



WORKING PAPER

Policy Pathways to Sustainable Cities: Lessons from Lancaster, California's Net-Zero Transformation

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Policy Pathways to Sustainable Cities: Lessons from Lancaster,
California's Net-Zero Transformation.

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Feedback for Final Publication

This working paper is the first in IPPG's series of case studies under the "Global Energy Transition: The Role of Sustainable Cities" project. We welcome comments, feedback, and questions from readers to enhance the findings, ideas, and recommendations presented in this paper. All feedback, comments, and questions should be sent to ippg@ippgafrica.org.

The final publication will incorporate in-depth interviews with Lancaster city officials and other key stakeholders, in addition to a quantitative analysis of the economic and environmental impacts of Lancaster's clean energy successes. These additions will aim to provide a more comprehensive and nuanced understanding of the city's clean energy achievements, to meet the overall goals and objectives of the project.

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About Us

The International Perspective for Policy & Governance (IPPG) is an independent foreign affairs and international development think tank focused on enhancing the effectiveness of policy implementation, governance, and sustainable development across the African continent. Our mission is to drive impactful change in Africa by providing policymakers and stakeholders with data-driven insights and actionable policy recommendations.

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ABBREVIATIONS

AVTA	Antelope Valley Transit Authority
BYD	Build Your Dreams
CAP	Climate Action Plan
CCA	Community Choice Aggregator
CCI	California Climate Initiatives
CO ₂	Carbon Dioxide
CSWES	Co-Located Small Wind Energy Systems
DoE	Department of Energy
EV	Electric Vehicle
EVCS	Electric Vehicle Charging Stations
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air Conditioning
IPCC	Intergovernmental Panel on Climate Change
JETRO	Japan External Trade Organization
LCE	Lancaster Choice Energy
MoU	Memorandum of Understanding
NEDO	New Energy and Industrial Technology Development Organization
PACE	Property Assessed Clean Energy
PV	Photovoltaic
TIRCP	Transit and Intercity Rail Capital Program
U.S.	United States
VAWTS	Vertical-Axis Wind Turbine Systems

Executive Summary

This working paper explores the strategies and policies that enabled Lancaster, California, to become the first net-zero energy city in the United States (U.S.). Drawing on a comprehensive review of policy documents, academic literature, and media reports, the paper highlights how Lancaster's strong leadership leveraged state and federal level policies, its administrative autonomy, and innovative policies and partnerships to advance its clean energy and sustainability agenda.

Key policy initiatives adopted by Lancaster included mandating renewable energy use for residential and commercial buildings, revising municipal codes to accelerate renewable energy adoption, simplifying permitting processes, and introducing financial incentives for residents and businesses. In addition to these measures, Lancaster implemented a comprehensive strategy to decarbonize its transportation sector. This included putting in place policies to accelerate electric vehicle (EV) infrastructure, supporting public transit electrification, and integrating renewable energy into transportation systems, further enhancing the city's carbon reduction efforts.

The findings offer important insights into the transformative role of local governance in advancing climate action, particularly for urban areas in developing economies. The paper also identifies lessons and best practices that can be adapted to inform policy and practice in the implementation of climate action strategies in cities worldwide, with a focus on their applicability to emerging markets and developing regions. Further research, including stakeholder interviews, will expand on these findings to provide a deeper analysis of Lancaster's success and its potential replication in other urban contexts.

Key Policy Insights

- Administrative Autonomy as a Catalyst for Climate Action:** Lancaster's ability to lead its sustainability efforts was rooted in its administrative autonomy, which enabled the city to create localized solutions tailored to its unique challenges and opportunities. For cities in developing economies, empowering cities and local governments with decision-making authority can enhance the effectiveness of climate initiatives, allowing them to design and implement projects that align with local priorities and conditions.
- Strategic Leadership Drives Transformation:** The leadership of Mayor R. Rex Parris was instrumental in Lancaster's transition to a net-zero emissions city. His proactive approach in driving policy reforms and creating the right partnerships highlights the very important role of strong, visionary leadership in advancing ambitious climate goals. For cities worldwide, cultivating leaders and mayors who can champion sustainability initiatives is essential for building public support and securing the necessary resources for climate action.
- Regulatory Frameworks that Mandate Clean Energy Use:** Lancaster's revision of municipal codes to mandate renewable energy installations in new buildings, along with retrofitting existing structures with renewables and energy-efficient technologies, highlights the effectiveness of regulatory clean energy policies. Such policies embed sustainability into urban development to promote extensive adoption of renewable energy. Cities in developing economies can adopt similar mandates to expedite their clean energy transitions and secure long-term sustainability.
- Simplifying Regulatory Frameworks:** Streamlined permitting processes, as demonstrated in Lancaster, are crucial for reducing administrative bottlenecks and accelerating renewable energy adoption among residents and businesses, while also attracting clean energy investments. In many developing cities, regulatory inefficiencies delay project approvals and deter investments. Introducing clear, transparent, predictable, and digitalized permitting systems can significantly enhance efficiency, encourage compliance with policy mandates, and improve the overall ease of doing business for investors. Such a framework for clean energy policies can serve as a model for other sectors and potentially be scaled up to the national level.

5. **Innovative and Diversified Financing Mechanisms:** While Lancaster benefited from substantial state and federal funding, such resources may be limited or unavailable in developing countries. To overcome this, cities in developing countries must explore a variety of financing options, including international climate funds, green bonds, concessional loans, public-private partnerships, and revenue-generating tools like carbon pricing or development impact bonds. Leveraging multiple funding streams ensures financial resilience and enables the successful implementation and scaling of climate policies and targets.

