Cities and Climate Change

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Foreword

Climate change has been on the OECD agenda since the late 1980s. As an intergovernmental organisation, the OECD represents 32 member countries committed to common principles to support economic development including social and environmental protection. We help governments to improve their collective and individual performance of climate change policies through peer reviews, dialogue and shared policy assessments. We provide an objective forum, away from international negotiations, for countries to discuss and develop a shared understanding of good practice on climate policy issues.

The OECD is actively working with government to highlight the role of cities in delivering cost-effective policy responses to climate change. Cities are central to the climate policy challenge. This is because they are home to the majority of global energy use and thus a large source of emissions. Also, their prevalent coastal locations, exposed infrastructure, and large numbers of poor and elderly residents make cities particularly vulnerable to sea level rise, storms and heat waves, all of which are likely to be exacerbated by climate change. Importantly, urban policy provides opportunities to respond to climate change, with the potential to stimulate innovation and advance clean energy systems, sustainable transportation, spatial development and waste management strategies to reduce greenhouse gases. With access to up-to-date climate science, impacts and vulnerability assessment, local authorities can also work with local stakeholders to design and implement effective adaptation strategies.

This book draws on the findings of a number of projects at the OECD that have advanced the understanding of the roles that cities can play to respond efficiently and effectively to climate change. It is a joint publication of the Public Governance and Territorial Development Directorate and the Environment Directorate of the OECD, and the core of the work was originally published as two working papers: "Competitive Cities and Climate Change", in the OECD Regional Development Working Papers Series, *and "Cities, Climate Change and Multilevel Government", in the* OECD Environmental Working Papers Series.

The Executive Summary and other relevant material from the book can be downloaded on the OECD website: www.oecd.org/gov/cities.

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Acronyms and Abbreviations

AAAS	American Association for the Advancement of Science
ABI	Association of British Insurers
ACIA	Arctic Climate Impact Assessment
ADEME	*Agence de l'Environnement et de la Maîtrise de l'Énergie*
AFLRA	Association of Finnish Local and Regional Authorities
APA	American Planning Association
BEA	Bureau of Economic Analysis
BEST	Built Environment and Sustainable Technologies Research Center
BINGO	Business and Industry Non-Governmental Organisation
BLFGE	Bandeirantes Landfill Gas to Energy Project
BRIC	Brazil, Russian Federation, India and China
BS	Baseline Scenario
C40	Large Cities Climate Leadership Group
CAC	Command-and-control
CalEPA	California Environmental Protection Agency
CAFE	Corporate Auto Fuel Efficiency Standards
CARB	California Air Resources Board
CBD	Central business district
CCAR	California Climate Action Registry
CCI	Clinton Climate Initiative
CCP	Cities for Climate Protection
CCSR	Center for Climate Systems Research
CDM	Clean development mechanism
CERs	Certified emission reductions
CGE	Computable General Equilibrium
CH_4	Methane
CHP	Combined Heat and Power
CIER	Center for Integrative Environmental Research
CIP	Climate Integration Programme
CO	Carbon monoxide
CO_2	Carbon dioxide
CPA	City of Palo Alto
CPER	*Contrats de plan État-Régions*
CPUC	California Public Utilities Commission
CRADAs	Co-operative Research and Development Agreements
CSP	Concentrating solar power
DOE	Department of Energy
DS	Densification Scenario

ECJ	European Court of Justice
ECMT	European Conference of Ministers of Transport
EE	Energy Efficiency
EEA	European Environment Agency
EECBG	Energy Efficiency and the Conservation Block Grants
EIA	Energy Information Administration
ENGO	Environmental Non-Governmental Organisation
EPA	Environment Protection Authority
EPB	Environmental Protection Bureau
eq	Equivalent
ERMS	Emissions Reduction Market System
ESCOs	Energy Service Companies
ESD	Ecologically Sustainable Development
ETS	Emission Trading System
EU	European Union
FCCC	Framework Convention on Climate Change
FCM	Federation of Canadian Municipalities
FIRST	Financing Initiative for Renewable and Solar Technology
GDP	Gross domestic product
GEF	Global Environmental Facility
GHG	Greenhouse gas
GLA	Greater London Authority
GRP	Gross Regional Product
Gt	Gigaton
Gwh	Gigawatt hour
HEAT	Harmonized Emissions Analysis Tool
HFC, PFC	Fluorocarbon
HOT lanes	High occupancy toll lanes
HOV lanes	High occupancy vehicle lanes
ICLEI	International Council for Local Environmental Initiatives
ICMS	Tax over Circulation of Goods and Services
ICMS-E	Ecological ICMS
ICP	Integrated resource planning
ICT	Information and communication technology
IEA	International Energy Agency
IPCC	International Panel on Climate Change
ITF	International Transport Forum
JI	Joint Implementation
KLIMP	Climate Investment Programme
KLIP	Climate Protection Programme
KTNs	Knowledge Transfer Networks
kW	Kilowatt
kWh	Kilowatt hour
LADWP	Los Angeles Department of Water and Power
LCC	Life cycle costing
LCP	Least-cost-planning
LGAs	Local Government Associations

