



THE LONDON SCHOOL  
OF ECONOMICS AND  
POLITICAL SCIENCE ■

LSE **Cities**

# Copenhagen

## Green Economy Leader Report

A report by the Economics of Green Cities Programme at  
the London School of Economics and Political Science.



# Executive Summary

## Objectives

This independent report has been prepared by the Economics of Green Cities Programme at the London School of Economics and Political Science in partnership with the City of Copenhagen. The overarching aim of the report is to provide an overview of Copenhagen's green economy and assess some of the major challenges.

## Copenhagen: a green economy leader

Copenhagen is widely recognised as a green economy leader. The wider Copenhagen region accounts for 39% of Denmark's output and has enjoyed stable growth over the long term. Copenhagen's growth has been delivered at the same time as improving environmental performance and transitioning to a low-carbon economy.

At the national level, Danish GDP per capita ranks in the top 10 countries in the world and the country is one of the 15 most competitive economies globally. Denmark's small, open economy is characterised by innovative, hi-tech services and manufacturing for export; and a large, effective public sector.

Copenhagen remains one of the most productive cities in Europe, with gross value added exceeding US \$83,000 per worker in 2010. However, productivity and income in other OECD countries and cities have been catching up with Denmark over the last decade. Relatively slower employment and productivity gains over recent years have been identified as an area of concern by Copenhagen policy makers.

## Drivers of Copenhagen's green economy

Copenhagen's high levels of income and environmental performance are underpinned by a strong combination of the city's eight green economy drivers. A number of these drivers rank among the best in Europe and the world, including urban form, innovation, skills and employment, low carbon, and environmental quality.

Energy and resource effectiveness and low carbon drivers are central to Copenhagen's goal to be carbon neutral by 2025, and have potential for substantial additional policy support, in particular with regard to the district heating system, energy efficiency, waste management and decarbonisation of the transport sector.

While Copenhagen's drivers of investment and enterprise perform strongly at an international level, other high performing cities and countries are closing the gap and, in some cases, overtaking. National rates of Foreign Direct Investment compared to other high performing countries represent a particular risk to Copenhagen's growth.

**Driver 1: Urban form.** Copenhagen's relatively compact urban form is a result of its 1947 Finger Plan, which has largely concentrated development along the city's main public transport corridors. Growth over the past decade has been stronger in inner city areas compared to the suburbs, reversing a post-war trend.

**Driver 2: Innovation.** Denmark is one of the leading countries on innovation, and the Copenhagen Capital Region is a globally important centre for innovation development. Copenhagen's range of high quality tertiary education and research institutions, with their linkages to private business, is likely to contribute to its innovation excellence. Research and development (R&D) spending in Denmark, at 3.1% of GDP, is one of the highest in the OECD. However, further research is required to assess how these input factors are translating into growth.

**Driver 3: Investment.** Copenhagen's levels of Foreign Direct Investment (FDI) are relatively high, and the Copenhagen Capital Region has been particularly attractive to businesses in the ICT and life sciences sectors. However, national FDI levels have remained largely unchanged between 2000 and 2011, with FDI stock ranging between 45 and 52% of GDP. Over the same period, FDI in other European countries has grown more rapidly, and Denmark is now close to the EU-27 average. This could be a risk to Copenhagen's growth and competitiveness.

**Driver 4: Skills and employment.** Copenhagen has a highly-skilled workforce and low unemployment. Copenhagen has the European Union's fifth-highest rate of adults with a university degree at 46% - a rate that exceeds Denmark's four other regions by a large margin. The city's 7.7% unemployment rate in 2012 is also 2.5 points lower than the EU average.

**Driver 5: Enterprise.** Copenhagen is a city of entrepreneurship. Around one-third of Denmark's enterprises are registered in the Copenhagen Capital Region, accounting for almost half of Danish business exports and, at US \$175 billion, 44% of the country's total business turnover. The number of adults reported as involved in 'early-stage entrepreneurial activity' is well above levels in many wealthy East Asian and European cities, although below several cities in the UK, Germany, Australia, and North America. However, SMEs report more difficulties in securing access to finance in Denmark compared to some other OECD countries.

**Driver 6: Energy and resource effectiveness.** While Copenhagen's economy continues to grow, total energy consumption has been reasonably stable. Per capita consumption of household district heating energy and electricity fell by around 10% between 2005 and 2011. Water efficiency in the city is also high, with 108 litres consumed per capita per day in 2010 - 36% lower than in 1989. Municipal waste production in Copenhagen has fallen by 19% between 2006 and 2010. In 2010, 71% of waste was incinerated, 27% was recycled, and only 2% was sent to landfill.