6. **Harnessing Job Creation Through Renewable Energy Ecosystems:** Lancaster's approach to clean energy deployment extended beyond setting renewable energy mandates. It focused on building a supportive ecosystem for job creation through clean energy manufacturing and supply chains. For cities globally, building similar ecosystems can drive job creation and stimulate economic growth while advancing climate goals to support a just transition to sustainable energy.

7. **Comprehensive Decarbonization of Key Sectors:** Lancaster's holistic approach to decarbonization emphasizes the importance of tackling emission reduction across multiple urban systems, including residential, commercial, and industrial energy use and transportation. Cities in developing countries can adopt similarly integrated strategies to decarbonize the energy, industrial, and transportation sectors to achieve their long-term climate goals



Solar Farm in Lancaster
Source: City of Lancaster.

SECTION 1

Introduction

The Paris Agreement aims to limit global warming to well below 2°C above pre-industrial levels, with efforts to achieve the more ambitious target of 1.5°C. Meeting this goal requires reducing CO₂ emissions to net zero by 2050. This demands swift and widespread transitions across the energy, transport, industry, and urban infrastructure sectors from fossil fuels to renewable energy to reduce greenhouse gas (GHG) emissions (Seto et al., 2021).

Urban areas and cities are vital for mitigating climate change because they contribute significantly to the global GHG emissions. Cities and urban areas are responsible for 70 percent of global CO₂ emissions and two-thirds of global GHG emissions, with transport and buildings being among the largest contributors (IPCC, 2022). Cities also consume about 70 percent of the world's resources, thereby contributing to a large proportion of GHG emissions (Bibri, 2017).

Global urban population and urban infrastructure is expected to expand over the coming years and if the current trends in urban growth, i.e. low-density, expansive, energy-intensive, and car-dependent, continue, then energy consumption in cities could expand more than threefold by 2050 which will lead to increased GHG emissions (Seto et al., 2021). Given the large share of urban GHG emissions and its potential to grow rapidly in the future, global climate mitigation strategies that overlook urban emissions risk failing to meet the 1.5°C target set by the Paris Agreement. It is within this context that the concept of sustainable cities has emerged as a framework for reducing urban emissions and promoting low-carbon, resource-efficient urban development.

From the literature, the concept of a sustainable city encompasses diverse perspectives, but it generally rests on three foundational pillars: economic, social, and environmental sustainability. At its core, a sustainable city strives to achieve a high quality of life while minimizing demands on energy and other resources sourced from surrounding areas (de Jong et al., 2015). A narrower interpretation of a sustainable city is the “net-zero city,” focused specifically on achieving substantial reductions in GHG emissions. This approach targets a minimum 80 percent reduction from baseline emissions by a given year, necessitating systemic changes across urban sectors through deep decarbonization efforts (Seto et al., 2021; Seto, 2023). In light of these perspectives, we define a sustainable city as one that balances economic prosperity, social equity, and environmental integrity to foster a high quality of urban life while reducing its carbon footprint and advancing toward net-zero emissions.

Recognizing their pivotal role in addressing climate change, cities worldwide are increasingly adopting sustainable practices to reduce emissions and foster resilient, low-carbon urban environments. Lancaster, a city in California, embodies this vision as the first net-zero energy city in the United States (U.S.). Aligned with the principles of a sustainable city, that is, balancing economic prosperity, social equity, and environmental integrity, Lancaster has launched transformative policies and projects focused on renewable energy deployment, clean transportation alternatives, and the local manufacturing of green and sustainable energy (City of Lancaster, n.d.; Antelope Valley Transit Authority, n.d.).

This working paper presents findings from our preliminary research on the policy mechanisms driving Lancaster's progress toward reducing GHG emissions and achieving sustainable urban development. It draws on a comprehensive review of academic and grey literature, policy documents, and media reports to analyze Lancaster's economic and environmental gains. The objective is to extract key policy insights and lessons applicable to cities worldwide, particularly in emerging markets and developing economies, which are projected to become large contributors to global GHG emissions as they grow and industrialize.

Building on this initial publication, further research, including qualitative interviews with city officials and other stakeholders, will be conducted to deepen the analysis and produce a finalized report.

SECTION 2

Lancaster's Journey to Sustainability

Lancaster, California, is a city of approximately 175,000 people located in the northern part of Los Angeles County within the Antelope Valley of the western Mojave Desert. The city is ambitiously pursuing a vision to become the first carbon-neutral city in the United States. With approximately 300 sunny days every year, Lancaster is well-positioned and an ideal location for solar energy generation (VCA Green, 2020). Leveraging this solar advantage, the city has branded itself as the “alternative energy capital of the world” (Kennedy & Stock, 2021), and since 2009, Lancaster has undertaken a comprehensive shift towards sustainability, transforming its economy and infrastructure with a strong focus on green energy (DW, 2024).

In 2019, Lancaster achieved the milestone of becoming the first net-zero energy city in the United States (Kennedy & Stock, 2021; PR Newswire, 2024). As a net-zero city, Lancaster generates more energy than it consumes by maximizing energy efficiency, reducing overall demand, and producing ample renewable energy to meet its consumption needs (City of Lancaster, n.d.-I; Regeneration, n.d.). Mayor R. Rex Parris, who led Lancaster's transition to clean energy, aimed not only to reduce the city's energy needs and enhance efficiency, but also create green jobs to promote economic growth locally and regionally (PR Newswire, 2024). In addition, Mayor Parris sought to capitalize on Lancaster's geographical advantage to create a sustainable revenue stream that could support essential city programs and services, particularly during economic downturns (Mead, 2015).