LGO Protocol	Local Governments Operations Protocol
LECZ	Low Elevation Coastal Zone
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design building certification system
MACCs	Marginal Abatement Cost Curves
MCA	Multi-analysis criteria analysis
METREX	Network of European Metropolitan Regions and Areas
MIG	Municipal Infrastructure Grant
MRV	"Measurable, reportable and verifiable" procedures
MTC	Metropolitan Transportation Commission
Mtoe	Million tonnes of oil equivalent?
MW	Megawatt
N_2O	Nitrous oxide
NACP	North American Carbon Program
NAS	National Adaptation Strategy
NCI	Navigant Consulting, Inc.
NGCC	Natural gas combined cycle
NGO	Non-Governmental Organisation
NHTSA	National Highway Traffic Safety Administration
NPCC	New York City Panel on Climate Change
NOAA	National Oceanic and Atmospheric Administration
NO_x	Nitrogen oxide
NSDP	National Spatial Development Perspective
NYCDEP	New York City Department of Environmental Protection
O_3	Tropospheric ozone
ODPM	Office of the Deputy Prime Minister
OHCS	Oregon Housing and Community Services
ONERC	*Observatoire National sur les Effets du Réchauffement Climatique*
PADD	*Projets d'aménagement et de développement durable* (Urban Planning and Sustainability Plans)
PAG	Palo Alto Green
PDU	Plans de déplacement urbains (Urban Transport Plans)
PECT	*Plans énergie-climat territoriaux* (Territorial Energy and Climate Plans)
PLU	*Plans locaux d'urbanisme* (Local Development Plans)
ppm	Parts per million
PPP	Public-private partnership
PV	Photovoltaics
R&D	Research and Development
RDP	Reconstruction and Development Program
RE	Renewable Energy
RECs	Regional Environment Centres
RECLAIM	Regional Clean Air Incentives Market
RINGO	Research Non-Governmental Organisation
RJV	Research Joint Ventures
RWQCP	Regional Water Quality Plant
SCOT	*Schémas de cohérence territorial* (Territorial Coherence Plans)

SDRIF	Master Plan for the Île-de-France region
SEPA	Swedish Environmental Protection Agency
SF_6	Sulfur hexafluoride
SHW	Solar Hot Water
SIAM	Scenarios, Impacts and Adaptation Measures
SMEs	Small and medium entrepreneurs
SO_x	Sulfur Oxide
TEKES	Finnish National Technology Agency
TL	Territorial Level
TLOs	Technology licensing offices
TPF	Third-Party Financing
TS	Tax Scenario
TSP	Total Suspended Particulates
TTOs	Technology transfer offices
UCLG	United Cities and Local Governments
UHI effect	Urban heat island effect
UKCIP	United Kingdom Climate Impacts Programme
UN	United Nations
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UN-HABITAT	United Nations United Nations Human Settlements Programme
USNAST	US National Assessment Synthesis Team
VOC	Volatile organic compound
VOMs	Volatile organic materials
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
WTO	World Trade Organization
WWF	World Wildlife Fund

Executive Summary

Cities are major contributors to climate change and also vulnerable to its impacts

Cities are major contributors to CO_2 emissions.

