OECD Green Growth Studies

Green Growth in Stockholm, Sweden

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BETTER POLICIES FOR BETTER LIVES

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Foreword

Green growth has been a strategic topic of the OECD's work since 2009, when OECD member countries mandated that the organisation develop a *Green Growth Strategy*. Green growth has entered a number of areas of work in the OECD, including the Directorate for Public Governance and Territorial Development. The Directorate's mission is to help governments at all levels design and implement strategic, evidence-based and innovative policies to strengthen public governance, respond effectively to diverse and disruptive economic, social and environmental challenges, and deliver on governments' commitments to citizens.

This publication is one of four metropolitan-level case studies undertaken by the OECD Green Cities Programme, which was initiated by the 2010 OECD Roundtable of Mayors and Ministers in Paris. The aim of the programme is to increase understanding of the concept of green growth in cities, to enhance the potential of urban policies to contribute to urban and national green growth, and to inform national, sub-national and municipal governments as they seek to address economic and environmental challenges by pursuing green growth. This publication is part of the *OECD Green Growth Studies* series and feeds into a synthesis report of the Green Cities Programme on *Green Growth in Cities*.

Green Growth in Stockholm, Sweden draws on data provided by the City of Stockholm and the *OECD Metropolitan Database*. The analytical approach draws on the OECD Green Cities Programme's conceptual framework "Cities and Green Growth", and best practices are shared with other green city case studies (Chicago, Paris, Kitakyushu). This report benefited from guidance by the OECD Territorial Development Policy Committee and its Working Party on Territorial Policy in Urban Areas, and the support and co-operation of the City of Stockholm's local team.

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Acronyms and abbreviations

EC	European Commission
ERDF	European Regional Development Fund
ESCO	Energy service company
EU	European Union
GDP	Gross domestic product
GRP	Gross regional product
ICT	Information and communications technology
IEA	International Energy Agency
IRECO	Institute for Research and Competence
IT	Information technology
IVL	Swedish Environmental Research Institute
KSL	County Association of Local Authorities (*Kommunforbundet Stockholms Lan*)
KTH	*Kungliga Tekniska Högskolan* (Royal Institute of Technology)
PCT	Patent Co-operation Treaty
R&D	Research and development
RUFS	Regional Development Plan for the Stockholm Region
SBR	Stockholm Business Region
SBRD	Stockholm Business Region Development
SEK	Swedish kroner (currency)
SME	Small and medium enterprises
SMTC	Stockholm Environmental Technology Centre
STING	Stockholm Innovation and Growth
VAS	Council for Regional Co-operation for Water and Wastewater
VC	Venture capital
VINNOVA	Swedish Governmental Agency for Innovation Systems

Executive summary

This case study analyses the economic and environmental performance of the City and County of Stockholm, identifying best practices for green growth in policy and governance, and providing recommendations to further strengthen Stockholm's potential for green growth. The unit of analysis is the Stockholm metro-region, defined here as Stockholm County, albeit with special attention paid to the performance, policies and institutions of the City of Stockholm.

Green growth aims to steer economic growth in a different direction to ensure that natural assets continue to provide the resources and environmental services on which our well-being relies. Urban green growth can be understood as fostering economic growth and development through urban activities that reduce negative environmental externalities, the impact on natural resources and the pressure on ecosystem services. These activities, including policies and programmes, are intended to reduce either: *i*) negative "environmental externalities" (for example, air pollution and carbon dioxide emissions that arise from urban activities); or *ii*) the consumption of natural resources and environmental services, including water, energy and undeveloped land.

Stockholm, which was declared the first European Green Capital in 2010, has earned a reputation as a leader in urban sustainability. The City of Stockholm is a leader in reducing local greenhouse gas emissions, most notably through widespread district heating and cooling systems, and through the application of a vehicle congestion charge.

Stockholm's population and economic growth are well above the OECD average. In the past decade, the service sector has been Stockholm's fastest-growing economic sector, and this economic success has been matched by strong environmental performance. CO_2 emissions per capita are among the lowest of any OECD metro area, water quality is excellent, very little waste goes to landfill, and air pollution is below critical measures for almost all pollutants.

In co-operation with other levels of government and an impressive array of stakeholders in civil society, Stockholm County and the City of Stockholm have built up an effective network governance to promote green growth. The growing sector of green technologies accounted for 3.4% of Stockholm County's Gross Regional Product in 2008. The biggest segments are waste and wastewater management, renewable energy sources and environmental consultancy, all of which showed strong growth between 2003 and 2009.

The metro-region has remarkable research and development assets and expertise in cutting-edge environmental technology, and has recently experienced an unusually high rate of growth in venture capital investment. Its eco-district developments in Hammarby Sjöstad and in the forthcoming Stockholm Royal Seaport district have provided innovations for redevelopment of brownfields into districts that systematically reduce the environmental impact of urban activities.

However, as the report's findings show, despite Stockholm's excellent record in many aspects of environmental policy and its strong specialisation in high-tech goods and services, it has room for improvement. In particular, its current mechanisms of regional governance may not be strong enough to help it fully realise its green growth potential and compete internationally on green technologies.

Key findings and recommendations

- Both the City of Stockholm Vision 2030 and the Stockholm County RUFS (Regional Development Plan) 2010 plan could more explicitly identify environmental and sustainable development initiatives as sources of growth.
- Private property owners should be further encouraged to undertake energy-efficiency retrofits, which are already common in the public sector, and information and cost barriers that prevent access to energy service companies should be removed.
- Congestion charges could be further extended, and the national government should consider giving the City and County of Stockholm further discretion over the expenditure of the increased revenues.
- The growing population and the comparatively low density of the Stockholm metro-region call for stronger public transport linkages between emerging urban development nodes.
- The City and County could support national regulatory changes to make it easier for small-scale renewable energy generators to contribute to the electricity grid.
- Given Stockholm's objective to become the most innovation-driven economy by 2025, the key elements of its green technology regional innovation system could be more clearly identified, and an institutional structure or platform set up to address strategic issues and challenges to collaboration. Meanwhile, Stockholm County may not be fully exploiting its expertise in green innovation, which should be commercialised and disseminated more widely.
- To streamline this institutional structure and avoid duplication of work, innovation policy needs to more closely align R&D activities with the comparative advantages of the Stockholm region. Greater coherence could be brought to the array of public-private partnerships that support the development of cleantech activities, and Stockholm's green cluster could be better mapped.
- The green technology sector is currently limited in its ability to generate spinoffs and to nurture the growth of small and medium enterprises. Small and medium enterprises (SMEs) should be further encouraged and entrepreneurial activities incentivised.
- Green technology activities should be placed on an equal footing with other major industries, such as ICT or biotechnology. The central government, Stockholm County and the City of Stockholm could streamline programmes aimed at stimulating green technologies.
- In co-operation with other levels of government, other local governments and an impressive array of stakeholders in civil society, Stockholm County and the City of Stockholm have built up a network governance whose broad mechanisms appear key to fostering green growth. Yet they could go further by increasing the co-ordination of

regional governance. Scaling up smart-grid technology offers an opportunity for expanding green regional governance.

- Raising the profile of Stockholm's green technology exports internationally should also be made a priority, using strategies grounded in combined regional leadership. There is a need for better regional co-ordination, working with the Swedish Trade Council and other agencies.

Chapter 1

Economic and environmental trends in Stockholm

Chapter 1 provides an overview of socio-economic and environmental trends and challenges in Stockholm City and County and identifies areas of opportunity for green growth. It assesses the economic and environmental assets and performance that underpin Stockholm's competitiveness and attractiveness, reviews urban sectors that merit attention for improving green growth prospects and focuses on the emerging green sector and its potential to contribute to growth in Stockholm City and County.

Key findings on environmental and economic performance

- Stockholm benefits from a strong economy and rapidly growing population, supported by diverse industries and a strong environmental performance. Stockholm County accounted for 22.5% of the Swedish population in 2011 and over half of Sweden's population growth. The city is in an advanced stage of structural transformation towards a service-based and knowledge-intensive economy. Services and construction have been Stockholm's fastest-growing sectors over the last decade. Activity is dominated by large multinational companies, with small and medium enterprises accounting for a relatively small share.
- Environmental criteria have long played an important role in the city's policy making, resulting in high environmental quality. CO_2 emissions per capita are among the lowest in OECD metro areas, water quality is excellent, very little waste goes to landfills and air pollution is below critical measures for almost all pollutants. Former brownfield sites are increasingly being redeveloped and complemented by strong protection for parks and green spaces. Significantly, the City of Stockholm has reduced greenhouse gas emissions per capita over a period of continuous economic growth and population increase.
- Some environmental challenges remain, particularly related to land use and transport. While the increase in population has been faster in Stockholm's urban core than on the periphery, accelerated population growth is putting pressure on the housing supply and increasing the risk of urban expansion that is not adequately connected to public transport. Road transportation is an important factor for air pollution and greenhouse gas emissions, despite the fact that congestion charges are in place. While landfill rates are low, recycling rates could still improve, particularly for organic and bulky waste. Finally, Stockholm's high-quality freshwater supply, 90% of which comes from Lake Mälaren, could be at risk of seawater intrusion from rising Baltic Sea levels.
- The small but growing green sector may offer an emerging source of growth. Approximately 1 598 green technology firms accounted for 3.4% of Stockholm County's Gross Regional Product (GRP) in 2008. Employment in the sector was estimated at 11 216 in Stockholm County in 2009. The biggest segments are waste and wastewater management, renewable energy sources and environmental consultancy, all of which grew strongly between 2003 and 2009. With regard to green innovation indicators, Stockholm no longer figures among the top 20 regions in the OECD for green patent applications, although it ranked first on the list in the 1970s. However, over the last decade, green patent applications have strongly increased.
- Given the growing demand for medium- to high-skilled labour, in particular in the green sector, current skill levels may not meet future needs. Stockholm ranks first for regional specialisation in knowledge-intensive services among all OECD regions. A growing share of the population with a college, university or degree in higher education reflects growing education requirements in Stockholm. Skill shortages may occur, particularly in activities that need science and engineering skills, many of which are required in the green sector.

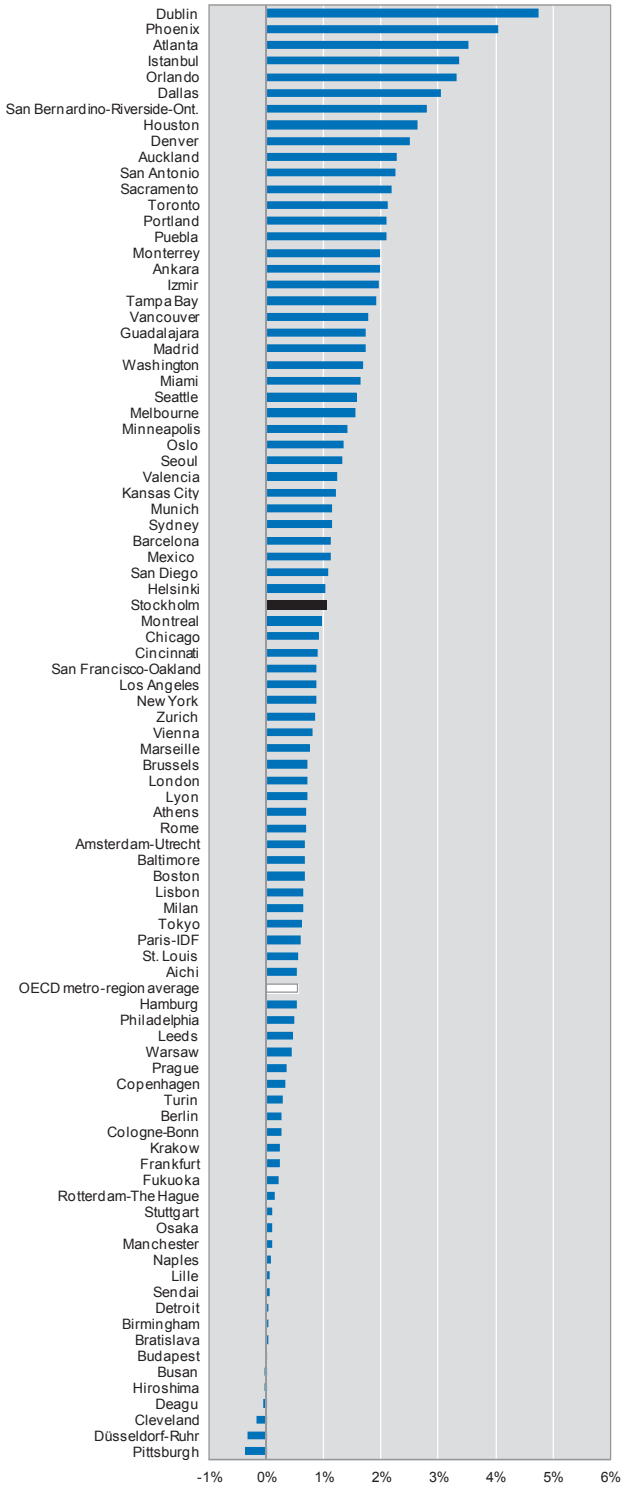
A range of economic and environmental assets underpin Stockholm's attractiveness

Stockholm has gained increasing recognition for its economic and environmental performance. Solid economic growth, exceptional environmental assets and a stable business environment make Stockholm an attractive place to invest, live and work. This has been confirmed through the strong and increasing presence of major multinational companies, particularly ICT firms, that profit from the world's largest open fibre network, which the city owns and administers. Most of Sweden's R&D assets, skills, universities and research centres are located in the Stockholm region, and Stockholm regularly places among the top ten cities in international competitiveness rankings. For example, the "Cities of Opportunity" study ranked Stockholm fourth out of 26 cities assessed worldwide, due primarily to its strong intellectual capital, innovation, sustainability, demographics, liveability, health and security (Clark, 2011; PricewaterhouseCoopers, 2011). As the capital of Sweden, Stockholm concentrates important domestic assets, which puts it in an advantageous position among Swedish cities and may contribute in part to its performance on several important indicators, such as productivity growth or knowledge-intensive services.

A diverse, service-based and knowledge-intensive economy provides sustained growth

Continuous economic and demographic growth has strengthened Stockholm's position as Sweden's economic centre. With over 2 million inhabitants, Stockholm County accounted for 22.5% of the Swedish population in 2011 and for more than half of the Swedish population growth, which situates it clearly above the OECD average (Figure 1.1). Stockholm generates 27% of Swedish GDP, and its GDP per capita grew by an impressive 3.1% per year during 1995-2008, placing it among the strongest-performing European metro-regions, on par with London, Helsinki and Guadalajara (Figure 1.2). Labour productivity (GDP per worker) is higher than the OECD average (Figure 1.3) and has grown strongly over the last decade (Figure 1.4). Much of this good performance can be ascribed to Stockholm's diverse and innovative economy, which is underpinned by well-performing industry clusters in ICT, life sciences, financial services, automation, cleantech and logistics. While many of these activities contribute indirectly to green growth (such as ICT), green technologies alone accounted for 3.4% of Gross Regional Product (GRP) in 2008. Reinforcing the nexus of green, innovative and knowledge-intensive industries will be crucial for making Stockholm's performance sustainable both in economic and environmental terms.

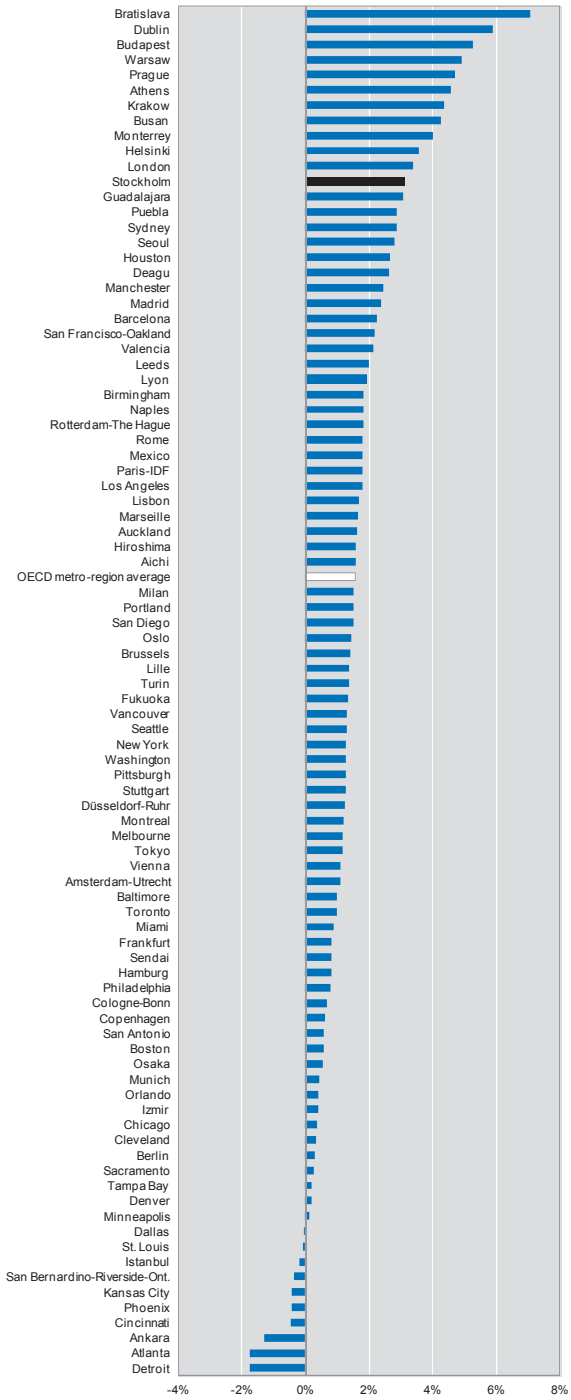
Figure 1.1. **Population annual average growth in OECD metro-regions, 1995-2008**



Note: Data for Australia and the Slovak Republic refer to 1996-2008; data for Belgium refer to 2000-2008; data for Denmark and Germany refer to 2005-2008; data for the Netherlands refer to 2003-2008; data for Poland refer to 2001-2008.

Source: OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.

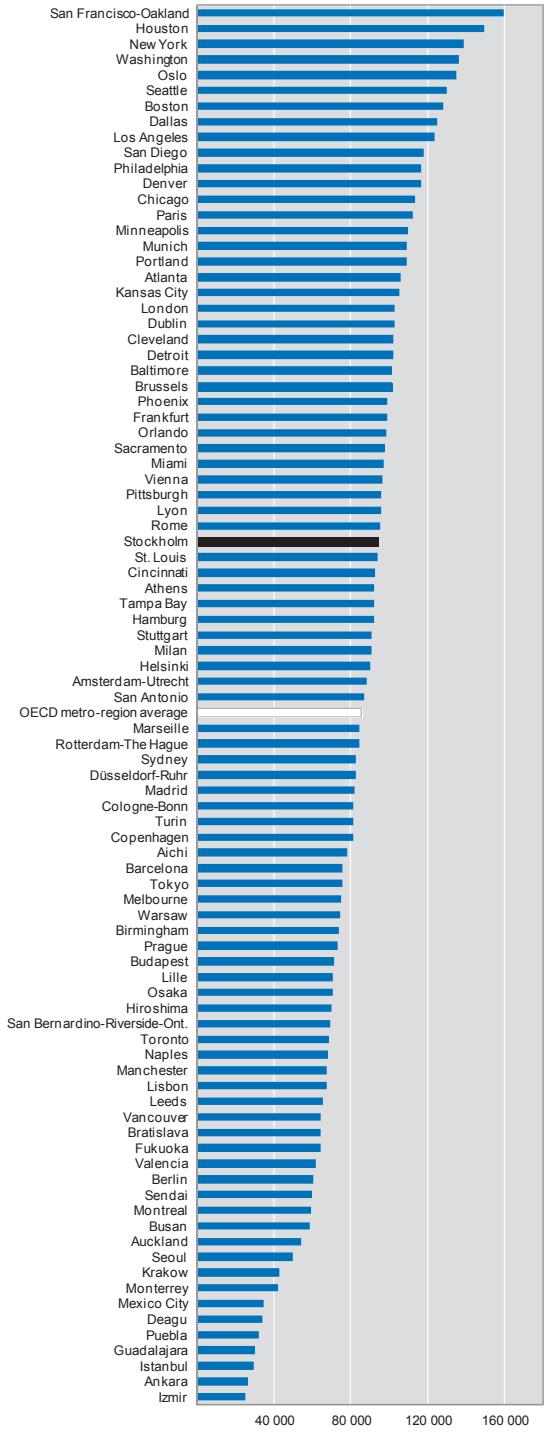
Figure 1.2. **Per capita GDP annual average growth in OECD metro-regions, 1995-2008**



Note: Data for Austria, Czech Republic, Finland, France, Greece, Hungary, Ireland, Italy, Japan, Korea, Portugal, Slovak Republic, Spain, Sweden and United Kingdom refer to 1995-2007; data for Belgium, Germany, Netherlands and Poland refer to 2000-07; data for Denmark refer to 2006-07; data for New Zealand refer to 2000-03; data for Norway refer to 1997-2007; data for Turkey refer to 1995-2001; data for the United States refer to 2001-08.

Source: OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.

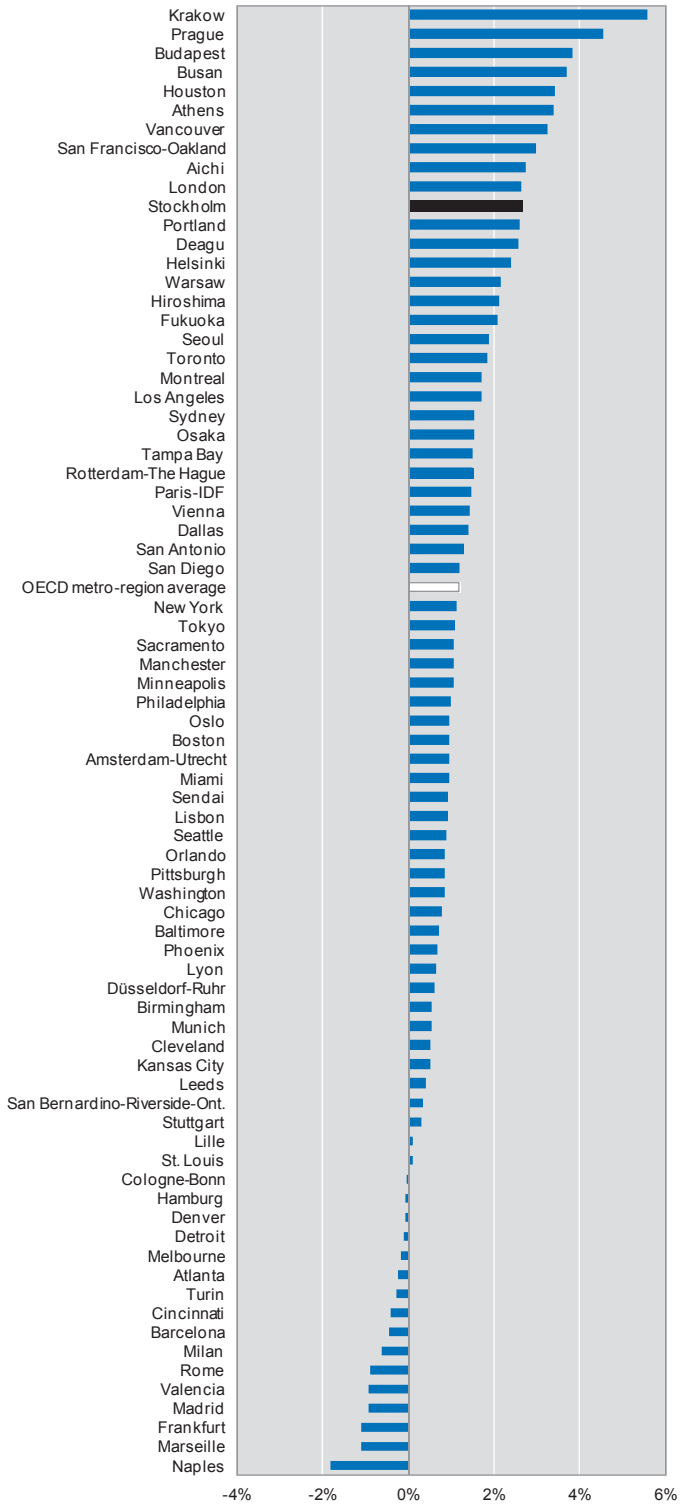
Figure 1.3. **Labour productivity in OECD metro-regions (GDP per worker, USD, PPP)**



Note: Data for Austria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Japan, Korea, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden and United Kingdom refer to 2007; data for Belgium and Ireland refer to 2006; data for New Zealand refer to 2003; data for Mexico and Turkey refer to 2000; data for Switzerland was not available.

Source: OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.

Figure 1.4. **Average annual growth of GDP per worker, 2001-2007**



Source: OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.

Stockholm's competitiveness draws on a diverse, service- and knowledge-intensive economy that nonetheless has not fully exploited the potential of small and medium enterprises. Over the past decade, Stockholm's growth was driven chiefly by service sectors, in particular finance, insurance and real estate, R&D and education, and personal and cultural services (Table 1.1). Declining sectors were mining, as well as quarrying and manufacturing, which in 2008 represented together only 9% of employment. This suggests that the city is in an advanced stage of structural transformation towards a service-based and knowledge-intensive economy. Stockholm has the highest share of employment in knowledge-intensive services among OECD metro-regions; private-sector services account for almost half of the employment in Stockholm County (49.1%), while in Sweden this share is only 36.5% (2008) (Figure 1.5) (Stockholm County Council, 2010a). Some services, such as health care, social services and environmental and climate-related services, have been identified as having significant untapped potential, which is true also for entrepreneurship and exporting industries in a variety of sectors (Stockholm County Council, 2010a). A relatively small share of SMEs partly reflects the strength of large multinational companies in Stockholm. This is particularly relevant to the green sector, much of which still consists of infant industries. Focusing on good conditions for entrepreneurs and SMEs thus represents an important element for the city to enhance its green growth potential.

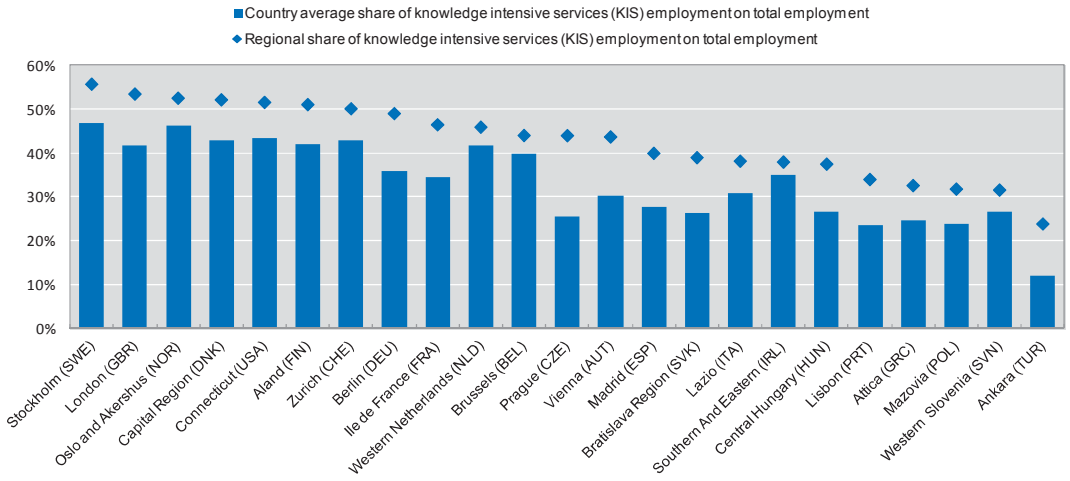
Table 1.1. **Change in employment by sector (employees working in Stockholm County)**

	Employees (2008)	% of total (2008)	Growth 1988-1998 (%)	Growth 1998-2008 (%)
Personal and cultural service activities	259 530	24	27	42
Wholesale and retail trade; transport, storage and warehousing; post and telecommunications	222 410	21	-10	9
Public authorities, national defence; extra-territorial organisations	127 590	12	-15	1
Financial institutions, real estate activities, business activities	105 787	10	-10	60
Research and development; education	101 415	10	2	28
Mining, quarrying and manufacturing	89 968	9	-16	-12
Health and social work establishments	64 274	6	-4	12
Construction industry	62 773	6	-23	46
Major groups missing	8 475	1	15	-72
Electricity, gas and water supply, refuse disposal	7 848	1	-19	16
Agriculture, forestry, hunting and fishing	4 185	0	-28	11
Total	1 054 255	100	-5	17

Source: Swedish Statistic State Agency, based on "Industrial Classification SNI 2007".

Figure 1.5. **Share of knowledge-intensive services in OECD countries and regions**

Knowledge-intensive services as % of total employment, 2008



Source: OECD (2011), *Regions and Innovation Policy*, OECD Reviews of Regional Innovation, OECD Publishing, doi: *10.1787/9789264097803-en.*

Great environmental assets and performance support Stockholm's attractiveness

Stockholm offers key assets to attract a highly educated workforce for its knowledge-based economy, notably a high-quality environment. For decades, environmental criteria have played an important role in the city's policy making and have been the main drivers behind Stockholm's strong environmental performance. CO_2 emissions per capita are among the lowest in OECD cities, water quality is excellent, very little waste goes to landfills and air pollution is below critical measures for almost all pollutants. Former brownfields are increasingly being redeveloped and complemented by strong greenfield protection. Stockholm municipality features 160 kilometres of shoreline, with 13% of its surface being water and 42% of its land being green parks and forests (55% in the County) (City of Stockholm and SBR, 2010). These economic and environmental assets and achievements are important features of the region's attractiveness, taken into account by the highly educated and mobile workforce on which Stockholm's economy is increasingly built.

Greenhouse gas emissions have been reduced without sacrificing economic growth

The City of Stockholm reduced its per capita greenhouse gas emissions over a period in which its economy and population grew. Between 1990 and 2007, the City of Stockholm reduced its per capita carbon dioxide equivalent (CO_2e) emissions[1] by 30%, while the GDP per capita for Stockholm County (including the City of Stockholm) rose by 76%, the city's population grew by 18%, and total energy consumption increased 22% (Table 1.2) (Stockholm County Council, 2010b). This decoupling between CO_2 emissions

and growth in population, GDP and energy consumption may be due in part to the shift from manufacturing to services (Table 1.1). If this is the case, goods consumed in Stockholm but produced elsewhere may be contributing more to global greenhouse gas emissions, if they are produced in places with more carbon-intensive production than Stockholm or Sweden as a whole; this can depend on a wide range of factors, including the sources of power generation, the technology used in production and the carbon emissions associated with transporting the goods. Accounting for carbon embedded in imports that are consumed in Stockholm would require a consumption-based approach to measuring CO_2 emissions, which, in view of the large number of variables involved and the vast number of different points of origin for such imports, would be extremely complex. Currently available data only allow for measuring CO_2 emissions produced in the area of Stockholm City and County. In 2009, CO_2 emissions per capita in Stockholm City were at 3.4 tonnes (City of Stockholm, 2012b) (Figure 1.6). In Stockholm County, per capita CO_2e emissions are still significantly higher than in the city, with over 8 tonnes per capita in 2006, related mainly to emissions from transport, buildings and services (City of Stockholm, 2012a). Per capita emissions in the City of Stockholm have decreased since 1990, mainly due to two factors: *i*) district heating and cooling, powered primarily through renewable energy; and *ii*) low-emission electricity, 71% of which comes from hydropower or nuclear energy sources (Figure 1.7).