2.1. The Journey

Lancaster's clean energy transformation commenced in 2009 through a partnership with eSolar, a solar energy company to build the 20-acre, 5MW Sierra SunTower project in the city, the first solar thermal power plant in the United States (Kennedy & Stock, 2021; City of Lancaster, n.d.). Lancaster also equipped municipal buildings with solar photovoltaic (PV) panels, using the generated electricity to power public lighting and facilities. This initiative led to substantial cost savings, which were subsequently reinvested into additional solar installations across the city. These efforts culminated in an ordinance requiring that all new single-family homes include at least 1 kWh of solar PV (VCA Green, 2020; Kennedy & Stock, 2021; DW, 2024; City of Lancaster, n.d.). This ordinance made Lancaster the first U.S. city to implement such a mandate.

Around the same time, Mayor Parris identified bureaucratic obstacles hindering renewable adoption by households. Previously, residents faced a lengthy permitting process, sometimes waiting up to six months for approval to install solar panels. To address this, Mayor Parris issued a directive to reduce permit processing without any delays (DW, 2024).

In 2014, the city established the Lancaster Choice Energy (LCE) program, California's first Community Choice Aggregation program, which provides residents with clean energy at reduced prices (Mead, 2015; PR Newswire, 2024). Over the years, Lancaster has collaborated with local school districts to install solar panels in all 26 schools to meet their energy needs. This initiative saved the districts approximately \$1 million in under three years.

By 2020, Lancaster had become more than 50 percent solar-dependent and produced the most solar energy per resident in California (VCA Green, 2020). As the city's clean energy network expanded, excess electricity was redirected to produce hydrogen for public transportation to position the city as a pioneer in green energy solutions. The availability of low-cost electricity and hydrogen not only improved public services but also attracted large companies to the area, establishing Lancaster as a booming green economy.

For example, in 2013, BYD, a leading electric vehicle (EV) company, opened its first two manufacturing facilities in the U.S. in Lancaster, and as of early 2024, it has committed to opening a third facility. In 2023, the city also partnered with Element Resources to develop the Lancaster Clean Energy Center, one of California's largest green hydrogen facilities, expected to produce about 60 tons of green hydrogen daily. Furthermore, Lancaster has been designated as a regional hydrogen hub by the U.S. Department of Energy and has been granted up to \$1.2 billion to promote clean energy and green hydrogen development. These strategic initiatives and the growth of clean energy businesses have boosted local jobs. Lancaster's unemployment dropped from 17 percent in 2009 to 6 percent in 2023, a reflection of the economic benefits of green growth (Mead, 2015; DW, 2024).

Lancaster's success with clean energy deployment and consumption has been achieved through a robust mix of policy and regulatory measures. The city's approach includes revising municipal land use policies and zoning codes, streamlining permitting and inspection processes for residential and commercial clean energy installations, and adopting a business-friendly stance to attract more clean energy manufacturers to establish facilities in Lancaster. The next chapter explores these policy factors in detail.



Mayor R. Rex Parris of Lancaster, California, and CEO Sora S. Chigusa of Choshu Industries Corp. of America (CICA) sign a partnership agreement to integrate advanced hydrogen technologies into the City's Green Energy Microgrid (GEM) system.

Source: City of Lancaster.

SECTION 3

Policy Framework Driving Clean Energy Deployment in Lancaster

Lancaster's green energy successes must be considered within the framework of several California state policies, including executive orders and legislative bills, which set clean energy and emissions reduction goals for cities across the state. For example, Executive Order S-03-05 mandates that California reduce its emissions to 2000 levels by 2010, achieve 1990 levels by 2020, and cut emissions to 80 percent below 1990 levels by 2050. The California Global Warming Solutions Act of 2006 (Assembly Bill 32) codified the 2020 target into law, requiring California to reduce emissions to 1990 levels by 2020 through a combination of market-based and regulatory actions.

The Sustainable Communities and Climate Protection Act (Senate Bill 375) further requires the California Air Resources Board to implement plans to reduce GHG emissions through land use and transportation planning (Senate Bill No. 375, 2008). Executive Order B-30-15, issued in 2015, establishes an additional target for reducing greenhouse gas emissions to 40 percent below 1990 levels by 2030. The California Energy Efficiency Strategic Plan calls for new residential buildings to achieve net-zero energy by 2020 and for new commercial buildings to reach this goal by 2030 (California Public Utilities Commission, 2011). These legislative and policy measures create the foundation for California's journey towards net-zero emissions. Lancaster's renewable energy exploits align with, and build upon, the broader goals established by the state of California.

3.1. Revisions of Municipal, Zoning, and Building Codes to Accelerate Clean Energy Deployment

Lancaster has implemented extensive revisions to its zoning code to encourage clean energy adoption among its residents. A key measure is Chapter 17.08.305 of the Zoning Code, adopted in 2013, which mandates that builders provide solar energy systems for new single-family homes or, alternatively, pay a solar mitigation fee. Chapter 17.08.310 of the Zoning Code further allows for the installation of Vertical-Axis Wind Turbine Systems (VAWTS) on residential lots which expands clean energy options for homeowners. Lancaster has also taken steps to support EV infrastructure. Chapter 17.08.330A (2013) requires that new residential developments include provisions for electric vehicle charging stations (EVCS), with single-family garages and all units of a duplex constructed to accommodate EV charging through a conduit connection.