Roughly half of the world's population lives in urban areas, and this share is increasing over time, projected to reach 60% by 2030. Cities consume a great majority – between 60 to 80% – of energy production worldwide and account for a roughly equivalent share of global CO_2 emissions. Greenhouse gas (GHG) emissions in OECD cities are increasingly driven less by industrial activities and more by the energy services required for lighting, heating and cooling, electronics use, and transport mobility. Cities can in principle use energy in a more efficient way than more dispersed areas because of reduced costs and economies of scale, however this depends on urban design and form. Growing urbanisation will lead to a significant increase in energy use and CO_2 emissions, particularly in non-OECD countries in Asia and Africa where urban energy use is shifting from CO_2-neutral energy sources such as biomass and waste to CO_2-intensive energy sources.

Climate change also poses key threats to urban infrastructure and to urban populations.

Many of the world's largest cities are located in coastal areas and this increases their vulnerability to rising sea levels and storm surge, presenting unprecedented risk to livelihoods, property, and urban infrastructure. Port cities most at risk for coastal flooding are located in both rapidly developing countries such as India and China (*e.g.* Kolkata, Shanghai, Guangzhou) and in wealthier countries such as the United States (*e.g.* Miami, New York City), the Netherlands (*e.g.* Rotterdam, Amsterdam) and Japan (*e.g.* Tokyo, Osaka). Heat waves will also be more intense in urban areas due to urban heat island effects which are exacerbated by large amounts of concrete and asphalt and excess heat from equipment such as air conditioning; average annual temperatures tend to be 3.5 to 4.5 °C higher in cities than rural areas, and this difference is expected to increase by 1 °C per decade (up to a difference of 10 °C in large cities. Poor populations, often concentrated in cities in both rich and poor nations, are among the most vulnerable to climate change, in part because they tend to settle in sub-standard housing in more vulnerable areas, and because they lack the resources to quickly and effectively protect themselves from extreme weather patterns and shifting climatic conditions.

Given their role as predominant consumers of energy, cities should be part of the climate solution: urban form, lifestyles and energy sources are what count

How cities grow and operate matters for energy demand and thus for greenhouse gas emissions.

Energy use and related CO_2 emissions are driven by how much energy is required to light, heat and cool buildings as well as to operate home appliances and office equipment, by how electricity is generated and by the energy used to move around the city and its peripheral areas. Urban density and spatial organisation are key factors that influence energy consumption, especially in the transportation and building sectors. The acceleration of urbanisation since the mid-half of the last century has been accompanied by urban sprawl, with urban land area doubling in the OECD and growing by a factor of five in the rest of the world. The expansion of built-up areas through suburbanisation is still growing in OECD metropolitan areas (66 out of the 78 largest OECD cities experienced a faster growth of their suburban belt than their urban core over 1995-2005). Increasing density could significantly reduce energy use in urban areas and CO_2 emissions. For instance, Japan's urban areas are around five times denser than Canada's, and the use of energy per capita (as measured by total primary energy supply) in Japan is around 40% that of Canada's. If we take countries in the same geographical context with similar heating needs, such as Denmark and Finland, the link is still visible: Denmark's urban areas are denser than Finland's by a factor of four and people in Denmark consume 2.5 times less energy than the Finns.

Lifestyles, spatial form and public transport availability are also crucial in the generation of CO_2 emissions.

It is not cities, or urbanisation *per se*, that contribute to greenhouse gas emissions, but rather the way in which people move around the city, sprawling urban development, the amount of energy people use at home and to heat buildings that make cities the great consumers of energy and polluters that they are. As urban areas become denser and rely more on public transport, carbon emissions are reduced. Similarly, not all cities in the same country are home to the same spatial form and lifestyles, nor do they contribute to carbon emissions in the same way. For example, the United States is the OECD country with the highest per capita carbon emissions, however the level of emissions varies greatly within the country, in part due to differences in density. The City of Los Angeles has higher personal vehicle use, much lower density and higher total CO_2 emissions than the city of New York, even though the latter has the largest population concentration in the country (60% higher than Los Angeles).

Energy sources and technology choices also matter.

The greenhouse gas emissions impact of energy consumption depends not just on how much is consumed, but also on the energy source, and in the case of electricity it depends on the mode of power production. For example, Cape Town has comparatively lower per capita electricity consumption than Geneva but its electricity consumption has a higher greenhouse gas emissions factor per unit since South Africa uses coal to generate 92% of its electricity whilst Switzerland relies heavily on hydropower. Technology also matters: urban areas relying on inefficient or wasteful energy technologies contribute more greenhouse gas emissions than those that consume the same amount from more efficient sources.