Table 1.2. **Demographic, economic and environmental indicators, 1990-2007**

	1990	2000	2001	2002	2003	2004	2005	2006	2007	1990-2007 (%)
CO_2e (tonnes/capita)	5.4	4.7	4.4	4.1	4.1	4.1	4.0	4.0	3.8	-30
Energy consumption (TWh)	46*	52*	55*	54*	53*	54*	54.5*	55	56*	22
GDP per capita (PPP) in USD	28 073	38 547	38 116	39 729	40 846	44 102	44 947	46 587	49 300	76
Total population (million)	1.641	1.803	1.823	1.838	1.850	1.860	1.872	1.889	1.918	17

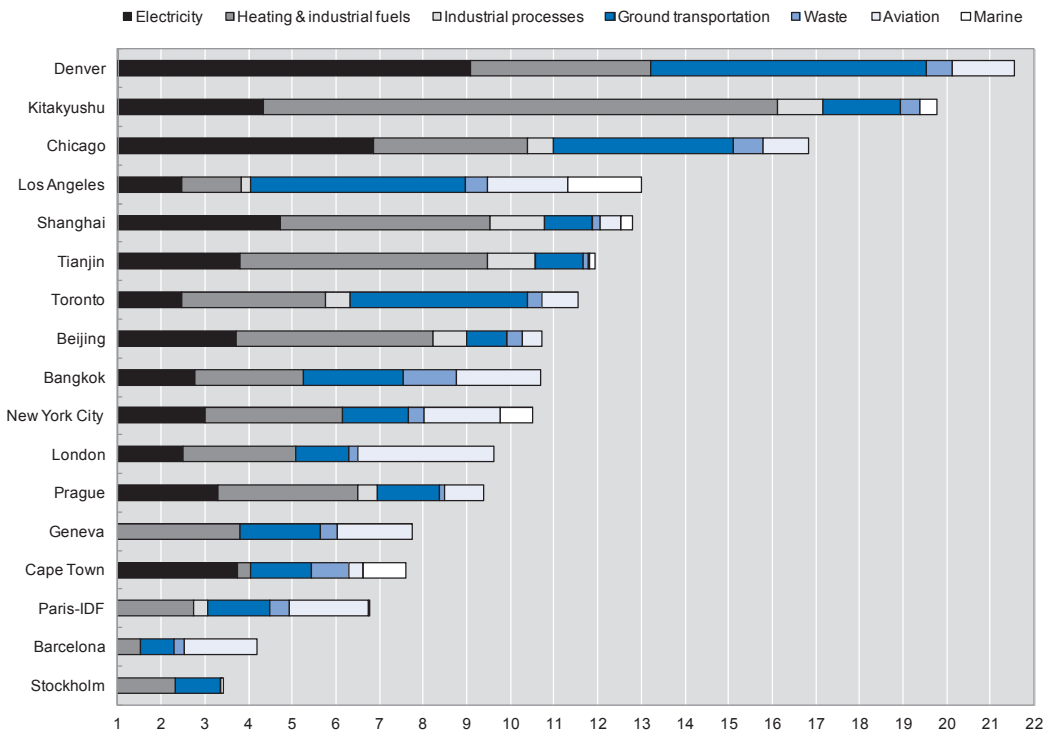
Note: * represents estimated values. Energy consumption, GDP/capita and population values refer to Stockholm County; CO_2e emissions values refer to City of Stockholm.

Source: Stockholm County Council (2010), *The Development in the Stockholm Region*, follow-up of *OECD Territorial Reviews: Stockholm, Sweden*, Stockholm County Council, Stockholm; Stockholm County Council (2010), Energy Future for the Stockholm Region 2010-2050, Stockholm County Council Office of Regional Planning, *www.tmr.sll.se/Global/Dokument/publ/2010/2010_r_energy_future_of_the_stockholm_region_2010-2050.pdf; OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.*

The extensive district heating and expanding cooling system is a major contributor to low emissions per capita in Stockholm. The heating and cooling systems currently meet over 80% of the city's total heating and cooling requirements. Since the 1950s, when oil-based heating was widespread, a district heating system has been introduced that is powered through co-generation plants, which also supply 10% of the region's electricity. A significant part of heating energy is produced with biofuels (37%), about a third (32%) with fossil fuels (coal and oil) and the rest (31%) through waste incineration. In addition, a growing district cooling system contributes to energy savings in air conditioning (City of Stockholm, 2012a).

Figure 1.6. **CO_2 emissions in selected cities, 2009**

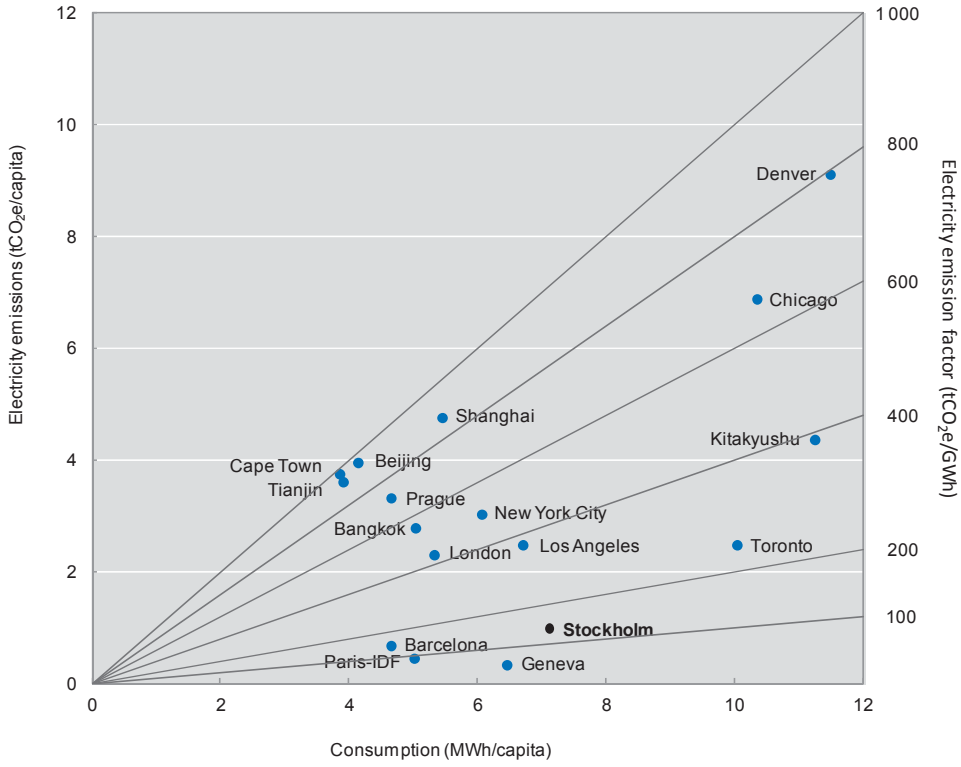
Tonnes per capita



Source: Kennedy, C. (2011), personal communication, calculations adapted by C. Kennedy, October 2011, using methodology from Kennedy, C. et al. (2009), "Greenhouse Gas Emissions from Global Cities", *Environmental Science and Technology*, Vol. 43, No. 19, American Chemical Society, Washington, DC; Data for Chicago comes from the Center for Neighborhood Technology (2009), "Creating a Chicago Regional Building Energy Efficiency System", Center for Neighborhood Technology, Chicago; Data for Stockholm and Kitakyushu were provided by the city administrations.

Stockholm could further reduce its emissions by reducing the use of fossil fuels and increasing the efficiency of its district heating system. In 2009, 32% of the energy for the district heating system was produced with fossil fuels (City of Stockholm, 2012a). Since 2010, renewable electricity has been added to the energy mix, representing 9% of the total in 2011. Increasing the share of renewable electricity, as well as the share of biofuels, could further reduce the net carbon intensity of heating energy in Stockholm. Local emissions could also be reduced through a better use of heat pumps and by reducing energy losses in the distribution system. So far, geothermal energy has been used only on an individual basis. Integrating geothermal heat into the district heating system could further improve the system's environmental efficiency and optimise the exploitation of a disposable emission-free energy source.

Figure 1.7. **Greenhouse gas emissions from electricity in selected cities**



Note: The data (2009) for Chicago correspond to the Chicago Metropolitan Agency for Planning region (seven counties); the data for Kitakyushu (2007) and Stockholm (2009) correspond to the cities.

Source: Kennedy, C. (2011), Personal communication, calculations adapted by C. Kennedy, October 2011, using methodology from Kennedy, C. et al. (2009), "Greenhouse Gas Emissions from Global Cities", *Environmental Science and Technology*, Vol. 43, No. 19, American Chemical Society, Washington, DC,; Data for Chicago comes from the Center for Neighborhood Technology (2009), "Creating a Chicago Regional Building Energy Efficiency System", Center for Neighborhood Technology, Chicago; Data for Stockholm and Kitakyushu were provided by the city administrations.

Transport, waste and water merit attention

Stockholm's environmental performance is one of the best among OECD metro regions, but spatial and environmental challenges remain. The continuing influx of population into the Stockholm region has put pressure on spatial planning and infrastructure and driven up the demand for energy. This could result in environmentally undesirable spatial development patterns and rising energy consumption in transport and buildings, as well as an increase in local pollution and greenhouse gas emissions. While Stockholm County has the lowest share of cars per capita among Swedish counties, the total number of cars was rising until 2011, and high levels of PM_{10} on major traffic routes temporarily exceed World Health Organisation (WHO) air-quality standards. Waste recycling in Stockholm is still quite low. While freshwater quality and supply is not yet an urgent concern, the risk of saltwater intrusion from the Baltic Sea into Stockholm's freshwater reservoir, Lake Mälaren, presents a notable risk for future freshwater supply and a challenge for water management and strategies.

Accelerated population growth may result in lower-density developments

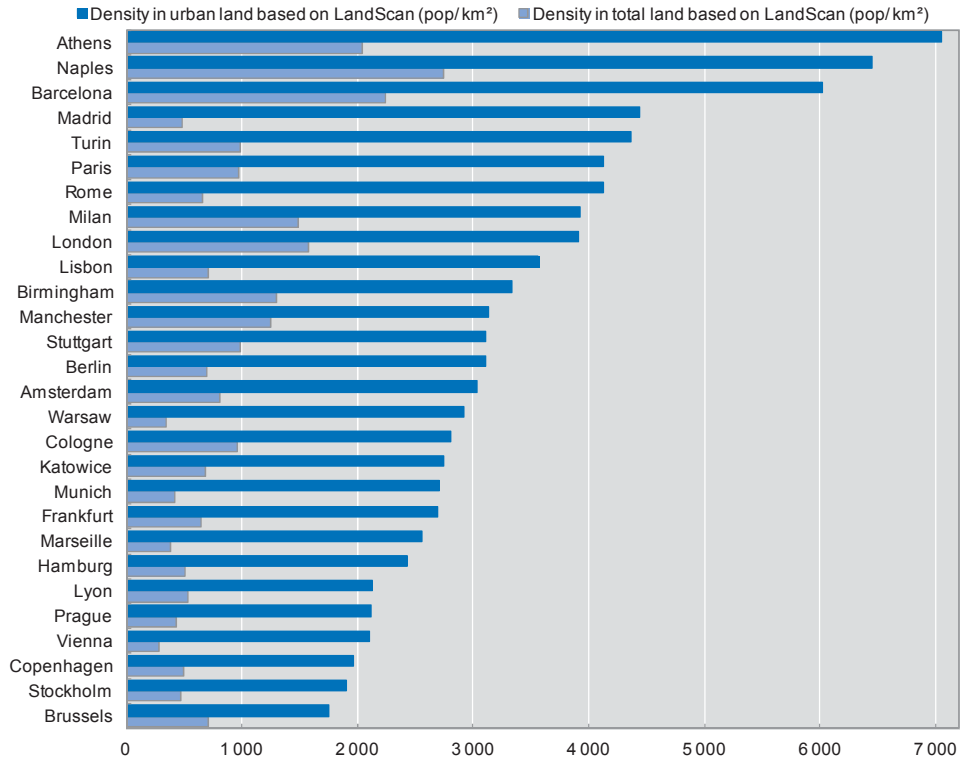
Stockholm was able to contain much of the development to its urban core in the past, but continued and accelerated population growth puts pressure on housing supply and

increases the risk of urban expansion that is not adequately connected to public transport. The population of 863 000 people living in the City of Stockholm in 2011 is expected to rise to 1 million in 2024, and the County of Stockholm is expected to have 500 000 additional inhabitants by 2030 (City of Stockholm, 2012a). By 2030, approximately 100 000 additional housing units are expected to be needed in the City of Stockholm, plus approximately 200 000 additional housing units in the County of Stockholm (City of Stockholm, 2012a).

The population density of the Stockholm Metropolitan Area (OECD definition) is one of the lowest in Europe (Figure 1.8; Figure 1.9). For instance, Stockholm consumes more than twice as much land for urban purposes as Turin, which is similar in population size (1.7 million). While Stockholm has so far managed to keep growth higher in its urban core, extensive development is expected in urban nodes outside the city centre, which may be developed at lower densities (Figure 1.10). Less dense areas are more likely to generate higher greenhouse gas emissions from transportation (Kennedy et al., 2009). The challenge of Stockholm's polycentric regional vision is to build a sustainable regional transport system that not only connects nodes to the centre of Stockholm but also connects the nodes to one another.

Figure 1.8. **Population densities on urban land and on total land**

28 OECD metropolitan areas in Europe



Note: Based on the OECD definition of the Stockholm Metropolitan Area. This definition is applied to 28 OECD countries and identifies 1 148 functional urban areas. The methodology identifies urban areas as "functional economic units", overcoming previous limitations linked to administrative definitions and increasing the possibility of cross-country comparison. The methodology consists of three main steps. The first step identifies contiguous or highly interconnected, densely inhabited urban cores. The second step identifies interconnected urban cores that are part of the same functional areas, and the third step defines the commuting shed or hinterland of the functional urban area.

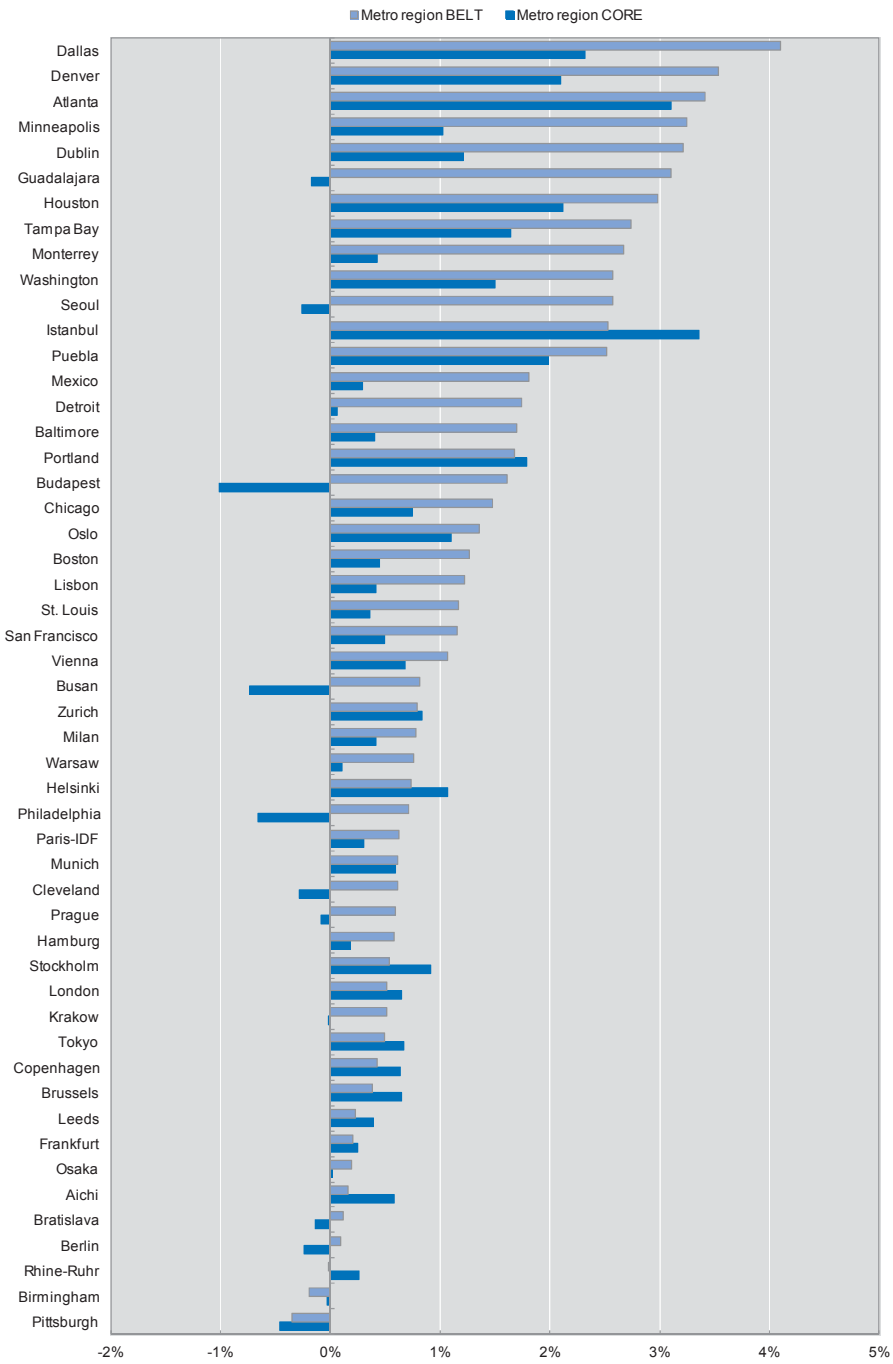
Source: Based on *LandScan Global Population Database* (2009), *www.ornl.gov/sci/landscan/*; and CORINE Land Cover (2006), *www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2*.

Figure 1.9. **Stockholm Metropolitan Area (OECD definition)**

Note: Based on the OECD definition of the Stockholm Metropolitan Area. This definition is applied to 28 OECD countries and identifies 1 148 functional urban areas. The methodology identifies urban areas as "functional economic units", overcoming previous limitations linked to administrative definitions and increasing the possibility of cross-country comparison. The methodology consists of three main steps. The first step identifies contiguous or highly interconnected, densely inhabited urban cores. The second step identifies interconnected urban cores that are part of the same functional areas, and the third step defines the commuting shed or hinterland of the functional urban area.

Source: OECD Metropolitan Database, *http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES*.

Figure 1.10. **Annual average population growth in OECD metro-regions' core and belt, 1995-2007**



Note: Data for Belgium, Denmark, Germany, Mexico, Sweden and United States refer to 1995-2005; data for Poland refer to 2000-07.

Source: OECD Metropolitan Database, *http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES* and *OECD Regional Database*, *http://stats.oecd.org/Index.aspx?datasetcode=REG_DEMO_TL3*.

Transport-related emissions and air pollution are still high

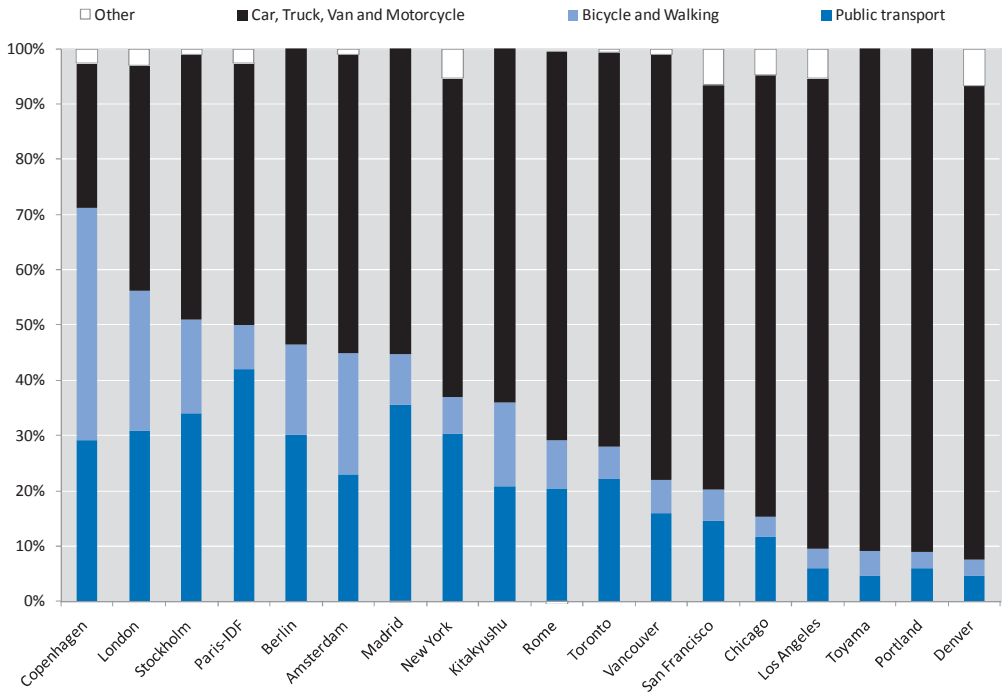
Road transportation is an important factor for air pollution and greenhouse gas emissions in Stockholm City and County, and the public transport system could be further improved to respond to this challenge. Transport is the biggest energy consumer after residential and commercial buildings and accounts for 40% of greenhouse gas emissions in Stockholm County (Stockholm County Council, 2010b). While biofuels have helped to bring down transport-related net CO_2 emissions, they have not significantly altered transport-related air pollution. In 2010, the annual mean of NO_2 at street level, as well as the daily mean for PM_{10} at all monitoring stations, exceeded European health standards. A key driver for high PM_{10} levels is the use of studded tires during winter and early spring months. Since 2010, the ban of studded tires on Homsgatan, an inner-city arterial road, has led to a significant reduction in pollution and is planned to be expanded to other parts of the city. Several stations also measured ozone levels that exceeded standards for periods of one or two days in 2011 (although the values are still below the European average) and since 1980, ozone levels have increased by 15%. All other pollutant levels comply with both Swedish and European standards (City of Stockholm, 2012a).

While these remaining challenges are closely linked to on-road traffic, the introduction of a congestion charge has significantly reduced traffic and transport emissions in the inner city of Stockholm. Also, a growing number of greener – low fuel consumption, hybrid or electric – vehicles are actively being introduced in Stockholm, which helps to reduce both local emissions and pollution. Compared to other cities, commuting via public transport, bicycles and walking is quite high in Stockholm County,[2] higher than in Berlin, Amsterdam or New York, but not yet at the levels of London or Copenhagen (Figure 1.11). The share of commuting to central Stockholm via public transport is at 60%, and the share of public transport in Stockholm City during peak travel hours goes up to 79% (City of Stockholm, 2012a). While inner-city transport data show an increase in the use of public transport over time, Stockholm County shows the reverse long-term trend. The use of cars is rising faster than population growth, and the share of public transport has decreased since 1980 (City of Stockholm 2012a; Stockholm County Council, 2012). The average time of journeys to work (2003-06) in Stockholm (35 minutes) is still higher than that of European cities such as Hamburg (26.5 minutes) or Barcelona (26.7 minutes) (Eurostat, 2012).

Solid waste recycling has not fulfilled its potential

Waste production in Stockholm City is below the OECD average. However, a large proportion of solid waste is incinerated, and recycling rates are only moderate. Stockholm generates 1.43 kilogrammes of municipal waste per capita per day on average, which is slightly below the OECD average of 1.48 kg, but above the Swedish average of 1.32 kg per capita per day (Figure 1.12). While incineration in Stockholm City has led to low landfill rates of only 3% (28kg/capita/year) and waste-to-energy is a renewable fuel in the city's district heating energy mix, recycling rates in Stockholm City are comparatively low, notably for organic and bulky waste. Policies to increase recycling or composting of waste are the most effective in reducing greenhouse gas emissions, as they have been shown to consume less energy than disposing of the waste in landfills or by incineration, even when taking into account the potential energy that may be captured in landfills or

Figure 1.11. **Modal share for commuting in selected OECD urban areas**



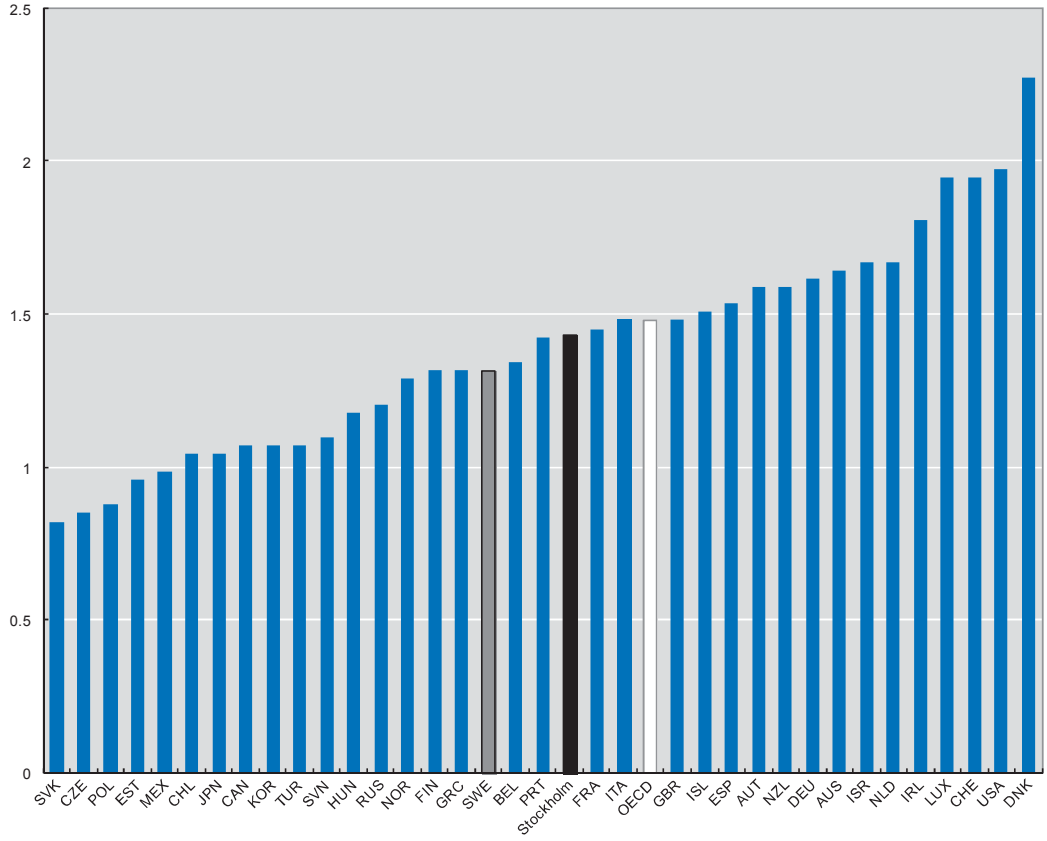
Note: For London, the category "Other" comprises motorcycles and bicycles.

Source: Units of analysis, sources and years: Paris-IDF (Paris-IDF region, Insee, Enquête Nationale Transport, 2008); Melbourne (Melbourne Statistical Division, Victoria State Government, 2007); Vancouver (Census Metropolitan Area, Census Statistics Canada, 2006); Toyama (Toyama-Takaoka Wider Urban Zone, Third-Person-Trip Survey, 2001); Portland (Metropolitan Statistical Area, American Community Survey, 2009); Chicago (Chicago Tri-State metro-region (MSA), American Community Survey, 2005-09); New York, Los Angeles, San Francisco (OECD metropolitan regions definition, American Community Survey, 2005-09); London (London Boroughs, Department of Transport, 2008-09); Berlin, Copenhagen, Stockholm (Eurostat metropolitan regions definition (larger urban zone), Eurostat, 2003-06); Toronto (Census Metropolitan Area, Statistics Canada, 2006); Denver (OECD metropolitan regions definition, American Community Survey, 2005-09); Madrid, Rome, Amsterdam (Eurostat metropolitan regions definition (larger urban zone), Eurostat, 2003-06).

incinerators (Morris, 2005). In the City of Stockholm, 69% of total household waste was incinerated in 2010, and in Stockholm County, 95% of non-recycled household waste was incinerated in 2006 (City of Stockholm, 2012a; Stockholm County Council, 2010b). The recycling rate for household waste in Stockholm City is at 21% (2010) and has not significantly evolved in recent years (City of Stockholm, 2012a), putting it on a par with cities such as Kitakyushu (30%) or Paris (22%). Of the household waste that is incinerated, 38% is organic waste. While some organic waste is processed in anaerobic digestion to produce the biogas used in city buses and cars, the amount would need to be increased significantly to satisfy the current rising demand for biogas in the city.

Figure 1.12. **Municipal waste generation in OECD countries and the City of Stockholm**

Kilogrammes per capita per day, 2009 or latest year available



Note: Municipal waste as defined by the OECD is waste collected and treated by or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden waste, street sweepings, the contents of litter containers and market-cleansing waste. The definition excludes waste from municipal sewage networks and treatment, as well as waste from construction and demolition activities. Waste data for Stockholm excludes street sweepings, contents of litter containers and market-cleansing waste. The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Source: OECD (2012), *OECD Factbook 2011-2012: Economic, Environmental and Social Statistics*, OECD Publishing, doi: *10.1787/factbook-2011-en*; City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", internal document, City of Stockholm, Sweden.

Water management faces climate change risks

Stockholm enjoys a high-quality freshwater supply but might face increasing challenges in protecting its freshwater reservoirs from increased storm-water runoff and potential saltwater intrusion. Lake Mälaren currently provides 90% of its drinking water to Stockholm County, and regular testing, in compliance with the EU Water Directive, reveals that over the past ten years, 96% of samples have received the highest water-quality rating, with 4% receiving the next-highest water-quality rating (City of City of Stockholm, 2012a). However, the expansion of hard surfaces as a result of development along the lake and more frequent extreme weather events may result in increasing storm-

water run-off into Lake Mälaren and combined sewer system overflows. The other big risk for fresh water is a potential saltwater intrusion from the Baltic Sea. With sea levels expected to rise 50 centimetres by 2050, saltwater intrusion could become a major challenge, requiring massive infrastructure investments. The current reconstruction of the Lake Mälaren lock in central Stockholm, and the construction of new drainage channels, aim to protect the lake from seawater intrusion risks through 2050, allowing time for the development of long-term adaptation measures for the following 100-year period (City of Stockholm, 2012a).

Leveraging green growth in Stockholm's existing industrial, innovation and education assets

The green sector is a promising source of growth

Stockholm's green sector still represents a small part of the regional economy, but growth rates and investments in different green segments indicate that it is emerging. Approximately 1 598 green technology firms accounted for 3.4% of Stockholm County's GRP in 2008, counting 11 216 employees in 2009 in Stockholm County (City of Stockholm, 2012a). The biggest segments are waste and wastewater management, renewable energy sources and environmental consultancy, all of which grew strongly between 2003 and 2009. Some smaller sectors exhibit even higher growth rates (Table 1.3). Total revenues of the green technology sector grew by 34% during 2003-08, outperforming total GRP growth by 4 percentage points (Table 1.4). The only shrinking segments were education, research and monitoring, and recycled materials. The decline in the recycling sector may to some extent reflect the current waste and energy strategy, which could put greater emphasis on recycling. Areas of strong potential investment and business development are renewable energy, water purification (including conversion of wastewater to energy), alternative fuels and green infrastructure systems (City of Stockholm, 2010).

Table 1.3. **Employees in the green sector (Stockholm County)**

Segments	2009	Growth 2003-09 (%)
Air emissions control	128	106
Wastewater management	1 052	0
Waste management	3 096	8
Land and groundwater	243	8
Noise and vibrations	23	21
Environmental consultancy	1 583	11
Education, research and monitoring	1 211	-6
Recycled materials	627	-8
Renewable energy sources	1 688	26
Heating/energy savings	531	36
Sustainable agriculture and fishing	248	65
Sustainable forestry	11	57
Miscellaneous (including eco-tourism)	776	132
Total	11 216	14

Source: Swedish Statistic State Agency; City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", internal document, City of Stockholm, Sweden.

