THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

LSECities

Stockholm

Green Economy Leader Report

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

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

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Contents

Figures

Tables

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 Stockholm. The overarching aim of the report is to provide an overview of Stockholm's green economy and assess some of the major challenges and opportunities for the city in fostering green growth in the future. The report is divided into three main parts:

- **Framework for assessing green economy leaders.** This section sets out the framework for assessing the urban green economy in terms of short-term economic competitiveness, environmental performance, and long-term sustainable growth. In particular, eight drivers of green growth are described: 1. Urban form; 2. Innovation; 3. Investment; 4. Skills and employment; 5. Enterprise (including fair competition); 6. Energy and resource effectiveness; 7. Low carbon; and 8. Environmental quality.

- **Drivers of Stockholm's green economy.** This section examines levels of productivity and economic growth in Stockholm over the last 20 years. Each of the eight drivers of green growth are then analysed and compared to national and international benchmarks.

- **Stockholm's policy programmes.** This section examines three strategic areas where integrated policy programmes will be required to meet Stockholm's longer term goals of becoming carbon neutral by 2050, maintaining a 'world class' economy, and maximising the economic opportunities from green innovation and clean technology. These three areas are: (a) low carbon, energy and resources, (b) urban form, transport and accessibility, and (c) innovation, business and eco-districts.

I. Framework for urban green growth

A green economy leader is a city that displays high productivity and economic competitive advantage in the short term, high and growing levels of environmental performance, and long-term sustainable growth. Underpinning the urban green economy are eight key drivers:

- Urban form
- Innovation
- Investment
- Skills and employment
- Enterprise (including fair competition)
- Energy and resource effectiveness
- Low carbon
- Environmental quality

These drivers can face a range of market failures and institutional barriers that reduce their impact on economic growth. City, regional and national governments can use a range of policy instruments to overcome market failures and strengthen economic growth including: pricing; urban planning and regulation; public finance; public procurement; and information.
If these policy instruments are to be successful, cities also need strong institutional fundamentals, including city leadership; effective governance at national, state and city levels; and public private partnerships.

II. Drivers of Stockholm's green economy

Stockholm's sustainable growth

At the national level, Swedish GDP per capita ranks in the top 15 countries in the world and the country is one of the four most competitive economies globally. The economy is characterised by its combination of innovative, hi-tech industry and a large, effective public sector.

The wider Stockholm region accounts for 42% of Sweden's GDP and has enjoyed strong and stable growth over the long term. Between 1993 and 2009, growth of Stockholm County averaged 4.1% per year. This growth is underpinned by relatively high levels of productivity, though lower than some other cities such as New York.

Stockholm's strong growth has been delivered while increasing environmental performance and transitioning to a low carbon economy. A range of triggers has led to early action green policies in Stockholm over the last 50 years. Major triggers include population growth and building the city's metro system; pollution and the rise in environmental awareness; the oil crises of the 1970s and expansion of district heating; the 1992 Rio Earth Summit; and Stockholm's 2004 Olympic bid.

Green economy drivers in Stockholm

Stockholm's high wealth, productivity and environmental performance are driven by a strong combination of the city's eight green economy drivers. Seven drivers of Stockholm's green economy rank among the best in Europe and the world: urban form, innovation, investment, skills and employment, enterprise, low carbon and environmental quality. One driver - energy and resource effectiveness - has significant potential for future policy support. Energy efficiency, waste management and water efficiency are particular areas of potential. In addition, barriers to clean technology start-up companies and small and medium-sized enterprises (SMEs) are worth further investigation.

Driver 1: Urban form. Stockholm has a relatively compact urban form, with development concentrated along the city's main public transport corridors. Today's urban form is a result of early strategic planning beginning in the 1950s.

Driver 2: Innovation. Stockholm has an innovation-led economy with first class universities, research institutions, and public private technology centres. At the national level, Sweden ranks first on the EU's Innovation Union Scoreboard.

Driver 3: Investment. Sweden has one of the highest levels of inward foreign direct investment (FDI) in the world. Over the past two decades inward FDI has averaged 4.7% of GDP, well above the European average of 2.8% and higher than that for the United States, Japan and Brazil. The number of foreign-owned businesses in Stockholm County increased by 520% from 1998 to 2010, with the number of employees in these companies almost tripling from 75,000 to 208,000.

Driver 4: Skills and employment. Stockholm has one of the highest employment rates in Europe, averaging 77% over the last 10 years. The city also has a highly skilled workforce, providing talent for productive knowledge-economy sectors.

Driver 5: Enterprise. Stockholm is based on a business environment that provides start-ups and SMEs with opportunities to enter and compete fairly in markets and access to substantial venture capital. Over 24,000 companies were newly registered in 2011 - 29% higher than in 2005, despite the global economic downturn.

Driver 6: Energy and resource effectiveness. Stockholm's energy and water security are strong. Enhancing energy and resource efficiency should be a greater priority for the city in the short term. Stockholm County's energy consumption per capita is lower than the national average due to lower industrial activity. However, since 1990, overall energy use in the county has remained unchanged. Water use in Stockholm remains substantially higher than the European average, while incineration for district heating maintains high demand for waste.

Driver 7: Low carbon. Stockholm has one of the lowest levels of greenhouse gas emissions in Europe. In 2011, Stockholm's emissions were 3.5 tonnes per person, compared to an average of 7 tonnes in OECD Europe. The national grid is now 97% low carbon (mainly hydro and nuclear), while Stockholm's extensive district heating system increasingly uses waste incineration and biofuels. However, Stockholm's ambitious target to be fossil fuel free by 2050 requires major strategic decisions on pathways to eliminate carbon entirely from domestic heating and transport.

Driver 8: Environmental quality. Environmental quality. Stockholm's air and water quality have improved substantially over the last 50 years. Policies have successfully reduced SOx and NOx in the air, as well as phosphorus and nitrogen in the surrounding lakes. However, PM10 levels remain above WHO's international standards.

III. Stockholm's policy programmes

If Stockholm is to maintain its international competitiveness, high levels of environmental performance and long-term sustainable growth, it will require integrated policy programmes that can deliver effectively and efficiently. Three broad strategic areas are of particular importance to Stockholm's future as a green economy leader:

- **Low carbon, energy and resources.** While Stockholm's 2050 goal to become fossil fuel free is long-term, it is also ambitious. 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 Stockholm's relatively compact urban form and strengthening its efficient public transport system will play an important role in meeting the city's green growth objectives.

- **Innovation, business and eco-districts.** Maintaining Stockholm's competitive business environment and providing effective support for the growth of clean technology innovation, inward investment and enterprise will influence the growth of the city's green economy.

Low carbon, energy and resources

Stockholm has a well-structured policy strategy for transitioning to a low carbon, resource efficient economy, underpinned by an extensive range of policy instruments. Key frameworks include *Vision 2030*, the *Environmental Programme* and *Climate Action Plan*. However, while Stockholm has achieved substantial success in reducing carbon emissions, the city's ambitious target to be fossil fuel free by 2050 requires major strategic decisions on pathways to eliminate carbon entirely from the economy. This will require strong and early policy action over the next few years to overcome long-term lock-in of high carbon infrastructure, systems and technology.

In maintaining Stockholm's position as a green leader, two strategic areas emerge as particular challenges – and economic opportunities: (a) energy for heating and (b) energy for transport. The other key area for emissions reductions is electricity supply, which will require strong national policies for decarbonisation while maintaining energy security.

Eliminating fossil fuels from heating will require an integrated approach to policies on energy efficiency of buildings, district heating and energy from waste incineration. The city authority has steadily reduced carbon-emitting fossil fuels from the energy sources fuelling the system, and has also integrated district heating with its approach to waste management. With most waste incinerated and supplying energy for heating, waste to landfill rates are now very low compared to other cities in the EU, while waste is being re-used as an energy resource.

This inter-related system of district heating and waste incineration will require reform and careful policy attention to ensure Stockholm achieves both continued carbon reductions and more effective use of resources. All the strategic pathways available for reform present considerable challenges, and require decarbonisation of the electricity grid through national policy measures. Potential pathways include:

1. switching district heating fuel sources entirely from coal and waste incineration (which currently includes carbon emitting waste plastic) to biofuels or other renewable energy sources;
2. a mixed waste and biofuels approach with carbon emitting plastics being phased out of the waste incineration process through policies for reducing and recycling plastic waste;
3. carbon capture and storage (CCS) of emissions from combined heat and power and waste incineration plants;
4. carbon offsetting with emissions in other sectors, regions or countries in a global carbon market; or
5. replacing the district heating system entirely with a combination of electric heating (such as air sourced heat pumps) and micro-renewables on buildings.

Eliminating fossil fuels from transport will require an integrated approach to policies on public transport, clean vehicles and electric mobility. Stockholm faces a number of policy options in further pursuing its clean vehicle goals. At the strategic level, there are choices to be made about the policy priority given to promoting clean vehicles in relation to other transport and land-use policy programmes. In reducing carbon emissions and air pollution from the sector, alternative strategies focused on reducing personal vehicle travel or shifting travel to more

sustainable modes may be more cost-effective than measures such as subsidies to promote clean vehicle purchases.

A range of alternative pathways for eliminating carbon from Stockholm's transport sector – and the policy instruments required for shaping these pathways - could be investigated further by the City of Stockholm. Alternatives include:

1. investing further in sustainable transport modes;
2. actively incentivising biofuels for vehicles;
3. actively incentivising electric or hydrogen vehicles; and/or
4. incentivising a mix of vehicle technologies.

The City of Stockholm has considerable control over policy levers in the two areas of heating and transport, though both will require coordination with national and regional levels of government.

Urban form, transport and accessibility

Stockholm's relatively compact urban form has a range of benefits for the green economy. These include low-cost, low-carbon and resource efficient passenger and goods transport facilitating agglomeration economies, job matching, larger labour pools, knowledge spill overs and firm clustering. Stockholm has a well-structured spatial and transport policy strategy to improve environmental performance and low carbon development, underpinned by an extensive range of policy instruments.

Public transport accessibility - measured by walking distance to public transport stations - is exceptionally high for both workplaces and residents in Stockholm. Accessibility levels are close to those in Hong Kong - a global leader.

Stockholm profits from strong agglomeration advantages and labour accessibility with peak values of 440,000 economically active people that can be reached within 30 minutes - compared to, for example, 365,000 in Copenhagen.

Travel time efficiency in Stockholm appears to be limited by multiple factors. For example, the city displays a certain degree of segregation of work-places and living for some urban centres that facilitates clustering but compromises proximity. For the metro region, theoretical time costs for commuting are 5.8% of Stockholm's GDP compared to 3.4% in Copenhagen and 8.4% in London. The City of Stockholm has a mature policy programme to reduce urban sprawl and promote higher density and brownfield-oriented developments. Land use policy is well integrated with public transport infrastructure (predominantly rail and metro) and sustainable transport policies (congestion charging, parking fees, promotion of cycling and walking).

However, Stockholm features relatively low levels of cycling and bus travel. Furthermore, car use continues to dominate, both in terms of total number of trips and kilometres travelled. The overall average distance travelled in Stockholm is significantly higher than in Copenhagen and this contributes to higher levels of transport related energy demand.

There is great potential to focus more directly on strategies to reduce overall travel demand in Stockholm. Further strengthening the mix of land uses particularly for the redevelopment of employment nodes such as Norra Station and Värtan/Royal Seaport should be prioritised. Across the metropolitan region, the city could examine policies that enhance the integration of living with working while limiting the segregation of residential areas and locally isolated employment locations.

Stockholm could consider further 'push' policies to reduce car ownership and car use by introducing car-free developments and additional restrictive measures. Related 'pull' policies could include the promotion of bus travel (Bus Rapid Transit, bus lanes and bus corridors), further multi-modal integration, and a comprehensive cycle strategy.

Finally, significant potential exists for the redistribution of public street space from private car use to public transport and walking with a focus on shifting travel patterns from private motorised to public or non-motorised travel.

Innovation, business and eco-districts

In an urban green economy, policies for stimulating all types of innovation should be encouraged. Governments also have a role in supporting green innovation more specifically, as it contributes not only to total factor productivity in the short to medium term but is also necessary for the transition to a low carbon, resource efficient economy – one that delivers higher rates of growth over the long term.

One of the key policy instruments for stimulating and supporting innovation is targeted research and development (R&D) spending. **Sweden already invests heavily in R&D.** Between 1997 and 2008, national spending on R&D averaged 3.7% of GDP compared to 1.8% across Europe.

The City of Stockholm has stimulated innovation by developing new-build eco-districts. The eco-districts at Hammarby Sjöstad and Royal Seaport are clean technology demonstrator projects delivered through public private partnerships. These eco-districts have made Stockholm one of the leading cities in the world for developing and demonstrating innovative green solutions at the district level.

A number of opportunities exist for Stockholm to capitalise further on the success of its eco-districts including:

1. rolling out eco-district innovations in publicly owned buildings;
2. rolling out innovations across existing districts in the private market;
3. developing additional eco-districts in the future; and
4. expanding export promotion, particularly through Symbiocity (a Swedish Trade Council agency), to continue supporting the growth of exports into international markets.

Currently, the majority of public funding support for green enterprise is provided through general business initiatives supported by the Swedish Government. Within Stockholm, green business support is provided by smaller scale organisations such as STING (Stockholm Innovation and Growth), a Kista-based non-profit incubator and dedicated venture capital fund, and the Stockholm Cleantech Association.

Support from city and national governments has not yet translated into particularly strong growth in the green business sector. Turnover in Stockholm's green business sector grew by an average of 3.0% per year between 2004 and 2009. Over the same period, the number of green sector firms grew by 4.2% - similar to the 4.3% growth overall in firms, while employment in the green sector declined more rapidly than overall employment during the global recession.

While Stockholm's ICT cluster is internationally recognised and the city's strengths in life sciences innovation are well known, other cities have a stronger brand for cleantech clustering. The lack of strong growth in Stockholm's green sector, combined with the lack of a strong cleantech cluster brand suggests that the City of Stockholm should assess the benefits and costs of building a stronger, more centralised cleantech cluster in the city.

The City of Stockholm's spending on procured goods and services amounted to US$2.86 billion in 2012. Consequently, green public procurement has substantial potential as a policy instrument for shaping green business markets. While the city has various targets for green procurement, other cities have comprehensive green public procurement policies that are integrated into the detailed procurement guidelines of the authority and its public agencies – an area that the city authority could investigate further.

The global market for green goods and services is currently estimated to be around US$6 trillion. If Stockholm's businesses can capture activity in this large and growing international market, the green sector represents a major source of future growth. The global market for low carbon building technologies alone is worth US$650 billion annually. Based on Stockholm's expertise in green building developed through its eco-districts programme, substantial opportunities are likely to exist in this sub-sector.

Stockholm's Green Wedges

Despite decades of growth and development, only 47% of the total city area of Stockholm is built-up, with the rest dominated by green spaces and water. The close integration between new developments and the public transport network have created a structure where green areas and parks radiate out from the city centre in a star shape. These 'green wedges' are important ecological corridors that contain urban sprawl and contribute significantly to the well-being of the city's residents.

Photo credit: Yanan Li

1 Introduction

Key messages

The objectives of this Report are to:

- Examine the strength of Stockholm's green economy compared to other cities in Sweden, Europe and worldwide.
- Assess the eight drivers of Stockholm's green growth: urban form, innovation, investment, skills and employment, enterprise, energy and resource effectiveness, low carbon, and environmental quality.
- Examine major integrated policy initiatives in Stockholm aimed at strengthening the green economy. These policy programmes can provide lessons for Stockholm's future policy direction as well as for other cities that can learn from Stockholm's experience.
- Identify alternative strategic pathways for Stockholm's future green growth, and areas of policy and economic research that the city could prioritise to analyse these pathways.

Three broad strategic areas for the city's green economy were examined:

- Stockholm's 2050 goal to become fossil fuel free. While long term, this target is ambitious. Policy decisions taken in the next few years may lock in pathways that are challenging, and costly, to reverse.
- Maintaining Stockholm's relatively compact urban form and strengthening its efficient public transport system.
- Maintaining Stockholm's competitive business environment and providing effective support for the growth of clean technology innovation, inward investment and enterprise.

One important area of Stockholm's carbon footprint that is not part of the scope of this Report is the city's consumption patterns. The review is based on the city's production accounting system for carbon emissions. While consumption impacts are not within the scope of this Report, it is an area that the City of Stockholm may wish to explore in the future.

1.1 Objectives of this report

The overall aim of this Report is to assess the early action policies that have led Stockholm to emerge as a green economy leader today, and to examine the long term strategic options facing the city if Stockholm is to maintain its leading position in the future. In particular, the Report has the following objectives:

1. Examine the strength of Stockholm's green economy compared to other cities in Sweden, Europe and worldwide.

2. Assess the eight drivers of Stockholm's green growth: urban form, innovation, investment, skills and employment, enterprise, energy and resource effectiveness, low carbon, and environmental quality.

3. Examine major integrated policy initiatives in Stockholm aimed at strengthening the green economy. These policy programmes can provide lessons for Stockholm's future policy direction as well as for other cities that can learn from Stockholm's experience.

4. Identify alternative strategic pathways for Stockholm's future green growth, and areas of policy and economic research that the city could prioritise to analyse these pathways.

The Report examines the strength of Stockholm's drivers of the urban green economy, reviews past and current green policy programmes to determine their potential impact on these drivers, and recommends areas of further research in particularly strategic areas.

The aim of this Report is not to undertake a detailed economic cost benefit analysis of all the city's policy programmes – a task that would require substantial time and resources. Furthermore, such an undertaking would not be able to capture the considerable diversity of direct and indirect channels through which economic and environmental policies impact on the wider economy.

Narrow cost benefit analyses on the impact of green policies on economic growth often fail to provide the whole economic picture; both the socio-economic costs of negative externalities (e.g. from climate change and local pollution) and the wider benefits that green cities can foster (e.g. attracting young entrepreneurs and skilled professionals through a green, high tech urban environment) are generally underestimated or entirely ignored. Indirect costs of green policies on the wider economy are also challenging to measure quantitatively.

Three broad strategic areas for the city's green economy are worth mentioning here. The first is Stockholm's 2050 goal to become fossil fuel free. While long term, this target is ambitious. Policy decisions taken in the next few years may lock in pathways that are challenging, and costly, to reverse. For this reason, the Report reviews potential policy pathways that will impact on the City of Stockholm's ability to meet their carbon target effectively, efficiently and equitably, as well as indicating economic opportunities that well-designed policy frameworks for meeting the target could create and support.

The second broad strategic area is maintaining Stockholm's relatively compact urban form and strengthening its efficient public transport system. As a result of early strategic planning beginning in the 1950s, the city's development is focused along the main public transport corridors. This provides very high levels of accessibility. Building on this success, the Report reviews potential opportunities for land use strategies that could reduce overall travel demand in the future, as well as strengthening alternatives to car travel such as bus rapid transit (BRT) systems.

The third strategic area is Stockholm's objective to maintain its competitive business environment and provide effective support for the growth of clean technology innovation, inward investment and enterprise. Green innovation can be stimulated both through targeted support for clean technology companies and through support to more generic technology companies that may have a branch in the clean technology business or could be supported to move into new green growth markets created by national, regional and city policy frameworks.

One important area of Stockholm's carbon footprint that is not part of the scope of this Report is the city's consumption patterns. The review is based on the city's production accounting system for carbon emissions. Clearly, the consumption of imported, energy intensive goods such as plastics, steel, aluminium and a large range of manufactured products fosters growth in emissions from other parts of the world (e.g. China and India). Furthermore, while Stockholm itself represents a knowledge economy, it also relies on the products of heavy industry in other parts of Sweden. While consumption impacts are not within the scope of this Report, it is an area that the City of Stockholm may wish to explore in the future.

1.2 The Economics of Green Cities Programme

This Report forms part of a wider research programme at the London School of Economics and Political Science (LSE): the Economics of Green Cities (EGC). The EGC is a global collaborative programme chaired by Lord Stern at the LSE. The Programme was set up with the aim of examining the risk-adjusted costs and benefits of green policy frameworks on the sustainable economic growth of cities in different parts of the world. The purpose is to provide robust, evidence-based recommendations for city and national policy leaders and other stakeholders. In particular, the two key areas that the Programme focuses on are:

- the economic rationale for cities to undertake early-action green policies in developed and developing countries; and

- the policy programmes, institutions and tools that are most promising for policy makers to implement, measure and monitor green city policies.

The EGC Programme focuses on the effects of early action versus delayed action green policies. Currently, there is a lack of rigorous analysis of early mover advantage in the transition to green city economies. While narrow economic studies have been carried out on the costs of green infrastructure, these rarely take account of the longer term and indirect economic impacts, including the negative externalities of pollution, climate change and reductions in green space. The Programme examines the economic impacts of innovation, new technologies and new markets that are created by early versus delayed action.

The Programme also takes an integrated approach to the green economy. While discrete sectoral approaches are useful for national and international policy making, city policy strategies require a particularly strong integrated approach. For example, planning decisions that lock in urban form, such as the layout of buildings, transport routes and green space, affect the policy options available, or required, for reducing carbon emissions and air pollution, promoting innovation clusters and attracting professional workers and companies to the city. The Programme uses integrated methods to examine the most promising policy instruments, financing models and partnerships that can maximise the net benefits of investing in green infrastructure and technology.

The LSE collaborates with a wide range of other public research institutes and private sector research groups under the EGC Programme. Working with international organisations such as the World Bank and OECD, the Programme draws on a wide range of expertise and data. Considerable research support for this Report was provided by The Climate Centre (TCC Seneca) in Brussels.

1.3 Methodology

The overall research approach aims to position Stockholm in a global context, as well as providing a detailed examination of specific policy programmes within the city and surrounding county. A range of methods were used in the review, drawing on data and information from a diversity of sources. Methods included desktop reviews of policy documents and academic literature, interviews with city policymakers and businesses, analysis of statistical data, geographic mapping and spatial analysis of Stockholm. In addition, the review drew on the LSE Cities global research on urban green economies, including the LSE Cities/ICLEI global cities survey undertaken in 2012, and specific research on other leading green economy cities such as London, Copenhagen, Hong Kong, Portland Oregon and Berlin.

The drivers and policy instruments of Stockholm's green economy are benchmarked using a range of comparators. Time series are used to examine Stockholm's growth and changes in key variables over time. Time series data range from 35 years to 4 years, depending on the availability of data. Stockholm's green economic drivers are also compared to other regions in Sweden to examine the strength of the city and county's growth relative to the national average and to other leading regions in Sweden. As a capital city and a green economy leader, Stockholm's performance is also compared to other capital cities and leading green economies around the world. Where impacts on Stockholm's green economy are closely linked to national policies, and where comparable data across world cities is not sufficiently robust, international comparisons of indicators are made between Sweden and other countries.

Part II of this Report makes extensive use of internationally comparable quantitative indicators to assess Stockholm's green economy and growth, along with the underlying eight drivers of the green economy.

Part III of the Report uses case studies to investigate city-level policy programmes more closely. The case studies were selected to include an analysis of Stockholm's most important green economy policy programmes. The three case studies were chosen to enable examination of how city-level public policy is supporting all eight green economy drivers identified by the Economics of Green Cities Programme's framework for green economy leaders.

Statistical data were used to examine time series and comparisons between Stockholm and other cities and regions. Data were sourced from Statistics Sweden, the City of Stockholm, international organisations such as the World Economic Forum (WEF), Eurostat, United Nations, World Bank, Organisation for Economic Cooperation and Development (OECD), World Health

Organisation (WHO), and the global database held by LSE Cities. The majority of data was publically available. The review also drew on additional data held by the City of Stockholm. In undertaking global comparisons, comparative analysis of cities was undertaken where data were available. In many cases, however, city-level data for comparison was not available and in some cases illustrative comparisons at the national level were used.

A further important element of the research methodology involved spatial analysis of urban areas. Combining spatially-defined demographic data with information on transport infrastructure and land-use patterns was particularly important for the land-use and transport case studies.

This Report drew on the LSE Cities global survey of city governments conducted in 2012 (for a summary of results previously published see Rode and Floater 2012). The survey targeted elected representatives and city government officials and was conducted as an online survey available in English, Chinese and Spanish. A total of 90 cities responded to the survey, including Stockholm. The cities represented a diverse range of city types and sizes located across different geographic regions (Europe, Americas, Asia and Africa).

The survey included an overall questionnaire of 40 questions, with sections on green policies, green economy, smart city technology, green policy assessment and roles, actors and governance. In addition, six shorter sector-specific surveys provided more detailed information about green economy progress in the following sectors: buildings, energy, land use, transport, waste and water. Responses to questions from the global sector-based survey were collated, averaged and given quantitative weightings to produce results that could be compared to those from the Stockholm survey.

Interviews were also conducted with a mix of public-sector policy makers and representatives from private-sector businesses involved in each of the policy programmes. The interviews were designed to reveal different perspectives and attitudes on the challenges and opportunities of establishing a policy environment conducive to green growth.

1.4 Report structure

This Report is structured in three parts. Part I presents the framework used to assess the drivers of the urban green economy. The framework focuses on eight key drivers: 1. urban form, 2. innovation, 3. investment, 4. skills and employment, 5. enterprise, 6. energy and resource effectiveness, 7. low carbon, and 8. environmental quality. The market failures hindering these drivers are discussed along with the main policy instruments available to overcome the barriers.

Part II comprises two chapters on Stockholm's green economy and its underlying drivers. Chapter 3 examines Stockholm's long-term economic growth and the city's current economic performance in terms of competitiveness, labour productivity and output. The second part of the chapter examines the major triggers that contributed to the development of Stockholm as a green leader. Chapter 4 explores the eight drivers of Stockholm's green economy and compares each against national and global benchmarks. The development of each driver is also examined over the long term to provide a more comprehensive understanding of how the driver has strengthened or weakened over time.

Part III examines the city's integrated policy programmes in place today and their potential impact on the eight drivers of the green economy. Areas of further research are recommended in particularly strategic policy areas. Chapter 5 examines the city's policies for supporting energy and resource effectiveness, the low carbon transition, and environmental quality (including reduced air pollution). The chapter covers five key sectors in this area: transport (including low carbon vehicles), buildings (including energy efficiency), energy, water and waste. The chapter concludes by identifying cross-cutting strategic areas for particular policy attention that will be central in defining the long-term pathways to Stockholm's future green economy.

Stockholm's compact urban form is a key driver of the city's green economy, impacting through agglomeration economies, more efficient energy use and lower carbon emissions. Chapter 6 analyses employment accessibility, travel time efficiency and transport sustainability, and

benchmarks Stockholm's performance against relevant comparator cities in Europe. The chapter also discusses future challenges and opportunities for the development of Stockholm's urban form.

Finally, Chapter 7 examines the role of the private sector, public research, and the effectiveness of Stockholm's public private partnerships (PPPs) for stimulating green innovation and clean technology. The city's eco-districts at Hammarby Sjöstad and Royal Seaport are reviewed as examples of innovation demonstrator projects delivered through PPPs. The chapter concludes by discussing future challenges and economic opportunities for maintaining and growing the city's position as a leading knowledge-led economy. Areas examined include clustering of clean technology firms, capitalising on Stockholm's eco-district innovations, and accessing international markets for export.

A walkable city

Stockholm's highly accessible urban form supports public transport, walking and cycling, and results in transport-sector carbon emissions that are substantially lower than in most other advanced economies. More than a third of all weekday trips in the city are completed on foot. This high walking rate is complemented by an excellent multi-modal public transport system, and the use of innovative policy instruments such as congestion charging to further manage transport demand.

Photo credit: Yanan Li

PART I

FRAMEWORK FOR URBAN GREEN GROWTH

2 Assessing green economy leaders

Key messages

A green economy leader is a city that displays high productivity and economic competitive advantage in the short term, high and growing levels of environmental performance and long-term sustainable growth.

There are eight key drivers of the urban green economy: 1. urban form; 2. innovation; 3. investment; 4. skills and employment; 5. enterprise; 6. energy and resource effectiveness; 7. low carbon; and 8. environmental quality.

These drivers can face a range of market failures and institutional barriers that reduce their impact on economic growth. City, regional and national governments can use a range of policy instruments to overcome market failures and strengthen economic growth including: urban planning and regulation; pricing; public finance; public procurement; and information.

If these policy instruments are to be successful, cities also need strong institutional fundamentals, including city leadership; governance at national, state and city levels; and public private partnerships.

2.1 What is an urban green economy?

2.1.1 Cities as engines of green growth

More than half the world's population now lives in urban areas. The World Bank estimates that over 90% of urban growth is in the developing world, adding around 70 million new residents to urban areas each year (World Bank 2010). Over the next 20 years, the urban population of South Asia and Sub-Saharan Africa, which includes some of the poorest people in the world, is expected to double. At the same time, cities in Europe, North America and other countries in the rich world continue to expand as urbanisation continues. As a consequence, the importance of cities in powering economic growth, development and prosperity worldwide continues to increase.

Furthermore, cities are not only important geographic units of economic activity in their own right, they are anchors of regional economies and are often key drivers of national growth. Already today, 150 of the world's largest metropolitan economies produce 46% of global GDP with only 12% of the global population (Brookings Institution, LSE Cities et al. 2010).

While cities are often engines of growth and prosperity in the short term, in the longer term they can have negative economic impacts. As centres of energy demand and industrial production, urban areas are responsible for up to 80% of anthropogenic greenhouse gases. This not only has consequences for the environment, but also creates negative impacts on long-term economic growth (Stern 2006). Furthermore, in the short term, poor resource efficiency can increase economic and social costs substantially, while pollution and reduced biodiversity can potentially act as negative externalities, affecting productivity through e.g. reduced health of the population and reductions in natural resources.

For many cities, these costs are likely to increase substantially over the coming years as resource constraints (including energy, water, raw materials and food commodities) continue to deepen in the face of growing demand from rapidly industrialising countries. In the last 10 years alone, global food prices have more than doubled (FAO 2013; Lee, Preston et al. 2012).

This then raises the question: is there an economic rationale for early-action policies that foster green growth in cities? This will depend on the economic benefits of green policy programmes (both locally and globally) weighed against their associated costs. Even where a clear case for public intervention can be made, care must be taken in its design and execution so as to limit the scope for market failures to be replaced by policy failures. Policies need to be non-discriminatory, where possible using market instruments to avoid inefficiencies and prevent rent-capture by wasteful vested interests.

Cities are natural units for driving innovative policy solutions for green growth. They combine a mix of specialisation and diversity derived from a concentration of people and economic activity that generate a fertile environment for innovation in ideas, technologies and processes. As hubs of regional economic activity, they produce and distribute the resources that provide better livelihoods for urban and rural residents alike.

At the same time, cities have a degree of self-governance, and city policymakers are often able to deliver integrated policy programmes that have a more direct, systemic impact on citizens. City authorities are closer both geographically and culturally to their citizens than national governments. City-specific issues such as congestion, clean water, waste, energy, education and crime require considered city-specific public intervention. Examples include energy efficient buildings, renewable energy, efficient distribution of clean water and waste, green transport schemes, congestion charging and clean air zones. For these reasons, cities may have more potential for making a significant impact on green growth relatively rapidly.

In addition, their high population density and relatively compact form can allow for economies of scale, efficiency gains and collaboration. Although per capita emissions are generally higher in cities than in rural areas, much of this reflects higher incomes in urban areas. By contrast, emissions per unit of output are usually lower in dense cities than in surrounding rural or suburban areas.

2.1.2 The rationale for green growth

There is more to individual and collective welfare than economic growth, especially where it is used to finance current consumption over investment. Yet it must be recognised that economic growth will continue to play the central role in lifting billions of people out of poverty in the developing world (Collier 2007). Growth also tends to be correlated with a number of desirable properties in all parts of the world, such as education opportunities, rule of law and reduced crime and conflict, gender equality, physical and mental health, tolerance and social mobility (Coyle 2011).

The green growth literature points out that 'business as usual' is likely to undermine growth as the impacts of climate change take their toll, while rising demand for key raw materials of finite supply steadily pushes up their price. With billions of people in Asia and other developing regions rightly aspiring to the living standards and consumption levels of richer countries, investment in resource efficiency and renewables will be essential to raise productivity without environmental limits threatening growth (Hepburn and Bowel 2012; Murray and King 2012).

Until a decade ago, resources appeared to be limitless, while climate change was considered too far in the future to impact on economic decisions today. Indeed, there seemed to be empirical support for the view that commodities were becoming more economically abundant, given the long-term trend of declining commodity, food, mineral and energy prices over the 20th century (Johnson 2000). However, over the past decade growing demand from large developing economies such as India and China has spurred a marked reversal of century-long commodity price declines.

In order to assess the channels through which green policies foster growth, we must first identify the main drivers of the urban green economy. Classical growth theory assumes that output (Y) is a function of physical capital stock (K), labour input (L) and total factor productivity (T) (Solow 1956):

$$Y = f(T, K, L)$$

T is regarded as a function of technological progress and efficiency, along with other intangible variables. Growth in output results from growth in physical capital and labour, as well as increases in total factor productivity (T). Growth in T reflects innovation in the processes, techniques, and technologies with which these inputs are used. Growth accounting suggests that economic growth in the majority of rich countries stems almost entirely from growth in T. At the same time, T is itself a function of the level and type of human and capital investment in the economy, that is to say T is endogenous. New equipment enables new ideas and better technologies (Zenghelis 2011b). For example, investing in computers induces bright ideas on how to use them. This fuels increasing returns to scale in production, where investment in knowledge leads to increased

output and resources for further investment: a virtuous circle of endogenous growth (Romer 1991).

Once a firm or an economy embarks on a high-innovation, high-productivity path, that path tends to reinforce a technological lead (Acemoglu, Aghion et al. 2009). The benefits of induced innovation from learning and experience are already evident across a range of renewable technologies. Onshore wind energy costs have fallen by 38% in the last four years and generation is now competitive with conventional coal, while the cost of solar photovoltaic has fallen by a factor of five in the last five years and could be fully competitive with coal this decade (Bloomberg New Energy Finance 2012).

Nonetheless, resource-efficient innovation will not occur without an active policy steer to invest in alternatives that are initially more expensive. Fostering green growth requires policies to shift the tax base towards materials and resources and away from intellectual activity by focusing on the factors that generate knowledge and induce innovation.

This is particularly important at the urban level. The potential to lock in to physical infrastructure that induces changed mind-sets, behaviours and technological adoption and innovation is great. It underlies the large disparities in the use of technologies and behaviours in cities of similar size and incomes across the world. Endogenous growth is arguably a major factor in determining the growth pathway of cities that is either sustainable in the long term or not.

The rewards of these active policies are potentially great. Intellectual activity has never been more productive. Rapid technical change is always disruptive, but the impact of the information and communication technology (ICT) revolution is probably greater than that of steam or electricity. Networked ICT has the potential to increase resource efficiency substantially by providing a platform for knowledge dissemination and real-time monitoring and management of resource flows (Zenghelis 2011a). There is no previous example of a new technology whose price has fallen so quickly or diffused through the economy so rapidly as innovations in computers and mobile devices.

2.1.3 Green policies and economic recovery

Setting public sector challenges boosts innovation (Mazzucato 2011). Economic history tells us that investment flows to pioneers (Pérez 2002). Furthermore, there is growing evidence that environmental concerns enhance prosperity. Prosperous states and cities in Germany, Scandinavia, Asia and the US have a track record of applying green policies to energy, public transport and buildings. These regions benefit from resource efficiency, energy security, reduced pollution and more desirable vibrant neighbourhoods. Additional green comparative advantages will be forged over the coming century, and although there are certainly risks to firms and nations moving too early, in a world where the transition to resource-efficiency is all but inevitable, the risks of moving too late are arguably greater.

Many will accept the need to invest in resource efficiency in ‘normal times’, but will argue that now is not the time to make costly investments. Instead, the focus now should be on jobs and growth. In fact, far from there being some trade-off between investing in green or investing in growth, the current period of low confidence and sluggish private investment presents a unique opportunity for policy-makers to boost employment and economic growth by supporting resource-efficient green markets.

To understand the growth potential that comes from green markets, it is useful to remind ourselves of recent macroeconomic history. Growth requires investment, yet investment has slumped to record post-war lows in the rich world. Households, businesses and banks are nervous about future demand, and have responded by foregoing more risky investment in physical capital.

Much of the slowdown in business and household spending was inevitable. In the aftermath of the financial crash—which many governments helped fuel through excess fiscal borrowing at the peak of the economic cycle—households, businesses and banks undertook necessary and unavoidable long-run stock readjustment in balance sheets (Zenghelis 2012). This required additional saving and a reduction in private spending in order to restore private sector net

worth. A slowdown in growth, or even recession, was an inevitable consequence of this balance sheet adjustment. But when everyone retrenches simultaneously over a period of years, fear of recession becomes a self-fulfilling prophecy, sustaining a vicious circle of low demand and low investment that affects the whole economy.

The problem is that once sentiment collapses, economies can enter a downward spiral that is hard to escape. This is the mirror image of the hubristic confidence that fuelled the previous bubble. Where ten years ago the talk was of a 'new economy' which would secure non-inflationary growth, now it seems the rich world is destined for decades of slow Japanese-style growth recession. In reality, the underlying productive capacity of the economy is likely to have changed little over the last five years. It is only sentiment that has swung.

Consequently, instead of investing in assets whose prices have fallen in recent years, companies and households are hoarding private savings into 'risk-free' assets such as solvent sovereign bonds. As a result, annual private sector surpluses (net lending – the difference between saving and investment) over the past few years have reached record levels. For example, private sector surpluses in the UK amounted to 6% of GDP - £99bn (around US$150bn) in 2011 - with figures for 2012 coming in only marginally lower. In the US they reached close to $1trillion.

As private spending and incomes collapsed, so net fiscal revenues slumped, fuelling a strikingly symmetrical surge in global public sector deficits. With the public sector mostly borrowing from the private sector, net borrowing from abroad (given by the current account balance) has in most major economies remained little changed.

Desired saving has exceeded desired investment to such a degree that global real "risk-free" interest rates for the next 20 years have been pushed to zero and below. Savings are losing value by the day as pension funds and financial institutions pay real interest to (rather than receive interest from) governments; a truly perverse state of affairs given the need for productive investment. These low rates do not reflect a collapse in the underlying returns to capital, but instead reflect desperately depleted confidence. This is no longer simply a market adjustment – it is a crisis of confidence.

Standard macroeconomics tells us that the best time to support low-carbon investment is during a protracted economic slowdown. Resource costs are low and the potential to crowd out alternative investment and employment is small. There is no shortage either of private capital or investment opportunities with potential for profitable returns.

But why green? Unlike much conventional infrastructure investment, which requires large sums of public spending, private green investment can be leveraged through coherent policy signals such as standards and regulations (with low cost to the government) or carbon pricing (which raises revenues). Investment in the sector is credible in the long run because a transition to resource efficiency is widely recognised as inevitable. This means that the private sector, perceiving credible low risk profit opportunities, will drive the investment. Given that collapsing private confidence and investment are responsible for the extended downturn, this is precisely what is required. It will be transformative, creating sizeable new markets in all the world's economic sectors: transport, buildings, manufacturing, communications and agriculture. The green sector is currently one of the few vibrant parts of the global economy.[1]

HSBC forecasts that the global low-carbon energy market will triple to US$ 2.2 trillion per year by 2020 (HSBC 2010). Even in the present uncertain global green policy environment with a lack of ambitious, coordinated policy response, renewable energy generation and energy efficiency investment has quadrupled since 2004 according to Bloomberg New Energy Finance. New investment in clean energy surpassed investment in conventional energy generation in 2010, rising to between US$180 and US$200 billion.

This is about more than correcting market failures, such as those associated with greenhouse gas emissions; it is about restoring confidence through mission-driven investment which spurs innovation in a way comparable, though larger in scale, to previous programmes to restore economic growth such as Roosevelt's New Deal, rearmament or the space race.

However in many countries, the private sector is not investing as heavily as it could in green innovation and infrastructure because of a lack of confidence in future returns in this policy-

[1] UK Department for Business, Innovation and Skills (BIS) shows that the UK low-carbon and environmental goods and services sector had sales of £122.2bn in 2010-11, growing 4.7% from the previous year.

driven sector. Governments could incentivise such investment by taking on elements of this policy risk which it "controls". By backing its own low-carbon policies, it can stimulate additional net private sector investment and thereby make a significant contribution to economic growth and employment. [2]

The short-term opportunities in most developed economies as a result of getting the timing and credibility of green policies right cannot be underestimated. Sending clear market signals in the form of clearly identified market-based policy instruments - involving long-term carbon pricing, standards and regulations, together with carefully designed technology support - has the potential to unlock private investment in renewable energy, energy efficiency and low-carbon vehicles. This could unleash sizeable macroeconomic benefits by boosting private spending, creating jobs, generating tax revenues, and allowing the monetary authorities greater leeway to stimulate demand.

2.1.4 Definition of a green economy leader

Drawing on the definitions of green growth and green economy discussed in this chapter, we define a city as a green economy leader using three key attributes: competitive advantage in the short term and medium term, strong levels of environmental performance and long-term sustainable growth.

First, a green economy leader should display **competitive advantage** in the short and medium term, with levels and/or growth of productivity and income of the city performing strongly relative to other cities of comparable size and development. Productivity and growth are underpinned by competitiveness. The World Economic Forum (2012) defines competitiveness as:

> "the set of institutions, policies, and factors that determine the level of productivity of a country. The level of productivity, in turn, sets the level of prosperity that can be earned by an economy. The productivity level also determines the rates of return obtained by investments in an economy, which in turn are the fundamental drivers of its growth rates".

Second, a green economy leader should display high and growing levels of **environmental performance**, with low environmental impacts relative to other cities. Environmental performance includes low carbon emissions, high levels of air and water quality (termed "environmental quality" in this report), high levels of green space and biodiversity, and low impacts on stocks of natural resources.

Third, a city with a leading green economy is one that promotes **sustainable growth in output and welfare over the longer term** through strategic policy decisions that lock in low carbon, high growth pathways. As discussed in previous sections, long-term growth and high environmental performance are not simply compatible. Policies that lead to higher environmental performance, if well designed, raise growth through various channels including innovation, efficiency in the use of the factors of production, and increased private investment. To the extent that other large cities act accordingly, it can also be expected to ease pressure on resource prices, as well as ameliorating the negative externalities of climate change and pollution that reduce global and local growth in the longer term.

Box 2.1 International definitions of green growth

The importance of policies for driving green growth has been recognised and discussed by a range of international organisations including the World Bank, UNEP and the OECD:

World Bank
The World Bank defines green growth as "growth that is environmentally sustainable. It is efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management in preventing physical hazards and excessive commodity price volatility."

[2] For example, through a Green Investment Bank offering loans to private companies sharing some of the investment risk.

UNEP
The United Nations Environment Programme (UNEP) defines a green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities."

OECD
The Organisation for Economic Cooperation and Development (OECD) defines green growth as "fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies."

In all these definitions, green growth is compatible with sustainable development, but goes further to recognise that green policies can, if well-designed, raise productivity and growth. In this way, green growth integrates the economic and environmental pillars of sustainable development.

Sources: OECD 2011c; UNEP 2013; World Bank 2012b

2.2 Drivers of the green economy

Based on the attributes of competitiveness, environmental performance and long-term sustainable growth, urban green growth can be achieved only if the city's economic and environmental impacts are compatible. Building on definitions of sustainable development, green growth additionally implies that green policies are not only compatible with growth, but can positively foster growth (Jacobs 2012).

Recalling Equation 1 above, no explicit account is made of the environment or "natural capital" as a factor of production in driving output, except in so far as it is captured implicitly through its effect on the productivity of labour and capital inputs. As discussed previously, the rise in population and wealth, particularly in Asia, is already starting to impact on the demand for limited natural resources – a trend that is set to continue as global population heads towards nine billion by 2050. The World Bank has discussed an inclusive green growth accounting framework that takes separate account of limited natural resources in the production function (World Bank 2012b):

$$Y = f(T, K, L, N)$$

where N represents the environment (natural capital).

A range of drivers can impact on the production function through various channels. Innovation, enterprise and competition can all accelerate technological change and raise total factor productivity (T). Inward investment increases physical capital stocks (K), while skills and training can raise the quality of labour (L). At the same time, constraints on natural resources (N) will reduce growth unless these resources can be substituted by physical capital. While this may be possible for some resources, total substitution of natural capital is unlikely.

While natural resources are an important potential constraint on growth, environmental degradation can impact on growth through a range of channels acting on all factors of production. Wasteful energy and resource use can impact negatively on physical capital stocks (K) through inefficiencies as well as increasing the scarcity, and consequently the price, of natural resources (N). Carbon emissions – through climate change – can impact on future physical capital (K) and natural capital (N) through weather-related damage to cities, crops and infrastructure, as well as impacting on labour (L), for example through disruptions to travel and health impacts. Reductions in environmental quality, e.g. through air pollution, can also impact on labour through reduced health and associated levels of productivity.

Most of these negative impacts of environmental degradation on production are market failures that can be addressed at least partly through well-designed policies. Furthermore, green policies can overcome other market failures in the economy. For example, policies that accelerate innovations in green technologies can raise total factor productivity (T) and attract and grow private investment (K). Some authors have also argued that green cities are more attractive, other things being equal, to international students, highly skilled professionals and relocating companies, impacting on labour (L), physical capital (K) and technological progress (contributing to T).

During times of low demand for employment in the economy, such as the recent global downturn, policies that provide green jobs, e.g. in the insulation retrofitting industry, can impact positively on employment and impart multiplier effects on demand and output by reducing excess saving while leaving a lasting capital legacy. At other times, green jobs would be expected to crowd out employment in other, potentially more productive areas of the economy. This is because in a tight labour market, demand for labour will push up wages and therefore reduce employment elsewhere. In a similar vein, when the economy is operating close to full capacity, green investment would be expected to crowd out alternative investment by pushing up the cost of capital. This means that the long-run returns to green investment must be considered carefully relative to potential alternatives.

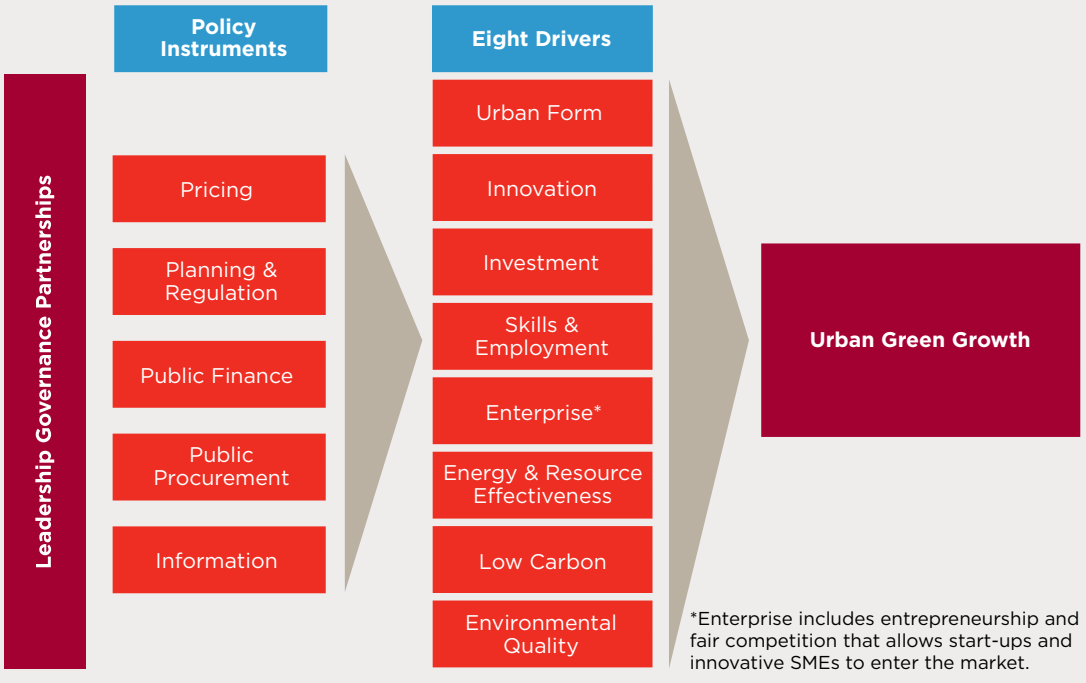
This examination of the production function leads to three important insights. First, environmental degradation can reduce economic growth substantially. Second, "green policies" that reduce environmental degradation and stimulate innovation and investment in the technologies to this end can, if well designed, lead to higher rates of growth. And third, the channels through which environmental degradation and counter-acting green policies act on the overall economy are complex, which raises challenges in quantifying the net benefits (or costs) of policy action and inaction.

Indeed, the scale of the environmental challenge, and the difficulties involved in separating out environmental management from other economic sectors, has led some green growth advocates to argue for a more radical approach (Bowen and Stern 2010). In this view, the economic changes required to combat challenges such as climate change are not marginal, as most traditional models suggest, but transformative and system-wide, on a par with the technological paradigm shift of the industrial revolution or the advent of information technology (Pérez 2002).

The corollary claim is that the creation of a green economy will affect not simply a few sectors but the product mix and production processes of virtually the whole economy; if accepted, such a view further complicates the issue of identifying 'green' sectors. It also means that if the world is to become carbon and resource constrained, then developing comparative advantages in key growth sectors such as energy efficiency and renewables is a source of profitability, innovation and growth relative to the alternative of sticking with business as usual.

While the drivers of green growth represent a complex web of interacting market forces and policies, policy makers require a clear framework if policy decisions are to be made effectively, efficiently and equitably. Under the Economics of Green Cities Programme, we set out eight key drivers of the urban green economy that can act as a focus for city, regional and national policy makers (Figure 2.1). These drivers are: (1) urban form; (2) innovation; (3) investment; (4) skills and employment; (5) enterprise and competition; (6) energy and resource effectiveness; (7) low carbon; and (8) environmental quality.

Figure 2.1 Framework for assessing urban green growth



All eight drivers have economic and environmental impacts and many interact with one another; for example, compact urban form not only has potential agglomeration effects on the economy, it also impacts on the drivers of energy effectiveness and low carbon. As discussed above, policies for social welfare, including considerations of equity, should not be ignored. Indeed, green growth policies should operate hand in hand with social policies for enhancing aggregate utility. Similarly the impact of a green policy on social welfare (e.g. fuel poverty) needs to be considered when assessing the net benefits (or costs) of the policy on wider society and the economy. For a more detailed discussion of the eight drivers of urban green growth, see Floater, Rode et al. 2013.

In the next sections we examine the areas of market failure that can hinder these eight drivers, where government intervention is justifiable. We go on to discuss the broad policy instruments that can be used to overcome these market failures, along with the institutional and governance arrangements that provide the most effective policy environment and which limit the scope for public intervention to generate welfare-eroding policy and efficiency failures of its own.

2.3 Overcoming market failures

As discussed in previous sections, early action government policy can overcome market failures that hinder green growth. It is worth reiterating that policy instruments should be used only where an identifiable market failure exists; markets should be allowed to operate without unnecessary intervention from government.

A range of market failures can be identified with regard to the drivers of green growth. The following provides an illustrative discussion of some of the main market failures facing urban economies.

Spill-over effects of R&D. Markets tend to under supply innovations through research and development (R&D) that would otherwise increase socio-economic growth (Stern 2006; Ambec et al. 2011). Information is a public good, and once an idea has been created, the cost of spreading it (knowledge spillovers) is very low. This means that an individual company may be unable to capture the full economic benefit of its investment in innovation. Although intellectual property rights (IPR) reduce an individual firm's risk to return ratio, IPR is not always straightforward to enforce.

Negative externalities. One particular example of market failure on socio-economic returns are the negative externalities from environmental degradation such as air pollution or the effect of greenhouse emissions on climate change. The costs of these externalities are borne not by the polluter but other individuals and firms in society through poorer health, lower labour productivity and, in the case of climate change, weather-related damages to physical and natural capital (Stern 2006; Graff Zivin and Neidell 2011). As a consequence, polluters and corresponding consumers have no market incentive to reduce their impact on the environment.

Network externalities. Network externalities are also increasing in the economy. These occur where the value of joining a network depends on how many others are on it, such as telephones, public transport, pervasive fast broadband, electricity grids and community-based insulation schemes. These are central to generating successful green urban policies but will require government frameworks to help firms reap increasing returns to scale by supporting new networks. Otherwise, the private sector is likely to underinvest, or not invest at all, in such key enabling services.

Market power. Fair and effective competition among enterprises increases production efficiency, reduces prices and spurs innovation. However, monopolies and powerful vested interests can hinder enterprise and fair competition. This can occur in a number of ways including barriers to the entry of innovative enterprises and new technologies into the market; the formation of cartels to set higher market prices; lack of consumer opportunities for product substitution; weak buying power by consumers and SMEs; and strong buying power of large corporations.

Imperfect and asymmetric information. The efficiency of energy and other resources is often not maximised by firms and individuals (Gillingham et al. 2009; Dobbs et al. 2011). One of the reasons for this is imperfect information. For example, consumers may not be aware that loft insulation can reduce their household costs after a payback period and would take action if they

were informed. In other cases, those responsible for financing the investment may not reap the benefits as in the case where landlords fail to invest adequately in efficiency measures that benefit tenants.

The presence of physical, institutional and behavioural lock-in means that the development of the urban economy is very much path-dependent. In other words, decisions taken today have echoes decades and even centuries in the future. In the urban context this requires public intervention and planning that goes beyond traditional notions of correcting market failures, but are better phrased in terms of providing strategic direction or shaping the long term economic strategy.

2.4 Policy instruments

Where a market failure that hinders green growth needs to be addressed, a range of major policy instruments may be considered by government. These include pricing instruments such as cap and trade and taxation; public finance in the form of subsidies, grants or loans; regulatory measures such as standards and regulations; communication policies for providing consumers with more comprehensive information; and government procurement practices. The following sections discuss each of these instruments in turn. In addition to these major policy instruments, other tools may be used. For example, voluntary agreements can be used between government authorities and the private sector that go beyond statutory requirements.

2.4.1 Pricing

The most important instrument in tackling the negative externalities of greenhouse gases and environmental pollutants is pricing. Pricing provides a clear signal for consumers and producers to change behaviours. At the same time it is entirely non-discriminatory. The choice of behavioural or technological change is left to individuals and not chosen by governments. This further limits the scope for lobbying and rent-seeking by powerful vested interests, for example, incumbent energy, communications and transport providers. Those who produce emissions (the "polluters") impose costs, whether locally (in the case of urban water pollution) or globally (in the case of carbon emissions which impact on climate change). These costs bear down on other people in the same city, other parts of the world and on future generations, as the stock of greenhouse gases emitted today remains in the atmosphere for hundreds of years. However, the polluters do not face the full consequences of their own actions. In short, these negative externalities represent a market failure (Stern 2006).

An appropriate price can be put on a pollutant to ensure that polluters face the full social cost of their actions. An explicit carbon price can be introduced through cap and trade or taxation. Regulation (discussed later in this section) can also be regarded as placing an implicit cost on pollutants. Examples of cap and trade systems include the EU's Emissions Trading System and Australia's carbon pricing scheme (Australian Government 2011; European Union 2009a). Examples of environmental taxation include fuel duties and taxes on fossil fuel energy production such as North Sea oil.

The Stern Review suggested that economic efficiency points to the advantages of a common global carbon price, with emissions reductions taking place wherever they are lowest cost (Stern 2006). With cap and trade, the limit of pollution levels (the cap) is set, with the price (and therefore lowest cost) for meeting the cap being determined by the market. In contrast, while taxation provides certainty over the price of the pollutant, being fixed by the government, the precise reduction in pollutants cannot be certain as the relationship between the price of a good and demand cannot be predicted reliably.