**Driver 7: Low carbon.** Copenhagen is already a low carbon city by international standards. Carbon emissions have dropped consistently between 1991 and 2012, from 7.9 to 3.2 tonnes per person. This is largely due to district heating expansion and national wind energy deployment. However, continued policy support and business innovation will be needed to meet Copenhagen's ambitious carbon-neutral target by 2025. Achieving net-zero transport sector emissions will be particularly challenging.

**Driver 8: Environmental quality.** Air quality in Copenhagen has improved substantially over the past 20 years due to energy and transport policies. SO<sub>2</sub> pollution fell by 83% between 1990 and 2000, while carbon monoxide fell by 72% between 1994 and 2007. However, PM<sub>10</sub> levels remain above the World Health Organisation guideline of 20µg/m<sup>3</sup>, while NO<sub>2</sub> levels remain high in the city centre. Water quality has improved significantly over the last 20 years. Swimming in Copenhagen's harbour has become an iconic symbol of Copenhagen's recent pollution remediation efforts and broader economic restructuring away from locally polluting industries.

## Copenhagen's policy programmes

If Copenhagen is to maintain its international competitiveness along with high levels of environmental performance and long-term sustainable growth, integrated policy programmes will be required that are effective and efficient. Three broad strategic areas are of particular importance to Copenhagen's future as a green economy leader:

- **Low carbon, energy and resources.** Meeting Copenhagen's highly ambitious goal to be carbon neutral by 2025 will require a number of major strategic policy and infrastructure investment decisions. Policy decisions taken in the next few years may lock in pathways that are challenging and costly to reverse.
- **Urban form, transport and accessibility.** Maintaining Copenhagen's relatively compact urban form, continuing to increase cycling rates, and increasing efficiencies in the public transport system will play important roles in meeting the city's green growth objectives.
- **Innovation and business.** Maintaining Copenhagen's leading position as a cleantech cluster and in public private partnerships, and providing effective support for growth in innovation, inward investment and enterprise will influence the growth of the city's green economy.

## Low carbon, energy and resources

Copenhagen is a global leader in a range of low-carbon policies, including extensive district heating, combined heat and power generation, and high rates of cycling. Furthermore, the 2025 Climate Plan, created in 2012, proposes to make Copenhagen the world's first carbon-neutral capital city. The plan aims to complement and coordinate the objectives of several other existing policy frameworks in energy, transportation, development planning, and waste. While Copenhagen is starting from a very strong base, this highly ambitious carbon-neutral target will require rapid and sustained policy action in order to deliver a transformative agenda. Other Copenhagen policy initiatives for water supply and wastewater management support Copenhagen's already strong performance in resource efficiency.

Under Copenhagen's carbon-neutral target, two strategic areas emerge as particular challenges (and economic opportunities): (a) energy supply and demand, (b) transport and mobility. At the same time, reducing emissions from electricity supply will require strong national policies for decarbonisation of the national electricity grid.

**Eliminating fossil fuels from energy supply** will require an integrated approach based on fuel substitution, integration of distributed energy resources to the energy network, and improved efficiency. Existing generation technologies and waste management practices may need to evolve and could require substantial investments in infrastructure as well as changes in management and institutional arrangements.

**In the near term, strong momentum exists to replace coal with biomass as the primary fuel for the city's combined heat and power generation plants.** This makes effective use of existing assets and allows near-term carbon reductions to scale quickly. At the same time, implementation of management practices to ensure the sustainability of the biomass supply is needed. Reducing energy demand, principally in buildings, will also be important.

**Although fuel substitution will continue in the near term, other energy supply and management options are available in the medium term and should be examined further by the City of Copenhagen.** These are linked to initiatives for energy efficiency. Potential pathways include:

- (1) increasing investment in gas / biogas generation for district heating and in integrated grid energy storage to increase system flexibility and allow for more seamless integration of intermittent renewable energy such as wind and solar;
- (2) reducing the proportion of waste (including plastics) in the district energy fuel mix;
- (3) increasing the amount of distributed generation controlled through micro-grids, and scaling down or replacing the district heating system with a combination of electric heating (such as air source heat pumps) and micro-renewable generation and storage within buildings; and
- (4) removing barriers to energy efficiency improvements and significantly scaling up energy efficiency retrofits in buildings, which is particularly important for increasing the effectiveness of micro-generation and micro-grids.

**Eliminating fossil fuels from transport** will require an integrated approach to policies on public transport, non-motorised mobility, and electric / hydrogen vehicles. The Copenhagen carbon-neutral plan recognises that direct decarbonisation by 2025 is not feasible and that carbon offsets will deliver a majority share of the sector's carbon-neutral total. Of the 544,000 tonnes of CO<sub>2</sub> emissions attributed to the transport sector, 409,000 tonnes will be reduced via offsets. Nonetheless, Copenhagen has a number of policy options to meet its direct 2025 reduction of 135,000 tonnes, with further decarbonisation of the sector in the longer term.