Table 1.4. **Green sectors as a share of GRP (Stockholm County)**

	2003	2004	2005	2006	2007	2008
Revenues* in the green technology sector (SEK millions)	24 041	25 622	26 346	26 847	28 651	32 153
Total regional GRP (SEK millions)	721 429	766 400	808 596	847 013	910 669	940 342
Green technology sector's share of GRP (%)	3.3	3.3	3.3	3.2	3.1	3.4

Note: * The income generated from the sale of goods or services, or any other use of capital or assets, associated with the main operations of an organisation before any costs or expenses are deducted.

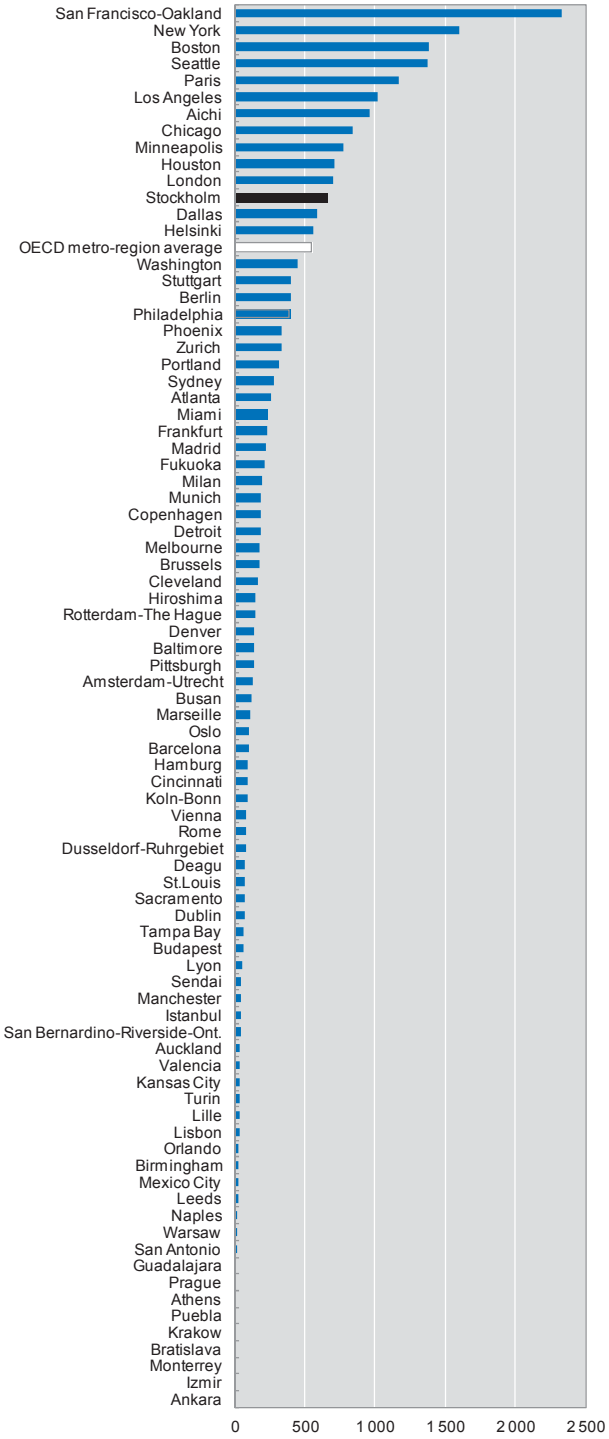
Source: Swedish Statistic State Agency; City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", internal document, City of Stockholm, Sweden.

Some areas of the green sector not yet accounted for in these statistics have significant potential for job creation and further greening, in particular in building and transport. Residential buildings account for 35% of energy consumption in the City of Stockholm. The majority of the current building stock has a life expectancy beyond 2030, which means that retrofitting existing buildings offers considerable potential for energy savings in the long term (Stockholm County Council, 2010b). Given the need to construct 250 000 housing units by 2030, new green buildings also show potential for energy and emission savings. The building industry, real estate and financial services are currently the highest-growth sectors in Stockholm, with 46% and 60% respectively from 1998 to 2008. Retrofitting existing building stock and constructing energy-efficient green buildings would not only reduce energy consumption and energy costs for households and businesses, but could also contribute to the creation of new jobs and higher property values.

Stockholm's innovation assets are important for fostering green growth

Stockholm can build on its innovation assets, notably in information and communications technology (ICT) and green technologies, but should not underestimate its international competition. Stockholm is the headquarters of a number of large innovative companies, which contribute to its ranking in terms of total Patent Co-operation Treaty (PCT) patent applications, clearly above the OECD average. In patent applications in green technologies, ICT, biotech and nanotech, Stockholm displayed strong growth in the past decade, but it has lost the leading position among OECD regions in green technologies and ICT that it enjoyed during the 1970s. Stockholm vanished from the list of the top 20 regions for green patent applications in the late 1980s, as well as from the top ten list for ICT patent applications in the 1990s, mainly due to the emergence of strong innovation regions in the United States, Germany and other OECD countries (OECD, 2011). At the same time, the number of patent applications has continued to rise: green patent applications in 2005-09 were 37% higher than in 2000-04. For ICT patent applications, Stockholm still ranks above the OECD average (Figure 1.13).

Figure 1.13. **Patent Co-operation Treaty (PCT) patent applications for ICT in OECD metro-regions, 2009**



Note: ICT data for Guadalajara and Izmir refer to 2008; data for Puebla refer to 2003; data for Ankara refer to 2000.

Source: OECD Metropolitan Database, http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES.

Current skill levels may not satisfy growing demand in the green sector

Stockholm faces a growing demand for skilled labour, in particular in the green sector. Stockholm ranks first for regional specialisation in knowledge-intensive services among all OECD regions, and employment in research, development and education represent 10% of Stockholm County's workforce, having grown by 28% between 1998 and 2008 (Figure 1.5; Table 1.1). While the share of population with a college, university or some higher degree reached almost 46.6% in 2008, compared to 41% in 2003, there is concern that the current growth in educated workers will not keep up with demand (Stockholm County Council, 2010a). For example, education levels in the green sector have grown continuously, with 61% of workers in this sector in the City of Stockholm having at least some post-secondary education in 2009, up from 54% in 2003 (Table 1.5) (City of Stockholm, 2012a). Current projections estimate an even greater demand for a highly educated workforce: 220 000 people with at least three years' college education and 70 000 people with three years of upper secondary vocational training (*e.g.* in construction and electrical engineering) will be needed by 2030 in Stockholm County; and a shortage of 73 000 skilled workers may occur by 2030 (Stockholm County Council, 2010a). The shortage concerns scientific education and engineering in particular – which are also key for the green sector – as well as graduates for health care and social services (Stockholm County Council, 2010a).

Table 1.5. **Skill levels in the green sector (City of Stockholm)**

	2003	2004	2005	2006	2007	2008	2009
Employed	5 088	5 360	5 295	5 372	5 791	6 074	5 888
Breakdown:							
Pre-secondary education	615	593	497	477	545	522	475
Secondary education	1 733	1 789	1 680	1 741	1 933	1 920	1 813
Post-secondary education, less than three years	659	753	752	716	762	823	801
Post-secondary education, more than three years	1 860	1 994	2 115	2 176	2 261	2 503	2 472
Researchers	221	230	252	263	289	306	326
Percentage of total:							
Pre-secondary education	12	11	9	9	9	9	8
Secondary education	34	33	32	32	33	32	31
Post-secondary education, less than three years	13	14	14	13	13	14	14
Post-secondary education, more than three years	37	37	40	41	39	41	42
Researchers	4	4	5	5	5	5	6
Total share of post-secondary education (%)	54	56	59	59	57	60	61

Source: Swedish Statistic State Agency; City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", internal document, City of Stockholm, Sweden.

Notes

1. CO_2 emissions are calculated based on energy consumption and emission factors for the City's energy supply. Emission factors are defined by the Swedish Environmental Research Institute Ltd (IVL). Direct biofuel emissions in district heating or small household appliances are set to zero, but indirect life-analysis emissions are included. Road transport emissions are calculated with Airviro, a model that describes the traffic movements street by street within the city, and ARTEMIS, a model that takes into account speed, fuel and vehicle types. Emission reductions due to the use of biofuel in transport are calculated based on Swedish National Transport Authority standards.
2. In this case, the unit of analysis is the Eurostat definition of the Stockholm Larger Urban Zone.

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Chapter 2

Policies to further promote green growth in Stockholm

Chapter 2 reviews the visions and sectoral policies already in place in Stockholm and discusses their potential for further strengthening green growth. It assesses urban sectors and activities that foster growth and reduce pressure on the environment, focusing on land use and transport, including eco-districts, energy efficiency in buildings, waste recycling, district heating and renewable energy.

Key policy findings and recommendations

- Visions: Both the City of Stockholm Vision 2030 and the Stockholm County RUFS 2010 need to identify more explicitly environmental and sustainable development initiatives as potentially important sources of growth.

- Land use: The development of "nodes", as presented in the City of Stockholm and County of Stockholm land-use plans, should be carefully planned and implemented. Public transport should link the proposed nodes more effectively, particularly those planned in the City of Stockholm with those planned elsewhere in the County. It is also important that existing urban areas in each node are densified, to prevent urban sprawl around the nodes. As a leader in brownfield development since the mid-1980s, the City of Stockholm is in a position to disseminate the best practices from the eco-districts that have been developed on brownfield sites to other developments throughout the City and County. It is also important to monitor performance in a more public and open fashion, so that policy makers in the City and County can use the information to evaluate their brownfield policies.

- Transport: Congestion charges are a Stockholm success story, and consideration should be given to expanding them. Giving local governments greater autonomy over the revenues from congestion charges would permit the charges to be more closely tied to public transport. This could increase public acceptance for further congestion charges or restrictions.

- Buildings: The City of Stockholm's initiatives for energy-efficient construction are ambitious but could be further expanded if the City or County helped facilitate energy-efficiency retrofits by private property owners. Information sharing and pooling potential customers would be one way of approaching this. Job opportunities could also figure more prominently in building energy-efficiency plans, particularly in retrofitting projects, which could potentially provide job opportunities for local residents.

- Waste: Stockholm has made great strides in diverting waste from landfill, but three opportunities remain for promoting growth while reducing waste. First, recycling rates could be increased through introducing recycling sorting bins alongside household waste collection, rather than just at collection points. Second, the existing pilot programmes for composting should be scaled up, giving residents stronger incentives to participate. Finally, the City of Stockholm could consider policies to increase the energy yield of waste incinerators and recover more value from incinerated materials.

- Energy: Stockholm distinguished itself in becoming an early proponent of widespread district heating. Its performance could be enhanced by creating incentives for Fortum, the majority owner in the system, to embrace a wider range of renewable sources. The City and County could also make it easier for small-scale renewable energy sources to connect to the electricity grid.

- Water: Water quality is an important factor in the region's attractiveness, and protecting Lake Mälaren from sea levels should be considered a regional priority. Adaptation technology offers an opportunity to develop products and services that can be exported to other coastal cities.

As the first European Green Capital, Stockholm is seen as a model for successfully combining growth and policies that reduce environmental impact. The metro-region exemplifies a range of best practices, particularly in congestion management, district heating and eco-districts. A number of opportunities remain, however, to further stimulate growth through activities that reduce environmental impact. This chapter first describes the green growth lens through which Stockholm's policies will be evaluated and then discusses how local vision and strategy documents might more explicitly combine environmental and economic goals. It then considers opportunities for stimulating green growth in the sectors of land use, transport, buildings, energy, waste and water. A recurring finding is that Stockholm has continued to build on its areas of strength but may nevertheless be overlooking growth opportunities from other urban activities that reduce negative environmental impacts.

The concept of green growth has given rise to much debate. Green growth aims to steer economic growth in a different direction, addressing externalities and other factors poorly served by current measures of economic activity. It also recognises that environmental policies that do not support economic growth and wealth creation are not sustainable in the long term. For the purposes of this case study, we define green growth in cities as:

> Fostering economic growth and development through urban activities that reduce negative environmental externalities, the impact on natural resources and the pressure on ecosystem services. (OECD, 2013)

This definition draws from the OECD Green Growth Strategy, which applies to national-level policies and which emphasises fostering economic growth and development while ensuring the continual provision of resource and ecosystem services (OECD, 2011a). The definition for green growth in cities differs in that it explicitly takes into account negative environmental externalities. This is crucial, because economic growth and development on the urban level can be undermined by the negative externalities of urban agglomeration, including traffic congestion, air pollution and development on land that provides ecosystem resources.

It is valuable to examine opportunities for green growth in cities because it is at the urban level that complementarities between environmental and economic policies can be most easily identified. Such complementarities can yield benefits in the returns generated when one policy is enacted alongside another (Macedo & Oliveira Martins, 2006). Cities' activities to deliver the public services and conditions that will foster growth can enhance, and be enhanced by, cities' activities to improve environmental quality and reduce pressures on the environment. In this way, cities may more effectively deliver on national-level environmental and economic objectives – whether or not they are identified as "green growth"– than national-level policies.

To assess the potential benefits of pursuing green growth in cities, we focus on the impact of policies to reduce environmental pressures and externalities on:

i. Urban attractiveness, defined here as the conditions that will attract firms and high-skilled workers to a metropolitan region.

ii. Job creation, which includes job opportunities at low, medium and high skill levels. Ultimately, the key metric here concerns not employment growth in the green sector but the aggregate employment impact of moving to a low-carbon economy. However, owing to limitations of the available data, we do not attempt to calculate net job growth or employment changes, but rather look at which

activities might foster job creation in a particular green growth sector. As an indicator, this must be seen as second-best, but a feasible second-best.

iii. Increasing the supply and demand of regionally produced green goods and services, which we define as those that reduce negative environmental externalities, the impact on natural resources and the pressure on ecosystem services.

Visions for an attractive, sustainable city, but potential divergence between County and City plans

Both the City and County of Stockholm have developed long-term visions that address many of the aspects of green growth, even if this is not explicitly identified. At the regional level, the RUFS 2010 non-binding regional plan focuses on sustainability, innovation, diversity and cohesion, while the City of Stockholm Vision 2030 focuses on versatile experiences, innovation and growth, and accessibility for all citizens (Stockholm County Council, 2010; City of Stockholm, 2007). Both visions include goals for transport, urban development patterns, housing, innovation, education and environmental quality.

The driving force of both Vision 2030 and RUFS 2010 is a focus on Stockholm's attractiveness. The plans' goals for strengthening the economy and improving environmental quality were developed in the context of attracting new residents, and to a lesser extent firms, to the Stockholm metro-region. It can therefore be assumed that attractiveness is the primary driver behind City and County efforts to foster growth through greener policies. Both documents assume an increase in population as a given, and attempt to mitigate the environmental impacts of this growth. RUFS is very much focused on reducing environmental impact while increasing growth. Vision 2030 projects that the population increase will have little or no effect on the environment, and the sectoral plans related to it provide details on how this can be achieved.

There may be further opportunities to integrate plans for economic and sustainable development. While both plans focus on the importance of bolstering innovation and fostering the region's attractiveness, neither explicitly identifies environmental or sustainable development initiatives as potentially important sources of growth. In contrast, the plan for the City of Amsterdam, *Plan Amsterdam* (2011a), specifically identifies improvements to environmental quality and the promotion of environmental technologies as an integral part of the city's economic development strategy. Hannover, Germany, has even merged its economic and environmental departments, bringing both activities together under the same plan. While this arrangement may not suit all cities, it would be valuable to revise both County and City visions to explicitly promote economic growth through policies to improve environmental quality and impact.

Green growth opportunities by sector

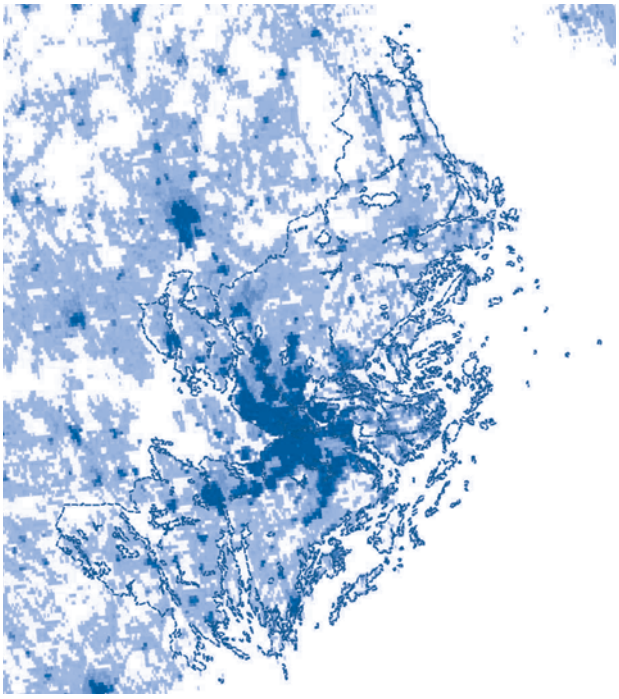
Land use and transport

Land-use and transport policies are crucial for reducing Stockholm's energy consumption from transport and for creating the conditions for long-term growth. In the Stockholm region, 66% of greenhouse gas emissions come from traffic. While CO_2 emission levels from transport have remained stable despite an increase in the total volume of traffic (thanks mainly to cleaner vehicles), further effort will be needed to meet the metro-region's low-carbon targets, given the projected population growth. Land-use

and transport policies to create an urban form with shorter commuting distances and greater use of public transport could reduce greenhouse gas emissions in the region in the long run (OECD, 2012a). Land use and transport can also create conditions for long-term growth. Promoting dense and proximate development patterns, diversifying land use and integrating investment in public transport and private urban development could usefully be explored. Higher residential densities can increase the cost-effectiveness of public transport by providing greater demand. Stockholm County has a few areas of high density (over 5 000 persons per square kilometre) as well as widely dispersed urban areas of low and medium density (Figure 2.1). This dispersed pattern of development can partly be attributed to its unique geographical characteristics (since the area is divided by many lakes and straits) and partly to post-war urban policies. New suburban towns were developed relatively far from the centre – accompanied by subway and regional train expansion – and valuable green areas were protected. While this transit-oriented development model has been working efficiently, it has resulted in a dispersed urban agglomeration. Stockholm now faces the challenge of how to accommodate population growth within the existing residential neighbourhoods without impinging on its green space.

Figure 2.1. **Urban land density map and density gradient graph in the County of Stockholm**

Landscan data



Note: The centre is considered to be the densest grid cell in the county.

Source: Based on *LandScan Global Population Database* (2009), *www.ornl.gov/sci/landscan/*; and CORINE Land Cover (2006), *www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2*.

Urban development strategy: Development of "nodes" should be carefully planned

In the RUFS 2010 regional development plan, Strategy 4 is of most relevance to land use and transportation, as it aims to further develop a dense, polycentric region (Stockholm County Council, 2010). New development in the region is being planned around eight cores, in addition to the central regional cores. The City of Stockholm's new Walkable City Plan also introduces the concept of node development (Box 2.1) (City of Stockholm, 2010). It paves the way for an increase in density in the expanded city centre and in a number of strategic nodes in the outer suburbs of the city. It also sets out strategic links that will connect the different parts of the city. Measures that include the development of the inner city and the strategic nodes in the outer city, linking these with new public transport, and establishing more cohesive urban environments and more attractive parks and green spaces are all intended to increase the city's sustainability (City of Stockholm, 2012a).

Box 2.1. **Stockholm's new city plan: The Walkable City**

The new City of Stockholm Plan outlines four urban development strategies, to be carefully phased in, for a more integrated and interconnected city. The focus is on making space for 200 000 new residents by 2030, while developing features that make the city attractive. The City Plan paves the way for an increase in density in the expanded city centre and in a number of strategic nodes in the outer suburbs. It also establishes strategic links that will connect the different parts of the city. Development of the inner city and the strategic nodes in the outer city, linking these with new public transport and establishing more cohesive urban environments and more attractive parks and green spaces are all presented as important elements of the city's sustainability. Key strategies for achieving this outcome include:

Strategy 1: Continue to strengthen central Stockholm. Plan for a cohesive, dense and dynamic urban environment in Stockholm's inner suburbs. Safeguard the need for high-amenity parks, attractive public spaces and corridors. In particular, examine appropriate development in the border zone between central Stockholm and surrounding districts.

Strategy 2: Focus on strategic nodes. Co-ordinate the development of nodes with the future transport system in the Stockholm-Mälardalen region. Develop a cohesive network of nodes in the southern and western suburbs. Increase links between nodes and neighbouring districts.

Strategy 3: Connect city areas. Prioritise the completion of the infrastructure projects referred to as the Citybanan line (cross-town rail tunnel) and the Stockholm Bypass to create strong links between southern and northern Stockholm. Expand public transport to encourage continued integration in the Stockholm-Mälaren region.

Strategy 4: Create a vibrant urban environment. Prioritise the interests set out in the City Plan. Examine appropriate use in the border zones between different areas in continued planning.

Source: City of Stockholm (2010), *The Walkable City, Stockholm City Plan*, City of Stockholm, Sweden.

Such development of "nodes" should be carefully planned and implemented so that public transportation can link each proposed node more effectively; each node keeps and develops its own character and diversity; and existing urban areas in each node are densified so as to prevent undesirable sprawl around the nodes. Both the City and the County are planning to connect the nodes in their plans through public transport. For example, in its new Walkable City Plan, the City recognises that many areas in Stockholm are poorly integrated with surrounding neighbourhoods, and public transport as a rule does not encourage travel to destinations other than the inner city. A long-term strategy to link the different areas of Stockholm into a more integrated urban environment would increase the opportunities for residents to meet and travel to work, education and leisure activities in a sustainable way (City of Stockholm, 2010). RUFS 2010 also lays out a vision of how the regional urban cores should be interlinked (Stockholm County Council, 2010).

The City's and the County's nodes could be more effectively connected through public transport. Developing these nodes will not solve the congestion problem in the absence of public transport connections between them. With insufficient investment in public transportation, such a development pattern could potentially reduce the modal share of public transport in the region at large. Closer co-ordination between the Public Transport Company (owned by the Stockholm County Council) and the planning authorities in the City and County would help to build a more effective public transport network among the nodes. Promoting mixed land use in each node will increase its urban attractiveness and allow residents to work closer to their homes. Diversified nodes will also allow existing infrastructure to be exploited more efficiently, since more people will be travelling outwards from the inner city during the peak traffic period (City of Stockholm, 2012a).

Existing urban areas could also be further densified. The designated city and regional nodes are not necessarily densely developed. This represents a potential for densification but also a risk that low-density development continues between the nodes, not within or adjacent to them. If the region fails to transform them into denser nodes, it will fail to accommodate the target population, or new suburban development will create further urban sprawl around the nodes.[1] The City of Stockholm is keenly aware of how changes to the built environment can affect property values (City of Stockholm, 2012a). Furthermore, the value of existing green spaces must be taken into account alongside the opportunity to develop the built environment. Development in the nodes needs to be accompanied by active planning to create more high-amenity and accessible parks for the growing population.

Accelerate infill development

Stockholm has become a leader in brownfield development. In the mid-1980s, the City began to develop previous industrial or railway land, and since the end of the 1990s, it has made the densification and re-utilisation of already developed land a priority. In the past five years, Stockholm's infill development rate (the share of infill development to the total urban development) has been well over 50% (City of Stockholm, 2012a). During 2000-07, a total of 25 000 new flats were built in the City. More than one-third of these (9 000 units) were built in larger brownfield areas (City of Stockholm, 2012a). Still, expanding brownfield redevelopment to the rest of the region is crucial to head off new urban development on the periphery. Monitoring performance in a more public and transparent fashion can help policy makers can to evaluate their brownfield policies. In Portland, Oregon, the Buildable Lands Inventory and the "refill rate" indicator are used to

monitor where under-utilised land is located and to what extent new urban development occurs through "infill" and "redevelopment" (Box 2.2). Setting a target for brownfield development might also be useful, although it should be handled with care, so that actual development takes the site's local conditions into account. Investment in public transport, such as new tramways to the Stockholm Royal Seaport as well as to Djurgarden, and inner-city transit-oriented development, such as urban redevelopment along with "Horseshoe" light-rail transit, are two powerful tools for attracting private investment in brownfields.

Box 2.2. **Portland's Buildable Lands Inventory and "refill rate" as monitoring tools for brownfield development**

Portland's Buildable Lands Inventory ensures periodic revisions of the boundaries by weighing the necessity of enlargement. While a state law requires Portland Metro to review the capacity of the Urban Growth Boundary (UGB) every five years to ensure a 20-year land supply, Metro has developed a detailed and sophisticated land-monitoring process to inventory vacant land and track the "refill rate". This is defined as the rate at which new development occurs through "infill" (when more units are constructed on an already developed lot) or "redevelopment" (when a structure is removed and another is built in its place).

In 2009, Metro found that the refill rate for new industrial development was 20%. For non-industrial use, 52% of new capacity was built on developed land (Metro, 2009). The residential refill rate has climbed steadily, from 30.4% from 1997-2001 to 33% from 2001-06 (Metro, 2009). Metro predicts the rate will rise to 38% from 2010 to 2030 (Metro, 2010). If it does, the urban growth boundary will be able to accommodate 11 300 additional dwellings without expanding. Refill rates are highest in the central city and lowest in suburban residential neighbourhoods. Most residential refill is multi-family housing, often as part of transit-oriented development. Portland prioritises transport projects that support refill and investment in transit-oriented developments to achieve higher density and a greater mix of uses than prevailing market conditions would support in terms of developers' construction costs and income from rent or sale (Metro, 2011).

Source: OECD (2012), *Compact City Policies: A Comparative Assessment*, OECD Green Growth Studies, OECD Publishing. doi: *10.1787/9789264167865-en*.

Stockholm's experience in the eco-districts (Hammarby Sjöstad and Stockholm Royal Seaport) is a brownfield development model to be expanded to other areas in the region. Since the 1980s, Stockholm has been engaged in the development of Hammarby Sjöstad, the Sweden's first large-scale eco-district. Hammarby Sjöstad demonstrates state-of-the-art eco-technologies for reaching energy-efficiency and waste-reduction targets, and it offers several interesting lessons in land use and transport.

- The district is located very close to the city centre.
- It has dense and mixed land use. Hammarby Sjöstad was developed with a density target of 150 dwellings per hectare. While this number is not particularly high, it is three times as dense as similar suburbs. The area has over 100 restaurants, to which people from around the city travel primarily on public or non-motorised transport. The ground floors of buildings facing the street are required to be non-residential, which at the time was a new approach in Swedish urban development projects. This requirement

underscores the City's commitment to avoid urban sprawl and to build the city "inward".

- The district has introduced a new tramway system, public ferries and a car-sharing system to reduce energy consumption from transport. Another important feature of Hammarby Sjöstad is that its private-sector investment was six times greater (EUR 3 billion) than public investment (EUR 0.5 billion).
- The project demonstrates that the cost of soil clean-up is not a critical impediment to brownfield development. The developer (Skanska) demonstrated that redevelopment in Hammarby Sjöstad resulted in construction costs of only 4% to 5%, while resulting in market values 15% to 20% higher than in other urban developments. However, this is probably a function of the high value of inner-city land. Such a return would be more limited in areas where urban infill land is less in demand. The city is currently engaged in another flagship brownfield development, Stockholm Royal Seaport (Box 2.3).

Box 2.3. **Stockholm Royal Seaport**

Stockholm Royal Seaport is a new urban district that is being built with environmental concerns as a guiding principle. It is built on a former brownfield industrial area of 236 hectares (previously used for gas, oil depots and containers) that is being transformed into a state-of-the art waterfront area. In 2008, the City Council decided on its environmental profile, with three explicit targets, building on the experience of Hammarby Sjöstad. Major features include:

- High-density development close to public transport.
- Green cluster innovation projects. While Stockholm Royal Seaport is not explicitly inviting green companies to locate in the district, it will provide space to use the innovations being applied in the eco-district as test cases for interested companies. Stockholm Royal Seaport is expected to be a showcase of business opportunities such as smart grids.

Source: City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", 13 January 2012, City of Stockholm, Sweden.

The success of Stockholm's eco-district policies will depend not only on the success of each district but also on how widely the lessons from the eco-districts can be applied to other developments in the region (up-scaling). It will also hinge on whether private vehicle use can effectively be reduced, and on other elements of urban sustainability, including innovation clusters and housing. To date, up-scaling seems to be occurring to a certain extent. For example, the energy efficiency standards in the development on city-owned land were made more stringent in response to the high standards set by Hammarby Sjöstad. The lessons of Hammarby Sjöstad are also being applied to Stockholm Royal Seaport. At present, the City may not be sufficiently taking into account the experience of eco-districts in other municipalities in the County, and it would do well to facilitate exchanges between them to share information.

In addition, a systematic approach is needed to expand the eco-district concept for forthcoming large urban developments such as Hagastaden[2] and Högdalen.[3] The public sector should create conditions, for example by investing in traffic infrastructure, so that the private sector can help redevelop brownfield land in the region, building on past experience in the eco-districts. The Stockholm Agreement is a good example in this regard. This is particularly important for brownfield developments located in the periphery of a region, where market values are not as high. In addition, the mix of residential, service and commercial uses should be considered to be sufficient in future brownfield development so as to sustain low use of private vehicles. The data from Hammarby should be carefully examined to determine how much the residents and employees in the district are using public transportation and are satisfied with the level of service. Finally, it is important to utilise eco-districts not only as a place to test eco-technologies but also as a model of sustainable urban development, by incorporating other elements of urban sustainability, including innovation cluster and housing. As shown in Kista, Hagastaden and Stockholm Royal Seaport, collaboration with private developers, industry and universities can create profitable opportunities for diverse urban districts.

Effectively managing the demand for private transport

Congestion charges, which the city first implemented in 2006, are a Stockholm success story. The data indicate that they have reduced car traffic in Stockholm to and from the city centre by an average of approximately 20%, and queuing times in and around the city centre has decreased by 30% to 50%. Greenhouse gas emissions have fallen by approximately 10% in the city centre and are stable in the city as a whole, despite population growth (City of Stockholm, 2012a). In other cities, congestion charges have reduced CO_2 emissions by up to 19.5% and decreased other air pollutants as well (Beevers & Carslaw, 2005) (Table 2.1). The system could be further improved to achieve higher air quality, promote more energy efficiency and counteract the impact of a growing population. For example, higher-polluting vehicles may be charged higher rates (as in Singapore and Milan), which more closely tie the congestion charges to greenhouse gas reduction goals.

Table 2.1. **Impacts of selected urban congestion charges**

	London	Stockholm	Singapore	Milan
Introduced	2003	2006	1975 1998 (2nd generation)	2008
Reduction in CO_2 emissions (%)	19.5	13	n.a.	9
Period of effect	2002-03	January-July 2006	n.a.	January-December 2008
Other effects	Reduction in emissions (NOx, PM10), car traffic	Reduction in emissions (NOx, CO, PM10), vehicle passages	Reduction in car traffic and car share in modal split	Reduction in emissions (PM10, NOx) and traffic volume

Source: OECD (2010), *Cities and Climate Change*, OECD Publishing, doi: *10.1787/9789264091375-en*.

Congestion charges can also be improved by using the revenue to finance public transport, as cities such as London already do. National regulations may in some cases constrain local governments' ability to redirect congestion charge revenue to public transport. In the case of Stockholm, the national government currently decides how to use

revenue from congestion charges, which are considered a national tax. Discussions are under way to allow the City of Stockholm, in co-operation with the County, greater control over the use of these revenues. This would be an important first step in getting public buy-in for an expansion of the congestion charge or implementation of restrictions based on vehicle size.