Both cap and trade and taxation are most often used as national level instruments. However, examples of green pricing do exist at city and regional state levels. For example, congestion charging, which has been introduced in cities such as London and Stockholm, is targeted explicitly at inner city areas. Furthermore, as urbanisation continues to grow globally, national level governments need increasingly to consider the outcomes of their pricing policies in cities and ensure that pricing is coordinated effectively with other policy instruments at city, national and international levels.

2.4.2 Planning and regulation

Regulation is a powerful policy instrument and one that governments may decide to use in cases where other instruments, such as changing the price of goods or providing incentives through subsidies, are deemed insufficiently effective. For example, where information or agency problems render consumers or producers unable or unwilling to respond to price signals, regulation can ensure a desired environmental outcome as well as creating substantial new markets for innovation to flourish.

Areas where regulation is considered include building regulations, the installation of energy efficiency measures such as smart metering in existing buildings, recycling waste, and banning the discharge of pollutants such as waste water and sulphur oxides into water-courses and the atmosphere respectively. Low carbon vehicle standards are another example, such as the EU's regulations to limit average vehicle emissions to 130gCO_2 per kilometre by 2015 (European Union 2009b).[3]

In mature institutional and political environments, planning and regulation are also the most common policy instruments that shape urban development. Common instruments range from strategic and land-use planning to building codes and environmental regulation.

The most effective green city planning strategies have a direct impact on the shape and size of a city and its metropolitan hinterland. Reusing existing urban land while restricting urban sprawl and peripheralisation is central to the creation of sustainable urban environments, especially when retrofitting mature cities with previously developed industrial land. Increasing and maintaining urban density levels is desirable but can only be successful if associated with other services, such as high quality public transport and public space. Urban design and public space standards and a polycentric urban structure that encourages mixed-use developments and varying densities with peaks around nodes supported by public transport are essential. To ensure environmental sustainability, there should be a policy bias against greenfield development in mature or recently established cities, until all available urban land is developed at appropriate densities.

Besides regulating for desired environmental outcomes, they help to kick-start green innovation and create demand for green products at various levels. The recent UN-Habitat Global Report on Human Settlements seeks to bring planning back to the centre of urban development debates (UN Habitat 2009), reinforcing the idea of strategic spatial planning that focuses on a "directive, long range, spatial plan, and broad and conceptual spatial ideas" as opposed to traditional master planning with detailed spatial designs. A central component of strategic planning is the linking-up of spatial and infrastructure plans and the promotion of public transport to drive urban compaction and accessibility.

Regulation is a relatively blunt instrument if applied widely and indiscriminately. However, when targeted, it can be a highly effective instrument for driving changes in production and behaviour relatively rapidly. Regulatory measures are particularly powerful for creating a shift from infrastructure investment that locks in high carbon pathways to new green technologies in the urban economy. An example includes the transition to smart electricity grids and modern energy markets that are needed in parallel with the development of renewable energy production.[4]

2.4.3 Public investment and subsidies

New technologies should, where possible, be financed by the private sector. However, if market failures are substantial and other policy instruments are insufficient to overcome the barriers to private investment in clean technologies and green innovation, public finance can be an essential policy tool. In cities, this is often the case for large infrastructure projects where networks such as electricity grids, rail transport and broadband may be underprovided by the private sector. Other examples include investment in public research (universities and research institutes), as well as supporting the development and deployment of effective new technologies that may not otherwise reach the market and flourish due to a banking sector that is still coming to terms with the credit crunch and averse to lending in new, untested markets.

In principle, public spending that generates economic returns (either directly through rent or indirectly by generating future taxes) is entirely compatible with debt sustainability because it

[3] See also European Union (2013). Modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars.

[4] See for example Department of Energy and Climate Change (2012). Electricity market reform: policy overview.

bolsters the value of public assets and reinforces public net worth. In practice, public spending has certain disadvantages. First, discretionary government spending is constrained both by levels of government income and prudent borrowing, as well as the need for balancing spending on green research, development and deployment with spending on other areas of public policy such as education, health and a variety of local services.

Given the current global economic environment and the fiscal constraints faced by many countries and cities around the world, public spending needs to be administered wisely. Nonetheless, as set out in previous sections, green investment is one of the most effective means of driving economic growth and prosperity if undertaken wisely. This means creating transparent procurement processes that limit opportunities for lobbying by vested interests, where governments are required to choose among competing technologies or "pick winners".

In many cases, an efficient mechanism for public investment in green growth is through public private partnerships, with public funds leveraging investment from the private sector. Partnerships are not only effective means of raising capital, but also vehicles for knowledge sharing and collaboration innovation for solving technological challenges that no one firm, research institute or government department can solve alone. Examples include public private waste policy programmes in Durban, eco-district innovations in Portland, Oregon and the city governments of London and Berlin bringing together the large range of actors needed to make electric mobility succeed economically and environmentally (Rode, Floater et al. 2012).

2.4.4 Public procurement

Public procurement is the purchase of goods and services on the market by public authorities. As well as a necessary means of ensuring the effective working of government, procurement is also a major policy instrument, the economic potential of which is sometimes underestimated by authorities. Government as a large purchaser has significant power and possesses the capability to shape markets.

In rich countries, procurement typically represents around 10-20% of GDP, while some estimates suggest that procurement may reach levels above 40% of GDP in some developing countries (Perera 2010; World Trade Organization 2013). Furthermore, with globalisation, public procurement impacts not only on domestic suppliers but also on major international supply chains, with an estimated one trillion euros per year of world trade flows being driven by the purchase of goods and services by public authorities (European Commission 2013).

While municipal and regional state spending is generally considerably lower than spending at the national level, public procurement by city governments can still be used to create and shape markets in green goods and services, providing incentives for private enterprise to innovate and commercialise green technologies. Procurement policies can also be used to shape the evolution of land use, compact urban form and public transport networks that lock in urban green growth for the future. Examples include construction tenders for major transport routes that minimise congestion, carbon emissions and air pollution, retrofitting government buildings to meet LEED standards of energy use, upgrading bus fleets that run on hydrogen or other low carbon technologies, and purchasing energy efficient computers and other electrical appliances.

Procurement decisions should always aim to meet the criteria of value for money, transparency and fair competition, while also minimising the transaction costs of the procurement process for bidders (World Trade Organization 2013). Value for money should be based on achieving the most effective outcome at lowest cost and should take account of short, medium and long term outcomes. This is consistent with policy programmes for green growth that are effective, efficient and equitable. However, it is also important that green procurement is not used to favour vested interests or as a means of protectionism, favouring domestic companies over international firms. Balancing the value for money benefits of green procurement with fair competition remains a key challenge.

2.4.5 Information

While economic policy instruments such as pricing, public subsidies, regulation and public procurement are necessary for effecting green growth and the transition to urban green economies, in some cases they will be insufficient. Where the demand for goods does not respond greatly to changes in price (price inelastic goods), regulation can often be used as an alternative instrument. However, in some cases, targeted consumer information can have a more efficient and more politically feasible outcome.

For example, energy consumers may not be aware that the upfront capital of insulating their homes or installing more efficient boilers may be offset by energy cost savings following installation. By communicating the net economic benefits, governments and other stakeholders can have potentially substantial impacts on behaviour change. Information campaigns can be particularly effective when combined with other tools such as consumer grants or loans.[5] Regulation can also be used to support informed consumer decision making, for example in the case of mandatory installation of smart meters that allow consumers to monitor their own energy spending in real time. Communication policies may be particularly effective at the city level, where governments interact more directly with citizens and where campaigns can be targeted towards local challenges and opportunities.

[5] The UK Government has combined the use of economic policy instruments with information campaigns for incentivising the uptake of renewable heating measures and higher standards of insulation.

Stockholm's waterways

Water has always played an important role in shaping Stockholm's urban identity. Over the past decades, targeted policies to address pollution levels have substantially improved water quality. However, high phosphorus levels and continued surface water run-off remain a threat to the ecological integrity of the city's many waterways. The abundance of water also means that *per capita* water consumption remains much higher in Stockholm than in most other European capitals.

Photo credit: Yanan Li

PART II

DRIVERS OF STOCKHOLM'S GREEN ECONOMY

3 Stockholm: a green economy leader

Key messages

At the national level, Swedish GDP per capita ranks in the top 15 countries in the world and is one of the four most competitive economies globally. The economy is characterised by its combination of innovative, hi-tech industry and a large, effective public sector.

The wider Stockholm region accounts for 42% of Sweden's GDP and has enjoyed strong and stable growth over the long term. Between 1993 and 2009, growth of Stockholm County averaged 4.1% per year. This growth is underpinned by relatively high levels of productivity, though lower than some other cities such as New York.

Stockholm's strong growth has been delivered while increasing environmental performance and transitioning to a low carbon economy.

A range of triggers has led to early action green policies in Stockholm over the last 50 years. Major triggers include population growth and the metro; pollution and the rise in environmental awareness; the oil crises of the 1970s and expansion of district heating; the 1992 Rio Conference; and Stockholm's 2004 Olympic bid.

This chapter examines Stockholm's long-term economic growth and the city's current economic performance in terms of competitiveness, labour productivity and output. The second part of the chapter examines the major triggers that contributed to the development of Stockholm as a green leader. In some cases, policies with far-reaching consequences for the city's green economy were not implemented with green objectives at the time. The chapter also draws on findings from the LSE's global city survey to highlight how Stockholm's green policy triggers contrast with those in other cities around the world.

3.1 Stockholm's economic growth

3.1.1 National economy

Stockholm is a wealthy city with an advanced and diversified economy. The city's economic success is strongly tied to a nationwide political and economic framework that is widely admired as a global model for economic development. As the capital, largest city and business centre of the country, Stockholm plays a central role in Sweden's policy-making environment and innovative business climate.

At the national level, Swedish GDP per capita ranks in the top 15 countries in the world. The economy is characterised by its combination of innovative, hi-tech industry and a large, effective public sector. Furthermore, the country is today very well integrated with the global economy, with internationally competitive industries driving recent strong growth that has allowed a continued high level of welfare and extensive public service provision.

Internationally-oriented industry, particularly in the manufacturing and business services sectors, has been the most important source of recent growth. As a small country with a small domestic market, international integration has been important and has accelerated dramatically since economic reforms were introduced through the 1990s, combined with Sweden's membership of the European Union in 1995. Sweden's major trading partners include Germany and neighbouring Scandinavian countries. Exports include machinery, motor vehicles, wood, paper and pulp, iron and steel products and chemicals.

Swedish economic growth rates have outperformed most other Western European countries and the US since the early 1990s. The country has benefited from high levels of innovation associated with its well-educated labour force and high levels of research and development spending (Pierre, Jochem et al. 2011). Sweden's international business specialises in sectors where knowledge and innovation have been central to maintaining global competitiveness. Swedish

industry is unusually dominated by large companies, and a significant number of multinationals have been successful in global markets.

Sweden benefits from effective public policy frameworks that ensure good conditions for growth and resilience in the face of recent global economic problems (OECD 2012). The regulatory environment has been significantly reformed since the 1980s, contributing to recent good performance. The state continues to play a major economic role. The public sector in Sweden is larger than the OECD average, with government expenditure measured at 51% of GDP.

Stockholm is at the heart of the Swedish economy, the seat of national government and the base for many of the country's large multinational companies. The wider Stockholm region, comprising five counties and 51 municipalities, accounts for 42% of Sweden's GDP (Stockholm Business Region Development 2012a). The city concentrates business and financial services and is a major centre for research, with many universities and corporate research headquarters. It has one of the world's largest ICT clusters and one of Europe's largest life science clusters. The city also functions as a regional headquarters for many global businesses. Stockholm's strengths in advanced innovation-led industries and its position as a political and business centre contribute to very high levels of income, well above the national average.

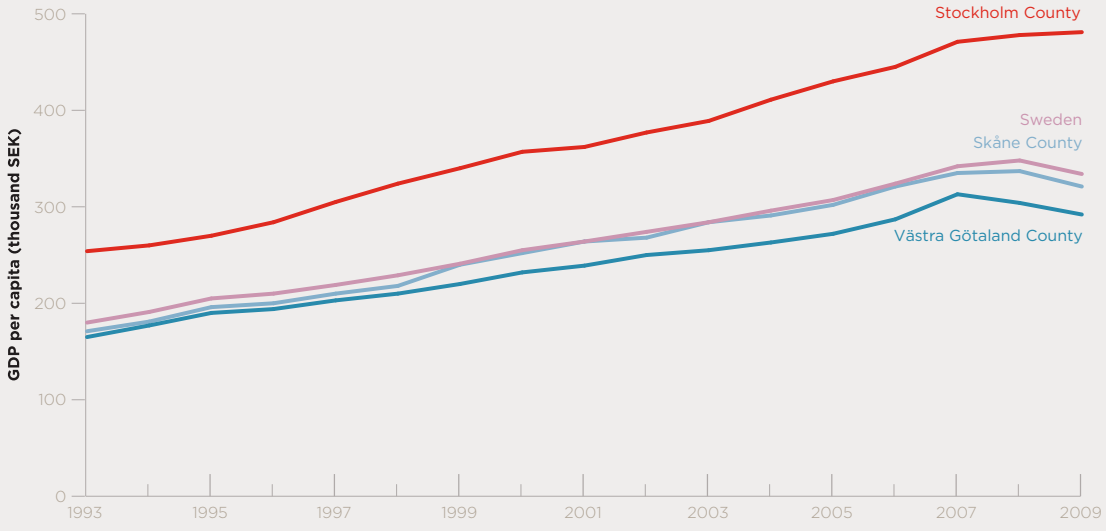
3.1.2 Long-term growth

Stockholm's economic output

Stockholm's economic performance has been strong over the past fifteen years. A comparison with both national and global benchmarks shows relatively high growth – especially relative to other cities with similar levels of wealth. At a national level Stockholm benefits from its position as the capital city, drawing in government and business investment. As the largest city in Sweden it also enjoys agglomeration economies arising from its large and concentrated labour market and the possibility of extensive linkages between networks of proximate and diverse firms, government organisations and research institutions.

Since the early 1990s, Stockholm County has experienced more rapid economic growth than the majority of other Swedish counties (Figure 3.1). Between 1993 and 2009, growth averaged 4.1% per year - slightly above the national average of 3.9% and higher than growth rates in the regions centred on Malmö (Skåne county, 3.6%) and Gothenburg (Västra Götaland county, 4.0%). Stockholm's economy also seems to have been more resilient to the global downturn in 2008 than the rest of Sweden (Figure 3.1).

Figure 3.1 GDP per capita in Sweden and selected counties 1993 -2009



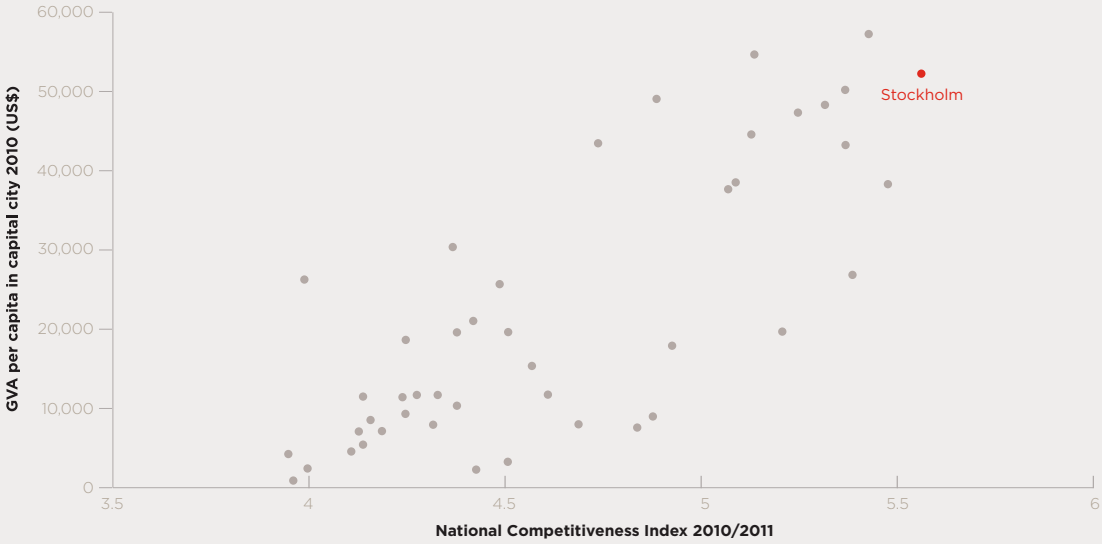
Source: Statistics Sweden 2012d

However, being a capital city is not sufficient in itself to explain Stockholm's strong and stable growth. The city has enjoyed higher levels of growth than most other European capitals that also benefit from agglomeration economies and the advantages of government activity. As shown in later sections of this Chapter, Stockholm's labour productivity, supported by high levels of innovation and investment, plays a strong role in the city's economic success (see also Chapter 4 for a discussion of innovation, investment and other drivers of Stockholm's economy). National competitiveness, an important driver of productivity in cities, also plays a role (Figure 3.2). Sweden consistently ranks as one of the world's most competitive economies, with very high standards of living (see Box 3.1).

Figure 3.2 Relationship between national competitiveness and economic output of the country's capital city

Competitiveness is based on the World Economic Forum's competitiveness index. Output is measured as Gross Value Added per capita.

Sources: Brookings Institution, LSE Cities et al. 2010; World Economic Forum 2012



Box 3.1 Sweden: one of the most productive and competitive economies in the world

Sweden ranked fourth in the World Economic Forum's Global Competitiveness Index for 2012/13. Only Switzerland, Singapore and Finland scored more highly on the WEF's large range of competitiveness indicators. The following is a short extract from the WEF Report:

"[Sweden] has been placing significant emphasis on creating the conditions for innovation-led growth. The quality of its public institutions remains first-rate, with a very high degree of efficiency, trust, and transparency. Private institutions also receive excellent marks, with firms that demonstrate excellent ethical behavior. Nevertheless, we registered a slight but consistent deterioration in the country's institutional framework over the past three years. Additional strengths include goods and financial markets that are very efficient, although the labor market could be more flexible (ranking 92nd on the flexibility subpillar). Combined with a strong focus on education over the years and a high level of technological readiness (1st), Sweden has developed a very sophisticated business culture (5th) and is one of the world's leading innovators (4th). Last but not least, the country boasts a stable macroeconomic environment (13th), with a balanced budget and manageable public debt levels. These characteristics come together to make Sweden one of the most productive and competitive economies in the world."

Source: World Economic Forum 2012

Stockholm's relatively high growth rate compared to other parts of Sweden has reinforced Stockholm's substantially higher levels of wealth compared with other Swedish metropolitan regions. In 2009, the City of Stockholm's Gross Value Added (GVA) was over SEK480,000 per person (US$72,000), 65% higher than in Skåne and 50% higher than in Västra Götaland. Stockholm's per capita GDP was also 44% higher than the Swedish average. The city's economic advantage over other parts of the country has increased in recent years, particularly against other metropolitan regions which appeared to suffer more during the recession from 2007/08. Stockholm's relative economic resilience during this period was reflected in continued slow growth, while other regional economies contracted.

Relative to other western European capitals, Stockholm's growth has been relatively strong. Only Dublin, London and Lisbon experienced higher GVA growth. Despite higher rates of growth, Dublin and Lisbon both grew from much lower bases and by 2010 their levels of per capita GVA remained substantially lower than Stockholm's. Even London's slightly higher growth rate did not result in per capita GVA exceeding Stockholm's. At US$47,000 it remains 9% lower than in Stockholm. Compared with Scandinavian capitals, Stockholm's 58% growth in per capita GVA over 17 years was higher than in Copenhagen (46%), Helsinki (41%) and Oslo (32%). Only Oslo's GVA remains higher than Stockholm's in 2010. Population growth was slightly higher in Helsinki and Oslo, but substantially lower in Copenhagen.

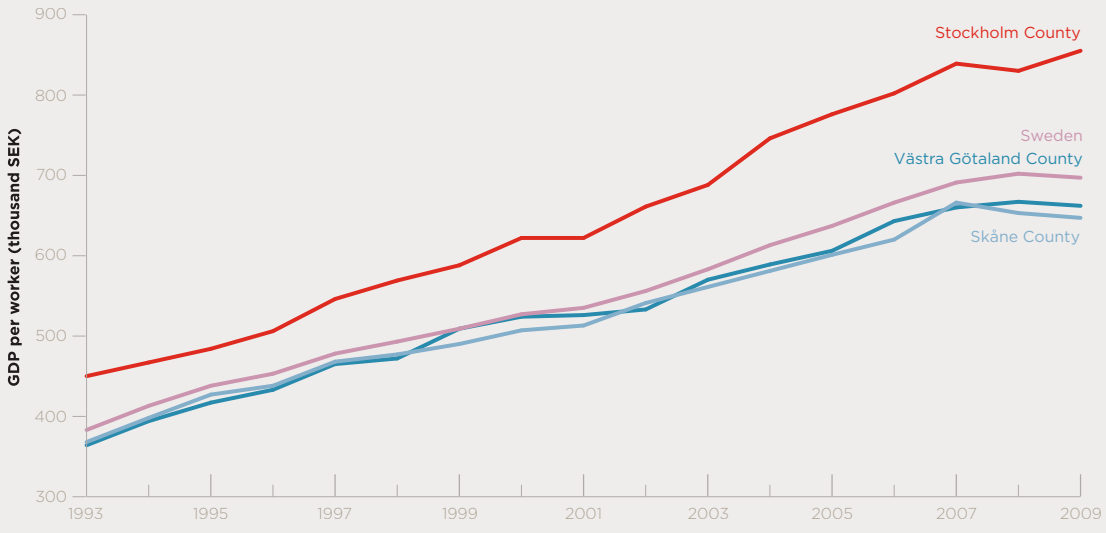
Stockholm has grown more strongly than other very wealthy capitals, and since 1993 has closed the wealth gap with all wealthier capital cities, while growing more strongly than cities such as Amsterdam, Vienna and Paris.

3.1.3 Productivity

Stockholm's high economic output is due to a combination of an increasing population and relatively high levels of productivity. The population of Stockholm County has grown continuously over the past 40 years, from around 1.5 million in 1971 to 2.1 million people in 2011. Average annual growth was 0.9% between 1968 and 2011, more than double the rate across Sweden, and substantially higher than in the country's other major metropolitan regions of Malmö (Skåne County) and Gothenburg (Västra Götaland County). Population growth has accelerated since 2005, with annual growth averaging 1.7% during the past seven years - again more than double the national average over the same period.

Labour productivity (calculated as GVA per worker) is higher in Stockholm than in other regions of Sweden (Figure 3.3). At SEK 855,000 (around US$136,000) per worker, Stockholm's labour productivity in 2009 was 23% higher than the national average, and around 30% higher than both other major metropolitan regions in Sweden. Productivity growth rates since 1993 have also been higher in Stockholm than in other regions. Growth has been consistent, aside from slight contractions in 2000 and 2007. During the period 1993 – 2009 annual productivity growth averaged 4.1%, compared with 3.8% across Sweden.

Figure 3.3 Labour productivity in Sweden and selected counties 1993 -2009

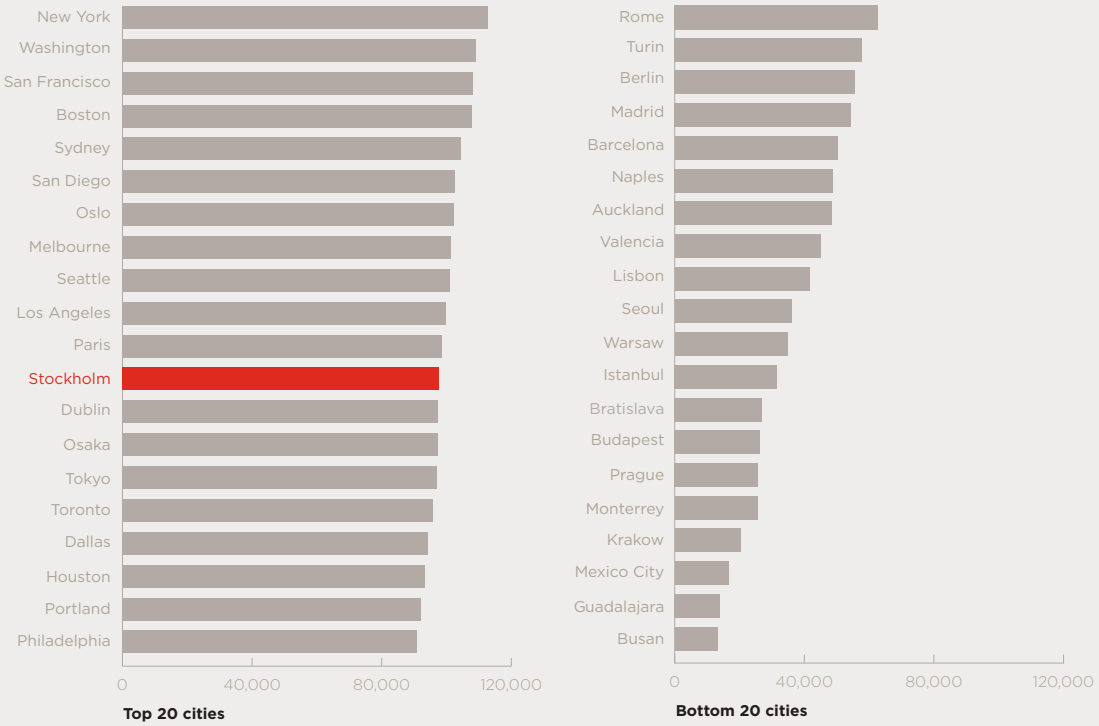


Source: Statistics Sweden 2012d

Comparing labour productivity across a global selection of OECD metropolitan regions, Stockholm also performs well (Figure 3.4). Stockholm ranks 12th out of 79 cities profiled. Among European cities, only Oslo and Paris have higher labour productivity, although at $US98,000 per worker Stockholm's productivity is still lower than North American leaders such as New York, where it is around 15% higher at $US113,000 per worker.

Figure 3.4 Labour productivity in OECD metropolitan regions

Productivity is measured as GVA per worker in 2010.



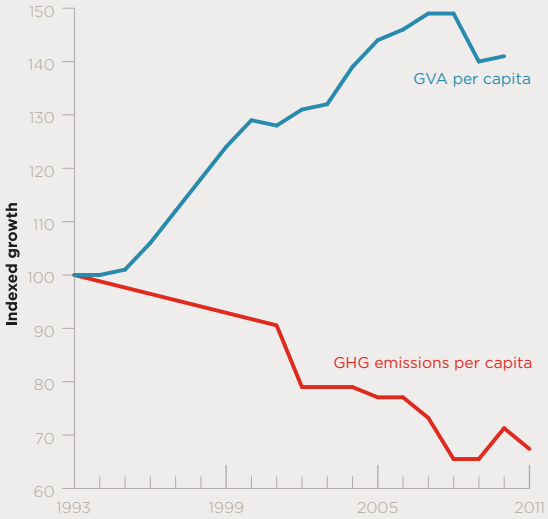
Source: Brookings Institution, LSE Cities et al. 2010

3.1.4 Green growth

As discussed in the sections above, Stockholm's long term growth, current levels of wealth and rates of productivity are among the highest in the OECD. At the same time, the growth in the city's population and economy has been delivered while simultaneously improving the city's environmental performance and transitioning to a low carbon economy (Figure 3.5). This has resulted in Stockholm being one of the greenest and most economically productive metropolitan regions in the world.

Figure 3.5 Sustainable growth in Stockholm

Stockholm's metropolitan economy, measured as Gross Value Added (GVA) per capita, grew by 41% from 1993 to 2010. Over the same period, greenhouse gas (GHG) emissions per capita in the City of Stockholm decreased by 35% from 5.4 tCO_2e to 3.5 tCO_2e. Comparable GHG data for the metropolitan scale were not available. Variables are indexed: 1993 = 100.



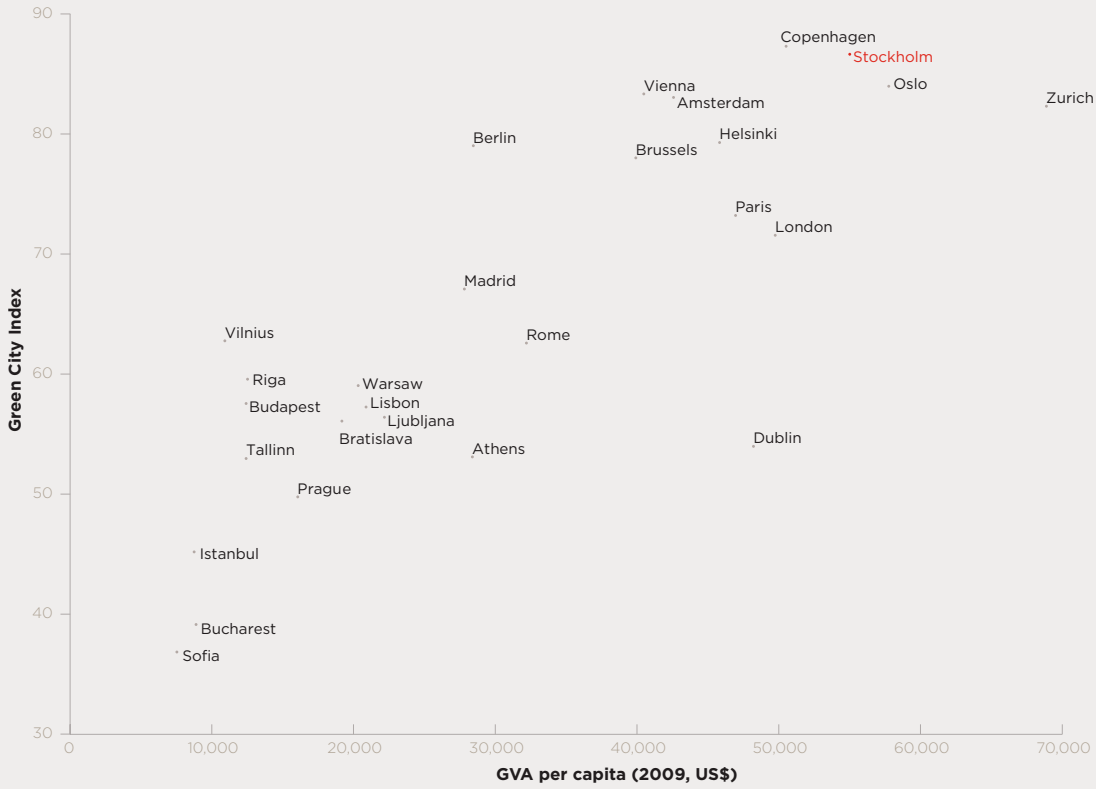
Source: Brookings Institution, LSE Cities et al. 2010; City of Stockholm 2012

The long term trend is compelling and demonstrates that strong sustainable growth – the decoupling of economic growth and negative environmental impacts – can be delivered effectively in the long term. Part of Stockholm's success in reducing environmental impacts is likely to be due to its level of wealth, with high wealth driving environmental improvements. However, as Stockholm's urban environment continues to become greener, the economic benefits should also increase. As the city's 'green appeal' grows, it should attract more international students, skilled professionals and innovative businesses that help maintain Stockholm's high level of human capital, productivity growth and inward investment in a virtuous cycle of green growth (see Chapter 2).

Other indicators suggest Stockholm's green economic success relative to other cities. In 2009, the Siemens European Green City Index assessed and compared European cities based on their environmental performance. Stockholm ranked second due to its particularly strong record on CO_2 emissions, air quality, buildings, transport and overall environmental governance. Coupled with one of the highest levels of wealth per capita, Stockholm is a green economy leader (Figure 3.6).

Figure 3.6 Relationship between environmental performance and wealth in European cities

The green index is based on Siemens European Green City Index 2009. Wealth is measured as Gross Value Added (GVA) per capita in 2009.



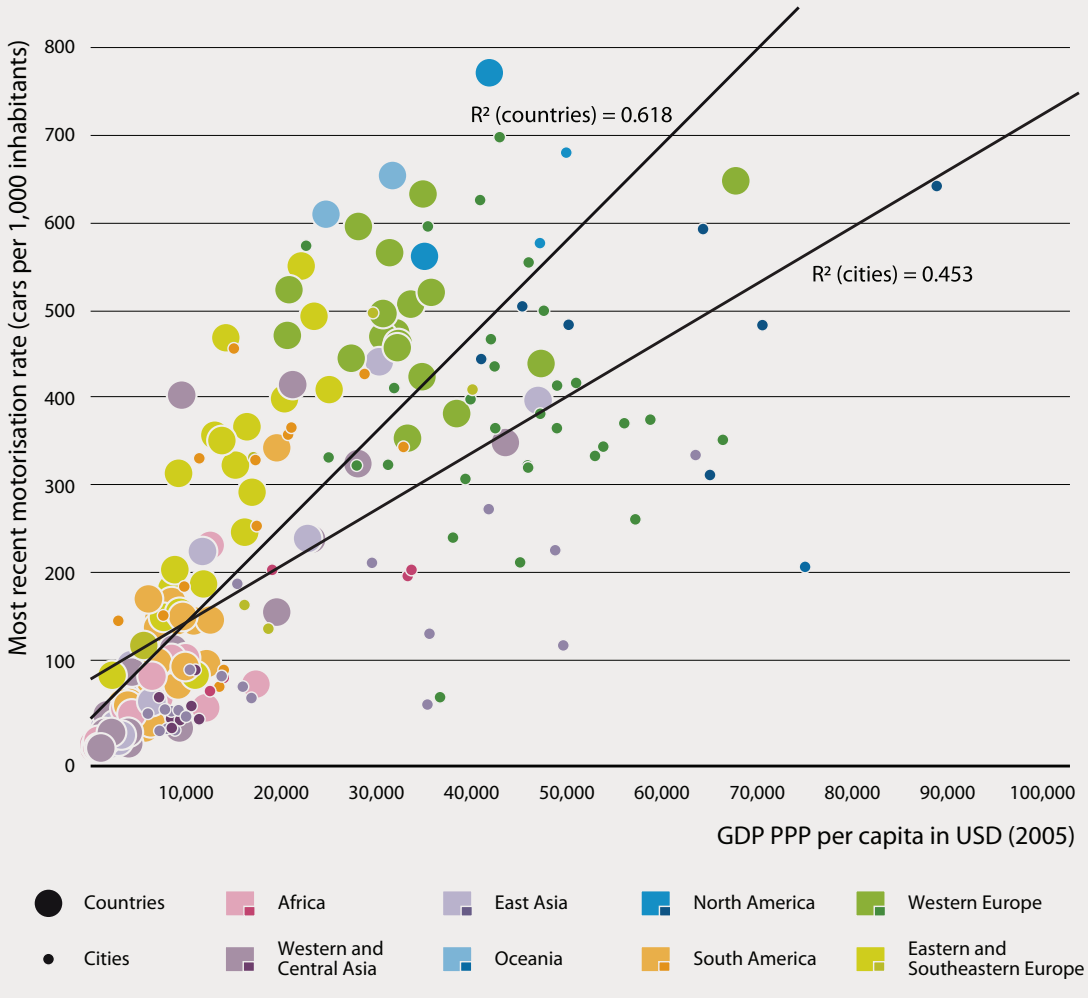
Sources: Brookings Institution, LSE Cities et al. 2010; Siemens 2009

Using indicators for comparing the 'greenness' of an economy has a range of caveats. Data availability varies among cities, as do the assumptions underlying the statistics collected and calculated. The different ways in which a country's territory is administratively organised also plays a crucial role in the availability of sub-national indicators. This is a particular challenge when comparing data for cities given (1) the physical expansion of built-up land which outgrows the administrative boundary, (2) the lack of a universal definition of the functional urban region, and (3) the interconnectedness of a global economic network and ecosystem.

Partly to address these challenges, one proxy for environmental performance is the number of cars per 1,000 inhabitants. The advantage of car ownership data is that it is widely available at the local level and generally comparable - rare characteristics for environmental data. Alternative transport indicators such as modal share are less easily comparable between cities due to variations in the precise methodologies used to calculate modal split – for example whether the indicator refers to journey to work trips or all transport trips. While car ownership data does not directly measure car use (for instance in some wealthy societies cars may be used only infrequently for weekend leisure travel), levels of use and ownership are strongly associated. The indicator is also useful in providing information about the wider infrastructure requirements associated with car ownership such as parking and road space that in themselves have significant environmental and economic impacts. The indicator provides a useful way to grasp the sustainability of cities' urban form, the sustainability of inhabitants' lifestyles and levels of resource consumption.

Figure 3.7 below confirms that there is a strong positive correlation between the wealth of countries and car ownership levels, with North American and Western European countries displaying high levels of car ownership, on average above 300 cars/1000 people. For cities, the correlation is less clear. Indeed, the wealth of a city is not a good predictor of high car ownership. For cities with a GDP per capita above USD$25,000, there is no correlation between car ownership and wealth for this sample of world cities. Comparing car ownership between Stockholm and Sweden confirms a degree of de-coupling of environmental impact and economic prosperity. While featuring a significantly higher income per capita compared to the national context, Stockholm has lower car ownership levels, with just below 400 cars/1000 people.

Figure 3.7
Motorisation rate and wealth for selected countries and cities



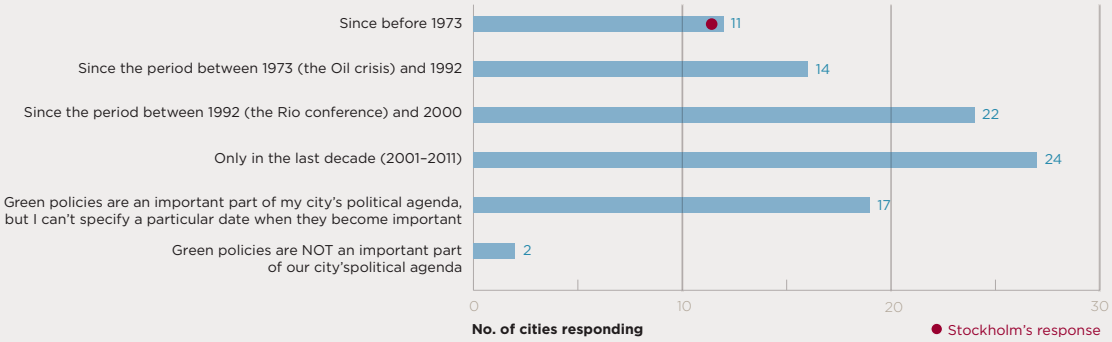
LSE Cities analysis based on multiple data sources.

3.2 Triggers for early action green policies

In the LSE/ICLEI global survey of 90 cities, of those who could identify the time at which green objectives became an important part of the city's agenda, only 35% report that green objectives emerged before the 1992 Rio Summit. A small group of early action cities (15%) have been developing green priorities for 40 years or more. As Figure 3.8 below shows, Stockholm belongs to this group of green leaders.

Figure 3.8 Timing of green objectives in cities around the world

How long have green objectives been an important part of your city's political agenda?

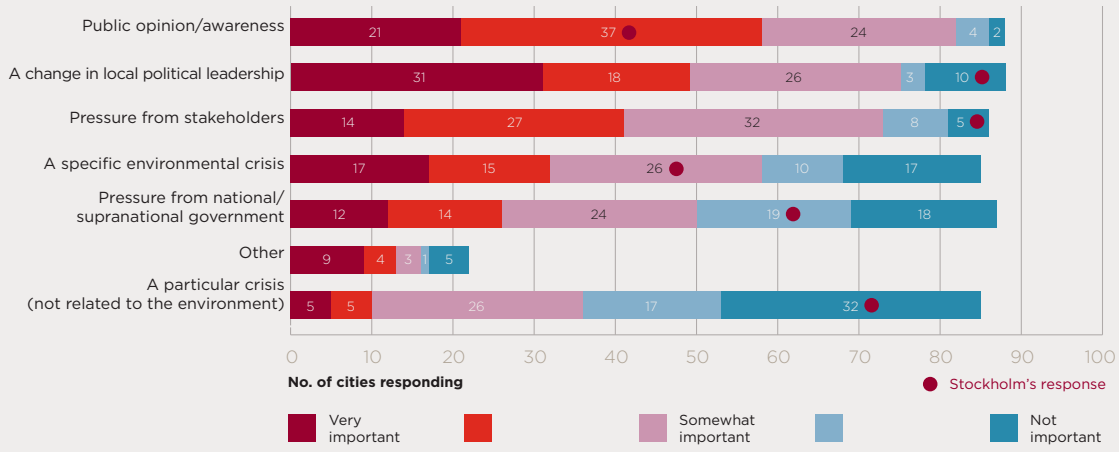


Results from the LSE Cities Going Green global survey.

The growing importance of green objectives for cities seems to be driven more often by social and political changes than environmental tipping points (Figure 3.9). The majority of cities identify the most important triggers for adopting green objectives as public opinion and awareness (66%), changes in local political leadership (55%) and pressure from stakeholders (47%). While public opinion and awareness have been important drivers in Stockholm, changes in local political leadership and pressure from stakeholders were both reported as not important.

Figure 3.9 Triggers prompting cities' adoption of green objectives

How important were/are the following triggers in making green objectives an important part of your city's political agenda?



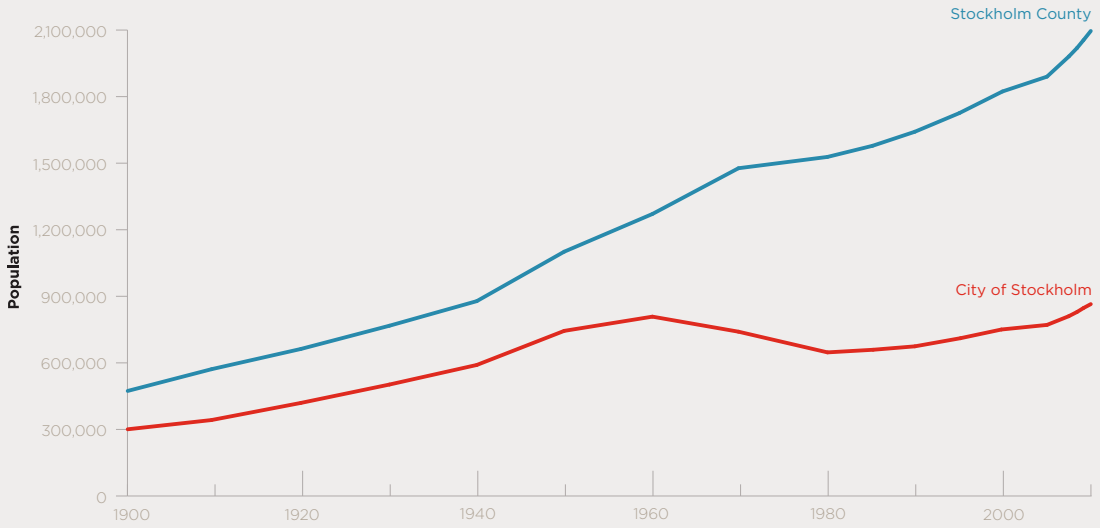
Results from the LSE Cities Going Green global survey.

In the following sections, we outline some of the major triggers that led to early green policy action by the City of Stockholm policy makers over the last 60 years. These include the building of the Metro in response to population growth planning; the rise in environmental awareness; the oil crises of the 1970s; the 1992 Rio Earth Summit; and Stockholm's 2004 Olympic bid. It should be noted that some of the most important triggers led to policies that, while not considered as green goals at the time, led to green outcomes.

3.2.1 Population growth and the Metro

Stockholm experienced rapid and sustained population growth in the first few decades of the 20th century, in large part due to the continued economic shift away from agriculture and towards manufacturing and service industries (Leung 2007). The city's population doubled in the first half of the century, reaching 744,000 by 1950 and more than 1 million at the county level (Figure 3.10).

Figure 3.10 Population growth for the City and County of Stockholm 1900-2010



Source: Statistics Sweden 2012a

The expanding population and corresponding changes to the mobility needs of its residents led the city to rethink its existing transport infrastructure and land-use planning. In the 1940s, Stockholm started developing plans for the construction of a metro system (Interview with Christina Leifman 2012; Interview with Daniel Firth 2012; Interview with Gunnar Soderholm 2012). There was widespread political consensus that developing a strong public transport system was central to future growth, especially given rising traffic congestion along the city's main road arteries (Ducas 2000).

This long term strategic view influenced planning decisions related to the metro from the beginning, and also explains why the system had a substantially higher capacity than was initially needed .With the first line completed in 1950 and additional lines added over the next 25 years, the Stockholm Metro became the centre piece of the city's transport infrastructure and formed the skeleton for the growth of the city, strongly influencing future land-use planning while also reducing the city's dependence on private motorised transport.

3.2.2 Pollution and the rise in environmental awareness

Beginning in the 1960s, a growing awareness of environmental issues and the importance of protecting natural resources started to emerge around the world. In Sweden this environmental movement took hold early on. During this time, the public was primarily concerned with issues related to deteriorating air and water quality as well as habitat protection (Interview with Carl Cederschiöld 2012).

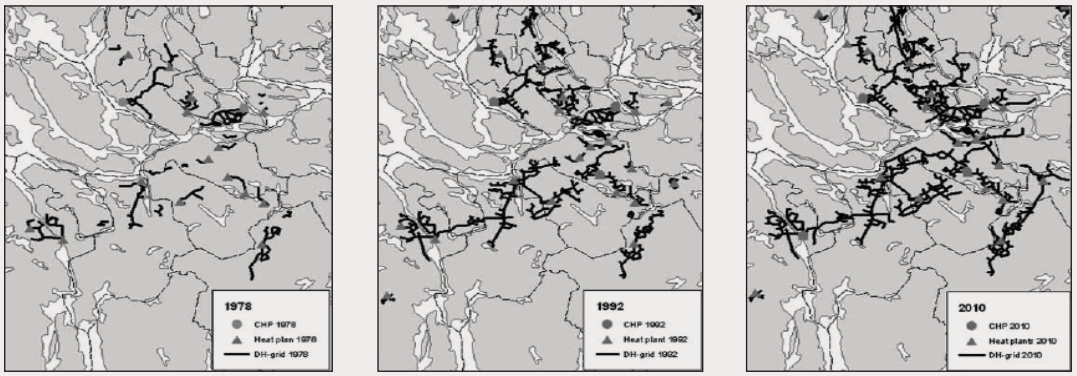
This growing environmental awareness amongst the public and local politicians was further consolidated when Stockholm hosted the first United Nations Conference on the Human Environment in 1972, which accelerated the debate around the importance of environmental protection both within Stockholm and globally (Interview with Carl Cederschiöld 2012).
The relatively high levels of education in Sweden facilitated the wide-spread interest and understanding of environmental issues such as the impact of sulphur dioxide emissions. According to Carl Cederschiöld, Mayor of Stockholm in the 1990s until 2002, this new awareness precipitated a gradual social and political paradigm shift, leading to the establishment of the first generation of environmental policies and regulations in Sweden and Stockholm (Interview with Carl Cederschiöld 2012).

3.2.3 Oil crises and the development of district heating

Beginning in the 1960s, a growing awareness of environmental issues and the importance of The global oil crises of the 1970s had a substantial impact on Stockholm's energy prices, as the city's energy system was almost exclusively dependent on imported oil. This triggered the city to examine alternative energy sources and energy management (Interview with Christina Leifman 2012). In parallel with the development of nuclear energy for electricity, national legislation to improve municipal-level energy management played an important role in accelerating this development (Magnussen 2011).

Stockholm invested heavily in expanding the city's district heating network (Figure 3.11). While district heating systems had already been established in central Stockholm and surrounding municipalities since the 1950s, these systems were fragmented and their overall capacity was limited. The city began to work on integrating these systems, eventually leading to a highly connected regional energy infrastructure (Magnussen 2011).

Figure 3.11 Development of district heating in Stockholm County, 1978 – 2010



Source: Magnussen 2011

District heating systems across Sweden continued to rely primarily on oil during the 1970s, but coal and a variety of other energy sources became the main inputs starting in the 1980s. Since the 1990s, fossil fuel inputs have gradually been reduced and today Sweden's district heating systems are primarily fuelled by renewable sources such as biomass, municipal waste, waste heat and heat pumps (Ericsson 2009).

3.2.4 The 1992 Rio Conference

The 1992 United Nations Conference on Environment and Development accelerated the widespread acceptance of sustainable development in Stockholm as a key policy goal for the city, prompting the implementation of a host of new policies related to urban planning, buildings, energy and transport that would come into effect over the next decade. Rio also influenced Stockholm's long-term strategy, consolidated in the *1999 City Plan* (Interview with Gunnar Jensen 2012, Interview with Christina Leifman 2012).

3.2.5 Stockholm's 2004 Olympic bid

In 1997, Stockholm put forward its candidacy to host the 2004 Olympic Games. The city's campaign focused on portraying Stockholm as a green and modern city that would host the most environmentally friendly games ever. This was the first time that an Olympic bid had focused so explicitly on the environmental impacts of organising such a large-scale event.

Although Stockholm did not win the bid, the city's candidature acted as a trigger for a renewed focus on improving water and air quality in the city and resulted in the innovative eco-district at Hammarby Sjöstad (see Chapter 7). Hammarby Sjöstad is widely considered a model for green urban planning projects and contributed to Stockholm being named the first European Green Capital by the European Union in 2010 (Interview with Gunnar Bjorkman 2012; Interview with Thomas Andersson 2012).

Construction at Hagastaden

Hagastaden is one of Stockholm's largest urban development projects. By 2025, the area around Norra Station on the outskirts of Stockholm will be developed into an entirely new neighbourhood with a mixture of apartments, workplaces, cultural attractions, green areas, world-leading research and highly specialised life sciences facilities. New public transport links will connect Hagastaden to central Stockholm and other commercial and residential hubs around the city.

Photo credit: Lennart Johansson

4 Green economy drivers in Stockholm

Key messages

Stockholm's high wealth, productivity and environmental performance are driven by a strong combination of the city's eight green economy drivers.

Seven drivers of Stockholm's green economy rank among the best in Europe and the world: urban form, innovation, investment, skills and employment, enterprise, low carbon and environmental quality.

One driver - energy and resource effectiveness - has significant potential for future policy support. Energy efficiency, waste management and water efficiency are particular priorities.

Meeting Stockholm's 2050 fossil fuel free target will be particularly challenging and will require early action policy decisions.

Driver 1: Urban form. Stockholm has a relatively compact urban form, with development concentrated along the city's main public transport corridors. Today's urban form is a result of early strategic planning beginning in the 1950s.

Driver 2: Innovation. Stockholm has an innovation-led economy with first class universities, research institutions, and public private technology centres. At the national level, Sweden ranks first on the EU's Innovation Union Scoreboard.

Driver 3: Investment. Inward investment has grown strongly in Stockholm over the last 10 years, particularly in the high-end services sector. Sweden has one of the highest levels of inward foreign direct investment in the world - higher than that for the United States, Japan and Brazil.

Driver 4: Skills and employment. Stockholm has one of the highest employment rates in Europe, averaging 77% over the last 10 years. The city also has a highly skilled workforce, providing talent for productive knowledge-economy sectors.

Driver 5: Enterprise. Stockholm is based on a business environment that provides start-ups and SMEs with opportunities to enter and compete fairly in markets and access to substantial venture capital. Over 24,000 companies were newly registered in 2011 - 29% higher than in 2005, despite the global economic downturn.

Driver 6: Energy and resource effectiveness. Stockholm's energy and water security are strong. Enhancing energy and resource efficiency should be a greater priority for the city in the short term. Stockholm County's energy consumption per capita is lower than the national average due to lower industrial activity. However, since 1990, overall energy use in the county has remained unchanged. Water use in Stockholm remains substantially higher than the European average, while incineration for district heating maintains high demand for waste.

Driver 7: Low carbon. Stockholm has one of the lowest levels of greenhouse gas emissions in Europe. In 2011, Stockholm's emissions were 3.5 tonnes per person, compared to an average of 7 tonnes in OECD Europe. The national grid is now 97% low carbon (mainly hydro and nuclear), while Stockholm's extensive district heating system increasingly uses waste incineration and biofuels. However, Stockholm's ambitious target to be fossil fuel free by 2050 requires major strategic decisions on pathways to eliminate carbon entirely from domestic heating and transport.

Driver 8: Environmental quality. Stockholm's air and water quality have improved substantially over the last 50 years. Policies have successfully reduced SOx and NOx in the air, as well as phosphorus and nitrogen in the surrounding lakes. PM10 levels remain above WHO's international standards.

4.1 Drivers of green growth

Stockholm has one of the most competitive economies in the world, with high rates of wealth and productivity (see Chapter 3). The city is also a green economy leader, displaying not only short to medium term competitive advantage, but also a high level of environmental performance due to early action green policies, low carbon emissions and a history of long-term stable economic growth.

It is worth noting that Stockholm has not always been a green city with a thriving economy. In the 1950s, air pollution levels were very high and the city was almost entirely dependent on fossil fuels. Furthermore, before the deregulation and taxation reforms that began in the late 1980s, Stockholm's economy was relatively isolated from global investment flows. Through policies that have on the one hand directly addressed the negative externalities of carbon, air pollution and water pollution and on the other encouraged more open flows of capital, labour and products, Stockholm has emerged with a strong green economy based on innovation, open markets and environmental performance. At the same time, it is also worth noting that Stockholm's position as a green economy leader has not been achieved overnight, but consolidated over six decades through early planning and policy actions.

In this chapter, we examine the drivers of Stockholm's green economy. As discussed in Chapter 2, an urban green economy results from eight key drivers: urban form, innovation, investment, skills and employment, enterprise, energy and resource effectiveness, low carbon, and environmental quality. Not only does each of these drivers contribute directly to long-term growth, they reinforce one another. For example, actions to reduce carbon emissions can not only contribute to long-term global economic benefits of climate change mitigation, but also stimulate innovation, investment, enterprise and skills as new markets are created for low carbon infrastructure and technological solutions.

The long term benefits of these eight drivers on the urban green economy can be supported through well-designed policy instruments that address market failures where they exist, while otherwise allowing markets to operate freely and efficiently (see Chapter 2). The main policy instruments available in the urban context include: pricing, planning and regulation, public finance, public procurement and information. Some of these policy levers lie within the responsibility of city governments, while others rest with the national or regional authorities. Here we examine the economic factors (such as physical and natural capital, labour and technology) and policies at all levels of government - city, county, national and European - that are most relevant to the drivers of Stockholm's green economy.

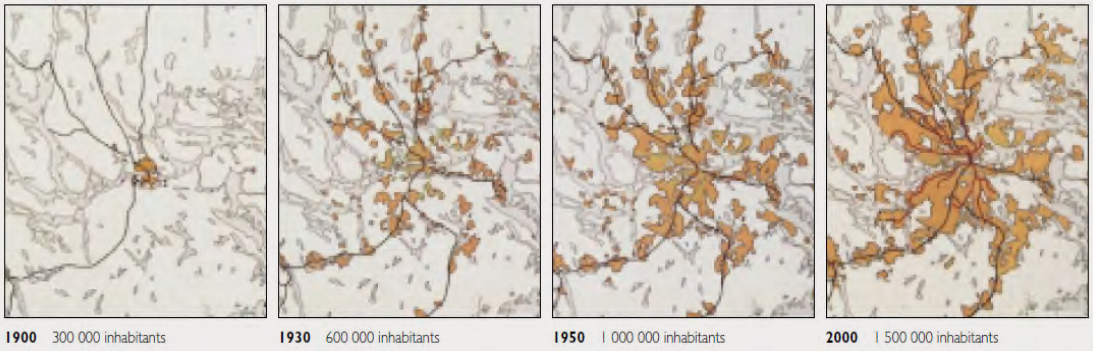
4.2 Driver 1: Urban form

Stockholm's compact and public transport-oriented urban form provides the basis for the city's advanced agglomeration benefits and relatively resource efficient economy. Over the last decades, the Stockholm metropolitan region has successfully managed to sustain this physical structure, which also allowed for some progress on shifting towards a more sustainable urban transport system.