Urban policies are economically rational and can contribute to a global climate agenda

Urban policy can contribute to least-cost national CO_2 emissions reduction targets and mitigation strategies.

Findings from a computerised general equilibrium model (IMACLIM-R) with an urban module demonstrate that urban policies can lead to a reduction of total OECD global energy demand and, consequently, of CO_2 emissions at relatively low cost. Under a policy scenario where national emissions reduction objectives are implemented, the aggregate mitigation costs can be reduced if economy-wide environmental policies are complemented by urban policies, such as congestion charges or increasing spatial density. This is due to complementarities with other policy objectives, such as lower local pollution and health benefits, and the enhancement of city attractiveness and competitiveness through lower local pollution levels.

The lower tradeoffs between economic growth and environmental priorities at the urban level may be due to complementarities of policies observed only at the local scale.

An example is local pollution, which increasingly impacts city attractiveness and competitiveness. Results from the CGE model shows for instance that by 2030 cities that could become more attractive will do so while also curbing local pollution (*e.g.* Ankara, Auckland, Barcelona, Krakow, Lille, Melbourne, Montreal, Monterrey and Toronto). It also highlights that some metropolitan regions risk losing economic attractiveness if their current pollution trends continue (*e.g.* Chicago, Los Angeles, New York, Osaka, Paris, Philadelphia, Seoul and Tokyo).

The costs of delaying action on climate change are high.

While climate change mitigation and adaptation policies require significant investment, delaying action can increase future costs and limit future options for adapting to climate change impacts or reducing emissions in cities. Direct costs from climate change impacts can be staggeringly high, especially related to natural disasters and sea level rise. For example, shoreline retreat in the United States is projected to cost between USD 270 billion to 475 billion for each metre of sea level rise; analogous costs in some developing nations can amount to one-third of annual GDP. Beyond direct costs of climate change in urban centres – such as from increased intensity of extreme events – the economic impacts of climate change can have rebound effects in the job market and reduce tax revenue. These stresses on the local economy may limit investment opportunities and deplete funds for infrastructure and innovation, leaving cities more vulnerable to future change. Ripple effects from outside the city can also affect the profitability of many economic sectors in the city and the income of city inhabitants, as well as human security. Changes to the built environment both to adapt to climate change and to limit emissions require long lead times, which heightens the urgency of implementing land-use zoning, spatial, building and transportation policies now.

Some urban climate policies may be no-regret policies as they can provide co-benefits that offset their cost.

These include public health benefits, cost savings from reduced energy use and increased efficiency, energy security, and improved urban quality of life. These additional non-climate benefits may also help to explain the lower tradeoffs and synergies between economic growth and greenhouse gas emissions reduction at the metropolitan level. For example, if achieved in the transport sector, greenhouse gas emissions reductions are often accompanied by reduced emissions of other air pollutants and thus can benefit human health leading to relatively large economic benefits. Furthermore, policies to reduce greenhouse gas emissions through increasing energy efficiency can result in significant energy cost savings and these can compensate for the initial investment costs in as little as a few years.

Cities and regions could play a key role in fostering the green growth agenda

Cities and regions can promote green growth through many levers.

Cities can help stimulate growth through the creative use of procurement; better screening of investments in infrastructure, transport, communication networks and utilities; financial and tax incentives; partnerships and regulation of energy suppliers; and consumer awareness and training programmes for green jobs. They also have significant opportunities to lead by example. An effective green growth strategy for cities should search for employment gains in the short-to-medium term through targeted investments, and should pursue systemic changes in the way cities function and grow over the long term through the continuous generation and application of new technologies or other innovations that increase connectivity and reduce resource use. Public-private partnerships, leveraged for example through green infrastructure funds, have great potential for reducing the burden on local finances and increasing the efficiency of green investments.

Cities and regions can help create stronger markets for renewable energies and energy-efficient products and services and promote eco-innovation.