Lancaster's Building Code, Title 15, further supports the city's clean energy efforts. Chapter 15.12.050(a), introduced in 2022, allows residents and business owners to construct and operate off-grid renewable energy systems, including solar PV, battery, and wind systems. To facilitate rooftop solar adoption, Lancaster has streamlined its permitting process through the Small Residential Rooftop Solar Energy System chapter of the building code which removes barriers and minimizes costs for property owners. This streamlined process requires only one inspection to verify structural stability, and once an application meets all requirements, the necessary permits are issued without delay.

3.1.1. Provision of Incentives for Renewable Energy Adoption

Lancaster has introduced several measures to facilitate and incentivize the adoption of renewable energy by its residents. One such initiative is the Solar Lancaster Program, created in partnership with SolarCity which provides affordable solar financing for homeowners, businesses, and non-profits (City of Lancaster, n.d.-a). The program aims to make adopting solar energy easier by lowering energy bills, offering flexible financing options, discounted solar pricing, alongside custom solar system designs with monitoring. Through this initiative, various businesses, schools, and public facilities, including stadiums, have switched to solar power. The program is expected to save the city \$6 million over 15 years (City of Lancaster, n.d.).

The Lancaster Choice Energy (LCE) program also serves as the city's Community Choice Aggregator (CCA), an electricity supply model that allows the city to purchase and provide electricity directly to its residents and businesses, with a focus on offering cleaner and more affordable energy options compared to traditional utility

providers (Kennedy & Stock, 2021). This electricity can be sourced from the market or generated locally. The LCE program offers several options with varying levels of renewable energy. The Standard Choice provides 35% renewable energy, primarily from solar and wind. The Smart Choice offers 100% renewable energy sourced from wind (Lancaster Energy, n.d.-g). Lastly, the Personal Choice option allows customers with solar or other personal energy systems to offset costs by generating and selling excess energy back to Lancaster Energy to earn credits for the power supplied to the grid (Lancaster Energy, n.d.).

To further support clean energy consumption, Lancaster offers rebates, subsidies, and energy efficiency programs to assist residents in reducing energy costs and upgrading to cleaner technologies. Programs like the GoGreen Home Energy Financing offer attractive loan terms for energy efficiency improvements, while partnerships with Property Assessed Clean Energy (PACE) providers enable financing for home upgrades such as solar installations and HVAC improvements.

For commercial and industrial areas, Lancaster's Chapter 17.40.690 adopted in 2010 encourages the installation of co-located small wind energy systems (CSWES), providing guidelines for these systems on non-residential lots within the city. In addition, Chapter 17.08.390A(4) adopted in 2013 requires all new heated pools to primarily use a solar energy system for heating, ensuring that additional energy demands align with the city's renewable energy goals.

Chapter 15.46.010 of Lancaster's Municipal Code introduced in 2022 also establishes an expedited permitting process for electric vehicle charging stations. Applicants can submit their documentation electronically, and if the application satisfies the checklist requirements, it is deemed complete and processed immediately. This expedited review process ensures that Lancaster residents can install EV charging stations quickly to further support the city's clean transportation efforts.

3.2. Partnerships with Renewable Energy Providers and Companies

Lancaster's commitment to becoming a carbon-neutral city goes beyond revising its zoning and building codes. Recognizing the potential of public-private partnerships to accelerate clean energy adoption, the city has actively collaborated with a range of energy innovators and companies by creating strategic alliances to offer residents more affordable and accessible clean energy solutions, while also attracting investments that create jobs and stimulate the local economy.

These partnerships have primarily been made possible due to Lancaster's proactive approach to fostering a business-friendly environment. The city has achieved this by waiving local development fees, fast-tracking permits, and offering low tax rates. In addition, Lancaster provides tax incentives and credits to these companies to make the city an attractive location for clean manufacturing investments (Los Angeles Daily News, 2007; Foerch, 2019; Li & Sewell, 2013; Mead, 2015).

3.2.1. Partnerships with BYD and KB Homes

In 2010, Lancaster collaborated with BYD, a Chinese clean energy conglomerate, and KB Home, a U.S.-based home building company, to provide affordable green energy homes equipped with BYD's solar panels, LED lighting, energy storage, and other efficiency technologies. To expedite this project, Lancaster waived local development fees and accelerated the approval process for the projects (City of Lancaster, 2010; Planning Report, 2010).

3.2.2. Partnerships with Tesla and SolarCity

Through the LCE program, Lancaster partnered with Tesla to install rooftop solar panels and Tesla Powerwall batteries at homes without upfront costs or credit requirements. The city's Power Choice Fund covers the entire system's cost, and tax incentives go back to the fund, allowing it to continue offering these benefits. Residents only pay for the energy generated and a monthly fee for the Tesla battery (Lancaster Energy, n.d.). Lancaster also teamed up with SolarCity to introduce an affordable solar financing option which enables residents and businesses to install solar systems at reduced costs (City of Lancaster, n.d.).

3.2.3. Clean Energy Production, Manufacturing, & Innovation Partnerships

Lancaster has signed multiple Memorandums of Understanding (MoUs) with green hydrogen manufacturers to establish production facilities in the city. For instance, in 2023, Lancaster partnered with Element Resources to set up a green hydrogen plant powered by solar PV, expected to produce 20,000 tons of green hydrogen annually starting in 2026 (Element, n.d.; City of Lancaster, n.d.). SGH2, another green hydrogen company, is constructing a facility to generate hydrogen from recycled mixed paper waste, a process touted as both more environmentally friendly and cost-effective than conventional green hydrogen production methods. This facility will be the world's largest green hydrogen production facility when it begins operations (SGH2 Energy, n.d.).

