

Discussion on Economic Benefit Analysis and Sustainable Development Path in Low-Carbon City Development

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Abstract

The construction of low-carbon cities has emerged as an important strategy to realise the harmonious development of urban economy and climate change mitigation. Cities account for about 70% of global energy-related carbon dioxide emissions. The economics of urban decarbonisation – the costs of transition, the benefits of energy efficiency, green jobs, health co-benefits and carbon market revenues – is therefore of critical policy relevance. In this article, we explore three complimentary ways in which low-carbon city development might bring economic benefits: (i) direct cost savings and employment benefits; (ii) carbon market and green finance methods; and (iii) comparative development trajectories between leading jurisdictions. Using data from the IEA, IRENA, OECD and the EU Emissions Trading System, and case studies from Copenhagen, China's Low-Carbon City Pilot programme and the European Union, the paper makes the case that the economic case for low-carbon urbanism is solid and is getting stronger if policy frameworks can be crafted to align financial incentives with decarbonisation objectives. The report concludes with policy recommendations regarding the design of carbon pricing, the mobilisation of green funding and the management of an equitable transition.

Keywords

Low-carbon City; Economic Benefits; Sustainable Development; Carbon Pricing; Green Employment; Urban Decarbonisation; Green Finance.

1. Introduction

1.1. Research Background

Climate change in the urban dimension is one of the most important policy challenges and substantial economic opportunities of the twenty-first century. According to the International Energy Agency, cities use almost two-thirds of the world's primary energy and produce over 70% of energy-related CO₂ emissions, despite covering only about 2% of the Earth's geographical surface. Global energy-related CO₂ emissions hit a record 37.4 billion tonnes in 2023, partly fuelled by growing urbanisation in emerging Asia, which now accounts for over half of global emissions. The clustering of emissions in urban areas is a product of the spatial logic of economic activity but also points to cities as the principal loci where decarbonisation initiatives need to be undertaken and assessed.

In this context, the idea of the low-carbon city, which is a city which tries to reduce greenhouse gas emissions in a systematic way while preserving economic dynamism and social equality, has passed from academic debate to the main stream of policy. The Paris Agreement framework of nationally determined contributions, the growing number of net-zero pledges from major cities, and the emergence of dedicated policy instruments such as carbon pricing, green bonds, and urban energy efficiency regulations have created a complex landscape in which the economic costs and benefits of low-carbon transition require careful, evidence-based assessment.

1.2. Research Questions and Contributions

Three research questions are addressed in this work. The main types of economic benefit from low carbon city development and their relative sizes as suggested by available information are: Second, what institutional and policy approaches have the leading cities and jurisdictions used to generate these benefits and with what results? Third, what are the best policy means to connect economic incentives with sustainable development goals in the urban context? This study provides a comprehensive synthesis of empirical evidence and comparative case analysis connecting the economics of climate policy with the practice of urban development.

2. Theoretical Framework

2.1. The Economics of Low-Carbon Transition

There are a number of theoretical traditions that inform economic research of low-carbon city development. The basic rationale for carbon pricing draws on externality theory in the Pigouvian tradition, which argues that since carbon emissions impose costs on third parties not reflected in market prices, a corrective tax or tradeable permit system is needed to internalize these externalities and guide economic activity towards lower-emission pathways [1]. The theoretical basis for calibrating the level of carbon pricing is the social cost of carbon, defined as the present value of all future costs associated to one more tonne of CO₂ emissions, however actual estimates fluctuate widely between study and discount rate assumptions [1][15].

The Porter hypothesis of Porter and van der Linde [2][12] provides a complementary perspective: well-designed environmental regulation does not impose a net burden on firms and cities, but rather spurs innovation which can partially or fully offset compliance costs, and can improve productivity and competitive positioning. In a multi-country meta-analysis published in *Humanities and Social Sciences Communications* in 2024, the author confirmed the “narrow” version of the Porter hypothesis for both developed and developing country contexts and found that command-and-control regulations have the highest consistency in driving green innovation [2]. This evidence shows that the economic benefits of low-carbon urban policy include not only direct cost reductions, but also dynamic innovation effects.

2.2. Sustainable Development Frameworks

Low-carbon city development has important connections with the UN Sustainable Development Goals (SDG), particularly SDG 11 (sustainable cities and communities) and SDG 13 (climate action). Decoupling, in which positive economic growth is achieved while the carbon intensity or absolute emissions are reduced, is a key element in the framing of sustainable development. A growing body of empirical evidence shows decoupling is possible, with several high income cities achieving sustained economic growth and significant emissions reductions. The concept of Triple Bottom Line, which measures development results on three dimensions of economic, social and environmental development, provides a practical evaluation framework for urban low-carbon policy that cannot be reduced to single-metric optimisation [3].