Greening effort and housing affordability

Affordable housing should also be considered a part of a green growth strategy. Currently, there are 400 ongoing projects in the City of Stockholm (50% rental, 50% condominiums, no social housing projects). This will create 100 000 new housing units (in addition to the current 400 000) by 2030. However, the affordable housing market is still tight and very hard to access. It will be a challenge not only to provide sufficient numbers of housing units, but to build them in the right locations. In particular, it is important to consider transport costs and connections and avoid creating areas of cheaper housing with lower accessibility. Regional development plans should address the location of housing development from the perspective of affordable housing, in particular in the development of regional nodes.

Buildings

Policies for increasing the energy efficiency of buildings can contribute to green growth by creating jobs in energy-efficiency services, fostering the growth of regional firms that specialise in energy efficiency and increasing attractiveness. As discussed in Chapter 1, residential buildings alone account for 35% of energy consumption in the City, and reducing their energy needs can yield a significant improvement in urban greenhouse gas emissions. Policies to increase the energy efficiency of existing buildings through retrofitting are perhaps the urban sustainability initiative most linked to job growth. While this job growth may not offset job losses in industries that are not energy-efficient, it is worth noting the job opportunities that building retrofits can offer. Job creation in building retrofits is estimated at around 11 jobs per EUR 1 million in investment, one of the highest direct job creation ratios of any form of green investment (Arene, 2007). In the City of Chicago, building retrofits are expected to add the highest number of green jobs (3 700 jobs over 2009-2020), followed by smart-grid activities (2 000 jobs over 2011-2020) and water/wastewater system upgrades (2 000 jobs over 2009-2020) (Jensen, 2011; Schrock, 2009; Schrock & Sundquist, 2009). Both the construction of new, energy-efficient buildings and the retrofitting of existing buildings can help increase demand for green services produced regionally, and help to attract firms and workers interested in reducing or offsetting their energy consumption.

The City is now leading three major energy-efficient building initiatives, one of which is focused on energy-efficient retrofitting of existing buildings. The two new-construction initiatives involve the Stockholm Royal Seaport eco-district and in the up-and-coming West Liljeholmen eco-district. The energy-efficiency retrofitting initiative concerns the buildings constructed in the 1960s-1970s as part of the Swedish "One Million Homes" project. Built with industrialised construction methods to quickly accommodate the needs for decent housing for a growing population, these buildings are very energy inefficient. The City's project in the Järva district, in the northwest of the city, is intended to both improve the energy performance of these city-owned buildings and reduce the degree of social isolation experienced by the inhabitants (Andersson, 2012; Enarsson, 2012). The Järva project aims to reduce the energy consumption of the retrofitted buildings by 50%. The energy efficiency measures are

expected to be paid back through energy savings in 15 years, and the total cost of the renovation is expected to be paid back in 30 years (Enarsson, 2012).

It is worth noting that the strong performance on energy efficiency retrofitting of Stockholm's publicly owned buildings does not extend to privately owned buildings. The vast majority of energy-efficiency retrofits in Sweden occur in the public sector. One reason for this lack of private retrofitting may be obstacles to the greater use of Energy Services Companies (ESCOs), particularly related to public information and education (Soroye & Nilsson, 2010). In many cities, it has been easier for ESCOs to conduct energy-efficiency retrofits of the commercial building sector, as they offer larger economies of scale. This is the case in the Chicago Tri-State metro-region, where ESCOs have been filling the need for commercial and institutional energy retrofits but have been involved in comparatively few residential retrofitting projects (OECD, 2012b). Some cities have sought to increase the number of energy-efficiency retrofits of privately owned residential buildings by bringing potentially interested consumers together and linking them to ESCOs. These, in turn, agree to achieve an agreed amount of energy efficiency savings in each property. Berlin provides a leading example of this, although its model may not directly apply to the Swedish banking system (Box 2.4).

Box 2.4. **The Berlin Energy Agency, Energy Saving Partnerships and the KfW bank**

The City of Berlin has worked with Investionsbank Berlin and the German public investment bank Kreditanstalt für Wiederaufbau (KfW), a key financial institution for financing retrofits in Germany, providing private building owners, tenants and housing corporations with access to loans. Since 1991, over EUR 4 billion has been invested in retrofits that save roughly 631 000 tonnes of CO_2 every year (City of Berlin, 2011). Loans are in principle refinanced through energy savings. Landlords have the right to increases rents up to 11%, which applies to many cases in Berlin, where a large part of the housing stock consists of rented flats (much as in other German cities). The higher rent in renovated buildings should be balanced against the tenants' savings on their heating and electricity bills. As a result of various KfW programs since the early 1990s, around one-third of the residential buildings in Berlin have been retrofitted, including 273 000 prefabricated apartments, for which energy consumption was reduced by 50% (City of Berlin, 2011).

Source: City of Berlin (2011), *Climate Protection in Berlin*, Senatsverwaltung für Gesundheit, Umwelt und Verbraucherschutz, Berlin.

Solid waste

Policies for recycling, composting or efficiently incinerating solid waste can create work for local firms and potentially reduce local governments' spending on waste disposal services. Solid waste contributes to climate change through the release of greenhouse gases from landfills and from older, less efficient waste incinerators. Methane from landfills, which represents the largest share of greenhouse gas emissions produced by the waste sector, is of the greatest concern, because it has a significantly greater impact on climate change than CO_2 emissions and continues to be released for decades after waste disposal (IPCC, 2007). As discussed in Chapter 1, recycling and composting

tend to be most effective in reducing greenhouse gas emissions, as they have been shown to consume less energy than disposing of the waste in landfills or by incineration, even when taking into account the potential energy that may be captured in landfills or incinerators (Morris, 2005). Waste incineration of non-recyclable material is a vast improvement on landfills, because "scrubbing" technologies can minimise the release of greenhouse gases and other pollutants, and the incinerators can generate heat and electricity. Both recycling/composting and waste incineration-to-energy activities can contribute to economic growth by stimulating innovation and demand for local service providers and potentially reducing the amount local governments spend on waste collection and disposal services.

Stockholm has made great strides in diverting waste from landfill. The only items landfilled are stabilised fly-ash and bulky household waste (Lundkvist, 2012). Very little household waste in the City of Stockholm goes to landfill, with 21% of the total recycled and 70% incinerated (Table 2.2) (City of Stockholm, 2012a). The recycling system is entirely paid for by an association of producers, or companies who sell packaging (either manufactured or imported), and who are legally responsible for separation, collection and recycling. This system does not involve household collection but rather relies on collection points throughout the city. The City has also initiated voluntary food waste disposal, which so far involves approximately 800 businesses. Before 2011, most of the separately collected food waste was processed by composting, but since the beginning of 2011, 100% of the food waste has been converted to biogas for vehicles (City of Stockholm, 2012b). The 75 trucks that collect household waste in the city run on biogas, which is also produced by the Sjöstaden and Henriksdal wastewater treatment plants (Lundkvist, 2012).

Table 2.2. **City of Stockholm waste-processing totals**

	2007	2008	2009	2010
Household waste for incineration (kg per capita)	409	391	368	363
Household waste for materials recycling (kg per capita)	110	110	103	101
Volume of household waste going to landfill (kg per capita)	39	34	27	28
Household waste for central biological processing (kg per capita)	3.1	3.9	6.2	8.1
Household waste composted at home or deposited via waste disposal units (kg per capita)	1.0	-	-	0.9
Share of household waste recycled via materials recycling, including biological processing (%)	20	21	21	21
Share of food waste from households, restaurants, commercial kitchens and stores that recycle via biological processing (%)	3.5	3.4	4.5	6.7

Source: City of Stockholm (2012), "OECD Green Cities Stockholm Background Report", 13 January 2012, City of Stockholm, Sweden.

Stockholm is a leader in cleanly incinerating non-recyclable waste and generating power and electricity. Its first incineration plant was established in 1909 (City of Stockholm, 2012a). The City's waste incineration currently takes place at the Högdalen combined heat and power plant, which is a cornerstone of the City of Stockholm's district heating system (Lundkvist, 2012). A small share (8%) of the organic waste (food waste and other biowaste) is sorted separately and digested or combusted to become biofuel,

which is used by Högdalen and by the Hammarby thermal power station. What is not sorted out is incinerated for energy recovery. One potential problem with this reliance on waste is that it skews incentives, blunting the policy stress on trimming resource intensity through reducing unnecessary trash. Sweden as a whole is in fact so dependent on waste in the fuel mix for its district heating that it imports 800 000 tonnes of it, primarily from Norway. The waste-to-energy plants generate 20% of Sweden's district heating and generate enough electricity to supply 250 000 homes (Wright, 2012).

National regulations have played an important role in the City's success in reducing the waste going to landfill. A national ban has existed since 2002 on sending unsorted combustible waste to landfill, and this was extended in 2005 to cover nearly all organic waste (City of Stockholm, 2012a). These bans, along with a national landfill tax, are largely responsible for the very low share of waste going to landfill (Lundkvist, 2012). Another national policy that has played a large role in Stockholm's waste disposal patterns is the "Producer Fees" requirement, under which companies that market packaging fund the collection, sorting and processing of recyclable materials. This is unusual in that it shifts all responsibility for materials recycling to the private sector.

Despite Stockholm's low rates of waste going to landfill, there remain three main opportunities through which waste policies may contribute to growth.

- While only non-recyclable waste is supposed to go to incinerators, the low rates of recycling suggest that more could be done to divert recyclable waste. In its most recent analysis of a solid waste sample in October 2011, the City found that 24% of the material being incinerated was packaging, 8% was paper, and 38% was biowaste, including food (City of Stockholm, 2012b). While an argument may be made that waste provides fuel for waste-to-energy plants, the question may be raised whether more value could be extracted from waste by recycling it. Currently, residents must bring household recyclables to collection points, which are managed by FTI AB, an association of producers, and serviced by companies hired by the association. Municipalities have in the past argued that the FTI AB does not put enough collection points in the low-density areas, where they are less profitable. In these cases, municipalities often create additional collection points, at a cost to their residents (Kalmykova, 2012). Introducing recycling sorting bins alongside household waste collection, as many cities across the OECD do, would make it easier for residents to sort and deposit recyclables, which could lead to higher shares of waste being recycled. However, this would require a renegotiation of the private sector's requirement to fund recycling activities, as the collection costs would be higher. A recent national government report has suggested that municipalities be responsible for the collection of packaging and newspapers, and offer recycling of food waste for households. This proposal is under study, and a decision is expected in June 2013 (Swedish Ministry of the Environment, 2012).
- Another opportunity is to significantly increase the share of waste that is composted. In the City's voluntary composting programme, double dustbins are provided that split food waste from non-recyclable household waste. The goal is to recycle 40% of the food waste in the city. However, this is complicated to organise in multi-family buildings, especially in the oldest parts of the city (Lundkvist, 2012). Work is ongoing to connect more restaurants and other businesses. Today, the roughly 800 businesses that are connected represent an increase of 60 percent since 2010. During the same period, the number of connected apartment buildings has also doubled. In July 2012, a weight-based tariff was introduced for residential households, combined with extended

information about the possibility of sorting food waste. The number of connected residential households doubled over the period July-September 2012 (City of Stockholm, 2012c).

- Finally, the City could consider measures to recover even more value from incinerated materials. Högdalen and other waste incineration plants could further recover valuable raw materials from the bottom ash (Jonkhoff, 2012). The City of Amsterdam's Waste and Energy Company provides an example of greater recovery of incinerated materials (Box 2.5).

Box 2.5. **City of Amsterdam's Waste and Energy Company**

The City of Amsterdam's Waste and Energy Company (Afval Energie Bedrijf, or AEB) has developed innovative technologies for combining waste recovery and incineration. AEB recycles 99% of the waste it processes, which amounts to over 1.4 million tonnes of recycled domestic and industrial waste per year. This represents 20% to 25% of the total annual quantity of combustible waste in the Netherlands. AEB generates 1 million MWh of electricity, enough to meet 1% of the energy demand of the Netherlands. AEB also generates 500 000 gigajoules of energy for district heating and hot water.

AEB's Waste-Fired Power Plant (WFPP) has set a new global standard for electrical efficiency and maximising products from waste. New technology has achieved an energy efficiency that is 30% higher than the average. The Dutch Ministry of Infrastructure and the Environment therefore awarded AEB "Recovery" (R1) status. This means that the government regards the method applied by AEB to convert waste into energy and construction materials as recycling. This also enables AEB to import waste for processing.

Both the bottom ash and airborne ash that remain after incineration are mined for materials. First, valuable metals, such as iron, copper and aluminium, are extracted from the bottom ash and are sold to specialised recycling companies. AEB recovers 17 740 tonnes of iron and 2 595 tonnes of non-ferrous metals (such as copper and aluminium) from bottom ash (the incombustible materials left over after incineration). The remaining bottom ash is used as fill material for road embankments. The airborne ash particles ("fly ash") that are captured during the cleaning process are used in the asphalt industry. Additionally, gypsum is extracted during the treatment process and can be put to use in the construction industry.

Source: City of Amsterdam (2011), "Energizing Society: Source of Energy, Raw Materials and Innovation", City of Amsterdam Waste and Energy Company, the Netherlands; Jonkhoff, E. (2012), "Briefing note OECD case study mission Stockholm, 16-20 April 2012" by Eveline Jonkhoff, senior advisor, sustainable strategy, City of Amsterdam, the Netherlands.

District heating and smart grid

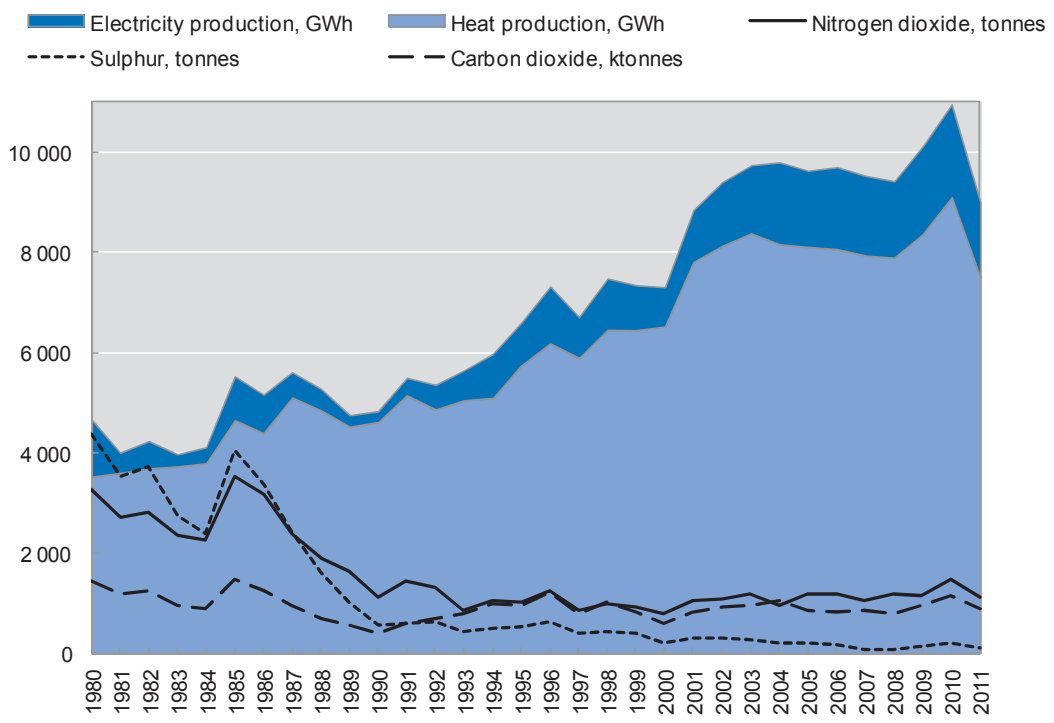
Moving to a renewable energy mix and implementing efficient energy delivery infrastructures can contribute to green growth by increasing a metro-region's attractiveness and potentially creating a market for regionally generated renewable energy. It can also decrease environmental pressures such as greenhouse gas emissions and air pollutants. Efficient energy delivery infrastructures include district heating/cooling and smart grids, which can facilitate the use of renewable energies, such as wind, solar and biomass. District heating/cooling and smart grids have the potential for reducing energy costs by making energy delivery more efficient and more responsive to

users' needs. Investments in district heating/cooling and smart grids, as well as in the generation of renewable energy, can foster demand for regional firms specialising in these technologies.

District heating

Energy generation is one of the sectors in which Stockholm most stands out as a green city. District heating's large market share, as well as the change in its fuel mix to renewables and away from fossil fuels, contributed most to Stockholm's ability to constrain the growth of its greenhouse gas emissions (City of Stockholm, 2009). There are four major production plants that supply Stockholm with its district heating. The district heating system expands annually by about 200 to 300 GWh per year, and currently covers about 80% of Stockholm's total heating needs. The shift away from fossil fuels has reduced not only CO_2 emissions but also emissions of sulphur and other pollutants (Figure 2.2). Over 1982-2012, CO_2 emissions per kWh of heat decreased by 72%, sulphur emissions decreased by 97%, and NO_x emissions decreased by 86% (Fortum, 2012a).

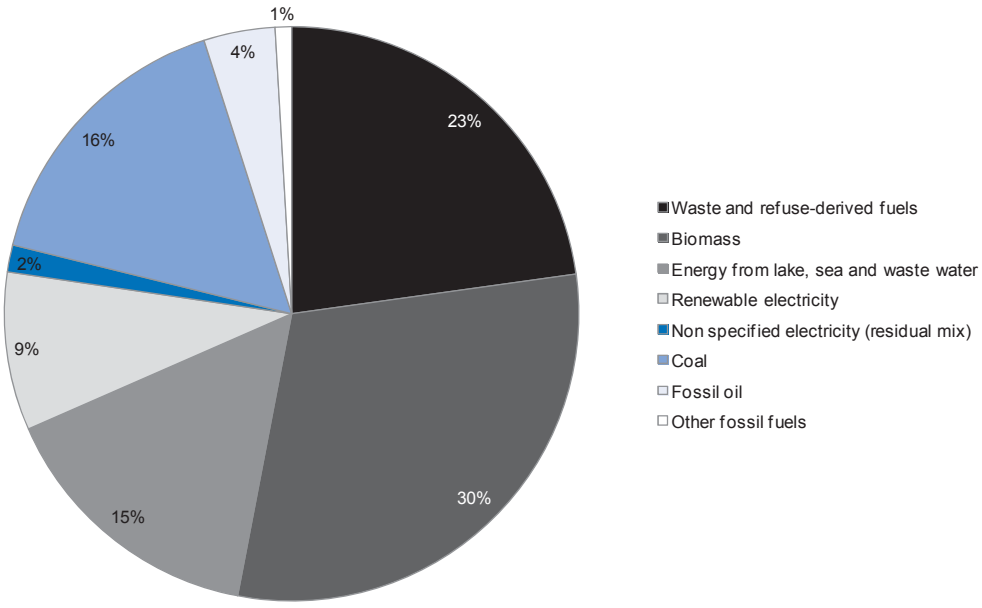
Figure 2.2. **Emissions from co-generation heat and electricity production**



Source: Fortum (2012), personal communication from Ulf Wikström, Sustainability Manager, 2 November 2012, Fortum, Stockholm, Sweden.

Energy for the district heating system comes from a range of sources, most of which are renewable (Figure 2.3). Roughly one-fifth of the sources are fossil fuels, however, with coal representing a 16% share and oil representing a 4% share. The largest share of energy comes from waste (23%) and bio-mass (30%), which is primarily derived from wood products but can also include waste (City of Stockholm, 2012d). The district heating plants are owned and operated by Fortum, a private firm, but the City of Stockholm maintains a 50% controlling share. The biofuels used by Fortum are verified sustainable biofuels, which means that their source is traceable and confirmed as sustainably harvested (Fortum, 2012b). There is nevertheless room for improvement on the sources of energy for the district heating. The reliance on waste and biofuel has led Fortum to import waste from other countries, as discussed above. Some observers argue that another promising option is the opportunity to create long-term, large-scale demand for other renewable energy sources that may be less finite than biomass and waste but might otherwise have trouble securing a market. This is particularly the case of wind energy, which local governments have so far found problematic to develop inside city borders. This stands in contrast to the experience of the City of Copenhagen, which is actively developing wind farms both within and outside the city (Box 2.6).

Figure 2.3. **Energy mix in district heating production, 2011**



Source: Fortum (2012), personal communication from Ulf Wikström, Sustainability Manager, 2 November 2012, Fortum, Stockholm, Sweden.

Box 2.6. **The City of Copenhagen's wind energy plans**

Copenhagen's proposed new climate plan, KHB 2025 Klimaplan, published in May 2012, sets the City's goal for carbon neutrality by 2025. Copenhagen will have to produce surplus energy from renewables to set off against the carbon emissions that will still be a reality in 2025, such as those from transport. To achieve the goals of the plan, more than 100 large wind turbines will have to be built on the initiative of the City of Copenhagen.

The climate plan's goals for the erection of wind turbines inside and outside the City of Copenhagen include:

- The erection by 2015 of a total of approximately 140 MW wind turbines offshore and onshore.
- The establishment by 2015 of wind turbine co-operatives, with a view to selling shares in wind turbines to citizens and enterprises.
- The erection by 2025 of a total of approximately 360MW wind turbines offshore and onshore.

The goal for wind turbines in Copenhagen in 2025 covers almost one-fifth of Danish national wind energy goals in 2020. These wind turbines will deliver carbon reductions of 340 000 tonnes in 2025. The wind turbines will thus meet almost one-third of the total reduction of 1.16 million tonnes of CO_2, which is to ensure the city's carbon neutrality.

Copenhagen Energy has been signed on as the contractor for the erection of the turbines by the Copenhagen City Council. Total investments are at around DKK 5.5 billion. The City of Copenhagen has agreed to provide guarantees for loans taken by Copenhagen Energy for all wind turbine projects. The City has also provided Copenhagen Energy with a mandate to participate in joint ventures for the purpose of bidding for state offshore wind turbine projects.

The City of Copenhagen already has eight smaller wind turbines within its limits: seven by the wastewater treatment facility at Lynetten, and one by the large conference centre, Bella Centre, which hosted COP15. A new survey has identified four suitable locations for onshore wind turbines within the City of Copenhagen's limits. The planning process for the first two locations is expected to end in 2012. If everything goes well, the first turbines will be put into operation in 2013.

Four suitable locations have also been identified for new coastal offshore wind turbines in Øresund. Coastal offshore wind turbines are placed up to 20 kilometres off the coast, in part to reduce nuisances they might cause by shade, noise and construction. Given that the establishment costs for coastal turbines are greater than for onshore wind turbines, but the Danish subsidy for coastal wind turbines is the same as that for onshore wind turbines, coastal wind turbines are currently not economically feasible. In co-operation with other Danish municipalities, the City of Copenhagen is working for an amendment to the economic framework conditions in the area.

Copenhagen also finances onshore wind turbines in other municipalities, given the limited room for wind turbines in the densely built-up city. Copenhagen Energy is looking to obtain permission to erect around 16 turbines in east and west Denmark. The precise locations have not yet been decided, but a large number of municipalities have identified areas that are suitable for wind turbines. Copenhagen Energy is therefore in the process of contacting land owners to establish contracts for the establishment of wind turbines.

In compliance with Danish regulations (see above), Copenhageners will be provided opportunity to buy shares in the planned wind turbines in Copenhagen. In a 2011 study of 1 051 Copenhageners, as many as 89% back the idea of erecting wind turbines in Copenhagen. They also support the specific plans for the erection of wind turbines in or outside Copenhagen. The plans to erect respectively two and four wind turbines in two different locations within the City's limits are receiving support from 84% and 88% respectively.

According to estimates, the erection of around 100 Copenhagen wind turbines will provide employment equivalent to 5 000 man-years in the construction phase, and 150 man-years in the operation phase. The job effect will stretch over a number of years and will probably include jobs in both Denmark and abroad.

Source: Fogh, L. (2012), "Big Cities' Involvement in Wind Power Expansion", briefing note, OECD case study mission Stockholm, 16-20 April 2012", Document no. 2012-535463, City of Copenhagen, Denmark.

Smart grid

Smart grid technologies are just beginning to be implemented in Stockholm. Smart grids involve improvements to the electricity grid that allow real-time monitoring of user demand. They also allow for the flexibility needed to incorporate the contribution of small-scale renewable energy sources. The Stockholm Royal Seaport Eco-District is the site of a set of smart-grid projects that were initiated by Fortum in its role as a grid owner in 2009, and which aim to develop a power grid that allows for real-time information on electricity consumption throughout the district. The smart-grid research is the first R&D project of the Stockholm Royal Seaport innovation centre (City of Stockholm, 2012a). Led by Fortum, ABB and KTH, the Royal Institute of Technology, the project is intended to increase the use of renewable energy sources, to reduce the energy demand from buildings and to establish infrastructure for the large-scale use of electric vehicles (Stockholm Royal Seaport, n.d.). The City of Stockholm is involved in the project, in part to help Fortum develop business models to identify the right financing for the grid improvements, which is currently the biggest obstacle. Furthermore, many of the institutes involved in the development of the smart grid receive about 50% of their funding from the national government.

One issue that project partners are attempting to address is how residents will interact with smart meters and how this will affect their energy usage. This is the subject of a three-year study starting in 2012. The Royal Seaport smart-grid project is one of many smart-grid projects currently being developed and tested, including in Kitakyushu, Japan (Box 2.7). Regulatory and market barriers may be preventing small-scale, distributed renewable electricity from connecting to the electricity grid. While Swedish national legislation has since April 2010 given small-scale electricity producers access to the electricity grid (City of Stockholm, 2012d), more could be done to incentivise smart-grid improvements and lower barriers to distributed renewable energy generation. The need for a regional approach to the governance of smart grids is further discussed in Chapter 4.

Box 2.7. **Kitakyushu Smart Grid "Smart Community Demonstration Area"**

Currently in the making, the City of Kitakyushu is setting up a Smart Community Demonstration Area in the Yahata Higashida area of Kitakyushu, in co-operation with Nippon Steel Corporation and with support from the national government. This project is one out of four smart community and smart-grid projects the Japanese government is running in parallel to test different technologies and community approaches. The core of the Kitakyushu Smart Community Demonstration Area is a smart grid that allows flexible integration of electricity demand – from consumers and businesses – and supply through a co-generation plant, which also supplies heat to adjacent industries. The main objective of this project is to experiment with smart-grid technology and consumer behaviour in order to extend the project to larger areas in Kitakyushu. The Smart Community Demonstration Area also includes sustainable mobility solutions, such as electric bicycles and hydrogen-powered cars. Hydrogen is directly supplied as a by-product from industrial facilities next to the Higashida area.

Source: OECD (2013),*Green Growth in Kitakyushu, Japan*, OECD Green Growth Studies, OECD Publishing, doi: *10.1787/9789264195134-en.*

Water quality and adaptation

Improving water quality and protecting water sources from potential climate change impacts can contribute to green growth by attracting firms and high-skilled workers, potentially creating a market for regionally produced water technologies. While water quality is generally high across the OECD, regular investments in water distribution and

wastewater treatment infrastructure are needed to maintain water-quality levels. Water quality is increasingly threatened by climate change. The increasing frequency of severe weather events, combined with sea-level rise, can result in hydrological changes that stress the capacity of drainage infrastructures, sewage systems and water treatment facilities in cities (Hallegatte et al., 2011). This is all the more urgent given that some insurance companies are raising their premiums in response to perceived climate change risks (Kuipers, 2012; Marr, 2011). In 2008, Ernst & Young identified climate change as the top strategic risk for the insurance industry (Ernst & Young, 2008). Reducing vulnerability to potential climate change impacts could soon become a factor in attracting firms and workers, particularly those sensitive to rising insurance rates.

The high quality of Stockholm's water is used to promote the region's attractiveness. Drinkable, swimmable water is a means of signalling a metro-region's environmental quality, and an important symbol of a city's ability to manage the negative environmental externalities that can be associated with urban agglomeration. Given the role it plays in attractiveness, it is important to consider adaptation measures and other potential threats to water quality. As mentioned in Chapter 1, a rise in the level of the Baltic Sea could contaminate Lake Mälaren with salt water, threatening the metro-region's primary water source. While the current reconstruction of the Lake Mälaren lock in central Stockholm has begun to address this problem, greater infrastructure investments may be needed in the future. One strategy for addressing sea level threats is to turn the adaptation technology into a model that can serve as a basis for the development of technologies that can be exported to other coastal cities. This can preserve attractiveness, while also supporting local green firms involved in adaptation technologies. An important example of this is the Venice MOSE project (Box 2.8).

Box 2.8. **Venice's MOSE flood protection system**

The City of Venice has undertaken massive infrastructure improvements to protect the city from rising sea levels and more extreme storm impacts, at a cost of EUR 4.272 billion. The main aim of this complex system of mobile dams and permanent works is to protect the cities of Venice and Chioggia, the Venetian lagoon's historical centres and the broader lagoon basin from the detrimental effects of medium-to-high tides and the devastating effects of exceptional storm-surge tides. MOSE is a series of projects under the broader General Work Plan for the Protection of Venice and the Lagoon, started by the Italian Ministry for Infrastructure in 1987 together with Venice's Magistrato alle Acque (the operational branch of the Ministry for the lagoon), which exemplifies the largest plan ever for the defence, recovery and restoration of the environment carried out by the Italian State. The MOSE includes several complementary public works to safeguard Venice, such as:

- 1 400 hectares of tidal mudflats and saltmarshes and sandbars have been reinstated and protected;
- 35 kilometres of industrial channels and five former landfills have been protected;
- 100 kilometres of embankments have been raised;
- 45 kilometres of beaches have been rebuilt and 10 kilometres of wharfs have been restructured.

The MOSE's mobile dams will protect Venice and its lagoon from tides up to 3 metres high and from an increase in sea level of at least 60 centimetres, which could occur over the next 100 years. Even when the dams are up, the port's operations will still be assured, thanks to the construction of a large shipping lock at the mouth of the lagoon.

Source: OECD (2010), *OECD Territorial Reviews: Venice, Italy 2010*, OECD Publishing, doi: *10.1787/9789264083523-en*.

Notes

1. Urban sprawl is defined here as uncontrolled expansion of urban development characterised by low density, segregated land use and insufficient provision of infrastructure. Urban sprawl can take the form of "leapfrog development", in which development "leaps" over undeveloped land (OECD, 2012a).
2. A large urban development project is to be built by 2025 on the ring road of Stockholm, to include nine car lanes, three transit lines and housing on top of the infrastructure. High property values are projected.
3. South of Stockholm. Expecting 60 000 workers by 2020 with the goal of reducing commuting distances. Energy will be provided by waste incineration. IT will also serve as a demonstration site for water treatment.

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Chapter 3

Green innovation in Stockholm

Chapter 3 reviews the regional green technology innovation ecosystem in the Stockholm metro-region. It assesses the metro-region's innovation performance, institutions, infrastructure and key players for a regional innovation system. It focuses on conditions for entrepreneurship, spinoffs and venture capital, the profile of Stockholm's green technology exports, higher education infrastructure and skills development, as well as research and innovation policies.