Additionally, Lancaster signed an MoU with Heliogen in 2022 to build a facility in Lancaster that uses solar thermal technology to produce green hydrogen, converting sunlight into steam, heat, power, and hydrogen fuel (City of Lancaster, n.d.). Similarly, Hitachi Zosen Inova is developing a \$100 million anaerobic digestion plant in Lancaster, expected to commence operations in 2024. This facility will convert organic waste into renewable natural gas, which will then be transformed into green hydrogen (Hitachi Zosen Inova, n.d.; City of Lancaster, n.d.).

Beyond green hydrogen, Lancaster has emerged as a hub for clean manufacturing. In 2013, BYD established two manufacturing plants in the city to produce electric city and school buses and large-scale batteries. Building on this momentum, BYD plans to launch a third facility in 2024 dedicated to manufacturing electric school buses (Mead, 2015; Drake, 2024).

Further solidifying its leadership in clean energy innovation, Lancaster partnered with Toyota in 2021 to promote the Mirai hydrogen fuel-cell vehicle, initially deploying it among a select group of residents as part of its goal to become the first “Hydrogen City” in the United States (Fuel Cell Works, n.d.). Finally, Hydroplane, an emission-free aviation technology company, has headquartered its operations in Lancaster, focusing on developing and testing hydrogen-powered aircrafts to provide sustainable air coverage for the region (City of Lancaster, n.d.).

3.2.4. Collaborations with Sister Cities

In addition to collaborating with businesses to advance clean energy adoption, Lancaster has forged partnerships with other cities to explore clean energy solutions. Notably, Lancaster has established a “Sister City” agreement with Namie, a city in Fukushima Prefecture, Japan, facilitated by the Japan External Trade Organization (JETRO) (City of Lancaster, n.d.). Under this agreement, both cities have committed to integrating hydrogen into their green energy strategies, aiming to drive workforce development and economic growth through green hydrogen while prioritizing environmental justice.

Both cities have also partnered with Hawaii to exchange expertise, networks, and strategies aimed at accelerating the adoption of green hydrogen and fuel cell technologies (City of Lancaster, n.d.). Additionally, Lancaster has signed an MoU with the U.S. Department of Energy (DoE) and Japan's New Energy and Industrial Technology Development Organization (NEDO) to secure funding and support for green hydrogen projects.

3.3. Public Transportation

Public transportation in Lancaster is provided by the Antelope Valley Transit Authority (AVTA)¹, which operates local bus services within the city. In 2020, AVTA became the first all-electric local bus fleet in the U.S. (AVTA, n.d.). This transition began in 2016 when AVTA set a goal of becoming the first U.S. fully electric fleet.

¹The Antelope Valley Transit Authority (AVTA) is a public transportation agency serving the Antelope Valley region in northern Los Angeles County, California. Its primary service area includes the cities of Lancaster and Palmdale, as well as unincorporated areas of northern Los Angeles County (AVTA, n.d.).

To reach this goal, AVTA committed to converting all of its aging diesel buses to a 100 percent battery electric in addition to signing a \$79 million contract with BYD to purchase 85 electric buses over five years (AVTA, n.d.). The contract was awarded to BYD's manufacturing unit in Lancaster, its first U.S.-based manufacturing plant (Mead, 2015; Antelope Valley Transit Authority, n.d.).

The initial phase of converting Lancaster's diesel buses to electric was funded through a \$24.4 million grant awarded to AVTA by the California State Transportation Agency (CalSTA), supplemented by \$15 million from AVTA and federal funds (AVTA, n.d.). A part of AVTA's electric bus fleet was financed through a \$28.5 million fund provided by the Transit and Intercity Rail Capital Program (TIRCP), administered by the California Department of Transportation (Caltrans) and CalSTA (Royal, 2022). These funds originated from the California Climate Initiatives (CCI), a statewide program utilizing cap-and-trade revenue to reduce GHG (Royal, 2016).

Lancaster has further strengthened its position as a leader in zero-emission transportation through its existing partnership with BYD as indicated in Section 3.2.3, which includes a manufacturing facility projected to produce approximately 4,000 electric buses annually (Drake, 2024). This initiative aligns with the city's broader commitment to sustainability, innovation, and strengthening the local economy.



Lancaster's Mayor R. Rex Paris champions net-zero emissions in his speech at the 21st Annual Science and Technology in Society (STS) Forum in Kyoto, Japan.

Source: City of Lancaster.

SECTION 4

Economical & Environmental Benefits

4.1. Economic

Lancaster's clean energy policies have significantly contributed to its economy by creating jobs, generating revenue, and reducing the city's operational expenses. BYD's EV and battery manufacturing unit in 2013 is estimated to have created about 250 jobs in the city (City of Lancaster, 2016). In early 2024, BYD expanded its operations to include an electric school bus manufacturing facility, which is expected to create 100 office jobs and 550 manufacturing jobs (Drake, 2024).

As of April 2015, private solar developments are estimated to have generated more than 1,100 jobs in the city (Mead, 2015). Moreover, Element Resources is set to establish a Clean Energy Center in Lancaster, creating 35 permanent jobs and hundreds of construction jobs (PR Newswire, 2024). Similarly, SGH2 Energy's green hydrogen facility will provide 600 construction jobs and 35 full-time positions once operational (SGH2 Energy, n.d.).