2.3. Green Finance and the Investment Imperative

To decarbonise cities in a sustainable way requires huge amounts of capital invested in the energy systems, the building stock, transport infrastructure and industrial processes. Green finance, encompassing green bonds, sustainability-linked loans, ESG investment requirements and climate-aligned government spending, has now become the key mechanism for mobilizing private resources for these efforts [4]. The OECD reported that the global investments in clean energy reached USD 2 trillion in 2024, a 61% increase from USD 1.2 trillion in 2019, which is an indication of the growing financial scale of the low-carbon transition [4]. Whether this

mobilisation of capital is enough to finance the degree of urban decarbonisation necessary to meet the targets of the Paris Agreement is an active subject of research and policy debate.

3. Economic Benefits of Low-Carbon City Development

3.1. Direct Economic Benefits: Energy Efficiency and Employment

The direct economic benefits that can be measured from developing low-carbon cities are improvements in energy efficiency in buildings, industry and urban transport systems. The IEA states that energy efficiency investments often yield immediate cost savings that exceed the initial capital outlay over the economically viable payback time, making efficiency the most economically self-sustaining element of urban decarbonisation [5]. In city plans in Europe and East Asia, retrofitting actions in the building sector targeting insulation, glazing and heating systems have consistently achieved pollution reductions and net cost savings over medium-term horizons [5].

A final class of direct economic benefit is the employment effects of low-carbon investment. According to the IRENA and ILO Annual Review 2024 [6], in 2023, renewable energy employed 16.2 million people globally, up 18% from 13.7 million in 2022. Solar photovoltaics alone supported 7.2 million jobs worldwide, with 4.6 million jobs in China and 1.8 million renewable energy jobs in the EU [6]. These employment gains are especially important for the development of low-carbon cities, since renewable energy and energy efficiency retrofitting are labour-intensive enterprises located in metropolitan areas.

3.2. Health Co-Benefits and Avoided Costs

Reductions in urban air pollution linked to decarbonisation provide large economic co-benefits in terms of saved health care expenses and lower mortality. The OECD's 2014 report on the cost of air pollution estimates the health burden of outdoor air pollution in OECD countries, including both premature deaths and illness, was almost USD 1.7 trillion in 2010, with an additional USD 1.4 trillion attributed to China alone [7]. The same study projected that in the absence of governmental intervention, the expenses of health care attributable to air pollution might reach USD 176 billion per year by 2060. Low carbon city strategies that displace fossil fuel burning in transport, heating and power generation yield health co-benefits that greatly increase the direct economic returns on decarbonisation investment [7].

3.3. Carbon Market Revenues and Green Finance Flows

A third form of economic gain for low-carbon cities is the direct fiscal and financial flows generated by carbon pricing regimes. During the fourth trading phase (2021–2030) of the EU Emissions Trading System (EU ETS), carbon permit prices increased from below €10 per tonne in the early 2010s to over €100 per tonne in February 2023, before settling down to an average price of €65 per tonne in 2024 [8]. As a result, the covered emissions under EU ETS by 2024 were about 50% lower than the 2005 levels, which is the cumulative effect of the system [8]. The ETS allowance auction profits – some of which are redistributed to member states for climate investment – are an important source of public cash for urban decarbonisation initiatives.

According to the Climate Bonds Initiative, worldwide green bond issuance reached USD 385.1 billion in the first half of 2024, up 14% compared to the same period in 2023, with Europe accounting for 62% of aligned green volume [14]. According to OECD data [4], corporate green bond issuance in 2024 was USD 382 billion (full-year). According to the GSIA's 2024 Global Sustainable Investment Review, the value of fund assets reporting the adoption of responsible or sustainable investment methodologies reached USD 16.7 trillion, an increase of roughly USD 5.5 trillion (49%) over two years [9]. Increasingly, these capital flows are targeting urban

infrastructure, such as low-carbon buildings, clean transit networks and distributed energy resources.

4. Sustainable Development Pathways: Case Analysis

4.1. European Model: Copenhagen and the EU Policy Framework

In 2012, the City Council of Copenhagen adopted CPH 2025 Climate Plan, with the ambition of becoming the world's first carbon neutral capital city. The concept listed four pillars: reducing energy consumption, developing renewable energy, greening mobility and urban planning. The progress has been spectacular. The CO₂ emissions per capita declined from 4.7 tonnes in 2010 to 1.3 tonnes in 2022 and the city trajectory shows a further decrease below 1.0 tonne by 2025 [10]. This has been done without sacrificing economic dynamism. In fact, Copenhagen consistently ranks among the most economically competitive and desirable cities in Europe, giving empirical confirmation of the decoupling hypothesis in a high-income city setting.

At European level, the EU ETS is the economic backbone for low-carbon industry and energy transition, with its fourth phase boosting the annual linear reduction factor to promise rapid emissions cuts until 2030 [8]. The EU's Fit for 55 package targets a 61% reduction in emissions covered by the ETS in 2030 relative to 2005 levels, providing consistent price signals for investment decisions in cities [8].