Key innovation findings and recommendations

- The City of Stockholm and Stockholm County enjoy remarkable R&D assets and cutting-edge environmental technology. However, the cleantech sector is limited in its ability to generate spinoffs and to promote the growth of SMEs. This suggests a need for a consolidated central and regional innovation policy that places cleantech activities on an equal footing with other major industries, such as ICT or the life sciences.
- To bolster research and innovation infrastructure it is important that a regional innovation strategy emphasise the full functional region, and that it align with the National Environmental Technology Strategy adopted by the Parliament at the end of 2011 and its linkages with an innovation strategy.
- The Stockholm green technology regional innovation system could usefully be institutionalised and more clearly identified. This should include mapping of the Stockholm green cluster to better understand its main assets in the region. Greater coherence could be brought to the array of public-private partnerships that support the development of cleantech activities. There is an urgent need to create an appropriate structure or platform to address strategic issues and collaboration challenges.
- To strengthen cleantech entrepreneurship and SMEs, the central government, as well as Stockholm County and the City of Stockholm, could further encourage the formation of new innovative business in the green sector and help SMEs to expand their R&D activities.
- The cleantech exports of the Stockholm region do not currently have a high international profile, despite the fact that Stockholm has accumulated expertise in systems thinking and is well placed to disseminate holistic cleantech solutions abroad. The central government, Stockholm County and the City of Stockholm would do well to streamline all programmes aimed at stimulating green technologies under a coherent and ambitious strategic initiative. The international branding of Stockholm's cleantech activities could also be enhanced by putting them in the context of – but distinguishing them from – other cleantech clusters in Sweden, such as Gothenburg (Cleantech Inwest), Malmö and the Jämtland/Västernorrland counties.
- Innovation stakeholders in Stockholm could expand collaboration among the cleantech elements of Swedish universities and across Nordic countries and beyond. An umbrella organisation similar to the life sciences-oriented Stockholm Science City Foundation should be established in the field of cleantech technologies, to provide support for of interdisciplinary research programmes and better connect Stockholm higher education institutions involved in cleantech research with their counterparts at the Malmö Cleantech Cluster, Cleantech Östergötland and the Uppsala cluster. The role of university innovation offices should not be limited to technology transfer but rather should serve a convening function for SMEs and as brokers and co-ordinators of the cleantech clusters and subclusters.
- To streamline this institutional eco-system and avoid duplication of work and inefficiencies, innovation policy needs to more closely align R&D activities with the comparative advantages of the Stockholm region. Other innovation-relevant agencies, such as Tillväxtverket, the Swedish Agency for Economic and Regional Growth, would do well to follow the lead of VINNOVA, the Swedish Governmental Agency for Innovation Systems in undertaking programmes with a sustainability goal. A minimum share of these agencies' project portfolios should be linked to green growth.

At the beginning of this decade, the Stockholm region's growth trajectory is being built on solid ground. Its achievements in a number of fields are remarkable. Its R&D has developed cutting-edge environmental technology including advanced water purification systems and efficient waste management, the ability to tackle green house gas emissions in the transport and housing sectors and the capacity to make the city more compact. Stockholm is also well known for its district heating and cooling infrastructures, its automated waste management system and its wastewater treatment plants. This strong performance is in part the result of the growing competitiveness of the cleantech regional innovation system operating in the City of Stockholm and Stockholm County. Green activities increasingly overlap with a robust ICT cluster based in Kista and interact to a lesser extent with the life science hotspots centred around the Karolinska Institutet.

However, while the green cluster[1] has been resilient during the financial crisis, its ability to generate spinoffs and to nurture SME growth has not significantly expanded. This calls for the central government and the authorities in the City and County of Stockholm to strengthen their innovation policy effort. In the same vein, export capacities of green products and services have remained below their potential and are only slowly being used to build networks in the Nordic countries and abroad. New policy initiatives to help broaden the innovation base, to favour the development of niches on the green frontier and to facilitate the implementation of ambitious trade strategies would be welcome. Universities continue to play a major role in public R&D, but they have been less efficient in supporting innovation through start-ups and SMEs, as well as in the advanced service sectors. Obstacles to closer university-industry relationships have limited the number and size of collaborative cleantech projects. Recent efforts by public authorities, including the new innovation strategy presented by the central government in the summer of 2012, recognise these points (Government Offices of Sweden, 2012). They share the view that cleantech activities are not yet on an equal footing with other major industries, such as ICT or biotech, and that this gap needs to be closed.

Strengthening the green technology knowledge economy

In Stockholm, framework conditions seem to be very favourable for innovation. The City/Region offers a solid R&D environment (Box 3.1). The gross expenditure in R&D as a ratio of GDP is 4.3%, which is higher than both the national average of 3.7% as well as the EU27 average of 1.8% (2003-06 averages). Moreover, the share of gross expenditure in R&D that represents private, rather than public investments is higher in the Stockholm region than the EU27 average (72.1% and 63.6% respectively). This high level of expenditure in business R&D may be explained by the presence of several research-intensive companies, particularly in the sectors of ICT (Ericsson, IBM Svenska and TeliaSonera) and life sciences (Pfizer). The increasing number of patents can be traced to the strong ICT and life sciences clusters present in the region. While patent numbers do not tell the full story, Stockholm's offerings declined until it disappeared from the list of the world's 20 top regions for green patents in 1995-1997.

Box 3.1. **Swedish R&D performance**

Sweden is considered one of the most advanced countries in the world in terms of innovation. It typically ranks high in international reports on science and technology indicators, such as the ones regularly published by the OECD or Eurostat. In 2009, Sweden invested 3.75% of its GDP in R&D, well above the United States (2.77%) and Japan (2.44%) (OECD, 2010). The number of full-time R&D employees per 1 000 employees was 17.0 in 2000, below only Finland (22.4) and Iceland (17.5) in the ranking of OECD countries.

This high performance in research and development is partly due to Sweden's industrial structure, which is dominated by large R&D-intensive multinational groups (such as Ericsson) as well as a strong specialisation in high-tech industries and services. Both the National Innovation System as well as the Global Innovation Networks in which Sweden participate are highly influenced by the industrial structure of Sweden.

As with many small countries, the Swedish economy has a strong international orientation, which is also reflected in the national innovation system. The national innovation system is dominated by internationally oriented industrial firms and universities. Furthermore, since 1988, the country has experienced a growing number of mergers and acquisitions of technology-intensive firms by foreign companies (Arnold et al., 2007) whose presence, particularly in certain industries, is very noticeable.

In terms of innovation output, the performance is less satisfactory. In 2008, Sweden ranked only 14th in energy and environment patents (OECD Patent Database), below the OECD average. Between 2000 and 2008, the number of its international patent applications in green technology submitted to Patent Co-operation Treaty (PTC) has increased relatively slowly.

Source: OECD (2010), *OECD Science, Technology and Industry Outlook 2010*, OECD Publishing, doi: *10.1787/sti_outlook-2010-en*; Arnold, E. et al. (2007), *The Role of Industrial Research Institute in the National Innovation System*, VINNOVA Analysis VA, Swedish Governmental Agency for Innovation Systems, Stockholm.

Stockholm offers solid research and development environments, but there are signs that the region's position is at risk of deteriorating. Investment in research and innovation infrastructure (investments that permit concept testing, demonstration and verification) needs to be increased. These provide platforms for collaboration between academia and industry and can lead to new co-operation and business opportunities. Access to venture capital and business skills for seed-stage companies could also be improved upon, along with the strengthening of innovation and growth in small and mid-size companies.

Innovation is included within the framework of the RUFS 2010, which is intended to serve both as a regional plan and a regional development programme. It describes the direction for joint long-term development efforts in Stockholm. The Stockholm County Administrative Board has now identified priorities for the county's regional growth for the period 2014-20 in line with RUFS 2010, and has completed the regional innovation strategy in collaboration with the Karolinska Institute, Stockholm County Association of Local Authorities, KTH Royal Institute of Technology, Stockholm Business Region, Stockholm Chamber of Commerce, Stockholm County Council, City of Stockholm and Stockholm University (Box 3.2) (Stockholm County Council, 2012).

Box 3.2. ***Stockholm 2025: The World's Most Innovation-Driven Economy***

Stockholm is in a strong position in Europe but needs to actively consolidate its competitive advantages in its objective to become the most innovation-driven economy by 2025. To achieve this goal, the County and City authorities will continue to focus on the international accessibility of the City, but their main targets are directly related to innovation, i.e:

1. R&D and innovation infrastructure. This will necessitate supplementary investment in research and test equipment. In the area of cleantech, much of the attention will be devoted to demonstration opportunities and proof-of-concept procedures.

2. Innovation procurement. New approaches and mindsets are to be developed, including pre-commercial procurement and innovation awards.

3. Supply of capital. Funds for early-stage innovation processes are not sufficient. Financing models other than venture capital (e.g. loans, investments from private investors and love money) will also be considered

4. Cross-sectoral approach. The Stockholm region wants to encourage a cross-sectoral exchange of knowledge and ideas to revitalise research and support the knowledge-intensive business community.

5. Global attractiveness. Promoting Stockholm's excellent quality of life will make it easier to recruit highly qualified workers and ensure that they remain in the area.

An action programme linked to all these areas will specify how the goals will be achieved. The Project Innovation Power Stockholm has helped not only to design this programme but to provide platforms for dialogue among many agents, including public as well as private stakeholders.

Source: Stockholm County Council (2012), *Stockholm 2025: The World's Most Innovation-Driven Economy, Innovation Strategy for the Stockholm Region*, Stockholm County Council, Stockholm.

To boost research and innovation infrastructure, the present regional strategic effort might take into consideration:

- The functional region. A regional innovation strategy could be extended to municipalities outside the County of Stockholm, integrating the potential for collaboration with other areas, such as Uppsala.[2]
- The National Environmental Technology Strategy and its linkages with an innovation strategy. Adopted by the Parliament at the end of 2011, this initiative invested SEK 400 million to promote 13 Swedish "solutions". It would be helpful to analyse how these could lay the foundation for a more competitive eco-innovation cluster in Stockholm. More generally, the different documents laying out Sweden's innovation strategy (including the recent National Strategy) need to be brought together within one framework.
- International collaboration. Stockholm's international visibility could be enhanced. Increased attention should be devoted to co-operating on R&D and innovation with countries and regions outside the EU and on open innovation in general.

- The multidisciplinary dimension of green innovation and the ways of promoting it, such as through innovation labs and new technology demonstrations.

Identifying and institutionalising Stockholm's green regional innovation system

Cleantech activities in Stockholm have been built upon Sweden's strong legacy of engineering. The emergence of climate and environment-driven businesses is nevertheless relatively recent, and this was not much of an area of focus before the mid-2000s. Sweden's strengths are bioenergy, biogas for transportation, green building, solar and wind power, heating and cooling, waste management and recycling and water and waste water. According to the Nordic Cleantech Association (NCA), the cleantech industry is expected to employ roughly 100 000 people in Sweden by 2020. The main cluster is located in Stockholm (including Uppsala). It is particularly strong in biofuels, wind power and solar cell manufacturing. The environment and climate sector in the Stockholm Mälaren region has grown from roughly 20 800 to 23 200 employees since 2003. Despite this relatively moderate increase, the sector is believed to have good growth potential in the long term (Stockholm County Council, 2010).

An important aspect of the cluster profile is the large variety of technological fields covered, and the possibility of creating new products and processes by combining different techniques and elements of the supply chain. Companies working in strategic green segments include renewable vehicle fuel (*e.g.* Swedish Bio-fuels), combustion technologies and gasification (*e.g.* Chemrec, Cortus), energy storage (SEEC), engine technologies (Skidberg Powertrain), solar cells (Midsummer), transport systems (SkyCab) or wind power (Scanwind AS and Chapdrive AS). Large firms play an important role in the Stockholm cleantech clusters, notably in the energy and the waste management sector. Big business such as Alfa Laval (heat transfer, centrifugal separation), Sandvik (materials), ABB, Electrolux, Vattenfall, Fortum (smart grid) or medium-size businesses such as Envac (automated waste collection) or Purac (plants for water treatment and biogas production) are important players in eco-industry development and the generation of innovation.

Stockholm's strength resides not only in supplying green manufacturing products but also in supplying services and designing socio-ecological systems. It hosts specialised and highly performing institutions, such as the SciLife Lab, for example. Another is the Stockholm Resilience Centre, a joint initiative between Stockholm University, the Stockholm Environmental Institute and the Beijer International Institute of Ecological Economics at the Royal Swedish Academy of Sciences. Funded by Mistra, the Swedish Foundation for Strategical Environmental Research, the centre generates new insights and ideas to improve eco-systems management practices and long-term sustainability. It aims to be an internationally recognised transdiciplinary research centre advancing the understanding of complex socio-ecological systems.

Another advantage of Stockholm is the potential of the cleantech cluster to co-operate with a nearby strong ICT cluster, mainly located in the Kista Science City in the northern outskirts of the city (Box 3.3).[3] This ICT cluster is particularly robust because *i*) world leaders in communication technologies, like Ericsson, Nokia, IBM Svenska and Infineon, are located in Kista; *ii*) the pool of qualified labour in related communication technologies is significant; and *iii*) Swedish customers' willingness to try new technology makes Sweden a good test market for new applications. The ICT cluster has attracted a large number of R&D centres from multinational corporations all over the world,

including some from BRIC (Brazil, Russia, India and China) countries, such as TCS and Infosys from India or ZTE, Huawei and Lenovo from China.

There are also some linkages with companies in the materials industry that can provide inputs for the generation of eco-products and environmental technologies. The specialisation of the Swedish national innovation system in materials science can be explained by the combination of research specialisation at the university and the accumulation of industrial know-how in pulp and paper and packaging technologies based on cellulose fibre, an outgrowth of Sweden's forestry industry, as in the case of Tetra Pak.

Finally, efforts have been deployed to mobilise companies to work in co-operation with research centres and universities. For example, the Stockholm Environmental Technology Centre (SMTC) is a business network established in 2005 representing new concepts within green technologies (such as bio-energy, waste management, biofuels, energy storage and efficiency, municipal water management system and expertise in sustainable city development) in the Greater Stockholm Region. SMTC aims to enhance co-operation between business, research bodies and public actors for a broad range of environmental services and international co-operation. SMTC collaborates with a leading environmental research centre, the IVL (the Swedish Environmental Research Institute). It also partners with STING (Stockholm Innovation and Growth), SBR, SBA and the Vallentuna Business Centre.

The Stockholm Regional Innovation System could nevertheless more closely realise its potential. This would require addressing the following issues:

- The Stockholm green cluster could be mapped to better understand its main assets in the region. Some directories have been established of firms working with core components of green activities, such as energy, water, waste management or measurement instruments, but linkages with related research and businesses such as ICT, materials or biotech often remain poorly defined. The collection of information should be improved, more refined analytical research undertaken and appropriate methodologies set up. This would make it much easier to define frameworks and policy incentives to support the cleantech cluster.
- A second prerequisite would be to consolidate governance of the cluster. So far, this issue has been left to a great number of intermediaries, such as the Electrum Foundation, Stockholm Science City Foundation, Stockholm IT Region, Stockholm Teknikhöjd or the two Innovation Relay Centres (see Box 3.3). Most of these are public-private partnerships and support the development of the Stockholm regional innovation system. To this list could be added the regional offices of ALMI Business Partners and the Innovation Bridge, as well as the Stockholm Business Alliance, a partnership between 50 municipalities in the Stockholm NUTS 2 (Nomenclature of Territorial Units for Statistics) area and the surrounding Stockholm-Mälardalen region. The Stockholm Business Alliance is designed to co-ordinate marketing activities of Stockholm under the trademark "The Capital of Scandinavia". All these organisations have been set up to provide answers to specific questions but not to solve general co-ordination and cluster management issues. Given that the cluster is now entering a more mature phase of development, it seems urgent to bridge the gap and to create an appropriate structure or platform to address strategic issues and collaboration challenges. The New England Clean Energy Council could serve as an useful model in this context (Box 3.4).

Box 3.3. **Kista Science City**

Kista is a district of Stockholm municipality, northwest of central Stockholm, belonging to Rinkeby-Kista. Kista was supposed to become a town with a residential area separated from commercial properties, with extensive public services and a range of commercial businesses. The construction of the industrial section of Kista began in the 1970s, when firms such as SRA (Svenska Radio Aktiebolaget, now a part of Ericsson), RIFA (later Ericsson Microelectronics and now Infineon Technologies) and IBM Svenska AB (the Swedish branch of IBM) located their offices there. However, the real growth in the number of IT companies in Kista has mainly occurred since 1992.

Today, the Kista urban area is Sweden's largest corporate centre and one of the most important ICT clusters in the world, including multinational companies such as Ericsson, IBM, Sun, Tele2, TietoEnator and Nokia. Ericsson has its head office in Kista and, with a staff of more than 9 000, is the largest single employer. It estimated that some 28 000 employees are currently working in some 750 Kista companies, two-thirds of them in the ICT sector.

Kista is the location of two leading education institutions in Sweden, the KTH School of Information and Communication Technology and Stockholm University. Research is conducted in a broad range of high-tech areas mainly related to the ICT sector, such as materials and semiconductor physics; electronic devices; optics, photonics and quantum electronics; electronic and computer systems; communication systems; information and software systems/system analysis; software development; communication and cognition; IT and society; and IT security. The Kista campus is close to shops, restaurants and transportation junctions, between Arlanda Airport and the City of Stockholm. Some 65% of its establishments perform IT-related activities, and 50% are active in the production of software, R&D, trade and the publication of software or data processing. Larger entities (with fewer than 200 employees, however) also conduct some R&D within this field, whereas small companies are more focused on activities such as consulting, service and trade in IT-related areas (Sandberg et al., 2007).

The actions promoting the Stockholm region as a world IT cluster are supported by the network of various private and public institutions, such as: Ericsson, TeliaSonera, IBM, Logica (former WM-data), Microsoft, Intel, Stockholm Business Region, IT and Telekomföretagen, Kista Science City, Stokab, the Stockholm County Council as well as different organisations such as:

1. The Electrum Foundation. Its work is to match strategies, objectives and activities within the framework for each area contributing to the realisation of the Kista Science City vision.
2. Stockholm Science City Foundation. The Foundation is commissioned by the Karolinska Institutet, KTH and Stockholm University, as well as the City, the County and the business sector, to attract academia and business to the Norra station and Albano areas in Stockholm.
3. Stockholm Innovation and Growth Organisation (STING). This runs incubation activities for KTH at Campus Kista and at Campus Valhallavägen, as well as for the Karolinska Institutet in Flemingsberg.
4. Innovation Relay Centres. The network consists of 150 offices in 15 European countries, of which two are located in Stockholm. This network is a service for companies, especially for SMEs.
5. Stockholm IT Region. A joint venture between several public and private players, including Kista Science City AB, it aims to enhance competitiveness for the ICT sector in the Stockholm region.
6. Stockholms Teknikhöjd. This supports the commercialisation of research and business ideas originating from students from KTH and the University of Stockholm, by offering office space and information infrastructure, and giving advice in patenting, licensing, marketing and financing. At present, its members include roughly 40 innovative firms.

Source: Runiewicz-Wardyn, M. (2009), *Innovation Systems Learning Process in the EU and US Regions*, Kozminsky University, Warsaw.

- To streamline this institutional eco-system and avoid duplication of work and inefficiencies, innovation policy needs to more closely align R&D activities with the

comparative advantages of the Stockholm region. Other innovation-relevant agencies, such as Tillväxtverket, would do well to follow VINNOVA's lead in undertaking programmes with a sustainability goal. A minimum share of these agencies' project portfolios should be linked to green growth.

Box 3.4. **The New England Clean Energy Council**

Formed in 2007, the mission of the New England Clean Energy Council is to accelerate New England's clean energy economy and elevate it to a position of global leadership by building an active community of stakeholders and a world-class cluster of clean companies. The council represents nearly 150 members, comprising clean energy companies, venture capital investors, major financial institutions, local universities and colleges, industry associations, area utilities, labour and large commercial end users. Its ranks include more than 50 clean energy CEOs, representatives from most of the region's top 10 law firms, and partners from over a dozen of the region's top venture capital firms (with a total of over USD 8 billion under management). Working with its stakeholders, the council develops and executes a range of programmes in five key focus areas: innovation, growth, education and training, adoption and policy. Cluster success stories include Seven Solar, Next Step Living, Ze-Gen.

Source: Cleaner Energy Council website, *www.cleanenergycouncil.org.*

Entrepreneurship, spinoffs and venture capital

The central government, city and regional authorities would do well to focus their innovation policy more on small firms and new companies, for several reasons. First, green clusters in the global arena are characterised by a higher relative number of SMEs compared to other types of clusters (MEEDDM, 2010), and Stockholm is no exception. Second, SMEs are an increasingly important source of innovation. In Sweden, the national innovation system is still dominated by large R&D-intensive multinational groups, which have a strong focus on basic research. Rebalancing the share of SMEs seems a necessity to better cope with the technological trends at work in the sector. Third, SMEs also need special attention because they can exert considerable pressure on the environment. In the United Kingdom, it is estimated that they account for 60% of total CO_2 emissions from enterprises and 70% of all pollution (IEEP, 2006). It is therefore crucial that SMEs are equipped with higher-performance environmental technologies. Business start-up rates vary greatly between the different green sectors. Sweden is a leader in the collection, purification and distribution of water (with a business start-up rate of 18%). For sewage and sanitation, its performance is less impressive (around 8%), a ranking below that of Spain, Italy, the Netherlands and Finland (OECD, 2011a).

According to the Global Entrepreneurship Monitor (2011), Sweden has a low level of entrepreneurial activity, and few new companies are being started, even though Stockholm's performance is higher than the rest of the country. The percentage of adults engaged in the process of starting a business (nascent activity) or those operating a business established within the last 3.5 years, is lower than in countries such as Australia, Czech Republic, Ireland, Finland, Korea, Norway, Portugal, Switzerland, the United Kingdom or the United States. The statistics show nevertheless that new start-ups increased in recent years, until 2008. A decline in the number of new start-ups was seen

in 2009, probably in response to the global economic crisis (Stockholm County Council, 2010).

Attitudes towards entrepreneurship offer one important explanation for this underperformance. The annual survey of young people's attitudes toward entrepreneurship conducted by the Swedish Agency for Economic and Regional Growth (Tillväxtverket) show that no major changes in these attitudes can be discerned over an extended period. There is still a high percentage (70%-80%) of young people who could picture themselves as business owners, but only a minority (30%-40%) would prefer to be business owners. These studies also show that attitudes towards entrepreneurship are more positive in Stockholm than in the rest of Sweden.

SMEs may also be co-operating less with each other. Every three years or so, Tillväxtverket conducts a general survey on small business. An important finding of the last survey (2011) is that the rate that SMEs are collaborating is declining.[4] While 60% of firms were engaged in collaborative projects in 2005, only 42% were in 2011. This trend is likely to have set back the process of clustering, which could have a negative impact on innovation. During the same period, obstacles to growth were nevertheless perceived as stable.

It is particularly important for the SME sector that a business environment be established that is conducive to innovation. At present, small firms and start-ups are eligible for a number of programmes. For example, start-ups, including those that are rapidly expanding, can obtain assistance through a programme managed by the County Administrative Board of Stockholm, Stockholm Business Region (SBR) and ALMI, together with a private partner. A EUR 1.5 million grant, co-funded by the European Regional Development Fund (ERDF), is available to co-ordinate services and to provide them free of charge. Innovation Power Stockholm, initiated by County Administrative Board of Stockholm and the City of Stockholm Council, aims to establish a regional arena for innovation development and indirectly assists entrepreneurs. Entrepreneur Stockholm, also intended to improve the business environment, works with operators that offer advice to entrepreneurs, and facilitates access to these professional advisors. In addition, a project to develop the Kista Science City as a leading world cluster was conducted between 2009 and 2011 to stimulate co-operation between companies. The budget was underwritten by the ERDF and Kista Science City AB.

So far, there have also been some initiatives from regional universities in support of a strong innovation culture and promoting co-operation. The Stockholm School of Entrepreneurship (SSES) is one example of an initiative that encourages new businesses. A collaboration between five schools in Stockholm: the Karolinska Institutet, the University College of Arts, Crafts and Design, the KTH, the Stockholm School of Economics and Stockholm University, it was established to provide member schools with students who have education and training in applied entrepreneurship.

Meanwhile, the government and the County of Stockholm could do more to help new companies. When programmes exist, they are not particularly targeted at green activities. The STING (Stockholm Innovation and Growth) initiative is an exception, although with a moderate impact on the cleantech industries (Box 3.5). It is in any case an interesting and comprehensive programme, offering innovators an incubator framework, a business lab and a business accelerator. Its activities are financed in part using public funding from

the Electrum Foundation and from its main collaborative partner, Innovationsbron, and in part from private partners and its own financing. Other incubators hosted by Karolinska Institutet Innovations and Stockholm University are focused respectively on the life sciences and on biotech and services and have few interactions with cleantech companies.

Box 3.5. **The STING Programme**

STING's mission is to support new global growth technology companies that are focused on exports with promising profiles and aim to employ roughly 15 to 30 employees within five years of starting the programme. STING offers incubator and accelerator services and uses business coaches to assist firms. A venture capital (VC) fund, STING Capital Sweden, and the investment network of STING angel investors offer financing in the early stages of a company's development. STING Capital is one of the few venture capital funds in Sweden to invest in the earliest stages of development. It is often the first external investor to offer financial support for business ideas or concepts, and can invest up to SEK 4 million per company.

STING operations started in 2002, and the initiative has so far contributed to the success of about 30 Swedish technology companies. Since its inception, 1 134 companies and projects have been evaluated. Of these, 92 have been admitted, for a total value of EUR 228 million. In 2011, the total turnover of companies incubated was EUR 33 million, with 82% in exports and 503 employees. The cleantech sector accounted for 20% of the firms admitted. Accumulated capital investment by STING Capital amounted to EUR 6.5 million (in 25 companies), and 37% of this was dedicated to cleantech projects.

Source: Stockholm Innovation and Growth Website, *www.stockholminnovation.com/EN/11/sting-stockholm-innovation-growth*, accessed March 15.

In Sweden, virtually all industrial research is conducted within universities, but industrial research institutes also have the potential to play a supporting role for small and new firms, notably in the cleantech sector. They focus on applied research and are jointly funded by the government and the industry. These institutes, therefore, in principle tackle two of the problems of the Swedish Innovation system: *i*) the low participation of SMEs in R&D investments and *ii*) the focus on basic research (Chaminade et al., 2010). Industrial research institutes that could contribute to the development of the green cluster include the Institute for Electronic, Optics and Communication Technologies (ACREO), the Institute for Manufacturing Technology (SWEREA IVF), the Swedish Environmental Research Institute (IVL), the Pulp and Paper Institute (STFI), the Metrology Institute (SP) and the Swedish Institute for Food and BioTechnology (SIK). So far these institutes (often called IRECO institutes) are minor actors in the Swedish innovation system, and their budgets have even decreased over time (Arnold et al., 2007).

VC companies, on the other hand, are flourishing. The venture capital sector in Stockholm is dynamic and among the fastest-growing in the world. In the last five years, it has grown by more than 200% per year. Today, about 130 venture capital companies have a total of more than SEK 80 billion in funds under management. The majority of the Swedish venture capital firms are naturally based in Stockholm. The range of companies is large, from a number of individual business angels to large companies like Investor and SEB Venture Capital. A number of actors such as ALMI and the Connect network create platforms and events where angel investors and entrepreneurs can meet. In 2011 in Sweden, venture capital investments, amounting to EUR 247 million, were made in

innovative technologies, new materials, alternative fuels and green energy. In terms of venture capital scaled by GDP, Sweden is the leader of the EU 27 with a 0.64 rate, ahead of Denmark (0.52), the United Kingdom and Finland (0.45), France (0.32) and Germany (0.27) (European Commission, 2012).

The central government and the City of Stockholm could nevertheless take additional steps to encourage the formation of new innovative business in the green sector and to induce SMEs to elevate their R&D standing. Priorities for action are:

i. Mobilise the green-tech-relevant IRECO institutes to enhance innovation in the cleantech industries.[5] A follow-up of the 2007 VINNOVA study (Arnold et al., 2007) on industrial research institutes could be undertaken, with a specific application to the green-tech sector.[6] This should lead to new initiatives (for example, the creation of green vouchers for SMEs) to strengthen the link between institutes and green SMEs (Box 3.6) and also with universities.

ii. Consider opportunities and provide incentives for new green incubators. So far these have been restricted to the STING initiative in Kista and the KTH structure on Walhallavägen campus. The Royal Seaport and Högdalen would be ideal candidates for new incubator investments.

iii. Boost green procurement. Stockholm's public sector has already invested in green ambulances and waste collection vehicles that run on biogas, but more could be done to promote public consumption of cleantech-based materials and systems. The City of Vienna, for example, saved 13 000 tonnes of CO_2 through the purchase of green electricity, water-saving devices in public buildings and organic food. London set up a greener Fire Brigade and supplied sustainable concrete for the Olympics. To improve its performance, Stockholm could review its procurement programmes, introduce eco-products to the furthest extent possible and decrease its public-sector carbon footprint.

Box 3.6. **Eco World Styria (Austria)**

This Austrian region of Styria bills itself as Europe's Green Tech Valley. Despite its small size, Styria is one of the largest clusters in Europe. More than 150 cleantech companies are based there, of which 12 are world technology leaders in their field. The cleantech revenue of Styrian companies totals EUR 2.7 billion, or 8% of the Gross Regional Product, and is one of the highest concentrations of leading clean technology companies in Europe. The companies have an average (real) growth rate of 22% per year, well above the worldwide cleantech market growth of 18% a year. The region created roughly 2 000 additional green jobs in 2008 alone. Among the key reasons for the area's phenomenal performance are its numerous specialised research centres, its strong tradition of engineering, as well as a leading research quota of 4.3% of the Gross Regional Product. Cluster success stories include Andritz AG, Komptech, KWB Bio-mass Heating Systems, Binder+c.

Source: Eco World website, *www.eco.at/cms/415/Downloads/*, accessed 15 March 2013.

Export strategy and trends

Becoming a region with world-class appeal is one of the principal objectives of the City of Stockholm and of Stockholm County. This might at first sight appear to be an odd strategy for a city with as many assets. Sweden in recent years has ranked either as the second or the third most competitive in the world (see World Economic Forum ranking). Stockholm is furthermore the first region on the European innovation scoreboard and a leader in green technologies. Sweden ranks third on the cleantech innovation index (Cleantech Group and WWF, 2012). However, despite these outstanding successes, Stockholm's performance lacks visibility on the international level, at least outside Europe.

A first explanation might be that the performance of Stockholm's Mälaren region is blurred by a number of caveats. Stockholm and Sweden are intensively investing in R&D, but the way they transform these investment into new products and processes could be improved.[7] Sweden is highly ranked for technological readiness and innovation but comes in in 19th place in terms of foreign direct investment and transfer of technology (WEF 2012). Worryingly, Stockholm was among the top 20 world performers for green patents in 1977-1979 and 1985-1987 but disappeared from the list in the 1990s and 2000s. It also does not appear in the top 20 regions for ICT patents or biotech patents in the 2000s (OECD, 2011b).

A second explanation might reside in the relatively moderate involvement of Sweden in the cleantech R&D and innovation international networks of co-operation. OECD patent statistics show that the share of PCT patents held by Sweden in co-operation with other countries was comparatively low (17.9%) in the late 2000s (compared to total Swedish patents). This share is significantly higher in countries such Austria, Belgium, Canada, Denmark, Portugal, Switzerland and the United Kingdom.

Moreover, participation in green supply chain and networks out of Sweden seems suboptimal. So far, 25% of Swedish SMEs are internationalised, according to the last Tillväxtverket SME survey. The share of small firms that export has decreased between 2008 and 2011 from 14.1% to 12.7%. Exports from the environmental sector in Sweden represent about 17% of the turnover (EEO, 2009). Stockholm accounts for about a third of this amount. Given that the country exports about half of its GDP, the potential for trade in the environmental sector seems high.