With multiple green hydrogen manufacturing units expected to become operational in Lancaster in the coming years, the city anticipates more jobs to be available. These initiatives could generate further revenue for the city by supplying hydrogen to refueling stations across California and potentially neighboring states (SGH2 Energy, n.d.). Additionally, Lancaster saves about \$325,000 annually by installing solar-powered parking shades at 26 public schools, with projected savings of over \$8 million in 25 years (Mead, 2015). Transitioning to an electric bus fleet has also led to net savings of \$4,725,000 for AVTA (Antelope Valley Transit Authority, n.d.). Lancaster's partnership with Heliogen to produce green hydrogen is expected to lower hydrogen costs to \$10/kg, compared to California's average of \$21.28/kg as of 2022 (Heliogen, 2023).

4.2. Environmental

According to Lancaster's Climate Action Plan (CAP), overall emissions from community and government operations dropped by 12 percent between 2010 and 2015. As of January 2024, the Antelope Valley Transit Authority (AVTA) reported that its 100 percent electric bus fleet has saved 3.5 million gallons of diesel fuel and reduced CO₂ emissions by 83.16 million pounds (AVTA, n.d.). Despite Lancaster's renewable energy and clean transportation successes, there is limited data on its environmental impact beyond the data provided by Lancaster's CAP and AVTA's carbon emissions, a gap we hope to fill in our subsequent study.

Nevertheless, it can be reasonably inferred that the city's efforts have delivered environmental benefits. The shift to renewable energy is likely to contribute to reduced air and water pollution, enhanced public health, and improved resource conservation. Lancaster's ongoing clean energy initiatives are expected to further advance environmental sustainability by reducing reliance on fossil fuels and lowering GHG emissions.

SECTION 5

Discussion

As noted in Section 2, Lancaster has implemented a range of policies, programs, and initiatives toward achieving net-zero emissions to become a sustainable city. The city's success stems from a combination of forward-thinking municipal and zoning policies, robust partnerships with clean energy businesses, and resident-focused initiatives to position Lancaster as a model for green urban development.

5.1. Transforming Land Use and Building Policies to Foster Renewable Energy Adoption

Lancaster's renewable energy transition illustrates how effective policies and regulatory changes can lead to transformative outcomes. The city revised its municipal and zoning codes to mandate solar energy systems in new homes, a policy that shifted the burden of upfront installation costs from homeowners to builders. For existing homes without pre-installed solar systems, Lancaster's revised building codes allow homeowners to install standalone renewable energy systems and electric vehicle charging stations. To further encourage clean energy adoption, the city implemented a simplified, cost-effective permitting process that can be completed online. The online application streamlines compliance checks and instantly approves applications that meet local and state regulations which reduces delays and bureaucratic hurdles.

In addition, tailored incentives such as rebates and flexible payment plans have eased the financial burden on residents and businesses to accelerate the uptake of renewable energy technologies and ensuring that the shift to renewable energy is both equitable and widespread. Lancaster's model offers a replicable blueprint for cities aiming to balance ambitious climate goals with tangible benefits for their populations.

5.2. An Enabling Regulatory Framework for Local Climate Action

Lancaster's net-zero transition is underpinned by a broader legal and regulatory framework established by California's progressive climate legislations. State-level mandates like the California Global Warming Solutions Act of 2006 (AB 32) and subsequent legislations have created a conducive environment for cities in the state to adopt and implement aggressive clean energy policies. These laws not only set ambitious emissions reduction targets but also offer the legal and regulatory backing necessary for municipalities to innovate.

However, Lancaster's success lies not just in following state directives but in its ability to innovate within this enabling framework. While state laws provided a roadmap, Lancaster's proactive approach to revising its municipal codes, establishing of strategic partnerships, and adopting targeted incentives illustrate how state or central government mandates can be leveraged to drive comprehensive local climate and clean energy action.

This dynamic interplay between state and municipal governance indicates that while state policies set the stage, local governments play a pivotal role in tailoring and implementing these directives. Lancaster's experience exemplifies how cities can act as catalysts for broader systemic change, leveraging state or central government laws to pioneer innovation and localized solutions that address unique urban challenges.

5.3. Strategic Partnerships with Clean Energy Manufacturing Companies

Lancaster's clean energy success is further deeply rooted in its ability to create an enabling environment that attracts and nurtures clean energy businesses. What sets Lancaster apart is not just its partnerships with major companies like Tesla, BYD, and SGH2, but its deliberate efforts to position the city as a hub for clean energy manufacturing. For example, recognizing the critical role that green hydrogen will play in the global energy transition, the city has entered into agreements with various green hydrogen manufacturers including Heliogen and Hitachi Zosen Inova to establish itself as a key production center.

5.4. Strategic City Alliances for Expanding Clean Energy Horizons

Lancaster's alliances with cities and organizations also illustrate a forward-thinking strategy that extends beyond local initiatives. These collaborations are not merely transactional; they serve as a major platform sharing of ideas, experiences, and knowledge for clean energy innovation. Partnerships with cities like Namie in Japan and entities such as NEDO have enabled Lancaster to integrate cutting-edge technologies and align its efforts with global sustainability benchmarks.

These alliances also strengthen Lancaster's ability to attract investment by positioning the city as a credible and ambitious player in the clean energy sector. Beyond this, the partnerships could provide insights and access to specialized expertise, allowing Lancaster to remain at the forefront of emerging clean energy solutions like green hydrogen.

