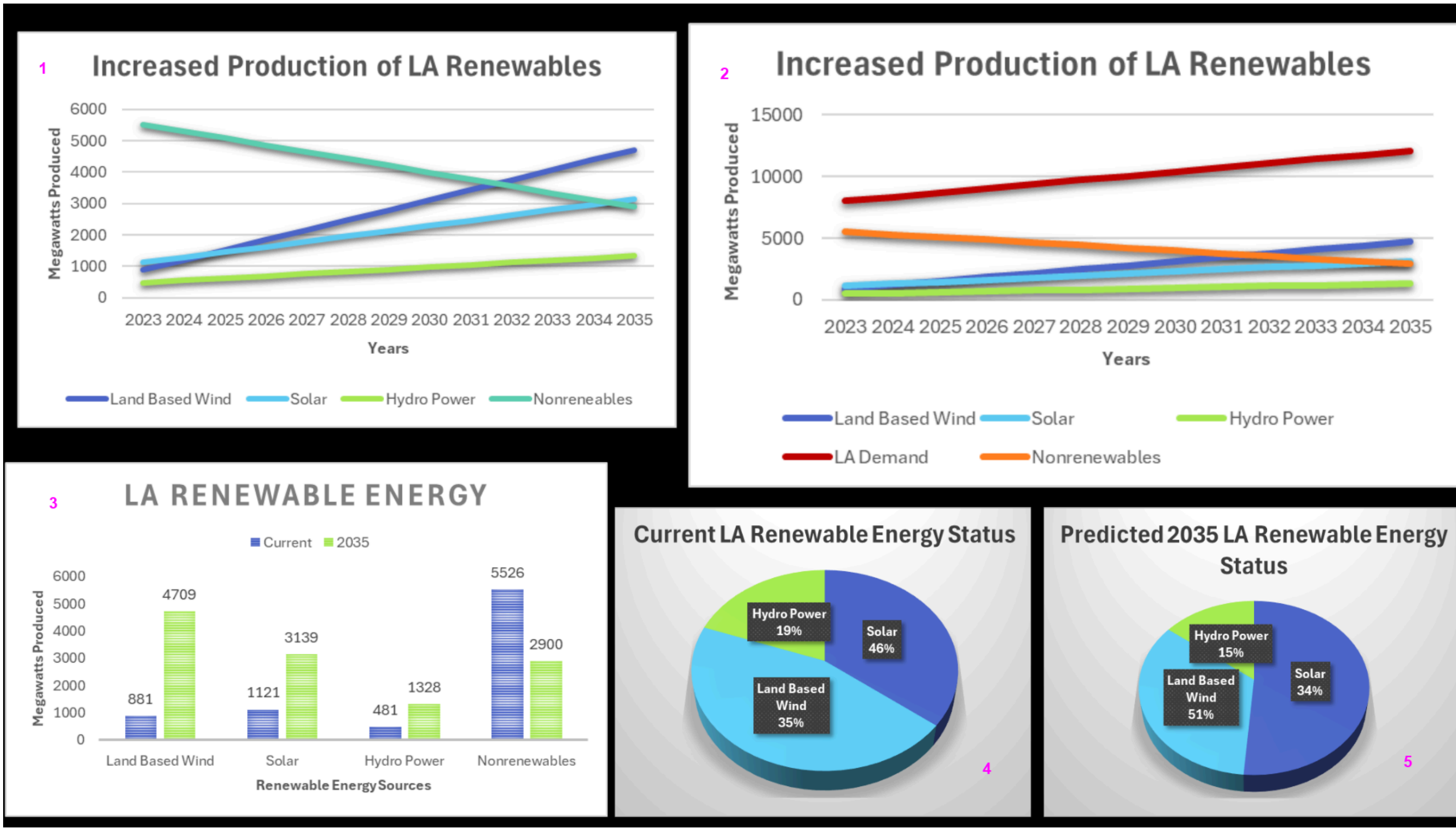


Image 1 is a line graph showing the increase in the amount of land based wind, solar, hydro power used and the decrease in the consumption of nonrenewable sources from the years 2023 until 2035.