To a certain extent, the national and regional authorities have encouraged the Stockholm metro-region to bridge this export gap. The Swedish Environmental Research Institute (IVL), Stockholm Business Region Development, Tillväxtverket and the ERDF funded the Environmental Technology for Growth, or Miljöteknik för Tillväxt, a three-year project (2009-11) to stimulate growth and internationalisation of small and medium-sized companies and to provide environmental technology and other solutions for sustainable development in the Greater Stockholm Region (Stockholm-Mälardalen).[8] The project, administered by the IVL and the SMTC, had a total budget of EUR 2.25 million.[9] The consortium created through the project continues to operate, but under a different name, Stockholm Cleantech. STING is also mandated to actively support the formation and growth of 12 new technology companies per year in Stockholm. The companies are selected based on their good

commercial prospects and potential as exporting companies. The goal is that companies should grow to 15 to 30 employees and graduate from STING´s support programme within five years.

The promotion of trade in green activities is relatively fragmented. The Swedish Trade Council worked within the framework of the recently concluded Swedentech programme to support international expansion, mediate contacts, foster co-operation and provide analysis of markets and guidance in the sectors of air, water, waste, bio-energy and wind energy. The Swedish Environmental Technology Council (Swentec), which recently ended, aimed to strengthen Swedish environmental technology through improving efficiencies. Swentec mapped a number of areas for companies with export potential: bio-energy, water purification technology and waste management. A mapping of renewable energy sources, such as solar and wind power, is planned. These organisations and their action plans, however, are only a first step in the effort to build a comprehensive export policy for green products.

The example of other Nordic countries, notably in Copenhagen and the Finnish cleantech clusters, show that the potential for green export is huge, especially towards emerging countries (Box 3.7 and Box 3.8). Innovation is a powerful driver of exports. The Stockholm region seems to lack a distinct international profile. Stockholm has accumulated expertise in systems thinking and is well placed to supply holistic cleantech solution. Priorities for action are:

i. Overhaul regional export policy. The central government, Stockholm County and the City of Stockholm could undertake a review of all programmes aiming at stimulating green exports, streamline them and reorganise the assistance under the framework of a coherent and ambitious initiative for green export.

ii. Improve the branding of Stockholm and other cleantech centres in Sweden. Communication about the Stockholm green clusters could be organised at the national level, in collaboration with, for example, Gothenburg (Cleantech Inwest), Malmö and the Jämtland/Västernorrland counties. The marketing of these different regional clusters should be linked to their innovation capacities and their specialisation and become the subject of a common trade policy at the national level. The possibility of pooling the resources of different cleantech areas in order to provide holistic system solutions could also be explored.

iii. Capitalise on the new city projects such as Royal Seaport or Sustainable Järva. Several development projects of international visibility are being conducted and co-operation agreements have been signed with several major Swedish companies, academic institutions and research organisations. These could be used not only as pilot experiments in Stockholm and Sweden but also as platforms for export markets.

Box 3.7. **The green industry in Copenhagen**

Danish cleantech solutions are world famous, and Denmark is one of the world's largest exporters of cleantech as measured by GDP. The Copenhagen Cleantech Cluster operates on a USD 30 million budget financed by the EU, Region Zeeland and the Danish Capital Region. It also has a unique set of partners, including Copenhagen Capacity, Scion DTU, the Confederation of Danish Industries (DI), Risø DTU and the University of Copenhagen, as well as a number of municipalities and huge companies, including Dong Energy, Vestas, Haldor Topsøe, Novozymes, Siemens and Better Place Denmark.

The green sector in the Greater Copenhagen Area is substantial and accounts for more than 25 000 employees. Most green growth activities are in manufacturing, construction and knowledge-intensive business services. Labour productivity in these industries is 40% above the average company in the Greater Copenhagen area. Half of green-growth turnover is realised in the City of Copenhagen itself, which captures 43% of the employment. The greatest proportion of turnover comes from activities associated with water management (51%), waste (23%), air pollution and chemical and soil cleanup (7%).

The Green Growth sector also contributes to the overall export of the region, with an export intensity of 36%. Export of green products in the greater Copenhagen area have boomed, with an 80% increase over the 2004-09 period. Interestingly, the green growth industry in Denmark is more conspicuous in global markets outside the EU and notably in the BRICS countries (Brazil, Russia, India, China and South Arica), than other Danish industries. Greater Copenhagen green exports are concentrated in products with cellulose, chemical products, base metals and plastic and rubber.

Increasing investments in R&D have proven to have both a significant and positive effect on productivity in Danish companies and consequently on their capacity to increase their sales on international markets. The green sector R&D growth outperforms growth in total R&D investments in the country. In only six years (2003-09), the number of green R&D employees in Copenhagen has increased by more than 300%.

Source: DAMWAD (2011), *Green Growth in Copenhagen*, Badstuestraede 20, DK 1209 Copenhagen.

Box 3.8. **The Finnish Cleantech cluster**

The Finnish Cleantech Cluster and its centres operate under the Centre of Expertise Programme (OKSE) run by the Ministry of Employment and the Economy. The programme's main objectives are: *i*) to create new innovations, products, services, enterprises and jobs based on top expertise; *ii*) to support the specialisation of regions and division of duties between them in order to create internationally competitive centres of expertise; and *iii*) to enhance the attractiveness of regional innovation environments, in order to draw international companies, investments and top experts to the country. The cluster is a network of four centres in various geological regions working with each other and with companies within those regions of Lahti, Kuopio, Oulu and Uusimaa.

The Finnish Cleantech Cluster is a true Finnish success story. The cluster features access to over 250 cleantech companies, 60% of Finland's cleantech business and 80% of cleantech research in Finland. Among the primary goals of this cluster is to create 40 new high-growth companies annually, a goal that has already been reached. It also aims to increase cleantech VC investments to 15% of total investments. In terms of job creation, the Finnish Cleantech Cluster has created 500 new green jobs, and the target for 2012 was more than 900 new positions.

Box 3.8. **The Finnish Cleantech cluster** (*cont.*)

Lahti Science and Business Park is the co-ordinator of the Finnish Cleantech Cluster. It hosts numerous cleantech investor events annually, such as cleantech workshops and Cleantech Venture Day. Cluster success stories include Eagle Windpower, EcoCat, Numcore and Green Stream Network. Lahti market operations now cover:

1. Russia. The Russian programme consists of three mini-clusters: energy and environmental clusters, with more than 30 companies, and the Cleantech Lahti Russia cluster, with eight companies. Leading companies in each field act as driving forces behind the clusters. In these mini-clusters, the companies get help in such matters as searching for partners and project negotiations.
2. China. The Finnish Environmental Cluster for China (FECC) helps both individual companies and company clusters in their efforts to enter the Chinese market. More than 100 companies are involved in FECC activities. In the last two years, commercial contracts have been concluded for a total value of EUR 120 million. The FECC plays an active part in strategic discussion on cleantech business between China and Finland, in implementing letters of intent and in technical co-operation.
3. India. Lahti has embarked on a strategic collaboration with YES Bank India.

Research in Kuopio is focused on environmental health, environmental risk assessment, environmental safety and informatics. Kuopio acts as an umbrella organisation for projects such as small-scale wood combustion, impacts of fine particles on human health and climate change, and overall effects of the alternative means of bio-energy production and utilisation. With cutting-edge expertise in environmental informatics, Kuopio's co-operation between companies, research institutes and international partners has resulted in successful new innovations.

Oulu's areas of specialisation are emissions measurements, catalytic air cleaning for vehicles and industry and the treatment of volatile organic compound (VOC) emissions. The SkyPro Oulu Centre of Expertise is developing the Oulu region into a nationally and internationally renowned centre of industry and research into air-related technologies and clean air.

Uusimaa places special emphasis on environmental monitoring and clean energy – especially energy efficiency in an urban environment. Special attention is given to the cross-disciplinary integration of environmental and ICT expertise in order to create new innovations and business. While only a few success stories have been registered, the cluster has implemented projects to a total value of EUR 65 million within the last few years.

Source: MEEDDM (French Ministry of Ecology, Energy, Sustainable Development and Sea) (2010), "Les clusters mondiaux dans les éco-technologies, enseignement, perspectives et opportunités", MEEDDM, Paris, April, translated by the author.

Higher education and skills

Public research in Sweden strongly favours university research and development. Higher education R&D amounts to 26% of all Swedish expenditures for R&D and 0.8% of the country's GDP. Stockholm captures the lion's share of these expenditures. Its superior performance (23% of the population holding a tertiary education degree) and the large population of researchers (27% of the national total) can be explained by the existence of several major universities within the region, along with a number of

specialised university colleges. Three of them, Uppsala University (ranked 195 for research activities out of 3 200 universities and research organisations worldwide), the KTH (ranked 253) and Stockholm University (ranked 370) are particularly involved in green activities.[10] Main areas of research include: biofuels, biogas, cellulosic bio-energy, CO_2 separation, combustion technology, soil treatment and third-generation solar cells.

Although not among the largest universities (28 200 students enrolled full-time), Stockholm University outperforms the others by the quality of its research and its participation in international co-operation (Table 3.1). The other major higher education institutions in the Stockholm/Uppsala region (apart from the Karolinska Institutet) are not, however, faring as well as their Danish counterparts.[11] Moreover, according to several indicators, including the share of high-quality publications, citations, excellence and leadership indexes (see note to Table 3.1), the Denmark Technical University appears to do better than the KTH.[12] These results are in line with the rankings in the Shanghai Jiao Tong University list. However, compared to other Nordic regions and many European regions, the leadership of Stockholm's higher education institutions is well established. In global rankings (including education and research), Stockholm University and KTH have improved their position from 2011 to 2012 (*e.g.* see The Times of London ranking).

Table 3.1. **Scimago ranking of major Swedish and Danish universities (a ranking based exclusively on research performance)**

Ranking	HE Institutions	Output	IC (%)	Q1 (%)	NI	Spec	Exc	Leadership
102	University of Copenhagen	19 302	54.3	69.9	1.7	0.5	20.5	9 556
118	Karolinska Institutet	18 341	55.0	74.4	1.8	0.7	21.2	8 545
143	Aarhus University (DK)	17 038	51.3	67.4	1.7	0.5	19.9	9 628
159	Lund University	16 141	55.0	66.6	1.6	0.4	19.2	8 339
195	Uppsala University	14 068	54.0	69.7	1.5	0.5	18.5	7 042
250	DK Technical University	11 803	51.2	59.0	1.7	0.6	20.7	6 995
253	KTH	11 553	51.5	51.2	1.4	0.6	16.7	6 754
334	Göteborg University	9 557	46.7	66.8	1.5	0.5	17.7	5 100
370	Stockholm University	8 699	55.7	70.2	1.7	0.6	20.6	4 477
439	Chalmers Technical School	7 491	47.0	50.2	1.4	0.7	15.9	4 443
470	Lindköping University	7 034	39.0	54.6	1.4	0.5	15.5	4 300
498	Umea University	6 595	48.1	68.4	1.5	0.5	17.3	3 525
610	University of Southern Denmark	5 551	52.4	65.3	1.6	0.6	19.6	2 552

Note: Universities are ranked according to their publication output (O), *i.e.* the total number of documents published in scholarly journals indexed in Scopus (see column 3). IC (International collaboration) in Column 4 is the institution's output ratio produced in collaboration with foreign institutions. Q1 (Column 5) stands for high-quality publication, the ratio of publication that an institution is published in the most influential scholarly journals of the world. For NI, *i.e.* normalised impact, the value shows the relationship between an institution average scientific impact and the world average (Column 6). A NI score of 0.8 means that the institution is cited at 20% below world average. Spec (Column 7) is a specialisation index. This index indicates the extent of thematic concentration/dispersion of an institution's scientific output (1 for the most concentrated, 0 for the most dispersed). Exc (Column 8) index measures the percentage amount of an institution's scientific output that is included in the set of the 10% of the most cited papers in their respective scientific field. It is a measure of the high-quality output of a research institution. The last column indicates an institution's output as the main contributor, that is, the number of papers in which corresponding authors belong to the institution.

Source: Simago Institutions Rankings (2012).

One important challenge is to transfer the knowledge accumulated in these higher education institutions to industry. The Swedish government in 2008 suggested that Innovation Offices should be established in higher education institutions to stimulate innovation and commercialisation of research through qualified advisory services (for example, relating to patenting, licensing and contract research). In 2010, eight universities received funding for developing innovation offices. Two of those offices were located in Stockholm, at Karolinska Institutet (EUR 0.5 million/year) and at KTH Royal Institute of Technology in Stockholm (EUR 0.7 million/year).

Following the reform, a platform called the Swedish Network for Innovation and Technology Transfer) was created to help technology transfer professionals share their experiences and improve their competences. This network also intends to increase international collaboration and facilitate good practice, carry out policy work and support the network members in developing their skills and innovation assignments. Sweden has not had a strong track record of rendering new firms sustainable, and licensing is rarely exploited. In many cases, technology transfer is inefficient (Box 3.9).

Box 3.9. **KTH Royal Institute of Technology**

KTH is responsible for one-third of Sweden's capacity for technical research and is the country's largest organiser of technical/engineering education at the university level. KTH education and research covers a broad spectrum, from natural sciences to all branches of engineering, plus architecture, industrial economics, urban planning, work science and environmental technology. It also hosts a large number of national and local competence centres, as well as research programmes financed by various research foundations.

KTH is the Swedish university most networked with industry. Research at KTH is organised in five Research Platforms, designed to depart from traditional academic disciplines. The goal is to deliver practical results that can help solve overarching global challenges. These platforms include energy, ICT, materials, life sciences and transport and bring together expertise from different schools (*i.e.* architecture, electrical engineering, industrial engineering and management, ICT, chemical science, engineering science and technology and health). These platforms enable faculty to incorporate systems, policy and technology research into relevant solutions. They provide seed funding for leading-edge interdisciplinary research projects and help young researchers acquire the skills necessary to thrive in changing environments. One of KTH's key priorities is to contribute to renewal and innovation in Sweden, and for that reason, KTH is collaborating with the business world and firms in various development projects. For example, KTH Business Liaison builds relationships with companies, alumni, foundations and organisations that are interested in, or committed to, supporting KTH. On campus, KTH Innovation offers researchers and students support for innovation development, intellectual property issues, business development, agreements and early financing, among other things. The innovation system associated with KTH includes everything from training in entrepreneurship, to project financing with external actors. Individual Business Development Coaches and other resources from KTH can be made available to specific projects, but an important part of the collaboration is to strengthen the local capacity for early, innovative development of research results. KTH Innovation Office partners with Mälardalen University and Stockholm University. It also collaborates with STING in the programme Entrepreneurial Startup in the health sector.

Source: KTH Royal Institute of Technology website, *www.kth.se/en.*

Extending inter-university co-operation to the business sector is another way to boost the supply of green knowledge. During the last few years, participation in regional development and co-operation between the leading universities in Stockholm has intensified, partly as a result of an increased demand from the government for collaboration outside the academic world. New frameworks have been established. For example, the Stockholm Academic Forum (StAF) has been established as a co-operative organisation of 19 Stockholm colleges and universities, in which the City of Stockholm is involved as an additional partner. The StAF approach is based on the analysis of the region's potential and co-ordination of projects between universities, colleges and the business world.[13] Science/industry co-operation has also been targeted by programmes such as Innovation Power STHLM, a platform for dialog and co-operation.[14]

The impact of these programmes on green technology R&D and businesses seem relatively weak, however, and are in any case difficult to assess. Some of these programmes are "triple-helix initiatives" that aim at the exchange of knowledge between academia, local policy makers and the private sector, and at leveraging a critical mass of expertise in the three leading universities (Karolinska Institutet, KTH and SU). But the main focus seems to be the life sciences, and the convergence with cleantech technologies seems marginal at this stage. The potential for bringing greater attention to cleantech nevertheless exists (Box 3.10). Green technologies also do not appear to be a major topic for the bilateral co-operation between KTH and the University of Stockholm. Although some initiatives have been taken in the ICT sector (within the framework of the Electrum Foundation), the local R&D collaboration between the university and companies is rather limited. Only 12% of the Kista establishments co-operated actively with the universities and 6% with other research institutes, according to a recent study (Chaminade, 2009).

Co-operation between universities and industry in Sweden and notably in Stockholm has nevertheless a strong potential for improvement. The share of higher education expenditure on R&D financed by the business sector is only 5% in Sweden, which is below the OECD average, and the cleantech sector is no exception. In this context, innovation stakeholders in Stockholm should expand collaboration among the cleantech elements of Swedish universities and also across Nordic countries and beyond. Priorities for action are:

i. An initiative similar to the Stockholm Science City Foundation (mainly devoted to life sciences) should be taken in the field of cleantech technologies. This could provide an umbrella to the universities in the establishment of interdisciplinary research programmes. It would also help in better connecting the Stockholm higher education institutions involved in cleantech research to universities co-operating with other green clusters in Sweden, such as the Malmö Cleantech Cluster, Cleantech Östergötland or the Uppsala cluster.

ii. It is important to offer the universities incentives to consolidate and professionalise their innovation offices. These offices should operate within the framework of broadly defined strategies. Their role should not be reduced to a narrow interpretation of technology transfer but rather should serve as a convening function for SMEs and as brokers and co-ordinators of the cleantech clusters and subclusters.

iii. Renewed efforts to support university/industry collaboration are necessary. The Central government seems to have moved in this direction in recent years. For example, VINNOVA has launched a new programme for challenge-driven

Box 3.10. **Cleantech San Diego, a joint effort by university, business and the city to boost green technology**

Since 2006, more than 100 new cleantech companies have been established in San Diego, many of them affiliated with the city's world-class universities and biotechnology industry. Given its early support and its commitment to nurturing this sector, San Diego stands to become a hub for the development and commercialisation of cleantech products and technology.

San Diego has around 50 research centres, higher education institutions and related institutes. Several of them are members of the Cleantech San Diego Cluster, as is the University of California San Diego (UCSD), which is notably involved in renewable energy pilot projects.* Scripps Institute of Oceanography, also a cleantech cluster member, develops algae-based biofuel. Other relevant centres include San Diego State University, the Salk Institute for Biological Studies and the San Diego Centre for Molecular Agriculture.

San Diego's cleantech cluster is distinctly different from the biotechnology and wireless telecommunication sectors. While those sectors tend to be geographically concentrated in the Torrey Pine Mesa and Sorrento valley area in close proximity to UCSD, the local cleantech industry is scattered throughout the region, dictated by proximity to natural resources, specific land-use requirements and access to affordable land.

A number of San Diego's cleantech companies have roots in other technological disciplines. The region is seeing the convergence of technologies from biotech and wireless/telecommunications, with cleantech innovations in areas such as alternative fuel, smart wireless sensor technologies and biomimetic solutions.

San Diego has a strong track record in cleantech. Although its population is less than a third of the size of Los Angeles', San Diego has installed 60% more solar roofs. In July 2009, San Diego was recognised as the leading solar city in the state, with the most solar installations, including over 2 200 rooftop installations and the greatest solar capacity in the state. Cluster successes include Siliken Renewable Energy, Clear Edge Power, Synthetic Genomics and Sapphire Energy.

Note: In the field of solar energy, Cleantech San Diego Cluster also helps local governments access the clean Renewable Energy Bonds Fund, a federal programme with a USD 800 million budget, to finance solar panel installation projects.

Source: MEEDDM (French Ministry of Ecology, Energy, Sustainable Development and Sea) (2010), "Les clusters mondiaux dans les éco-technologies, enseignement, perspectives et opportunités", MEEDDM, Paris, April, translated by the author.

innovation, implemented by consortia of academic institutions and private enterprises. National support for collaborative research nevertheless continues to be fragmented and limited. A greater commitment is needed to bridge the gap between research and industry. This sustained effort could take the form of incentives, additional funds for projects and the development of secondment.

Support for innovation and research

Innovation policy in Sweden is mainly implemented by central agencies, such as the above-mentioned Tillväxtverket (formerly NUTEK) and VINNOVA (which is in charge of programmes such as the VINN Excellence centre). Tillväxtverket addresses entrepreneurship, business development and regional development issues, whereas VINNOVA focuses on innovation and knowledge spillover. A third body dealing to some extent with cluster and innovation policy is the Invest Sweden agency (under the Ministry of Foreign Affairs).

The innovation budget of the main agencies and governmental departments amounts to about EUR 400 million. About EUR 239 million is earmarked for VINNOVA, EUR 113 million for the Swedish Energy Agency, EUR 6 million for Tillväxtverket and EUR 34 million for the Knowledge Foundation (KK). Of VINNOVA appropriations, 30% goes to strategic sectors including the sustainable use of resources (EUR 30 million) and transport and the environment (EUR 19 million).

Following the new regional development plan (RUFS 2010) and the Stockholm Business Alliance initiatives, a regional innovation strategy has been designed (Box 3.1) (Stockholm County Council, 2012). An Innovation Strategy has also been recently completed at the national level, approved by parliament in October 2012 (Box 3.11) (Government Offices of Sweden, 2012).

Box 3.11. **Swedish innovation strategy with a vision for 2020**

The Vision for 2020 is a benchmark for many policy areas. Innovation to address the challenges facing society should inform all policy implementation, since innovation will help to achieve political objectives more quickly. The challenges that Sweden faces, together with the rest of the world, are complex. No single actor or particular area of society has adequate knowledge and resources to offer the solutions needed. Continued co-ordination between different actors will create the best possible conditions for innovation. Efforts to formulate this strategy have been implemented in a dialogue with stakeholders from different sectors of society. There has also been a high degree of participation and involvement from all departments of government.

This strategy is the basis for a long-term approach to the development climate for innovation in Sweden. This approach needs to consider the importance of enhanced co-ordination between policies, policy control levels and sectors of society. This strategy establishes a road to a world-class innovation climate in 2020 and notes:

1. Innovators not only need knowledge, skills and expertise but also the courage and willingness to embark on the innovation process. Sweden's work environment should appeal on an international level and diversity and mobility should be welcomed.
2. University education and research should satisfy the knowledge and development needs of business and society. Swedish research nodes should position themselves efficiently in global knowledge networks.
3. Framework conditions and infrastructures for innovation are also critical, in particular the functioning access to competent capital that promotes business capacity for innovation and growth, as well as sustainable in-person and digital communications that stimulate new products and processes.
4. Businesses and organisations should grow by offering innovative solutions for global markets. The potential of social entrepreneurship to contribute to innovation in meeting societal challenges should not be overlooked.
5. Effective, collaborative public services are also key for Sweden's competitiveness and innovation performances. The public sector needs to work systematically with innovation to increase the quality of service and availability.
6. Swedish regions should enhance their innovation environments to augment their international appeal. They must build strategies grounded in combined regional leadership.

Source: Government Offices of Sweden (2012), *The Swedish Innovation Strategy*, Government Offices of Sweden, Stockholm, Sweden, *www.government.se/content/1/c6/20/25/58/ace0cef0.pdf.*

Environmental industries are targeted by different agencies, which are financing initiatives to develop businesses and increasingly considering cleantech to be a flagship sector in the Stockholm region. For instance, VINNOVA initiated a new strategic process in 2010 to emphasise demand-side policy measures. Four areas are prioritised, one of which is sustainable cities.[15] EUR 28 million is earmarked for these challenge-driven activities. Tillväxtverket is also increasing its focus on cleantech, if modestly, and is involved in a programme for environment-driven markets. This programme has funded *Stockholm Cleantech Venture Day*, a forum for investors and businesses in this sector organised by the Stockholm Cleantech Association. In 2009, the Swedish Trade Council launched a special initiative to promote Swedish environmental technology exports, with an emphasis on small and medium-sized businesses. Invest Sweden has worked to promote investment by foreign companies in Sweden as well as the Stockholm Business Region. Collectively, these initiatives can help to make Swedish clusters more competitive, and can integrate small and medium-sized businesses into the innovation system.

The Stockholm region has been a pioneer in launching several spatial initiatives to rehabilitate several districts of the city. These programmes have an important green component and involve the construction, waste management and heating sectors. However, the mechanisms through which they could influence the next generation of cleantech products and processes are so far not very clear. This is particularly true for Hammarby Sjöstad, even though some positive steps have been taken, with the development of the SymbioCity concept and the recent launching of the Symbiocity Academy. The potential of showcasing and demonstration sites could be significantly enhanced. Further investigation and economic analysis appears to be needed to guarantee their eventual influence on innovation dynamics and enterprise creativity.

National and regional cluster policy

The Stockholm region is one of the most competitive knowledge-based regions in Europe. Promoting clusters is an important part of RUFS 2010, the regional development plan for the County of Stockholm. This emphasises the already strong clusters in the region, such as the ICT cluster in Kista, in the life sciences and the Robot Valley clusters. The regional development plan also promotes and supports new and emerging clusters, such as the cleantech and environmental technology industries in the Stockholm region. The regional authorities, in co-operation with the City and the central government, have worked actively to promote co-operation between local administration, universities and clusters. One of the problems of Stockholm's clusters is their dependency on one or two dominant companies, which results in limited competition within the clusters.

As indicated above, many intermediate institutions and venture capital organisations have been established to strengthen co-operation and competition in the clusters. Stockholm Business Region (SBR) is one, working to promote clusters and "triple-helix" principles in the region. Stockholm Business Region Development (SBRD), a subsidiary of the Stockholm Business Region, is the official investment promotion agency of Stockholm. Its goal is the marketing and development of the Stockholm region as a business destination. Globaliseringsrådet is another institution that promotes Sweden's competitiveness. One of its missions is to come up with the ways in which Sweden and Stockholm can improve their innovation system and their worldwide business leadership.[16] Last but not least, the Swedish Agency for Growth Policy Analysis aims to help Swedish authorities better understand patterns of growth, analyse cluster dynamics and evaluate government policies (Clusterobservatory, 2012).

To sum up, the innovation system and cluster policies have been national priorities in Sweden for 10 to 15 years. The regional dimension of innovation and cluster policies increased in importance due to the Regional Development Plans, but this seems to have resulted in a proliferation of framework organisations and co-operation structures. The priority for action is to streamline this institutional framework to avoid redundancies and inefficiencies. In other words, more attention should be paid to the specialisation of the new intermediary structures.

EU Structural Funds support for the Stockholm Region

In August 2007, the European Commission approved a Regional Operational Programme for the region of Stockholm for the 2007-13 period, which is co-funded by the European Regional Development Fund under the Regional Competitiveness and Employment Objective, with a total budget of around EUR 94 million. European Community assistance through this programme amounts to roughly EUR 38 million, 2% of the total EU investment for Sweden under the Cohesion Policy for 2007-13.

The programme aims to strengthen the international competitiveness of the Stockholm region, with special emphasis on SMEs and increased co-operation between industry, R&D institutions and the public sector. The programme also supports entrepreneurship, innovation, knowledge development and the integration of immigrants, as well as increasing exports and promoting effective energy use. The programme envisions creating 1 300 new jobs and 300 new businesses, and involving 400 businesses in the development of markets, product development or lowering energy consumption. Women's participation in all projects is at least 40%.

Green innovation policy recommendations in a nutshell

It is important to bear in mind Sweden's success in cleantech activities. Sweden and Stockholm County have achieved outstanding results in R&D and innovation, as demonstrated by the last European Innovation Scoreboard. For cleantech activities *per se*, Sweden ranks third among 38 major countries, as shown in the World Wide Fund global cleantech innovation index. However, when it comes to cleantech-specific innovation drivers, (*i.e.* government policies, public R&D spending, access to private finance, infrastructure for renewable energy, cleantech organisation), Sweden ranks behind Denmark, Finland, Germany, Korea, India, China, Australia, France and Italy. This suggests that Swedish cleantech innovation policies need to catch up.

Priorities for action are:

i. Ensure that innovation policy favours an alignment of R&D activities with the comparative advantages of the Stockholm region (smart specialisation).

ii. Better target policy programmes. Since 2011, VINNOVA has embarked on programmes with a distinctive sustainability goal. The sustainability lens should also be applied by other innovation-relevant agencies, such as Tillväxtverket. A minimum share of the portfolio of projects of these agencies should be linked to green growth.

iii. Encourage cleantech SME access to the next EU Horizon 2020 Framework Programme.

Notes

1. This report takes green innovation to embrace more than simply manufacturing, and includes the whole set of eco-industries linked with water, waste, air pollution, energy, noise and soils. These industries include not only equipment suppliers, engineering industries and measurement instrument manufacturers, but also eco-related counselling, audit and service suppliers.
2. The chambers of commerce of Stockholm and Uppsala have merged to form a joint chamber of commerce.
3. One of the reasons why Stockholm received the Green Capital of Europe award was its well-developed and highly acclaimed IT infrastructure, which makes many green IT solutions possible. For example, Stokab's new node was named "Sustainable IT Project of the Year" by the magazine *CIO Sweden*, using waste heat from the broadband equipment to heat the Östra Real upper secondary school in Stockholm.
4. In 2011, 30 000 Swedish SMEs were surveyed. Around 19 000 SMEs responded (60% response rate). The survey was previously conducted in 2002, 2005 and 2008.
5. IRECO is the generic name for public industrial research institutes in Sweden.
6. This would be coherent with the new VINNOVA innovation policy that assumes that 75% of new investment should be linked to green growth.
7. For example, Sweden is placed second in the WEF ranking for technological readiness and innovation, but 19th for Foreign Direct investment and Technology Transfer (see 2011/2012 edition).
8. Important activities are exports, product development, business development and financing. A test facility for research and tests on water purification has won international attention and stimulated global co-operation. Another test facility and showcase for renewable energy has been established in the city of Stockholm.
9. About EUR 0.9 million was provided by the European Regional Development Fund (ERDF), EUR 0.6 million by IVL, EUR 0.15 million by the Stockholm municipality and EUR 0.6 million by Tillväxtverkert.
10. Rank in the international Scimago classification (ranking 3 200 university and research institutes in the world) based on the quantity and quality of research output, including articles.
11. Given that technical universities focus on applied research, their scores can appear lower than general- purpose universities. It is important to be careful when making comparisons and better to compare technical universities with their counterparts in other countries.
12. For these indexes, several German Technische Hochschule are outperforming KTH, notably Hamburg and Munich. This is also the case for the Federal Polytechnics of Zurich and Lausanne in Switzerland and the Eindhoven and Delft Universities of Technology in the Netherlands.

13. StAF disseminates information about universities and their importance for the development of the region of Stockholm. StAF also strives to influence public opinion and to develop relations with actors in the region. Its main activities are organised in three working fields, *i*) analysis*:* StAF initiates, conducts and publishes analysis and research concerning Stockholm as a knowledge region; *ii*) influence: StAF exerts influence by participating or creating meeting places to make the case that the region's universities can play a role in creating an attractive knowledge region: and *iii*) co-ordination. StAF acts as a liaison between universities, the public sector and the private sector.

14. The project, in operation during 2011 and 2012, was co-ordinated by the County Administrative Board of Stockholm, and co-funded by the County Council of Stockholm (EUR 0.55 million) and VINNOVA (EUR 1.75 million).

15. VINNOVA is also involved in a number of transnational programmes. One of them is a top-level research initiative, a Nordic programme targeting environmental, climate and energy issues and in particular the adaptation to climate change, the relationships with the cryosphere, energy efficiency using nanotechnology, the integration of large-scale wind power, sustainable biofuels and CO_2 capture and storage.

16. Founded in 2006 on the model of existing Finnish and Danish institutions, it consists of representatives of the government, public administration, academia, the business world, trade unions and the media.

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Chapter 4

Governance of green growth in Stockholm

Chapter 4 examines the local, regional and national institutions available for strengthening green growth in Stockholm. It reviews Stockholm's network style of governance as well as challenges that existing governance mechanisms face when fostering green growth, such as in scaling up energy efficiency or smart-grid technologies, which could profit from enhanced regional governance and co-ordination. Furthermore, it focuses on support for innovation commercialisation and policies to accelerate the diffusion of eco-innovations and to boost green technology exports.