This strategic city partnerships underscore the value of cities acting as global collaborators, where shared goals and pooled resources accelerate progress toward sustainability.

5.5 Strategic Leadership

Strategic leadership was pivotal in Lancaster's journey to becoming the first city in the U.S. to achieve net-zero energy emissions. This was exemplified by Mayor R. Rex Parris, whose vision and proactive governance were instrumental in driving the city's clean energy initiatives. Mayor Parris led efforts to revise municipal codes, mandating renewable energy adoption in residential and commercial buildings, and simplifying permitting processes to accelerate clean energy deployment. These regulatory changes facilitated the widespread adoption of solar power and other renewable technologies and also created a streamlined, business-friendly environment.

Furthermore, his leadership extended beyond policy and regulatory successes, with an eye for fostering alliances with other cities and clean energy firms to share technology, attract investments, and create jobs. Mayor Parris' strategic leadership demonstrates the importance of visionary political figures in advancing ambitious climate goals, particularly in setting a clear agenda, mobilizing resources, and inspiring collective action within the community.



Mayor R. Rex Parris of Lancaster, California, and Mayor Kazuhiro Yoshida of Namie, Japan confirms their partnership to advance green hydrogen during Japan's Hydrogen Energy Ministerial Meeting.

Source: City of Lancaster.

SECTION 6

Recommendations and Conclusion

6.1. Recommendations

Lancaster's clean energy transition offers several policy lessons for cities in developing countries. However, it is important to recognize the distinct political, geographical, and economic contexts that differentiate Lancaster from many urban centers in developing regions. For instance, Lancaster, with a population of about 172,237, functions as a relatively small and close-knit urban community, unlike the more densely populated cities in developing countries (City of Lancaster, n.d.). Additionally, unlike Lancaster, cities in Asia, Latin America, and Africa are less urbanized than other regions and are expected to rapidly urbanize by 2050 (Palanivel, 2017).

Urbanization in developing economies often occurs without adequate planning, leading to challenges such as congestion, pollution, poor housing, and fragmented infrastructure (Olubi & Fadamiro, 2022). Furthermore, Lancaster benefits from administrative autonomy and access to financial resources, allowing Lancaster to implement its urban development plans effectively, an advantage that many city administrations in developing countries may lack. Despite these contextual differences, Lancaster's clean energy transition provides insights that can inform policy approaches for cities in developing countries.

6.1.1. Accelerating Renewable Energy Adoption

Clear mandates for renewable energy in urban planning, such as requiring solar installations in new developments, can provide a strong foundation for cities in developing economies. For instance, mandates could be set to require all new commercial and residential properties to install renewable energy systems, such as rooftop solar PVs, to meet a specific percentage of their energy needs. These mandates should be complemented by revisions to building codes or bylaws to prioritize clean energy and energy efficiency in existing buildings through retrofitting with renewables and energy-efficient technologies.

Efficient permitting processes for such mandates, similar to those implemented in Lancaster, would also be crucial to overcoming administrative bottlenecks, a persistent challenge in securing government approvals in developing countries. Ideally, an efficient permitting process should be available online and predictable, with affordable fees for residents. This approach reduces administrative hurdles and encourages greater public participation.

Importantly, city authorities must introduce programs to incentivize residents and businesses to make the transitioning both convenient and affordable. For instance, offering attractive loan financing options through partnerships with financial institutions can encourage the adoption of energy-efficient and renewable energy technologies.

6.1.2. Establishing Legally Mandated Decarbonization Goals at the National or State/Provincial Level

California's mandated emission reduction targets provided a policy framework for Lancaster to revise its municipal codes and implement policies to meet state-level goals. This demonstrates the importance of embedding emission reduction objectives in laws or policy plans at the national, state, or provincial level. Such legal mandates can serve as a catalyst for cities in developing countries to formulate and enforce climate action plans that align with broader, legally binding national or state targets.

However, climate action plans in many developing countries often lack specificity, featuring broad and unenforceable goals, which diminishes their potential impact (Fuo et al., 2022). To ensure meaningful progress, it is important that these laws and plans include clearly defined, measurable, and enforceable targets. This will provide a concrete framework for climate action and further enhance accountability to drive sustained efforts toward achieving decarbonization goals.

6.1.3. Innovative and Value-Enhancing Partnerships

A key component of Lancaster's clean energy transition was forming strategic partnerships with clean energy businesses, organizations, and sister cities. This approach provides a valuable model for cities in developing countries. Direct partnership with clean energy companies can grant residents and businesses access to affordable renewable energy systems and energy efficient technologies. Furthermore, such partnerships create investments and job opportunities to ensure an alignment between decarbonization and socio-economic development goals for cities.

In addition, cities in developing countries stand to benefit greatly from partnerships with other similarly positioned cities in the Global South or with cities in the Global North that are further along in their decarbonization journeys. These partnerships offer ideal platforms for knowledge exchange, technology transfer, and sharing best practices in clean energy and sustainability strategies for city-level administration.

6.1.4. Exploring Diverse Sources of Climate Finance

A major obstacle to the implementation of clean energy and sustainability measures in developing countries is the lack of adequate access to climate finance, which is essential for operationalizing climate mitigation and adaptation plans. While Lancaster leveraged federal and state-funded grants and private partnerships to support its decarbonization efforts, such resources may not be readily available to cities in developing countries. Instead, these cities often may have to explore financing from various sources including limited national government support, global climate finance grants, green bonds, market and concessional loans, and private sector investments (Accra Metropolitan Assembly & C40 Cities, 2020).