Feasible options for local public investment that can reduce emissions and sustain employment include improving the energy efficiency of buildings through retrofitting (Freiburg) and selective public purchasing (Berlin, Helsinki); integrating environmental targets in transportation and planning (Toronto, Chennai, India); and increasing the share of renewable sources in energy supplies, through distributed technologies (*e.g.* Berkeley's programme for individual photovoltaic installations) or centralised utilities (*e.g.* wind farms in Samsø, Denmark). Green jobs can result from smarter management of energy at the urban level, through regulatory innovations such as local feed-in tariffs for renewable energy (*e.g.* several German cities) or strong market support for the deployment of information and communication technologies (ICT) and other energy-saving technologies (*e.g.* the Gangnam-gu district of Seoul and the Paris suburb of Issy-les-Moulineaux). The employment benefits of energy efficiency at the local level are largely the result of multiplier effects, as households and businesses shift expenditures from a capital-intensive sector (energy) to more labour-intensive sectors (*e.g.* local services). Cities can also be effective in greening industrial production by developing one-stop support services for green industry start-ups (Los Angeles); enabling existing businesses to reach energy conservation goals (the Eco-Efficiency Partnership in British Columbia) or realise profits through energy recycling (Kitakyushu and other Japanese "Eco-Towns"); providing training tailored to local labour market needs (Oakland Apollo Alliance); and by developing awareness programmes to raise consumers' preferences for green products (Blacktown, Australia Solar City project). Cities can also play a facilitative role, through the development of networking platforms for enhanced knowledge-sharing in climate change mitigation and adaptation, and an enabling role, through well-designed support for R&D and for industrial and public research collaboration in eco-innovation clusters. Cities can also promote the development of green clusters by facilitating synergies and by enabling private R&D through joint ventures (*e.g.* the Lahti Cleantech cluster in Finland, with 20 new clean-tech companies and more than EUR 30 million in total investment).

Cities can serve as laboratories for innovative and complementary climate policy packages

Cities have key competencies to act on climate change through their authority and responsibility in key urban sectors.

These sectors include land-use zoning, transportation, natural resources management, buildings, waste and water services. Urban authorities make decisions that determine or influence public transportation systems, the built environment, renewable energy and energy efficiency measures, and the sustainability of public services delivery. Cities and metropolitan regions are well positioned to develop policy and programmatic solutions that best meet specific geographic, climatic, economic, and cultural conditions. They are equally well placed to develop innovative policy solutions that can be scaled up into regional or national programmes, or to provide a laboratory for national pilot programmes on the urban level.

Cities serve as policy laboratories for action on climate change.

Urban governments are taking serious action on climate change – even in the absence of national policies – through local regulations, urban services, programme administration, city purchasing and property management and convening of local stakeholders. While some local and regional governments have taken action independently, others have benefited from guidance provided by networks of local governments, such as the Nottingham Declaration in the United Kingdom, and transnational networks such as ICLEI – Local Governments for Sustainability and the EU Covenant of Mayors. Activities involving government-owned property or operations are common, in part because cities have direct control over them – examples include many cities' purchase of hybrid or alternative fuel vehicles and improving the energy efficiency of street and traffic lights (*e.g.* Los Angeles and Graz, Austria). Important opportunities exist where cities are service providers (water services system in Melbourne, capture of methane gas from landfills for energy in Toronto and Monterrey, and use of district heating in Copenhagen, Stockholm and Mannheim). However, cities generally are still reluctant to make full use of their regulatory authority to achieve climate goals, with the notable exceptions of Barcelona's Solar Thermal Ordinance and San Francisco's recent introduction of mandatory recycling.

Systematic, multi-sectoral strategic planning is required to exploit synergies between climate and other urban policy goals

Effective climate policy packages seek policy complementarities among and within urban sectors to implement policies that enhance each other's effectiveness.

For example, land-use zoning policies that allow for higher densities and greater mixing of residential and commercial uses can enhance transportation climate goals by reducing trip distances and frequency while strategic mass transit linkages can attract development and thus promote compact growth. Long-term growth plans in a number of OECD metropolitan areas aim to maximise such complementarities (*e.g.* Paris, New York, London). Important opportunities exist to develop and exploit adaptation and mitigation win-wins. For example, natural resource policies to increase vegetation and green space can reduce emissions and reduce the impacts of heat extremes and flooding (*e.g.* São Paulo's development of linear parks along urban waterways). Within the transportation sector, policies to increase the quality and availability of public transport facilitate the application of policies to discourage or restrict personal vehicle travel (*e.g.* coupling congestion fees and bus service improvements in London). Energy efficiency standards for new buildings are well complemented by projects to retrofit existing buildings with energy efficiency technologies, with models including Berlin's innovative model for contracting with private companies to meet efficiency targets and Toronto's Mayor's Tower Renewal programme.