4.2.1 Trends and current performance

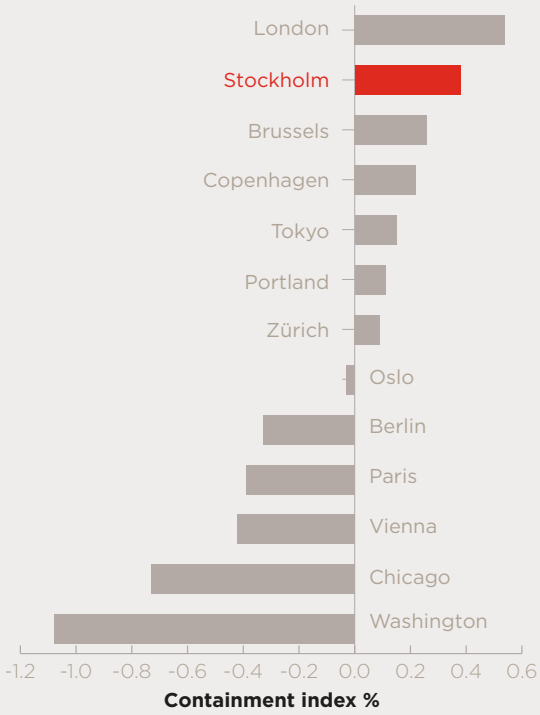
The growth of Stockholm's built-up area has generally followed the city's main public transport corridors (see Figure 4.1). Over the decades, the containment of urban development along these corridors has ensured a threshold level of density which in turn has facilitated a public transport-oriented transport system.

Figure 4.1 Stockholm's star-shaped development along main transport lines



Source: Stockholm City Planning Administration 2001

Figure 4.2 Urban containment index: selected cities



LSE Cities graph based on multiple data sources.

Even over the last 10 years, Stockholm's containment index - representing the growth of population within the core city compared to the outer belt - has remained positive. With an index of 0.38%, Stockholm displays a strong focus of new developments within the existing city. Furthermore, compared to cities in other major OECD countries, Stockholm's urban containment is second only to London (see Figure 4.2).

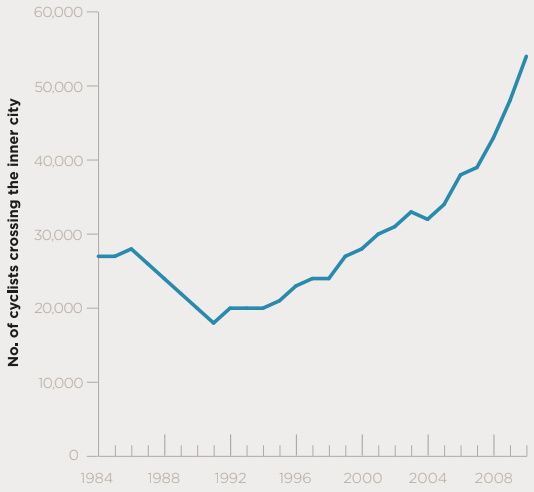
Stockholm's success in physically containing its development to areas accessible by public transport has played a central role in a sustained shift of travel patterns, away from private car use towards public transport and cycling, particularly for accessing the inner city (see Figure 4.3 and Figure 4.4). Trends toward sustainable transport are, however, less evident when considering the wider metropolitan region. There are a number of fast-growing employment centres outside the city centre such as Kista which have lower levels of public transport use than the city centre (see Chapter 6).

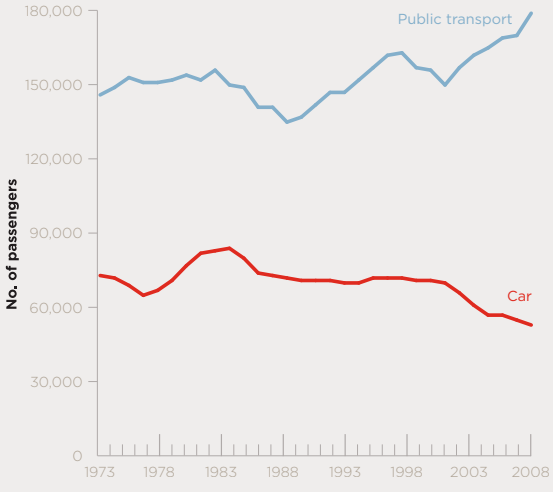
On the left: Figure 4.3 Growth in cycling in inner-city Stockholm

On the right: Figure 4.4 Public transport and car use in inner-city Stockholm

Measured as the average number of weekday passengers to the city centre between 6 and 9 am, 1973-2010.

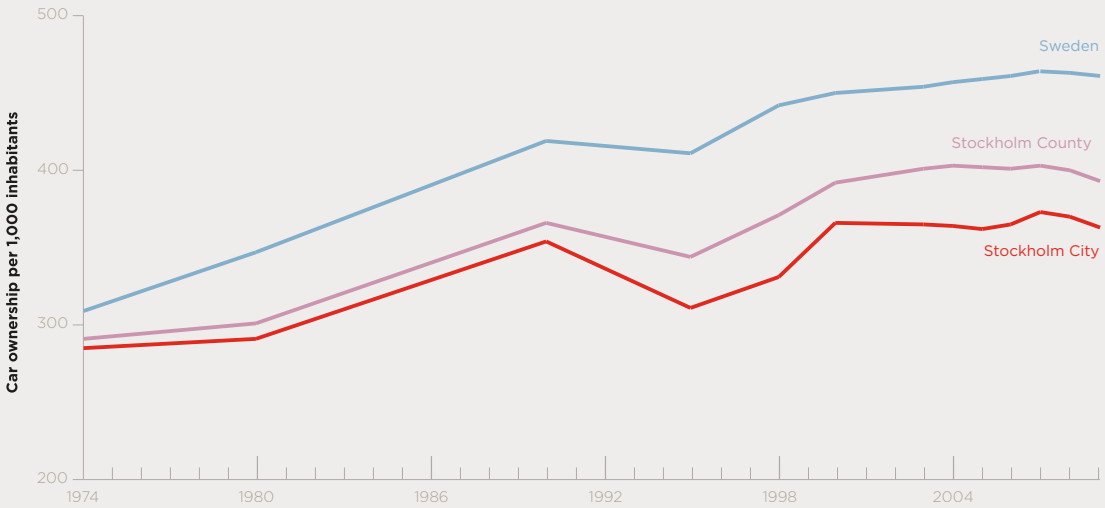
Sources: City of Stockholm 2012a, City of Stockholm 2012q





Motorisation rates in the City of Stockholm have increased since the 1970s but car ownership levels in Sweden's capital city are substantially lower than the national average (Figure 4.5). In recent years, the city has even recorded a small reduction in car ownership.

Figure 4.5 Car ownership in Stockholm and Sweden 1974-2009



Source: City of Stockholm 2011

4.2.2 Policy supporting compact urban form

Four important planning policy components have shaped Stockholm's spatial development over the last 50 years: the *1952 General Plan*, green wedges, developing the city centre, and redevelopment of industrial zones with a greater emphasis on sustainability.

The 1952 General Plan

The rapid growth in Stockholm's population in the first half of the 20th century required a new planning strategy to manage the demographic changes. The new strategy was set out in the *1952 General City Plan*, which served as a framework to guide urban development over the next 20 years and permanently altered the city's urban form.

The *General Plan* focused on building new suburbs along the expanding metro lines, an approach facilitated by the fact that the city owned the land around the metro stations. A central component of the strategy was that new developments would be self-contained neighbourhoods with their own social and commercial core, but would remain connected to the city centre by clustering high-density housing close to public transport nodes (City of Stockholm 2001). This made it possible for people to live outside the city in close proximity to parks and recreation areas and commute into the city or special work areas using the metro and commuter trains (Ducas 2000).

The development of these suburban "metro neighbourhoods" helped the city absorb the large numbers of people moving to the capital from across Sweden in the 1950s and 1960s, a period characterised by rapid economic growth and expansion. Overall, Stockholm built around 25 new neighbourhoods during this time, with a capacity to house approximately a quarter of a million residents (City of Stockholm 2001).

Although this public transport-led suburbanisation established a more dispersed, and lower-density pattern of urban development than the older city core, this suburban growth has generally been well planned to ensure high levels of accessibility to public transport. Some recent analysis suggests that if market-led urban development had been pursued rather than the metro-based suburbanisation strategy, Stockholm may now have higher residential densities and a smaller urban footprint (Börjesson, Jonsson et al. 2012). Nevertheless, careful planning around public transport nodes has meant that relatively low-levels of density co-exist with high levels of public transport use compared with other cities around the world.

Figure 4.6 Stockholm's green wedges

Source: Åkerlund 2011

Green wedges
The close integration between new developments and the public transport network created a structure where green areas and parks divided the new neighbourhoods, radiating out from the city centre in a star shape (Figure 4.6). While these green areas developed primarily as a by-product of the planning policy of the time, they have received increasing recognition as important ecological corridors that successfully contain urban sprawl and contribute significantly to the well-being of the city's residents (Åkerlund 2011).

Despite the decades of growth and development, only 47% of the total city area is built-up, with the rest dominated by green spaces and water (Egero 2004). In 1990, the Stockholm Regional Planning Office recognised the importance of protecting the City's "Green Wedges" and began to integrate these areas actively into city planning and ensure that they were protected from future development (Stockholm Regional Planning Office 2010).

Developing the city centre
In 1962, the City Council approved the *1962 Downtown Plan*, which set out a strategy for developing the Central Business District (CBD) and turning the core of the city into a well-connected, modern and walkable city centre (Leung 2007). The subway was extended throughout the downtown core during this period and a traffic tunnel was constructed beneath the new CDB, with exit ramps leading to a number of central parking garages. This allowed the centre to remain highly accessible for pedestrians, while at the same time creating road and public transport access for those living outside the city (Ducas 2000).

While the *Downtown Plan* led to the construction of large-scale office blocks and commercial infrastructure, provisions were also made for exclusively residential areas. This allowed a critical mass of the population to continue living in the inner city, encouraging a continued thriving commercial and cultural hub in Stockholm's centre (Leung 2007).

Redevelopment of industrial zones and sustainability
The *1999 City Plan* set out a strategy based on the premise that Stockholm's urban form was essentially complete and that further extending the urbanised areas was not desirable. Instead the focus was placed on revitalising existing urban areas on the outskirts of the city and developing 12 former industrial zones into mixed-use residential and commercial areas (Ducas 2000). Redevelopment of industrial zones was possible following the economic trend in the 1980s, when the city experienced a noticeable decline in manufacturing and growth in the services sector and financial and creative industries (City of Stockholm 2001).

The *1999 City Plan* also emphasised the need to increase accessibility through more affordable, high-quality housing and improved public transport, with a particular focus on sustainability, preserving green spaces and reducing the city's environmental impact (City of Stockholm 2001).

In 2010, Stockholm adopted a new city plan *The Walkable City*, which outlines four main strategies on the City of Stockholm's roadmap to 2030: 1. continue to strengthen central Stockholm; 2. focus on strategic nodes, coordinating their development with the expansion of Stockholm's infrastructure; 3. connect city areas which are currently not well integrated with the rest of the city and 4. create a vibrant urban environment.

4.3 Driver 2: Innovation

Stockholm has an innovation-led economy that contributes to its high levels of productivity and growth. The city has a world-class 'science system' with a strong skill base in science and technology, excellent universities and research institutions, and research centres for many global innovation-led companies.

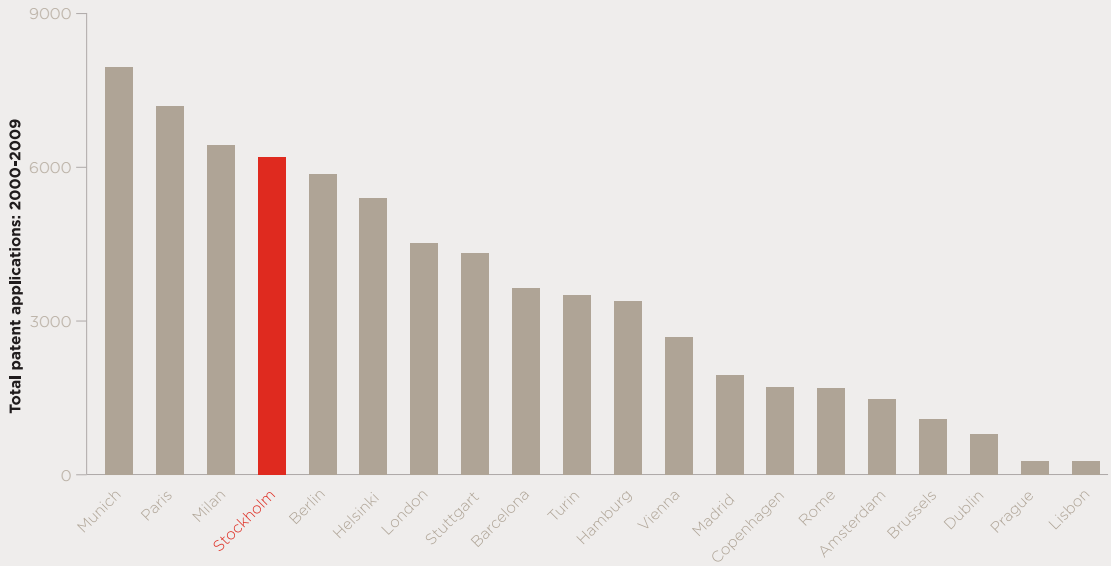
4.3.1 Trends and current performance

Stockholm benefits from being the capital of a country with excellent conditions for innovation, including high quality infrastructure, an effective public sector and a supportive regulatory environment. Sweden consistently ranks as one of the world's leading countries for innovation. Sweden ranks first in the European Union's Innovation Union Scoreboard, and ranks second behind Switzerland in the Global Innovation Index; a collation of various measures of innovation capacity and outputs (European Commission 2012b; INSEAD/WIPO 2012; PRV 2012).

Although the level of innovation in a city is impossible to quantify precisely, the rate of patent applications emanating from the city provides an indication of innovation activity. Of Sweden's 39,000 patent applications between 2000 and 2011, 32% were registered by companies based in Stockholm County. Only Uppsala County, with its major university and smaller population, approaches Stockholm's rate of patent applications per head of population (PRV 2012). A total of 779 patent applications corresponded to Stockholm County in 2011, a rate of 0.37 per 1,000 people. In comparison 286 patent applications corresponded to Skåne County, 246 to Västra Götaland and 117 to Uppsala.

Comparisons with other European cities also suggest that Stockholm has relatively high levels of innovation. For example, Stockholm-based companies and research organisations submitted over 6,000 patent applications to the European Patent Office between 2000 and 2009, with only the cities of Munich, Paris and Milan having higher levels of patent applications (Figure 4.7).

Figure 4.7 Patent applications to the European Patent Office 2000-2009



Source: Eurostat 2012d

4.3.2 Policy supporting innovation

Stockholm's innovation-led economy is a result of a long-term and wide-ranging approach to Swedish economic development involving partnerships between government, research and industry. Historical policy approaches to education, industry promotion and infrastructure development have all contributed to creating conditions for today's high levels of innovation. Both private and public sector actors have contributed to Stockholm's innovation-based economy (OECD 2012d).

Stockholm's economic policy frameworks prioritise innovation and seek to build on the city's strong position. The city's overarching *Vision 2030* positions 'Innovation and Growth' as one of three key themes (City of Stockholm Executive Office 2010). It focuses on creating a climate that attracts internationally competitive businesses and education at all levels for 'a world-leading knowledge region'.

The *Regional Development Plan* includes a strategy to 'develop ideas and the capacity for renewal' – with commitments to a wide range of improvements to the region's innovation environment. (Stockholm County Council 2010). A more specific strategy for innovation '*2025 Stockholm: the world's most innovation-driven economy*' has been developed by a broad collaboration of local authorities, the Stockholm Chamber of Commerce and the city's universities and research institutes (City of Stockholm 2012t). It places particular emphasis on the life sciences, ICT and cleantech sectors and on collaboration between public and private actors.

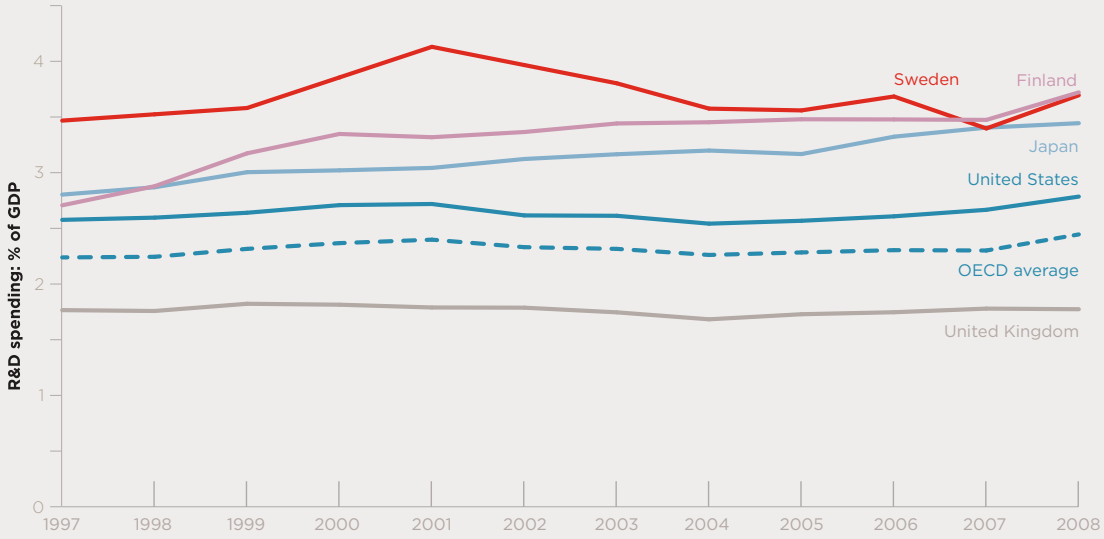
The city also aims to support innovation through urban development strategies, including ongoing promotion of Kista Science City, a cluster of ICT businesses and site of major university campuses since the 1980s. Collaboration between the city authorities, businesses, real estate developers and universities is also enabling the development of Hagastaden, intended as a future centre for life sciences (City of Stockholm 2012s).

In addition to policies for innovation at the city and regional level, a number of Swedish government policies have relevance to Stockholm. *The Swedish Innovation Strategy* includes goals to strengthen the framework conditions for innovation and extend innovation to public services (Swedish Ministry of Enterprise Energy and Communications 2012).

Furthermore, during the past 15 years, total private and public research and development spending has been consistently high, averaging 3.7% of GDP between 1997 and 2008. This is one of the highest levels in the world and well above the average of 2.3% across OECD countries (Figure 4.8). However, a number of countries are increasing their rates of spending, and Sweden will continue to face international competition for research locations in global production chains.

Figure 4.8 Research and development spending in selected OECD countries 1997-2008

The measure includes public and private sector spending.



Source: World Bank 2013

The government's latest *Research and Innovation Bill* commits SEK11.5 billion (US$1.8 billion) for research funding between 2013-2016 (Swedish Ministry of Education and Research 2012). The focus of investment includes life sciences and research leading to new products. VINNOVA, the Swedish government agency for innovation, and the Swedish Research Council play key roles in distributing government funds and promoting collaboration between companies, universities, research institutes and the public sector.

4.4 Driver 3: Investment

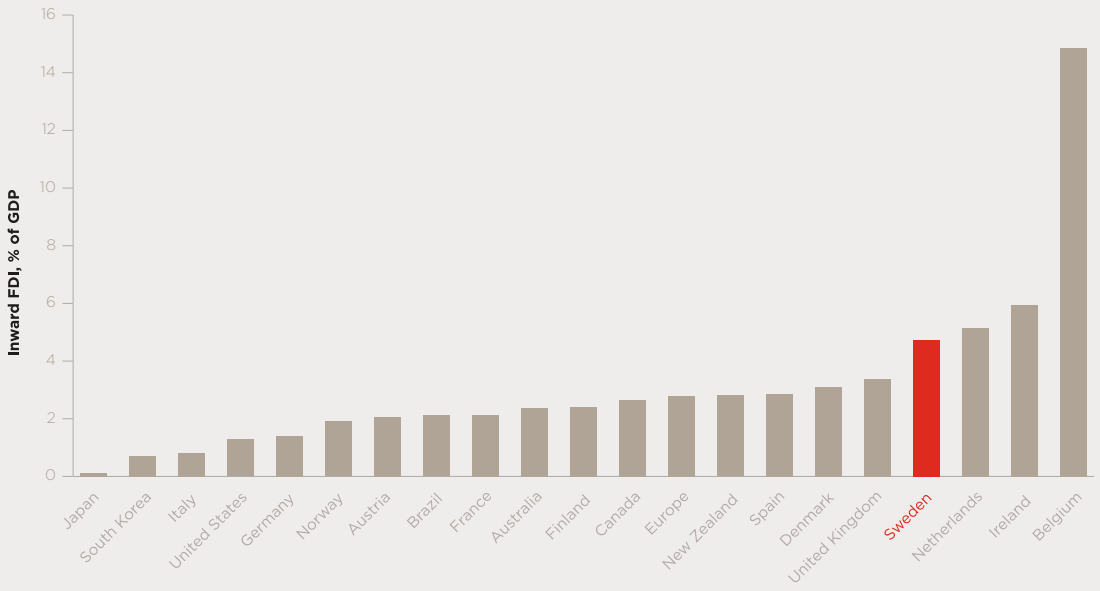
Stockholm's economy benefits from high levels of inward investment, providing capital for growing businesses and supporting integration with the global economy.

4.4.1 Trends and current performance

As the capital and largest city of Sweden, Stockholm benefits from the country's high level of inward foreign direct investment (FDI). As a proportion of GDP, Sweden has one of the highest levels of inward investment in the world (Figure 4.9). Annual investment flows vary considerably year-to-year, but over the past two decades inward FDI has averaged 4.7% of GDP, well above the European average of 2.8% and higher than that for the United States, Japan and Brazil.

Figure 4.9 Inward investment in selected countries

Measured as annual average Foreign Direct Investment (FDI) 1990-2011.



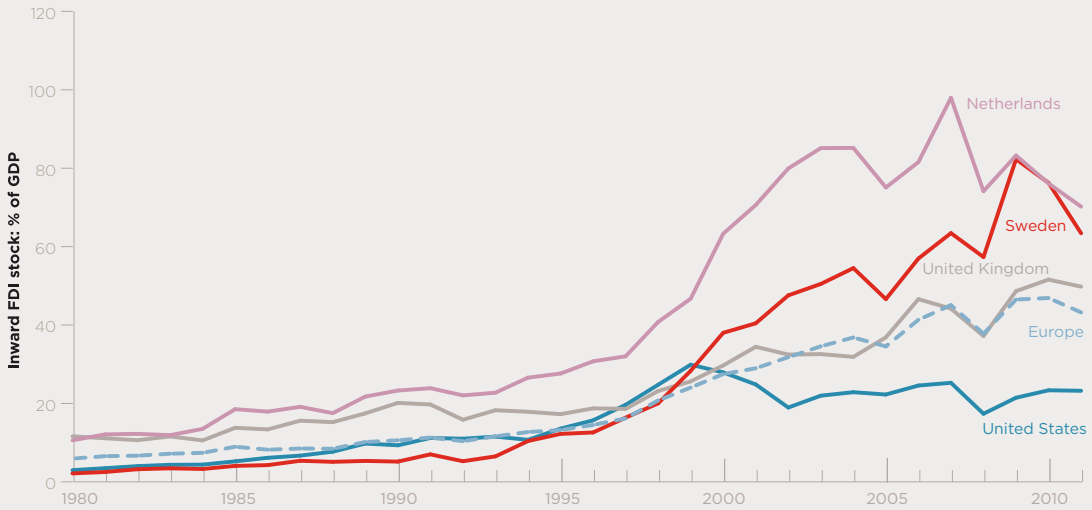
Source: UNCTADstat 2012a

Inward FDI flows grew strongly in Sweden during the 1990s, peaking at almost 24% of GDP in 1999 (UNCTADstat 2012a). This followed a series of national policy reforms initiated in the late 1980s, opening up Sweden's economy to inward investment from foreign companies (discussed below). Since then, inward flows of FDI to Sweden have fluctuated with economic cycles in Europe.

While Swedish FDI flows rebounded to just over 2% of GDP in 2011 after falls during the recent recession, investment levels currently remain below those of countries such as Canada, Australia and Brazil that have benefited from strong investment in resources and commodities. In contrast, the major sectors for inward FDI in Sweden are advanced knowledge economy industries, including chemicals and pharmaceuticals, engineering and financial services.

Strong inward investment flows have resulted in Sweden becoming closely integrated into the global economy. Measures of FDI stock (total assets held by foreign interests) have increased rapidly from a low base in the 1980s (Figure 4.10). Sweden's level of inward FDI stock, at 63% of GDP, is now well above the European average of 43%. High levels of FDI not only provide capital for investment, but also reflect Sweden's strong economic performance and attractive business climate. An index developed by the United Nations Conference on Trade and Development (UNCTAD) measures the contribution that FDI makes to national economies, including impacts on employment, value added and research and development. Sweden scores 12th out of 79 countries in this FDI Contribution Index (UNCTAD 2012).

Figure 4.10 Growth in the stock of inward Foreign Direct Investment (FDI) 1980-2011



Source: UNCTADstat 2012b

Foreign investment in Stockholm has followed national-level trends. Foreign ownership of companies in Stockholm has increased significantly, both through acquisitions and the establishment of new businesses. The number of foreign-owned businesses in Stockholm County increased from 1,900 in 1998 to 11,800 in 2010 (City of Stockholm 2012c). Over the same period, the number of employees in these companies almost tripled from 75,000 to 208,000 – the majority in companies based in the UK, United States and Norway. Stockholm County is the location for 58% of all foreign-owned companies in Sweden, and 31% of the 660,000 employees of foreign-owned companies. The city has particular concentrations of foreign investment in the business consultancy, corporate services, commerce and transport sectors (City of Stockholm 2012c).

4.4.2 Policy supporting investment

A broad range of public policies impact on Stockholm's attractiveness as a destination for inward investment. The high quality of Sweden's public institutions, the overall competitiveness of the economy, skilled workforce and excellent infrastructure combine to attract inward FDI.

National economic policies have played an important role. In the 1980s, outward investment flows in Sweden were substantially higher than flows of inward investment. For example, between 1981 and 1990, inward FDI amounted to around US$9 billion, while outward FDI was around US$48 billion (Andersson and Fredriksson 1993). This imbalance changed dramatically following economic reforms initiated in the late 1980s. These included taxation reforms; the relaxation of restrictions for foreign participation in the financial sector and for M&As of Swedish companies; the removal of exchange controls; and deregulation of various industries such as telecommunications and electricity (see Box 4.1 for a discussion of national taxation reforms in the 1990s) (UNCTAD 1999).

Sweden's entry into the European Union in 1995 also contributed to the rapid growth of inward flows of investment during the late 1990s, while according to UNCTAD, multinationals also began locating in Sweden as a base for eastern expansion to the Baltic States, Russia and Poland (UNCTAD 1999). More recently, further regulatory reforms and the sale of state assets since 2006 have continued to increase investment inflows (US Department of State 2012).

Aside from nation-wide education, infrastructure and regulatory policies that contribute to Sweden's competitive economic environment, a number of city-level policy programmes aim to ensure Stockholm remains an attractive destination for investment. The Stockholm Business Alliance is a partnership of fifty municipalities focused on attracting foreign investment to the region (Stockholm Business Region Development 2012c). The Stockholm Business Region Development is the agency charged with promoting investment. It does so through a marketing campaign based on the message: 'Stockholm: capital of Scandinavia' – positioning the city as a regional base for global companies, as well as a green and attractive city in which to live and work. The agency targets international businesses in the ICT, life sciences and cleantech sectors, providing local contacts, advice and services to help attract investment. In 2011, Stockholm

Business Region Development facilitated 32 major investments totalling SEK470 million (US$74 million) and involving over 200 new jobs (Stockholm Business Region Development 2012a).

Box 4.1 Corporate and Capital Gains Tax in Sweden

The contemporary Swedish tax system has its roots in the 1991 Tax Reform, designed to align Swedish taxation with international norms and make the system more efficient and equitable. Under this reform, a proportional tax of 30% was introduced on capital gains, including interest on income and dividends received. At the same time, the corporate taxation rate was reduced from 52% to 30%.This reform resulted in Sweden's corporate taxation rate being substantially lower than those of many EU, OECD and BRIC countries, contributing to an influx of foreign investment in Sweden in the 1990s.

Since then, however, other countries have made significant changes to how they tax corporate income, which has slowly eroded Sweden's relative tax advantage. The 30% flat rate on capital gains remains in place in Sweden today, even though GDP-weighted average capital gains tax rates have dropped substantially among OECD, EU and BRIC countries and now averages just 14.9% compared to 20.8% in 2000.

In 2010, corporate taxation was lowered from 28% to 26.3% of net profits. In August 2012, the government unveiled plans to further lower this rate to 22% in 2013. This reduction reflects a desire to ensure Swedish businesses remain competitive internationally while strengthening the domestic investment climate.

Source: Ernst and Young 2012; KPMG Global 2012; Swedish Tax Agency 2013

4.5 Driver 4: Skills and employment

Stockholm's high employment rate and the city's highly educated workforce contribute to its strong economic growth. High levels of employment allow for high utilisation of potential human resources, while high education levels contribute to labour productivity and innovation. Stockholm's skilled workforce allows it to specialise in high productivity, globally competitive knowledge-economy industries.

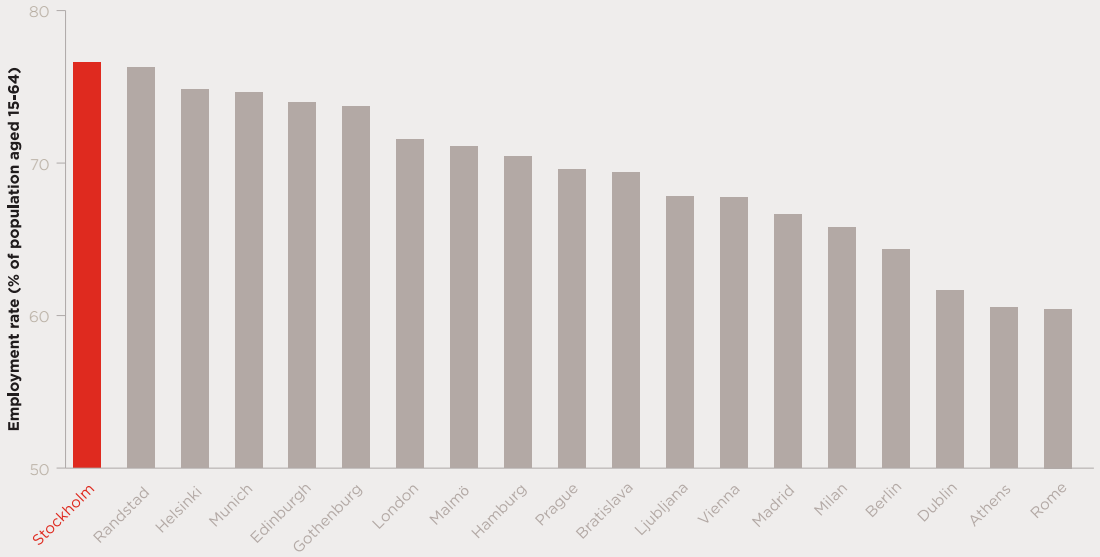
4.5.1 Trends and current performance

Stockholm's employment rate is significantly higher than in other major metropolitan regions across Sweden (Statistics Sweden 2012c). In 2009, 83% of working age people were in employment, and over the 17-year period 1993 to 2009, the employment rate was consistently high, averaging 84%. In comparison the employment rate since 1993 has averaged 70% in Malmo and 74% across Sweden. Stockholm's employment rate dipped slightly between 2001 and 2007 and also decreased in 2009 during the global economic downturn.

Stockholm's employment rate also compares well with other European cities (Figure 4.11).[6] Compared with a selection of European urban regions, Stockholm has the highest employment rate, averaging 77% during the period 2001-2010.

Figure 4.11 Employment rates in European urban regions

Measured as average rate 2001-2010.

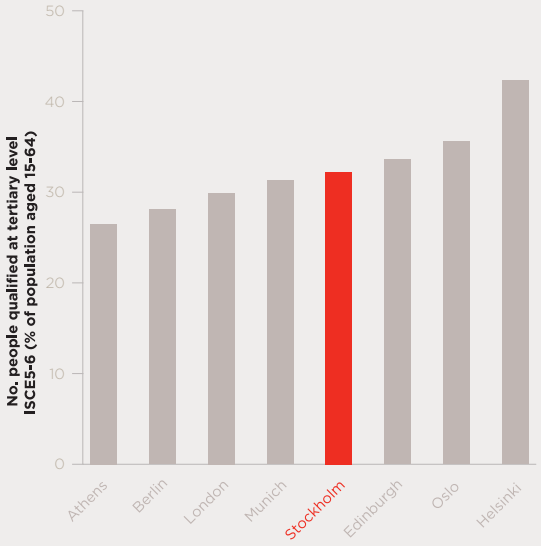


Source: Eurostat 2012b

Stockholm has a highly skilled workforce, providing talent for highly productive knowledge-economy sectors. Over 30% of the city's working age population have at least three years of university-level education (Statistics Sweden 2011a). Stockholm County has the highest number of highly educated workers in Sweden. Education levels also compare favourably against European benchmarks (Figure 4.12). A greater proportion of the population are tertiary-educated in Stockholm than in most large German cities and in London, a world city attracting global talent. However, levels of educational attainment remain lower than other Scandinavian capitals such as Helsinki and Oslo.

[6] Note that data for a selection of high performing European capital cities including Copenhagen, Oslo and Zurich were not available for comparison.

Figure 4.12 Tertiary educational attainment in European cities 2005-2011



Source: Eurostat 2012a

4.5.2 Policy supporting skills and employment

Stockholm's high levels of skills and employment can be attributed to an excellent education system and successful nation-wide policies for integrating citizens into the labour market. While national-level policies are most influential in this sector, Stockholm's municipalities have responsibility for delivering on the national educational framework. The Stockholm Education Administration has a goal for a 'world class school system' and prioritises education as central to achieving broader ambitions for the city, including Vision 2030's goal for 'extensive opportunities for work and education' (City of Stockholm Education Administration 2011).

There are 21 universities and university-colleges in the Stockholm region and planning policy seeks to integrate higher education with research institutes and clusters of knowledge-intensive industry, as is evident at Kista Science City (City of Stockholm 2010b).

At the national level, Swedish education policy contributes to Stockholm's highly skilled labour market. Equitable access to all levels of education is a hallmark of the Swedish education system (OECD 2012a). The system is almost entirely funded through public sources (97% of funding across all education levels) and spending is high compared with other OECD countries. Sweden has devoted considerable public investment in education over many years and spending currently equates to 7.3% of GDP compared with the OECD average of 5.5%. Educational attainment is also high, with 87% of 24-65 years having at least an upper secondary education compared with 74% across OECD countries. Despite these successes, recent concerns about educational outcomes among children have prompted the revision of the Swedish Education Act in 2011 and the introduction of new school curricula (The Swedish Institute 2012).

Employment is a priority for Swedish government policy. The 2013 Budget Bill prioritises 'more people in work' as one of four themes, with particular attention to young people and people born abroad (Government of Sweden 2011). The government is introducing education, training and apprenticeship programmes in response to the particular challenge of unemployment among young people. Government spending on labour market interventions is at a moderate level compared with other European Union countries. Spending is relatively low on financial support for the unemployed, reflecting relatively low unemployment. However, spending is higher than average on employment support measures such as training, rehabilitation and direct job creation (European Commission 2012a).

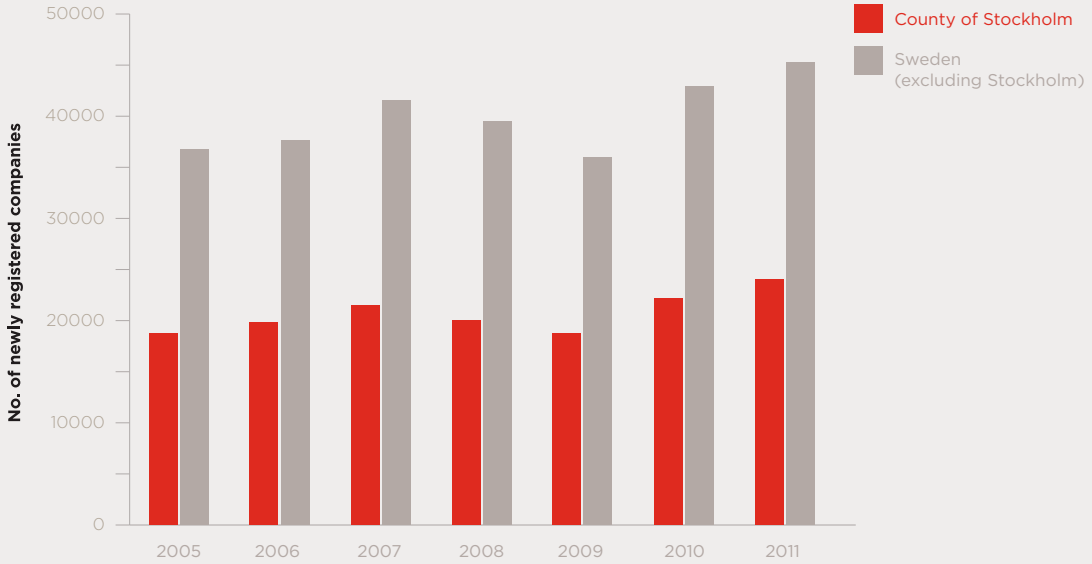
4.6 Driver 5: Enterprise

Stockholm's economy benefits from a favourable business climate that supports enterprise: a driver of economic growth. Based on research conducted on US cities, evidence suggests that higher levels of entrepreneurial activity are correlated with higher growth rates (Zoltan and Armington 2003). Furthermore, a competitive business environment that is enhanced by the entry of new firms can enhance total factor productivity (see Chapter 2). As well as being a driver of productivity growth, successful enterprises are part of the foundation of thriving local communities, contributing to economic prosperity and social cohesion. Consequently, enterprise plays a role in delivering sustainable regeneration and higher living standards.

4.6.1 Trends and current performance

In 2011, there were almost 239,000 companies in Stockholm County, 45% higher than in 1998. Almost 35% of new companies registered across Sweden do so in Stockholm - evidence that the city is a centre of enterprise and new business formation. Measures of new business formation also show growth in recent years. Over 24,000 companies were newly registered in 2011, up 29% from the 18,700 newly registered in 2005, and despite a dip in registrations during the global economic downturn. This growth rate is slightly higher than the Swedish average of 25% over the same time period (Figure 4.13).

Figure 4.13 Newly registered companies in Stockholm and Sweden



Source: City of Stockholm 2012i

While new business formation rates are higher in Stockholm than in Sweden as a whole, the city also benefits from a nationwide environment that is itself relatively favourable to company start-ups. A European Commission review of conditions for small and medium-sized businesses showed that Sweden generally enjoys better conditions than the average across the European Union (European Commission 2012c; Stockholm Business Region Development 2012c). For instance, the availability of finance for new business ventures is very good – and reflected in the highest rates of venture capital investment among European countries (European Private Equity and Venture Capital Association 2011).

The entrepreneurship rate in Sweden is also higher than the EU average, with 15% of adults having started a business compared with 12% across the EU (European Commission 2012c). International comparisons of conditions for doing business also place Sweden as a leading country. The World Economic Forum's *Global Competitiveness Index* ranks Sweden as the fourth most competitive economy in the world - after Switzerland, Singapore and Finland (World Economic Forum 2012). On more specific measures within the index, Sweden scores fifth for the efficiency of its legal framework, third for the effectiveness of its anti-monopoly policy and eighth for the number of procedures needed to start a business. The excellent public institutions across Sweden as a whole benefit Stockholm's economy by providing a stable and efficient framework within which businesses can operate.

4.6.2 Policy supporting enterprise

Policies for entrepreneurship at the city and regional levels are less explicitly defined compared to economic policies focussed on areas such as innovation. However, the *Stockholm Innovation Strategy* identifies 'innovation procurement' and the 'supply of capital' as areas for policy attention with impacts on entrepreneurship (City of Stockholm 2012t). The *Regional Development Plan* includes few mentions of entrepreneurship, but does follow national-level policy in highlighting the introduction of entrepreneurship into education (Stockholm County Council 2010). The *Stockholm City Plan* includes spatial planning policies that support the provision of appropriate spaces for business needs – particularly for the service and knowledge industries (City of Stockholm 2010b).

At the national level, Swedish policies aimed at supporting emerging businesses include the Swedish Agency for Growth (Tillväxtverket, previously known as NUTEK), which plays an important role in facilitating enterprise and entrepreneurship through providing advice (Swedish Agency for Economic and Regional Growth 2011). The state-owned company, ALMI Business Partner, is also important in providing financing and business development support that may complement market-led investments (Almi Företagspartner AB 2012).The government has also recently introduced a programme to reduce administrative burdens on businesses, and a programme that includes entrepreneurship at all levels of education (Stockholm Business Region Development 2012c).

Sweden's overarching political and regulatory framework supports a competitive business sector. The OECD states: "Sweden's product markets are relatively lightly regulated. The regulatory framework is favourable to entrepreneurship and puts up few barriers to trade and investment. However, the scope of public ownership is still large compared to other OECD countries" (OECD 2011a). The OECD suggests that barriers to business competition and administrative burdens on startups are generally less significant than in other comparable countries.

Barriers to competition have been reduced with the government's regulatory reform since the 1990s, and this has opened up sectors to competition and reduced regulatory burdens on business (OECD 2010). Sweden's recent privatisation programme has also reduced the role of government monopolies. However, the continued dominance of large companies and limited competition in some sectors such as construction is resulting in high costs and few opportunities for small firms (OECD 2012c).

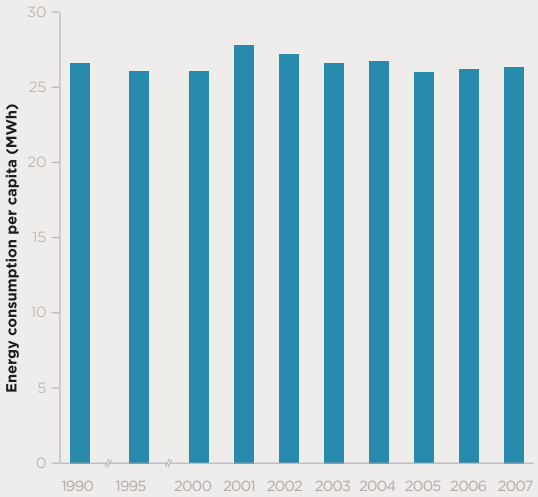
4.7 Driver 6: Energy and resource effectiveness

4.7.1 Trends in energy efficiency

Sweden's energy consumption per capita is relatively high compared to other countries in Europe. In 2010, total primary energy consumption in Sweden amounted to 63 MWh per capita – twice as high as the EU average of 31 MWh. This is partly related to Sweden's high level of wealth and geographical location at high latitude, which puts a higher demand on heating. For example, Sweden's energy consumption per capita is similar to comparable countries such as Finland (77 MWh per capita) and Norway (65 MWh per capita) (International Energy Agency 2012b).

In terms of energy intensity (measured as energy consumption per unit of economic output), Sweden's energy use is closer to the EU average. In 2010, Sweden consumed 159kg of oil equivalent per 1000 euros compared to the EU average of 152kg. In contrast, Finland consumed 225kg (Eurostat 2011).

Figure 4.14 Energy consumption per capita in Stockholm County 1990-2007

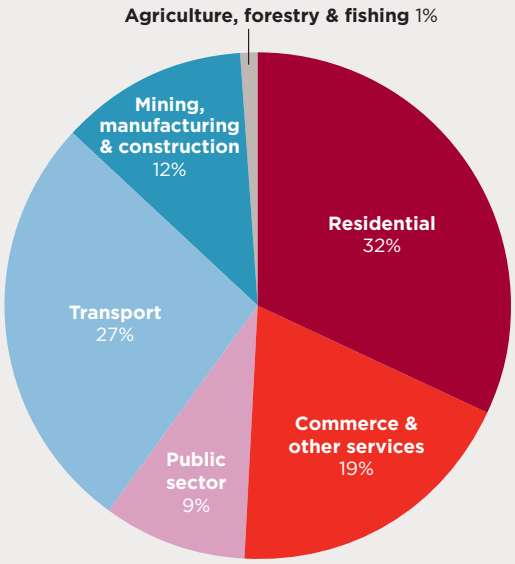


Source: Statistics Sweden 2012b

Stockholm County has lower energy consumption per capita than the Swedish average. For example, in 2007 Stockholm County accounted for 10% of the total final energy consumed in Sweden while representing over 21% of the Swedish population. However, this lower consumption rate is due almost entirely to lower levels of industrial activity in Stockholm County compared to other counties in Sweden. In terms of other sectors, Stockholm is comparable to the national average (Statistics Sweden 2012b). Furthermore, energy efficiency per person has changed little in Stockholm over the last 20 years. In 2007, the average resident of Stockholm County consumed 26.4 MWh of energy compared to 26.6 MWh in 1990 (Figure 4.14).

Figure 4.15 Energy consumption per sector in Stockholm County

Figures show most recent available data, year 2004.



Source: Statistics Sweden 2012b

The largest sector for energy demand in Stockholm County is the residential sector, comprising around 32% of total energy consumption (Figure 4.15). Commerce and services comprise a further 19% of energy used in the county. In both these sectors, a large proportion of energy is supplied via district heating. Stockholm's regional and municipal governments have traditionally worked collaboratively to expand the area covered by Stockholm's district heating network, and pipes now cover the main populated areas in the county. This has led to higher district heating consumption rates in Stockholm than, for example, in Mälmo or Gothenburg (Figure 4.16).

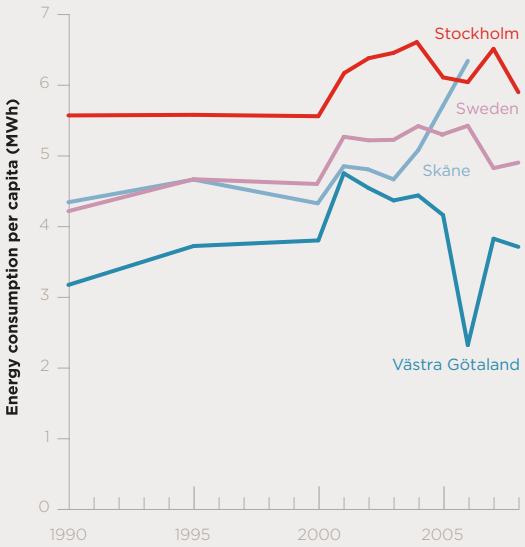
The other major energy consuming sector in Stockholm County is transport, representing 27% of total energy demand (Figure 4.15). Unlike other areas of Sweden, industry plays a relatively minor role in energy consumption, with manufacturing, construction and mining comprising 12% of energy demand. This is not much higher than public sector energy consumption in the county, which stands at 9%. In Sweden, of the 46 MWh of energy consumed per capita in 2004, 20 MWh was consumed by industry. In contrast, industry accounted for only 3 MWh per capita in Stockholm County (Statistics Sweden 2012b).

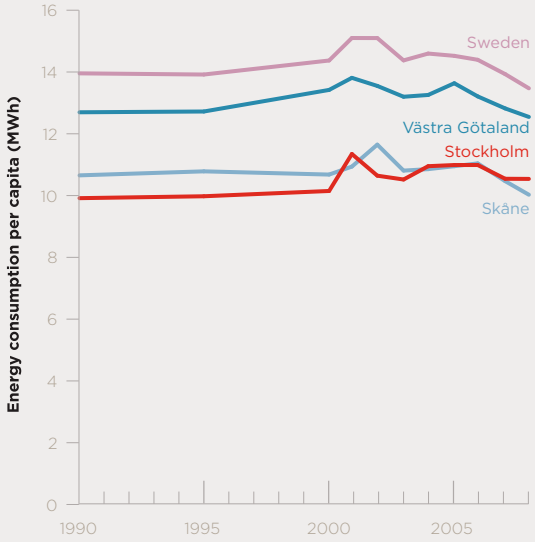
Sweden is an electricity-intensive country, with an annual average consumption of 16MWh per person - one of the largest per capita levels in the world. According to the International Energy Agency, this is due to high demand from its electricity-intensive industry (especially mechanical pulping), the rapid expansion of electric space heating during the 1980s, and traditionally low electricity prices (IEA 2009). Electricity consumption in Stockholm County is substantially lower than the national average, which is partly due to the concentration of industrial hubs in other parts of the country and the widespread development of district heating in Stockholm relative to other regions of Sweden (Figure 4.16 and Figure 4.17).

On the left: Figure 4.16 District heating consumption in Sweden and selected counties, 1990-2008

On the right: Figure 4.17 Electricity consumption in Sweden and selected counties, 1990-2008

Source: Statistics Sweden 2012b



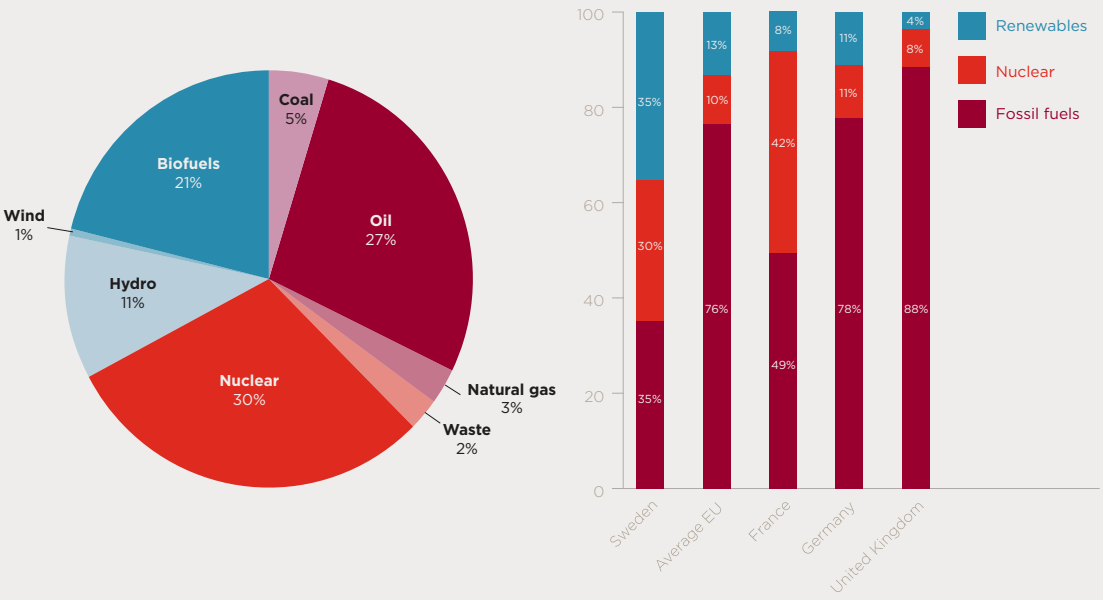


4.7.2 Trends in energy security

Sweden has a relatively strong security of energy supply, in large part due to the low share of fossil fuels in its energy mix. Prior to the successive oil crises of the 1970s, a large percentage of the country's energy was fossil fuel based and relied on imports. Today, Sweden has reduced its dependence on energy imports substantially and meets the majority of its energy needs, including all of its electricity needs, through domestic production.

Sweden's concerted effort to move away from the use of fossil fuels has resulted in the country now having the lowest share of fossil fuels in the energy supply mix among IEA member countries (International Energy Agency 2012a). In 2010, oil made up around 27% of total primary energy supply, with coal (5%) and natural gas (3%) representing an even smaller share. While this has improved overall energy independence since the 1970s, Sweden still remains entirely dependent on imports of foreign oil to meet demand in the transport sector. In 2011, Sweden imported nearly 18.8 Mt of crude oil, primarily from Russia (50%), Norway (20%), and Denmark (15%) (International Energy Agency 2012a). With no gas extraction of its own, 100% of the natural gas consumed in Sweden is currently imported from Denmark (Energy Regulators 2011).

Figure 4.18 Sources of total primary energy supply in a) Sweden and b) selected EU countries, 2010



Source: IEA 2012c

Nuclear power was commissioned following the oil crises of the 1970s and in 2010 accounted for 30% of primary energy supply (Figure 4.18) and 38% of total electricity production - second only to hydro (IEA 2012c). Nuclear is likely to remain an important energy source for Sweden in the foreseeable future, particularly given the country's ambitious carbon emissions targets. Nuclear energy plays a dual role in meeting national goals; not only safeguarding the country's energy independence, but also helping Sweden reach its emissions targets while renewable energy sources are still in transition.

Hydro makes up 11% of energy and 48% of the electricity produced in Sweden. The main areas of production are located in the north of the country, with the counties of Norrbottens, Västernorrlands, Västerbottens and Jämtlands responsible for the large majority of production. Hydro plays an important role in reducing Sweden's dependence on energy imports, even making the country a net exporter of electricity during periods of excess supply. However, fluctuations in supply due to seasonal variations in precipitation mean that the country has also invested in other domestic energy sources such as nuclear and renewable energies (Swedish Energy Agency 2011).

Renewables other than hydro make up around 24% of the primary energy consumed in Sweden, with the majority being biofuels (Figure 4.18). Sweden's energy policy specifies that renewable energy sources should provide half of all energy and 10% of all transport needs by 2020, with all vehicles being fossil fuel free by 2030 (International Energy Agency 2012a). While this will reduce Sweden's dependence on imported oil, it will not necessarily guarantee full energy security. Much of the ethanol used in alternative fuel vehicles is imported from Brazil, Russia and other EU countries and although Sweden is investing heavily in the production of second generation biofuels, this is not sufficient to meet rising domestic demand (IADB 2008; Börjesson, Ericsson et al. 2009). Sweden also imports waste from Norway and Denmark to supply district heating systems and despite its high domestic production of wood pellets for use in CHP plants, Sweden relies on imports of wood pellets from Canada, Poland and Finland to meet nearly 20% of its annual consumption (Force Technology 2009).

4.7.3 Water

Globally, population growth and increasing wealth, combined with other factors, are leading to increased water consumption and associated demands on the environment (UNEP 2012). Furthermore, while the socio-economic impacts of water scarcity are particularly acute in warmer climates, including many areas of the developing world, policy makers in all regions are becoming aware of the cost savings and economic benefits associated with water efficiency (World Bank 2004).

Historically, Stockholm's access to large areas of fresh water lakes has provided an abundant, relatively low cost supply of water. However, as urbanisation and Stockholm's population

continue to grow, the city authorities have goals for more efficient water consumption in the future (City of Stockholm 2012m). Given that a high proportion of water used domestically is heated – e.g. for showers, washing machines and dish washers - water efficiency also reduces energy consumption and decreases the quantity of waste water that has to be treated.

Stockholm has already reduced average per capita water use over the last 20 years both at the city and county levels (Lindblom 2012; Statistics Sweden 2012f). The total per capita water consumption in Stockholm City decreased from 306 litres per day (lpd) in 1991 to 229 lpd in 2011; a reduction of 25%. This reduction can largely be attributed to an increase in water efficient appliances and technologies in the industrial sector.