Key governance findings and recommendations

- Stockholm is attempting to further institutionalise the synergistic links between green growth and building a robust international business opportunity. In co-operation with other levels of government, other local governments and an impressive array of stakeholders in civil society, Stockholm County and the City of Stockholm have built up a network governance whose broad mechanisms appear key to fostering green growth. Yet they could go further, by taking advantage of opportunities to increase the co-ordination of regional governance while pursuing pay-offs from greater energy efficiency.
- Stockholm would do well to use price and related mechanisms to achieve greater levels of energy efficiency and conservation. The faster Stockholm can deploy renewables, whose costs are diminishing, the more the city can meet its stated goals of moving to a sustainable, renewable-centred economy.
- Stockholm is making headway on smart-grid technology in its Royal Seaport and other initiatives. But it is advised to innovate a more pro-active role in the development and diffusion of the smart grid and related governance mechanisms. Stockholm has the incentives and ability to help to accelerate the diffusion of smart grids and thus achieve green city goals more rapidly. Greater regional co-ordination on governance of the grid could help advance this goal.
- Stockholm has ambitious goals for its green export business. But the city has had some difficulty in commercialising its innovations. The problem here may not only one of co-ordination but also of incentives. This suggests the need for better regional co-ordination, working with the Swedish Trade Council and other agencies.
- Finally, Stockholm could consider increasing some of its policy support for the diffusion of eco-innovation in its eco-district and more generally throughout its city project. A comparative perspective on the efforts by some of its competitors in this respect suggests that the city may fall behind competitors with more robust incentives. The current stage of eco-innovation development may very well be a point where first movers gain significant advantage.

Stockholm is an exemplar of green urban governance, and many of its initiatives have appropriately received international accolades. Its 2007 congestion tax, which curtailed downtown vehicular traffic by 25%, is a global benchmark (Gullberg et al., 2012). So too is Stockholm's Hammarby Sjöstad eco-district, whose impressive features include innovations for increasing the rate of recycling resource inputs. It is no wonder that Stockholm is seen as a leader in fostering urban sustainability. Stockholm's impressive performance is based on assets that include a well-educated and environmentally conscious public, a political culture open to experiment with both market and public-sector mechanisms, high levels of trust in public institutions (OECD, 2012) and world-class innovation clusters. Stockholm is perhaps unrivalled in its deft use of its natural endowments, its concern for equity and its commitment to comprehensive stakeholder consultation in designing and deploying the elements of its green city. Indeed, Sweden as a whole has been recognised as a leader in "ecological governance" (Lundqvist, 2004; Meadowcroft, 2005) and deservedly won the first European Green City award in 2010.

At the same time, there is growing scientific evidence and international recognition that the scale of the climate challenge is larger and more immediate than has generally been assumed. The so-called food-water-energy nexus is one cause for concern, in which

apparently accelerating changes in the hydrological cycle and other phenomena increasingly call into question the sustainability of conventional agricultural practices, patters of energy consumption, forms of urbanisation and related economic activity (Brown, 2012; McDermott and Nilsen, 2012; Vliet van et al., 2012). Environmental signals work together with those from the market, to amplify the appeal and potential returns from investment in sustainable urban design, alternative energy and related infrastructure. Against this backdrop of increasing challenge and opportunity, Stockholm faces increasing numbers of competitors in urban sustainability, and many appear to be gaining ground. Most, for example Singapore and Seoul, do not enjoy Stockholm's plentiful resources and are driven by economic, resource and other crises, robust policies that foster the diffusion and drive down the costs of sustainable energy and other eco-innovations; and the compelling evidence that these elements of sustainable growth present real and significant economic opportunity. For example, the global low-carbon environmental goods and services market has been assessed at GBP 3.3 trillion for 2010/11, with Sweden's share ranking 34th in the world and 0.4% of the total. Strong annual growth is projected for 2014/15 in such key sectors as alternative energy (+9.1%), wind power (+5.2%), energy management (+4.4%) and building technologies (+3.3%) (BIS, 2012).

In the face of increasing opportunity and competition in low-carbon and sustainable markets, Stockholm is strongly advised to accelerate its green-city initiatives. Stockholm is clearly committed to a green trajectory and building a robust international business opportunity into the bargain. It has dedicated several planning efforts to precisely this task. It needs to harness this ambition to the longstanding aim of bolstering regional institutional capacity. Regional co-ordination can help maximise resource efficiency and scale up "eco-districts" (Box 4.1) and disseminate best practices as rapidly and efficiently as possible. It can also help commercialise these practices and get them to the market.

Stockholm and its surrounding municipalities have gone through several iterations of co-operation on climate strategies, green growth and regional planning, the most prominent of which is the RUFS 2010 process. This resulted in a planning document that is not binding on the region and its various actors, but a steering document, with comparatively weak implementation. This collaborative approach, as opposed to one centred on binding targets monitored by an empowered regional agency, raises governance implications relevant to Stockholm and other greening metropolitan areas. In general, it is seen as desirable for relevant parties to empower a regional actor with sufficient authority to guide and monitor the implementation of regional agreements. One political problem is of course the path dependence of institutions that have forged more or less productive working relationships over a long period. Stockholm has been pursuing green growth successfully for decades, and it is not clear that creating a powerful regional administration in this specific context would result in better outcomes. Moreover, the practical business of building the green city cuts across several policy areas, including transport, health, energy and several others. It also requires the co-operation of the many stakeholders in the business community and civil society. Stockholm's productive background of environmental collaboration among the national, regional and local authorities, along with societal interests, gives it a rich texture of governance. There is a widely diffused and well-developed understanding of the sustainable and circular society and the need to aim towards it. The region already deploys a range of projects as well as quite advanced tools for measuring its energy and related resource flows. Notable among the latter are the Long-Range Energy Alternatives Planning and Water Evaluation and Planning systems (Box 4.2). This report strongly recommends that Stockholm's network expand collaboration and co-operation to accelerate green growth by reducing those resource flows.

Box 4.1. **Eco-districts as building blocks of sustainable cities**

The eco-district is an emergent paradigm in policy studies and applications of urban sustainability. The Carbon Disclosure Project describes the eco-district as "the smallest building block of the city, often coinciding with a single section of the electrical network (for example, the network supplied by one single substation), which can be isolated and treated as a real ecosystem." It adds that each implementation of the eco-district is differentiated by local particulars, but that the overall strategic objectives generally focus on greenhouse gas reductions and energy efficiency.

The eco-district therefore appears to afford a rough template for mixing an array of eco-innovations into a modular system that can, in turn, be flexibly scaled up to the smart city-region. Moreover, the Portland Sustainability Institute notes that most of the technological means for achieving local sustainability are already available, including recycling, renewable energy, water and energy management, and other aspects of increasing resource efficiency/conservation.

The eco-district as building block for the green city also offers a format for testing the technical and financial viability of various applications as well as their acceptability to residents. The eco-district is also a means of maximising resource efficiency while achieving an attractive densification, rather than an overly planned and consequently sterile urban environment. This approach can help residents understand that densification in the context of designing sustainable regional transport, water, energy and other infrastructure need not lead to the homogenisation of individual neighbourhoods and the sacrifice of aesthetic values.

The eco-districts are thus a key feature for making green urban growth into a system that is more than the sum of various technical advances. The perceived need for sustainability, combined with promising market assessments, have prompted a steadily growing number of countries and city regions to espouse green-growth strategies. Stockholm's Hammarby Sjöstad and Royal Seaport are model examples of eco-districts, as are Kitakyushu's Jono district, the University of British Columbia's UTown EcoDistrict and Portland's five districts of Foster Green, Gateway, Lloyd District, SoMa and South Waterfront.

Source: Portland Sustainability Institute (2012), "EcoDistricts: Building Blocks of Sustainable Cities", *http://pdxinstitute.org/*, accessed 15 March 2013; Carbon Disclosure Project (2012), "Seven Climate Change Solutions from the Cities of Europe", CPD Cities, *www.cdproject.net/CDPResults/CDP-Cities-2012-European-Report.pdf.*

Box 4.2. **Long-range energy alternatives planning (LEAP) and water evaluation and planning (WEAP)**

LEAP and WEAP systems are software platforms developed by the US Centre of the Stockholm Environmental Institute (SEI) and used by Stockholm as well as thousands of organisations in over 190 countries. The LEAP software tracks energy use, energy efficiency and the environmental dimensions of energy planning. The software is used by at least 85 countries in reporting to the UN Framework Convention on Climate Change. On 30 August 2012, the SEI launched an updated version that integrates LEAP with the Water Evaluation and Planning (WEAP) software – used by over 170 countries – to model the water-energy nexus in urban and other contexts.

Source: Stockholm Environmental Institute (2012), "Integrating the WEAP and LEAP Systems to Support Planning and Analysis at the Water-Energy Nexus", *http://sei-international.org/mediamanager/documents/Publications/Air-land-water-resources/SEI-2012-WEAP-LEAP-Factsheet.pdf.*

Stockholm clearly has a network style of governance in which a multiplicity of public-sector agencies, private-sector firms, NGOs and other actors collaborate on the complex problem of sustainability (Huppe et al., 2012). This approach to governance relies on robust social capital and trust among the relevant parties, particularly in the public sector. The network approach may not be easily translatable to other countries, given the increasing distrust elsewhere of public sector authorities and friction among the actors of civil society. At the same time, there is an ongoing shift of authority and responsibility to regional and lower levels of government in most developed and developing societies. And most countries within and outside the OECD do not have well-developed institutions for regional governance of the green city.[1] The green city presents many new challenges, for example getting economic and environmental departments to work together. This affords Stockholm an additional opportunity. In innovating incentives and institutional structures to enhance its network governance, it can strengthen its regional co-ordination, as well as perhaps trail-blaze for other countries and regions (Plummer, 2012).

Hourglass governance: Constraints on the regional level

Stockholm's green city programme is operating in the context of an "hourglass" of institutions that match powerful and competent central-government ministries and agencies with strong administrative capacity at the local level. The national level of government includes 11 ministries, which largely set policy and are relatively compact in size, and about 200 agencies. Many of these have some degree of involvement in the broad portfolio of building and marketing the green city. The agencies do not set policy, but have considerable latitude in the application of law as well as in making decisions in specific matters.[2] The profusion of agencies has been a matter of concern for the Swedish authorities. The co-ordination problem appears, moreover, to carry across a wide variety of sectors, including transport, communications and other areas. This is not a new issue, nor is it restricted to a small area of the administrative machinery. Regional policy includes many different development programmes that are designed and implemented by a variety of national authorities, with little or no participation by the County Councils. Many institutional rules and other practices associated with these programmes were put in place a considerable time ago and no longer reflect what is best for the current institutional order. In short, there is significant scope for reform that could improve the performance of the overall governmental structure (OECD, 2010).

The Swedish central government's policy tools have made a valuable contribution in shaping the incentives for green and sustainable growth (Box 4.3). But over the past two decades, the national government has retreated from a decidedly top-down orientation in programme delivery, and devolved considerable responsibility to local levels of government. Stockholm has always been a special case in this context, less reliant on the centre, but even so, this shift matters. The centre's co-ordinating role in setting the framework for policy is weaker, even though it retains potent regulatory authority and deploys an array of powerful agencies. It may indeed lack adequate incentives to foster reasonably autonomous regional governance, because it is not a monolithic actor but rather a multiplicity of ministries and agencies. Many of these institutions are doing important work to foster green development and help Stockholm's eco-innovation gain entry into rapidly growing overseas markets. But at the same time, these institutions' individual concerns to maintain influence at the regional and local level appear at times to conflict with the broader society, in using strong regional governance to maximise the country's resource efficiency, competitiveness and planning capacity (Hudson, 2005). The central government also disburses the EU's structural funds, which although limited, might be of

interest to an empowered regional level (Niklason and Tallberg, 2010). Sweden appointed a government commission in 2009 to review how administration at the regional level could be made more effective. This also covers the county administrative board's organisation and how the County Board's responsibility to co-ordinate the various social interests and other government agencies' efforts can be strengthened. Keeping to the spirit of seeking diverse solutions in regional policy, the central government has stressed that reforms must emerge locally and regionally. The commission will report its findings in December 2012.

Box 4.3. **Green policy and the Swedish national government**

In 1997, the Swedish national government declared its commitment to building a "sustainable Sweden". This objective emphasised three areas: *i*) protecting the environment; *ii*) the efficient use of resources and greatly reduced reliance on fossil fuels; and *iii*) assuring the sustainable supply of resources. Among the policies deployed to these ends were investment programmes. Between 1998 and 2002, a Local Investment Programme (LIP) was put in place. This was followed by the more focused Climate Investment Programme (KLIMP). Between 2003 and 2008, the KLIMP awarded SEK 1.8 billion in local climate investments. The last of these grants was awarded in 2008, with all programmes set for completion in 2012. The grants were distributed to 67 municipalities, 7 municipal associations, 5 County Councils as well as 4 firms throughout the country. The projects centred on energy and transport initiatives in particular, including expansion of district heating, biofuels initiatives and energy efficiency programmes.

It is worth noting that the local authorities were required to develop a coherent strategy, through working with local stakeholders, in order to receive the grant. The programmes were monitored by the regional state agencies (County Administrative Boards) and by the "chief local operator", which usually meant a municipality. The management of the funds saw the Swedish Environmental Protection Agency transfer the grants in a lump sum to the chief local operator, which then contracted with local stakeholders.

This approach fostered an intensification of interaction among the local authorities and stakeholders. In Stockholm County, there were a total of 159 LIP and KLIMP projects, worth SEK 756 million and SEK 3.08 billion in overall environmental investment. Among the programmes implemented in Stockholm were, for example, support to Hammarby Sjöstad, biogas-powered buses and fuelling infrastructure. These biogas projects helped to further the overall national goal of switching from fossil fuels to biofuels, and eliminating fossil fuels from transport by 2030. The project continues to attract great interest from other Swedish cities as well as overseas, including China, Japan and South Korea.

In 2009, the government launched a new initiative, the Support Programme for Sustainable Cities. This has substantially less money to spend than its predecessors, receiving SEK 359 million for 2009-12. It is focused on all three dimensions of sustainability – ecological, social and economical – and is aimed at funding advanced urban design projects, as well as enhancing their visibility internationally. Stockholm has received SEK 55.3 million for the Sustainable Järva project (see also page 36-37) and SEK 2.1 million for parts of the Royal Seaport initiative. Among other things, the fund contributes to the smart grid. A number of smaller projects in the Stockholm region, most of them run by private companies, have also received support from the Delegation for Sustainable Cities. These funds amount to roughly SEK 10 million in total.

Source: The Delegation for Sustainable Cities (2012), "Sustainable Urban Development Projects", *www.hallbarastader.gov.se/Uploads/Files/804.pdf*; Swedish Environmental Protection Agency (2009), *Climate Investment Programmes: An Important Step Towards Achieving Sweden's Climate Targets*, Naturvårdsverket, Stockholm, *www.naturvardsverket.se/Documents/publikationer/978-91-620-8468-4.pdf*; Swedish Environmental Protection Agency (n.d.), "Green Investments in Sweden", *http://klimp.naturvardsverket.se/mir/index.jsp?lang=en*, accessed 14 March 2013.

A strong local level

Swedish municipalities are comparatively strong administrative actors. For one thing, they are much larger than municipalities of average size in OECD countries. Since 1952, the number of Swedish municipalities has shrunk from 2 498 to 290 at present. The municipalities also have considerable fiscal and administrative autonomy, levying their own flat-rate income tax and covering roughly 68% of their revenues via taxation. Their reliance on central government specific and general grants is only 4% and 12% respectively (SALAR, n.d.). They also account for roughly 70% of public expenditure. Perhaps as important, they are animated by a very powerful ethic of local autonomy.

The City of Stockholm itself is the largest of Sweden's municipalities, with about 860 000 residents and a density of 4 580 residents per square kilometre. The city accounts for 9% of the overall Swedish population. The City of Stockholm Council is the primary agency of governance and decision-making for the city, with its social and other services delivered via administrative or corporate bodies. The city's organisational resources also include 16 specialist administrations that cover such important functions as real estate, city planning and city development. In addition, the city has 17 municipal companies, whose areas of operation include housing, management of school building, the water supply and operation of ports. The municipal companies are co-ordinated by their parent firm, Stockholm Stadshus AB, and many are important actors in the green-city initiatives.

The City of Stockholm is in turn divided into 14 geographically separated district councils, whose primary function includes schools and social services. The members of the committees and boards of the district councils are appointed by the City Council, and the distribution of seats reflect the City Council's composition. The city distributes roughly three-quarters of its revenues to the councils, based on individual needs, number of residents, age, living conditions and other such factors. Stockholm's districts were first instituted in 1997 to make local government more effective. The number of districts was reduced to 14 in 2007 in order to increase efficiencies and re-centralise some operations, such as education. In short, Stockholm itself clearly demonstrates a background of administrative reform in search of efficiency and effectiveness.

Co-ordination challenges

The regional level is administratively defined by the county. The entire nation is divided into 21 counties. The County of Stockholm is home to 22% of the overall Swedish population and 29% of the country's GDP, and comprises 26 municipalities. The 26 municipalities also have their own regional organisation, in form of the Stockholm County Association of Local Authorities (KSL). The KSLs' task is to support and develop municipal autonomy and safeguard municipal interests, but also to promote co-operation between municipalities and assist municipal operations. The national role at the regional level is exercised through appointed county governors and 21 counties that play a central role in designing the growth agreements. These actors represent the national government, and monitor regional conditions while performing a range of general administrative tasks. There are also a variety of regional boards and agencies that are part of the governance mix, but they are not especially influential. Co-existing with these actors at the regional level, and co-operating with them, are the County Councils. Unlike the County Administration and regional boards, the County Councils are elected bodies. They focus on health care, which accounts for about 90% of their activities, and also maintain some competency in transport, regional planning and cultural matters. In

Stockholm County, the County Council has a greater responsibility for public transport than other regions. Public transport in Stockholm represents more than a quarter of the county budget. Half of this transport spending is financed by taxes, and the remainder comes from ticket revenue.

Swedish policy makers have worked for well over a decade to increase co-ordination and coherence among the complex network of actors involved in regional development. The main actors in regional development initiatives, including green growth and sustainability, are the national and regional agencies, the municipalities, large firms, academic and research centres and other elements of civil society. The EU also plays a major indirect role through its rules that mandate planning and often set very specific requirements. There has been measurable success on regionalisation in the two other regions besides Stockholm with over 1 million inhabitants. In the late 1990s, Västra Götaland (population 1.5 million) and Skåne (population 1.2 million) saw the amalgamation of previously existing counties and the transfer of health care from the councils and planning and development from the County Administration. Research on the subsequent performance of Västra Götaland and Skåne suggests that their increased capacity has yielded benefits in critical areas. As a result of this administrative reform, they have been able to draft coherent visions for their regions, drawing in private partners and working out regional strategies (COE, 2005). They have also found an important role in serving as a locus for strengthened relations between the national and municipal levels of government. The pilot regions were therefore made permanent in the 2010 budget bill, and the county councils of Halland and Gotland were granted similar competencies for regional development. Sweden is moving towards regional capacity building, but without a clear configuration as yet (OECD, 2010).

In spite of its hourglass configuration, the Stockholm County region has shown itself quite able to take the lead on reaching agreement on major regional planning initiatives. Working together, the regional actors devised an important regional energy and climate report, in conjunction with the larger RUFS 2010. This process included several of the regional stakeholders, including the environment and regional planning office of Stockholm County Council, the Stockholm County Administrative Board and the Stockholm County Association of Local Authorities (*Kommunforbundet Stockholms Lan*, or KSL). They focused on enhancing energy efficiency with a special priority on "socially effective energy planning" (SEF, 2011). The extent of collaboration in the planning processes is remarkable, and reflects the special character of Stockholm's inclusive networks of ecological governance. Beginning in 2006 and up to its May 2010 adoption by Stockholm's county council, RUFS 2010 involved four years of work and input from over 250 organisations (Stockholm County Council, 2010). The more limited process of drafting Stockholm's City's "The Walkable City" plan began in November of 2007 and continued through to December of 2010. In that period, 277 meetings were held, of which 186 included external (to the City of Stockholm) agencies and interests. Like RUFS 2010 and other initiatives, this plan is a steering document rather than a legally binding one.

The Stockholm region's network governance includes a diverse array of public and private-sector actors. Many of these are grouped in more or less permanent partnerships that adapt to current needs for each area depending on what has been the most effective way to work. The KSL is found at the focus of many of these partnerships. Perhaps the broadest public-private regional initiative relevant to the green city is the Stockholm Business Alliance (SBA). This is a new partnership between 50 municipalities in seven counties in and around Stockholm. Its focus is on attracting foreign investment to

the region, including such areas as ICT, robotics and technology. The partnership is by five-year agreement, and runs from 2011 to 2015, with a business plan that focuses on promoting Stockholm as "the Capital of Scandinavia" and a mandate of retaining Stockholm's position as Europe's leading growth region. Another important and institutionalised collaborative mechanism is Regional Co-operation for the Environment. This is a co-operative project between Stockholm County's municipalities, the KSL and the County Administrative Board, which aims to streamline the environmental offices' inspection work and increase consensus. It is aimed at encouraging more efficient resource utilisation, increased exchange of experience and greater opportunities to delve into different issues and achieve long-term sustainable development in municipal environmental work.

The KSL also works to implement regional environmental objectives with other regional stakeholders by contributing to clearer connections between municipal, regional and national environmental objectives. The aim is to make current environmental work visible, investigate the need for additional measures, decide on new measures and follow-up efforts, as well as carry out programmes of action. Swedish municipalities are obliged to provide reliable water supply and wastewater treatment. To this end, the KSL acts primarily through the Council for Regional Co-operation for Water and Wastewater in Stockholm County (VAS *rådet*) and its committee, which was formed in 2005 to protect water environments in the Stockholm region. VAS has produced a number of reports that provide support documentation for political decision-making and municipal management planning. Stockholm understands that the need for regional co-operation in the field of water and wastewater has increased in the past few years. This need arises from population growth, climate change and the EU framework directive for water. Future reports from the VAS appear likely to be extended to providing decision-makers with more information on the implications of climate change and the municipalities' overall responsibilities and options. The municipalities are also responsible for ensuring that waste-management operations stress sustainability. The KSL oversees joint efforts of this type through the Regional Co-operation in Waste Management. Its objective is to ensure that municipalities, waste companies, transport companies and recycling companies promote ecologically sustainable development within the waste sector. The Stockholm authorities emphasise that municipal responsibility for waste is the grounds for ensuring that one of the community's most basic resource systems works. Waste operations that work well are a prerequisite for health, regional development and growth. It is also one of the issues that must be dealt with by co-operation among different stakeholders.

Since 1976, the KSL has also had the task of co-ordinating mapping and surveying issues for the municipalities in Stockholm County. This task is managed through KSL's Geodata advisory board. The Swedish geodata strategy forms the primary basis for regional co-ordination within this area. The strategy is a long-term plan for handling information management for the geodata field at a national level. The Swedish strategy, in turn, is rooted in the EU directive, INSPIRE (Infrastructure for Spatial Information in Europe), which aims to establish a geodata infrastructure in Europe. The administrative infrastructure for Geodata and well-developed geographic information system (GIS) support provide municipalities with a valuable means of improving public services in such increasingly important areas as e-governance and e-services, school transport, home help and services. The KSL also participates in and manages a variety of projects in the energy sector. One example is the Energy Advice Service, a co-operative effort among municipalities in the Stockholm region. Its purpose is to provide residents with advice in reducing their energy consumption.

Is the network enough?

Stockholm City and other stakeholders in the region therefore collaborate extensively and through a wide variety of mechanisms. Stockholm County's 26 municipalities are linked through KSL and other institutions, but they lack robust institutionalisation able to broker and implement difficult decisions for the region as a whole. The current institutional arrangements reflect a political culture marked by a very high degree of collaboration and negotiation, framed by an over-arching context of trust and transparency.

Some observers regard this structure as problematic, and suggest that Stockholm's frequent meetings and negotiation are rendered less effective than they might be due to the conspicuous absence of an empowered regional institution. According to Nordregio (2012), there are divergent views between planners at the municipal level in Stockholm County and the regional-level planners. The report argues that Stockholm's "regional and municipal strategies for polycentric development are not explicitly co-ordinated", and suggests that a major cause is the lack of a sufficiently empowered regional arbiter. The Nordregio report suggests a tension between and regional and municipal level planning that may indicate weak regional governance. The Nordregio report is worth quoting at length. It reveals that:

> Interviews with municipal planners in 2010 demonstrated a wide range of ideas on what their designation as an urban core meant and help to underline the political nature of Stockholm County's development strategy. For some municipalities, the designation represented a clear opportunity that served as the catalyst for developing denser, more intensively used centres. For others, there was little interest in promoting urban qualities such as higher densities or a greater mix of uses. For these municipalities, the designation was more of an honour than the foundation for a new urban core. Ensuring that stakeholders are aware of their opportunities and responsibilities in becoming centres of growth is key to fostering an urban form that is more conducive to public transit and densification. (Nordregio, 2012)

This argument suggests that at least some of the stakeholders in the planning process either do not understand what was agreed to or view it as more symbolic than a process with practical consequences. Moreover, among those that do understand the content, there appears to be an element of concern about the tension between the city's plan to develop itself internally and the RUFS 2010 proposals for designated urban cores. In their own wide spheres of competence, the other municipalities in Stockholm County are quite autonomous players. They apparently do not wish to cede that autonomy, especially in the face of perceived opportunities.

On the other hand, the Stockholm County authorities maintain that there are benefits to having regional stakeholders grouped in such inclusive non-binding planning processes as RUFS 2010. Their argument is that the looser, non-binding network produces stronger implementation than a top-down framework, where the plan would be formally binding and subject to change when new political parties come to power. Authorities stress the context of a strong Swedish tradition of local self-government. Moreover, they argue that large metropolitan regions are complex, with the powers to implement planning strategies spread out among a large number of private and public bodies. In this view, a genuine consensus on regional goals, strategies and commitments serves to lower the thresholds for concerted regional action, whereas a legally binding process where stakeholders empower a regional actor could in fact be counter-productive.

In making this argument, the Stockholm authorities point to such successes as the decision and construction of their Citybanan (railway tunnel through Stockholm), the Stockholm agreement on traffic in the region, and the implementation of RUFS. The Stockholm authorities also point out that the County municipalities took an active part in developing RUFS 2010. A major aspect of the plan is its large number of commitments in, for example, developing the regional polycentric structure described in Chapters 1 and 2. Stockholm authorities maintain that the municipalities are adhering to these commitments, as shown in ongoing comprehensive plans and local development projects. Moreover, in the process of devising a new investment plan for regional infrastructure, the municipalities, in dialogue with national authorities, have stressed the importance of retaining the planning principles and priorities in RUFS 2010.

An aspect of RUFS 2010 with respect to implementation is the use of regional action-programmes. One such programme run by the County Council in close co-operation with the communities centres on the development of regional city-cores in a polycentric regional structure, an important feature of RUFS 2010. At the same time there is an ongoing specific development process for each regional city-core under the auspices of the host community or in partnership with neighbouring communities. One example is the partnership between all of the communities in the northeastern part of the region in developing a regional city-core in Täby. Another is the close co-operation between the city of Stockholm and the community of Huddinge in forming a united regional city-core in Skärholmen-Kungens kurva. As in the case of infrastructure, the communities stress their commitment to implement the strategies and regional structure agreed upon in RUFS 2010 in the recent dialogue with government on housing and levels of construction of new housing units. Indeed the communities, as part of their case on this urgent subject, demand that state authorities fully live up to these strategies as well.

Since there is a network in place that has long been collaborating on sustainability, perhaps it is best fostered through greater visibility of targets and progress towards them. For example, placing energy efficiency at the centre of regional activities could allow for progress both on better co-ordinated regional governance and on more competitive green growth. The various plans for the region as well as the City share a common theme of increasing its resource efficiency, reducing its carbon emissions, enhancing its attractiveness and increasing its export opportunities. Indeed, the 1977 municipal law requires that each municipality have a current plan for energy's supply, distribution and use in the community, with an analysis of environmental impacts as well as matters related to health (Covenant of Mayors, 2012). Stockholm is greatly advantaged by the fact that there is a very high level of informed discourse on these goals and that all the actors are committed, albeit many in their own specific ways, to the overall objective of eco-innovation and growth through sustainable means.

What might be useful, then, is an objective standard that explicitly goes beyond the commitment to growth *per se*. The proper measure of growth that the city region is aiming at is sustainable growth, something all city-regions need to aim at, and the reduction of energy use is a core theme running through the planning documents. Hence, adopting the objective measure of reductions in energy consumption would seem to be an ideal standard for encouraging focused co-operation with the potential to increase regional resilience and competitiveness.

Orienting regional development around energy efficiency would pose a challenge to Stockholm, but one that it is well-equipped to meet. Reducing energy consumption is not a simple matter for the city, because the region enjoys hydropower and nuclear assets that

provide it with plentiful low-carbon electricity. It also has access to considerable biomass supplies, thanks not only to the good fortune of its geography but its own technical ingenuity in exploiting various forms of waste for generating biogas and biofuels. It is worth noting that it must also contend with long, cold winters. Notwithstanding, the city planners have specifically targeted a more efficient use of resources, because this is a central tenet of green growth and a key means of reducing the region's carbon footprint. Stockholm has powerful assets in its long commitment to environmentally conscious growth, its high level of technical development, its advanced democratic governance and other factors. Its chief disadvantage, paradoxical as this may seem, is that it is not as subject to the rigorous constraints on resources that many of its green-city peers must confront.

Another factor contributing to the significance of energy consumption, both as an objective measure and a potential standard for facilitating green-growth agreements, is the level of competition Stockholm faces in energy efficiency technologies. The global population is set to grow from the present 7 billion to perhaps 9 billion over the next four decades, during which the rate of urbanisation will increase from roughly 50% to about 70% (Credit Suisse, 2012). The vast majority of urban regions are dealing with increasingly significant constraints on energy, and thus exposure to price volatility. These constraints are driving demand and innovation for energy efficiency technologies.

National or regional actors that can offer a highly energy-efficient model of urban development, especially one that minimises environmental impact and maximises distributed renewable energy, are thus particularly well-placed in the larger competitive global marketplace for green technologies. The more consumer-friendly this model is, the more attractive it is likely to be to domestic and overseas customers. The value of this market sector is estimated at several trillion US dollars per year, and is growing more rapidly than most if not all other competing sectors. The competitors for Stockholm's eco-innovative clusters include an increasing number of US and other firms, such as Boeing and Siemens, that are working on reducing the resource-intensity of US military bases (Box 4.4).

A crucial first step for regional-level efforts to reduce energy consumption would be the regional co-ordination of the relevant stakeholders to implement the RUFS 2010 plan. This plan was very much driven by the concern to maximise resource efficiency through focusing densification of the growing Stockholm region into growth poles rather than allow it to sprawl into wasteful configurations. The regional planners have already calculated the energy-consumption implications of a variety of spatial growth scenarios. Based on these calculations, they decided that the RUFS 2010 proposal for nine polycentric growth nodes was the most efficient in terms of energy consumed in transportation. While Chapter 2 discusses the need to better connect these nodes to each other through public transport, the RUFS 2010 plan is an important starting point for an objective standard for encouraging regional players to co-operate on increasingly stringent targets.

Stockholm would be wise also to move ahead as rapidly as possible with an overall programme of energy efficiency and conservation through stressing the visualisation of consumption, as well as price and other incentives to reduce it. The visualisation of consumption can be augmented by the wide diffusion of smart meters and other devices for measuring household and building energy flows. Stockholm has already achieved 100% diffusion of smart meters as of 2009. Though there are as yet no overall energy use targets for the Stockholm region, the County Administrative Board, together with the

Box 4.4. **The US Navy and zero net energy**

Stockholm's competitors in the global marketplace include such firms as those involved in the redesign of American military bases, which have a commitment to zero net energy, zero net water and zero net waste. The American Navy, for example, adopted a new "Shore Energy Management Instruction" on 10 July 2012 that completely revises its previous management instructions of 1994. The Navy's ambitious goals centre on reducing energy consumption as well as shifting to renewable energy sources. Specifically, the Navy aims at 50% reduction in energy consumption by 2020, securing 50% of energy from alternative sources by 2020, making 50% of shore installations net zero energy consumers by 2020, and reducing the energy intensity of operations by 30% by 2015.