Successful policies for compact cities rely on strategic urban plans.

Policies to increase the density of urban areas in the long term and manage outward expansion have gained popularity across many OECD countries, particularly in the Netherlands, United Kingdom and Japan, which has initiated an "Eco-Compact City" policy. While the higher residential densities targeted by these policies have the most direct effect on greenhouse gas emissions, transportation linkages – particularly between employment centres and residential zones – are crucial to ensuring that increases in density translate into reductions in personal vehicle use. Increasing the mix of land uses in urban neighbourhoods also reduces travel distances between home, work, and activities and can also promote non-motorised travel. High quality urban services and amenities, including open space, are also crucial to the long-term attractiveness and effectiveness of compact cities' policies. Tools to assess costs and benefits and conduct cost-effectiveness planning also play a key role in strategic planning.

Long-term strategic planning needs to take into account interaction between urban development and vulnerabilities to climate change.

Cities and urban planning provide a key entry point to act on the adaptation agenda and reduce vulnerabilities. However, adaptation is made difficult by the fact that modifications to urban infrastructure and the built environment may be expensive, especially if not designed up front. Vulnerability to storm and hurricane risks can be reduced through spatial planning and land management, but land-use changes occur over decades and urban buildings typically last 50 to 100 years, if not longer. As a consequence, urban adaptation options often must be anticipated by at least decades to be effective. Vulnerability assessment models, developed by some cities (*e.g.* Washington DC, United States) are essential but they remain costly and require scientific expertise that may not be available to urban governments. Current adaptation efforts are challenged by the uncertainty about the nature of future climate change impacts, especially given that adaptation costs are immediate while benefits are delayed and based on present assumptions of climate impacts. Thus a risk management strategy that has both near and longer-term co-benefits is likely to be most attractive given inevitable resource constraints.

Integrating climate priorities into the urban policy-making process and improving inter-municipal and regional co-ordination can overcome barriers to effective local action

Climate priorities still need to be integrated in each stage of the urban policy-making process: agenda setting, policy design, implementation and policy evaluation.

While city leaders have begun to incorporate climate change mitigation priorities into city policy agendas, driven by the social, environmental and economic potential benefits of action, urban-level adaptation strategies are rare and need greater attention. The policy design stage represents an opportunity to use cities' roles as enablers of non-governmental action to involve individuals and the private sector in climate policy design. However, urban climate policies are often developed outside of an integrated urban planning framework, thereby favouring short-term responses and hampering long-term systematic approaches, such as those designed to address sprawl. Key barriers to climate integrated policies are a lack of appropriate climate governance institutions or necessary authority, insufficient expertise, and a lack of funding or central government support. Relatively few urban climate policy evaluations have been conducted, and measuring progress remains a challenge for many cities, although innovative approaches such as the greenhouse gas "speedometer" (Newcastle, Australia) provide models for monitoring of city emissions.

When climate policies spill over city borders, inter-municipal action is needed.

In many cases, the administrative structure of urban climate policy governance does not fall precisely within cities' actual boundaries, so that carbon-relevant functions, economic interchanges, flows of materials and energy, and transportation between activities and households in the city's core area and localities overlap across multiple municipalities. The task of co-operation with other local governments is often made challenging by an absence of regulatory frameworks to guide inter-municipal initiatives. Metropolitan regions that provide models of successful climate policy co-ordination among municipalities (London, United Kingdom; Hanover, Germany; Portland, Oregon, United States) are endowed with an inter-municipal collaborative framework or benefit from technical infrastructure that transcends city borders.

Regional approaches to climate change mitigation and adaptation can broaden the impact of urban actions.

