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Research Article

Towards Net Zero Cities: A Review of Best Practices and Prioritized Investment Areas

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Abstract

This paper explores and evaluates the potential of cities in achieving net-zero climate reduction targets and the solutions that are used in cities. Accounting for 70% of global carbon emissions and two-thirds of global energy demand, cities are key players in getting the world to net zero. A tool such as carbon budgeting and harmonized carbon accounting frameworks offer a starting point, and other solutions are discussed such as energy efficiency in buildings, electrification of transport, blue-green infrastructure to mitigate urban heat islands and airconditioning demand and digital integration of urban assets. A three-pronged strategy—optimize, electrify, and decarbonize—highlights that cities may drive impactful climate action through targeted investments in key sectors transportation, buildings, and energy systems. From there, key solutions in targeted sectors are explored, and investment themes are derived.

Keywords: Net Zero Cities, Decarbonization, Sustainable Transportation, Blue-Green Infrastructure, Urbanization

Introduction

If you are reading this, you are likely in a city. Cities are pivotal players in achieving a state of global net zero emissions. Now home to over half the world's population, cities are expanding as urbanization accelerates. Consequently, the number of megacities rises, and the options to build net-zero cities become increasingly important.

Cities matter for bottom-up climate action and investment, although cities are not legal entities that partake in the UNFCCC negotiations and negotiate COP agreements.

Cities are expanding at an rapid rate. In 1900, 13% of people lived in urban areas. By April 2023, this rose to 56% (4.4 billion), with projections of 70% by 2050 [1-3]. And, Asia is urbanizing at the fastest rate. In fact, 1.4 billion more people are expected to be living in Asian cities by 2050, compared with today. Recent studies such as UN-Habitat, 2023 reveal that urban areas now account for 75–80% of global carbon emissions and consume around 78% of the world's energy, even though they cover just 3% of the planet's land area.

According to a McKinsey report, some 600 cities form the backbone of the economy and not some 200 countries. McKinsey argues that cities often are the economic engines of their countries [4].

Cities are expanding their footprint; by the mid-century, 75% of the infrastructure that will exist has not been built [5]. That is why this paper argues that the investments needed must focus on decarbonization, as smarter investments are a chance to create cities with a much lower carbon footprint [6].

Cities with carbon neutrality targets are shooting up around the globe, as the paper will discuss below. Yet, scholars argue that carbon neutrality is a difficult and elusive concept and needs to be translated into practical frameworks and targeted investment areas.

More relevant to bridge the gap between theory and practice, there is a need for implementing harmonized carbon accounting methods in a city, consistent emission scopes, and context-sensitive stakeholder-informed action plans. Cities need support

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from climate networks like the C40, and systematic research to overcome barriers [7].

Rationale & Relevance

Cities are central to global decarbonization efforts. As hubs of energy demand and infrastructure expansion, they hold the potential to drive necessary climate action. This paper explores decarbonization strategies like renewable energy, energy-efficient infrastructure, and sustainable transportation. It highlights investment opportunities in key sectors that can accelerate a net zero urban transition. The findings are relevant for policymakers, investors, and urban planners.

Research Objectives

- Explore urban solutions for transforming cities into net-zero systems.
- Evaluate city-level governance models in driving effective decarbonization.
- Examine city decarbonization examples and investment needs.

Research Question

- What practical strategies have cities adopted to manage urban growth while moving towards net-zero emissions?

Research Methodology

This study uses a qualitative case study approach to examine city-level strategies for reducing GHG emissions [8]. The approach is empirical, emphasizing facts, key figures, and real-world examples.

The paper is not theoretical or conceptual but uses thematic analysis to identify patterns and investment themes across selected city case studies [9]. A literature review was conducted to assess existing research and recent developments on net-zero cities and their decarbonization practices [10].

Agreeing on a City Carbon Budget

Mayors have been moving in lockstep or even ahead of their governments in climate target setting. This is highlighted from Table 1 below.

Table 1: Notable Cities and Carbon Neutrality Targets

City	Original Target Year	Updated Target Year
Copenhagen	2025	2026–2028 [11]
Edinburgh	2030	2030 [12]
Helsinki	2035	2035 [13]
Berlin	2050	2045 [14]
London	2050	2030 [15]

A first step a city can take is to establish a carbon budget: the total amount of CO_2 that can be emitted over a designated time period to comply with the Paris Agreement pathway. Carbon budgets help cities align their climate actions with global targets and prioritize sectors like energy, transportation, and housing for decarbonization.