These aims are helping to shift the US public debate over the very validity of energy efficiency, raising it above partisan politics and establishing it as an element of national security. The objectives for shore installations include the diffusion of smart meters, smart grids, solar energy, energy management systems and other items that are core elements of the green city paradigm. Moreover, if the ambitious targets for the Navy and other military bases are examined in terms of the eco-district approach, it would appear that private-sector contractors are again at an advantage in their direct involvement in aggressive and ambitious projects. In addition, these projects come with a commitment to securing 50% of fuel needs from sustainable biofuels by 2020. These goals have caused considerable political controversy over whether the US Navy, and the military in general, should be involved in driving the diffusion of renewable energy sources. That the US military elite is apparently willing to risk the criticism of Congress is not only an indication of its level of commitment to reducing resource intensity and increasing its sustainability, but perhaps an indication of the risk it perceives in continued reliance on conventional energy.

The Navy authorities are also quite explicit in their desire to be the source of demand that leverages a transition to lower carbon use in the American political economy. Ray Mabus, the Secretary of the Navy, and others frequently make reference to the well-documented fact that military demand has been critical in previous energy transitions, such as from wind to coal and from coal to oil, as well as in the creation of the Internet, the development of global positioning systems, the innovation of flat-screen televisions and other disruptive technological breakthroughs. Quantifying the scale of the military demand in public policy terms, as a driver of green innovation and deployment, as well as comparing its effectiveness to more common public policies, such as carbon taxation and feed-in tariffs, is difficult. But the military has been innovating with long-term (30-year) power purchase agreements and other mechanisms to secure stable markets for renewable power. In terms of demand, the US military's total budget request for fiscal year 2013 is USD 613.9 billion. The military's outlays for renewable energy in 2012 also included a USD 420 million effort to drive biofuel production, the Navy's USD 62 million biofuel R&D programme, the US Army Energy Initiatives Task Force's USD 7 billion renewable deployment programme and others. The Pew Environment Group reported in September 2011 that Department of Defense clean-energy investments rose 200% between 2006 and 2009, with an increasing focus on vehicle efficiency, advanced biofuels and energy efficiency, and renewable energy on its bases.

Source: Chief of Naval Operations (2012). "Navy Issues New Shore Energy Policy to Achieve Energy Security Goals", US Navy Chief of Naval Operations Shore Readiness Division, *www.navy.mil/submit/display.asp?story_id=68304*; Magnuson, S. (2012), "Defense Department Needs Investors to Buy Into Its Renewable Energy Goals", *National Defence Magazine*, *www.nationaldefensemagazine.org/archive/2012/August/Pages/DefenseDepartmentNeedsInvestorstoBuyIntoitsRenewableEnergyGoals.aspx*; PEW Environment Group (2011), "From Barracks to the Battlefield: Clean Energy Innovation and America's Armed Forces", *www.pewenvironment.org/news-room/reports/from-barracks-to-battlefield-clean-energy-innovation-and-americas-armed-forces-85899364060*; Rampton, R. (2012), "Retired US Military Brass Wage Political Battle for Bio-Fuels", *Reuters, www.reuters.com/article/2012/07/13/us-usa-navy-greenfleet-idUSBRE86C00Y20120713.*

county's municipalities, authorities and industry, have developed a climate and energy strategy that includes regional targets to be determined in the near future. The diffusion of visualisation equipment could be part of a move towards implementing these targets as well as making it possible, perhaps, to exceed them (IRBC, 2012). The further

deployment of ICT, in conjunction with this approach, would also benefit the city's strategy to put ICT at the core of eco-innovation in order to maximise energy efficiency (Kramers and Svane, 2011). Innovating in this area, especially being the first mover, is likely to greatly advantage Sweden as a whole. This is especially the case in a global economic environment in which resource costs seem likely to maintain their high levels of volatility and their secular increase, due to increasing demand and geopolitical instability.

At present, the County of Stockholm's official goal is to reduce energy consumption by 40% by the year 2050 compared with 2006 levels. The annual consumption figures would therefore drop from the 2006 level of 55 terawatts to 33 TW. At the same time, the regional population is projected to increase by 40% over the same period, from 2.1 million to 2.8 million residents. Stockholm is also aiming to reduce greenhouse gas emissions by 80%, so that emissions in 2050 will be only one-fifth the level of emissions in 2006. To achieve these goals, the city authorities themselves understand that "in consultation with the public actors, energy companies – municipal, national and private – should review the possibilities of generally improving the efficiency of the infrastructure and distribution of energy in order to achieve a safe and environmentally friendly energy supply for all areas of the Stockholm region" (Byman, 2010). This goal is not only important for the region itself, but also for its ambitions of being a green city model for the international community.

Moreover, looking at the eco-district as the starting point, there are several promising areas for further diffusion and co-operation. One of Stockholm's network governance tools is the use of "arenas" (exhibits in physical space as well as on the Internet) to interact with residents in describing the merits of Hammarby and other projects and in getting feedback on them (Swedish Energy Agency, 2011). The Royal Seaport and other showcase initiatives can be supplemented by the efforts ongoing in the older areas of urban development, especially the "Million Home" buildings constructed during the 1960s and 1970s. The co-operation of the residents can also be facilitated with the broader use of "arenas", as well as concrete incentives for reducing energy consumption. Stockholm has achieved virtually 100% diffusion of smart meters, which gives it plenty of scope to innovate in dynamic pricing, negawatts and other areas where most of its green-city competitors are lagging. Some of the most innovative approaches to encouraging greater energy efficiency feature such low-cost measures as including average consumption of immediate neighbours and the larger urban area with the customer's power bill. The comparison helps to overcome the behavioural inertia that holds many individuals and businesses back from taking advantage of subsidies and other supports to install equipment that will reduce their energy costs.

Strengthening regional governance beyond energy efficiency

The region should then build up the basis of robust and regionalised green-city planning capacity by reaching agreement on reducing energy use. This co-operation could then be expanded to encompass the co-ordination of energy infrastructure, climate change adaptation, development of the smart grid and other areas that present both significant risks and rewards.

Smart grids

Smart-grid infrastructure could be used to facilitate regional co-operation, widen the diffusion of economic opportunity and enhance export potential. The region's own study of energy lends further support to the argument that energy-centred collaboration affords a multiplicity of productive ways for co-operating on concrete, readily measurable quantities. A key incentive for better regional governance in Stockholm Mälaren would be the oversight of a co-ordinated grid infrastructure, while maintaining a district heating and power network that is open to third-party access. An interesting and related issue here concerns the capacity for regional governance. The application of ICT appears to offer the opportunity of considerably more efficient and responsive "smart" district heating and cooling grids (Dyrelund, 2012).

On this front, it might be helpful to consider mechanisms for facilitating more competition in the district heating system, half of which is owned by Fortum and half by the city. The system operators should also be innovating, for example by using ICT or mechanisms akin to "negawatts" for promoting energy efficiency in heating. The current regulatory targets do not seem adequate for incentivising this. Devising an innovative and IT-centred means of negawatts for district heating might help the city make the system even more marketable as an attractive part of a resource-efficient green-city model. Fortum, which dominates Stockholm's energy business, is revamping its business model to allow for a greater integration of renewable energy as well as the interaction of the electricity and district heating system. Its big challenge is storage, which gives it an interest in working with the city and with other partners. There might be considerable potential in this direction for overseas collaboration initiatives.

Stockholm's district heating system is a promising base both for enhancing governance and offering export opportunities. To address its apparent dependence on waste and more equitably distribute business opportunities, Stockholm should consider opening up the district heating system to third-party access. The object of this reform would be to incentivise the provision of alternatives to waste and give yet another boost to biofuels and biomass with lower life-cycle carbon intensiveness. The EU's announcement on 17 September 2012 of a plan to limit crop-based biofuels to 5% of transport fuel is likely to increase the opportunities for Swedish expertise in alternative sources.

In recent years, Stockholm has seen significant new investment in combined heat and power plants using biofuels. These investments have been encouraged through such policies as green certificates, but such businesses could be incentivised further by expanding the scale of the market opportunity. Whether or not competition can be allowed through third-party access to district heating is a somewhat controversial issue in Sweden. Prices for district heating increased after the sale of the former municipal monopolies. In 1998, Stockholm began to sell just over half of its municipal district heating system to Fortum, and completed the process in 2002. Stockholm now owns 9% of Fortum, while retaining 50% of the economic interest and board positions in the district heating system *per se*. Price increases followed the sale of the asset, and these increases exceeded inflation. A number of investigations followed, with no clear recommendations (Magnusson and Palm, 2011). The result appears to be a politicised debate about the scope for further deregulation. Green-city opportunities are a good reason to revisit the issue.

Adaptation to climate change

Adaptation to climate change has featured prominently in the reports of the Intergovernmental Panel on Climate Change (IPCC) since it was established in 1988. But in recent years, the failure to reach agreement on robust and global mitigation strategies, coupled with growing evidence that the pace of climate change has been underestimated in most scenarios, has turned a great deal of attention to the mechanisms of adaptation. Very few global cities have managed to craft credible adaptation strategies (Box 4.5). Stockholm has an opportunity to innovate technological and governance solutions to this difficult challenge of building resilience, as it is seeking to do in Royal Seaport and other eco-district projects. Stockholm can also use this challenge of adaptation as yet another means to encourage better regional policy co-ordination. And it could in tandem play a valuable role internationally in diffusing not only greater awareness of the need for adaptive strategies but also in commercialising its own learning from the eco-innovation and eco-districts that it evolves in response. Stockholm's deployment of the newly linked WEAP and LEAP software to monitor and manage the water-energy nexus is likely to afford a powerful lesson in productive collaboration for other greening cities.

Box 4.5. **Cities adapting to climate change**

In the spring of 2011, the International Council for Local Environmental Initiatives (ICLEI) surveyed its membership local communities on their adaptation to climate change. Of 1 171 ICLEI members (as of spring 2011, at the time of conducting the survey), 468 responded with enough information to be included in the results. Of the 468 valid responses, 298 came from communities in the United States. The results of the survey and a more comprehensive report published by the Massachusetts Institute of Technology indicate that 79% of cities globally have seen some degree of change in temperature, sea level and other factors that they attribute to climate change. Moreover, 81% of the cities reported more natural hazards, with 41% noting an increased intensity in storms, followed by 31% indicating longer durations of drought, 13% reporting coastal flooding and 30% greater inland flooding. The second most common perceived change was in temperature. Fully 67% of the cities reported this, and of those, 40% indicate higher temperatures than usual. In spite of this and other evidence of encroaching climate change, only 19% of the cities had completed an assessment to measure their particular climate risks and vulnerabilities, and only 18% indicate that they are implementing some kind of adaptation plan. At the same time, 68% of cities globally indicate that they are pursuing adaptation planning *per se*. These adaptation activities are very much in the beginning stages, as they largely consist of such initial steps as meeting with local government departments on adaptation (61%), searching the Internet or other sources for information on adaptation, creating a specially tasked committee or some kind of organisation to advise on adaptation and working with such partners as other cities, community groups, businesses, NGOs and the like.

Source: Carmin, J., N. Nadkarni, and C. Rhie (2012), "Progress and Challenges in Urban Climate Adaptation: Results of a Global Survey", MIT, Cambridge, MA.

Sweden will be affected by climate change, regardless of the level of success it and its international counterparts achieve via mitigation measures to reduce greenhouse gas emissions. Continued climate change is inevitable due to already elevated greenhouse gas levels, increased water vapour in the atmosphere and other drivers. In order to reduce the risks and take advantage of whatever opportunities there are in a changing climate,

adaptation must be integrated into the country's urban planning and development.[3] Yet Sweden has no official, specific national adaptation strategy. As in other aspects of green governance, the responsibility is distributed among the various levels of government: "Adaptation tends to be the shared responsibility of several authorities" (European Commission, 2012).

A climate strategy for the Swedish government was proposed in the 2007 final report from the Swedish Commission on Climate Vulnerability, titled "Sweden Facing Climate Change: threats and opportunities." The report stressed the need for an adaptation strategy commensurate with what it deemed to be the increasing risk of floods, landslides and erosion in many regions. It also highlighted the risk of "dramatic changes" in the ecosystems of the Baltic Sea, adverse effects on water quality, and drying out of the alpine areas. The report looked to the national level of government's regional representation, suggesting that County Administrative Boards should be assigned strategic roles in gathering information and providing administrative support and advice to the municipalities and other local actors. In particular, the report called for "special climate adaptation panels" to be established within each County Administrative Board. Even more controversially, it called for the County Administrative Boards to be granted an important role in reviewing municipalities' plans for land use and development (Swedish Commission on Climate and Vulnerability, 2007). Not surprisingly, this proposal for enhanced central-government intervention in local affairs, though arguably rational in terms of the objective challenge, did not get very far. However, the examination of the evidence and advice to take action did have significant effect.

The City of Stockholm itself is aware of the challenge and willing to act. Its perspective on climate change and adaptation is evident in its June 2009 publication, *The City of Stockholm's Climate Initiatives*. The city argues that it "must adapt." The report expects that by the year 2100, the average annual temperature in Stockholm will have risen by 2.5 to 4.5°C, and that the area will experience much more rain and other forms of precipitation, as well as rising water levels both from the ocean and the lakes. City authorities are concerned that these increased water levels are almost certain to put additional burdens on the rainwater and sewage infrastructure as well as increase soil contamination. Greater humidity also risks increasing damage to the built environment. They have some confidence that the green areas around the city, and that extend into the city's central districts, will help to mitigate some of these effects. They believe that the green areas, which include eight nature reserves and a National City Park, help to moderate the flow of water, filter out contaminating substances, as well as produce oxygen.

One example of Stockholm and the surrounding region's co-operation on adaptation planning is the recent advice of Stockholm County Council to its municipal members that there be no building on the waterfront of Lake Mälaren. A climate and vulnerability analysis indicated that the lake's level is likely to rise, and the Council therefore drew up advisories for the municipalities on sustainable housing near its waters. The Stockholm region municipality of Botkyrka acted on this advice and recently vetoed a proposal to build 150 apartments on the shore of an inlet connected to the lake (Radio Sweden, 2012). Co-operation on adaptation planning is also seen in the development by the five County Administrative Boards abutting Lake Mälaren of three solutions to the problem of rising sea levels which threaten the lake, and thus the drinking supplies of over 2 million Swedes. Lake Mälaren faces contamination through salt water from the rising Baltic Sea. The lake surface is currently an average of 0.067 metres above the level of the Baltic Sea, but sea levels are rising and this becomes especially threatening in storms. The summer

of 2011 saw the release of a study that offered three solutions to the problem. One was to look for other water sources. The second was to use barriers and keep the surface level of Mälaren above that of the Baltic Sea. The third solution was to build three or more barriers in the Stockholm archipelago. This third alternative would create an area of low water downstream from the lake (Renvall, 2011).

Adaptation, too, would appear to afford a new door through which to grapple with the long-standing challenge of dealing with inadequate regional administrative capacity. Once the local authorities start expanding the regional powers to deal with this particular aspect of the green cities' needs, they are likely to find reason to do more of it. This is because adaptation addresses a fairly wide range of risks that include: *i*) sea level rise, including the risk of storm surges; *ii*) the effect of extreme weather events; *iii*) the effect of climate change-driven disease vectors and other items on overall public health; *iv*) the effects of climate change on energy use; and *v*) the effects of climate change on water availability. Aside from weather events, which appear to be impacting infrastructure with increasing frequency already, most of these are clearly medium to long-range challenges. Even so, because infrastructure investments have long-term implications, it is prudent to consider these risks in the present and on the table of regional governance. The best strategy for Stockholm is to innovate in this area of using mitigation and adaptation activities as a means to bolster regional governance. In tandem, it can work with the Swedish Association of Local Authorities and Regions" (SALAR). SALAR has sought to put regional governance and adaptation on the policy-making agenda, and has also asked for subsidy measures to help it achieve co-ordinated adaptation (SALAR, 2010).

Regional incentives to increase cleantech exports

Stockholm's ambitious goals for its green export business are often impeded by difficulties in commercialising innovations. The problem here may not be only one of pairing up innovators with venture capital and the right mechanisms to get to the market. There are in fact a host of agencies and other institutions, including the network Symbiocity, at work in the city-region, seeking to foster innovation as well as introduce firms to prospective clients.

But in addition to the inevitable mismatch between resources and ambitions, there may also be one of governance and the co-ordination of available resources. Stockholm's Arlanda Airport (Box 4.6) is managed by a public corporation (Swedavia) that is pro-active in deploying green solutions to energy and other challenges, and is innovating at a global level. Its projects include energy storage solutions as well as a range of managerial approaches that are likely to be exportable. Yet it appears to have inadequate resources to pursue a range of business opportunities, including a proposal to deploy its geothermal storage technology in Jakarta Airport. This suggests the need for better regional co-ordination, working with Swedish Trade Council and the other agencies that deploy human and financial resources but do not appear to mesh very well.

The recommendation here is not that a regional level of governance be empowered to instruct these agencies in how to deploy their resources. It would simply not be possible for the region to get direct control over a host of resources funded from other levels of government and managed by actors who have a variety of organisational missions. Nor would that suit Stockholm's network governance approach. But in the context of expanding regional competency to plan and implement effectively, this sphere too should become more of a focus for making collaborative compromises.

Box 4.6. **Arlanda Airport**

The regional airport, Arlanda, is managed by the public company Swedavia. The company itself was formed on 1 April 2010, after the Swedish Parliament split up the state-owned enterprise LFV, the group that had managed air traffic services in airports. All shares in Swedavia are owned by the Swedish state, with the Ministry of Finance representing the Swedish state's ownership at the firm's annual general meeting and nominating board members to the firm. The Swedavia group overall has revenues of about SEK 4.7 billion and employs about 2 500 people. By mandate, it is required to achieve 9% of return on equity over the business cycle, with the target equity/assets ratio being 35%. The dividend policy is an annual dividend of 30%-50% of the annual profit, after depreciation and taxes, distributed to the Swedish state.

The company is clearly an innovator, driven by robust environmental regulatory requirements including the world's only airport cap on carbon (in force at Arlanda). It applied for accreditation of Arlanda Airport as one of the 55 European airports that are in the Airport Carbon Accreditation voluntary initiative. The group, established in 2009, was the first industry-specific, performance-based and voluntary accreditation label. Carbon reductions at member airports are independently verified. Arlanda Airport has been a member from the start. The airport has managed to reduce its emissions by about 70 000 tonnes since 2009, when the program began. Swedavia is aiming for zero emissions by 2020, and at all of the 11 airports it manages. To reach this goal, the group is examining measures to alleviate the environmental impact of airports. The 11 airports owned by Swedavia were visited by 31.5 million passengers in 2011, a 13% increase over the previous year. Arlanda Airport represented 60.5% of the firm's business, or roughly 19 million passengers. The airport itself has 886 full-time equivalent employees.

The airport firm is focused on reducing emissions of greenhouse gases, discharges to ground and water, and noise reduction (a very important goal in Swedish environmental thinking). The firm was in fact one of the first major Swedish companies that chose to become climate-neutral. It offsets its CO_2 emissions by purchasing certificates from and engaging in projects in developing countries. The projects cited in purchased certificates meet the "gold standard requirements" for the World Wide Fund and Greenpeace. The firm has reduced carbon dioxide emissions by more than 60% over the past seven years. In 2011, its total emissions were 4 600 tonnes, or 44% lower than the previous year. In 2010, the airport was awarded ACI Europe's newly established environmental prize "for outstanding achievement in environmental performance and an innovative approach to environmental management." The airport receives its energy from Arlanda Energi. This firm operates a district heating network as well as the aquifer that supplies cooling during the summer months and ground heating during the winter. It also provides power. None of the required energy is derived from fossil fuels. The airport's aquifer thermal energy storage installation is the site of the world's largest thermal energy storage installation for heating and cooling.

Source: Government of Sweden, 2010. "Annual Report: State-owned companies, 2010", *www.Sweden.gov.se/content/1/c6/17/46/71/31df60e8.pdf.*

Stockholm would do well to consider increasing its policy support for the diffusion of eco-innovation in its eco-district and more generally throughout its city project. A comparative perspective on the efforts by some of its competitors in this respect (Box 4.7) suggests that the city otherwise risks falling behind competitors with more robust incentives. The current stage of eco-innovation development may very well be at a point where first movers gain significant advantage (UNEP, 2012).

Box 4.7. **Japanese city energy-efficiency initiatives**

In the wake of the 11 March 2011 Fukushima disaster and the ensuing restrictions on electricity supply, Japanese prefectures, large cities and other governments have attempted to build green cities centred on local resilience and distributed energy. Their incentives include a desire to alleviate undue reliance on highly centralised power-generation infrastructure, enhance the capacity of local green energy innovation clusters, diffuse economic opportunity as widely as possible, and maximise local opportunities afforded by the national feed-in tariff that came into effect on 1 July 2012. Their core incentive, however, is the fact that close to 30% of the country's power generation, nearly 50 nuclear plants, remained off-line in the summer of 2012 due to the political controversy over nuclear safety.

In order to cope with the immediate challenge of double-digit power cuts, Japan's local governments increased their energy efficiency and conservation and deployed as much solar, wind and other renewable generation capacity as possible. The mechanisms they used to achieve these ends included very low-interest loans directed at small and medium businesses in particular, local ordinances and other regulatory changes that simplify procedures for becoming a power producer, special tax measures that enhance economic incentives for businesses to locate solar and other power-generation assemblies in the local community, and an extensive array of subsidies and direct spending that encourage efficiency and the deployment of renewable power. Some of this spending is directed to local government facilities and is used to replace conventional lighting with highly efficient LED lighting as well as install solar capacity on the roofs of public facilities such as schools and event centres. Other spending is used to defray the costs of purchases, by businesses and residents, of power-generation equipment, energy management systems, LEDs and other devices for increasing renewable power generation as well as decreasing demand where possible.

Total spending by Japan's 47 prefectures and 20 designated cities (cities with more than 500 000 residents) for renewable energy, efficiency, storage and related innovation in the initial FY 2012 budgets amounted to USD 563 million. These figures were increased significantly in mid-year by a string of supplementary budgets. They were also backed up by at least USD 2.5 billion in central agencies' FY 2012 spending nationwide on immediate deployment of energy efficiency and renewable energy, as well as investment in next-generation technology and other measures.

One example of designated city investment in efficiency and renewable energy is seen in the city of Kitakyushu. It has been chosen as a green-model city by the Japanese government since the mid-1990s. The city's own total spending on environmental-oriented projects in its initial fiscal 2012 budget is just under USD 352.7 million. The green city of Yokohama went well beyond this level of commitment with its USD 3.88 billion FY 2012 spending on environmentally related projects. By contrast, over the period 2002 to 2011, Stockholm spent USD 1.28 billion (SEK 9 billion) on all facets of green technology, including transport, with roughly two-thirds being devoted to its Hammarby Sjöstad and Royal Seaport projects.

Source: Calculations based on Japanese central agency and sub-national budgets, FY 2012; Yokohoma City budget FY 2012, *www.city.yokohama.lg.jp/zaisei/org/zaisei/yosan/24yosan/pdf/24yosan-all.pdf*; environmental spending data provided by the City of Stockholm; Government Offices of Sweden website, *www.sweden.gov.se/sb/d/2102;* Swedish Association of Local Authorities and Regions website, *http://english.skl.se/municipalities_county_councils_and_regions*.

A contemporary example of first-mover success would appear to be Japan's rapid expansion of the LED market in 2011-12. Japanese LED makers were able to meet strong demand for energy-efficient lighting after the Fukushima accident of March 2011. LEDs accounted for 20% of the domestic consumer market for ceiling lights in March of 2011

but rose to about 75% by March of 2012. This demand has in large part been driven by eco-point and other subsidy packages that expanded the market until it reached a tipping point, in the post-Fukushima context. The result is that the Japanese firms of Panasonic, Toshiba and Sharp "are benefitting from a head start in scaling their capacity and progressing along the experience curve for assembling finished lighting fixtures from LED components. By the time other markets reach their tipping points, Japanese aggregators may have already established an unbreakable grip on the downstream of the LED lighting industry" (Ernst and Young, 2012).

Moreover, the relatively low level of adaptation governance and concrete preparedness visible in virtually all city-regions suggests that leadership in international forums would be a valuable contribution. In this case, we see an example of co-operation being rendered necessary by changing climatic conditions. So there are opportunities in the short run to co-operate on items like the smart grid and so on, and this co-operation will become institutionalised because it has a long-range task of adapting to climate change. After the June 2012 United Nations Conference on Sustainable Development in Rio de Janeiro, one of the conclusions was that international society will have to emphasise adaptation as well as mitigation of climate change. The smart grid and other programmes pursued in Stockholm's eco-districts are part and parcel of both (Herzog, 2012).

Stockholm's networked governance can pursue these interlinked initiatives at the international level as well, and through a wide range of forums. The city can also maximise the potential influence of the initiatives because it has a very flexible approach to membership in international organisations, permitting its large number of municipal companies and administrations to participate directly. The city has final approval, and regularly reviews these memberships to ascertain whether they contribute to the city's overall goals, so coherence in objectives can be maintained.

As to the city's own international and EU-level activities, Stockholm became a member of the International Council for Local Environmental Initiatives (ICLEI) in 1991, and is a founding member of the organisation. Membership in the ICLEI "Cities for Climate Protection" (CCP) commits Stockholm to five major targets. These include drawing up a greenhouse gas emissions overview and projection, setting up reductions targets, constructing a local plan of action, implementing policies to achieve it, as well as monitoring the results. Stockholm has pursued these as part of its membership. This demonstrates the increasing value of big-city green organisations and initiatives at the international level. National governments are often encumbered by the influence of conventional energy interests and others that fail to perceive how sustainability might benefit them, whereas city-regions tend not to represent such interests or be subject to their political influence.

Stockholm itself is a member of Euro Cities, which allows the city to influence policy in the European Union as well as participate in European Union projects and programmes to promote the city within the European context. Stockholm has been a member of Euro Cities since 1995, and its mayor is a member of the executive committee. Stockholm is also a member of the Union of Capitals of the European Union (UCEU), created in 1961. This organisation unites the 25 capitals of the European Union, and Stockholm has been a member since 1995. In terms of dedicated green organisational memberships, the city is a member of the C40 climate leadership group. This is an alliance of large cities devoted to working against climate change. It was set up in 2005, and now boasts 58 affiliated members. Their potential organisational weight is seen in the fact that the C40 cities

represent 20% of global GDP, 14% of total greenhouse gas emissions and about 8% of global population. The C40 partnered in 2006 with the Cities Programme of former US President Bill Clinton's Climate Initiative (CCI), in the C40-CCI, and focuses on energy efficiency through retrofitting building stock and the diffusion of clean energy (CCI, n.d.).

The C40 action plans focus on mitigation, in large part. This represents another institutional setting where Stockholm, if it works on adaptation and regional governance, could make a contribution at the international level in a concrete institutional setting.

Stockholm should also consider using these avenues of influence to pursue a greater level of international co-operation on the development of the smart grid. At present, a multiplicity of smart-grid projects are operating around the world, in which individual cities, universities and other actors (including the US military), use subsidies or other financial inducements to encourage a variety of global firms' participation in the development of a smart grid for the local city, military base or similar facility.

The provision of a more stable, cleaner and efficient supply of electricity through the smart grid clearly has the potential to become a public good, and it is not clear that this is being adequately addressed through the current institutional arrangements. At present, international collaboration centres on the International Energy Agency's International Smart Grid Action Network (ISGAN). ISGAN's work is valuable, but its impact appears to be constrained due to organisational characteristics (Box 4.8). ISGAN groups national governments rather than the urban communities where the grids have actually been tested and deployed. It would seem enlightened self-interest for green cities to co-operate both among themselves as well as via their international agencies, such as ICLEI and the C40-CCI, for the development of the smart grid. The green cities are, in the main, the sites of development and eventual deployment of the grids. Cities can help expand the range of stakeholders engaged in the smart-grid projects and exchange information on ongoing and crucial learning, on making them user-friendly, on governance issues and a host of other emerging concerns.

Box 4.8. **ISGAN**

The International Smart Grid Action Network, or ISGAN, is the International Energy Agency's effort to diffuse learning on the smart grid. The organisation was initiated in July of 2010 at the Clean Energy Ministerial. This meeting of energy and environment ministers as well as other stakeholders from 23 countries, including Sweden, was held in Washington, DC. Membership in ISGAN is not restricted to IEA members, but can be extended to non-members by invitation of the ISGAN executive committee. The ISGAN effort focuses on government-to-government collaboration on furthering understanding of the smart grid, but the participating governments can designate entities for inclusion. ISGAN is also in principle ready to collaborate with private sector and international agencies as it deems appropriate. ISGAN is affiliated with the Global Smart Grid Federation, which groups various national smart-grid alliances and associations, composed primarily of actors in the private sector. The range of stakeholders in these organisations is thus largely restricted to national governments and private-sector entities. Moreover, the scope of activity appears to be constrained largely within the membership circle, though the Global Smart Grid Federation expresses concern about the need for public acceptance of smart grids.

Source: Global Smart Grid Federation (2012), "Global Smart Grid Federation Report", Global Smart Grid Federation, *www.globalsmartgridfederation.org/documents/May31GSGF_report_digital_single.pdf.*

Stockholm has the rich network and hard-won credibility to initiate this kind of endeavour and do it well. It is perhaps time to go beyond the current international architecture of smart-grid collaboration that is focused on technical matters and the interests of a rather narrow range of stakeholders. Smart-grid development is getting increasingly close to serious deployment, so it would seem advisable to make the grid part of international green-city governance, akin to recycling, water management and other functions.

Urban green growth is a systemic solution to a multiplicity of challenges, including climate change and its impact on the water-energy-food nexus. It entails innovations in IT, energy and related sectors that encompass significant shares of the average industrialised economy. This suggests that the scope for innovation and sustainable growth is enormous. But that opportunity is best maximised by drawing on the strengths of the public sector, the private sector and the actors dispersed through civil society. Such collaboration among all of the stakeholders is an involved and time-consuming effort, but if not done equitably and transparently, risks resulting in outcomes that are not acceptable to the residents and businesses that are the intended consumers of the local eco-district or green-city initiative. That adverse outcome would not only waste resources deployed to develop the local initiative, but obstruct the success of the eco-district approach in overseas markets. Stockholm's network governance thus affords an impressive example. It clearly maximises the participation of relevant stakeholders in the design and deployment of the green city. In doing so, it aggregates essential information from academic, business, residential and other sectoral representatives and thus encourages an informed consensus on creating green growth.

Notes

1. A 2012 survey of 53 global city governments indicated that only about 20% have a co-ordinated strategy for green growth (LSE/ICLEI, 2012).
2. Indeed, the Swedish system of agencies dates back to 1632, long preceding the emergence of the government ministries in the late nineteenth century. The temporal precedence is an institutional advantage, and Swedish central government now confronts the challenge of finding means to increase "political control over certain agencies within the existing constitutional framework" (Lafuente and Nguyen, 2011).
3. As Nicholls et al (2008) point out in an OECD working paper on this issue, "[e]ffective adaptation is essential for managing risks against the background of developing cities and the changing climate. Coastal cities will face great challenges in managing the significant growth in exposure that will come about from both human and environmental influences, including climate change. The size and concentration of population and economic development in many of the world's largest port cities, combined with climate change, highlights the strong two-way linkage between development and climate change and the need for more effective governance for climate change adaptation at the city-scale. Effective adaptation strategies will require multilevel governance approaches to assist port cities to understand and to pro-actively manage current and future flood risk."

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