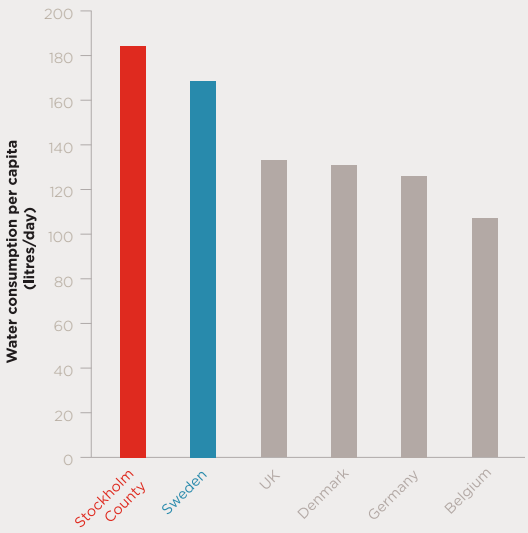
However, despite these reductions, water use in Sweden, and Stockholm in particular, remains substantially higher than the European average. This is particularly the case in the domestic sector. At 167 lpd in 2010, per capita water consumption in Sweden's domestic sector is higher than in most other European countries. By comparison, in 2008, the UK consumed 133 lpd, Denmark 131, Germany 126, and Belgium 107 (Figure 4.19).

The domestic water consumption rate in Stockholm has changed little over the last 20 years and remains higher than even the national average. In 2010, city households consumed 183 lpd compared to 199 lpd in 1995. Households represent the largest sector for water consumption, comprising 50% of total water use in Stockholm County, while industry uses a further 26% of the total. Agriculture is not a major sector of water use in the county (Statistics Sweden 2012f).

On the left: Figure 4.19 Domestic water consumption in Stockholm County, Sweden and selected EU countries, 2008

On the right: Figure 4.20 Domestic water consumption in Sweden and selected counties

Sources: Aquaterra 2008; Statistics Sweden 2012f



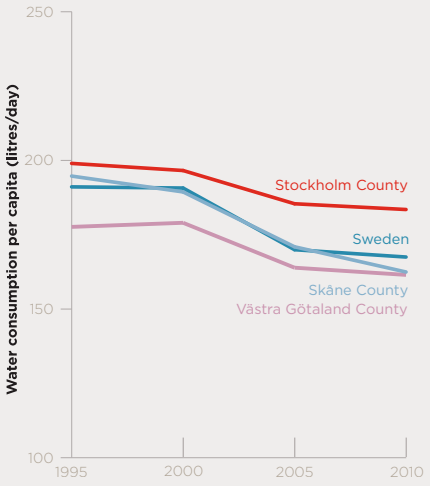
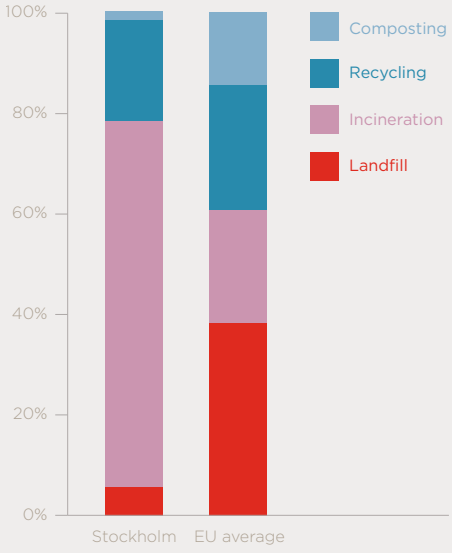


Figure 4.21 Comparison of municipal waste treatment in the City of Stockholm and the EU, 2010

Sources: City of Stockholm 2012r; Eurostat 2012c



4.7.4 Waste

Total municipal waste generation has remained relatively constant in the City of Stockholm since 2007 at around 500 to 550 kg per person (City of Stockholm 2012r) – a figure that is marginally higher than the European average. However, Stockholm's methods of waste treatment differ substantially from the European average, with incineration the dominant method of disposal.

Following various reforms to waste regulation and landfill taxation, Stockholm's landfill rate is particularly low. On average, 29 kg of waste per person went to landfill in the City of Stockholm in 2011, accounting for only 6% of the city's total waste disposal. This compares to 186 kg per person (37%) on average in the EU.

The majority of waste in Stockholm (74%) is incinerated, providing energy for the city's district heating system. While incineration reduces landfill waste, it may also reduce incentives to increase rates of recycling and other methods of re-using waste such as composting. The City of Stockholm recognises that low levels of composting or biological treatment of organic waste is a future challenge .The rate of composting is well below the national target to treat 35% of organic waste biologically, and both composting and recycling rates - at 18% and 2% respectively - are below the EU average (Figure 4.21) (City of Stockholm 2012m).

4.7.5 Policy supporting energy and resource effectiveness

Stockholm's energy consumption is partly a result of Sweden's high latitude position that creates higher energy demands. However, given that per capita energy consumption has changed little over the last 20 years, potential for energy efficiency improvements exists.

Stockholm's most recent planning documents include a number of policy goals related to energy efficiency including: 'stimulate more energy-efficient and resource-efficient transport', 'make the settlement structure denser', and 'enhance the efficiency of the energy supply and energy consumption' (Stockholm County Council 2010).

The city's *Environment Programme 2012-2015* includes specific targets for 'environmentally efficient transport', 'sustainable use of energy' and 'environmentally efficient waste management' (City of Stockholm 2012m). At the same time, the city's *Action Plan for Climate and Energy 2010-2020* sets out a comprehensive list of 'expected' and 'conceivable' policy measures across the transport, building and energy production sectors that aim both to reduce energy consumption and to shift the energy mix to meet an overall goal of reducing carbon emissions to 3 tonnes CO_2e per person by 2015. These policy programmes build on a series of Action Plans established by the city authorities since the mid-1990s that have supported measures such as shifting district heating to renewable energy sources, increasing energy efficiency, clean vehicles, the congestion tax, expansion of public transport and support for cycling (City of Stockholm 2010a).

At the national level, sustainability policies have also prompted improvements to Stockholm's energy and resource efficiency. Sweden has been a global leader in sustainable development policy since the emergence of the concept in the 1970s, and important sustainability policies include the Swedish Parliament's establishment of 'Environmental Quality Objectives' in 1999 (Swedish Environmental Protection Agency 2012). Of the current 16 objectives, energy and resource efficiency targets are included in the 'Reduced Climate Impact' and 'A Good Built Environment' objectives. The Parliament has also adopted a vision for Sweden of zero net emissions of greenhouse gases by 2050, with major implications for energy efficiency nationwide (Swedish Institute 2011).

Given that water consumption remains relatively high in Stockholm compared to the European average, potential exists for further improvements in efficiency. Stockholm residents pay a flat annual rate for water, regardless of consumption rates. The lower levels of household water use in many other European countries reflect a range of policies, including metering to provide quantity-based pricing. Pricing instruments provide incentives for reduced consumption. The City of Stockholm has a target for limiting per capita water consumption to 100 litres per day at the new eco-district of Royal Seaport (see Chapter 7 on Eco-districts). An examination of the potential policy instruments available to achieve that target would be recommended.
The Swedish Government has introduced a number of innovative policy instruments for waste management. Compulsory waste management planning for municipalities was introduced in 1991, a landfill tax in 2000 and successive bans on landfilling various types of waste, including burnable and organic waste. Compulsory producer responsibility for waste from vehicles, electronics, packaging, tyres, paper for recycling, batteries, medical and radioactive sources was introduced in 2005 and the current National Waste Management Plan includes a number of targets, for instance concerning biological treatment of waste (Swedish Environmental Protection Agency 2005).

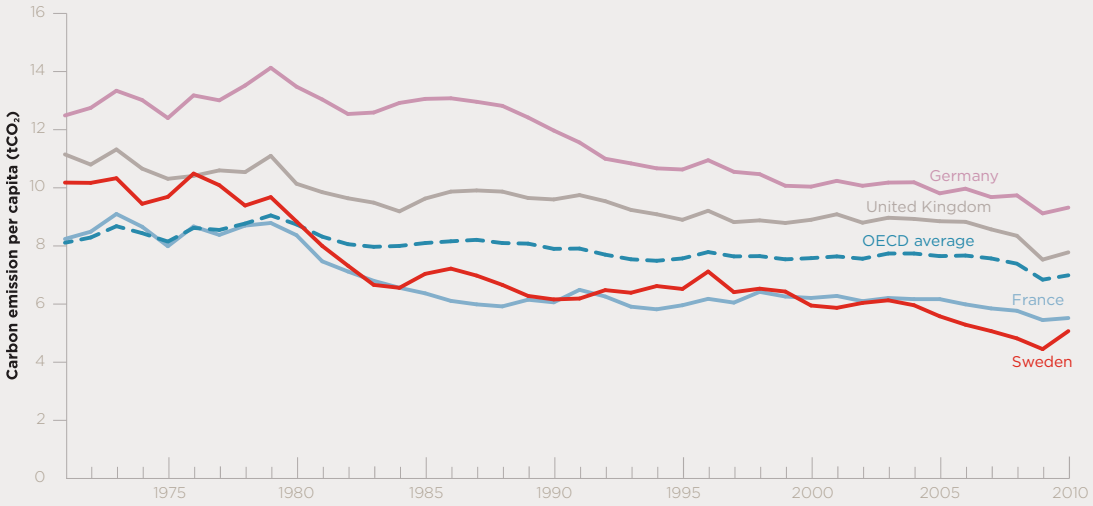
These national-level policies have been supported by policies at the city level for waste incineration as part of Stockholm's district heating system. This combination of policy levers has resulted in the low levels of landfill and high levels of incineration.

4.8 Driver 7: Low carbon

4.8.1 Trends and current performance

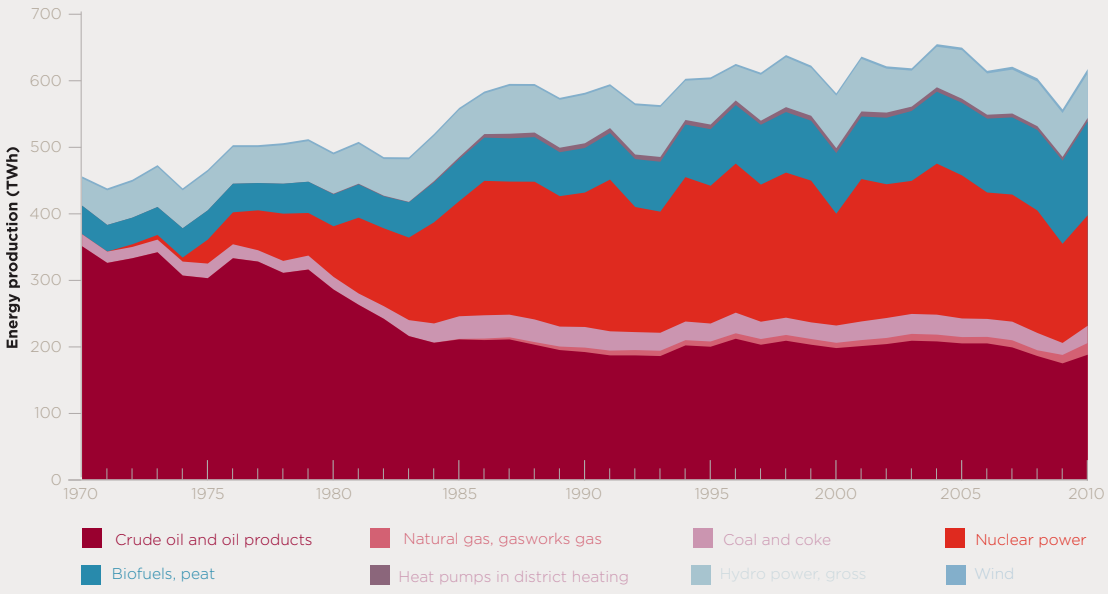
While Sweden's energy consumption per capita is relatively high compared to other countries in Europe, Sweden has one of the lowest levels of CO_2 emissions in the OECD. Sweden's per capita CO_2 emissions have decreased from 10.18 tonnes in 1971 to 5.1 tonnes in 2010 (Figure 4.22), a level almost 30% lower than the OECD European average of 7 tonnes. Sweden's low emissions rate is due partly to a high level of electricity production which is dominated by low carbon energy sources (particularly hydro and nuclear). National carbon emissions decreased steeply during the expansion of nuclear power for electricity production at the end of the 1970s (Figure 4.23). Since then emissions have declined gradually, leading to one of the lowest emissions rates in Europe – substantially lower than other wealthy countries such as Germany and the UK.

Figure 4.22 Carbon emissions in Sweden and selected EU countries 1971-2010



Source: IEA 2012a

Figure 4.23 Sources of total primary energy supply in Sweden, 1970-2010



Source: Swedish Energy Agency 2012)

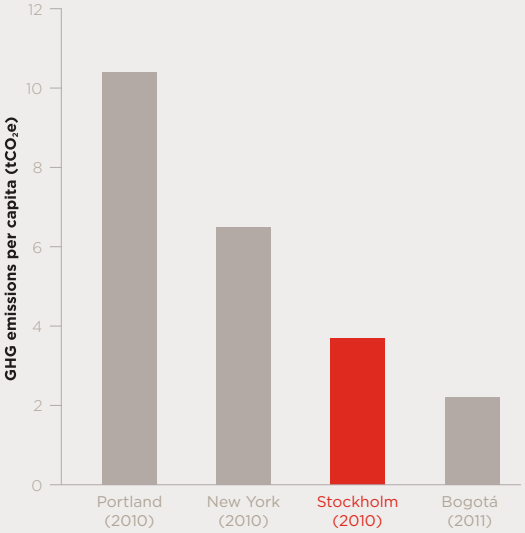
Greenhouse gas emissions (GHG) in different cities are not directly comparable, as calculation methods and assumptions vary. However, as an indication of Stockholm's performance in this area, reported GHG emissions from several cities are shown in Figure 4.24. The results indicate that Stockholm's per capita GHG emissions are very low compared to other cities of similar wealth.

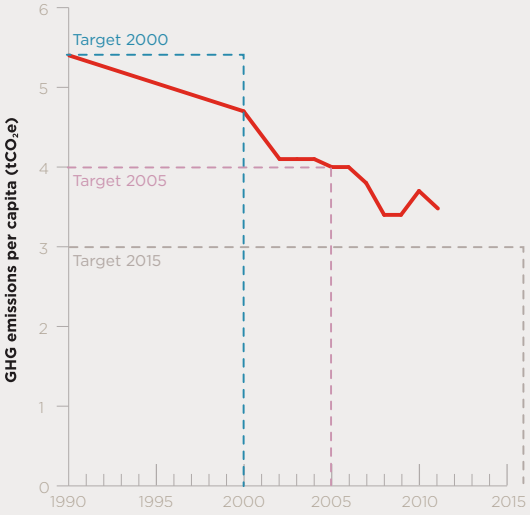
On the left: Figure 4.24 Comparison of reported GHG emissions in selected cities

Graph produced by LSE Cities based on multiple sources.

On the right: Figure 4.25 Reduction of GHG emissions in the City of Stockholm compared to policy targets

Source: City of Stockholm 2012m



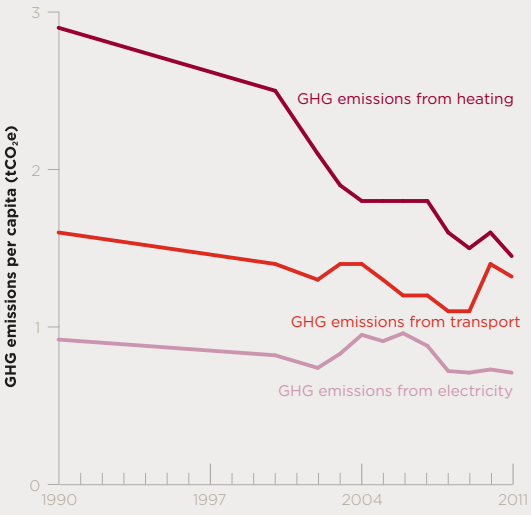


The City of Stockholm has set out a series of carbon targets over the last 20 years (Figure 4.25) (City of Stockholm 2010a). The target for 2000 was to limit greenhouse gas emissions to 1990 levels. This was successfully achieved, with carbon emissions not only stabilising but also falling by 13% from 5.4 tonnes per capita to 4.7 tonnes per capita. For 2005, a new target was set: reduction by 20% with respect to 1990 levels. This target was subsequently revised to the more ambitious level of 4 tonnes per capita, a level that was met. Since 2005, carbon emissions have been further reduced in Stockholm. According to the city authority, the official increase in emission levels from 2009 to 2010 in the transport sector (shown in Figure 4.26) corresponds to new emissions factors and an updated emissions model rather than an actual increase.

The City of Stockholm's GHG emissions comprise three key areas of consumption: heating (42% of total GHG emissions in 2011), transport (38%) and electricity (20%) (Figure 4.26). In all three sectors, emissions per capita have decreased from 1990 levels.

Figure 4.26 Heating, transport, electricity: Reduction of GHG emissions in the City of Stockholm 1990-2011

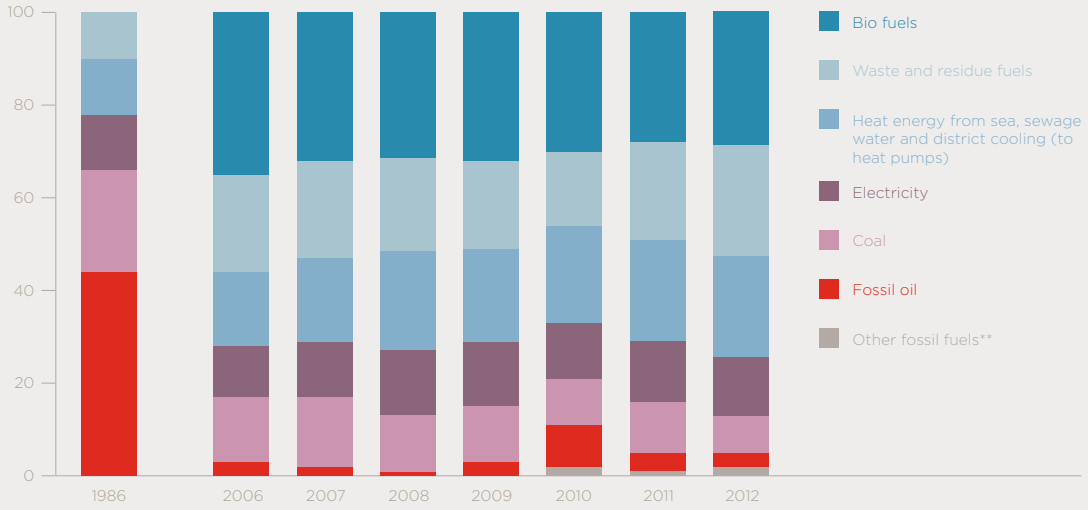
Source: City of Stockholm 2012m



The largest emissions abatement since 1990 has occurred in the heating sector. This is largely due to fuel switching from fossil fuels to low carbon energy sources for the district heating network. During the 1980s, production of heat for district heating primarily depended on fossil fuels: oil (with a share of 44% in 1986) and coal (22%). By 2012, oil – which is currently only used for peak load production - accounted for only 3%, and coal for 8%. At present, biofuels dominate the district heating mix (29%), followed by waste incineration (24%), heat from sea, sewage water and district cooling (to heat pumps) (22%) and electricity (13%) (Figure 4.27).

Despite significant decarbonisation of the heating sector over the last 20 years, heating – particularly domestic heating - remains the largest source of GHG emissions in Stockholm. This is due to the high levels of district heating in the city, coupled with emissions associated with incineration as well as remaining fossil fuels (such as the coal powered combined heat and power plant at Värtaverket).

Figure 4.27 District heating fuel mix in the City of Stockholm, 1986-2012



Sources: City of Stockholm 2012d; Fortum 2013.

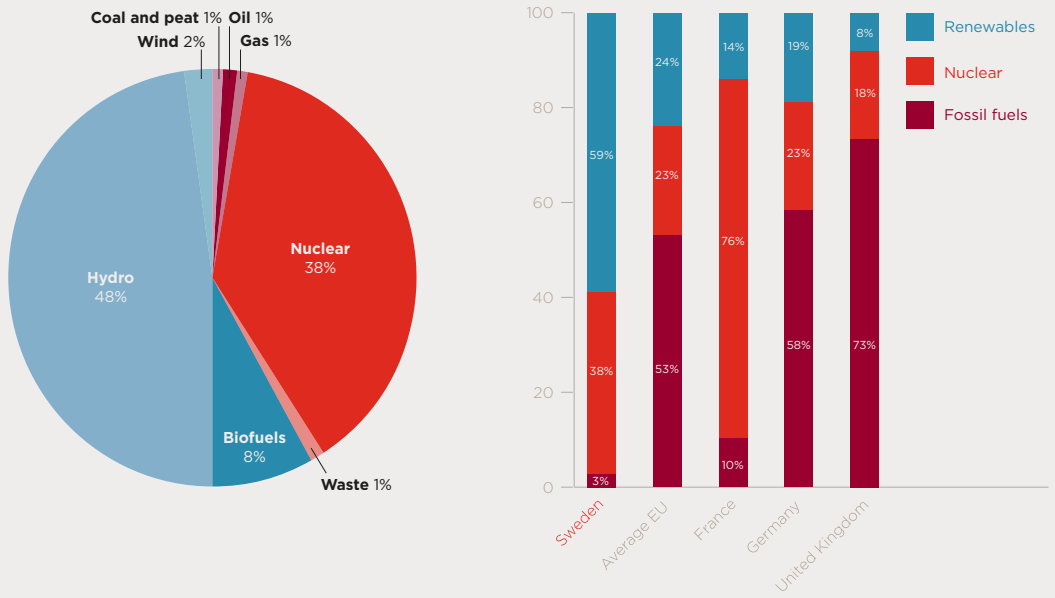
After heating, the transport sector is the second largest source of carbon emissions in the City of Stockholm. In 2010, the city's emission factors were updated and a more detailed emissions model introduced. As a result, according to the City of Stockholm, the apparent increase in transport emissions in 2010 (Figure 4.26) was due to the previous model underestimating emissions. This implies that transport emissions are in reality continuing to decline.

Greenhouse gas emissions in the transport sector are largely due to private vehicles. The car ownership rate in Stockholm is 373 cars per 1,000 people. Although this is not one of the highest rates of car ownership, it is still higher than one or two cities of similar wealth – notably Birmingham and Budapest (LSE analysis). For a more detailed discussion of car ownership and car use, see Chapter 6.

If the City of Stockholm is to meet its 2050 climate target to be fossil fuel free, a decarbonised electricity supply will need to play a central role. Sweden's CO_2 emissions per kWh of electricity (30 grams in 2010) are currently an order of magnitude lower than Europe's OECD average of 331 grams/kWh (IEA 2012a). Consequently, the electricity supplied to the City of Stockholm has relatively low carbon content. Nonetheless, further decarbonisation will be required to meet the long-term goals of both Stockholm and Sweden more generally.

As shown in Figure 4.28a, Sweden's electricity generation relies heavily on hydro power, which supplies almost 50% of total electricity, and nuclear power, producing close to 40%. Biofuels and wind constitute 9% of total generation, while fossil fuels account for only 3%. For this reason, Sweden's electricity production from low carbon sources (97% of total production) is substantially higher than the EU average (at 47%) (Figure 4.28b).

Figure 4.28 Sources of electricity production in a) Sweden b) selected EU countries, 2009



Source: IEA 2012c

4.8.2 Policy supporting low-carbon

Stockholm's success in reducing greenhouse gas emissions can be attributed to a mix of both city-based and national-level policy. At the city level, policy programmes for expanding the range of the district heating system and shifting its fuel mix towards renewables have been particularly important for reducing emissions. In addition, building energy efficiency measures and various sustainable transport policies have contributed to carbon reductions. All these policy programmes are expected to continue contributing to further reductions into the future – enabling the city to reach its latest target of less than 3 tonnes CO_2e per resident by 2015 (City of Stockholm 2010a).

The *Stockholm Action Plan for Energy and Climate 2010-2020* sets out the city's current policy programmes for carbon reductions. Reducing climate impacts is at the heart of the city's energy policy. Policies are organised around three sectors: transport, energy and buildings. The most significant emissions reductions to 2015 are expected to come from continued improvements and expansion of district heating, and within the energy sector as a result of replacing coal with renewable fuel at the city's Värtaverket combined heat and power (CHP) plant. Other programmes in the transport and building sectors are expected to contribute far less to emissions reductions in the short-term (City of Stockholm 2010a).

Stockholm has adopted ambitious goals, aiming to be 'climate neutral' and free of fossil fuels by 2050. Achieving these goals will require additional policy programmes to those currently envisaged. The Action Plan identifies 'conceivable' potential from expanding energy efficiency improvements beyond municipal property to all buildings in the city, and similarly for expanding uptake of green vehicles beyond the city's own procurement policy.

The transport sector will require particular attention in transitioning from fossil fuels in the longer term. The current Environment Programme includes a target to reduce emissions from transport by 15% by 2015 compared with 2011, with strategies to encourage a shift in transport to more sustainable modes including walking, cycling and public transport and improving the environmental impact of the existing transport system – including expansion of the green car fleet (City of Stockholm 2012m). In addition land-use policy at both the city and regional level aims to further support sustainable transport through a compact and polycentric approach to urban planning (City of Stockholm 2010b; Stockholm County Council 2010).

At the national level, the Swedish Parliament has adopted a long-term vision for a zero-carbon country by 2050. Since 2002, the Swedish government's Climate Investment Programme has been an important policy programme for reducing carbon emissions. The grant programme concluded in 2012, having distributed SEK 1.8 billion (US$283 million) to municipalities and other local actors, prompting total investment of SEK 8 billion (US$1.3billion) and estimated to

have reduced CO_2e emissions by 1.1 million tonnes per year. The bulk of grants were made in the energy and transport sectors (Swedish Envionmental Protection Agency 2012a).

The Swedish Government has also used taxation instruments to reduce emissions. Sweden became one of the first countries in the world to introduce a carbon dioxide tax. Taxes on energy had traditionally played a major role in Sweden, both as a fiscal tax source and as a policy instrument. During the 1980s, the tax system focused on discouraging oil use. The introduction of the carbon tax in 1991 was part of a comprehensive tax reform that also saw a 50% reduction in the energy tax on fossil fuels, which had been in place in various iterations since the 1950s (Heine, Norregaard et al. 2012).

The carbon tax was initially set at a rate of SEK250 (US$39) per t CO_2, with increases in 1997 to SEK365 per t CO_2 (US$57) and in 2007 to SEK930 (US$146) per t$CO_2$. The most important impact of this carbon tax has been an increase of biomass use in the Swedish district heating system, from 28% in 1991 to 68% in 2010. However, the effect of the carbon tax on energy and resource efficiency in industry has been limited. Reasons for this include: (1) the total taxation on fossil fuels in industry was reduced in the taxation reform in 1991, (2) the industrial taxation level is lower than the corresponding taxation on district heating, and (3) for many industrial companies, energy costs have low priority as they represent only a small fraction of their total annual costs (Johansson 2000).

While national-level climate policy is well regarded by international comparisons, further improvements will be necessary going forward. The IEA recommends particular attention is given to the transport sector, which continues to rely on fossil fuels and where emissions have continued to increase (International Energy Agency 2008b).

4.9 Driver 8: Environmental quality

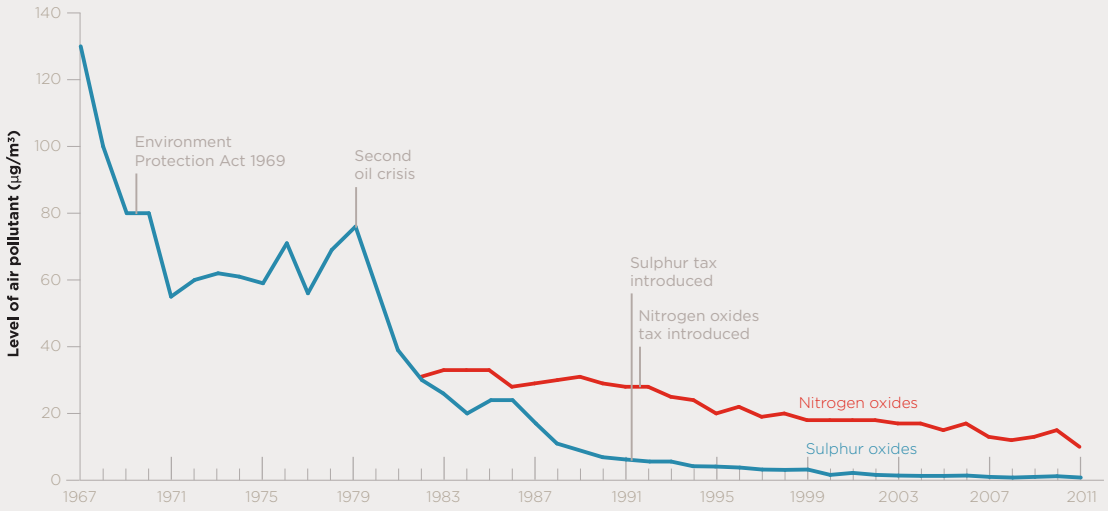
Environmental quality – air quality, water quality and the attractiveness of the cityscape - is a driver of the green economy through a range of channels. Levels of air and water pollution can have substantial impacts on the health of residents and workers, with associated socio-economic impacts on labour productivity. At the same time, a high quality urban environment with green spaces and attractive aspects also contributes to a city's attractiveness to international students, highly skilled professionals and young entrepreneurs. In this way, environmental quality can support other drivers of the green economy such as skills and enterprise.

4.9.1 Trends and current performance

Air quality

Air quality in Stockholm has improved substantially over the last 40 years, benefiting from a range of national pollution policies as well as a general shift away from manufacturing to a service-based economy. The command-and-control approach set by the Environment Protection Act in 1969 affected all industries dealing with a variety of pollutants, including the automobile industry. Levels of sulphur dioxide have declined since then (Figure 4.29). Furthermore, the second oil crisis in 1979 was followed by further reductions in SOx and NOx levels in the city. In 1991 and 1992, the Swedish government introduced sulphur and nitrogen oxides taxes. These policies resulted in further reductions in the concentration of these pollutants in Stockholm, decreasing by 87% and 68% respectively.

Figure 2.29 Air pollution in Stockholm, 1967 - 2011

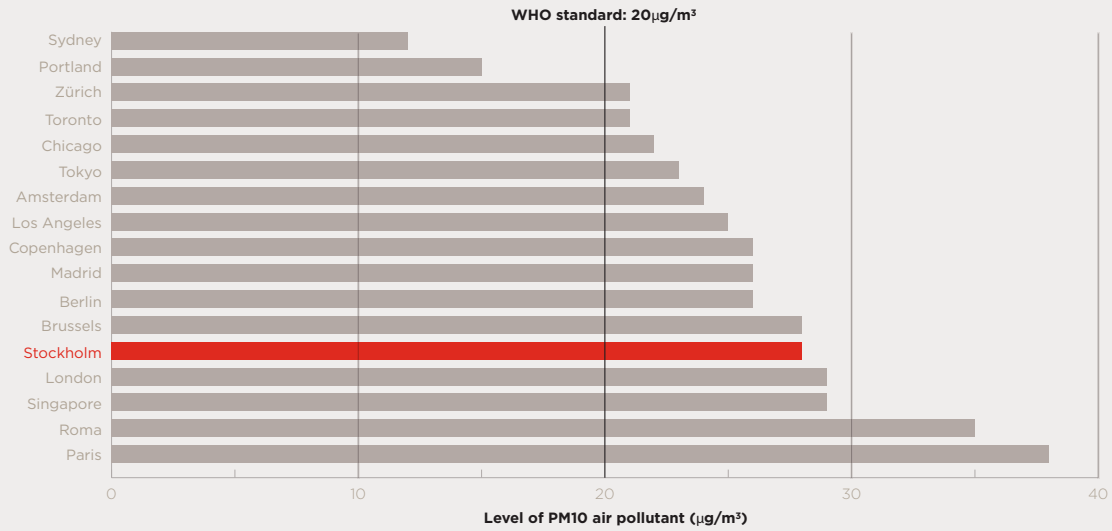


Sources: City of Stockholm 2012e, City of Stockholm 2012n

Although levels of SOx and NOx in Stockholm have improved enormously, the level of PM10 is still a challenge for the city. Exposure to PM10 can contribute to respiratory problems, cancer, lung tissue damage and premature death. The elderly, children, and those with asthma and chronic lung disease are particularly at risk. In 2008, levels of PM10 were 28µg/m3 in the City of Stockholm. Although this is below other cities such as Rome and Paris, it remains above the World Health Organisation standard of 20µg/m³ (Figure 4.30).

Figure 4.30
Air pollution in selected cities

Values are annual mean PM10 levels for 2008/09.

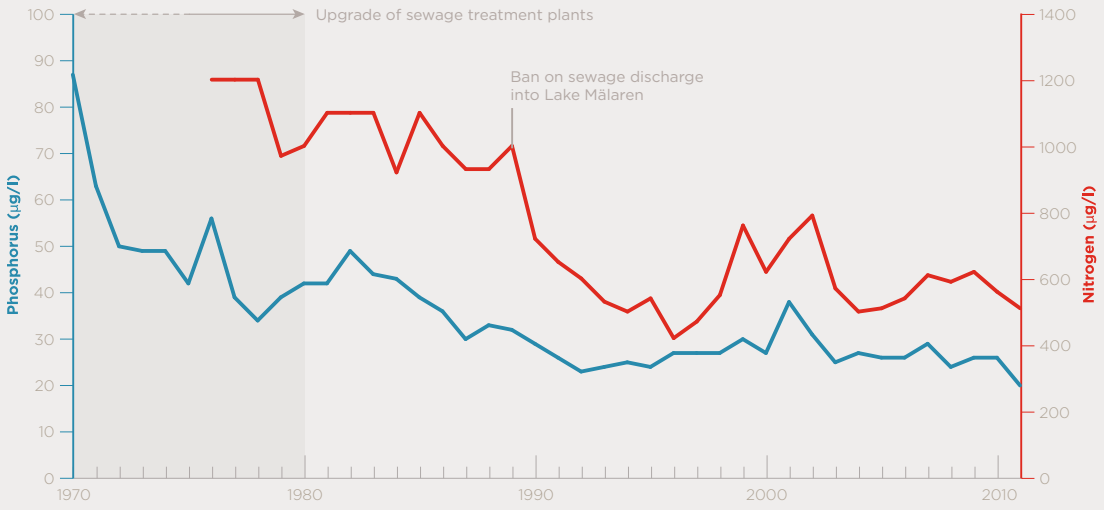


Source: World Health Organization 2010

Water quality

Stockholm's water quality policies over the last 40 years have had a substantial impact on total nitrogen and total phosphorus levels in Lake Mälaren. During the 1960s and 1970s, wastewater treatment plants in the city were upgraded for biological treatment and phosphorus reduction. Following these measures, total phosphorus levels in Lake Mälaren fell by 75% between 1970 and 2011. Furthermore, following a regulation in 1989 which prevented the discharge of wastewater into the lake, current values of total nitrogen are 58% lower with respect to 1976 levels (Figure 4.31).

Figure 4.31
Water pollution in Lake Mälaren, Stockholm, 1970 - 2010



Sources: City of Stockholm 2012o, City of Stockholm 2012p

4.9.2 Policy supporting environmental quality

Stockholm's environmental policies place importance on the 'green and blue structure' of the city, which is seen to provide benefits related to ecological services, biodiversity and recreational opportunities.

The City of Stockholm's most recent *Environment Programme* builds on historic successes in reducing air and water pollution and includes targets for meeting air quality standards and 'reducing or maintaining' phosphorus levels in the city's lakes. This policy document also includes a number of relevant targets in a section on the 'sustainable use of land and water' for both ecological and recreational purposes. Preventing encroachment on existing blue and green spaces is also linked to climate change adaptation policy, where these spaces are recognised for their benefits in adjusting to sea level rise and more intense periods of rainfall (City of Stockholm 2012m).

The City of Stockholm's Water Programme 2006-2015 includes a target for Stockholm's waterways to achieve the status outlined in the European Union Water Framework Directive. It seeks to balance ecological quality and recreational uses of waterways. The water programme also specifically mentions the protection of Mälaren as a drinking water source (Stockholm Vatten 2006).

The environmental quality policies of the city are supported by strong national level policy frameworks, including the Swedish Environmental Code that consolidated environmental protection legislation in 1999 (Swedish Envionmental Protection Agency 2012b). The Code, together with the 16 Environmental Quality Objectives, provide an overarching policy framework that comprehensively addresses goals ranging from 'Clean Air' to 'Zero Water Eutrophication' to 'Thriving Wetlands' (Swedish EPA).

District heating in Stockholm

Stockholm's extensive district heating system is supplied by several combined heat and power (CHP) plants, including the Brista CHP Plant pictured here. The plant in Brista produces 763 GWh heat and 293 GWh electricity every year through the burning of 350,000 tonnes of wood chips. Thanks to the combined production of both electricity and heat as much as 90% of the energy in the fuel is used, contributing to reduced CO_2 emissions and helping Stockholm to achieve its ambitious carbon targets.

Photo Credit: Fortum Sweden

PART III

STOCKHOLM'S POLICY PROGRAMMES

5 Low carbon, energy and resources

Stockholm has a well-structured policy strategy for transitioning to a low carbon, resource efficient economy, underpinned by an extensive range of policy instruments..

While Stockholm has achieved substantial success in reducing carbon emissions, the city's ambitious target to be fossil fuel free by 2050 requires major strategic decisions on pathways to eliminate carbon entirely from the economy.

This will require strong and early policy action over the next few years to overcome long-term lock-in of high carbon infrastructure, systems and technology.

In maintaining Stockholm's position as a green leader, two strategic areas emerge as particular challenges – and economic opportunities: (a) energy for heating and (b) energy for transport. The other key area for emissions reductions is electricity supply, which will require strong national policies for decarbonisation while maintaining energy security.

Eliminating fossil fuels from heating will require an integrated approach to policies on energy efficiency of buildings, district heating and energy from waste incineration. The city authority has steadily reduced carbon-emitting fossil fuels from the energy sources fuelling the system, and has also integrated district heating with its approach to waste management. With most waste incinerated and supplying energy for heating, waste to landfill rates are now very low compared to other cities in the EU, while waste is being re-used as an energy resource.

This inter-related system of district heating and waste incineration will require reform and careful policy attention to ensure Stockholm achieves both continued carbon reductions and more effective use of resources. All the strategic pathways available for reform present considerable challenges, and require decarbonisation of the electricity grid through national policy measures. Potential pathways include:

1. switching district heating fuel sources entirely from coal and waste incineration (which currently includes carbon emitting waste plastic) to biofuels or other renewable energy sources;

2. a mixed waste and biofuels approach with carbon emitting plastics being phased out of the waste incineration process through policies for reducing and recycling plastic waste;

3. carbon capture and storage (CCS) of emissions from combined heat and power and waste incineration plants;

4. carbon offsetting with emissions in other sectors, regions or countries in a global carbon market; or

5. replacing the district heating system entirely with a combination of electric heating (such as air sourced heat pumps) and micro-renewables on buildings.

Eliminating fossil fuels from transport will require an integrated approach to policies on public transport, clean vehicles and electric mobility. Stockholm faces a number of policy options in further pursuing its clean vehicle goals. At the strategic level, there are choices to be made about the policy priority given to promoting clean vehicles in relation to other transport and land-use policy programmes. In reducing carbon emissions and air pollution from the sector,
alternative strategies focused on reducing personal vehicle travel or shifting travel to more vehicle purchases.

A range of alternative pathways for eliminating carbon from Stockholm's transport sector – and the policy instruments required for shaping these pathways - could be investigated further by the City of Stockholm. Alternatives include:

1. investing further in sustainable transport modes;

2. actively incentivising biofuels for vehicles;

3. actively incentivising electric or hydrogen vehicles; and/or

4. incentivising a mix of vehicle technologies.

The City of Stockholm has considerable control over policy levers in these two areas, though both will require coordination with national and regional levels of government.

This chapter outlines Stockholm's green vision and policies for low carbon, energy and resource effectiveness. The chapter examines four key sectors: transport, energy (including energy efficiency and energy supply), water and waste. These sectors are central to delivering Stockholm's low carbon, energy and resource goals – all drivers of the green economy. The chapter draws on Chapter 4 to identify key challenges emerging from trends in each sector. Policy approaches are investigated through an analysis of both official policy documents and through a survey of city policymakers. The survey allows for global comparison of Stockholm's green policy approach with a selection of 90 cities worldwide. The survey also captures self-assessments of green policy progress.

The chapter concludes by identifying two cross-cutting strategic areas for particular policy attention that will be central in defining the long term pathways to Stockholm's future green economy: heating and transport. Eliminating fossil fuels from heating will require an integrated approach to policies on district heating, energy efficiency of buildings and energy from waste incineration. At the same time, fossil fuel free transport will require an integrated approach to policies on public transport (addressed in Chapter 6), clean vehicles and electric mobility.

5.1 Stockholm's green vision

Stockholm's green vision is articulated across a number of strategic policy documents. This strategic policy ranges from the high-level and long-term 'Vision 2030' to more specific short-term action plans and targets.

5.1.1 Vision 2030

Vision 2030 sets out an overarching, long term vision for Stockholm. Adopted by Stockholm City Council in 2007, the vision is of "a world class Stockholm" based around three themes: versatile and full of experiences; innovation and growth; and citizens' Stockholm.
The vision incorporates green principles throughout. For instance, attractive green spaces and waterways contribute to the 'experiences' available in the city, while a well-developed public transport system is seen as essential for a 'citizens' Stockholm' that is inclusive and accessible. Goals for innovation and growth include opportunities for clean vehicles and reduced energy consumption in the transport and building sectors.

While the City of Stockholm's population is expected to grow from around 800,000 to over 1 million in 2030, the city government aims to ensure that this increase has "little or no effect on the local environment, making Stockholm an international role model".

The vision places considerable emphasis on establishing an attractive business climate, although it does not explicitly mention the 'green economy' as part of innovation-led economic development. Spatial development plans for land-use and transport are also central to Stockholm's strategic green vision. The *Regional Development Plan and Stockholm City Plan* are discussed in detail in Chapter 6.

5.1.2 Stockholm Environment Programme

The Stockholm Environment Programme includes specific targets and actions that aim to achieve higher level environmental objectives established by both national and city-level governments. The latest Programme for 2012 - 2015 is the City of Stockholm's eighth since the first was introduced in the 1990s. It aims to influence both the city government's own operations and the broader environmental performance of the city.

The latest Programme is organised around six overarching goals: (1) environmentally efficient transport; (2) goods and buildings free of dangerous substances; (3) sustainable use of energy; (4) sustainable use of land and water; (5) environmentally efficient waste management; and (6) a healthy indoor environment. Within each goal are a number of more specific targets. A total of 29 'interim targets' identify immediate actions to be achieved under the current Environment Programme by 2015 (see Box 5.1).

Box 5.1 Stockholm Environment Programme 2012-2015: interim targets

Environmentally efficient transport
- The environmental impact from city transports and travel will be reduced
- Municipal vehicles will be environmentally certified and powered by renewable fuels, and the proportion of 'green' city transport contracts will be increased
- Air quality norms will be met
- Travel on foot and by bicycle will increase
- Increase in the proportion of people who travel by public transport
- At least half of all new private cars sold should be 'green'. 10% of newly registered heavy vehicles will be certified as clean trucks.
- Reduction in outdoor traffic noise

Goods and buildings free of dangerous substances
- The content of substances that are dangerous to the environment and to health will be reduced in procured goods.
- Emissions of dangerous substances from buildings and facilities will be reduced
- At least 25% of food purchases made by the City of Stockholm will be organic
- The spread of dangerous substances from households, commerce, construction and other actors in Stockholm will be reduced
- The proportion of environmentally certified buildings will be increased

Sustainable use of energy
- The City will through energy efficiency measures reduce energy use in its own operations by at least 10%
- Electricity procured for municipal activities will meet the requirements for eco-labelling
- In new buildings on land designated by the City, energy use will be at the most 55 kWh/m^2
- The City's buildings will be made energy efficient in connection with major renovations
- The City will strive to reduce emissions of greenhouse gases to a maximum of 3.0 tonnes of CO_2 per inhabitant of Stockholm.

Sustainable use of land and water
- Land and water areas of special significance for biodiversity will be preserved and developed
- Land and water areas of particular attraction for recreation will be preserved and developed
- Development of other land and water areas will be minimized and compensated
- Where changes are made in land and water areas, these will be designed with future climate changes in mind
- Maintenance of land and water areas will work to preserve biodiversity, ecosystem services and recreational qualities
- Improvement of water quality in lakes and waterways

Environmentally efficient waste management
- Waste from the City's activities will be reduced and unavoidable waste will be put to good use
- The proportion of incorrectly recycled hazardous waste will be reduced
- Waste from housing and industry in the city will decrease and unavoidable waste will be put to good use.

A healthy indoor environment
- The indoor environment will improve
- Indoor radon levels will be reduced
- Indoor noise levels will be reduced

Source: City of Stockholm 2012m

5.1.3 Climate Action Plan

The City of Stockholm's *Climate Action Plan*, adopted in 2010, identifies specific short-term actions for reducing the city's greenhouse gas emissions. The Plan outlines measures in the transport, building and energy sectors that will contribute to achieving the goal of reducing emissions from activities within the City of Stockholm to less than 3.0 tonnes of CO_2 per person by 2015. The Plan also works towards the city's longer term goal to be fossil fuel free by 2050.

The Plan forecasts that future carbon emissions will drop from 3.4 tonnes of CO_2 per Stockholm resident in 2010 to 2.8 tonnes in 2015. The Plan distinguishes between reductions arising from 'expected development' (technological improvements, changing population, planned improvement to district heating, etc.) and 'on-going and planned measures' (additional city-based policy initiatives). Around half of the forecast emissions reductions result from expected development and half from planned policy measures. Around 85% of reductions from active policies are estimated to result from fuel-switching from coal to renewables at the Varta combined heat and power plant located at Stockholm Royal Seaport in the city.

The Plan also includes a catalogue of 50 'conceivable measures' that, if implemented in full, could reduce emissions by a further 0.23 tonnes per resident. The Plan suggests this is unlikely and compares all measures based on the level of emissions reductions, financial costs and the level of control that the city government holds over the potential initiatives. It identifies efficiency measures in the buildings and transport sectors as areas with the largest potential for effective and economically efficient emissions reductions (City of Stockholm 2010a).

5.2 Transport

5.2.1 Key challenges

The key challenges for greening Stockholm's transport sector relate to reducing emissions of carbon and harmful air pollutants. The sector remains heavily dependent on fossil fuels and is responsible for almost 40% of the city's carbon emissions (see Chapter 4, 'Low Carbon'). Transport is also the main source of air pollutants in the city, contributing to Stockholm's relatively high levels of air pollution which exceed European standards according to measures of PM10 (this is partly due to the use of studded tyres for driving in winter conditions).

5.2.2 Strategy and goals

The city's strategy for transport infrastructure development is outlined in the *Stockholm City Plan*, and at the regional level in the *Regional Development Plan*. The *Environment Programme* includes a number of targets for improving the environmental performance of the transport system. These include mode-shift targets for increasing the proportion of travel by sustainable modes - on foot, by bicycle and public transport. There are also targets for meeting air quality standards and for increasing the proportion of clean vehicles to half of all new sales.

The survey of city policymakers suggests that the city's strategy for greening the transport sector prioritises *improving* the environmental performance of the existing transport system and *shifting* the transport system to more sustainable modes. In contrast to some other leading green cities, strategies for avoiding travel altogether and reducing private vehicle use are reported as less important for Stockholm's green transport agenda. The environmental performance of the transport sector is also influenced by land-use policy. Further information on land use and impacts on accessibility is provided in Chapter 6.

5.2.3 Policy instruments

Overall, Stockholm has a wide portfolio of green policy instruments in the transport sector. The City of Stockholm reports that 27 out of 32 of the transport policy instruments surveyed are used in the city (Table 5.1). Most instruments commonly used by other cities have been implemented in Stockholm. The city uses regulations for dense and mixed-use development to support sustainable travel, provides facilities for walking and cycling and invests in green transport infrastructure such as trams and heavy rail. The city is one of the few around the world that have successfully introduced congestion charging – a policy instrument that has led to significant reductions in central city traffic volumes, congestion, and emissions of carbon and harmful air pollutants (see Box 5.2).

A notable policy programme not used in Stockholm, though increasingly common among worldwide cities, is Bus Rapid Transit (BRT). Stockholm already possesses extensive train, tram and metro systems. However, increasing the efficiency of buses through upgrading fleets, automatic ticketing and more bus lanes would be worth investigating by the city and county authorities.

Other instruments that Stockholm does not employ (along with BRT) include high occupancy vehicle lanes, and licence plate vehicle-use restrictions. High occupancy vehicle lanes have been previously trialled in Stockholm but were abandoned due to lack of uptake. This policy instrument has, however, been successfully used in Californian cities including Los Angeles and San Francisco. Licence plate restrictions are used in Singapore, and the potential effectiveness and efficiency of such instruments could be examined for Stockholm, while taking into account the existing policy mix.

Table 5.1 Policy instruments in the transport sector

This table shows the transport policy instruments reported to be used by (a) cities in the LSE Cities global transport sector survey, and (b) in Stockholm. Column (a) shows the number of cities that report using the policy instrument out of the 27 cities that responded to the global transport survey. Column (b) shows the level of government administering the policy instruments that impact on Stockholm's transport sector.

Policy	(a) No. of cities using policy instrument	(b) Stockholm policy instruments administered at city, county and national levels		
		Stockholm City	Stockholm County	Sweden
Regulations promoting mixed-use development	25	●	●	
Improve Road Safety	25	●		●
Regulations promoting density	24	●	●	
Widening of pavements / pedestrian space	24	●		
Providing safe facilities for pedestrians and cyclist	24	●		
Parking Charges	23	●		
Introduction/expansion of Bus Rapid Transit	22			
Cycle network and bike paths	22	●	●	●
Dedicated lanes for buses	21	●	●	
Traffic Calming / Physical driving restrictions	21	●		●
Limiting Vehicle Speeds	21	●		
Introduction/expansion of Tram/Light Rail	20	●	●	
Street Closures	20	●		
Fuel Taxes	19			●
Introduction/expansion of Heavy Rail	18	●	●	●
Electric Vehicle Charging Infrastructure	18	●		
Parking Space Reduction	17	●		
Support for teleworking	15			●
Cycle hire schemes	15	●		
Minimum Emission Standards	15	●	●	●
Procurement policies	15	●		●
Electrify Road Transport	13	●		
Smart' Transport Systems	13	●	●	●
Road User Charges	12			●
Car Free Days	12	●		
High Occupancy Lanes	12			
Restricting Road Usage for Cars	11	●		
Congestion Charging	9	●		●
High Occupancy Toll Lanes	8			
Promoting Car Free Neighbourhoods	7	●		
Licence Plate Restriction/Auctioning	7			
Zero Emission Zones	6	●		

Box 5.2 Stockholm's Congestion Charge

The Stockholm congestion charge is a tax affecting most vehicles entering and exiting the centre of Stockholm. Following a trial period between January and July 2006, a public referendum supported the permanent establishment of a congestion pricing system, which came into force in August 2007.

Unmanned electronic control points are located at all entry points to the congestion charging area and vehicles are identified through automatic number plate recognition and are sent a bill charging them up to 60 SEK/6 EUR per day . The revenue generated through the congestion charge is used to fund road improvement projects across Stockholm. Initially, alternative fuel vehicles were not affected by the tax, leading to an increase in the purchase of electric and hybrid cars, but this exemption is no longer valid for vehicles purchased after August 2012.

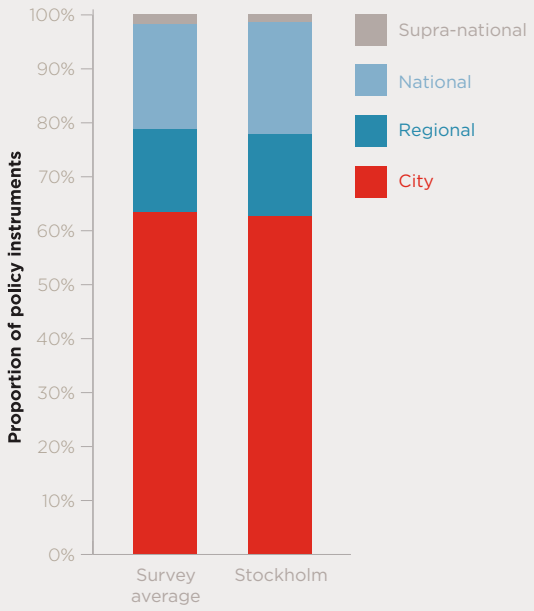
The congestion charge has had a significant impact on reducing the city's traffic congestion. Since 2006, Stockholm has experienced an average reduction of 20% in overall traffic to and from the city centre and a concurrent increase of around 7% in public transport use. Reduced traffic volumes have also led to a 10-15% decline in motor vehicle CO2 emissions in the city. This reduction in traffic volumes has been achieved even though the population is growing by around 40,000 people a year.

Sources: Börjesson, Eliasson et al. 2012; Börjesson, Ericsson et al. 2009; Eliasson 2008; Eliasson, Hultkrantz et al. 2009; Stockholm Traffic Administration 2009

5.2.4 Governance and policy coordination

Globally, the majority of urban transport policies tend to rest with the city authority, and Stockholm follows this trend (Figure 5.1). Around 60% of green transport policy instruments are implemented by city-level government in Stockholm. These include areas such as pedestrian and cycling infrastructure, car parking and electric vehicle infrastructure. Although the city authority holds the majority of policy levers, national and regional levels of government are also involved in key policy decisions such as land-use regulation, rail investment, taxation on fuel and congestion charging (Table 5.1).

Figure 5.1 Levels of government responsibility for transport policies



Results from the LSE Cities Going Green global survey.

Transport is a sector where the city authority will need to partner closely with national government departments if Stockholm is to meet its ambitious 2050 carbon targets and international standards on air quality. The city's goal for becoming fossil fuel free will be particularly challenging for this sector. One key strategic area will be decisions around the uptake of clean vehicles and roll out of electro-mobility infrastructure. As discussed in more detail later in the chapter, this will require a combination of city and national level policies that are coordinated effectively and efficiently.

5.3 Energy

5.3.1 Key challenges

The key challenges for the energy sector are improving energy efficiency and achieving Stockholm's long-term goal of becoming fossil fuel free by 2050. Despite progress towards decarbonising the city's energy supply, total energy consumption per person still remains high and there has been little progress in reducing energy use in Stockholm over the past 20 years (see Chapter 4). Although fossil fuel dependence has been reduced substantially over the last 50 years, oil, coal and gas are still used for heat and electricity production – comprising, for example, between 10-20% of Stockholm's district heating fuel mix over the past three years.

5.3.2 Strategy and goals

Stockholm's strategy for greening the energy sector prioritises the reduction in energy use and shifting supply to renewable sources. Important targets for the sector are included in the *Environment Programme and the Climate Action Plan*. The key short term target for carbon is to reduce emissions to a maximum of 3.0 tonnes of CO_2 per person by 2015.

The Programme also includes targets for energy use standards of 55kWh/m^2 for new buildings on land designated by the City of Stockholm. Stockholm's eco-district demonstration projects also play an important role in developing technologies for reducing energy consumption in buildings (see Chapter 7).

The City of Stockholm also aims to retrofit its existing building stock to reduce energy use by at least 10% by 2015. To this end, Stockholm has allocated SEK 10 billion (around US$1.5 billion) up to 2015 to carry out energy efficiency improvements and upgrade the municipality owned stock (City of Stockholm 2010a).