A city carbon budget defines the maximum cumulative amount of CO_2 emissions a city can emit within a specific timeframe to align with global temperature targets, such as those outlined in the Paris Agreement.

Carbon Accounting in a City

But establishing a carbon neutrality target year and developing a carbon budget is only the first step—implementation means overcoming governance issues and resource barriers [16]. A few cities are already finding that the target-setting has to be revised, as implementation challenges arise.

Implementing a city carbon budget involves translating the pathway into municipal planning, and regularly monitoring progress. In fact, the carbon budget must trickle down through urban policies and actions toward low-carbon urban development and sector-specific investments [17]. A carbon budget approach ensures that local planning actions contribute to carbon neutrality instead of a business as usual GHG pathway [18].

Some scholars argue that carbon-neutral cities is a concept that lacks clarity, and ideas such as harmonized carbon accounting turns the concept into a practical framework [19]. Harmonized city carbon accounting refers to the standardized methods used to measure, report, and verify GHG emissions across cities.

Harmonization ensures consistency in emission scopes (e.g., direct, indirect, and consumption-based emissions), and facilitates comparability between cities.

Harmonization aligns local efforts with global goals, avoids double-counting, and ensures transparency. This approach integrates standardized metrics, tools, and frameworks such as the GHG Protocol for Cities, to account for emissions systematically [20].

Empirical Insights: Short Case Studies on Net Zero Efforts in Leading Cities

Leading cities worldwide are attempting to move to net zero through approaches like carbon budgets, smart mobility, renewable energy, retrofitting buildings, and blue-green infrastructure. This is explored further in the short case examples below.

The Climate Budgeting Example from Oslo, Norway

Oslo aims to reduce its greenhouse gas emissions by 95% by 2030, compared to 2009 levels. To achieve this, the city has implemented a climate budget to monitor and limit emissions across selected sectors. The climate budget consists of reduction targets and mitigation measures.

Key initiatives involve transitioning to zero-emission transportation, promoting energy efficiency, and carbon capture and storage (CCS) at waste incineration facilities [21]. Oslo's climate budget serves as a governance tool, where the target is integrated into the city's financial planning to ensure accountability [22,23]. Oslo has pledged to make its public transportation system emission-free by 2028, including the electrification of buses and municipal vehicles.

The Smart Mobility Example from London

London exemplifies the integration of smart mobility solutions, particularly through the deployment of EV charging infrastructure. Some urban dwellers know well that having sufficient access to EV charging spots can be a challenge in an affluent neighborhood, where the number of EV's is on the rise. As of May 2024, London hosts some 20,000 electric vehicle charge points, accounting for one-third of the UK's total [24].

Electrification of transportation is seen through the bus fleet; as of March 2024, London operates 1,397 battery electric buses, comprising approximately 16% of its total bus fleet of 8,776 vehicles. This makes London's electric bus fleet one of the largest in Europe, contributing to cutting the city's emissions [25].

Other net zero policy tools include a congestion charge and Ultra Low Emission Zoning, but London also benefits from the UK's national plan to ban new petrol and diesel cars by 2035 [26]. London will need a 60% reduction in car mileage by 2035 to achieve net-zero by 2050.

The Renewable Energy and Digitization Examples from Copenhagen

Copenhagen's goal to become CO_2-neutral by 2025 was related to the efforts in 2009 of putting Denmark and Copenhagen on the map as a climate leader in the run-up to the COP15 in Copenhagen that year. But a 2020 report revealed a 33% shortfall, and one researcher has argued that city target-setting was hindered by over-reliance on governance flowing from one center (the municipality), and reliance on biomass conversion [27].

Initially guided by collaborative principles, political shifts post-2010 deprioritized departmental collaboration, favoring green growth and clean-tech innovation. Copenhagen subsequently updated its target to achieve carbon neutrality between 2026 and 2028 due to delays in not only the biomass transition but also in infrastructure projects [28].