At the strategic level, the city will face choices over the policy priority given to promoting clean vehicles in relation to other transport and land-use policy programmes, and managing potential conflicts in how infrastructure is allocated to various modes. Choices made in the transport sector can also influence how carbon emissions are driven down in the energy sector generally, for example in the case of electric vehicles also providing distributed energy storage services.

**A range of alternative pathways for eliminating carbon from Copenhagen's transport sector, and the policy instruments required for shaping these pathways, should be investigated further by the City of Copenhagen.** Alternatives include:

- (1) investing further in cycling infrastructure;
- (2) improving the efficiency and integration of the mass transit network, partly through deployment of 'smart' mobility ICT infrastructure; and
- (3) providing infrastructure for, and actively incentivising, electric or hydrogen vehicles.

The City of Copenhagen has a high degree of control over policy levers in the two areas of heating energy and transport, though both will require policy coordination with the national government.

## Urban form, transport and accessibility

Copenhagen has a long history of effective land use and spatial planning that strongly influences its environmental performance and has supported low-carbon growth. Its development largely along defined transit corridors means that transport accessibility in Copenhagen compares favourably to large world cities such as London and New York, and substantially outperforms low density car dominated cities such as Los Angeles and Sao Paulo.

Copenhagen's population is expected to grow by 100,000 people in the period to 2025. To accommodate this, policy and investment frameworks for land and infrastructure development are prioritising mixed-use, inner-urban / brownfield development areas. Copenhagen's Municipal Plan identifies major transport connections, employment centres, and the main development locations or 'Action Plan Areas' to which growth will be directed. Provisions under the Danish Planning Act also include the 'Station Proximity Principle', which generally requires new large offices of more than 1,500m<sup>2</sup> to be located within 600m of a railway station.

Transport policy is focused on reducing carbon emissions, reducing congestion and private vehicle use, increasing multi-modal integration, and increasing cycling, walking and use of public transport. These policies underpin Copenhagen's objectives to be the "world's best bicycle city" and for a minimum of 50% of journey-to-work and school trips to be made by bicycle by 2015. At present, cycling is used for 20% of all weekday trips in Copenhagen - one of the highest rates in the world.

Central Copenhagen has a dense urban core with a high degree of land-use diversity and integration of living and working environments. Its city centre peaks at 25,340 residents per km<sup>2</sup>. London, though a much larger city, has a similar peak residential density. Copenhagen's high inner-urban employment density and the clear dominance of central Copenhagen as an employment node are both similar to Stockholm.

Investments in its relatively new light rail 'Metro' network will improve access for people in Copenhagen, particularly with station proximity being within 500 metres. Travel times across different modes are also low in Copenhagen. This translates into significant economic benefits compared to Stockholm and London, where transport costs account for 5.8% and 8.36% of gross value added respectively, compared to a figure of 3.4% in Copenhagen. However, public transport journey times are considerably longer than car journeys in Copenhagen. This adds to the challenge of shifting transport away from private vehicles, which currently account for roughly 40% of mode share.

Carbon emissions have been reduced effectively from the transport sector over the period 2000 to 2010, reversing the trend in the previous decade. However, sustained policy efforts will be required to shift further away from private vehicles to other modes. **Mass transit ridership shows scope for improvement. Addressing regional fragmentation in bus route planning can assist in this, along with better coordination to achieve operational efficiencies.** Delivering the supporting infrastructure for low-carbon mode choices will require collaboration between multiple actors: Copenhagen and the Danish government for light and heavy rail, and multiple local municipalities for bus services.

**Support from national and regional government is also needed to ensure that areas with significant growth pressures, e.g. in the vicinity of Copenhagen Airport and ring-road locations, have the infrastructure in place to minimise trips by private vehicles.**

The City of Copenhagen has set highly ambitious goals to extend cycle use further. It is unclear whether the positive feedbacks, in terms of infrastructure and the existing cycle culture in Copenhagen, can continue to raise cycling substantially, or whether certain demographics will resist making a modal shift. Consequently, **the City of Copenhagen's broader approach to sustainable travel, including promoting use of public transport, walking and multi-modal trips - alongside cycling - should continue.**

## **Innovation and business**

Evidence suggests that the cleantech industry in Copenhagen and Denmark has strong growth and is highly productive. The 2013 European Cluster Excellence Scoreboard ranked the cleantech industry in Copenhagen first for growth in annual revenues; and second for growth in output and profit between 2010 and 2013. Other analysis on the cleantech sector nationally has shown that productivity rates were substantially higher between 2003 and 2009 in cleantech than in manufacturing and welfare technology, two nationally important industries. Turnover in Danish cleantech in 2010 was over DKK 250 billion (US\$46 billion), representing 9.2% of the national total. Cleantech also accounted for 10.4% of total Danish exports and more than 8.5% of employees in Danish enterprises in 2010.