The survey of city policymakers confirms that strategies for reducing energy demand and shifting energy generation towards renewables are the most important goals. Strategies based on improving the environmental performance of fossil-fuel based energy (for example carbon capture and storage) are generally not prioritised.

5.3.3 Policy instruments

A wide range of energy policy instruments are used for improving the environmental performance of the city's energy system. The City of Stockholm reports that 13 out of 21 of the energy supply policy instruments surveyed are used in the city. Commonly used green energy policy instruments include provision of government loans and subsidies for energy efficiency measures, subsidies for building-scale solar energy generation and, at the national level, subsidies for large-scale renewable energy generation.

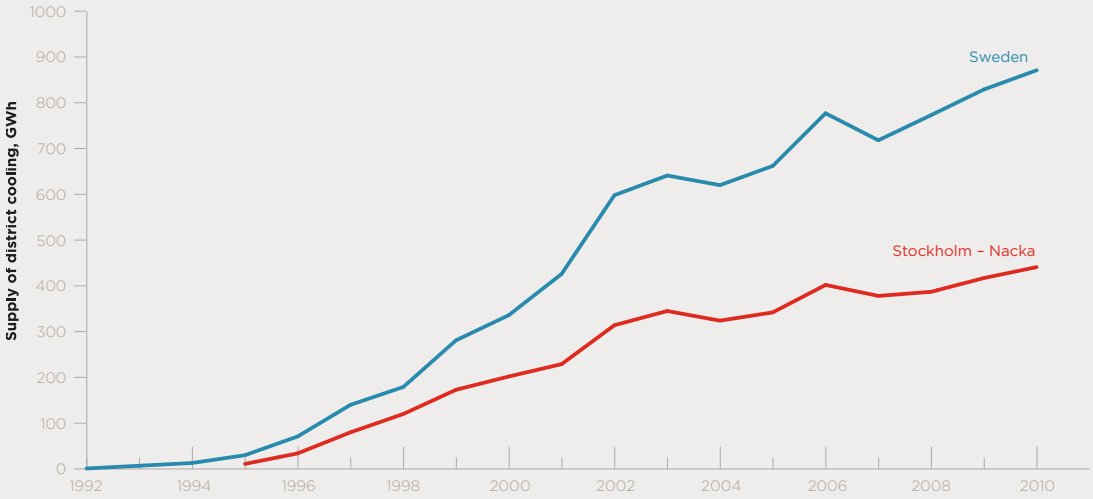
On the other hand, a number of policy measures used by the worldwide city survey are not applied in Stockholm. These include renewable energy sourcing minimums for utilities and subsidies for combined heat and power. Renewable energy sourcing minimums have been used within the city's eco-district projects at Hammarby and Royal Seaport (see Chapter 7), but there may be opportunities for more widespread application of this measure.

Although the city does not provide subsidies for combined heat and power (CHP) plants, the technology is well used in Stockholm. Public investment enabled the initial development of the district heating system, but the now privatised system is currently financially self-supporting (see also Box 5.3 on Stockholm's District Cooling system). While subsidies are available in Stockholm for various forms of building-scale distributed renewable energy generation, some technologies such as wind appear to be excluded. Cities that provide support for a full range of distributed renewables include Toronto with a tax rebate programme, and national level policy in the United Kingdom which provides grants for a range of micro-renewables.

Box 5.3: District Cooling

Despite its cold climate, Stockholm County accommodates the world's largest district cooling network, which started to be operative in the mid-1990s and has since been established in the city without any subsidies. In 2010, the Stockholm-Nacka network supplied 441GWh of cooling, corresponding to over 50% of the total district cooling supply in Sweden (see Figure below). Sources for the production of district cooling include cold water from sea and lakes, and heat pumps.

District cooling supply in Stockholm and Sweden 1992-2011



Sources: City of Stockholm 2012o, City of Stockholm 2012p, Swedish Energy Agency 2012

Table 5.2 Policy instruments in the energy sector

This table shows the energy policy instruments reported to be used by (a) cities in the LSE Cities global energy sector survey, and (b) in Stockholm. Column (a) shows the number of cities that report using the policy instrument out of the 23 cities that responded to the global energy survey. Column (b) shows the level of government administering the policy instruments that impact on Stockholm's energy sector.

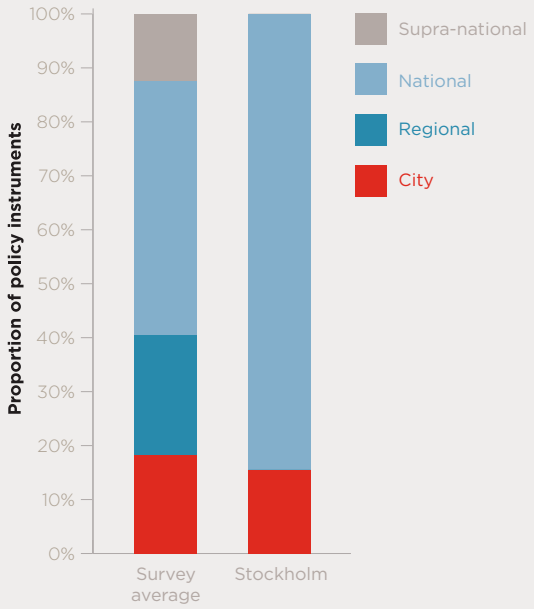
Policy	(a) No. of cities using policy instrument	(b) Stockholm policy instruments administered at city, county and national levels		
		Stockholm City	Stockholm County	Sweden
Government loans or subsidies for energy efficiency measures	21			●
Subsidies for home and building-scale solar energy generation	20			●
Subsidies for large-scale wind energy projects	18			●
Subsidies for large-scale biofuel energy projects	16			●
Subsidies for large-scale solar energy projects	15			●
Taxation on energy consumption	14			●
Renewable energy sourcing minimums for utilities	13			
Planning policies encouraging combined heat and power (CHP)	13	●		●
Subsidies for home and building-scale wind energy generation	12			
Subsidies for large-scale geothermal energy projects	12			
Feed-in tariffs for distributed electricity generation	12			●
Subsidies for combined heat and power (CHP)	12			
Planning policies encouraging district heating	12	●		●
Subsidies for large-scale wave/tidal energy projects	11			●
Subsidies and/or planning policies for carbon capture and storage	10			
Subsidies for large-scale hydro energy projects	9			
Mandatory smart meter installation	9	●		●
Formalising electricity access in informal communities	8			
Subsidies for home and building-scale fuel cell energy generation	8			
Subsidies for district heating projects	8			●
Enabling dynamic time-of-use energy pricing	7			●

5.3.4 Governance and policy coordination

The energy sector in Stockholm is notable for the very high level of involvement by national level government. Responsibility for over 80% of energy policy instruments rests with the Swedish Government, while the city authority plays a less important role (see Figure 5.2). This follows patterns evident across the world.

The main policy instruments that the city authority is involved with include loans for energy efficiency improvements, planning for district heating and smart meter installation. However, national-level government is also involved with all these policies and has additional responsibility for providing subsidies for building-scale solar energy generation, subsidies for large-scale renewables, taxation on energy and feed-in tariffs for distributed energy generation (Table 5.2).

Figure 5.2 Levels of government responsibility for energy policies



Results from the LSE Cities Going Green global survey.

This high level of national involvement in the sector highlights the importance for the city of partnering with central government to continue improving the environmental performance of energy supply. Decarbonising the national electricity supply will require national-level measures to phase out centralised fossil fuel power stations. A key strategic challenge for the city involves decarbonising the district heating system and this is investigated in more detail below. Policies for energy efficiency measures in Stockholm's buildings have been developed by various layers of city, regional and national government. City-level policies – representing almost 50% of all energy efficiency policy instruments used in Stockholm - are slightly more common in Stockholm than across the global sample of surveyed cities (LSE Cities global survey).

The main policy instruments for energy efficient buildings under the responsibility of the city authority are information campaigns for reducing energy consumption, procurement policies encouraging green buildings, subsides for renewable heat installations and renewable cooling systems. A number of policy tools, including low-carbon building regulations, smart meter installation and disclosure of building energy performance, involve both national and city-levels of government.

In December 2008, with the aim of raising demand for building services, the national government introduced financial support (in the form of tax reductions) for renovation, maintenance, conversions and extensions of buildings – known as the ROT reduction. The ROT reduction encourages the decrease in energy use in buildings by making energy saving measures financially more attractive (Swedish Energy Agency 2011).

5.4 Water

5.4.1 Key challenges

Key challenges for improving the environmental performance of the water sector in Stockholm include reducing water consumption and continuing to improve the quality of the city's lakes and waterways. Households are the major consumers of water in the city and domestic consumption levels are significantly higher than in many other European cities. While water quality has improved, there remain a number of waterways that face continuing quality threats from urban water runoff and heavy metal contamination.

5.4.2 Strategy and goals

The City's *Water Programme 2006 – 2015* has two overarching water quality objectives: achieving 'good' status under the EU's Water Framework Directive and ensuring the attractiveness of water areas for recreational purpose. The *Environment Programme* also specifies targets for the sector, including improving water quality and maintaining areas of water for biodiversity, ecosystem services and recreational qualities.

The survey of city policymakers shows that Stockholm's strategic approach in the water sector focuses on protecting freshwater supply, maintaining water quality, and improving wastewater treatment. In contrast with other cities, strategies focused on reducing water demand are not reported as so important. This may reflect relatively plentiful water supply in Stockholm. Nevertheless, some recent eco-district developments have included targets for limiting water consumption.

5.4.3 Policy instruments

Stockholm has implemented a broad range of green policies in the water sector. The City of Stockholm reports that 14 of 25 policy instruments surveyed are used in the city (see Table 5.3). Alongside many other cities around the world, the city uses water pricing, efficiency standards and subsidised efficiency technologies to manage water demand; and spatial planning instruments to protect supply sources.

Table 5.3 Policy instruments in the water sector

This table shows the energy policy instruments reported to be used by (a) cities in the LSE Cities global water sector survey, and (b) in Stockholm. Column (a) shows the number of cities that report using the policy instrument out of the 30 cities that responded to the global water survey. Column (b) shows the level of government administering the policy instruments that impact on Stockholm's water sector.

Policy	(a) No. of cities using policy instrument	(b) Stockholm policy instruments administered at city, county and national levels		
		Stockholm City	Stockholm County	Sweden
Pricing (e.g. user charges, volumetric water charging)	26	●		
Building standards for water use	26			●
Planning codes for the protection of pollution of other stream flows into reservoirs, lakes and ground water	24	●		●
Maxima on waste-water emissions from industries	23	●		●
Mandatory water meter installation	22	●		
Site planning for water polluting industries	21	●		●
Procurement policies	18	●		
Planning codes for waste-water separation and recycling	17	●		●
Subsidies for residential water efficiency mechanisms (e.g. flush savings, urine diversion toilets)	17			●
Credit for local rainwater infiltration	16	●		
Subsidies for rainwater harvesting	15			
Tax on unsustainable water resources	14			
Feed-in tariffs on local/sustainable sources	14			
Subsidies for natural water treatment (e.g. waste stabilisation ponds, soil aquifer treatment)	14			●
Formalizing water access in informal communities	14			
Subsidies for new technologies of water efficiency measures	14			●
Subsidies for active leakage management	14			
Feed-in tariffs for distributed water supply	13			
Subsidies for constructing storage and detention (wetlands, aquifer, recovers, ponds, basins)	13			●
Subsidies for resource efficient demonstrations and campaigns	13			
Subsidies for biogas production from sludge	13			●
Subsidies for commercial water efficiency mechanisms	12			
Subsidies for waste-water separation and recycling (e.g. reuse of treated wastewater effluent, greywater reuse, sludge reuse)	12			
Enable demand response through water market regulation	11			
Enable dynamic time of use water pricing	11			

While metering and water pricing instruments are used in Stockholm, the City may wish to examine the effectiveness and efficiency of these instruments for reducing water demand. Household consumption is at a higher level than many other European cities, and water prices have only increased marginally since 1990 (Lindblom 2012). Experiences in Copenhagen and Singapore show how integrated programmes, including education campaigns, water metering and progressive pricing mechanisms, have worked to reduce consumption by up to 40% (see Box 5.4).

Box 5.4 Demand management policies in Singapore and Copenhagen

Singapore and Copenhagen are two examples of cities that have successfully invested in education campaigns to encourage residents to reduce their water consumption by installing more water efficient appliances and changing their water use habits. Additionally, both cities have successfully introduced individual water meters and consumption-based water tariffs, which provide a financial incentive to further reduce water use. As a result, Singapore has managed to reduce its consumption from 165 litres per person per day (lpd) in 2003 to 150 lpd in 2012.

After introducing individual metering, Copenhagen experienced a decrease in water consumption of up to 40% over a six year period for those homes that had previously had the highest usage. For Copenhagen as a whole, per capita consumption has dropped from 171 lpd in 1987 to 108 lpd in 2010, one of the lowest rates in the developed world.

Sources: Green Growth Leaders 2011; Singapore Ministry of the Environment and Water Resources 2012

While the City of Stockholm did not report any water policy instruments used by Stockholm County in the LSE global survey (Table 5.3), several regional municipal cooperation programmes have been implemented or are on-going, with the aim of ensuring that Stockholm retains a sustainable supply of water. Networks have been established around the City of Stockholm: 11 municipalities in the southern part of the region, as well as the 14 municipalities comprising the Norrvatten Association north of Stockholm, have been connected in order to increase security of water supply. A water protection area was also established in the eastern part of Lake Mälaren in 2008, comprising part of the upstream catchment area for Stockholm.

Other innovative policies absent in Stockholm, but potentially relevant for further consideration, are measures promoting rainwater harvesting, grey water re-use, leakage management and commercial sector water efficiency (Table 5.3). Cities encouraging greywater re-use include Tokyo, which has introduced mandatory standards for installing greywater systems within new large buildings. National level policy programmes in Australia provide financial rebates for household-scale grey water infrastructure. Singapore and Tel Aviv have strong policies in place to reduce water leakage, including retrofitting of distribution infrastructure.

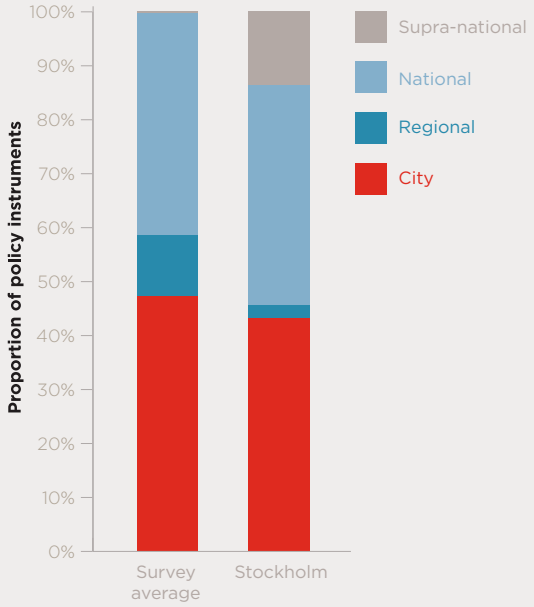
Stockholm reports more success than most cities in achieving a broad range of water policy goals. The survey results suggest the city is a global leader in natural wastewater treatment and integrated management of the urban water system. Stockholm also reports more success than average in protecting water resources, improving water quality, reducing water consumption and promoting local infiltration of rainwater rather than centralised storm water discharges.

The City of Stockholm's water policy recognises the need for a systems approach to water management, taking into account all aspects of the complex water cycle, from abstraction to discharge. The city uses innovative methods in the sector, such as recovering the heat content from treated wastewater through heat pumps that heat nearly 200,000 homes through the district heating system (Brattberg, Skogsfors et al. 2010). The city has also started using the biogas developed as a by-product of the wastewater treatment process as a renewable energy source to fuel cars and buses (Johansson, Perzon et al. 2008).

5.4.4 Governance and policy coordination

Water policy in Stockholm involves important roles for both city and national-level governments (Figure 5.3). Supra-national levels of government also play a more important role than in other sectors (possibly reflecting the role of European Union standards in driving water policy).

Figure 5.3 Levels of government responsibility for water policies



Results from the LSE Cities Going Green global survey.

The main policy instruments under the responsibility of the city authority are water pricing, mandatory water meter installation and procurement policies. The national government has responsibility for building standards for water use, subsidies for residential efficiency technologies and subsides for natural wastewater treatment. Key policy instruments such as planning controls preventing water pollution, standards for industrial water pollution and site planning for polluting industries involve both city and national governments (Table 5.3).

Policy levers at the city level appear to require most attention in further strengthening Stockholm's water policy. Policy instruments used for reducing water consumption, including pricing and metering, could be made more effective. While green developments such as Royal Seaport have included demand reduction targets, such targets could be adopted more widely throughout the city. Water efficiency 'retrofits' could be integrated with the City's building retrofitting programmes, currently focussed on energy efficiency.

With regard to water quality, the city's waterways are generally considered to be in very good condition and improvements have been significant. However, a number of challenges still remain. In particular, eutrophication due to high phosphorus levels in some of Stockholm's waterways remains a significant problem, and concentrations of phosphorus are considered unacceptably high in some lakes, threatening the stability of aquatic ecosystems. There are also some hazardous substances that are of concern, particularly copper and zinc which occur in moderate to high concentrations in most waterways (Stockholm Vatten 2006). Although discharges of untreated wastewater have largely ceased, periods of high precipitation can still cause the sewer system to overflow and contaminated water to enter the watercourse. This is recognised in the City of Stockholm's Stormwater Strategy that aims to reduce the impact of nutrients and hazardous substances.

5.5 Waste

5.5.1 Key challenges

Key challenges for improving the environmental performance of the waste sector include reducing overall levels of waste generation, ensuring the most effective re-use of waste resources and minimising carbon emissions from waste treatment. Despite advances in waste treatment, Stockholm's total levels of waste generation remain high, and are broadly equivalent with the European average. There are also challenges for the city in ensuring treatment maximises the resource potential of waste – and in particular avoiding incineration of recyclables and compostable organic waste.

5.5.2 Strategy and goals

Important waste sector targets are included in the city's Environment Programme. Stockholm aims to reduce levels of residential and industrial waste and to put unavoidable waste to good use. It also aims to reduce the proportion of incorrectly recycled hazardous waste.

The survey of city policy makers shows that green policy for the waste sector prioritises improvements to waste collection and treatment. Unlike most other cities, the respondents reported that Stockholm places slightly less importance on reducing waste generation. However, the city places more emphasis than average on reducing landfill sites.

5.5.3 Policy instruments

A comprehensive package of policy instruments is used to support green objectives for the waste sector. The City of Stockholm reports that all 21 of the surveyed policy instruments are used in the city. Conventional instruments such as collection of recyclables, regulations on waste toxicity, pricing and procurement policies are all used. The city also makes use of less commonly used policies such as feed-in tariffs for recycling and composting (Table 5.4).

Table 5.4 Policy instruments in the waste sector

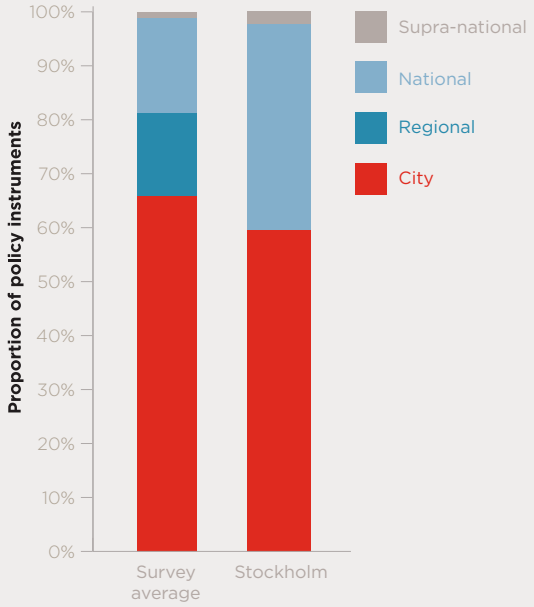
This table shows the waste policy instruments reported to be used by (a) cities in the LSE Cities global transport sector survey, and (b) in Stockholm. Column (a) shows the number of cities that report using the policy instrument out of the 30 cities that responded to the global waste survey. Column (b) shows the level of government administering the policy instruments that impact on Stockholm's waste sector.

Policy	Number of cities	City	County	National
Ensuring or supporting waste collection (e.g. clearing trash from areas, bins)	31	●		●
Ensuring or supporting collection of recyclable material	31	●		●
Ensuring or supporting organic waste composting	31	●		●
Ensuring or supporting separation of residential wastes	31	●		●
Ensuring or supporting community recycling drop-off sites, especially at the local landfill	29	●		●
Regulation on quantity/toxicity of waste	29	●		●
Pricing (e.g. user charges, volumetric waste charging)	28	●		●
Supporting education programs (e.g. home compositing)	28	●		
Regulation on trans-boundary movements of wastes and disposal (solid)	27			●
Ensuring or supporting waste to energy	27	●		●
Procurement policies for quantity/toxicity reduction and recyclability	26	●		●
Ensuring or supporting separation of industrial wastes	26	●		●
Formalizing waste collection in informal communities	24	●		
Site planning for waste disposal	24			●
Regulation on separation of wastes at site	24	●		●
Ensuring or supporting establishment of reusable and salvageable goods exchange	23	●		
Providing composting facilities within council operations (e.g. around canteen or kitchens)	18	●		
Tax on unsustainable waste production	11			●
Tax breaks to companies that recycle wastes or use recycled products	10	●		
Feed-in tariffs on recycling	8	●		●
Feed-in tariffs on composting	8	●		

5.5.4 Governance and policy coordination

Both city and national-level governments play important roles in developing waste sector policy. National-level government has a greater level of responsibility in Stockholm than average, when compared across the global sample of surveyed cities (see Figure 5.4).

Figure 5.4 Levels of government responsibility for waste policies



Results from the LSE Cities Going Green global survey.

Most policy instruments involve both city and national-level governments. These include policies to ensure waste collection, support recycling and composting, waste pricing, support for waste-to-energy schemes and regulations on waste toxicity. The main policy instruments under the responsibility of the city authority are education programmes, support for re-usable goods exchanges, and feed-in tariffs for composting. The national government has responsibility for regulating cross-boundary movement of waste, site planning for waste disposal and taxing unsustainable waste production (Table 5.4). Strong national-level policies in the sector have helped drive best practice in the sector – particularly in reducing landfill and improving the re-use of waste for energy. However, the role of incineration and its links with the district heating system present a major strategic area for further consideration (discussed later in this chapter).

5.6 Future challenges and opportunities

Stockholm has been more successful than most cities in achieving green policy objectives. However, the city has set itself even more stretching goals for the future. In particular, Stockholm's long-term climate target – to become 'fossil fuel free' by 2050 is ambitious and has the potential to transform the city's economy. Meeting this target, and maintaining the city's position as a leader in environmental, energy and resource performance more generally, will require a number of major strategic policy decisions over the coming years.

The objective of this Report is not to provide recommendations on detailed policy choices for the future. However, this review does provide evidence for determining some of the alternative strategic pathways that exist, and that warrant further research if Stockholm's climate goals are to be met and their associated economic opportunities maximised.

In maintaining Stockholm's position as a green leader, two strategic areas are recommended for further policy consideration:

- energy for heating - including district heating, energy efficiency in buildings and waste incineration; and
- energy for transport – including public transport, clean vehicles and electro-mobility.

These cross-cutting areas emerge as particular challenges – and economic opportunities – from the analysis of policies across sectors. The areas also focus on measures where the City of Stockholm has considerable control over policy levers, though both will require coordination with other levels of government, particularly with regard to national energy policy.

The two strategic areas involve challenges cutting across multiple sectors. Addressing these challenges will require integrated thinking that considers inter-related impacts on energy and resource efficiency, carbon emissions and environmental quality. Furthermore, policy decisions in the next few years will determine the long-term pathways to achieving these goals. These pathways are examined in the following sections and summarised in Table 5.5. The public transport component of energy for transport is discussed in detail in Chapter 6.

Table 5.5 Low carbon, energy and resources: Strategic policy pathways

Strategic policy area	Green challenges	Long-term pathways
Energy for heating	Low carbon: removing fossil fuels from district heating Resource effectiveness: maximising resource opportunities of waste management	1. Replace waste with biofuels / other renewables 2. Remove plastics from waste incineration 3. Carbon capture and storage 4. Carbon offsetting 5. Abandon district heating
Energy for transport	Low carbon: removing fossil fuels from vehicles Environmental quality: reducing air pollution from vehicles	1. Sustainable transport modes 2. Biofuels 3. Electro-mobility and grid decarbonisation 4. Vehicle technology mix

5.6.1 Energy for heating: district heating, buildings and waste

Stockholm faces some major challenges in meeting its targets for building energy efficiency – including the latest ambitious energy standard of 55kWh/m² for new city buildings. Past attempts at meeting less stringent energy use targets for buildings in Stockholm have proved difficult to achieve, most notably at the Hammarby eco-district demonstration development.

While the energy standard for new city buildings will be useful in demonstrating the potential for high levels of energy performance in the sector, the longer term challenge involves retrofitting existing building stock. The *Environment Programme* states that achieving the city's 2015 carbon target will require energy savings of 5% across all buildings in Stockholm. Further savings in this sector will be required for continued carbon reductions beyond 2015. Achieving continued reductions means an important role for retrofitting, and this presents a strategic area for further consideration by the city.

Current targets in this sector focus on publicly-owned buildings where the City of Stockholm has the most direct control. However, achieving longer term energy and low-carbon goals will require an extension of policy measures to increase the efficiency of privately-owned buildings. This will require strong policy coordination with the national government.

However successful Stockholm's energy efficiency policies are in the future, decarbonising the energy supply for heating buildings will remain a major challenge. Stockholm's district heating already provides green benefits to the city. The city authority has steadily reduced carbon-emitting fossil fuels from the energy sources fuelling the system. The city has also integrated district heating with its approach to waste management. With most waste incinerated and supplying energy for heating, waste to landfill rates are now very low compared to other cities in the EU, while waste is being re-used as an energy resource.

Despite these benefits, challenges remain within the current configuration of the city's district heating and waste incineration system. Fossil fuels still comprise 10 - 20% of the district heating mix (based on data from the three years 2010 – 2012 and depending on variable heat demand). Carbon emissions are also associated with the waste fuel component (24% of the fuel mix in 2012) – specifically from burning waste plastics. Consequently, although the fuel mix for district heating has improved substantially since the 1980s, heating still contributes almost 50% of the city's total carbon emissions (see Chapter 4). Removing fossil fuels from district heating (including some components of waste fuel) should therefore be a major priority for Stockholm if the city is to meet its fossil fuel free ambitions for 2050.

From a resource effectiveness perspective, there are opportunities to use waste resources by prioritising recycling and composting over incineration, and furthermore to reduce total waste volumes. Implementing these resource effectiveness measures would limit the availability of waste as a fuel source for district heating and would require alternative renewable fuel sources.

This inter-related system of district heating and waste incineration will require reform and careful policy attention to ensure Stockholm achieves both continued carbon reductions and more effective use of resources. All the strategic pathways available for reform, set out in the following sections, present considerable challenges. All assume decarbonisation of the electricity grid through national policy measures.

Pathway 1. One strategic route to eliminating fossil fuels in the district heating system is to **switch entirely from coal and waste incineration to biofuels or other renewable energy sources**. Steps along this path are already planned, with the fuel switch at the Vartan power plant scheduled to be implemented by 2015. This measure alone accounts for around 50% of total carbon reductions forecast between 2010 and 2015 in the *Carbon Action Plan*. At this stage it is not considered economically viable to make a complete switch to biofuels, and the plant will continue to rely on coal for 30% of its fuel (City of Stockholm 2012m). However, over the long term, a complete switch to biofuels may be considered – not only from coal but also from waste incineration that currently includes carbon emitting plastics.

While expanding the use of biofuels is a feasible strategic pathway, this shift requires consideration not only of the direct economic costs and benefits, but also of wider sustainability and energy security aspects of biofuel supply. Current use of biofuels for district heating is

dominated by local Swedish wood sources. However, a proportion of fuel is also imported. Consideration of the long-term supply of local biofuels would need to be included when assessing this option.

Shifting waste treatment strategies towards a regime that prioritised reducing waste generation from currently high levels and maximising recycling and composting rates may have significant implications for the amount of waste available for incineration and district heating. In moving away from incineration there are a number of inter-related issues that would need examination (see Box 5.5). However, based on Stockholm's high levels of overall waste generation, and relatively low recycling and composting rates it seems unlikely that increasing heat energy supply from incineration would be an option. Indeed a more sustainable approach may involve incinerating substantially lower levels of waste, prompting the need to look for alternative fuel sources for district heating.

Box 5.5 Waste incineration

Incineration of municipal solid waste is debated as a sustainable waste management disposal option. Recent advances in energy recovery have increased its acceptance and countries such as the UK and USA that had previously avoided incineration are now beginning to explore its potential.

Arguments in favour of incineration

- New incineration facilities with energy recovery have dramatically lower levels of harmful air emissions and associated health impacts than older technologies.
- Incineration reduces the amount of waste going to landfill by up to 90%, avoiding methane emissions that traditionally represent the largest share of greenhouse gas emissions produced by the waste sector.
- Energy recovery from incineration reduces the need to generate energy in other ways, which can help reduce dependence on fossil fuels.
- High costs of construction and operation can be offset through the sale of the energy produced and by optimising the size and location of incineration facilities.

Arguments against incineration

- Although new air emissions control technologies and more stringent emissions regulations have reduced the health risks from incineration, there are still concerns about potential long-term health effects from fine particle emissions of dioxides and heavy metals.
- The construction and operation of state-of-the-art incinerators with waste-to-energy capability is costly and may compete with investments in other waste management options such as recycling and composting, which should be prioritised according to the waste hierarchy.
- Waste-to-energy plants may also undermine recycling efforts due to the need for sustained volumes of waste to maintain electricity supply. Low recycling rates increase the need to manufacture new goods, which leads to increased energy and resource use.
- If plastics are a major component of waste energy, this could risk an increased dependence on fossil fuels to produce more plastic, leading to increased greenhouse gas emissions. This means that incineration could prevent the achievement of zero carbon goals.

Sources: Consonni, Giugliano et al. 2005; Global Alliance for Incinerator Alternatives 2012; Grosso, Motta et al. 2010; Health Protection Scotland 2009; Morris 2005; World Health Organization 2007

Pathway 2. A mixed waste and biofuels approach is an alternative option to eliminating waste incineration from the district heating system entirely. Under this pathway, carbon emitting plastics would be phased out of the waste incineration process through policies for reducing and recycling plastic waste. Organic waste could also be phased out through composting to improve resource efficiency. Considerations when examining this pathway would include the energy potential of remaining waste in the incineration process, resource effectiveness of maintaining demand for the remaining waste in the district heating system, and the economic costs of waste separation.

Pathway 3. Carbon capture and storage (CCS) of emissions from combined heat and power and waste incineration plants is another potential pathway. Under this option, carbon emissions would be eliminated without the need for total fuel switching to biofuels or other renewable energy sources. Carbon capture and storage is in its infancy, and the effectiveness of the technology is largely unproven. Furthermore, policy programmes in this area usually exist at the national, rather than city level. However, this may be an area for an innovative, forward-looking city to examine further. Other considerations include the fact that CCS would not address the resource effectiveness challenges associated with demand for waste in incineration.

Pathway 4. Carbon offsetting could be used to trade the emissions produced by the district heating system with reductions in emissions in other sectors, regions or countries in a global carbon market. With a fossil fuel free target, the city would need to trade its emissions with carbon polluters outside the city.

Pathway 5. Finally, the city could **replace the district heating system** entirely with a combination of electric heating (such as air sourced heat pumps) and micro-renewables on buildings. This option is unlikely, even in the long term. It would mean abandoning substantial infrastructural investment, including major assets such as the underground pipe networks. Such a scenario would be pursued only if the substantial investment loss were outweighed by even higher costs of pathways 1, 2, 3 or 4. Furthermore, the district heating system is an important part of Stockholm's green innovation image, which could be damaged if the system were abandoned.

5.6.2 Energy for transport: clean vehicles and electro-mobility

Stockholm has a sophisticated green transport strategy in place. The city has an excellent multi-modal public transport system, much of which is electrified. It uses innovative policy instruments including congestion charging to manage transport deman. The city's highly accessible urban form further supports public transport, walking and cycling, and results in transport-sector carbon emissions that are substantially lower than in most other advanced economies (see Chapter 6).

Nonetheless, despite the city's success in greening transport, the sector remains responsible for almost 40% of total emissions in the city (see Chapter 4). This is mainly due to continued dependence on oil for freight and private vehicle use. Vehicles are also the main source of air pollutants, contributing to Stockholm's PM10 levels remaining above WHO standards.

Despite relatively high rates of public transport use, vehicles still comprise more than 50% of passenger kilometres travelled, while fossil-fuel based taxis and buses make up an additional 10% of passenger travel (Chapter 6). Vehicle energy efficiency has improved, and in Stockholm efficiency improvements have been supported by the city's clean vehicles programme (see Appendix 1). However, steering a pathway that eliminates carbon emissions from the transport sector by 2050 will require major additional policy intervention in the coming years.

In meeting Stockholm's fossil fuel free ambition and improving air quality, cleaner vehicles will be an essential part of a reformed transport sector. Increased public transport, walking and cycling, as well as accessible land-use planning, will also play central roles in greening the sector (see Chapter 6).

The city's past experience with its Clean Vehicle Programme highlights challenges in establishing a market for emerging vehicle technologies (see Appendix 1). Consumer willingness to adopt new technologies is central to increasing uptake of clean vehicles, and high upfront vehicle costs remain a significant barrier. At the same time, clean vehicle technologies require broader infrastructural systems to operate. For instance, electric vehicle charging infrastructure or biofuel distribution networks are an essential pre-condition for establishing an integrated clean vehicle system and ensuring consumer confidence for embracing new technologies.

Stockholm faces a number of policy options in further pursuing its clean vehicle goals. At the strategic level, there are choices to be made about the policy priority given to promoting clean vehicles in relation to other transport and land-use policy programmes. In reducing carbon emissions and air pollution from the sector, alternative strategies focused on reducing personal vehicle travel or shifting travel to more sustainable modes may be more cost-effective than measures such as subsidies to promote clean vehicle purchases.

The city's *Climate Action Plan* notes that measures to promote electric vehicles are a high-cost method for reducing carbon emissions (City of Stockholm 2012m). At the same time, policies to promote clean vehicles may conflict with goals for shifting travel away from private vehicles and towards public transport, walking and cycling. This highlights the trade-offs and potential conflicts that need to be considered in allocating public resources to a mix of transport sector measures.

Pathway 1. Investing in sustainable transport modes is one potential option for Stockholm. Under this pathway, the city authority would not need to "pick a technology winner" but undertake land-use planning and investment in measures that increase accessibility and shift travellers away from private vehicles to more sustainable transit modes such as walking, cycling and public transport.

This option is potentially more effective, efficient and equitable at reducing carbon emissions. However, given Stockholm's target of eliminating carbon emissions entirely this pathway, though necessary to reduce energy demand, would not be sufficient, as eliminating private vehicle ownership in the next 40 years is unlikely. Consequently this pathway, if chosen, should represent one part of a long-term zero carbon transport strategy.

Pathway 2. Alongside more sustainable transport modes, **actively incentivising biofuels** for vehicles could potentially eliminate carbon emissions from the transport sector. The socio-economic costs and benefits of incentivising biofuels would need to be balanced against other technologies such as electric and hydrogen vehicles. An assessment would need to include the sustainability of global supply chains, including biodiversity, ecological impacts and energy security considerations associated with imported biofuels. Biofuels for transport are currently dominated by imports from Brazil, raising questions about ecological sustainability and the emissions produced from shipping the fuels globally.

Pathway 3. Actively incentivising **electric vehicles** would need to consider not only the direct socio-economic impacts compared to biofuels or other technologies such as hydrogen, but also the substantially increased demand on the national electricity grid (an energy effectiveness challenge), at the same time relying on the national government to decarbonise the electricity supply. Public private partnerships could be examined as a means of financing the electric charging infrastructure.

Pathway 4. Finally, the city could opt for a **vehicle technology mix**. One of the challenges for policy makers when designing incentives for the uptake of new vehicle technologies is the problem of "picking winners". In a well-functioning market, interventions to incentivise one technology over another prevent the market from determining the most efficient and effective technology through consumer preferences. However, the clean vehicle market is hindered by a considerable market failure – the need for infrastructure such as biofuel stations or electric charging points and associated grids (see Appendix 1).

One option would be to avoid picking a winner and invest in all potential vehicle technologies and their associated infrastructure. However, this would require substantial public investment. Not only would public funds be required for investment in more than one technology at sufficient scale to ensure uptake, the increased uncertainty around which technologies would fail could lead to the need for larger public investment to offset the higher risk to the private sector.

Regardless of the clean vehicle technology prioritised, there are further options concerning the type of policy instruments used to incentivise consumer uptake. The city has already made use of a broad range of instruments, including subsidies for private vehicle purchases, public investment in infrastructure and city procurement policies (see Appendix 1). Berlin and London offer examples of other instruments used for promoting electric vehicles (see Box 5.6). Berlin's experience suggests there may be opportunities in integrating clean vehicle technologies with broader developments in new mobility, including car sharing and integration with public transport networks.

Box 5.6 Berlin and London: leading the charge on electric mobility

Electric vehicle technology has made significant strides in recent years, making electric mobility an increasingly attractive prospect for cities trying to green their transport systems. Berlin and London provide two instructive case studies of cities that have pioneered electric mobility using distinct approaches and policy instruments.

Berlin

Policy Programme

- Berlin's electric mobility programme focused primarily on new urban mobility to decarbonise transport system, charging and parking infrastructure, and electricity storage systems
- Private sector investment plays major role, with city government acting primarily as facilitator
- US$60m from national government as part of part of National Development Plan for Electric Mobility
- Target: introduce 15,000 electric vehicles and install 3700 charge points by 2015

Impact

- More than 500 electric vehicles registered in the city and 220 public charging stations installed, supplying 100% certified renewable energy
- Introduction of fully electric car sharing programme, run by Citroën in collaboration with Deutsche Bahn, to provide up to 500 electric cars by end of 2013
- Berlin established as international innovation centre for electric mobility, cutting across universities, research centres and private sector
- Challenges remain in scaling up use of electric vehicles and establishing integrated public charging infrastructure that will increase the public acceptance of electric vehicles

London

Policy Programme

- Mayor's Electric Vehicle Delivery Plan at heart of London's programme, focused primarily on developing charging infrastructure through public private partnerships and public procurement of electric vehicles
- National support through electric vehicle subsidies, tax exemptions and funding for infrastructure; free parking and charging creates additional incentive at borough level within London
- Target: introduce 1,000 electric vehicles into the city's public fleet by 2015, install 25,000 public charge points and have 100,000 electric vehicles on London roads 'as soon as possible'

Impact

- 100% discount on congestion charge increased early adoption of electric vehicles: 2,300 electric vehicles currently registered in the city, more than most other cities in the world
- 745 charge points in Source London network, thanks to public private partnership with Siemens; 1300 charging points anticipated by end of 2013
- Establishment of knowledge-sharing consortium of organisations that already use electric vehicles in their fleets has helped increase uptake of commercial electric vehicles
- London positioned as attractive test bed for electric mobility but targets remain ambitious and limited integration of electric mobility policy with renewable energy strategies remains problematic

Sources: Berlin Agency for Electromobility 2011; Berlin Government 2012; German Government 2009; IEA 2012b; InnoZ 2012; Mayor of London 2009; Office for Low Emission Vehicles 2012; Source London 2012

Public transport and urban form

Stockholm has invested in high quality public transport networks over many decades, starting with the construction of the metro in the 1950s. For a city of its size, Stockholm has a very well developed metro network which greatly improves connectivity between the inner city and the suburbs. This provides a substantial accessibility advantage to comparable cities that have not made this investment and has enabled a high level of integration between public transport and urban land uses.

Photo credit: Yanan Li

6 Urban form, transport and accessibility

Key messages

Stockholm has a well-structured policy strategy for environmental performance and low carbon, underpinned by an extensive range of policy instruments.

Stockholm's relatively compact form has a range of benefits for the green economy. These include low-cost, low-carbon and resource efficient passenger and goods transport facilitating agglomeration economies, job matching, larger labour pools, knowledge spill overs and firm clustering.

Public transport accessibility - measured by walking distance to public transport stations - is exceptionally high for both workplaces and residents in Stockholm. Accessibility levels are close to those in Hong Kong - a global leader.

Stockholm profits from strong agglomeration advantages and labour accessibility with peak values of 440,000 economically active people that can be reached within 30 minutes - compared to, for example, 365,000 in Copenhagen.

Travel time efficiency in Stockholm appears to be limited by multiple factors. For example, the city displays a certain degree of segregation of work-places and living for some urban centres that facilitates clustering but compromises proximity. For the metro region, theoretical time costs for commuting are 5.8% of Stockholm's GDP compared to 3.4% in Copenhagen and 8.4 % in London.

The City of Stockholm has a mature policy programme to reduce urban sprawl including higher density and brownfield-oriented developments. Land use policy is well integrated with public transport infrastructure (predominantly rail and metro) and sustainable transport policies (congestion charging, parking fees, promotion of cycling and walking).

Stockholm features low levels of cycling and bus travel. Furthermore, car use continues to dominate, both in terms of total number of trips and kilometres travelled. The overall average distance travelled in Stockholm is significantly higher than in Copenhagen and this contributes to higher levels of transport related energy demand.

There is great potential to focus more directly on strategies to reduce overall travel demand in Stockholm. Further strengthening the mix of land uses particularly for the redevelopment of employment nodes such as Norra Station and Värtan/Royal Seaport should be prioritised. Across the metropolitan region, the city could examine policies that enhance the integration of living with working while limiting the segregation of residential areas and locally isolated employment locations.

Stockholm could consider introducing further 'push' policies to reduce car ownership and car use by introducing car-free developments and additional restrictive measures. Related 'pull' policies could include the promotion of bus travel (BRT, bus lanes and bus corridors), further multi-modal integration, and a comprehensive cycle strategy.

Significant potential exists for the redistribution of public street space from private car use to public transport and walking with a focus on shifting travel patterns from private motorised to public or non-motorised travel.

As reviewed in Chapters 2 and 4, Stockholm's compact urban form is a key driver of the city's green economy, impacting through agglomeration economies, more efficient energy use and lower carbon emissions. This chapter analyses urban form in more detail. In particular, employment accessibility, travel time efficiency and transport sustainability are examined and benchmarked against relevant comparator cities in Europe.

The chapter analyses the range of impacts resulting from Stockholm's land-use and transport policies. These are considered in terms of urban form, local mix-of-uses, metropolitan

accessibility, agglomeration, travel time and environmental impacts. The effects of land use and transport policies are analysed in terms of travel opportunities for residents, employment accessibility for businesses, travel times for typical journeys and the overall city transport CO2 emissions. Empirical GIS-based analysis techniques are employed alongside evidence from city surveys.

To provide an international context for Stockholm's performance, direct comparisons are provided between Stockholm and Copenhagen, a successful green city of similar scale, and between Stockholm and London. Although London is a much larger city, it provides a useful benchmark for where Stockholm has advantages and disadvantages compared to larger global city competitors.

6.1 Land-use policy programme

6.1.1 Strategy and goals

Based on the urban form policies introduced in Chapter 4, Stockholm has two central planning documents, the *Regional Development Plan* and the *Stockholm City Plan*, that determine contemporary spatial development of the Stockholm Metropolitan Region. Both build on the legacy of spatial development that was initiated in the early 1950s.

The *Regional Development Plan* (Stockholm County Council 2010) establishes four goals to guide long-term urban development to 2050. The plan covers the broader region of 'Eastern Central Sweden' and focuses on how planning the physical structure of the region can contribute to economic, environmental and social sustainability.

The plan was adopted by the Stockholm County Council in 2010, and has formal status as regional development plan under the Swedish Planning and Building Act. The plan incorporates green land-use planning and transport goals including "a resource efficient and accessible settlement structure". This involves promoting dense towns concentrated around public transport nodes and the preservation of 'green wedges'. The plan identifies four high-level goals:

- an open and accessible region;
- a leading growth region;
- a region with a good living environment; and
- a resource-efficient region.

The plan seeks to integrate both 'green' and economic objectives using principles of sustainability that include social, economic and environmental considerations. For instance, the plan mentions an efficient spatial structure for low carbon emissions, accessible transport for social inclusion and good conditions for business and innovation.

The *Stockholm City Plan* (City of Stockholm 2010b) is a spatial development strategy for Stockholm City - the centre of the broader metropolitan region. It was adopted by the Stockholm City Council in 2010. It outlines four long-term urban development strategies that aim to contribute to achieving *Vision 2030*:

- continue to strengthen central Stockholm;
- focus on strategic nodes;
- connect city areas; and
- create a vibrant urban environment.

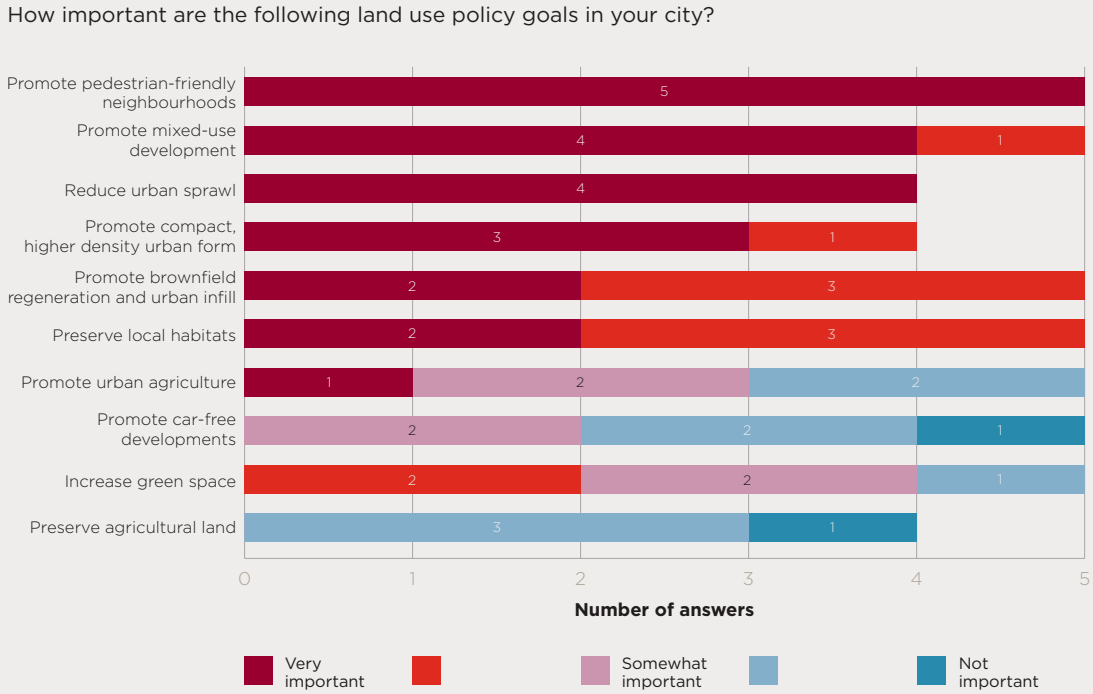
The plan identifies nine policy focus areas that are central to land-use and transport planning. Strategic nodes include major areas of redevelopment, such as the eco-districts, major employment centres, and transport nodes.

Similar to the *Regional Development Plan*, the *Stockholm City Plan* uses a broadly 'green' approach to land-use and transport policy, focusing on intensifying existing urban centres and connecting centres with environmentally efficient public transport.

A strategic approach to land-use planning is outlined in the *Stockholm City Plan*, and the *Regional Development Plan*. Both policy documents seek an accessible and efficient urban form based around intensification of development around public transport nodes. Policy also aims to minimise new development on existing 'green wedges', protecting the city's green and blue structure for recreation, biodiversity and ecosystem services. The city's *Environment Programme* has a number of land-use targets involving minimising urban expansion, particularly into land and water areas of special significance for biodiversity and recreation.

Figure 6.1 summarises local experts' views on the level of importance of land-use policy goals in Stockholm. Local experts all agreed that the overarching approach to land-use planning in Stockholm is based on a dual strategy involving densification of existing built-up land and expansion based on smart-growth principles – including higher density and orientation around pedestrian neighbourhoods and public transport nodes. The idea of some expansion of the existing built-up area was generally agreed to be part of the city's overall strategy. The preservation of agricultural land was not considered significant, although the avoidance of sprawl and preservation of local habitats were judged to be important policies. Car-free developments were not considered part of Stockholm's strategy.

Figure 6.1 Importance of land use policy goals in Stockholm



Results from Stockholm responses to the LSE Cities Going Green global survey.

Land-use policy goals and outcomes are closely connected with the transport sector. Consequently, survey results on the importance of transport policies are also outlined here in Figure 6.2. Transport policy priorities are closely aligned with land-use, compact city and sustainability goals. All experts consistently agreed on the importance of reducing transport CO_2 emissions, encouraging the use of walking, cycling and public transport, and reducing road congestion. There was also agreement on the importance of low emission vehicles. There was however much less agreement on the importance of reducing private vehicle use and particularly reducing car ownership. This is consistent with the low priority given to car-free developments in the land-use policy survey. Such demand management measures are considered important aspects of reducing transport environmental impacts in comparable cities to Stockholm.

Figure 6.2 Importance of transport policy goals in Stockholm

Results from Stockholm responses to the LSE Cities Going Green global survey.

6.1.2 Policy instruments

The City of Stockholm uses a comprehensive range of policy instruments to achieve its land-use objectives (Table 6.1). All the most commonly implemented land-use policy instruments have been adopted in Stockholm, including regulations for increasing density, ensuring mixed-use development, and investing in parks and green spaces. A number of less frequently used instruments are also employed, such as low emission zoning and support for urban manufacturing. In total, 15 out of 16 land-use instruments surveyed are used by the City of Stockholm. The overwhelming majority of land-use policies are at city level, with support at the national level for density standards and eco-district investment. Regional level policies are less numerous and focus on metropolitan planning issues such as growth boundaries and integrated metropolitan transport.

Table 6.1 Policy instruments in the land use sector

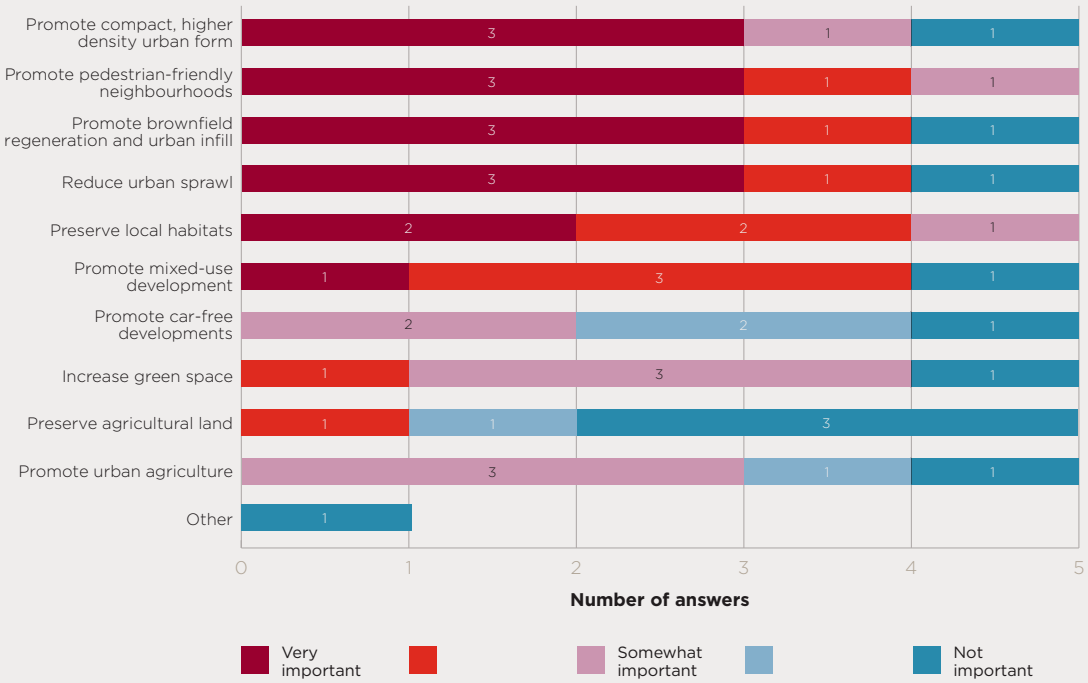
This table shows the land use policy instruments reported to be used by (a) cities in the LSE Cities global land use sector survey, and (b) in Stockholm. Column (a) shows the number of cities that report using the policy instrument in the global land use survey. Column (b) shows the level of government administering the policy instruments that impact on Stockholm's land use.

Policy	(a) No. of cities using policy instrument	(b) Stockholm policy instruments administered at city, county and national levels		
		Stockholm City	Stockholm County	Sweden
Increased development density standards or regulations	20	●	●	●
Regulations supporting mixed-use development	20	●		
Investment in parks and green spaces	19	●		
Metropolitan-wide integrated transport and land-use plan	19	●	●	●
Green space requirements in development standards and regulations	18	●		
Support of independent, small scale retailers	15	●		
Public subsidies for environmental remediation of brownfield sites	13	●		●
Urban growth boundaries/greenbelt	13	●	●	●
Plot size restrictions	13	●		
Investing in habitat creation	13	●		●
Public investment in eco-city demonstration projects	12	●		●
Support of urban manufacturing	11	●		
Zero-carbon/low emission development zoning	9	●		
Pricing ecosystem services	6			

Local experts were further surveyed on how successful they considered land-use and transport policies to have been in Stockholm. The results for land-use policy are presented in Figure 6.3. Overall, compact city policies of increasing urban densities, brownfield regeneration, promoting pedestrian neighbourhoods and reducing sprawl were judged to be very successful. Increasing mixed-use development, green space and preserving local habitats were also, in the main, successful. There are however several land-use policy aspects with limited or no success. Car-free development policies were unsuccessful, following their low priority in Stockholm's policy framework. Increasing green space and preserving agricultural land were of limited success, reflecting both the generous existing provision of green space in Stockholm and the land-use demands of Stockholm's expanding urban form.

Figure 6.3 Success of land use policy goals in Stockholm

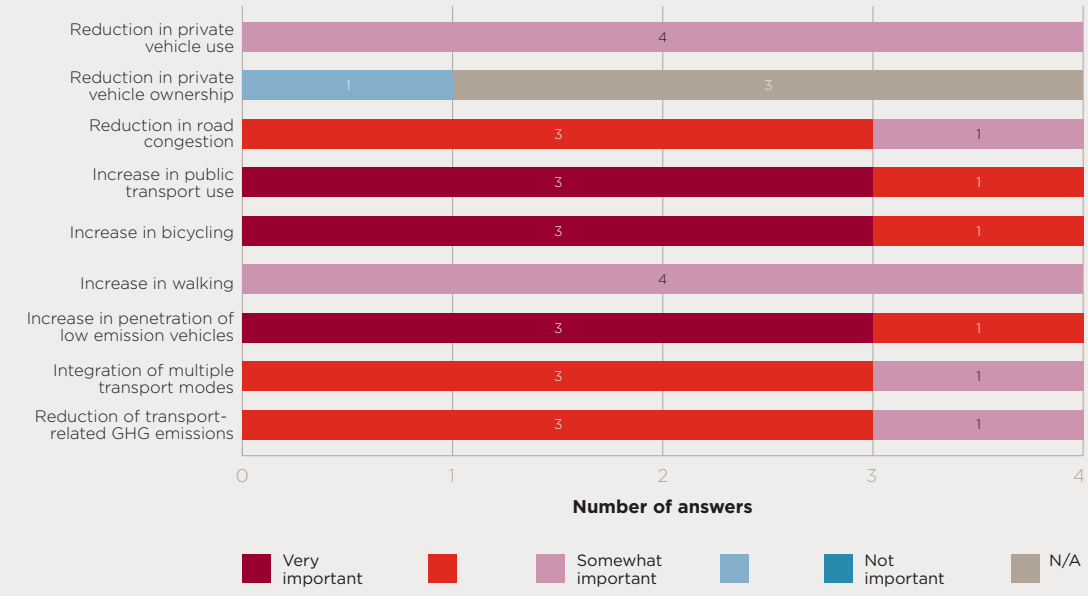
How successful have these land use policies been in your city?