Image 2 is a line graph showing a wider perspective of the amounts of increase in the production of renewable sources and the decrease in production of nonrenewable sources over time in comparison to the steady increase of the Los Angeles electricity demand.

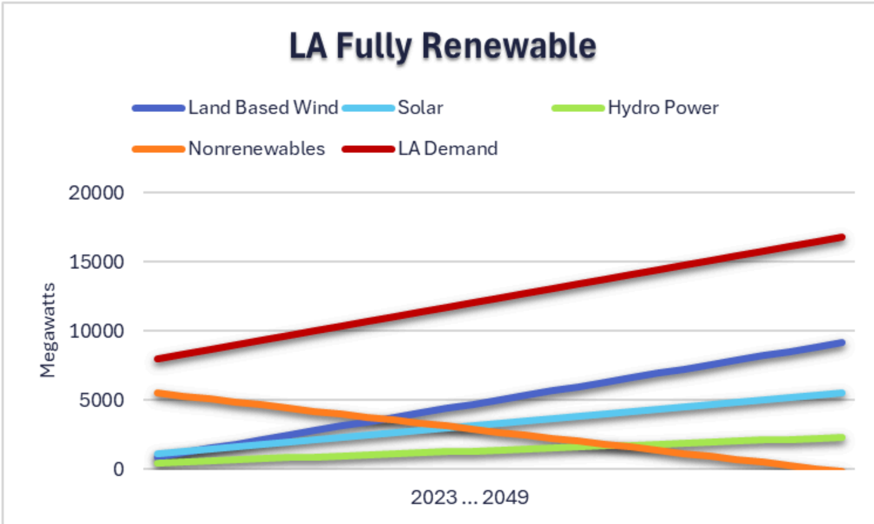
Image 3 is a bar graph comparing the current and 2035 amounts in the energy production per day of land based wind, solar, hydro power, and nonrenewables sources in megawatts.

Image 4 is a pie chart that shows the current renewable energy status and how the percentage each source contributes to the overall income of energy from the clear energy sector.

Image 5 is a pie chart that shows the predicted 2035 renewable energy status and how the percentage of each source contributes to the overall income of energy from the clear energy sector.

Year	Land Based Wir	Solar	Hydro Powe	Nonrenewabl	Total RE cost	LA Demand
2023	881	1121	481	5526	51989	8009
2024	1200	1289	552	5307	65696	8348
2025	1519	1457	622	5088	79404	8687
2026	1838	1626	693	4870	93111	9026
2027	2157	1794	763	4651	106818	9365
2028	2476	1962	834	4432	120525	9704
2029	2795	2130	905	4213	134232	10043
2030	3114	2298	975	3994	147939	10381
2031	3433	2466	1046	3775	161646	10720
2032	3752	2635	1116	3557	175353	11059
2033	4071	2803	1187	3338	189061	11398
2034	4390	2971	1257	3119	202768	11737
2035	4709	3139	1328	2900	216475	12076
2036	5028	3307	1399	2681	230182	12415
2037	5347	3475	1469	2462	243889	12754
2038	5666	3644	1540	2244	257596	13093
2039	5985	3812	1610	2025	271303	13432
2040	6304	3980	1681	1806	285011	13771
2041	6623	4148	1752	1587	298718	14110
2042	6942	4316	1822	1368	312425	14448
2043	7261	4484	1893	1149	326132	14787
2044	7580	4653	1963	931	339839	15126
2045	7899	4821	2034	712	353546	15465
2046	8218	4989	2104	493	367253	15804
2047	8537	5157	2175	274	380960	16143
2048	8856	5325	2246	55	394668	16482
2049	9175	5493	2316	-164	408375	16821

The chart above shows the increased productions of land based wind, solar, and hydro power sources from 2023 until 2049. These number were found by using the formula: $\frac{(2035\ predicted\ energy\ production\ for\ source\ x - 2023\ current\ energy\ production\ for\ source\ x)}{2035-2023}$*. Once this amount is found you can then add the average increase (decrease) to the year prior to show the progression in energy created per day over the years. The total RE (renewable energy) cost and LA demand was found using the same formula. The numbers in red are the years after 2035 with the corresponding data points in which Los Angeles' renewable energy goal is not met. The row in green shows the first year where LA will meet its renewable energy goal of being 100% sustainably sourced.*



The line chart above shows the increase in the production of land based wind, solar, and hydro power from 2023 until 2049 (the calculated year LA operates entirely on renewable energy sources). The red line shows the increase in LA demand during that same time period. The orange line shows the decrease in the production and reliance on nonrenewable energy sources.