At the regional level, greater technical and financial capacity, and environmental know-how may exist than within individual cities or towns. Regions can also develop strategies that can link policies and programmes that would otherwise operate in isolation (*e.g.* connecting initiatives in urban and rural areas). By achieving levels of scale not possible at the local level, regional strategies have the potential to make larger reductions to greenhouse gas emissions. Thus, whereas an individual city might be able to think of ways to improve energy efficiency in housing within existing structures, at the regional level it may be possible to consider urban planning strategies that will result in not only more efficient housing designs and standards, but also consider where houses are built and their relationship to the regional environment. Regions can also come together to fund research and development (Eindhoven Region, the Netherlands) and enact infrastructural and technological changes necessary to "green" transportation structures and reduce emissions from transport through the introduction of low emission and alternative fuel vehicles (San Francisco Metropolitan Transport Commission).

Robust frameworks for multi-level governance and enabling national policies can advance climate action

There is no "one-size-fits-all" framework for effective national-local co-ordination.

Successful co-ordination can be driven from the top by national or regional authorities, grow from the bottom up as local policy innovations provide models for regional or national action, or feature a hybrid of both approaches. Nationally led "top-down" approaches do best when they leave wide latitude for local authorities to shape policies on climate change to fit local contexts. "Bottom-up" frameworks allow for experimentation on models for urban climate action that regional or national governments can subsequently adopt or promote. They can provide urban climate policy knowledge and governance capacity that complement and may even exceed those of regional or national governments. Hybrid approaches, in which national frameworks also include opportunities for local policy experimentation, may involve voluntary guidelines from national authorities towards cities or may include mechanisms for involving the private sector.

National governments play a key role in supporting and removing barriers to greater urban governance and enhancing cities' capacity to act on climate change issues.

They can empower local governments, leverage existing local policy experiments, accelerate policy responses and learning, foster resource mobilisation and help engage local stakeholders. Key roles include providing funding and technical assistance to cities and regions, such as in Finland and Sweden. Climate mandates in national urban and regional policies in Australia, Austria, Canada, the Czech Republic, France, Germany, Japan, Mexico and the United Kingdom, and in the Korean "Green New Deal", can advance local climate action. Strong national targets for adaptation and GHG emissions reductions can help prevent regional competition based on environmental regulations and even promote a "race to the top" through incentives, such as Japan's "Environment-Friendly Model City" award. Identifying national policies that conflict with or prevent local climate action, such as through a regulatory impact assessment process, is an important way national governments can improve their alignment with local climate policies.

National regional development frameworks need to more systematically integrate climate change policy goals.

Very few OECD countries are applying a "climate change lens" to the implementation of regional spatial or economic development policy framework. Instead, regional development policies are typically applied independently of national sectoral strategies to address climate change. Similarly, national climate change polices are being applied in many countries without regard to regional strengths and opportunities. Greater horizontal co-ordination between national regional development and national sectoral climate change policies is lacking in most countries. Japan, Korea and Sweden provide the best examples of cross-sectoral, holistic regional approaches to address climate change by national governments. Alignment of incentives across sectoral and cross-sectoral policy areas is required to deliver policy coherence.

Finance is an issue – greening local revenues and financing local green activities

Climate change puts additional pressure on cities' budgets.

It calls for changes in urban infrastructure investments and thus will create new challenges for urban finance. Cities will need additional revenue sources to finance costly new transportation systems, service improvements, building retrofits and protections for the built environment. Cities are now responsible for a range of sectors that impact environmental sustainability and greenhouse gas emissions, sometimes as the sole authority, but more often in partnership with other levels of government. For example, local governments in OECD countries are responsible for 70% of total public investment and amounts of public spending on environmental protection (which includes waste management, waste water management, pollution abatement, protection of biodiversity and landscapes, and research and development [R&D] on environmental protection), which is almost similar in amount to that of their respective national governments.

Local fiscal instruments and incentives at the disposal of cities could be "greened" to achieve urban sustainability goals, including climate change targets.

Local revenue sources are not neutral: their provenance, rates, exemptions and composition all impact the price citizens and firms pay for certain goods and services, such as urban transportation options, land development and housing. Currently, some sub-national taxes in certain countries promote sprawl. For example, compact housing options, such as multi-family rental housing in the United States, bear an effective tax rate that is considerably higher (18% in 2001) than the rate for single-family owner-occupied housing. Several cities in the world depend on land sales for a large part of their revenues, which also can create incentives for urban sprawl: the contribution of land sales to local revenue in Guangzhou (China) has been estimated to be 55% in 2006. There is room for greening sub-national taxes, especially those that have an impact on the city's built environment, transport and energy, such as property taxes and transportation taxes.