Results from Stockholm responses to the LSE Cities Going Green global survey.

Figure 6.4 Success of transport policy goals in Stockholm

How successful are the following transport policy goals in your city?



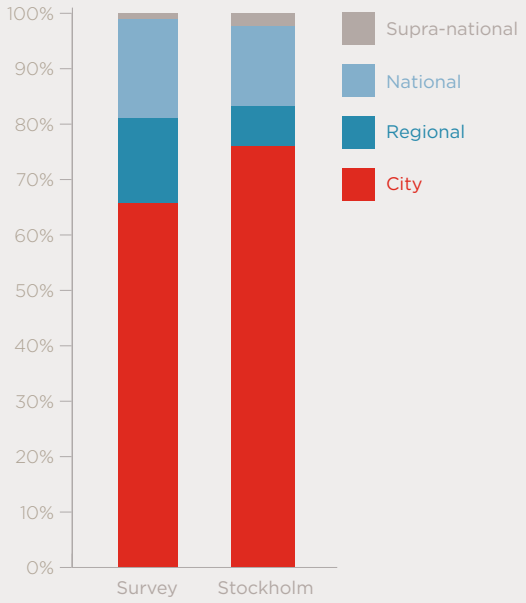
Results from Stockholm responses to the LSE Cities Going Green global survey.

Similar to the land-use survey results, local experts were more varied in their judgements regarding the success of transport policies (Figure 6.4). Increases in public transport use, cycling and the penetration of low emission vehicles were all considered to be strong successes. The integration of transport modes and reduction in GHG emissions from transport were also judged to be successful. Related to policy priorities, reductions in private vehicle use were considered only moderately successful, while reductions in private vehicle ownership were unsuccessful. Increases in walking were considered moderately successful, though this is likely to be related to the established high walking rates in Stockholm (discussed further in Section 6.2.6).

6.1.3 Governance and policy coordination

Urban land use is an area where policy powers are often held by the city authority (Figure 6.5). In Stockholm, the city authority has particularly high levels of responsibility in this area, being responsible for around 75% of land use policy instruments (compared to around 65% for the average city in the global survey). The second most important policy level is the national government, suggesting that the most important policy coordination lies between city and national levels for land-use planning.

Figure 6.5 Levels of government responsibility for green land use policies



Results from Stockholm responses to the LSE Cities Going Green global survey.

The main policy instruments under the responsibility of the city authority are regulations on mixed-use development, green space requirements and support for small-scale, independent retailers. Other key policy instruments such as density regulations, integrated transport and land-use planning, and urban growth boundaries involve multiple levels of government – across city, regional and national levels.

6.2 Impacts

6.2.1 Urban form: the distribution of living and working

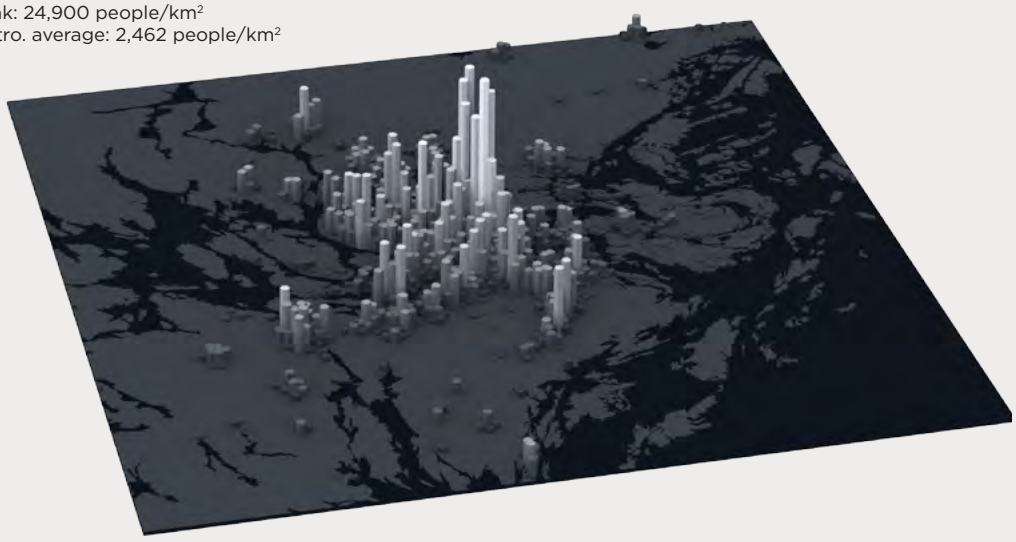
Density is a fundamental measure of urban structure. Higher urban density districts with mixed-use functions can facilitate more efficient travel patterns, and this translates into both productivity and environmental advantages as discussed in Chapter 4. Higher densities are associated with economic agglomeration benefits, with improved access to labour markets and close proximity between businesses and customers. The advantages of higher densities depend on high-quality urban design and effective city management to minimise negative impacts of overcrowding and pollution.

The residential population density of Stockholm on a 1 kilometre square grid is shown in Figure 6.6. The compact city structure is clearly evident, with Stockholm showing a high density centre, peaking at 24,900 residents per km², and a medium density inner city. Also evident in the wider metropolitan region is the degree to which development has been directed towards linear public transport corridors. Copenhagen has a very similar metropolitan structure, both in terms of its pattern of linear public transport corridors, and in the similar peak and average density characteristics (Figure 6.6). London is a much larger city and metropolitan area. London's peak residential density is only moderately higher than Stockholm, but average metropolitan densities are nearly twice as high, related to the larger population and many commuter towns in London's metropolitan region.

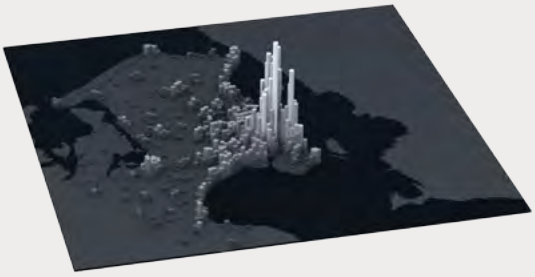
In addition to describing residential densities, employment densities provide a complementary perspective linking urban form to business location patterns. As well as relating to historic urban form and land-use policies, employment densities result from the economic structure and specialisations of particular cities. Agglomeration benefits can accrue from business clustering to share knowledge, labour markets and customers. As a result, the geography of employment is generally much higher density than residential patterns.

Figure 6.6 Residential population density maps for Stockholm, Copenhagen and London

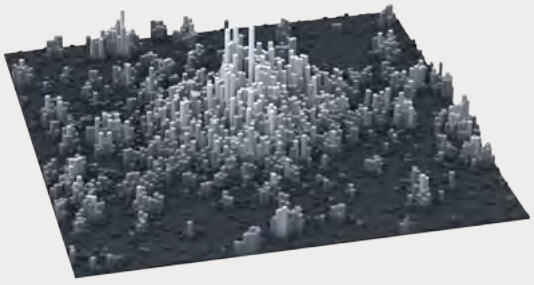
STOCKHOLM
Residential population density
Peak: 24,900 people/km²
Metro. average: 2,462 people/km²



COPENHAGEN
Residential pop. density
Peak: 24,050 people/km²
Metro. average: 2,814 people/km²



LONDON
Residential population density
Peak: 27,100 people/km²
Metro. average: 4,275 people/km²

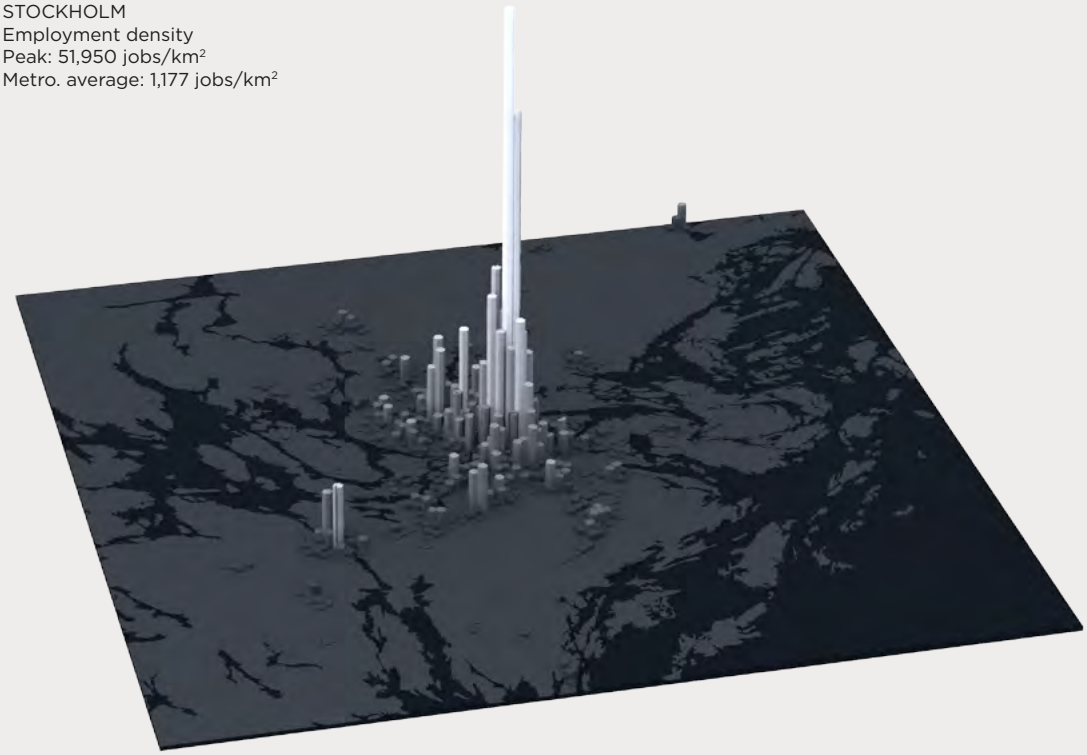


LSE Cities graphic based on the following sources: Office for National Statistics 2012; Statistics Denmark 2009; Statistics Sweden 2011b

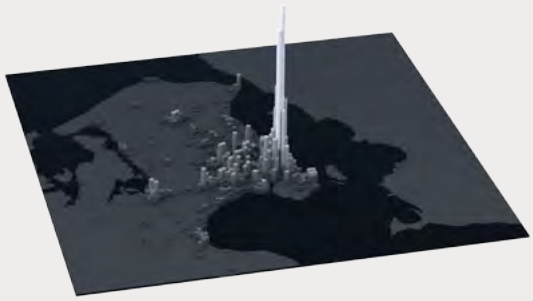
Figure 6.7 shows that Stockholm has a high density central cluster, peaking at just under 52,000 jobs/km^2. There are also several moderately high density employment sub-centres in the city outskirts, particularly to the north in locations such as Kista. The peak employment density in Stockholm is nearly 12,000 jobs/km^2 higher than the peak density in Copenhagen. This indicates that employment accessibility is higher in Central Stockholm and this pattern is likely to result from the existence of stronger agglomeration economies in Stockholm. The London example on the other hand provides a different context of extreme employment clustering in a very large international city. Here employment densities reach more than two-and-a-half times the level of Stockholm, with correspondingly higher employment accessibility and subsequently high office rents.

Figure 6.7 Employment density maps for Stockholm, Copenhagen and London.

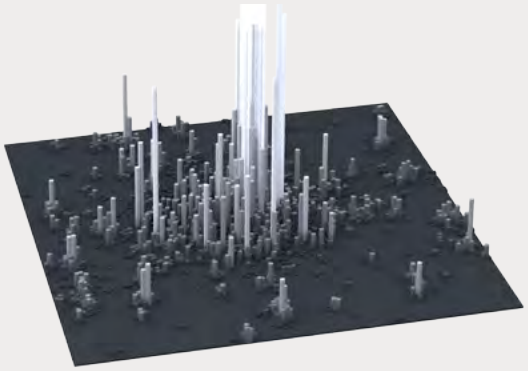
STOCKHOLM
Employment density
Peak: 51,950 jobs/km^2
Metro. average: 1,177 jobs/km^2



COPENHAGEN
Employment density
Peak: 40,100 people/km^2
Metro. average: 1,555 jobs/km^2



LONDON
Employment density
Peak: 141,600 people/km^2
Metro. average: 2,125 jobs/km^2



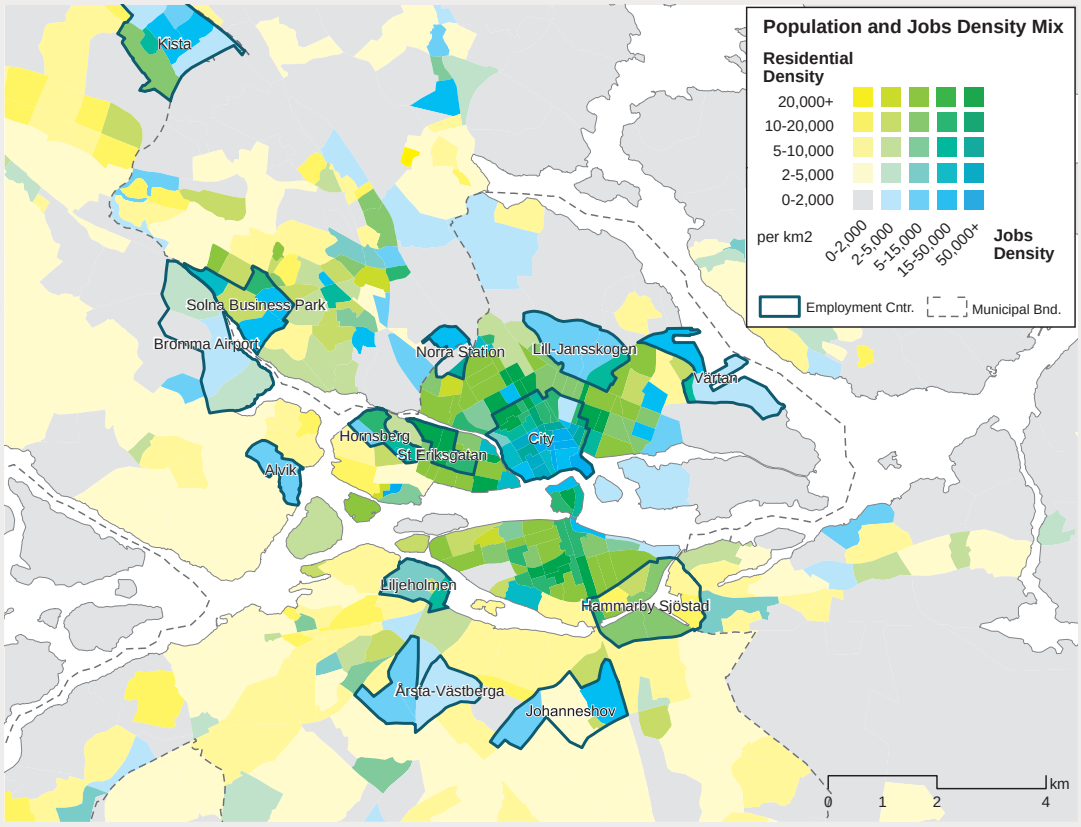
LSE Cities graphic based on the following sources: Office for National Statistics 2012; Statistics Denmark 2009; Statistics Sweden 2011b

6.2.2 Mix-of-uses and local accessibility

Shorter distance and more sustainable travel patterns can be facilitated through local mixed-use urban forms that closely integrate workplaces, shops and other services close to home locations. These land-use patterns can greatly improve opportunities for walking, cycling and shorter distance public transport trips. This section focuses in particular on the integration of residential areas with centres of employment.

A core method of analysing local mix-of-uses is to map residential population density and employment density together as shown for Stockholm in Figure 6.8. More intense green colours represent high density mixed-use areas. Stockholm's compact form translates into a dominantly mixed-use inner city, both in the city core and the neighbouring inner-city islands of Södermalm to the south and Kungsholmen to the west. Major employment centres are also highlighted in Figure 6.8. The City is by far the largest employment centre with over 100,000 jobs. It has relatively few internal residents, though it is surrounded by the densely populated inner city.

Figure 6.8 Stockholm population and employment density mix



LSE Cities graphic based on: Statistics Sweden 2011b.

In addition to the city centre of Stockholm, there are many more employment centres on the edge of the urban core and in the wider metropolitan region. While smaller in scale than the city centre (the largest Kista has just over 29,000 employees), these are growing centres and are more varied in their land-use patterns. Generally, centres close to the inner city have more diverse land uses and are integrated with residential areas, particularly centres to the west and the regeneration areas to the south of Hammarby Sjöstad and Liljeholmen. The centres to the north- Norra Station, Lill-Jansskogen and Värtan/Royal Seaport – are currently characterised by few residents and by their proximity to large unpopulated water and parkland areas. The land-use pattern for these northern centres limits opportunities for local travel and will potentially increase travel distances.

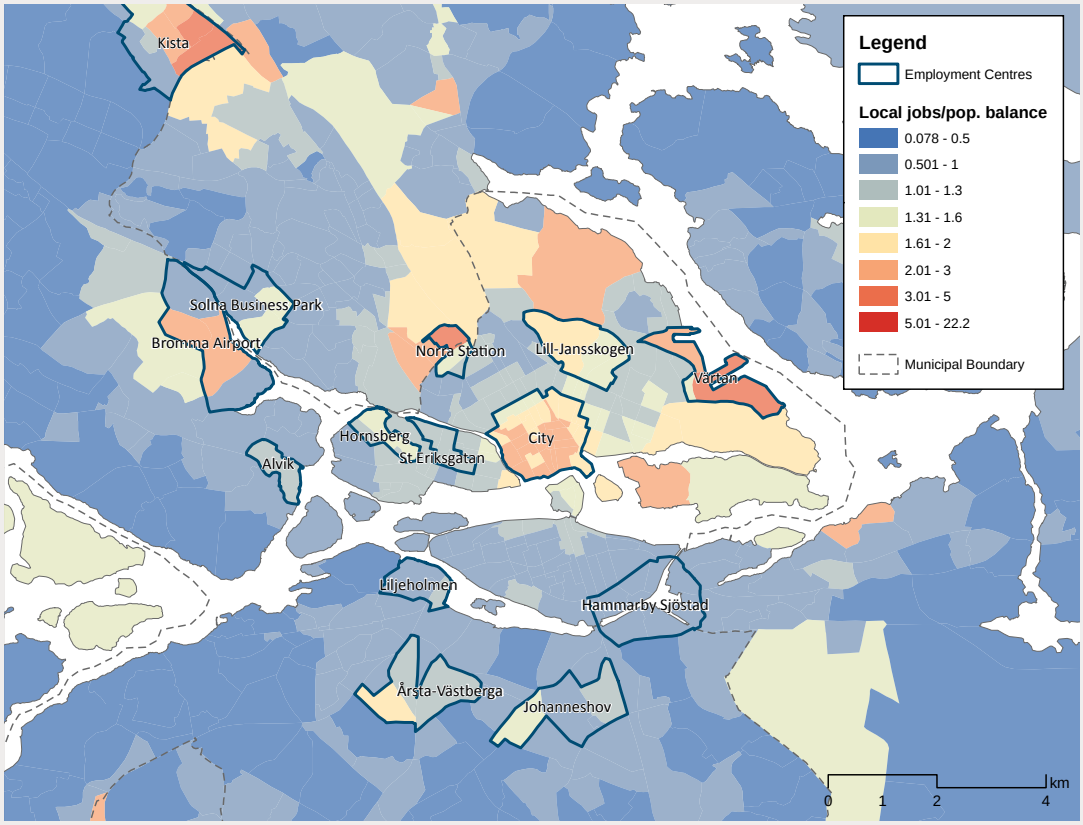
A complementary method of considering residential and workplace integration is to calculate a jobs-population balance indicator. This measure describes the degree to which jobs can be met by local residents through walking and public transport trips. For instance, an area with a jobs-population balance of 3 means that the total number of jobs is three times higher than the number of local residents who can access those jobs, and as a consequence longer distance travel will result. The indicator is mapped for Stockholm in Figure 6.9, where red colours show areas where

jobs exceed the number of local residents. A clear north-south division is evident for Stockholm, with fewer local residents to access jobs in northern centres. Värtan and Norra Station are both significant redevelopment areas undergoing major change. Clearly there is great potential to increase residential densities within and adjacent to these employment locations and increase the potential for shorter distance travel.

To examine how typical the jobs-population balance results are for Stockholm, the same indicator is mapped for Copenhagen in Figure 6.10. Copenhagen has several large peripheral employment centres, such as the airport, with extreme levels of jobs-population imbalance. Yet within the city centre and inner city there is generally a very high integration of workplaces and residents. This will increase the potential for local walking and cycling trips in Copenhagen.

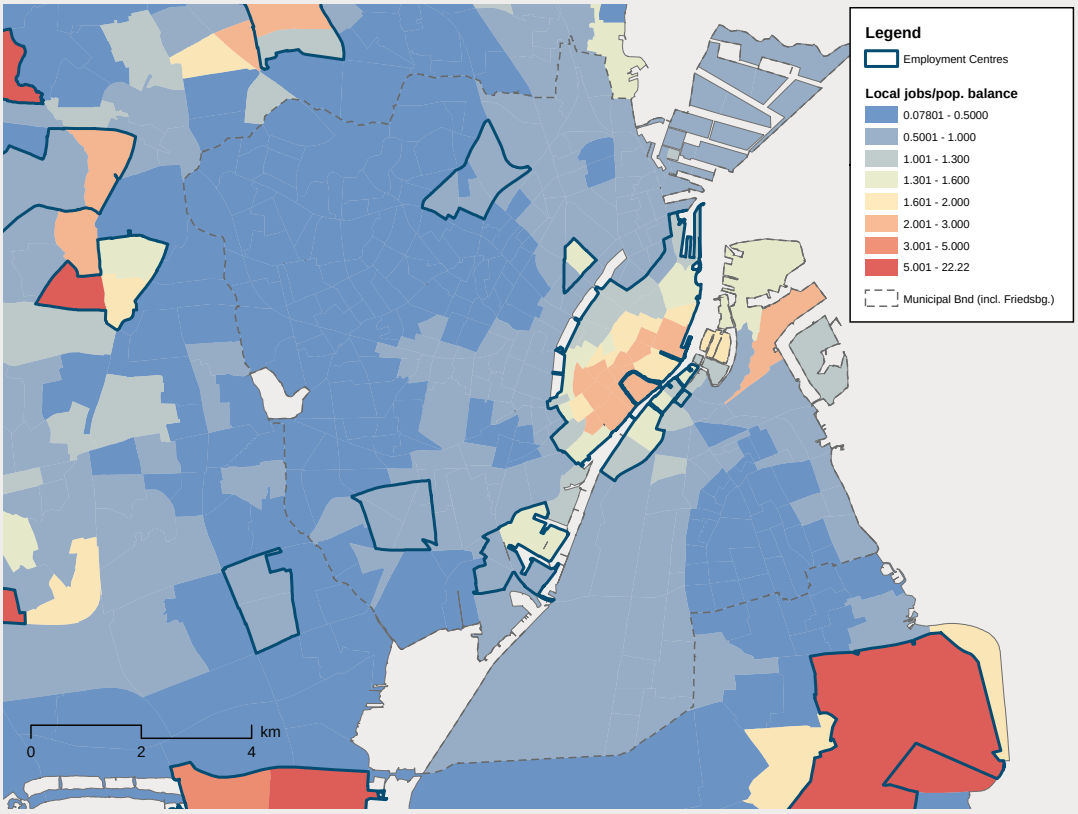
As the city centre is by far the largest employment centre in both Stockholm and Copenhagen, it is worth exploring in more detail. Stockholm has a high peak employment density in the city centre (described in the earlier urban form section), reflecting strong office market and agglomeration processes. This clustering has economic advantages, although it can increase travel distances, particularly if nearby residential densities are not at the same scale. Table 6.2 describes the total number of jobs and population within a standardised inner-city area for Stockholm and Copenhagen. Stockholm has nearly 100,000 more jobs due to its significantly higher employment density than Copenhagen. Residential densities are similar for both cities, and subsequently there is a higher jobs-population imbalance within the inner city of Stockholm.

Figure 6.9 Stockholm Jobs - Population Balance Indicator



LSE Cities graphic based on: Statistics Sweden 2011b.

Figure 6.10 Copenhagen Jobs - Population Balance Indicator



LSE Cities graphic based on: Statistics Denmark 2009

Table 6.2 Urban core jobs-population balance, Stockholm and Copenhagen

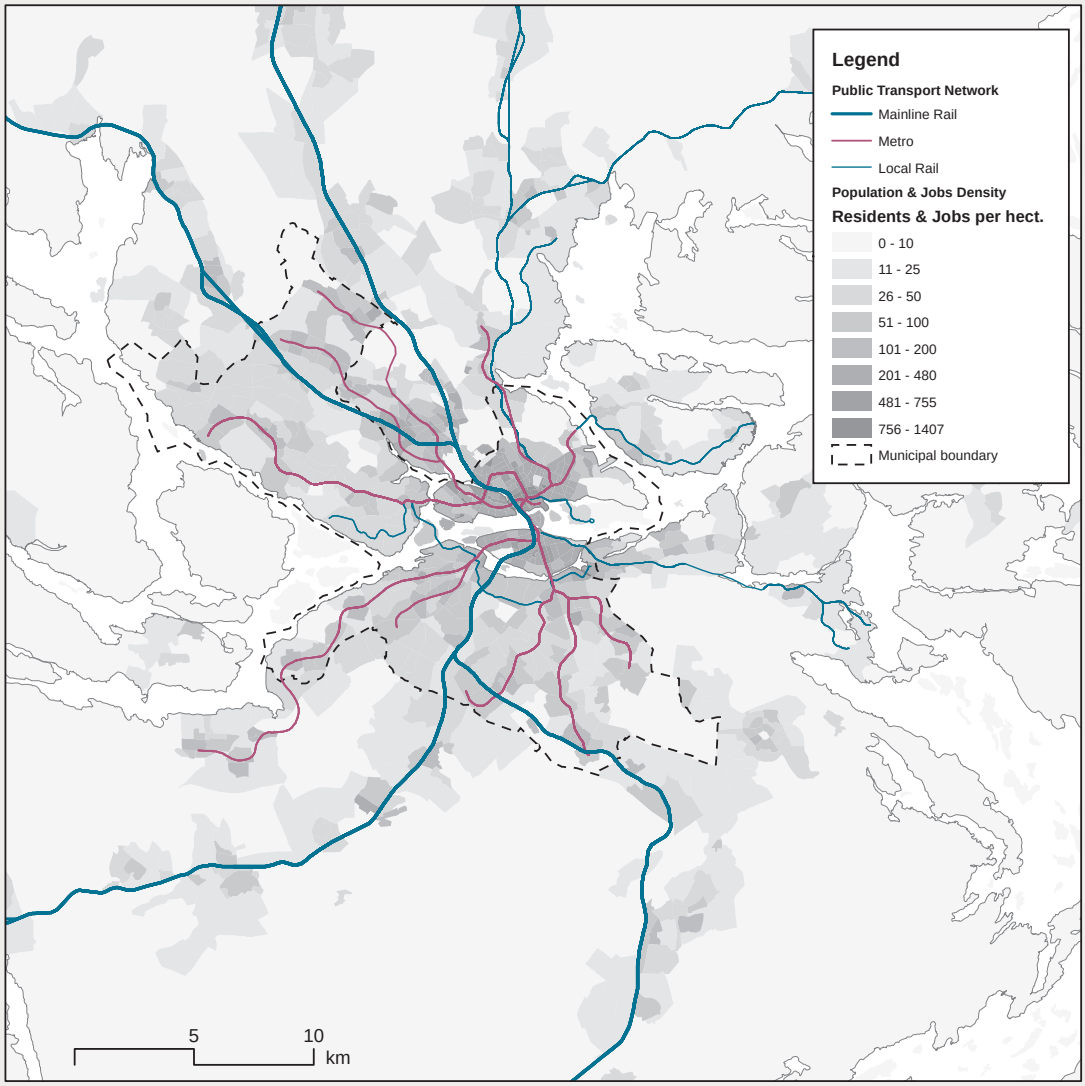
Sources: Statistics Denmark 2009; Statistics Sweden 2011b

	Municipal				Standardised Inner City			
	Jobs (000's)	Pop. (000's)	Area (km^2)	Jobs-Pop. Balance	Jobs (000's)	Pop. (000's)	Area (km^2)	Jobs-Pop. Balance
Stockholm	566	862	193	0.66	365	293	25	1.24
Copenhagen	385	614	99	0.63	273	302	28	0.90

6.2.3 Metropolitan public transport accessibility

In this section we move from land-use analysis to considering the relationship between land use and transport networks. Stockholm has invested in high quality public transport networks over many decades. In combination with strong municipal and metropolitan planning regulations, this practice has ensured a high level of integration between public transport and urban land uses. The regional rail, local rail and metro public transport networks are mapped in Figure 6.11 in relation to urban density, measured as the total number of residents and jobs per hectare. At the regional scale, linear corridors of urban land uses radiate from Central Stockholm in close proximity to rail lines.

Figure 6.11 Stockholm public transport networks and urban density



LSE Cities graphic based on: County of Stockholm 2011.

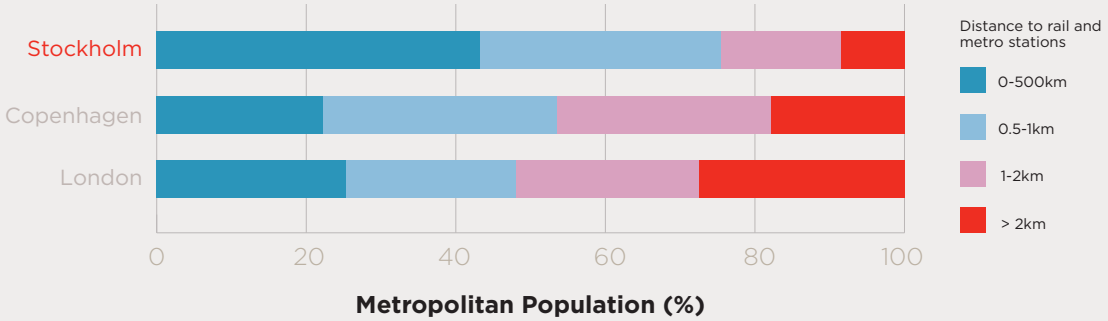
For a city of its size, Stockholm has a very well developed metro network which greatly improves connectivity for the inner city and suburbs. This provides a substantial accessibility advantage to comparable cities that have not made this investment. By comparison, Copenhagen began its metro development very recently in the last decade and consequently it covers only a small section of the city, as shown in Figure 6.12. London in contrast has a very old metro network which provides similar coverage to Stockholm over a more extensive built-up area. Copenhagen shares with Stockholm strong linear patterns of urban form development in the metropolitan region, while in London regional planning has been less integrated.

Figure 6.12 Copenhagen and London public transport networks and built-up area

LSE Cities graphic based on the following sources: City of Copenhagen 2012c; Ordnance Survey 2011.

The geography of population and employment, in combination with public transport network data, can be used to produce accessibility indicators describing the ease with which residents and employees can access public transport services. A threshold approach is used here, where the proportion of metropolitan populations within specific distances to rail and metro stations is shown. Figure 6.13 presents the proportion of metropolitan residents within 500 metres, 0.5-1km, 1-2km, and over 2km for Stockholm, London and Copenhagen. Compared to both London and Copenhagen, Stockholm displays a high level of accessibility. Overall, 43% of the population live within 500 metres (about 6 minutes' walk) of rail and metro stations, and 75% live within a moderate walk of less than a kilometre to rail and metro stations. This puts Stockholm substantially ahead of Copenhagen and London in terms of public transport coverage. Copenhagen lacks Stockholm's well developed metro network, while London has weaker public transport in its more extensive metropolitan region.

Figure 6.13 Residential accessibility to public transport stations

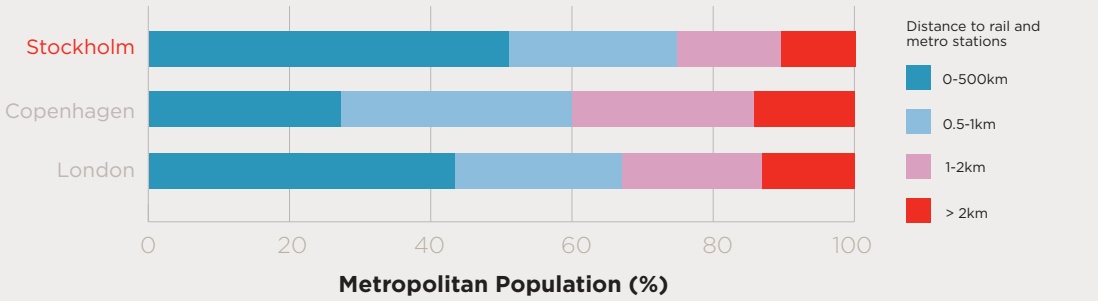


Sources: Office for National Statistics 2012; Statistics Denmark 2009; Statistics Sweden 2011b

The accessibility indicator can be repeated using employment data by workplace to investigate how closely business locations are integrated with public transport networks, as shown in Figure 6.14. Again Stockholm performs extremely well by this measure, substantially exceeding accessibility levels in Copenhagen. This result is linked to Stockholm's higher level of employment clustering, discussed earlier in Section 6.2.1. What is more surprising, however, is that Stockholm also marginally outperforms London, despite the extremely high peak densities in this large world city. The result is explained by London's high number of sub-centres spread across its large metropolitan region, where public transport access is much sparser than the city centre.

Figure 6.14 Employment accessibility to public transport stations

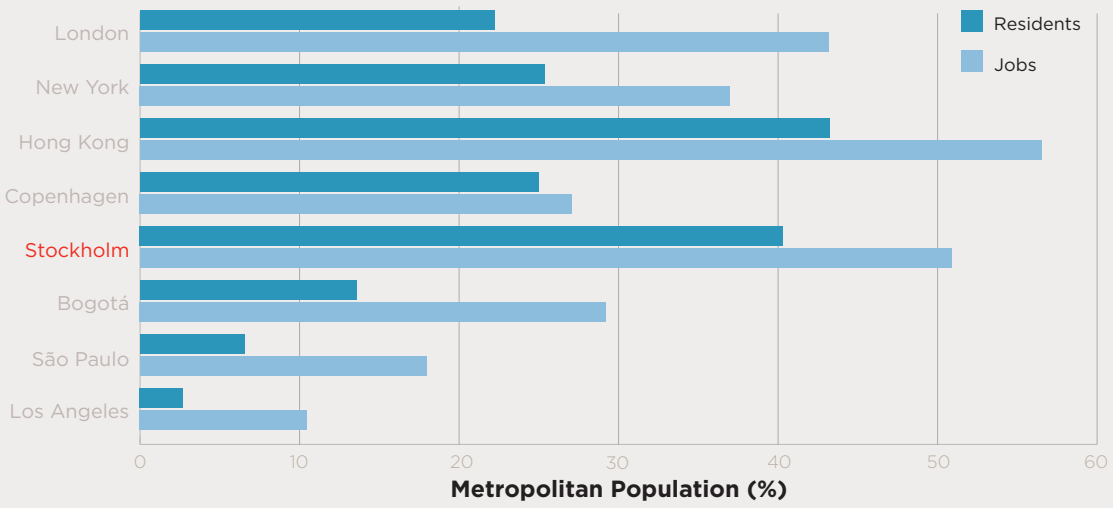
Source: Office for National Statistics 2012; Statistics Denmark 2009; Statistics Sweden 2011b



By drawing on LSE Cities research, Stockholm's accessibility levels can also be compared to a selection of global cities as shown in Figure 6.15. Stockholm substantially outperforms several large world cities in walk-accessibility to public transport for both residents and jobs. Only Hong Kong with its extreme high density urban form shows higher accessibility levels.

Figure 6.15 Residents and jobs in walking distance (500 metres) of public transport stations, selected metropolitan regions

Source: Smith 2012



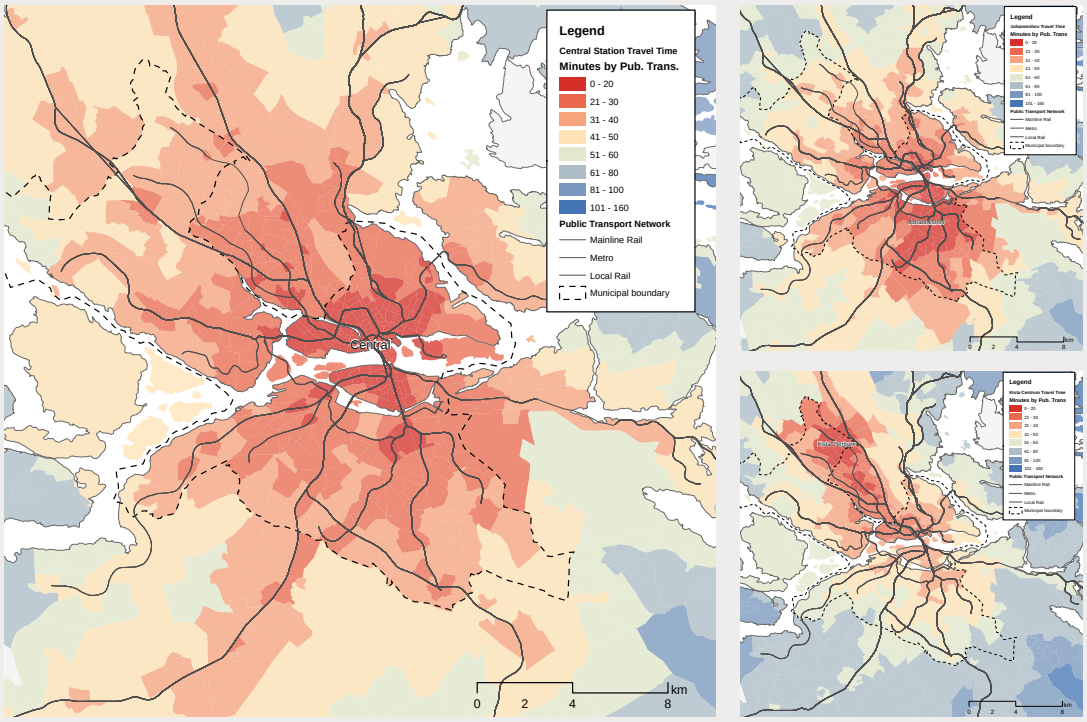
6.2.4 Agglomeration and labour accessibility

Agglomeration economies are competitive advantages that accrue to clusters of firms through sharing knowledge, labour markets and customers. Although data to directly measure agglomeration economies has not been available for this study, we can measure indirect proxy indicators for agglomeration such as employment density and workplace labour market accessibility. In areas of strong agglomeration economies demand is high and property rents increase. This process incentivises developers to intensify the built environment and results in high employment densities. The previous urban form section identified peak employment densities of 52,000 jobs/km^2 in Stockholm. This value is high for a city of Stockholm's scale and is nearly 12,000 jobs/km^2 greater than the peak density in Copenhagen. This indicates that agglomeration economies are strong in Central Stockholm.

High density clusters of knowledge-economy firms need to draw on large pools of skilled labour from across metropolitan regions to function effectively. Efficient public transport networks are ideally suited to this task, as their space efficiency advantages over private transport come to the fore. To analyse labour accessibility in the Stockholm metropolitan region, a public transport network model has been produced for this report. The GIS model uses the demographic and transport data presented in preceding sections, and is based on average mainline rail, metro, local rail and walking speeds. The model is calculated at the scale of census blocks. Examples of the output from the model are shown in Figure 6.16, with travel times to three employment locations in Stockholm shown. Dark red colours represent locations with short journey times below 30 minutes, light red and grey colours are locations with 30 minutes to 1 hour journeys, while blue locations exceed 1 hour. Stockholm Central Station has excellent public transport accessibility

across the region, as one would expect. High levels of metropolitan accessibility are shared with Johanneshov in the southern inner city, where both radial and orbital connections converge. The last example of Kista Centrum is more peripheral from Stockholm city centre and is restricted to a radial pattern of public transport connections. This limits the spatial extent of good public transport access to this location and will result in an increased proportion of commuting by car.

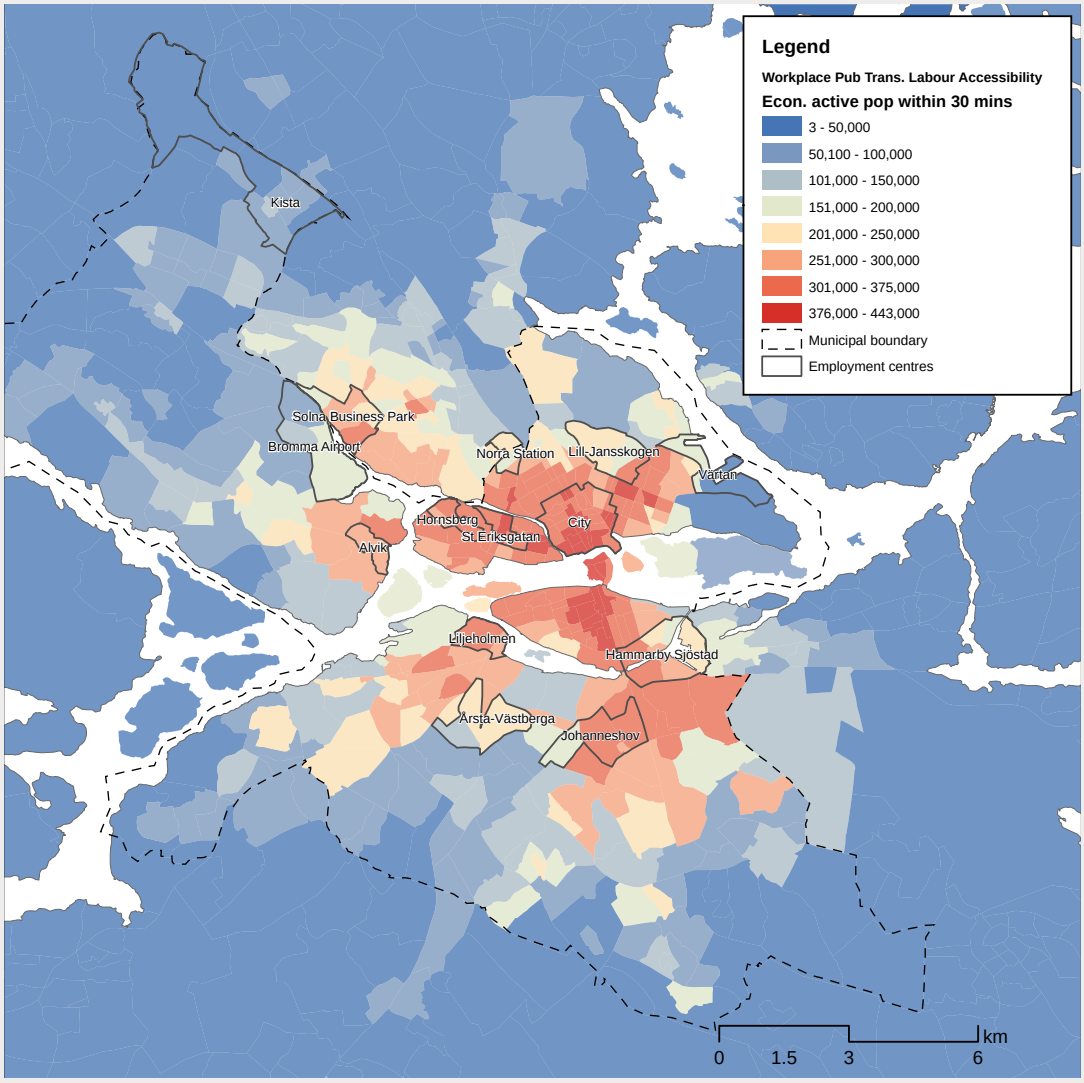
Figure 6.16 Stockholm Public Transport Model travel time examples: one-way travel time to Central Station (left), Johanneshov (top-right) and Kista Centrum (below-right)



LSE Cities graphic based on the following sources: County of Stockholm 2011; Statistics Sweden 2011b

The public transport model can be used to estimate travel times from all origins to all destinations within the metropolitan region and then used to calculate overall accessibility indicators. As labour accessibility is a key part of agglomeration economies, it is useful to measure the number of potential employees accessible to workplaces within typical commute times. In Figure 6.17 the total economically active population within 30 minutes travel time by public transport, foot or a combination of both is mapped. There is clearly very strong labour accessibility in the city centre and also to the south and west. The peak value of 440,000 economically active people within 30 minutes commute compares favourably to Copenhagen's peak of 365,000 economically active people. Values exceeding 300,000 are shared by inner-city employment centres to the south and west. Similar to the earlier mix-of-uses analysis, the centres to the north of the inner city perform less well relatively and are likely to have more car dependent travel patterns. The outlying centre of Kista has the lowest public transport access of all the centres.

Figure 6.17 Stockholm total economically active population within 30 minutes public transport trip of workplaces



LSE Cities graphic based on the following sources: County of Stockholm 2011; Statistics Sweden 2011b

6.2.5 Travel time efficiency

Drawing on the understanding of land use, public transport networks and accessibility developed previously, this section investigates travel times for typical journeys in Stockholm, with Copenhagen and London used as comparison cities. In the first instance potential travel times are estimated using the public transport model. These potential travel results are then compared to actual travel times from city travel surveys. Finally, the travel survey trip times are used to estimate financial costs based on average value of time coefficients for commuters.

The preceding sections have analysed Stockholm's compact city form and identified good public transport accessibility across the Stockholm metropolitan region. Copenhagen has been used as a comparison city, with the analysis showing lower public transport coverage in Copenhagen compared to Stockholm but a higher degree of local mix of uses and better balance between residential and workplace locations. In Table 6.3 the mean public transport and walking accessibility time and distance calculated by the model to all jobs within a standardised metropolitan region of 1000 km^2 is shown for Stockholm and Copenhagen. The model estimates distances and times to be lower for Copenhagen, indicating that the better local mix-of-uses is likely to translate into shorter travel times for public transport, as well as for walking and cycling compared to Stockholm.

Table 6.3 Public transport & walking model mean accessibility time & distance to all jobs, Stockholm and Copenhagen

LSE Cities model results based on the following sources: County of Stockholm 2011; Statistics Sweden 2011b

	Standardised Metropolitan Region					
				Mean accessibility to all employment		
	Jobs	Population	Area (km²)	Time (mins)	Distance (km)	Speed (km/h)
Stockholm	858,972	1,595,380	999	49.2	18.3	22.3
Copenhagen	839,193	1,415,730	1,004	42.7	13.3	18.7

Table 6.4 Travel survey journey-to-work times for Stockholm, Copenhagen and London (travel time units: minutes)

Sources: City of Copenhagen 2012b; ONS 2012; Statistics Sweden 2012e.

	Metropolitan Region					Municipal				
	Public Trans.	Car	Walk	Bike	All	Public Trans.	Car	Walk	Bike	All
Stockholm	46.2	35	16	25	37	38.4	33	16	20	31
Copenhagen	44.8	20	11	15	20	36.2	15	9	12	17
London	-	-	-	-	48	-	-	-	-	43

Travel survey results can be used to investigate the typical journey behaviour in Stockholm and to back up the results from the public transport model. Note that there are several methodological issues with directly comparing travel survey results from different cities, and values should be interpreted with care[8] . Average travel times for trips in the metropolitan region and trips within municipal cores are shown in Table 6.4. In line with the public transport and walking model results, Copenhagen has quicker journey times than Stockholm. The differences are marginal for public transport trips, but are relatively high for walking, cycling and for car travel. Similar travel time differences can be seen in the average times for all weekday trips in Table 6.5. The time advantages for walking and cycling trips in Copenhagen are likely to be connected to the local-mix-of-use and jobs-population balance factors described previously. Variations in car travel times will relate to levels of congestion, with Stockholm's island geography also likely to be contributing to more circuitous travel routes. Average figures for London have been included in the tables, highlighting that Stockholm retains trip time advantages over larger cities like London, particularly in relation to commuting.

[8] Stockholm has a significantly larger municipal (city government) area than Copenhagen which includes more suburban residents who will typically have longer travel times. This will increase recorded travel times for Stockholm vis-à-vis Copenhagen (though not against London which has an even larger municipal area). Furthermore metropolitan trips are defined as those trips which begin and/or end in the municipal area, therefore the municipal definition will also affect metropolitan results. Finally travel time results can also be affected by minor differences in how travel surveys are conducted, for example in the minimum cut-off distance for walk trips.

Table 6.5 Travel survey times for all weekday trips, Stockholm, Copenhagen and London
Sources: City of Copenhagen 2012b; ONS 2012; Statistics Sweden 2012e.

	Metropolitan Region					Municipal				
	Public Trans.	Car	Walk	Bike	All	Public Trans.	Car	Walk	Bike	All
Stockholm	43.6	32	16	19	29	35.7	26	17	17	24
Copenhagen	41	17	12	13	17	28	12	12	13	15
London	-	-	-	-	32	-	-	-	-	30

By using a value-of-time approach, journey-to-work travel times can be translated into estimated financial costs for the metropolitan economy and as a percentage of Gross Value Added for the metropolitan region. This calculation is presented in Table 6.6 using a commuting value-of-time coefficient standard from the UK Department for Transport (Department for Transport, 2012). It is estimated that journey-to-work comprises 5.8% of GVA in Stockholm. Stockholm lies inbetween the two comparison cities, with a lower proportion of GVA than London (8.36%) and a higher proportion than Copenhagen (3.41%).

Table 6.6 Total annual value of time costs, journey-to-work (2010 prices)
LSE Cities model results from various sources.

	Metropolitan Region			
	Cost per commute €	Annual cost per capita €	Metro total annual cost (€millions)	% of GVA
Stockholm	4.62	2,264	1,945	5.84
Copenhagen	2.49	1,224	1,027	3.41
London	6.00	2,937	23,712	8.36

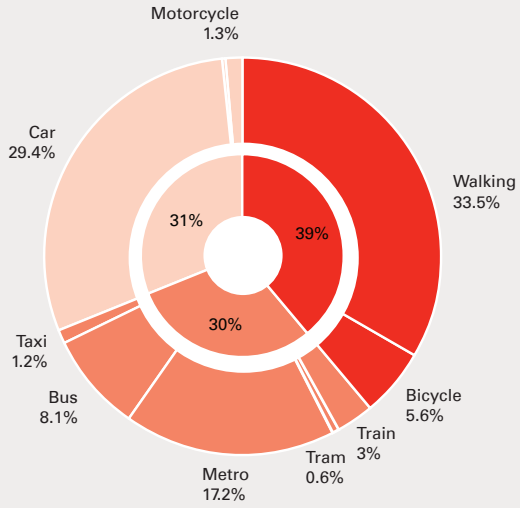
6.2.6 Environmental efficiency

This section analyses modal split and distance travelled using travel survey results and with respect to environmental impact. The modal split and total passenger kilometres travelled are shown in Figure 6.18. These figures are for residents of the city municipalities on typical weekdays. Stockholm displays both a high proportion of public transport travel and active (walking and cycling) travel. A major trend that stands out for Stockholm is the very high proportion of walking trips, comprising 33.5% of all weekday trips in the city. In combination with moderate cycling activity this adds up to the highest proportion of active travel of the three cities (Stockholm 39%; Copenhagen 38%; London 26%). However, cycling rates are considerably lower in Stockholm than in Copenhagen. In Copenhagen, 13% of kilometres travelled are by bicycle, with only 2% in Stockholm. Stockholm also shows a high proportion of public transport travel at 30% of trips, with the metro as the most significant mode by number of trips and by distance travelled for city residents. Public transport travel is less significant in Copenhagen at 22% of trips, while London has the highest level of public transport trips at 34%.