Investments in renewable energy sources like wind and solar power are fundamental to urban decarbonization. For Copenhagen, companies such as Orsted have been instrumental in developing offshore wind farms that supply clean energy to Copenhagen. This has reduced reliance on fossil fuels and lowered GHG emissions. Copenhagen's commitment to renewable energy is exemplified by the Middelgrunden Offshore Wind Farm, located 3.5 km off the city's coast. Commissioned in 2000, this offshore wind farm consists of 20 turbines with a total capacity of 40 MW, supplying about 4% of Copenhagen's electricity demand. Also, the Aflandshage Wind Farm project, approved in May 2023, will imply 26 large offshore wind turbines, each with a capacity of 11 MW, collectively producing green electricity equivalent to the consumption of 300,000 households, furthering the city's GHG reduction efforts [29].

Copenhagen is also actively integrating digital technologies to reach its target of carbon neutrality. The city's project EnergyLab Nordhavn exemplifies this effort by creating a smart energy system that combines electricity, heating, cooling, and transportation networks. This initiative utilizes data analytics and digital platforms to optimize energy consumption and reduce greenhouse gas emissions [30].

In 2016, Copenhagen launched a city data exchange to facilitate the sharing and analysis of urban data, enhancing the efficiency of public services and supporting sustainable urban planning [31]. Hitachi Insight Group developed the data marketplace, designing the solution, creating an initial set of applications, and testing it with real data in close collaboration with all contributing data partners [32].

Digital integration was key to Copenhagen's goal of carbon neutrality by 2025, and Copenhagen has issued green bonds to fund its goal. These green bonds financed various projects, including the development of offshore wind farms [33].

The Melbourne and San Francisco Examples of Retrofitting Existing Buildings

The City of Melbourne's "1200 Buildings" program aimed to retrofit 1,200 commercial buildings to improve energy efficiency. The program introduced Environmental Upgrade Finance (EUF), a loan mechanism repaid via property taxes. This financing gave building owners access to funds for energy-efficient upgrades, advancing Melbourne's net-zero goal [34].

Also San Francisco has focused on energy efficiency in buildings, and used Municipal Green Bonds to fund the initiative. These fixed-income instruments raise capital for energy-efficient retrofits. The bonds also involve the community, enabling residents to invest in the city's sustainability projects [35].

Mitigating Urban Heat Islands Through Blue-Green Infrastructure

Increasingly in focus in Europe during summer heatwaves, the Urban Heat Island (UHI) effect is a significant urbanization challenge. It is already well-known challenge in Asian cities, where the phenomena exacerbates heatwaves, making cities retain heat causing heat domes. The effect compromises livability and disproportionately affects vulnerable populations, including the elderly and individuals with heart conditions. Heat waves drive up demand for air conditioning significantly, leading to higher electricity demand.

What can be done? A recent review highlights key urban parameters—building density, surface albedo, and street orientation—as critical factors influencing UHI intensity. Focused on temperate climates, it proposes guidelines for integrating blue-green infrastructure such as urban forests, green roofs, and water bodies to mitigate these effects. By leveraging natural cooling mechanisms, blue-green infrastructure can help to reduce urban heat stress. These findings support microclimate-sensitive urban design and provide a basis for creating a dynamic blue-green infrastructure modeling algorithm to guide future climate-resilient urban planning [36].

Nature-Based Solutions offer an effective approach to mitigating the Urban Heat Island (UHI) effect. NBS may cut the reliance on energy-intensive air-conditioning systems. By integrating blue-green infrastructure, cities can enhance natural cooling through shade and increased surface reflectivity. These solutions improve microclimates, promote thermal comfort, and decrease energy consumption, contributing to lower GHG emissions. NBS not only address urban heat challenges but also enhance biodiversity, water management, and overall urban resilience, making the city more attractive to live in.

Cities invest in blue-green infrastructure to mitigate heat islands, and one notable example is Singapore. Singapore has adopted extensive green initiatives as part of its "City in a Garden" vision. These include vertical greenery (e.g., green walls and rooftop gardens), urban parks, and water-sensitive urban designs that integrate green and blue elements.

Some examples from Singapore are green corridors and urban forests, that reduce urban temperatures by increasing canopy cover and promoting shade. Other noticeable examples are green roofs and vertical gardens that are integrated into high-rise buildings. The green features reduce heat absorption. Bishan-Ang Mo Kio Park is a prime example of combining water management with greenery.