Clustering is also a key strategy for drawing the Copenhagen business community, research sector, and government organisations into partnerships. The Copenhagen Cleantech Cluster (CCC) is one of the world's leading organisations for building networks and for promoting commercialisation of goods and services that contribute to green economic growth.

Local and national policies on climate change and urban environmental quality have created business opportunities for local firms to apply their technologies and services. Experiences gained in Copenhagen become part of these firms' brand for export. Integrated strategies for large urban development projects such as Nordhavnen will help Copenhagen continue to act as a test bed for urban green growth.

At the same time, Danish policy support for innovation is focused on education, supporting business growth, and investment in research and development. Denmark ranks third in the EU-27 2013 EU Innovation Scorecard, and had the highest average growth rate (2.8%) in innovation performance between 2008 and 2012 of the top performing four countries.

Although Copenhagen's cleantech sector is very strong both nationally and internationally, areas exist for potential improvement. Challenges facing innovation and green business in Copenhagen include: barriers to attracting private investment at scale for low-carbon technology and resilient infrastructure; insufficient information for investors, entrepreneurs and the city government to make effective investment and business decisions; and the growth in competition in international markets.

These challenges have come at a time of continued low to moderate growth in the EU and wider global economy. Furthermore, the Danish economy has witnessed lower growth in productivity, employment and GDP compared to some comparable countries in the OECD over the past decade. Consequently, policy coordination between the City of Copenhagen and the national government will be important for overcoming the barriers to growth in the cleantech sector.

In terms of finance barriers, investors in low-carbon solutions typically trade higher upfront costs for longer term savings, whether in the form of reduced energy consumption through efficiency upgrades, or in low marginal cost energy supply sources such as wind and solar. Facilitating a match of finance sources to these longer return horizons, and shifting upfront costs into long, steady returns, will be important.

**The City of Copenhagen, in collaboration with the national government, could pursue a number of options to address finance barriers in the cleantech sector, and create opportunities through public-private collaboration, including:**

- (1) scaling the market for energy efficiency retrofits by leading or facilitating activities for bundling small retrofit projects into larger more bankable projects, backstopping energy savings guarantees, or tying energy efficiency loan obligations to the property rather than the occupant;
- (2) establishing an institutional mandate by seeding investment in a public-private 'Green Bank';
- (3) increasing participation in the green bond market; and
- (4) exploring models of public-private partnership for delivering goods and services, including those traditionally delivered by the public sector.

In terms of information barriers, governments at all levels have a role to play in collecting and disseminating information to help investors and entrepreneurs make effective decisions for business growth. Transparent and targeted information can motivate and inform entrepreneurs and investors of the scale of the opportunity, facilitate information symmetry for more realistic pricing of risk and confidence between counterparties (including public-private finance and innovation collaborations), and support policy decision-making and validate policy choices for green economic growth.

**The City of Copenhagen could pursue a number of options to overcome information barriers so that investors and entrepreneurs can make more effective investment and business decisions.** These include:

- (1) working closely with the national government to create standardised accounting and reporting tools for the cleantech sector and for setting up natural capital accounts; and
- (2) working with researchers, insurers, utilities and regulators, to develop risk-sharing metrics for low carbon and adaptation programmes, which can also be used in policy formulation.

**In terms of capturing opportunities in larger markets - both regionally and internationally - the City of Copenhagen could examine subsectors of green products and services where Copenhagen and Denmark have a comparative advantage globally.** Identifying and developing niche sectors will become increasingly important as competition in the global low carbon market intensifies.

**The City of Copenhagen should also promote greater cross-border collaboration with the research community and other partners in energy services to help create a larger, stronger regional market for low-carbon energy and other cleantech goods and services.** This would reflect the shared regional ambition for a transition to low carbon (though with differing timeframes) and increase integration of renewable energy into the regional energy grid. As the last incremental steps towards carbon neutrality in the years closest to 2025 will be the most challenging and costly to achieve, this regional focus may provide greater flexibility.

The full report is available for download from: <http://www.kk.dk/da/om-kommunen/indsatsomraader-og-politikker/natur-miljoe-og-affald/klima/co2-neutral-hovedstad>



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