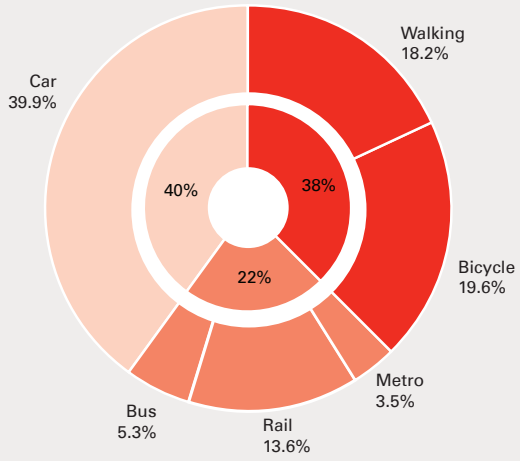
Figure 6.18 Modal split and passenger kilometres travelled for Stockholm, Copenhagen and London, municipal residents

Modal split, trips weekday (main mode of trip)

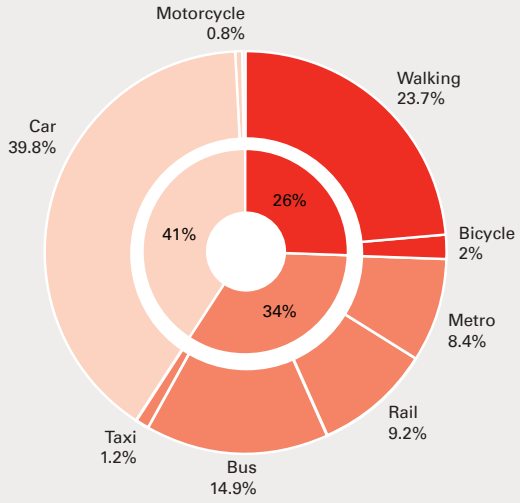
STOCKHOLM



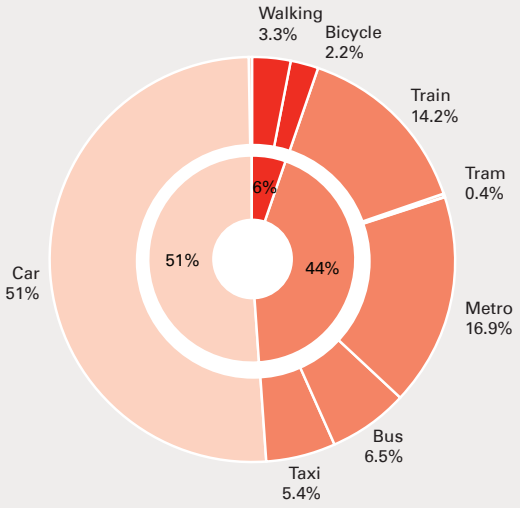
COPENHAGEN

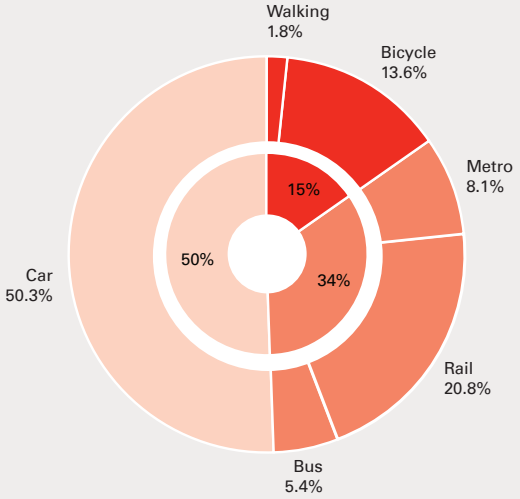


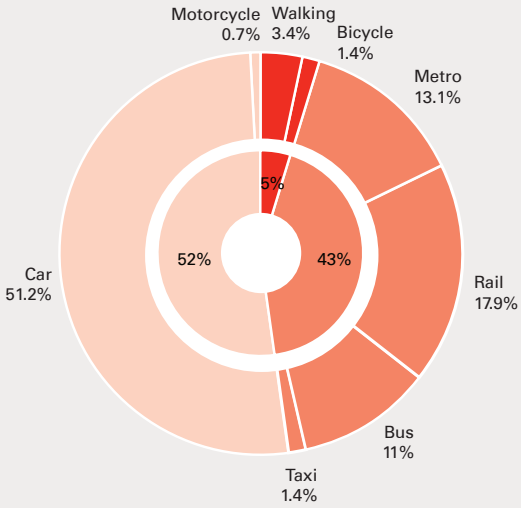
LONDON



Modal split, passenger kilometres weekday



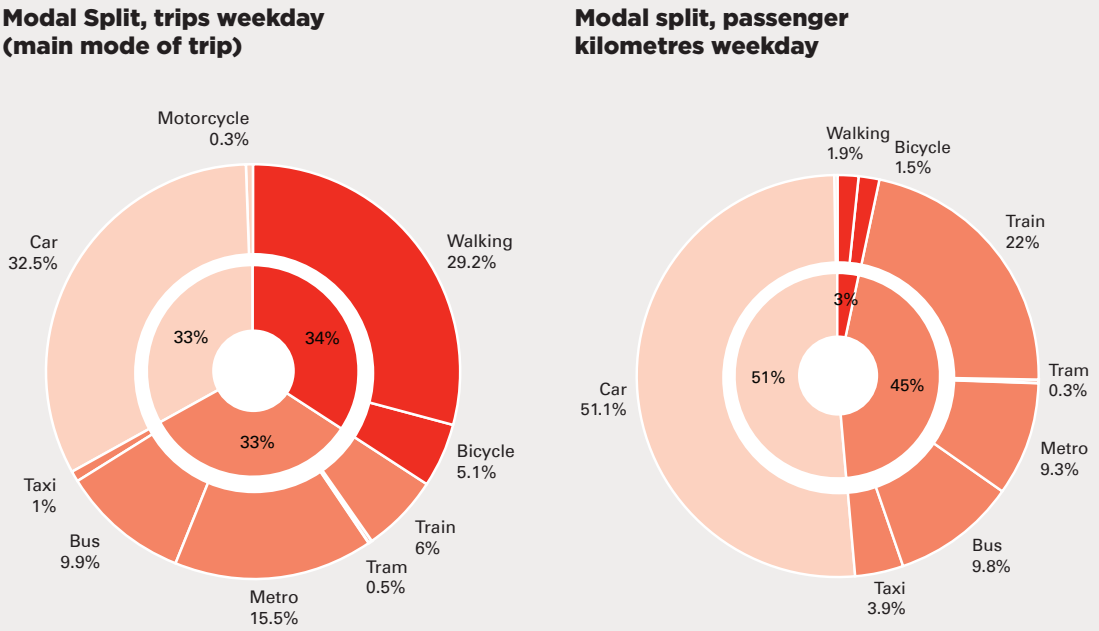




LSE Cities graphs based on the following sources: City of Copenhagen 2012b; ONS 2012; Statistics Sweden 2012e.

In Figure 6.19 the same travel indicators are shown, this time for trips starting and/or ending within the City of Stockholm. This better reflects trip patterns across the metropolitan region, although it does not include trips that begin and end outside of the City of Stockholm. Typically, regional trips are longer distance and use less sustainable modes of transport than trips within urban cores. Stockholm performs well in maintaining a high proportion of public transport and active travel across the region. The main change compared to the municipal data in Figure 6.18 is the shift from metro public transport trips to longer distance regional train travel.

Figure 6.19 Modal split and passenger kilometres travelled for Stockholm, trips that start and/or end in municipality



LSE Cities graph based on: Statistics Sweden 2012e.

Car-based travel makes up a substantial proportion of travel in Stockholm, similar to Copenhagen and London. This is despite the high levels of public transport provision and taxation policies implemented by respective municipal and national governments. In Stockholm the proportion of car trips is substantially lower than in London and Copenhagen (Figure 6.18), but in terms of passenger kilometres the pattern is very similar, with car travel constituting just over half of the distance travelled in all three cities. This indicates that car users are taking longer distance routes in Stockholm, which could relate to the city's island geography and possibly because drivers are taking longer routes to avoid congestion hotspots.

A key underlying factor in levels of car use is ownership. An international comparison of city and metropolitan car ownership is presented in Figure 6.20. The degree of variation is very high. In general, low car ownership cities are less affluent, though there are exceptions, particularly from the leading East Asian global cities. Stockholm lies in the middle of the distribution, with car ownership levels of 373 per 1,000 population in the city, and 405 per 1,000 population in the metropolitan region. These results are relatively low considering Stockholm's high GDP levels, though are not world leading and several cities are outperforming Stockholm by this sustainable transport measure.

Figure 6.20
Car ownership and GDP per capita in European cities and metropolitan regions

LSE Cities graphic based on multiple sources.

The transport modal split and distances travelled are directly related to CO_2 emissions for the example cities. Data on per capita transport emissions from residents of the cities of Stockholm, Copenhagen and London are shown in Table 6.7. Again, this data needs to be interpreted with care due to large differences in municipal areas and further differences in how transport emissions are modelled. In 2010 the City of Stockholm adopted a more comprehensive method of assessing transport emissions. Two figures are therefore provided in Table 6.7 for Stockholm's emissions in 2010; the original method consistent with 1991 and 2000 values, and the new higher figure. All the example cities have relatively low per capita transport emissions considering their levels of wealth. London has the highest transport emissions at 1.29 tonnes CO_2 per capita. Stockholm has 1.1 tonnes CO_2 per capita, significantly higher than Copenhagen at 0.76 tonnes CO_2 per capita. Note that Copenhagen's results will be affected by its smaller municipal area. Transport emissions in Stockholm show the greatest decrease, falling by 0.3 tonnes CO_2 per capita in the last decade (although using the new method of calculations emissions remain at 1.4 tonnes CO_2 per capita in 2010). Transport emission reductions in Stockholm can be attributed to the significant rise of low emission vehicles and the introduction of the city congestion tax, as well as increases in public transport use and active travel more generally.

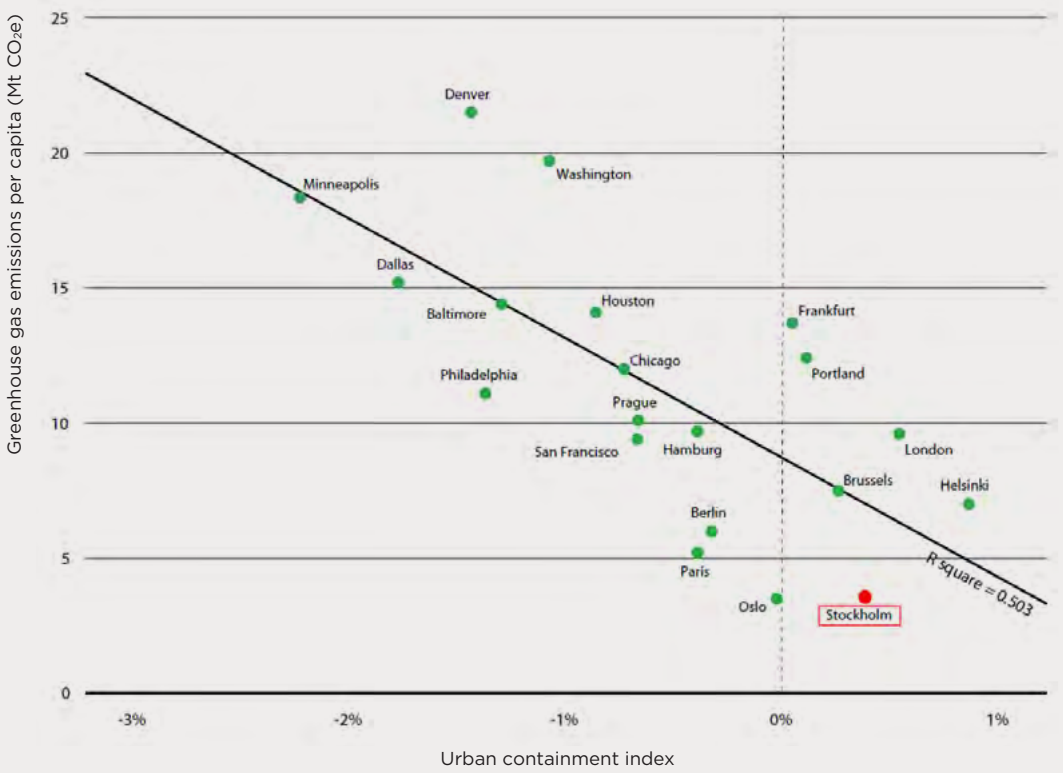
Table 6.7 Transport CO_2 emissions per capita, municipal residents
Sources: City of Copenhagen 2012a; City of Stockholm 2012m; Greater London Authority 2012

	Transport CO_2 emissions, tonnes per capita				
	1991	2000	2010	Change 1991-2010	% of GVA
Stockholm	1.58[1]	1.4[1]	1.1[1]/1.4[2]	– 0.48[1]	– 30.4[1]
Copenhagen	0.82	0.88	0.76	– 0.14	– 7.3
London	1.40	1.20	1.29	– 0.11	– 7.9

[1] Value from pre-2010 City of Stockholm emissions calculation methodology.
[2] Value from 2010 City of Stockholm emissions calculation methodology.

Stockholm GHG emissions can also be considered in a wider international context. Figure 6.21 graphs total GHG emissions and a regional containment index for prominent European and North American cities. Stockholm has the lowest emissions of all surveyed cities, reflecting its comprehensive sustainability approach to all urban sectors, including moderately low emissions from transport. As of 2011 the city of Stockholm reported per capita GHG emissions of 3.5 tonnes of CO_2e (City of Stockholm 2012m). The compact city land-use approach discussed throughout this chapter most directly influences transport emissions, but can also bring sustainability synergies in other sectors, particularly in building energy efficiency and economies of scale for district heating schemes.

Figure 6.21 Greenhouse gas emissions and containment index for selected metropolitan regions



LSE Cities graphic based on multiple sources.

6.2.7 Productivity impacts

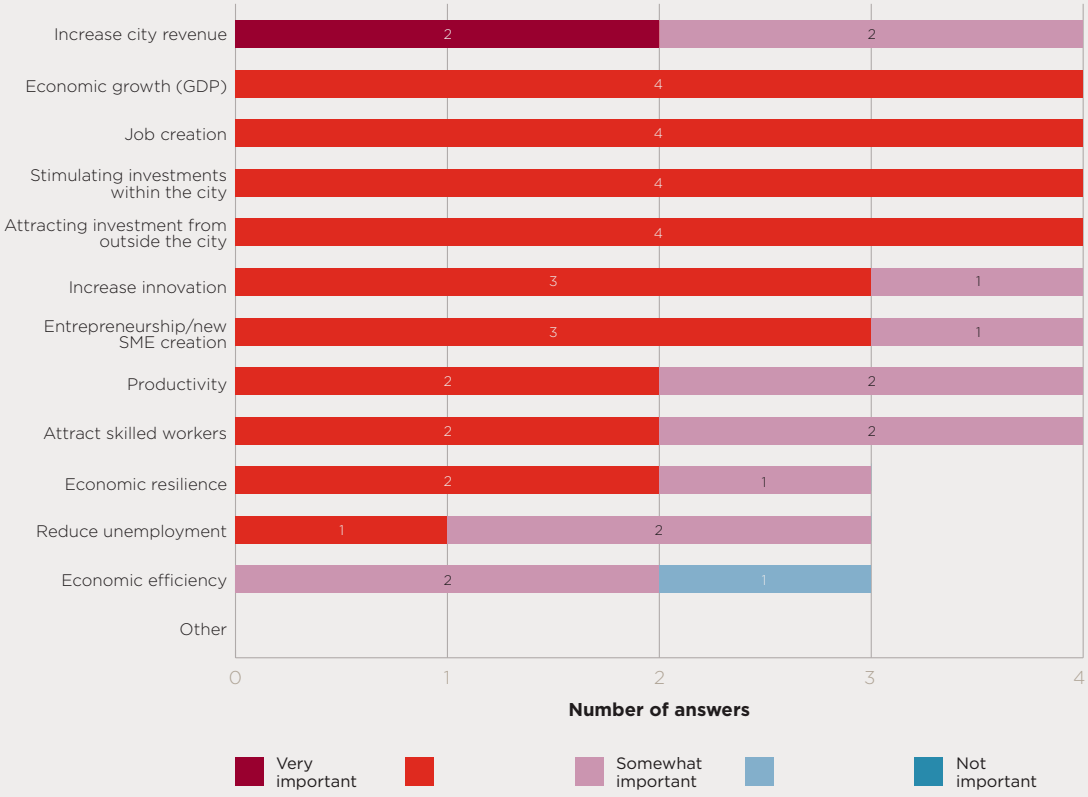
Stockholm's land-use and transport policies and compact urban form contribute to a wide range of economic impacts. Local experts were consulted on the economic factors that Stockholm's land-use policies (Figure 6.22) and transport policies (Figure 6.23) have impacted on. These potentially could include growth in employment, GDP, innovation, resilience, productivity, economic efficiency and city revenues.

The most significant influences identified for both land use and transport were economic growth and increased city revenues. Stockholm's accessible form improves its competitiveness as an attractive location for businesses and residents, stimulates agglomeration economies and therefore boosts economic growth. Increased city revenues come from higher returns from local taxation, and new revenue streams such as the congestion tax. Additional economic factors judged to have been moderately affected by land use and transport policy include economic resilience, stimulating investment within the city and increased entrepreneurship. Stockholm's very high levels of public transport accessibility should increase the city's ability to remain competitive in scenarios of sharp increases in fuel prices, and/or stringent carbon pricing. Further enhancement of opportunities for walking and cycling travel would further boost resilience.

Job creation was found to be a positive economic impact of land-use policy. This is likely to relate to specific policies for boosting key employment centres such as Kista, as well as more general job creation in the construction sector and managing the built environment. For transport policy, an increase in innovation was found to be a unique impact. Innovative policies have included the congestion tax and low emission vehicles innovation.

Figure 6.22 Economic impacts of land-use policies in Stockholm

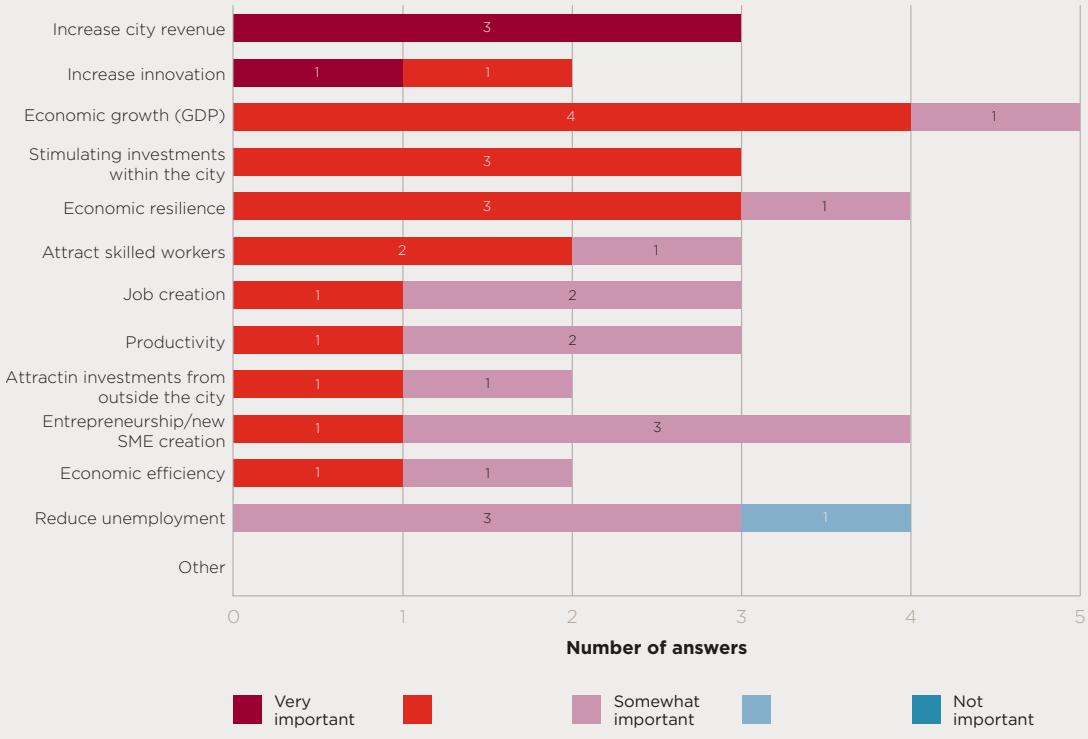
How negative or positive has the economic impact of your city's green land-use policies been on the following areas of the economy?



Results from Stockholm responses to the LSE Cities Going Green global survey.

Figure 6.23 Economic impacts of transport policies in Stockholm

How negative or positive has the economic impact of your city's green transport policies been on the following areas of the economy?



Results from Stockholm responses to the LSE Cities Going Green global survey.

6.3 Future challenges and opportunities

Stockholm's spatial structure and physical layout facilitates green growth, in terms of more sustainable travel patterns and supporting agglomeration economies. The geography of Stockholm features many elements of compact city form, with a high density centre, medium density inner city, and urban land uses closely tied to public transport infrastructure at the metropolitan level. This compact urban structure is generally being maintained and strengthened through a comprehensive and mature land-use and transport policy programme at the city level, with regional and national level policy support. Major policies include the promotion of compact urban development (higher density and brownfield-oriented developments aiming to reduce urban sprawl), integrated public transport infrastructure (predominantly rail and metro) and sustainable transport policies (congestion charging, parking fees, promotion of cycling and walking).

Stockholm's compact urban form results in significant economic and environmental impacts which have been analysed in this chapter. The economic impacts from integrated land use and transport relate to agglomeration economies. Stockholm has exceptionally high public transport coverage across the metropolitan region, with 75% of residents within a kilometre of rail and metro stations. Public transport networks provide a potential labour market of 440,000 economically active people within 30 minutes travel time of Stockholm's largest employment area, the city centre. These results will rise further with planned public transport improvements. The high levels of accessibility support the agglomeration benefits to firms of improved job matching, greater labour pools, knowledge spill overs, firm linkages, clustering, urban buzz and face-to-face contacts. The *Stockholm City Plan* further supports agglomeration benefits with the clustering of key industries in strategic locations.

Stockholm's compact form and high levels of accessibility also contribute to environmental benefits. Stockholm has successfully made significant reductions in transport CO_2 emissions per capita in recent decades. Based on Stockholm's former emissions calculation method, transport emissions have fallen from 1.58 tonnes CO_2 per capita in 1991 to 1.1 tonnes CO_2 per capita in 2010. Reductions are a result of the full range of land-use and transport policies, including the promotion of low emission vehicles, the congestion tax, successful increases in public transport use and continuation of Stockholm's walking culture. Currently, public transport comprises 30% of trips in the City of Stockholm and walking 34%. Note that Stockholm's newly adopted emissions calculation methodology puts 2010 transport CO_2 per capita at 1.4 tonnes, indicating that there is still further progress to be made.

The main area identified where Stockholm's urban form diverges from compact city aims was local mix-of-uses. Several large employment centres feature mono-functional land-use patterns isolated from nearby residential areas. This pattern will tend to increase travel distances. Indeed segregated land uses are likely to contribute to Stockholm's average travel times being less efficient than the comparison city of Copenhagen, in addition to further congestion and physical geography factors. Overall this contributes to theoretical time costs for metropolitan commuting of 5.8% of Stockholm's GDP, compared to 3.4% in Copenhagen and 8.4% in London.

Stockholm has a great potential to focus more directly on strategies to reduce overall travel demand. In terms of land-use policy, strengthening mix-of-uses is a clear priority identified in the analysis. This aim is closely aligned with strategies set out in the *Stockholm City Plan*, as employment centres with segregated land uses such as Norra Station, Värtan/Stockholm Royal Seaport, and Alvik are identified as strategic nodes. There is therefore a clear opportunity for the evolving centres to enable much better local integration of living and working environments. Across the wider metropolitan region, the city can improve the integration of living with working while limiting the segregation of residential areas and locally isolated employment locations. Stockholm's broadband strategy is also a useful supporting policy for reducing transport use by increasing opportunities for working at home.

Stockholm might consider introducing further 'push' policies to reduce car ownership and car use by introducing restrictive measures and car-free developments. The reduction of private car ownership is not currently a policy priority in Stockholm. Even with current restrictive policies such as the congestion tax, private cars comprise over 50% of passenger miles in the City of Stockholm. As well as further 'push' policies, complementary 'pull' policies could include the promotion of bus travel (BRT, bus lanes and bus corridors), multi-modal integration, a more

comprehensive cycle strategy, and further redistribution of public street space from private car use to public transport. While walking already represents a high proportion of travel in Stockholm, there is significant potential for further increases in cycling.

Related to the need to consider policies limiting car ownership and use, the current plans for major investment in new road infrastructure in Stockholm will create further pressure for increased car use. Infrastructure plans include the completion of the inner ring-road with the construction of the northern and eastern road links, and the Stockholm Bypass to the west. These improvements should decrease congestion in the city centre, and will greatly boost car accessibility to areas such as the north-east of Stockholm. The north-east area has good public transport links to the city centre, but lacks the more developed orbital networks present in the south and west of the inner city. Investment in orbital public transport connections to the north and north-east of the inner city should be considered. Similarly, the major employment centre of Kista already has strong road links and these will further improve with the Stockholm Bypass. Employment expansion in more peripheral locations should be limited to a small number of strategic locations, and growth redirected to more accessible inner-city locations.

Kista Science City: an innovation hub

Kista Science City forms the heart of Stockholm's ICT sector. Kista has fostered strong links among academia, industry and government, increasing agglomeration effects and strengthening its position as a highly productive business cluster. Today, Kista employs more than 65,000 people and plays an important R&D role in smart and sustainable communications technologies that are supporting the city's transformation to a low-carbon economy.

Photo credit: Yanan Li

7 Innovation, business and eco-districts

Key messages

In an urban green economy, policies for stimulating all types of innovation should be encouraged. However, governments also have a role in supporting green innovation more specifically, as it contributes not only to total factor productivity in the short to medium term but is also necessary for the transition to a low carbon, resource efficient economy – one that delivers higher rates of growth over the long term.

One of the key policy instruments for stimulating and supporting innovation is targeted research and development (R&D) spending. Sweden invests heavily in R&D. Between 1997 and 2008, national spending on R&D averaged 3.7% of GDP compared to 1.8% across Europe.

The City of Stockholm has stimulated innovation by developing new-build eco-districts. The eco-districts at Hammarby Sjöstad and Royal Seaport are clean technology demonstrator projects delivered through public private partnerships. These eco-districts have made Stockholm one of the leading cities in the world for developing and demonstrating innovative green solutions at the district level.

A number of opportunities exist for Stockholm to capitalise further on the success of its eco-districts including: (a) rolling out eco-district innovations in publicly owned buildings; (b) rolling out innovations across existing districts in the private market; (c) developing additional eco-districts in the future; and (d) expanding export promotion, particularly through Symbiocity (a Swedish Trade Council agency), to continue supporting the growth of exports into international markets.

Currently, the majority of public funding support for green enterprise is provided through general business initiatives supported by the Swedish Government. In its 2011 Environmental Technology Strategy, a key priority of the Swedish government was to ensure that Sweden becomes a global green technology pioneer, investing US$62 million in clean technology between 2011 and 2014.

Within Stockholm, the most important business accelerator is STING (Stockholm Innovation and Growth), a Kista-based non-profit incubator and dedicated venture capital fund. Also, the Stockholm Cleantech Association is a business network that promotes green innovation in the Greater Stockholm Region by encouraging cooperation between businesses, research bodies and the public sector.

Support from city and national governments has not yet translated into particularly strong growth in the green business sector. Turnover in Stockholm's green business sector grew by an average of 3.0% per year between 2004 and 2009. Over the same period, the number of green sector firms grew by 4.2% - similar to the 4.3% growth overall in firms. Employment in the green sector grew by 1.9% per year - the same as overall employment growth in Stockholm – and declined more rapidly than overall employment during the global recession.

While Stockholm's ICT cluster is internationally recognised and the city's strengths in life sciences innovation are well known, other cities have a stronger brand for cleantech clustering.

The lack of strong growth in Stockholm's green sector, combined with the lack of a strong cleantech cluster brand suggests that the City of Stockholm should assess the benefits and costs of building a stronger, more centralised cleantech cluster in the city.

The City of Stockholm's spending on procured goods and services amounted to US$ 2.86 billion in 2012. Consequently, public procurement has substantial potential as a policy instrument for shaping green technology markets. While the city has various targets for green procurement, other cities have comprehensive green public procurement policies that are integrated into the detailed procurement guidelines of the authority and its public agencies – an area that the city authority should investigate further.

The global market for green goods and services is currently estimated to be around US$6 trillion. If Stockholm's businesses can capture activity in this large and growing market, the sector represents a major source of future growth. At the same time, competition is also growing in the sector and maintaining a lead in the advanced technology sector will be challenging. For example, China has established a US$1.7 trillion public fund to support an active industrial policy based on low carbon growth.

The global market for low carbon building technologies alone is worth US$650 billion annually. Based on Stockholm's expertise in green building developed through its eco-districts programme, substantial opportunities are likely to exist in this sub-sector.

Innovation is one of the eight drivers of an urban green economy (Chapter 2). Chapter 4 showed that Stockholm has high levels of overall innovation against global benchmarks, making the city a knowledge-led economy. Chapters 5 and 6 went on to discuss the potential for Stockholm's policy programmes to foster green innovation in particular sectors, for example in the development of low carbon heating for buildings and greener transport. In this chapter, we examine the role of the private sector, public research, and the effectiveness of Stockholm's public private partnerships for stimulating green innovation and contributing to the city's position as a leading knowledge economy.

7.1 Green innovation and economic growth

Innovation of all types, and across all sectors, raises productivity levels through advances in technology, leading to higher growth and consequently higher wealth levels. In an urban green economy, policies for stimulating all types of innovation – whether or not they have positive or neutral environmental outcomes - should be encouraged in order to drive economic growth.

In addition to providing policy support for overall innovation growth, governments have a role in supporting green innovation specifically. Green innovation is a particularly powerful driver of growth. As well as contributing, like all innovation, to total factor productivity in the short to medium term, green innovation is also necessary for the transition to a low carbon, resource efficient economy – one that delivers higher rates of growth over the long term.

The transition to a green economy requires a comprehensive global shift to new and improved technologies in key sectors such as power generation and distribution, energy use and transport (Stern 2006). In cities, examples include the development of smart electricity grids, energy efficient heating for buildings, clean vehicles and electro-mobility. While the private sector plays the leading role in technology development, a range of market failures reduces the rate of innovation in the absence of targeted policy measures.

A major barrier that affects innovation in green city infrastructure is that new technologies may not become cost effective until a substantial investment has been made and experience developed. The upfront capital and learning time required, combined with uncertainties over future costs, product prices and competing technological developments, may result in firms waiting until a new technology has already been deployed and proven in the market. This can lead to 'lock-in' of existing technologies even if the effectiveness and cost efficiency of new, green technologies would be greater in the long run.

Free-riding is another barrier to innovation. Information is a public good, and once an idea has been created, the cost of spreading it ('knowledge spillovers') is very low. This means that an individual company may be unable to capture the full economic benefit of its investment in innovation. Although intellectual property rights (IPR) reduce an individual firm's risk-to-return ratio, IPR is not always straightforward to enforce.

Innovation may also be hindered when the long-term returns are greater socio-economically than for individual firms. Individual firms tend to focus on private costs and benefits and private discount rates to maximise short-term profits for their shareholders. Unless consumer demand through, for example, environmental awareness, is sufficiently strong to impact on these short-term decisions, companies have little incentive to factor in climate change or environmental costs

in their investment decisions. Policy intervention in this case is justified because of the increased socio-economic benefits resulting from higher long-term sustainable growth.

National, regional and city governments can boost innovation using a range of policy instruments including planning and regulation, carbon pricing, public funding and public procurement. In particular, city policy programmes can be used to support R&D and demonstration projects, as well as funding and leveraging early stage commercialisation investment. Governments can also address institutional barriers to innovation, particularly by fostering public private partnerships that share knowledge, ideas, skills and financial risk.

7.2 Policy programme

7.2.1 Research & development

One of the key policy instruments for stimulating and supporting innovation is targeted research and development (R&D) spending (Stern 2006). Between 1997 and 2008, Sweden spent an average of 3.7% of GDP on R&D compared to an average of 1.8% across Europe, and Sweden's R&D funding remains relatively high today. Among OECD Countries, only Korea, Finland and Israel are investing a higher percentage of GDP in R&D (OECD 2012b; World Bank 2012a).

R&D spending at the national level targets a range of actors, including publically-funded universities, research institutes, public private partnerships with large multi-national companies, and R&D at green technology SMEs. Vinnova, the Swedish Agency for Innovation Systems and part of the Ministry of Enterprise, Energy and Communications, provides support to companies at various stages of growth and across a variety of industries, mostly through research and early development support. Vinnova's Research and Grow programme targets new SMEs to help them invest in R&D programmes that can increase their innovation capacity and at the same time create new collaborative networks that lead to knowledge spill-overs. In recent years, increasing numbers of environmental technology companies have applied for this support, and SEK 25-30 million (US$4-5 million) is allocated to this sector on an annual basis.

Vinnova also established 19 'VINN Excellence Centers' that provide a forum for public private partnerships, each funded for a period of ten years. The centres cover various subject areas, from paper and packaging innovations to sustainable communications. All of them deal with both basic and applied research, with a mandate to ensure that new knowledge and technical developments can be turned into new products, processes and services.

Formas, the Swedish Resource Council, together with Vinnova awards funds for environmental technology research in six core areas: sustainable building, sustainable transport, environmental protection technologies, use of biological natural resources, simple and advanced materials and energy. Funding is awarded only if it is met by a 50% joint funding offer by industry (SWENTEC 2011).

Within Stockholm, specific support for green technology research is mainly based on seed funding for the development of the city's ICT and cleantech sector. The Electrum Foundation was established by several key representatives from Stockholm's ICT sector (Ericsson, IBM, Packetfront) together with the Royal Institute of Technology (KTH) and the City of Stockholm. The aim is to stimulate partnerships and growth in research-based, innovative growth companies in the ICT sector. The Foundation provides grants, loans and an opportunity for knowledge sharing for companies conducting R&D at Kista Science City, an ICT cluster on the outskirts of Stockholm. Between 2009 and 2011, the Foundation invested SEK6.7 million (US$1 million) to support R&D in companies working in Kista.

7.2.2 Hammarby eco-district: public private partnership

Alongside city and national policies for promoting R&D activities and supporting growth in green enterprise, the City of Stockholm has also stimulated innovation by developing new-build eco-districts. The eco-districts at Hammarby Sjöstad and Royal Seaport are clean technology demonstrator projects that bring the public and private sectors together. These eco-districts have made Stockholm one of the leading cities in the world for developing and demonstrating innovative green solutions at the district level.

In response to Stockholm's rising housing demand in the early 1990s, the city authorities decided to redevelop the area surrounding Hammarby Sjö lake in the south-east of Stockholm. On completion in 2017, the district will house over 25,000 residents in around 11,000 apartments.

The area was a former industrial and harbour area which, although highly polluted, was strategically placed as a continuation of Stockholm's south inner city. The project received additional momentum when Stockholm decided to bid for the 2004 Olympic Games, nominating Hammarby Sjöstad as the Olympic Village. Following the Olympic Committee's call for a sustainable approach in the bids, Stockholm's city council agreed to make the redevelopment an example of environmental best practice. (Svane, Wangel et al. 2011)

The overall environmental goal – far reaching for its time – was to create a residential zone with half the environmental impact of other comparable districts built during the 1990s. Economically, the project aimed to stimulate green innovation, attract private investment and create around 10,000 jobs.

These goals were underpinned by four overarching objectives: 1) energy and resource flows within the district should be closed and focused where possible on the local level; 2) energy should be produced from renewable energy sources; 3) transport needs should be minimised and 4) the knowledge, experience and technology generated in the process should be disseminated more widely (City of Stockholm 1996) cited by (Pandis and Brandt 2011).

Operational targets included limiting total energy use on the site to 60 kWh/m2, achieving water consumption levels that are 50% lower than the average water use in new housing in the inner city area, and ensuring that 80% of commuters use public transport, walking or cycling (for other operational goals see Table 7.1).

The City of Stockholm has used a range of policy instruments to deliver the goals at Hammarby Sjöstad, particularly the use of public finance for upfront capital to secure land ownership; and for decontaminating the site standard development procurement processes, along with public private partnerships, to share knowledge and innovative ideas for meeting the ambitious environmental targets of the project.

In 1995, following Stockholm's formal application for the 2004 Olympic Games, the city government started to increase its ownership of land within the district using municipal public funds. With the exception of Sickla Kaj (the first sub-district to be built) the city government secured ownership of the entire eco-district site at Hammarby Sjöstad. Given the prime lakeside location of the site, the city authority was able to offset the decontamination costs of the site with the higher market prices that development on the site offered. As a consequence, land price was part of the negotiations and could be used to compensate the developers for the extra costs associated with land decontamination.

Table 7.1 Key operational goals of Hammarby eco-district
Source: City of Stockholm 1996

Category	Target
Energy	Total residential energy consumption (including energy from renewable energy sources such as solar) to be below 60 kWh/m², of which electricity should not exceed 20 kWh/m².
Transport	80% of commuters to use public transport, walk or cycle.
Land Use	100% of all developed land to be recreated within and adapted to the district.
Waste	Recyclable and waste material to be reduced by 20% in weight.
Water	Water consumption per person to be reduced by 50% compared to the average water use in new housing in the inner city area. All storm water from roads and parking areas to be purified.
Building materials	Recoverable materials to be used as far as technologically and economically possible.
Soil decontamination	Areas of contaminated soil to be sanitised prior to development to such an extent that they no longer present a risk to public health or to the environment.
Noise/ disturbances	All housing to have a noise-free side, where the equivalent noise level outside the window does not exceed 40dB.

The city government also appointed a project team, with the aim of consulting and informing stakeholders in order to increase the likelihood of achieving the environmental objectives of the project (Johansson and Svane 2002; Svane, Wangel et al. 2011). The team comprised representatives of the city-owned companies and the city administration, who negotiated with developers through development contracts. The city government, through the project team, had responsibility for commissioning the development consortia for the twelve sub-districts of Hammarby Sjöstad (CABE 2011).

In 1996, the City of Stockholm adopted Hammarby Sjöstad's environmental programme. The document served both as a planning tool to coordinate the development and to help create consensus on how to achieve the environmental targets (Pandis and Brandt 2011).

7.2.3 Royal Seaport eco-district: public private partnership

Building on the lessons from Hammarby Sjöstad, the city authorities have embarked on a new eco-district at Stockholm Royal Seaport. The site is a former container port, oil depot and gasworks covering 236 hectares and now one of the largest urban development projects in Europe. It also represents an ambitious demonstrator project for green technology and innovation. Royal Seaport will integrate residential and commercial activities, ranging from port trade to IT, finance and media companies. Using modern, sustainable architecture and planning, the aim is to combine 12,000 household dwellings, 35,000 office spaces and 600,000 m2 of commercial areas with parks and green open spaces (Ahlberg No date; City of Stockholm No date).

The vision is for Royal Seaport to become "a world-class environmental urban district". The vision is underpinned by three overarching goals: 1) Royal Seaport will be adapted to future climate change; 2) by 2020, CO_2 emissions will be below 1.5 tonnes per capita; and 3) by 2030 the district will be fossil fuel free (Ahlberg No date). The city government has also specified five focus areas – energy, transport, climate adaptation, eco-cycle solutions and lifestyle – and outlined more specific operational goals for each. These include limiting residential energy use to 55kWh/m2 per year (of which electricity would contribute no more than 15kWh), and limiting water consumption to 100 litres per person per day (for other operational goals see Table 7.2).

[9] Cited by Pandis, S. and N. Brandt (2011). "The development of a sustainable urban district in Hammarby Sjöstad, Stockhol, Sweden?" Environment, Development and Sustainability 13(6): 1043-1064.

Table 7.2 Focus areas and operational goals at Stockholm Royal Seaport
Source: Ahlberg No date

Category	Target
Energy	• Energy consumption to be below 55 kWh/m²/year, of which only 15 kWh/m²/year would represent electricity consumption. • At least 30% of electricity consumed to be locally produced.
Transport	• Well-connected public transport links to be available. • Residential parking spaces to be prepared for recharging stations for plug-in hybrid vehicles. • Parking spaces to accommodate 2.2 bicycles per apartment, and 0.5 cars per apartment.
Climate adaptation	• The district to be equipped with "gas and water proof basements". • Water infrastructure to be capable of "handling large amounts of rain". • Storm water to be reused. • Buildings to have green roofs and yards, and vegetation for cooling. • House facades/windows/roofs to be climate adapted and capable of retaining heat during the summer.
Eco-cycles	• Water consumption to be limited to 100 litres per person per day. • Organic waste and urine to be recycled. • Waste disposal to be carried out at vacuum stations for three fractions of waste: paper, plastic packaging and residual waste.
Lifestyle	• All flows in and out of each apartment to be measured: heat, water, electricity, waste, etc.

The area will be supplied with a smart grid, benefit from a biofuel combined heat and power (CHP) system - including recovery of waste and heat - and use on-site renewable micro-generation of electricity.

In 2009, Stockholm Royal Seaport was granted funding from the Clinton Climate Initiative and the US Green Building Council under the Climate Positive Development Programme. The Programme funds projects worldwide with the aim of creating a model for cities that are pursuing environmentally sustainable growth (Clinton Climate Initiative No date).

Royal Seaport also received a grant of SEK1.6 million (around US$240,000) from the Delegation for Sustainable Cities, an initiative of the Swedish government aimed at promoting sustainable urban development across Sweden (Delegation for Sustainable Cities No date).

Building on the experience of Hammarby Sjöstad, Royal Seaport is envisaged as a test-bed for the most innovative solutions in sustainable urban planning. The Stockholm Royal Seaport Innovation Centre is an arena where stakeholders (the city government, private companies, research institutions and universities) can network and exchange knowledge and ideas on the research projects and technologies demonstrated in the eco-district. Four overarching projects are being undertaken to stimulate innovation (see Table 7.3): (a) Smart Communication; (b) Smart Grid; (c) Smart Waste Collection; and (d) Smart ICT for living and working in Stockholm.

These four innovation projects are directly linked to the five focus areas of the district: energy, transport, climate adaptation, eco-cycle solutions and lifestyle. The intention is to use the Royal Seaport as a pilot district where these initiatives will be demonstrated and tested before commercialisation. The city government also organises regular seminars and workshops with architects and developers where technical solutions for achieving the environmental targets are proposed.

Table 7.3 R&D projects at the Stockholm Royal Seaport Innovation Centre
Source: City of Stockholm

Project	Main partner	Focus area	Specifications
Energy	Ericsson	Energy, transport, eco-cycle solutions and lifestyle	Building the ICT infrastructure which will serve as the basis for Royal Seaport's smart grid and city-management systems.
Smart Grid	Fortum	Energy and lifestyle	Implementation of an urban smart grid in the district, which will integrate renewable energy supply with energy efficiency on the demand side.
Smart Waste Collection	Envac	Eco-cycle solutions	Development of a vacuum waste collection system, which will process three fractions of waste: paper, plastic packaging and residual waste.
Smart ICT for Living and Working in Stockholm	Swedish ICT	Lifestyle	Development of enablers for a generic ICT infrastructure that actively assists in reducing investment, climate and environmental costs.

7.2.4 Enterprise: innovation and business growth

While Sweden places a strong emphasis on R&D, it also recognises that research alone will not lead to sustainable growth and that there are a number of other barriers that prevent green technologies and innovative business ideas from reaching the market and becoming internationally competitive (Swedish Ministry of Education and Research 2012). The national government promotes business growth through the funding of technology incubators and business clusters that facilitate the commercialisation of new products and help new companies develop a market presence. Institutions that promote inward investment into local green technology companies and focus on exporting Swedish green goods and related expertise also play a role.

Vinn Nu is a Vinnova/Energy Agency joint initiative that provides follow up funding and support to start-ups that base their activities on proven R&D results, with chosen companies eligible for up to SEK 300,000 (US$50,000). This funding is aimed at supporting companies to prepare and clarify commercially interesting development projects at an early stage, find subsequent funding, scale up their operations and increase their international competitiveness. Companies in the environmental technology sector are eligible for this funding.

The Swedish Industrial Development Fund provides loans and equity for export-oriented SMEs that have already developed products and launched sales, but need additional capital to expand. In recent years, the Fund has invested SEK400 million (US$62 million) in the cleantech industry, with plans to expand this support by a further SEK300 million (US$48 million) to accelerate growth in this sector (SWENTEC 2011).

Within Stockholm, the Stockholm Cleantech Association, part of the Stockholm Environmental Technology Centre (SMTC), is a business network that promotes green innovation in the Greater Stockholm Region by encouraging cooperation between businesses, research bodies and the public sector. The Association is run by the Swedish Environmental Research Institute (IVL) in close collaboration with the Royal Institute of Technology (KTH), Stockholm Business Region and the Stockholm Business Alliance. SMTC offers seminars, networking events and support with research and financing for new businesses in the sector (Stockholm Environmental Technology Centre 2013).

The majority of Swedish incubator projects are linked to universities and public research centres and many receive joint funding from both government and industry. One of the most important national institutions in this area is Innovationsbron, owned by the Swedish Government (84%)

and the Swedish Industrial Development Fund (16%), and involved with 19 incubator projects across the country. Innovationsbron's main goal is to supplement the market in supporting projects and companies in the early stages of the development process, when accessing private funding is often challenging (Innovationsbron 2013).

Tillväxtverket (previousy Nutek), Sweden's central Agency for Economic and Regional Growth, focuses primarily on financing, information and guidance for start-up companies and provides targeted support for incubators with the objective of facilitating sustainable enterprise and entrepreneurship throughout Sweden. Tillväxtverket also supports private company incubators, spending a total of SEK 10 million (US$1.5 million) in 2009. The total innovation budget of the Agency for 2010 was SEK52 million (US$8 million), with up to 50% earmarked for environmental-driven market development (Melin, Håkansson et al. 2011).

Of the more than 40 incubator projects active in Sweden, 13 have a strong focus on green technology, although only one incubator, Cleantech Inn Sweden, supports green technology companies exclusively (SWENTEC 2011). Within Stockholm, the most important business accelerator is STING (Stockholm Innovation and Growth), a Kista-based non-profit incubator that is owned by the Electrum Foundation and co-financed by Innovationsbron, KTH and several private sector partners. STING provides business development, financing and networking to start-ups to help them succeed in the global market place. STING's goal is to support the development of 12 new export-oriented technology companies per year, with a particular focus on cleantech development. STING also runs a dedicated venture capital fund, STING Capital (STING 2013).

In its 2011 Environmental Technology Strategy, a key priority of the Swedish government was to ensure that Sweden becomes a global green technology pioneer. To achieve this, the government is investing SEK 400 million (US$62 million) in clean tech between 2011 and 2014, with a particular emphasis on strengthening the export potential of Swedish companies and attracting further foreign businesses and investment to promote growth in the sector (Government Offices of Sweden 2011).

To strengthen their commitment to export-led growth the government established Business Sweden in January 2013 by merging the Swedish Trade Council and Invest Sweden. Business Sweden is a public private partnership between the Ministry for Foreign Affairs and the Swedish Foreign Trade Association and is now the principal organisation supporting the global expansion of Swedish industries. Business Sweden has a special network for environmental technology companies that aims to simplify the export process for SMEs in the sector and promote inward investment (Business Sweden 2013). The network today includes more than 700 companies that are supported through consultancy services, skills development, market surveys, visits by foreign delegations, trade fairs and matchmaking with potential buyers and investors overseas (Government of Sweden 2012).

SymbioCity is a marketing and communications platform run by Business Sweden that is dedicated to exporting Swedish knowledge in environmental technology and sustainable urban planning. Within Stockholm, SymbioCity helps companies involved in the development of eco-districts market their skills and knowledge overseas (SymbioCity 2012). Further support for Stockholm based cleantech companies comes from Stockholm Business Region Development, the official investment promotion agency of the city that is working on marketing Stockholm as an international business destination and has made cleantech one of its focus areas (Stockholm Business Region Development 2012b).

7.2.5 Green procurement

As discussed in Chapter 2, governments at all levels represent powerful consumers of goods and services, and as such, public procurement can be used as a policy instrument for shaping markets for green technology. The City of Stockholm's spending on procured goods and services amounted to SEK 18.1 billion (US$ 2.86 billion) in 2012. This included SEK 2.7 billion (US$0.4 billion) on capital spend – mainly construction and building repairs – and SEK 15.4 billion (US$2.4 billion) on operating costs. As in other cities, operating procurement covers a broad range of spending, including education, care for the elderly and families, housing, trade and industry, leisure and cultural activities among others. Consequently, this represents a deep and extensive market with potential for green goods and services.

Although the municipal authority does not currently have a comprehensive policy on green procurement (pers. comm. City of Stockholm), the City of Stockholm's Environment Programme 2012-2015 includes a number of targets that relate to the purchase of green goods, services and public works (Box 7.1). However, there are few details over how these targets will be delivered. Furthermore, as discussed later in this chapter, opportunities exist for extending the city's green public procurement policy, both through the authority's own purchasing power and through municipal schemes to promote green procurement in the private sector.

Box 7.1. Targets for green procurement in the City of Stockholm

The City of Stockholm's Environment Programme 2012-2015 includes various targets for green public procurement. These include:

- Municipal vehicles owned or leased by the City of Stockholm's municipal committees and boards will be environmentally certified. Hybrid and biofuel vehicles should be powered by at least 85% alternative fuels. When contracting external transport services, at least 55% of these should be delivered by green vehicles.
- Electricity purchased for municipal activities will meet the requirements of eco-labelling following the guidelines of the Swedish Environmental Management Council: 'limited climate impact', 'clean air' and 'natural acidification-only'.
- The City's committees and boards will try to minimize the generation of municipal waste through their procurements; for example, by demanding packaging that produces the least waste possible.
- The City of Stockholm owns a great proportion of land and property within the city.
- The City's committees and boards regularly purchase building, construction, retrofitting and maintenance works, which should follow criteria set by the Environmental Evaluation of Building Materials, BASTA, Svaven, Bra Miljöval or EU Ecolabel. This also applies to the designation of land or the signature of development contracts.
- Dangerous or polluting materials such as PVC or copper taps will be avoided in new construction. When these substances are present in existing facilities, an effort to reduce emissions related to the use of the building should be made.
- The City of Stockholm will strive to reduce energy use in new builds to 55 kWh/m^2 in order to ensure that targets on new construction set by the EU Commission from 2018 are met.
- Through energy efficiency measures, energy consumption resulting from the City of Stockholm's operations will be reduced by at least 10% (with respect to 2011 levels) by 2015.
- The City of Stockholm's committees and boards should avoid the use of goods and chemicals considered dangerous for the environment. Procurement both by the city authority and by services contracted by the city authority should follow criteria set by the Swedish Environmental Management Council, Svaven, Bra Miljöval and EU Ecolabel.
- At least 25% of food purchases by the City of Stockholm will be organic.

7.3 Impacts

7.3.1 Research and innovation

As discussed in Chapter 4, Stockholm is home to a large number of first class research institutes. This is in large part due to substantial investments in research by the Swedish Government over the past decades, both through public-funded universities as well as through various grants for public-private research projects. Major public research institutes in Stockholm with environmental and technology programmes include the Royal Institute of Technology (KTH), Stockholm University, the Swedish Environmental Research Institute (IVL) and Stockholm Environment Institute (SEI) (see Box 7.2).

Box 7.2 Stockholm's public research base

Stockholm is home to several world-leading research institutions that play a central role in maintaining the city's status as an important research and innovation hub. Most of their funding comes from the Swedish government, which invests heavily in public education and research.

Royal Institute of Technology (KTH)
KTH, which is almost entirely funded by the Swedish Government, is the largest technical university in Sweden with over 15,000 students. The university's education and research branches are spread across nine schools covering areas such as natural science, engineering, architecture, economics, urban planning and environmental technology. One third of Sweden's technical research and engineering education capacity at university level is provided by KTH and the university hosts a number of national and international research projects within its various dedicated research centres. The majority of the schools at KTH are involved in green technology and sustainability research projects, including work on low-carbon energy systems, alternative fuel vehicles, sustainable ICT, and energy efficient buildings. In 2011, KTH Sustainability Council (KTH-S) was formed to enhance the focus on the environment and sustainable development throughout the university's research and education programmes.

Stockholm University
Stockholm University is regularly ranked among the top 100 higher education institutes in the world and educates more than 60,000 students in subjects spanning science, the humanities, social science and law across 69 departments and centres. The university receives 69% of its funding from the Swedish government, with an additional 23% coming from grants and other external funding and the remaining 8% covered by fees and private contributions.

The University covers a wide range of research subjects, only some of which are related to the environment and sustainability. The university has research projects in environmental science, policy and law and is also home to the Stockholm Resilience Centre and the Bert Bolin Centre for Climate Research.

Swedish Environmental Research Institute (IVL)
IVL is an independent, non-profit research institute that has worked on the development of solutions to environmental problems since 1966. IVL is owned by a foundation jointly established by the Swedish Government and Swedish industry, with the government contributing 50% of the funding. IVL's research covers six core areas: climate and energy; air and transport; water; resource-efficient products and waste; sustainable building; and sustainable production. IVL works on research projects both in Sweden and internationally, often in collaboration with other research institutes and universities.

Stockholm Environment Institute (SEI)
SEI was established in 1989 by the Swedish Government and is internationally recognized for rigorous and objective scientific analysis in the environmental field. Its research focuses on sustainable development, particularly the relationship between science and policy.

R&D investment has also enabled the development of sector specific research clusters: Stockholm's strong ICT sector plays a vital role in furthering research into smart and sustainable communications technologies that are accelerating the city's transformation to a low-carbon economy. Due to sustained public and private investment, Kista Science City today has the highest concentration of ICT researchers in northern Europe. More than 1000 researchers are working on a wide variety of collaborative R&D projects, including sustainable ICT and cleantech (see Box 7.3). Kista has fostered strong links between academia, industry and the public sector, increasing agglomeration effects and making it a highly productive business cluster. In total, there are more than 65,000 people working across 8,500 companies at Kista, of which more than a third are employed in ICT (Electrum Foundation & Kista Science City AB 2011).

Box 7.3 Swedish ICT – part of the Kista cluster

Swedish ICT is an example of the thriving innovation at the Kista ICT cluster in Stockholm. The group brings together several research institutes, including Acreo, Interactive Institute, SICS and Viktoria. The primary objective of Swedish ICT is to promote sustainable growth in Sweden by turning research into concrete innovations that contribute to increased competitiveness and business development. Among others, the group is leading the 'Smart ICT for living and working in Stockholm' project at Stockholm Royal Seaport Innovation.

The Swedish government owns 60% of Swedish ICT through RISE, the government's holding company for ownership of Swedish industrial research institutes. The other 40% is owned by two national trade associations, FMOF and FAV. In 2011, the group employed a total of 413 people and recorded a turnover of SEK429 million (US$ 68 million).

Acreo is an independent non-profit research institute that focuses primarily on R&D and business development in the area of optics, electronics and communication technologies (including broadband). Acreo currently employs 145 people. Since it was founded in 1999, the institute has spun off 17 new companies which now employ more than 500 people, and transferred over 100 high skilled experts to the industry.

Interactive Institute is a non-profit IT and design research institute that works on developing new research areas, concepts, products and services, and provides strategic advice to corporations and public organisations through commissioned work, licence agreements and various spin-off companies. The institute's research includes interaction design, visualization and user behaviour. Originally founded in 1998, the institute today employs 54 people and is wholly owned by Swedish ICT.

Swedish Institute for Computer Science (SICS) is another leading non-profit research organisation focused on applied information and communication technology to help Swedish industries increase their competitiveness. SICS works in close collaboration with Swedish government organisations, the wider research community and the business sector, both within Sweden and internationally. SICS is part of three Excellence Centers funded by Vinnova: the SICS Center for Networked Systems (CNS), the Mobile Life Center, and the Center for Wireless Sensor Networks. In total, 140 researchers work for SICS and the institute hosts an additional 30 researchers from KTH, as well as consultants and students who use the facilities for their research.

Viktoria was founded in 1997 with Ericsson and Volvo as its main partners. The research institute works in close collaboration with local industries in West Sweden, primarily on helping the Swedish automotive and transport industries to achieve sustainable development and growth. Viktoria employs around 40 people who work across four core application areas: cooperative systems, digitalisation strategy, electro-mobility and sustainable transport. Much of this work is focused on IT applications and services based on in-vehicle computing and communication platforms aimed at improving road safety and driving efficiency.

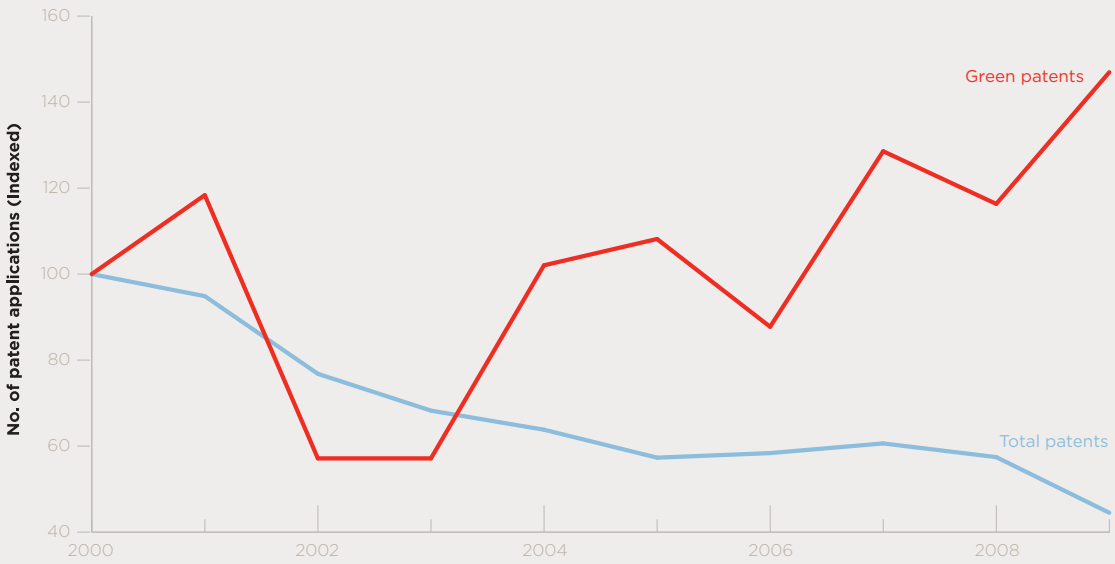
Sources: Swedish ICT Research 2011; Swedish ICT Website 2012

Support for R&D in Stockholm, and Sweden more generally, has contributed to the city's high levels of innovation. As discussed in Chapter 4, Sweden ranks first in the European Union's Innovation Union Scoreboard, and ranks second behind Switzerland in the Global Innovation Index, with a significant proportion of research and innovation taking place in Stockholm.