4.2. East Asian Model: China's Low-Carbon City Pilot Programme

The Low-Carbon City Pilot (LCCP) programme was launched by China's National Development and Reform Commission in 2010. The first batch of pilot areas included five provinces and eight cities, namely Tianjin, Chongqing, Shenzhen, Hangzhou and Baoding. The programme expanded twice in 2012 and 2017 to cover 81 cities and six provinces [11]. The empirical evaluation based on the difference-in-differences methodologies utilising the panel data from 212 prefecture-level cities from 2003 to 2016 showed that the pilot cities reduced carbon emissions by about 24.5% compared with non-pilot cities after the policy was implemented [11]. Under the scheme, Hangzhou, Xiamen and Shenzhen each cut annual carbon emissions by about 200,000 tonnes [11].

The results show that state-led low-carbon urbanisation plans can yield substantial decarbonisation outcomes at scale, especially when combined with renewable energy deployment, industry restructuring incentives and green construction requirements. China also leads in renewable energy employment globally, with an anticipated 7.4 million, or 46%, of the world's renewable energy jobs in 2023 [6].

4.3. Challenges in Emerging Economies

In rising and developing economies, cities are hampered in their low-carbon development pathways by the tension between development imperatives and decarbonisation commitments and the climate funding gap. In 2023, India overtook the EU to become the third highest contributor to global CO₂ emissions, indicative of the emissions intensity of its continuing industrialisation and urbanisation [5][13]. According to the IEA World Energy Outlook 2024, to reach net-zero by 2050, renewable energy capacity must be tripled, with cities being the main sites of implementation [13]. The funding requirements for low-carbon urban infrastructure in developing Asia and Africa are far greater than the flows of concessional capital available, and the gap between the needs and the availability of climate finance constitutes a structural barrier to equitable low-carbon urbanisation [4]. To address this gap, we need to scale up financing by multilateral development banks and create conditions for private green capital to flow into higher-risk urban markets.

5. Policy Mechanisms for Economic-Environmental Co-benefits

5.1. Carbon Pricing Design

Carbon pricing through either carbon taxes or tradeable permit systems is the most economically efficient instrument to incentivise low-carbon city development, since it generates pervasive price signals across all emitting activities without requiring regulators to specify which technologies or behaviours should change [1]. The experience from the EU ETS comparison shows that cap-and-trade systems can be effective in achieving aggregate emission reductions, when the cap is appropriately narrowly defined, as indicated by the 50% decrease in covered emissions between 2005 and 2024 [8]. The design characteristics that most affect the probability of success are the stringency of the cap or tax rate, the breadth of coverage across economic sectors, and the use of auction revenues for useful climate investment rather than general fiscal purposes [1].

5.2. Green Finance Mobilisation

The USD 639 billion global green bond market and USD 16.7 trillion of sustainable investment assets identified by GSIA provide a substantial source of finance for low-carbon urban development [4][9]. Effective green finance for cities requires clear taxonomies defining eligible green investments, robust disclosure and verification frameworks, and public de-risking tools such as first-loss guarantees and concessional co-investment to reduce the risk-adjusted cost of capital for urban green projects [4]. The OECD statistic that in 2024, USD 2 trillion was invested in clean energy globally illustrates that the market is responding to these instruments. Still, investment is highly unbalanced in high income urban regions [4].

5.3. Technology and Innovation Policy

There is empirical evidence for the Porter hypothesis prediction that environmental law stimulates green innovation in a variety of jurisdictions and levels of study [2]. Urban technology and innovation policy may enhance this effect through targeted support for research and development, procurement rules that favour low-carbon solutions and smart city platforms that aggregate energy management data across buildings, transit and industry [3]. The optimal economic outcome emerges from stringent carbon pricing combined with proactive innovation strategy. Carbon pricing boosts the relative expense of high-emission activities, while innovation policy accelerates the cost reduction of low-emission alternatives [2][3].

6. Discussion and Conclusion

6.1. Synthesis and Policy Recommendations

The evidence discussed in this study makes a strong economic case for the creation of low-carbon cities. Direct energy efficiency savings, the rise in renewable energy jobs to 16.2 million globally in 2023, health co-benefits valued in the trillions of dollars annually, and growing carbon market green finance flows all add up to an economic dividend from decarbonisation that extends much further than environmental protection. The case studies from Copenhagen and China illustrate that both market-based and state-led pathways can provide large-scale carbon reductions alongside economic vitality provided they are embedded inside unambiguous long-term policy frameworks. There are three policy recommendations. Firstly, carbon pricing instruments must be strict enough and provide price certainty to incentivise investment, with auction revenues recycled into urban de-carbonisation initiatives. Secondly, the laws for green finance must be standardised internationally to avoid fragmentation and stimulate capital flows into cities of emerging countries. Third, fair transition arrangements are vital in maintaining social legitimacy and ensuring that the economic benefits of low-carbon

growth are equitably shared, such as retraining programmes for displaced workers, and support for carbon-intensive urban firms 4.

6.2. Limitations and Future Research

Based on aggregated data and case studies released. Generalisability is limited by variability in the urban context. Future study should conduct longitudinal studies controlling for confounding factors, and collect city-level distributional statistics on the impact of carbon pricing to aid the design of just transition strategies.

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