Discussion

The purpose of our research is to create a cost-efficient guideline to achieve Los Angeles' 2035 goal of zero carbon emissions from power generation. Additionally, our research aliens with the Biden Administration's ambitious 2050 zero carbon emission target for the United States. Our research critically examines California's LA100 goals for 2035 and 2045[8], focusing on the economic feasibility of transitioning to renewable energy. Throughout this research, we have considered the available resources in LA County in accordance with SB100, passed by the state of California. As outlined in the bill, LA will exclude biofuels and will rely heavily on rooftop solar. Hydropower and land-based wind will also significantly supplement LA's future energy demands as outlined by the Los Angeles Department of Water & Power. We have analyzed the potential for maximizing LA's energy portfolio with renewable sources by 2035, ensuring that the city can achieve carbon neutrality in a cost-effective and sustainable manner. As detailed in the results section, this includes a current evaluation of renewable energy costs and a projection for 2035, suggesting strategic expansions in key areas.

From our comprehensive analysis, several key conclusions emerge, shaping our understanding of Los Angeles' path towards a sustainable energy future. Despite significant efforts, Los Angeles will not achieve its ambitious 2035 or 2045 carbon neutrality goals. However, our projections indicate that Los Angeles County is on track to become carbon-free by 2049, aligning with the national deadline for carbon neutrality set for 2050. Our study also reveals critical insights into the cost dynamics associated with transitioning to renewable energy. As the demand for energy is projected to double, the total cost of generating renewable energy is expected to increase sixfold, which underscores the financial challenges that lie ahead in the shift away from fossil fuels. In terms of the most viable renewable energy sources, our analysis challenges current projections by the Los Angeles Department of Water and Power, which prioritize solar energy. Instead, our data suggest that land-based wind power offers the most cost-effective solution for scaling up and should be considered as the primary source of renewable energy. By 2049, the anticipated energy breakdown is projected to be 54% from land-based wind, 32% from solar, and 14% from hydropower. These conclusions are crucial for policymakers and stakeholders, indicating that while the road to 2050 is feasible, it requires reevaluation of current strategies and may necessitate greater emphasis on cost-effective and scalable renewable energy sources like wind power.

The data collected and subsequent energy projections indicate that the goals set by the State of California and the LA100 project[9] will not be met. Initially, like many environmental goals set by U.S. governmental bodies, the objectives seemed unrealistic—a sentiment our lab group shared at the beginning of this project. Despite our initial skepticism, we were cautiously optimistic that 11 years might be sufficient to transform 45% of Los Angeles' power portfolio. Our study conclusively shows that if energy demand continues to increase at projected rates and renewable energy sources make significant strides, the 2035 goal will remain out of reach. While this outcome is disheartening, it does not diminish the significance of the information. Our methodology, which incorporates the most up-to-date projections and models, provides substantial evidence as to why the California government will likely fail to meet their targets. More importantly, it offers a method to evaluate and plan strategically for the future. This reflection on our methodologies highlights their effectiveness in providing realistic assessments of ambitious environmental goals. By grounding our projections in current data and trends, we ensure that our findings are both relevant and practical, guiding policy makers in making informed decisions.

While these findings highlight the challenges of meeting established environmental targets, it's crucial to consider the direct human impact of current energy practices. Transitioning from this big picture perspective to the individual level, the groups most negatively affected by Los Angeles' current energy practices are the residents of areas suffering from high levels of pollution. These high levels of pollution contribute notably to smog problems that are a result of biofuel facilities. Research consistently shows a correlation between lower-income communities and higher pollution levels in major urban areas. These same communities stand to benefit from the energy transition we propose, which focuses on switching to cleaner renewable energy sources such as solar, land-based wind, and hydropower. However, this transition is not without its challenges.