Much of this success is due to research and innovation in the ICT and life sciences sectors. However, there is evidence that green innovation has also increased over the last decade, with applications for green technology patents from companies based in Stockholm County being 40% higher in 2009 than in 2000 (Figure 7.1). This is despite a 50% fall in total patent applications over the same period. As a result, the proportion of green technology patent applications has risen from 3% of total patents in 2000 to 10% in 2009 (Figure 7.2). This is substantially higher than for Sweden as a whole, where green technology patent applications grew from 3% to 5% over the same period. This suggests that even with clusters of green innovation in other Swedish counties such as Skåne and Västra Götalands, Stockholm County is the primary hub for green innovation in the country.

Figure 7.1 Green patent applications from companies based in Stockholm County, 2000-2010

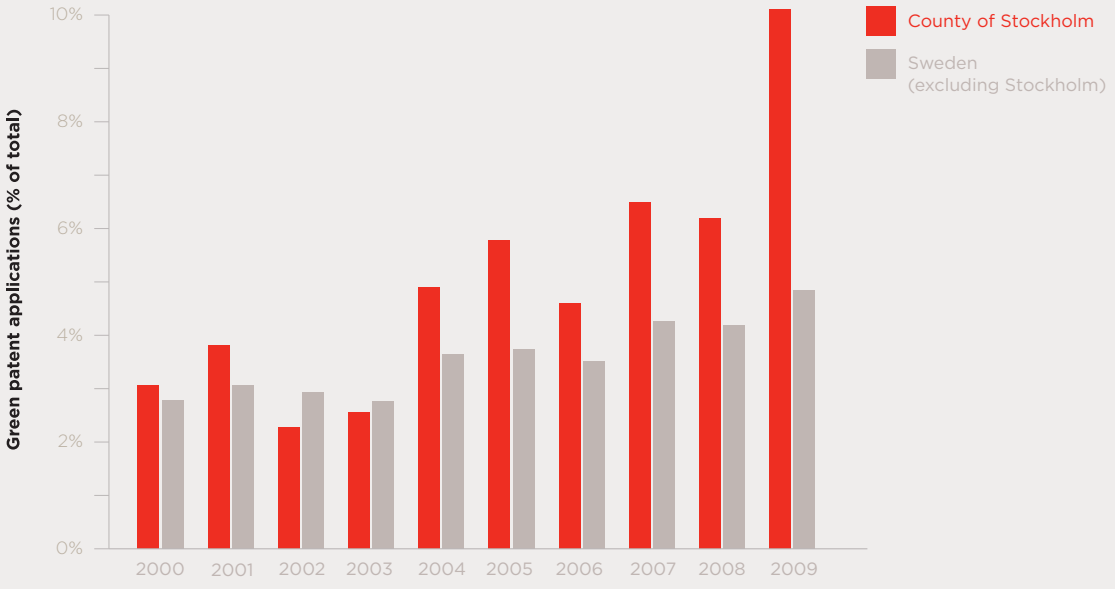
Variables are indexed: year 2000 = 100.



Source: City of Stockholm 2012h

Figure 7.2 Green patent applications from companies based in Sweden and Stockholm, 2000-2009

Figures show the proportion of green patent applications as a percentage of total patent applications.



Source: City of Stockholm 2012h

Applications for green technology patents are likely to be the best quantitative proxy for innovation currently available. Unlike application rates, levels of patents granted are sensitive to backlogs in processing procedures, while application rates also capture a more accurate picture of the generation of ideas – rather than simply their formal acceptance. Nonetheless, patent applications are not an entirely accurate measure of innovation. Today's rapid rate of technology obsolescence may mean that companies are less likely to apply for a patent on shorter lived products. Even when a patent is sought, Swedish multinationals may apply directly to their country of operation or to the European Patent Office (EPO). This may explain the trend of declining patent applications to the Swedish Patent and Registration Office (PRV). Furthermore, their classification does not necessarily capture new technologies that have indirect green impacts but which are developed for other primary objectives (see Box 7.4 for green patent classification).

Box 7.4 OECD Classification of environment-related technological patents

Technological patents that fall under the following fields are categorised as environment-related patents by the OECD (OECD 2011b).

- **General environmental management**: air pollution, water pollution, waste management, soil remediation.
- **Energy generation from renewable and non-fossil sources**, including: wind, solar, geothermal, hydro, marine, biomass and waste.
- **Combustion technologies with mitigation potential**, including: combined cycles, combined heat and power plants, heat utilisation in waste combustion/incineration and efficient combustion/heat usage technologies.
- **Technologies specific to climate change mitigation**: capture, storage, sequestration or disposal of greenhouse gases.
- **Technologies with potential or indirect contribution to emissions mitigation**: hydrogen production (from non-carbon sources), distribution and storage; energy storage and fuel cells.
- **Emissions abatement and fuel efficiency in transportation**, including: integrated and post-combustion emissions control in internal combustion engines, electric and hybrid vehicles and fuel efficiency.
- **Energy efficiency in buildings and lighting**: insulation, heating and lighting.

Sources: OECD 2011b

7.3.2 Eco-districts: demonstrators of innovation

The Hammarby Sjöstad eco-district is now 75% complete, with around 18,800 residents occupying 8,250 apartments (Interview Martin Skillbäck 2012). In terms of waste, wastewater and transport emissions, the project has broadly been an environmental success. Overall, 95% of the waste from the district is combusted at the local Hogdalen CHP plant, utilising 90–100% of the energy content of the waste (Pandis and Brandt 2011). Organic waste is used for the generation of biogas.

Wastewater is treated at the local Henriksdal treatment plant, where biogas is also generated from the extracted wastewater sludge. The purified wastewater passes through Hammarby Sjöstad's thermal power station, where the heat is regenerated as district heating. In terms of transport, a study in 2007 showed that 79% of commuter residents of Hammarby Sjöstad walked, cycled or used public transport – broadly meeting the 80% target set for the eco-district (Pandis and Brandt 2011). More recent evidence was not available. The model developed at Hammarby Sjostad, which integrates energy and resource flows to maximise the overall efficiency of the district, was named the 'Hammarby Model' and has served as the basis for the development of the SymbioCity initiative for green technology export promotion (GlashusEtt 2011).

Meeting Hammarby Sjöstad's energy efficiency goals for buildings has been less successful. The original target was to limit the total supplied energy to 60kWh/m2. However, the goal was perceived by developers at an early stage as unrealistic and was adjusted to 100 kWh/m2 in 2005 by the city (Pandis and Brandt 2011). As a result, levels of energy use at Hammarby Sjöstad are similar to those in comparable districts in Stockholm (Interview Jan-Ulric Sjögren 2012).

Nevertheless, Hammarby Sjöstad has acted as a useful learning exercise for the city government, which is now working more actively with developers and researchers on methods to reach the energy goal of 55 kWh/m2 at Royal Seaport and new developments across Stockholm (City of Stockholm ; City of Stockholm 2012m). "*Hammarby Sjöstad was a great success in many ways, but we're not satisfied with the energy consumption so far. We've learned a valuable lesson from that - at Royal Seaport we back up the new energy targets with contractual clauses, a technical working group and impact assessments.*" Martin Skillbäck, Project Manager, Development Department City of Stockholm

The impacts of Stockholm's eco-districts on innovation have been wide-ranging. Hammarby Sjöstad has provided opportunities to 30-40 developers, with incentives to collaborate with clean technology companies to meet the targets set out by the City of Stockholm (Interview Martin Skillbäck 2012). Green technology companies themselves have also benefited, from those producing control systems to solar cell companies to consultancies (Interview Jan-Ulric Sjögren 2012). In addition, those interviewed in the private sector report that new technologies and skills developed for Hammarby Sjöstad are now being rolled out to wider markets in Sweden and abroad (Interview Marcus Svensson 2012; Interview Matilda Gennvi Gustafsson and Rohan Richards 2012).

Developers and other companies report that they have also benefited from Stockholm's brand as a green leader, and from participating in the Hammarby Sjöstad project because of its large and continued exposure internationally as an example of best practice (Interview Marcus Svensson 2012; Interview Matilda Gennvi Gustafsson and Rohan Richards 2012). Stockholm is capitalising on the export potential of ideas and technologies developed for eco-districts through Symbiocity, a Swedish Trade Council agency (SymbioCity 2012).

The environmental and innovation benefits of Stockholm's eco-districts have required substantial investment. For example, around SEK6bn to 7bn (around US$0.9bn to 1.1bn) has been invested in Hammarby Sjöstad to date by the City of Stockholm, representing about 15% of the total investment. The costs of decontaminating the land were particularly high. However, the city authority is receiving a partial return through land leasing and selling. In the words of Martin Skillback, Hammarby Sjöstad's project manager:

Based on interviews with the authority, selling the land at the market price - around 14,000 SEK/m2 (around US$2,000) currently - should result in the project being close to break even on the investment in public finance terms. If realised, the wider economic, environmental and social benefits for the city will have been achieved at relatively low cost. However, a rigorous cost-benefit analysis of the Hammarby Sjöstad project is recommended.

Whether similar benefits could have been delivered more efficiently is not within the scope of this report. However, it is worth noting that the costs of new technologies developed and demonstrated at Hammarby Sjöstad should fall considerably if deployed more widely. This is because much of the upfront investment needed to travel the learning curve in testing and demonstrating the technologies will not be required in future. Whether local firms capitalise on rolling out their innovations across the city, nationally and internationally remains to be seen. Certainly, government support for export promotion (e.g. through SymbioCity) should benefit these companies and products.

It is also worth noting the City of Stockholm's success at leveraging other sources of public and private finance. The funding body for Hammarby Sjöstad comprises the City of Stockholm, Stockholm Transport, the National Road Administration and private investment. In addition, major funding allocations distributed by the City of Stockholm were provided by the Swedish Government's *Local Investment Programme* (LIP).

As Royal Seaport is in its early stages of development, it will be several years before its green economic impacts can be assessed. However, the eco-district has substantial business growth potential as an innovation hub. The Royal Seaport Innovation Centre has already attracted major

multinational companies with substantial inward investment potential, including Ericsson, ABB, Fortum and Electrolux – companies with a combined global turnover of around US$ 110 billion in 2011 (see Box 7.5).

Box 7.5. Stockholm Royal Seaport: a view from the private sector

The City of Stockholm has succeeded in attracting long-term investment in the Stockholm Royal Seaport and its Innovation Centre from major companies such as Ericsson, Fortum, ABB and Electrolux. The following extracts from the annual reports of Ericsson and Fortum highlight the perspective from the private sector.

Ericsson
"The Stockholm Royal Seaport project is initiated and driven by the City of Stockholm and aims at developing a former industrial and port area into an attractive and sustainable environment for living and working… The tough climate-positive target influences both core infrastructure performance as well as sustainable lifestyle ambitions. It will require a great deal of technological innovation, and collaboration across classic disciplines for urban development. ICT Solutions Ericsson engaged with the City at the earliest planning stages and supported development of an approach for taking advantage of ICT across several dimensions of the project. This has now evolved into a formal partnership in the Stockholm Royal Seaport Innovation Center, with our active participation in cross-sector innovation in several areas of the new city district area development.

So far, progress has mainly focused on optimizing the core infrastructure of the city area, with a focus on energy. With our early engagement, we have established close, hands-on collaboration with the power industry to implement a full smart-grid solution in the area, and with the car industry to develop solutions for electric vehicle charging. We are now exploring additional concepts for smart power usage in the public domain, for use in street lightning, etc. Ericsson is also driving research and development for mobility solutions and lifestyle applications in order to improve daily life in areas such as travel and transportation, remote working, and efficiency of city-based businesses."

Fortum
"Fortum engages in several smart grid-related R&D and demonstration projects… In Sweden, Fortum is contributing to the development of smart grids and smart heating and cooling solutions for the Royal Seaport of Stockholm. According to a pre-study conducted in 2011, the various parts of the energy system can be connected in a way that enables the consumer to participate more actively in the electricity market… The pre-study was managed by Fortum in a consortia consisting of 13 different partners. The project then proceeded with planning for the next phase of implementation and tests including partner negotiations and financing."

Sources: Ericsson 2011; Fortum 2011

The eco-district is also set to become a new hub for Sweden's financial industry, with Nasdaq agreeing to be one of the founding private sector partners in the district, while development of cruise and ferry transport should boost tourism and regional business links (City of Stockholm). So far, the first developments at Royal Seaport have involved 25 developers and almost the same number of architects.

Much of the successful implementation of eco-districts in Stockholm has been a result of effective public private partnerships (PPPs), particularly between the city, private sector and research institutes such as the Royal Institute of Technology (KTH). These partnerships have been formulated at different levels. For example, at a high level, Royal Seaport was originally created as a partnership between the City of Stockholm and six major companies: Nasdaq OMX (financial services), Tallink Silja (passenger shipping), Fortum Sverige (energy), Vasakronan (property), Länsförsäkringar (insurance) and Envac (waste). Since then, other companies such as Ericsson, ABB and Electrolux have also joined (City of Stockholm 2012f).

At the same time, partnerships at lower levels have been forged to tackle specific technological problems or to foster innovation in particular fields. For example, the City has formed a small partnership of four to five representatives to work on the detail of how to measure the City's new energy target of 55 kWh/m2.(Interview Jan-Ulric Sjögren 2012). The group includes a City-owned real estate company, a private sector building company, the City department responsible for selling land to developers, the environment department, and the Royal Institute of Technology.

Interviews with partners suggest that the City of Stockholm's commitment to the PPP model is providing business partners with the confidence to invest. Eco-districts require a top-down vision to draw together the broad range of objectives, policies and technologies into a focused direction. In addition, master planning and a long-term strategic commitment to eco-districts by the city provide business with the confidence to invest in medium to long-term innovation programmes. Anecdotal evidence suggests that Stockholm is providing an effective vision and commitment for business confidence: *"To get the subsidy injection for innovation is important, but more important is that we see the City of Stockholm really has a long-term commitment. For us to engage from a research perspective, we must know this is five to ten years."* Matilda Gennvi Gustafsson, Sustainability Director, Ericsson and Rohan Richards, Senior Strategy Consultant, Ericsson

Ericsson goes on to say: *"As individual companies, it simply wouldn't be worth tackling these challenges in the current market. But by providing clear targets, a firm long-term commitment, and a forum to combine the brains and know-how of our partners, the City of Stockholm has given us the right conditions for all of us to invest - and get a return in the future."* Matilda Gennvi Gustafsson, Sustainability Director, Ericsson and Rohan Richards, Senior Strategy Consultant, Ericsson

7.3.3 Green business

As well as being a hub of environmental research and green innovation, Stockholm is home to a range of businesses in the green sector. In Sweden, Stockholm County has the highest turnover in the green sector, accounting for SEK 34.1 billion (around US$ 5.3 billion) in 2010 (using the Environmental Goods and Services (EGS) classification). Stockholm is very closely followed by Västra Götaland County with a turnover of SEK 31.4 billion (US$ 4.9 billion) and Skåne County with SEK 21.6 billion (US$ 3.4 billion).

Despite Stockholm's leading position in Sweden, the green sector remains a small niche within the overall regional economy, representing between 3.1 and 3.4% of the County's GRP (Statistics Sweden 2012, years 2003 to 2008). Furthermore, the number of firms in the green sector represents only 1% of the total. Although the EGS classification does not capture the full scale of business growth associated with green technologies, it is the best proxy currently available for the wider green economic sector.[10] However, it is not currently possible to compare Stockholm's performance against European benchmarks. In Western Europe, the size of EGS ranged from 0.4% of GDP in Finland (where only renewable energy production and energy saving measures are included) to 11.5% of GDP in Austria (the only country, for example, to include R&D activities for resource management within the EGS classification).

In terms of growth, the green sector in Stockholm appears to be no higher than average compared to the rest of the economy. Turnover grew by 16% in Stockholm County between 2004 and 2009; an average annual growth rate of 3.0%. Unfortunately, direct comparisons with the county's total economy over this period were not possible as total GRP data were not available for 2008 and 2009. However, data at the city level were available for the growth in the number of businesses. The number of green firms grew by 22.7% in the City of Stockholm between 2004 and 2009; an average annual growth rate of 4.2%. This compares to growth of 23.7% in total firms over the same period, representing 4.3% average annual growth.

Employment in the green sector shows a similar picture of average growth. Employment in the sector grew by 9.9% in the City of Stockholm between 2004 and 2009; an average annual growth rate of 1.9%. This compares to growth of 10.1% in total employment over the same period, also representing around 1.9% average annual growth.

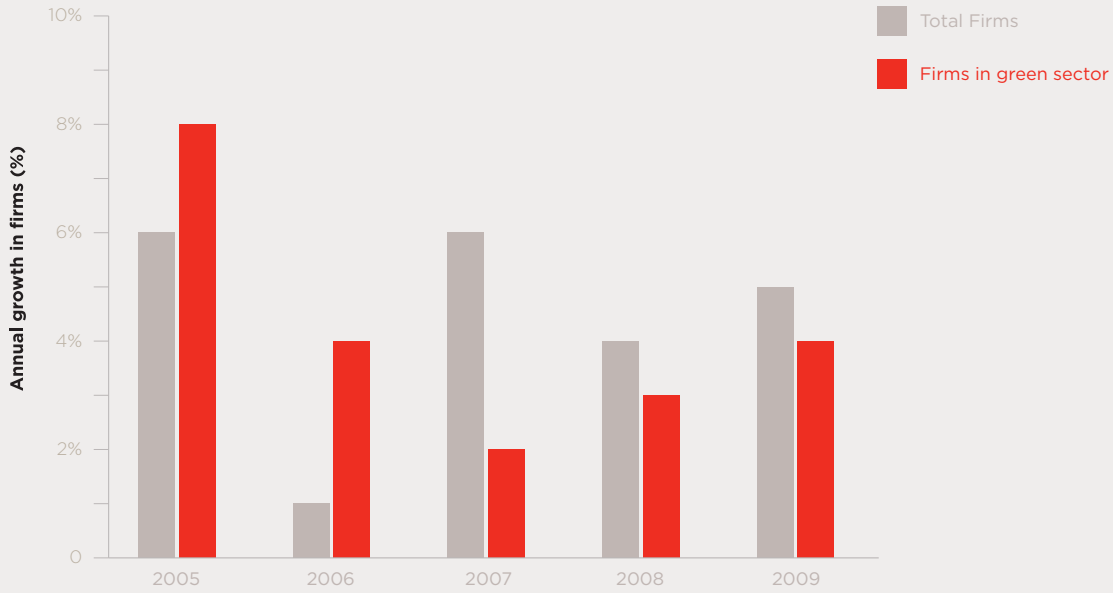
It is also worth discussing growth over the last three years of available data (2006/07, 07/08 and 08/09). Over this period, the number of green firms grew more slowly than overall business growth in the City of Stockholm (Figure 7.3). At the same time employment was more volatile, with higher than average growth in 2006/07 and 07/08, followed by a contraction of jobs in 08/09 as the global downturn began (Figure 7.4). Data for subsequent years is not yet available. This suggests that green technology firms are not growing in line with the wider economy despite previous policy support provided by the City of Stockholm.

Furthermore, given that employment increased more rapidly than the number of firms between 2006 and 2008, much of the employment in the city's green sector may have been due to recruitment by larger firms, rather than significant increases in the number of start-ups and

[10] A comprehensive evaluation of the "green sector" is challenging as no standard classification exists. In this chapter, we follow Statistics Sweden in using Eurostat's definition of the Environmental Goods and Services (EGS) sector unless otherwise stated. However, this definition does not include companies whose prime objective is not environment protection or resource management. For example, businesses that cover sustainable transport or companies that deal with renewables but also other energy sources are not included in this sector. Consequently, the EGS sector represents only part of the wider green economic sector.

micro-enterprises. Finally, jobs in the green sector appear to have been more sensitive to the global downturn. Overall, the less than average performance of firms in the green sector over recent years is an area that the City of Stockholm should investigate further.

Figure 7.3 Annual growth of green firms in the City of Stockholm 2005-2009



Source: City of Stockholm 2012g.

Figure 7.4 Annual growth of green sector employment in the City of Stockholm 2004-2009

Source: City of Stockholm 2012g.

Other evidence suggests that the green sector in Sweden more generally is not meeting its full potential. Based on research in the UK, while global growth in the sector was 3.7% between 2009/10 and 2010/11, growth in Sweden was only 2.2% (Department for Business Innovation and Skills 2012).[11] Countries that have witnessed high growth during this period include the Philippines (39%), Ukraine (16%), Pakistan (15%), the Czech Republic (13%), Saudi Arabia (13%), Turkey (13%) and Brazil (12%). While higher growth rates would be expected in countries starting from a lower base than Sweden, comparisons of absolute growth figures in the sector suggest Sweden could do more to strengthen this sector. For example, while turnover in the green sector grew by US$460m in Sweden between 2009/10 and 2010/11, the sector grew by US$1 billion in Norway, US$8.4 billion in the UK, US$11 billion in the Philippines and US$16 billion in Brazil (Department for Business Innovation and Skills 2012). Much of this may be due to high proportions of international climate finance (as donors, traders or recipients); however, it would be worth investigating further.

Global comparisons of clean energy manufacturing – an important growth area of the green business sector - also show Sweden to be under-performing. Sweden ranked 22nd of 25 countries on the level of clean energy sales relative to total GDP (WWF and Roland Berger Strategy Consultants 2012). In 2011, China became the world's largest clean energy manufacturing region, with turnover increasing to US$88 billion. Cleantech turnover in the EU declined by 5% from 2009/10 to 2010/11.

Despite the less than average performance of firms in the green sector between 2004 and 2009, green technology business in Stockholm, and Sweden more generally, has been successful at attracting private investment in recent years. According to Stockholm Business Region Development, 90 venture capital investments were made in Sweden in 2009 in the cleantech sector. These corresponded to a total of SEK 1.5 billion (US$ 229 million) and covered areas such as innovative technologies, new materials, alternative fuels and green energy (Stockholm Business Region Development 2012b).

The *Sustainable Technologies Fund,* a private equity fund that invests in sustainable technologies ranging from renewable energy to chemicals, materials and recycling, has brought in over SEK 0.5 billion (US$80 million) both from Swedish and foreign investors. Ikea has created Ikea GreenTech AB, a subsidiary that aims to invest around SEK 0.5 billion (US$80 million) during the next few years in five targeted areas: solar panels, alternative lighting, energy efficiency, water efficiency and new materials. The goal is to invest in companies with products that could be installed in existing Ikea facilities or sold in Ikea stores.

Volvo Technology Transfer also invests in environmental technology companies with products that can bring value to Volvo. This private equity firm has supported companies such as Chemrec, a biofuels technology company based in Stockholm.

The business accelerator STING, based at Kista Science City, contributes to private equity in the ICT, cleantech and life science sectors through its branches STING Capital and STING Business Angels. STING Capital normally invests a maximum of SEK 4 million (US$630,000) per company. To date, this venture capital fund has invested SEK 69.3 million (US$10.9 million) in 26 portfolio companies. Similarly, through the STING Business Angel Network, 37 business angels with entrepreneurial backgrounds have invested around SEK 68.4 million (US$10.8 million) in 23 companies (STING 2013).

As well as attracting private investment, Stockholm's green sector has also displayed strong export growth in recent years. Stockholm County's EGS exports underperformed compared to other major counties in Sweden during the mid-2000s. However, between 2008 and 2010, exports increased by 55% in Stockholm, reaching levels of around SEK5 billion (US$780 million) - similar to exports from Skåne and Västra Götaland.

[11] The research for the UK's Department for Business, Innovation and Skills used a classification of 'Low Carbon and Environmental Goods and Services' (LCEGS), that includes the large carbon finance activities in the City of London's financial sector.

7.4 Future challenges and opportunities

7.4.1 Eco-districts and public private partnerships

Stockholm is now internationally recognised as a leader in developing eco-districts as demonstrator projects of cutting edge green technology innovations. Developments at Hammarby Sjöstad and Royal Seaport have both involved the regeneration of former industrial land with new housing and commercial spaces that include innovations in environmental performance. Pioneering the eco-district concept has also supported Stockholm's international green reputation and enabled local companies to benefit from new export opportunities and development of cleantech expertise.

With strong leadership from the City of Stockholm, effective public private partnerships have been used to harness the innovative potential of multi-national companies and local research expertise. A clearly articulated vision and the pooling of city, state and national funding has provided the long-term commitment and investment to kick-start development and has provided stable conditions necessary to attract private sector finance.

A number of opportunities exist for Stockholm to capitalise further on the success of its eco-districts. In all cases, these opportunities come with challenges. In particular, it is worth examining four major strategic areas:

- rolling out eco-district innovations in publicly owned buildings;
- rolling out innovations across existing districts in the private market;
- developing additional eco-districts in the future; and
- expanding export promotion to continue supporting the growth of exports into international markets.

The first three of these areas are discussed below. The fourth, capitalising on export opportunities in international markets, is addressed later in this chapter.

One of the key challenges for the City of Stockholm is how to roll out innovative technologies developed and demonstrated at Hammarby Sjöstad and Royal Seaport across the city more widely: *"One of the key questions we have from the business perspective is how the City proposes to use the innovative platform at Royal Seaport to roll out solutions in other areas of Stockholm."* Matilda Gennvi Gustafsson, Sustainability Director, Ericsson and Rohan Richards, Senior Strategy Consultant, Ericsson

An area where the city authority has strong policy control is the **retrofitting programme of the City of Stockholm's publicly-owned buildings**, which is already underway. The city authority has a target to reduce energy consumption by 10% between 2012 and 2015 across its existing building stock, as well as having a consumption ceiling of 55kWh/m^2 for new build on publicly owned land. By combining policy instruments such as the city's building investment programme and the city's power to bring together public private partnerships, there is an opportunity to build on the lessons from the eco-district demonstrator projects.

Focusing on publicly owned buildings enables a relatively high level of policy control compared to retrofitting in the private housing market. At the same time, retrofitting has greater potential for reducing the city's overall energy consumption and carbon emissions compared to new-build projects, given the large proportion of existing buildings that will remain in Stockholm by 2030 and beyond.

This approach would focus on the residential sector and extend existing retrofit programmes such as the Sustainable Järva project to a broader range of municipal owned housing companies. Companies such as Svenska Bostader, Micasa Fastigheter, Familjebostäder and Stockholmshelm have already started to retrofit their building stock – and opportunities exist for using innovations and lessons from the eco-district projects. For example, there may be potential for using the eco-districts' integrated approach to re-using waste heat and promoting localised circular energy and resource flows within district-scale retrofit programmes. There may also be opportunities for benefiting from further public private partnerships (PPPs), using retrofitting projects as innovation demonstration sites in similar ways to the PPPs of Hammarby Sjöstad and Royal Seaport.

Working with old buildings of various ages and building typologies presents an array of challenges in applying eco-district innovations. Nevertheless, successful adaptations to different types of buildings are themselves innovations that offer further business and export opportunities. The retrofitting approach also needs to investigate how existing policy programmes can be accelerated and cost-effectively scaled up from pilot projects such as Sustainable Jarva. The City of Stockholm may wish to consider how it can best promote information sharing and collaboration that ensures retrofitting efforts maximise the lessons emerging from the eco-district projects.

Another opportunity – and challenge – facing the roll out of eco-district innovations, is the **uptake of green technologies by private residential and commercial property owners in existing districts**. Innovations could include building-level technologies such as improved insulation, as well as uptake of technologies that support larger scale green infrastructural systems such as smart grids, district heating and waste collection systems.

The policy levers available to the city authority are more indirect in the private market, and a coordinated approach with national energy efficiency policy programmes is likely to be required. If well designed, effective policy instruments could include upfront capital grants for household insulation, low or zero interest loans, payback schemes using energy bills, regulating energy efficiency standards in the private rental market, and information campaigns.

Cost effectiveness should be a key criterion when determining the policy instruments used. Any subsidy and loan schemes should ensure that public costs are not excessive and do not hinder other cost effective policy programmes. Regulatory standards could also be part of a mix of policy instruments used to improve private sector building performance. In addition, any policy instruments used should take account of fuel poverty and any impact on rising energy prices.

The city could partner with private sector property developers to **establish additional new build eco-districts in the future**, drawing on, and where relevant improving, the models established at Hammarby Sjöstad and Royal Seaport. This would involve the city authorities identifying large-scale urban development opportunities and playing a leading role in establishing a vision for the district, potentially co-financing development and convening private sector actors to further push innovations in the built environment sector. As with previous eco-districts, the city could partner with research institutes and businesses to explore new technologies and infrastructure systems.

Refinements and improvements to the eco-district model would enable Stockholm to remain at the cutting edge of eco-district innovation. It would also allow Stockholm to maintain its international reputation as a green technology city. At the same time, technologies tested and demonstrated at Hammarby Sjöstad and Royal Seaport could be rolled out in new brownfield eco-districts more efficiently than adapting technologies for retrofitting existing buildings and developments. If new eco-districts were considered, it would be recommended that a comprehensive economic assessment of the Hammarby and Royal Seaport projects is undertaken.

7.4.2 Clean technology clusters

While Stockholm's green technology innovation has grown in recent years, this has not yet translated into high growth in the green business sector. This may be due in part to lags between research, development and industrial deployment. Nonetheless, policy support for start-ups, SMEs and other enterprises to ensure that long-term cost effective technologies are not prevented from entering and growing in the market should be a priority for Stockholm's economic policy.

The city's broader green reputation may also be at risk if the city lacks a strong centre for cleantech industries. While Stockholm's ICT cluster is internationally recognised and the city's strengths in life sciences innovation are well known, other cities have a stronger brand for cleantech clustering (see for example Box 7.6). With a large and growing global market for green goods and services, there are major opportunities for the city to build on its existing niche industries such as waste-to-energy technologies, as well as developing new innovations such as smart grid technologies alongside the ICT sector.

Box 7.6. Copenhagen Cleantech Cluster: a case study

The cleantech sector in Copenhagen has experienced remarkable growth in recent years, and today employs 78,000 people across more than 600 firms, with a combined annual turnover of around US$40 billion.

The cleantech sector in East Denmark has grown, despite the economic downturn: 44% of companies have hired new people since the last benchmark while only 9% of companies have fewer staff.

Central to this success has been the Copenhagen Cleantech Cluster (CCC), an initiative launched by Danish cleantech companies, research institutions and public organisations in 2010. The CCC is dedicated to creating the necessary business conditions to aid cleantech research, development and implementation by providing a platform for stakeholders to exchange ideas and resources and foster new business opportunities. At the same time, the CCC also provides support to start-ups and ensures member firms are connected with other cleantech clusters around the world to facilitate knowledge transfer and collaboration.

The CCC's institutional framework is unique, bringing together stakeholders that represent the entire value chain of the Danish cleantech industry, ensuring close collaboration between research institutions, industry and governmental organisations. The emphasis is on facilitation and the creation of an enabling environment, rather than the enforcement of top-down policies. This structure has allowed cleantech companies to benefit from cutting-edge research findings and government support while maintaining a high degree of independence from political interference. Firms have the flexibility to experiment with new ideas and adjust to changing circumstances, leading to a more innovative and competitive cleantech sector and providing a significant boost to the city's green growth.

Sources: Complex Cleantech Solutions 2012; Copenhagen Clean Tech Cluster 2010; Oxford Research/Copenhagen Capacity 2011

Cleantech business policies should be targeted and designed to be effective and efficient. Importantly, any strong green technology cluster that is to emerge in Stockholm will be primarily a result of private sector actors, rather than being 'created' by public policy. Nevertheless public policy at the city level can make an important contribution to overcoming market failures that prevent long-term cost effective technologies from reaching the wider market in the short to medium term.

One challenge in targeting support for green business is how to define the sector. For example, while technologies in waste disposal and pollution control are relatively straightforward to define as 'green', innovations in sectors such as construction and ICT may also have substantial impacts on energy and resource efficiency and reductions in greenhouse gases. This diffusion of green innovation across firms not conventionally classified as 'green' needs to be examined in developing targeted support for the sector. The Royal Seaport eco-district is an example of the importance of bringing together innovation from ICT, EGS and traditional energy companies to develop green technologies.

In aiming to support green innovation and enterprise, the city faces a number of strategic options, including:

- developing a district-scale cleantech cluster;
- reinforcing green technology enterprise in an existing innovation cluster;
- reforming overall innovation and entrepreneurship policy to target green technology innovation.

One option for promoting green business and innovation would be to **develop a district-scale cleantech cluster**. A business park could be located at Hogdalen, which has been suggested as a potential site for a cleantech cluster by the City of Stockholm. An alternative would be to site a green technology business incubator at one of Stockholm's eco-districts. Cluster-based industrial policies have been well-used in cities around the world. Stockholm's own Kista Science Park has been developed using cluster principles, while Copenhagen's Cleantech Cluster offers an example of an effective cluster specifically devoted to clean technology (see Box 7.6).

Land-use planning policy instruments, business support and financial incentives could all be used to develop a cleantech cluster to which start-ups, SMEs and larger enterprises would be attracted. Many smaller businesses benefit disproportionately from free or low cost office rent, access to legal, accounting and financial expertise as well as from the advantages of knowledge sharing.

Using public resources to support the spatial clustering of firms and research institutes may offer considerable economic benefits. Research on agglomeration economies suggests that concentrating firms in the same industry can create productivity benefits and accelerate innovation. Proximate firms can benefit from knowledge spillovers: by comparing, observing, monitoring and learning from nearby collaborators and competitors (Maskell 2001; Porter 2000). The importance of face-to-face contact for innovation processes may also provide net economic benefits from the city's investment in supporting a spatial cluster (Storper and Venables 2004)

While there are potential benefits from a cleantech cluster, consideration of public policy support for such a cluster should pay attention to whether it is the most effective and economically efficient way of promoting growth in the sector. Challenges to cluster-based policy include questions about whether district-level agglomeration benefits are primarily a result of concentrating firms in similar industries, or depend instead on the proximity of a diversity of firms in different industries (Jacobs 1970; Audretsch and Feldman 2004). Furthermore, there are questions about the relevant spatial scale of industry clusters. For example, it may be that with Stockholm's efficient urban transport system and relatively small size, cluster-type benefits can be realised with a concentration of firms at the metropolitan rather than district scale.

Policy promoting the concentration of public and private green innovation and business development activities in a particular district of Stockholm may well help to strengthen the global competitiveness of the sector. However, the benefits of clustering are not straightforward and close investigation of the strengths and weaknesses of existing clusters within Stockholm and other green innovation districts in other cities is recommended before devoting resources to this approach.

Option 2. An alternative approach would be to **reinforce green technology enterprise in an existing innovation cluster**. Policy instruments, including business support mechanisms, land-use planning tools and international marketing efforts could be used to promote and strengthen innovation and business development towards green objectives at an existing cluster such as the Kista Science City. New businesses and research facilities working in low carbon and environmental industries could be encouraged to locate to the existing cluster, while established businesses could be encouraged to expand their products and services into green technology.

This approach could have benefits in building on the strengths of a world-class cluster of highly innovative educational, research and business activities. It would involve using policy programmes to shift the orientation of these existing activities and promote consideration of how green objectives such as energy and resource efficiency can be incorporated within diverse sectors such as ICT or biotechnology. While some innovation in these types of sectors already contributes to green objectives, policy could aim to incentivise environmental and low carbon research and business development opportunities further.

Building on the success, scale and reputation of an existing cluster could enable a faster shift toward green innovation, rather than relying on the longer timeframes necessary to build momentum and capacity within a newly developed cluster. This approach could involve promoting green innovation from 'inside' already strong research and business organisations, rather than leaving existing centres of innovation 'outside' an emerging green sector. This may promote collaboration between 'green' and conventional research sectors and avoid 'silo-effects' that may emerge around a separate green cluster that is not well integrated with existing innovation institutions and business networks.

Consideration of such an approach should, however, also address potential weaknesses. 'Greening' an existing cluster such as the Kista Science Park risks being a superficial re-branding exercise, with marketing efforts not reflecting any real growth in cleantech business development. Furthermore, a cleantech brand could confuse the strong ICT brand that Kista currently possesses. There are also risks that without a distinct zone for green innovation, the benefits of close spatial clustering for firms are diluted, and firms with green objectives are 'lost' within a broader mix of innovation activities that remain focused on other sectors.

Option 3. A third approach to targeting policy support for green innovation in Stockholm would be to avoid spatial, cluster-based policy programmes, and instead focus on **strengthening overall innovation and entrepreneurship policy to target green innovation**. This could involve more targeted policy support at both the city and national level, aimed at particular industry sectors including cleantech. For instance, Stockholm's *Innovation Strategy* could be re-oriented from promoting general conditions for all types of innovation activities to include more specific policy instruments aimed explicitly at growing the green sector. Similarly the City of Stockholm's entrepreneurship and international business marketing policy programmes could pay special attention to growing green businesses. At the national level, public research funding could be targeted at projects with low carbon or environmental objectives. Private sector innovation and research activities could be incentivised to accelerate green research through policy instruments such as tax breaks.

The advantage of this strategy over cluster-based policy programmes would be in the broader reach of the policy over a wider range of firms and research and innovation activities. Re-directing overall policy could prompt changes in innovation processes throughout Stockholm, and throughout industries not conventionally defined as 'green' - rather than within a narrowly defined spatial cluster of specifically green industries. Using national-level policy tools such as re-directing public research funding may be more effective in shifting behaviour than spatially-oriented policy.

However, this approach also has weaknesses. In contrast to a spatially-defined cleantech cluster, there would be fewer opportunities for city policy instruments, such as direct business support, to overcome barriers faced by start-ups and SMEs in penetrating the market under fair competition. Close collaboration between the city and national government would also be required to implement changes such as more targeted funding assistance for environmentally-oriented public and private research. In addition, a more general approach would not provide the branding and reputational benefits for the city that come from marketing a "physical" and coherent cleantech cluster.

7.4.3 Green procurement

The City of Stockholm's procurement of goods, services and public works represented a market worth SEK 18.1 billion (US$2.9 billion) in 2012. This provides a substantial opportunity for the city to purchase green goods and services and stimulate the green economy. Various opportunities exist for extending Stockholm's green public procurement policy through the authority's own purchasing power. While the city has various targets for green procurement, other cities have comprehensive green public procurement policies that are integrated into the detailed procurement guidelines of the authority and its public agencies. For example, the City of Vienna reduced costs by over €44 million and saved over 100,000 tonnes of CO_2 between 2004 and 2007 through its EcoBuy programme (City of Vienna 2012). Much of the savings were due to resource efficiencies such as lower volumes of cleaning products and greater energy efficiency. The European Commission has set out best practice guidance for public authorities that can be used in purchasing decisions and tender contracts (Box 7.7).

Box 7.7. Green public procurement in the EU: criteria for best practice

Buying Green! is the European Commission's guidance document to help public authorities buy goods and services with a lower environmental impact. It also acts as a reference for businesses responding to green tenders. According to the European Commission, green public procurement policy should:

- Set out clear targets, priority sectors and timeframes;
- Indicate the scope of the purchasing activities covered;
- Assign overall responsibilities for implementing the policy;
- Provide for effective communication of the policy and make appropriate guidance and training available;
- Include a mechanism for monitoring performance.

Stockholm could also encourage wider implementation of green procurement in the private sector. London has achieved this through a membership scheme, *The Mayor of London's Green Procurement Code*. The code was launched in 2001 with the aim of creating a market for recycled products. Since then, the scheme has expanded to include a comprehensive range of management and behaviour change, technical product specifications, energy and resource effectiveness, and the sourcing of green products.

Under the Code, the Greater London Authority provides a support service for boroughs, public agencies and businesses in the private sector to help embed green procurement into all areas of an organisation. In 2012, the 88 members of the Code reported spending £110 million (around US$ 170 million) on green products and services, with 32 organisations qualifying for gold, silver or bronze certification.

7.4.4 International markets

The global market for green goods and services was estimated at around US$ 5.1 trillion in 2010/11. Sales in this sector are forecast to increase to US$6.1 trillion by 2013/14 (Department for Business Innovation and Skills 2012).[12] If Stockholm's businesses can capture activity in this large and growing market, the sector represents a major source of future growth. For example, businesses in London's green sector are estimated to have made sales of £23 billion (US$ 36 billion) in 2009/10, representing 0.7% of the global market (see Box 7.8). London's share of the global market is almost 60% higher than that held by Sweden, with the value of Swedish sales estimated at US$22.4 billion in 2009/10.

The relatively small size of the Swedish market illustrates not only the potential for substantial growth in the sector within Stockholm and across the country, but also the importance of an orientation toward exports. With the Swedish market representing just 0.4% of global sales in the green sector, Stockholm's firms will need to engage with considerably larger and faster growing overseas markets. China and the USA alone account for one third of the global market in the green sector, while research for the United Kingdom shows that other important export destinations for the green sector include South Korea, Taiwan, India and Pakistan (Department for Business Innovation and Skills 2012).

[12] The green sector here is defined as low carbon environmental goods and services in the BIS research.

Box 7.8 London - a growing market for green goods and services

Box 7.8 London - a growing market for green goods and services
In the UK, increasing consumer demand for low carbon products and services to mitigate and adapt to the effects of climate change has led to a rapid growth in the country's Low Carbon and Environmental Goods and Services (LCEGS) sector. Legislative and regulatory changes at the European and UK level have accelerated this growth and enabled the establishment of a thriving low carbon market in the UK.

The LCEGS market in London was worth nearly £23 billion in 2009/10, accounting for 19% of the total UK market. Already, there are more than 160,000 people involved in the low carbon economy in London. These jobs are primarily in the service and R&D sector, spread across more than 9,000 companies in a variety of industries, from renewable energy technologies to low carbon finance, where London accounts for 97% of the total UK market value.

According to a study commissioned by the Mayor of London in 2011, London's LCEGS sector has experienced a strong annual growth rate of around 4% over the past 5 years, despite the economic downturn, and its market value is expected to increase to more than £27 billion by the end of the 2012/2013 financial year. The industries thriving the most in London compared to the rest of the UK are carbon finance, waste management, geothermal, and photovoltaics.

London's LCEGS sector has benefitted from changing environmental legislation at the EU and UK level as well as environmental targets set out by the Greater London Authority, including a 60% emissions reduction target by 2025. Combined with rising costs of fuel and other raw materials, this has created opportunities for low carbon growth in the capital (MTW/Urbis Regeneration 2012). Additionally, the city's strength in financial services and banking has created better access to adequate finance to deliver projects and enable long-term investments in smaller companies and new technologies. Perhaps even more importantly, London benefits from a host of world-class research institutions that drive innovation around disruptive technologies and act as a test-bed for new green technology concepts.

Sources: Fankhauser 2012; HM Government 2009; Innovas Solutions Ltd. 2011; MTW/Urbis Regeneration 2012

Stockholm can grow its export sales in the green innovation sector by building on a very strong platform based on capacities in research, education, investment and global networks. The city can capitalise on its existing strengths as a centre for world-class education and research and development activities in both the public and private sectors. Applying these research strengths to green and low carbon objectives represents a major opportunity.

Collaborating with global research networks through educational and business partnerships offers an opportunity to accelerate innovation. Stockholm can also build its green exports by leveraging the global networks built around a number of powerful Swedish multinational companies headquartered in the city. Furthermore, the city can attract global investment flows aimed at the green sector. Stockholm is already an attractive destination for foreign investment and capturing growing investor interest in the sector will be important for the city.

Stockholm has a further advantage in its existing well developed local market for green innovation. The city's innovations in areas such as renewable heat energy, waste-to-heat energy and constructing energy and resource efficient eco-districts provide excellent starting points for growing green export industries. The city's green reputation offers a marketing advantage and the city as a whole can play a role as a demonstration of the possibilities for low carbon urban living.

While there are major opportunities for Stockholm's businesses in international markets, significant threats are also growing through emerging global competition in the sector. China's ambitions to lead the world in industrial innovation will make it increasingly challenging to maintain a cutting edge in the advanced technology sector. China has established a US$1.7 trillion public fund to support an active industrial policy based on low carbon growth. Of the seven strategic industries identified in China's 2011 – 2015 Five Year Plan, five are in low carbon sectors (The Climate Group 2011).

Increasing the green innovation component of Stockholm's substantial export base will be central to taking advantage of emerging global growth opportunities in markets for low carbon and environmental goods and services. While innovations for domestic markets in areas such as building energy efficiency have already provided substantial economic gains, there are opportunities to further capitalise on these through export orientation.

In working to increase Stockholm's participation in the US$5 trillion global market, the city authority may wish to target policy support at particularly competitive niche sub-sectors where Stockholm businesses have potential for being world leaders. Further work at the city level may be useful in understanding particular sub-sectors where Stockholm has a specific comparative advantage.

In terms of global market opportunities, major growth areas of the green business sector include alternative fuels, low carbon building technologies, renewable energy generation technologies, water treatment and waste management systems. The global market for low carbon building technologies alone is worth US$650 billion annually (Department for Business Innovation and Skills 2012). Based on Stockholm's expertise in green building, developed through its eco-districts programme and long experience with energy efficient buildings for cold climates, substantial opportunities are likely to exist in this sub-sector.

In addition to identifying and developing niche sectors that can be competitive within the global green market, the city authority also has opportunities to promote exports from Stockholm's green businesses. The export promotion agency, Stockholm Business Region Development, may wish to develop targeted programmes for the green sector. In the built environment sector, there is potential to further capitalise on the success and exportable innovations emerging from Stockholm's eco-districts through the SymbioCity export promotion platform.

Hammarby Sjöstad green roofs

Stockholm's first eco-district was initiated in the 1990s using innovative design concepts such as green roofs to help achieve its ambitious environmental targets. New technologies and skills developed for Hammarby are now being rolled out across wider markets in Sweden and abroad, with economic benefits for the city. Stockholm is capitalising on the export potential of ideas and technologies developed for eco-districts through Symbiocity, a trade council agency.

Photo credit: Design for Health

Appendix

Biofuels and clean vehicles in Stockholm

Since 1994, the Environment and Health Administration of the City of Stockholm has been running the *Clean Vehicles in Stockholm Programme*, which aims to accelerate the transition to clean vehicles and renewable fuels - including biogas, ethanol and electric vehicles. The main objective in the early years was to improve air quality in the city. However, increased awareness about climate change, carbon emissions and security of energy supply has led to a shift in focus during the development of the Programme.

Initially, the intention was that the Programme focus on electric vehicles. However, due to the reduced number of electric vehicle models available at the time and their limited driving range, the focus of the Programme shifted to ethanol and biogas fuelled vehicles.

The main challenge faced by the City of Stockholm when initiating the Programme was the lack of a market for clean vehicles. Consumers had little incentive to purchase ethanol, biofuel or electric powered vehicles before infrastructure (e.g. charging points) and vehicle models were widely accessible. Stockholm approached this challenge by working on clean vehicles and the accessibility of fuels simultaneously. In order to ease the transition, the city authority also decided to lead by example, gradually switching the municipal fleet from conventional fossil-fuelled to clean vehicles.

The different policy measures that were implemented as part of the *Clean Vehicles Programme* and by the national government can be divided into two categories: pre-market or preparatory measures and market-stimulating measures (BEST 2009). In the case of Stockholm, different technologies and fuels are currently at different stages of development and hence require different types of policies. For example, ethanol cars appear to be establishing as a self supporting market, whereas electric vehicles are still at a pre-market stage.

As a first phase in the *Clean Vehicles in Stockholm Programme*, the City of Stockholm focused on identifying and removing barriers in order to initiate the development of a market for clean vehicles. Since 1998, the City of Stockholm has collaborated with Malmö and Gothenburg to engage with the national government on examining unfavourable taxation rates for clean vehicles, long-term tax rules for alternative fuels and simplification of the approval and control processes for clean vehicles.

Technology procurements and negotiations with car manufacturers were also carried out as part of pre-market measures. Between 1998 and 2001, the City of Stockholm initiated three procurement programmes of ethanol, biogas and hybrid vehicles. In addition, clean cars enjoyed free parking in the inner city between 2005 and 2008.

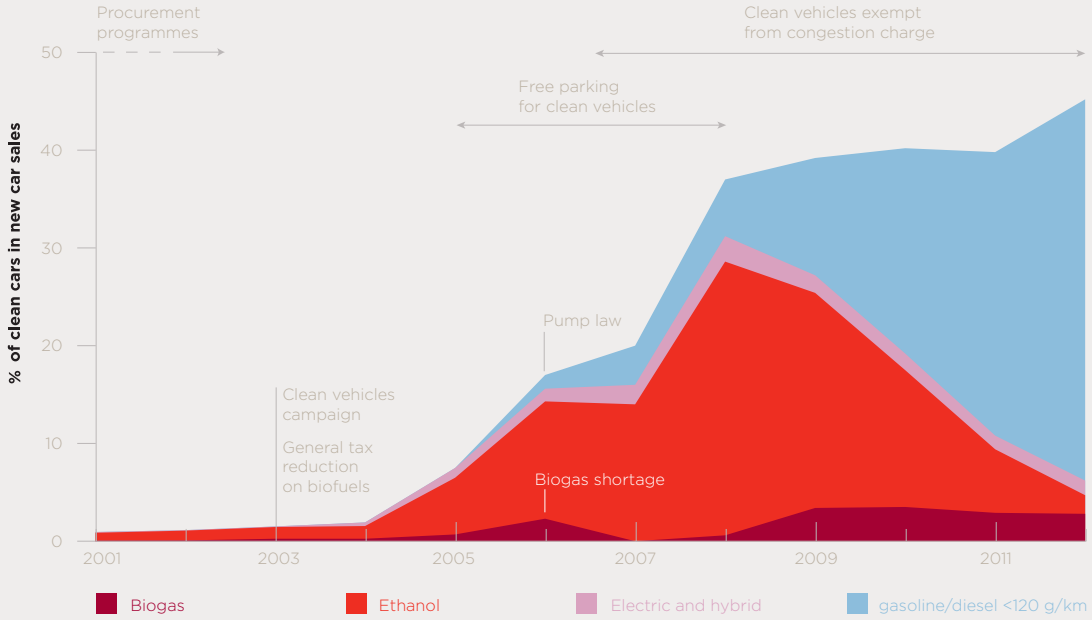
As the market for clean cars – especially for bioethanol cars – evolved from a developing market into a mature market, market-stimulating incentives which were primarily directed at end users started to play a major role. One of the most effective measures for the promotion of clean cars was their exemption from the congestion charge, both during the trial period in 2006 and since the permanent introduction of the congestion charge in 2007. Since 2006, eco-taxis have had a separate lane at Arlanda airport. In 2008, the city introduced a subsidy for transport companies purchasing clean vehicles that has facilitated the transition to clean cars by,for example, taxi companies.

At the national level, the Swedish Parliament introduced the 'Pump Law' in 2006, under which all petrol stations of a certain size are obliged, as a minimum, to supply a renewable fuel as an alternative to petrol and diesel (Swedish Institute 2011). Since ethanol pumps are more cost effective than those for other types of fuel, this law led to a rapid development of the ethanol E85 supply network (Figure A1.1).

Within the *Clean Vehicles in Stockholm Programme*, the city has taken part in numerous European projects (including Zeus, ELCIDIS, Trendsetter, Biogasmax, and BEST). As part of BEST, a statistical analysis was developed to identify which policy measures implemented in Stockholm had been most effective for ethanol vehicles. The results showed that the most effective

instruments were fuel pricing and congestion charge exemption. Incentives which targeted operating costs were determined to be more effective than those targeting capital costs (such as vehicle purchasing subsidies).

Figure A1.1 Green vehicle sales in Stockholm County, 2001-2012

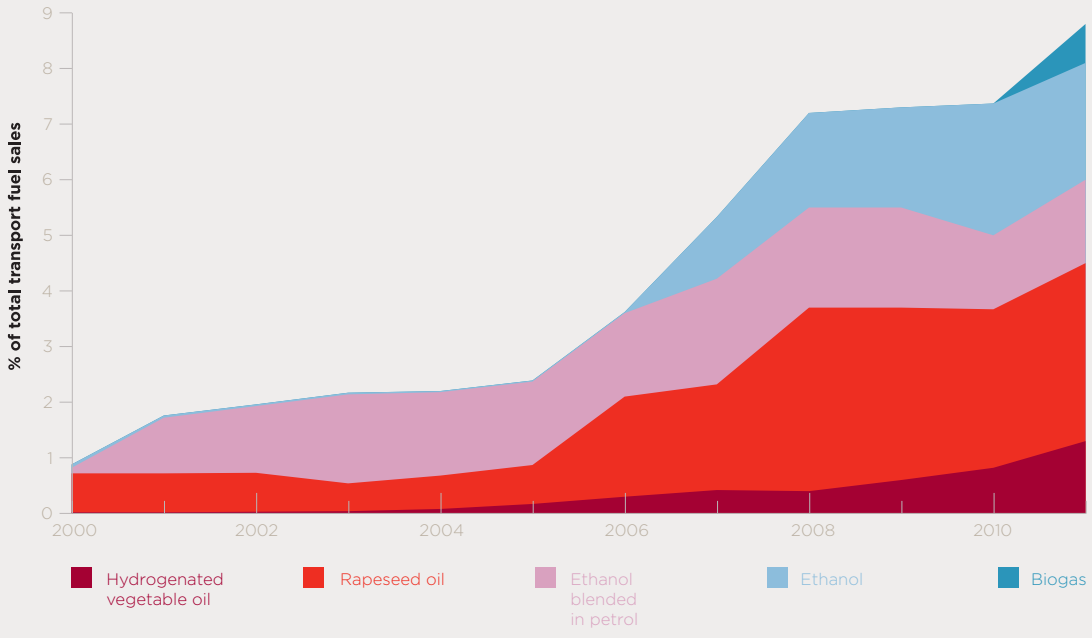


Source: City of Stockholm 2012l.

The City of Stockholm was an early mover in low carbon transport policies, implementing its Clean Vehicles Programme in 1994. New car sales of clean vehicles increased from less than 1% of total car sales in 2004 in Stockholm County to 45% in 2012 (Figure A1.1). This led to a substantial increase in biofuel sales: from 0.9% of total transport fuel sales in 2000 to 7.4% in 2010 (Figure A1.2). Although the percentage of biofuels sales decreased from 2009 to 2010, total figures actually rose. According to the City of Stockholm, the reason for the biofuels share decreasing is attributed to an increase in total petrol sales.

Despite these positive total figures, electric, hybrid and biogas vehicles still account for a very small share of new car sales. The outlook for ethanol vehicles is not promising: sales have declined from 71% of total clean vehicle sales in 2008 to 4% in 2012. Wide coverage in the media of both the food versus biofuel debate and the potential threat to rainforests posed by the development of biofuels have been identified as the main causes for this large decline in ethanol fuelled vehicle sales (City of Stockholm 2013).

Figure A1.2 Biofuel sales in Stockholm County, 2000-2011



Source: City of Stockholm 2012k.

Petrol and diesel cars with carbon emissions below 120g per km accounted for 87% of all sales of new clean vehicles in 2012. Although emissions attributable to these vehicles are below those of conventional petrol and diesel cars, they still contribute to CO_2 emissions in the transport sector within the city– to a much greater extent than ethanol E85 or electric vehicles (taking into account the very low CO_2 emissions per KWh from the Swedish electricity grid).

From January 2013, the Swedish Government adopted a new definition of clean vehicles - those emitting no more than 95g CO_2/km. The City of Stockholm will also adopt this new classification (Personal Communication, City of Stockholm).

Biogas production was not able to meet rising demand, leading to a shortage of biogas in 2006 which affected both biogas and biogas-fuelled car sales. Biogas is especially well suited for heavy vehicles (such as buses and lorries), and the City and County of Stockholm will need to examine the costs and benefits of improving the infrastructure for this biofuel – both from the production and distribution perspectives.

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