This park project transformed a concrete canal into a naturalized river, improving local microclimates, raising real estate values around the park, and mitigating the UHI effect [37,38].

A Basic Strategy and Prioritization of Key Sectors

Reflecting on these empirical examples, the question is whether some basic strategies can be derived. What needs to be done for a city to go zero carbon? Well, cities need basically to optimize, electrify, and decarbonize as explained in **Table 2** - and a further elaboration on broad sectoral strategies is expanded below in **Table 3.**

Table 2: Three Overarching Strategies to become a Zero-Carbon City

Strategies to become a Zero-Carbon City	Optimize, Electrify, Decarbonize
Optimize:	Efficient energy use in buildings is cost-effective and important for GHG reductions. Adopting new technologies like LED lights and equipment can improve energy efficiency, as seen in Los Angeles' refitting of street lights with LEDs.
Electrify:	A shift to electric power in transport and industry can reduce carbon emissions and noise pollution. Cost-effective renewable electricity sources can be used more—leading to electrification of buses and cars.
Decarbonize:	Cities can set ambitious goals and pathways and use clean and zero-carbon sources for electricity generation—with recent technological advancements enabling smarter integration in energy production, demand management, charge points for electric vehicles, and battery energy storage.

Table 3: Broad Sectoral Decarbonization Strategies in Cities

Key Decarbonization Strategies	Description
Energy-efficient buildings and infrastructure.	Retrofitting buildings, improving insulation, and deploying energy-efficient systems to reduce energy consumption.
Sustainable transportation	Investing in electric vehicles, public transit systems, and active mobility solutions like cycling and walking.
Renewable energy expansion.	Increasing the share of solar, wind, and other renewable energy sources in urban energy grids.
Expanding blue-green urban infrastructure	Implementing green roofs, urban forests, and water bodies to mitigate heat islands, reduce energy demand and improve urban resilience.
Smart digital technologies for urban systems.	Integrating digital platforms to optimize urban assets, enhance efficiency, and lower GHG emissions.

Transitioning cities to net-zero emissions necessitates investments across key sectors, each contributing to GHG reductions. Financial instruments such as green bonds, public-private partnerships, and environmental upgrade finance are pivotal in mobilizing capital toward these initiatives, and the key sectoral strategies are presented in **Table 3.**

Energy Efficiency in Buildings: Enhancing energy efficiency in buildings is crucial for reducing urban carbon footprints. Here, insulation through stone wool and retrofitting can minimize heating demands, significantly lowering energy consumption and reducing greenhouse gas emissions. Stone wool offers excellent thermal performance, durability, and fire resistance, making it ideal for energy-efficient building upgrades. Combined with retrofitting measures such as window replacements, smart thermostats, and sealing air leaks, retrofitting building projects can deliver significant GHG reductions over time.

Sustainable Transportation: Developing infrastructure for electric vehicles (EVs) and expanding public transit systems are vital for decreasing transportation-related emissions. Charging networks for EVs, electric trains and buses contribute to lower urban emissions. Expanding electric vehicle (EV) charging infrastructure is crucial for cities aiming to reduce emissions and promote sustainable transportation. Cities can set a precedent by converting their own vehicle fleets to electric, demonstrating commitment to sustainability and encouraging broader adoption. Cities with public housing and parking companies can invest in overnight EV charging infrastructure.

About 50 per cent of Nordic citizens live in apartment buildings owned by public, private, or co-operative tenant-owned corporations [39]. Deploying a charging infrastructure via local public housing and parking associations is a strategy likely to promote plug-in electric vehicles among households in multi-family dwellings. Some 46% of European Union residents live in apartments, with higher percentages in urban areas. This highlights the importance of providing accessible overnight charging solutions for apartment dwellers. Cities can collaborate with public housing and parking authorities to install charging stations in residential complexes and public parking areas [40].

Blue-Green Urban Infrastructure: Constructing sustainable and resilient urban blue-green infrastructure is key to long-term decarbonization. It may to start building projects that incorporate green materials and energy-efficient designs, so cities lower their carbon footprints and energy demand, but is also to do tendering for solution providers that can design urban water and forestry projects that can mitigate Urban Heat Islands, as discussed earlier.