While moving towards renewable energy, there will be an indirect effect of potentially raising energy prices in the short term. Currently, Los Angeles relies on fossil fuels for approximately 45% of its electricity, which are comparatively cheaper. As we phase out these fossil fuels to achieve carbon-neutral electricity, the initial investment and infrastructure changes required for renewable energy technologies could lead to higher energy costs. This change might disproportionately impact low-income families, who already spend a larger portion of their income on utilities. But overall, in the long term, these families will benefit the most from the switch to renewables with lower pollution levels.

Furthermore, this research can significantly influence policy decisions by identifying the most cost-effective renewable energy sources. Although this transition may have short-term downsides, such as higher energy costs, the long-term benefits justify this approach. If policymakers adopt these guidelines by 2025, they will have a decade to mitigate the impact of rising energy prices.

Proactive measures, such as the enhancements of tax incentives for renewable energy production, can be implemented. The Los Angeles Department of Water & Power in collaboration with

California lawmakers, can expand tax write-offs to maintain competitive energy prices. This strategy will not only keep energy costs affordable but also encourage a wider adoption of renewable energy, thus facilitating a smoother transition.

While focused primarily on Los Angeles, our research has the opportunity to extend further and offer a model for renewable energy transitions applicable globally. By showing the economic viability of renewable sources in a major city, our findings can guide urban planning and energy policy in other regions facing similar environmental and energy challenges. Additionally, this study contributes to environmental economics by providing data on the costs and benefits of renewable energy, further contributing to policy-making. Globally, it supports efforts towards carbon neutrality, demonstrating that large-scale transformations are economically feasible with strategic planning. Our framework can inspire and guide similar initiatives worldwide, aligning with international climate change mitigation efforts.

For our study, we decided to focus on the supply of energy, not the other extenuating factors that are involved with energy supply. That is why our study does not encompass all related issues such as distribution inefficiencies, regulatory changes, or consumer behavior, which could also significantly impact the energy landscape. Our analysis is predicted based on the assumption of major improvements to the grid. This assumption is not baseless; the City of Los Angeles recognizes that achieving their carbon footprint goals necessitates significant updates and expansions to the current grid infrastructure.

Another critical acknowledgement in our study is that it does not project LA to reach the 2035 or 2045 goals set forth by SB100. While these goals provide a pathway for Los Angeles, we have prioritized creating a more realistic pathway that projects actual carbon neutrality by 2049, rather than an optimistic but unfeasible energy portfolio for the next 11 years. This realistic approach informs government officials in California and Los Angeles that without major changes to energy supplies, the established targets will not be met.

Moreover, the data used in our analysis were gathered in 2019 and 2022. We have made adjustments for the time difference to reflect current energy demand and supply accurately.

However, our model does not fully account for the disruptive impacts of the COVID-19[10]pandemic, which have caused significant fluctuations in energy consumption patterns and interrupted supply chains. Additionally, the potential for rapid, exponential changes in demand due to technological advancements or shifts in consumer preferences post-pandemic could drastically alter the energy landscape. Another consideration is that our projections might be influenced by unforeseen technological innovations or regulatory changes that could either accelerate or hinder the transition to renewable energy. For instance, significant advancements in energy storage technology or changes in national energy policy could fundamentally alter the assumptions underlying our current models.

Our research provides a realistic path for Los Angeles to achieve carbon neutrality by 2049, despite not meeting earlier LA100 goals for 2035 and 2045. We recommend prioritizing cost-effective land-based wind, supported by solar and hydropower. This approach addresses economic feasibility and aids pollution-affected communities, particularly low-income areas. Our findings suggest that with adaptive policies and enhanced incentives for renewable energy, Los Angeles can lead in sustainable energy transition. This study offers valuable insights for global urban areas and underscores the need for collaborative efforts to develop environmentally and socially equitable energy strategies.

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