Local revenue generation through mechanisms like fees and the sale of development rights to private investors could also be considered (Fuo et al., 2022, p. 52). However, unlike Lancaster, which waived municipal development fees to expedite sustainable housing projects, cities in developing countries may face a tradeoff between accelerating green initiatives and maintaining revenue streams.

In addition, cities in developing countries could establish specialized technical teams to identify and develop bankable climate projects, create a database of climate investment opportunities, and develop compelling project proposals to attract and identify the suitable financial instrument that will best work for the local context. (Accra Metropolitan Assembly & C40 Cities, 2020).

6.1.5. Empowering Cities to Develop, Lead, and Manage Climate Action

A key factor that enabled Lancaster to become the first net-zero energy city in the U.S. is the decision-making and administrative autonomy it enjoyed in implementing clean energy projects and sustainability measures. This autonomy allowed the city to create its own sustainability roadmap, establish partnerships with clean energy businesses and sister cities, determine its funding mechanisms, and most importantly, procure, generate, and distribute clean energy to its residents.

To replicate such successes in other cities, particularly in developing countries, it is essential to empower local city administrations to identify key areas of their urban ecosystems that require decarbonization. Cities must have the autonomy to design and implement projects tailored to their unique contexts and decide on suitable financing methods. Nonetheless, institutional and policy support from higher levels of government will still be required to enable cities navigate their own path.

6.1.6. Building Supportive Political Leadership

Lancaster's successful clean energy transition was driven by the leadership of its Mayor R. Rex Parris. Mayor Parris' vision and proactive political leadership, coupled with administrative autonomy, were instrumental in transforming Lancaster into the first net-zero energy city in the U.S. In many developing countries, however, political inertia or opposition can significantly impede progress on climate action. Entrenched interests, lack of political will, or even conflicting priorities can derail efforts to decarbonize urban infrastructure or implement sustainability measures.

To address these challenges, it becomes important to cultivate political champions who can advocate for climate initiatives and build consensus across different levels of government. These leaders should work to align climate action goals with the city's broader developmental objectives to ensure that sustainability projects gain the necessary political and institutional support to succeed (Herslund et al., 2015).

6.2. Conclusion and Further Research

This working paper has explored Lancaster's journey toward becoming a net-zero energy city, offering insights into the city's policy framework and strategies. However, there are notable gaps that require further investigation to provide a holistic and nuanced understanding of Lancaster's clean energy success and to meet the overall goals and objectives of the IPPG "Global Energy Transition: The Role of Sustainable Cities Project".

Firstly, one area for further investigation is the role of stakeholder perspectives and decision-making in driving Lancaster's clean energy initiatives. While this working paper highlights the policies and outcomes, it does not delve into how decisions were made or the dynamics between city officials, clean energy businesses, and residents. Future research will explore how collaboration among these stakeholders influenced the success of Lancaster's initiatives, including the challenges faced during implementation and how they were overcome.

Secondly, there is limited analysis of the equity implications of Lancaster's clean energy transition. Understanding the impact of these policies on low-income and marginalized communities will be essential to assess the inclusivity of the city's sustainability efforts. Questions such as whether these groups have benefited equitably from renewable energy programs and what measures could ensure greater inclusivity warrant deeper exploration. This will provide valuable insights into how other cities can design policies that promote both sustainability and social equity to ensure a just transition.

A third area for further exploration is the economic and environmental benefits of Lancaster's clean energy initiatives. While some immediate benefits, such as job creation and cost savings, have been highlighted, more details and the long-term economic impacts remain underexplored. For instance, the extent to which clean energy investments have contributed to sustained economic growth, improved local business environments, and enhanced financial resilience in the face of external shocks could potentially be examined. Similarly, the environmental benefits including emission reductions, improvements in air and water quality, biodiversity conservation, and public health outcomes, require deeper investigation.

Another important gap is the equity dimension of Lancaster's clean energy transition. This working paper provides limited insight into how these policies have impacted different socio-economic groups, particularly low-income and marginalized communities. Our future research will seek to understand whether these groups have equitably benefited from the city's sustainability efforts and what additional measures might be necessary to promote inclusivity. This will offer policy lessons for other cities aiming to balance environmental goals with social equity.

Moreover, the replicability of Lancaster's model in other urban contexts, especially in developing economies, remains an open question. The city's success is underpinned by a unique set of conditions, including strong administrative autonomy, access to state and federal funding, and favorable geographic and climatic factors. Understanding how these elements can be adapted to cities with different governance structures, resource availability, and socio-economic challenges will be critical.

Finally, the role of community engagement in driving behavioral change toward clean energy adoption is another gap identified in this study. While Lancaster's policies have been successful, little is known about how the city engaged its residents and businesses to foster a culture of sustainability. Our future research will examine the methods used to engage the community and their effectiveness in influencing attitudes and behaviors. This will provide important lessons on the social dimensions of urban sustainability initiatives.

To address these gaps, the next phase of this study will build on this qualitative research by incorporating additional in-depth interviews with Lancaster city officials and other key stakeholders. In addition, a quantitative component will be introduced to analyze data on economic and environmental impacts to provide a more comprehensive and nuanced understanding of Lancaster's sustainability initiatives. This mixed-method approach will help address existing gaps and deepen the findings to meet the goals of the IPPG “Global Energy Transition: The Role of Sustainable Cities Project”.



Largest off-grid green hydrogen production plant in the U.S. in Lancaster operated by Element Resources.
Source: Element Resources.

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