Renewable Energy: Investments in renewable energy underpin electrification—cities can tender to support solar, wind, and other clean energy projects. Municipalities can issue green bonds to attract private investment or form public-private partnerships for funding large-scale renewable projects. Grants and subsidies from national governments or international organizations can also offset initial costs. Additionally, cities can implement power purchase agreements (PPAs) to secure long-term renewable energy at stable prices, incentivizing developers while ensuring consistent energy supply. An example is Orsted that has played a key role in Copenhagen's offshore wind farm development.

Digital Integration: Digital platforms that connect and optimize urban assets, such as buildings, EV chargers, and public services. These platforms enable cities to operate as cohesive, efficient systems, reducing emissions and improving services. Cities are a collection of interconnected physical assets. Digital integration of buildings, public services, and electric vehicle charging stations into an efficient urban system can enhance services.

Table 4 highlights key sectors for investment and examples of companies advancing decarbonization solutions.
By aligning urban investments with these sectors, cities not only achieve their climate goals but also unlock economic opportunities for investors in publicly traded companies driving the green transformation. Investing in these sectors not only advances cities toward their net-zero targets but also presents opportunities for stakeholders to support and benefit from the global decarbonization movement.

Table 4: Investment Sectors, Examples, and Solution Providers

Sector	City Example	Examples of Solution Providers	Rationale and Decarbonization Benefit
Renewable Energy	Copenhagen [41,42]	Ørsted, Siemens Gamesa Wind Power	Offshore wind projects for urban power generation. Development of offshore wind farms providing clean energy to urban areas.
Energy Efficiency	Melbourne [43,44]	Johnson Controls, Schneider Electric Rockwool, Saint Gobain,	Building retrofits for energy savings. Provision of building automation systems that optimize energy usage, reducing emissions.
Sustainable Transportation/ Charging Infrastructure	San Francisco [45,46]	Tesla, Alstom, ABB Ltd (ABB), Siemens AG, ChargePoint Holdings Inc.	EV infrastructure and electric public transport. Supply of electric trains, facilitating low-emission public transportation. Manufacturing of electric vehicles and establishment of charging infrastructure, decreasing transportation emissions.
Green Urban Infrastructure	Copenhagen Singapore	Vinci, AECOM	Construction of sustainable buildings and infrastructure, contributing to overall urban GHG reductions.
Digital Integration	Copenhagen	Siemens, Schneider Electric, Itron	Development of urban energy and water management platforms integrating buildings, EVs, and public services for optimized GHG reductions.

Conclusions

The paper has elaborated examples and strategies in cities. Thinking about how our cities can go carbon neutral is critical — as the concentration of wealth and power in cities will only increase. In 1970, just three cities had over ten million inhabitants. Twenty years later, there were ten such megacities. And, by 2014, there were 28 megacities. The United Nations World Urbanization Prospects (2022) estimates 43 megacities by 2030, with cities like Kinshasa and Lagos expected to see the fastest growth [47]. With 70% of carbon emissions and consuming two-thirds of global energy, the need to focus on cities as key climate actors is apparent.

This paper highlights how urban areas can lead the net-zero transition by using tools like carbon budgeting and harmonized carbon accounting frameworks. Case studies from Oslo's climate budget and London's smart mobility initiatives to Copenhagen's investments in offshore wind farms demonstrate targeted policies and investments.

Achieving net-zero cities requires ramping up investments in key sectors. Energy-efficient buildings, renewable energy projects, sustainable transportation, and blue-green infrastructure can cut urban emissions. Financial instruments like green bonds and public-private partnerships have funded initiatives. The paper emphasizes aligning investments with these sectors to not only accelerate decarbonization but also create robust opportunities for investors.

The pathway to net-zero cities lies in scaling innovative, integrated solutions. Digital technologies, as seen in Copenhagen's EnergyLab Nordhavn, optimize urban energy systems, while blue-green infrastructure mitigates urban heat islands and improves resilience. Cities can lead global efforts toward climate stabilization and in the end, help the world reach net zero.

Disclaimer

The contents of this research article are not meant to recommend courses of actions or investment decisions on the basis of the issues identified and analyzed. The contents are intended to inform you as a reader, and to identify research and policy gaps for further work. Any financial gain or loss incurred by a reader because of this article will result from decisions taken by the reader as an individual. The opinions expressed in this article are my own as an individual, and do not reflect the opinions of my current employer.

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