Cities and metropolitan areas could make more use of fees and charges as instruments to influence behaviour and thus mitigate climate change.

As they confront users with the real costs of their choices, these instruments could reduce the inefficient use of resources and limit sprawl. For example the congestion charge, applied in a growing number of cities, has proved effective in reducing congestion and reducing CO_2 emissions from transport (emissions reductions between 10% and 20% in London, Stockholm and Milan). Development charges and value-capture taxes, such as used in Miami, Milan and Bogotá, could finance the construction of new infrastructure needed to serve new suburban developments, whereas transport-related revenue sources (fuel taxes, congestion charges, parking fees) could charge for the use of the infrastructure. Congestion charges will arguably be more appropriate for those cities whose parking fees are already high. Fiscal disincentives for car use will be more effective when alternative traffic solutions, such as public transport, are in place, which is why some metropolitan areas, such as London, use these types of revenues to finance public transit.

Urban areas should leverage existing financial instruments and explore complementary new instruments.

The budget pressures caused by climate change might require cities to exploit available financial instruments, *e.g.* increased access to capital markets or carbon finance mechanisms. For example, increased access to capital markets could aid cities in seeking additional and complementary financing from carbon market mechanisms. Funding from the clean development mechanism (CDM) and the joint implementation mechanism – the two main Kyoto carbon offset instruments – currently provides a supplemental income stream through carbon offsets for projects that reduce cities' carbon emissions, such as landfill gas utilisation. Other CDM opportunities for the urban sector could be explored, including easily attainable targets for urban greenhouse gas sources related to urban transportation planning, urban forestry, street lighting, and waste energy used for transportation purposes; however, the CDM mechanism may need to be re-tooled to facilitate urban access to it.

National governments could play a key role in greening urban finance.

Their role could involve re-designing sub-national taxes and grants to sub-national governments, especially those that have an impact on the city's built environment, transport and energy. Re-design of sub-national taxation could include property tax reform to correct for biases towards unsustainable behaviour. For instance, property tax reform favouring compact development could be promoted through a split-rate property tax (Sydney; Hong Kong, China; Pittsburgh), differential taxation, a special area tax applied on suburban properties, or a set of cascading taxes that gradually increase as one moves away from the city centre towards the periphery (Austin). A relatively simple form of such a tax might be a higher standard property rate for suburban inhabitants or preferential rates for multiple dwellings (Denmark, Sweden). In addition, inter-governmental grants, such as those applied in Germany, Portugal and Brazil, could take environmental indicators into account to compensate local governments for the external benefits of their environmental expenditures. A comprehensive greening of urban finance would also increase the coherence between urban finance and urban planning frameworks to enhance urban sustainability and contain outward urban growth. Carbon taxes and climate change levies, although occasionally introduced at the local level (*e.g.* Boulder), may be more suitable instruments for the national or supra-national level rather than the city or regional level, as they could distort competition between regions.

National governments will need to create a sound institutional foundation and knowledge base to help local decision makers engage stakeholders and identify and carry out cost-effective actions

National governments have the opportunity to help cities fully engage the broad range of stakeholders and develop the relevant tools needed to address climate change.

Local and regional governments often are able to address problems within their jurisdictions by responding with solutions that are within their legal and financial authority. Yet, often local governments are not provided with sufficient support from intermediate and national levels of government to perform at their fullest or to implement what is expected of them. Working with sub-national and national governments, as well as with the international community on the development of a number of tools could assist cities to be more effective. Relevant tools or support mechanisms include:

- **Harmonised greenhouse gas emission inventory and reporting protocols for cities** to allow them to monitor and compare progress in mitigating emissions, to assess cost-effectiveness of additional mitigation options and eventually to become active participants in international carbon markets.
- **Regional impact science and other policy relevant research programmes** to support the interface between expert information and local knowledge and promote local understanding of climate change risk and policy options – from assessment to management – for better mitigation and adaptation decision making.
- **Urban climate policy networks,** building on regular channels of communication among national planners and regional and local government officials as well as among local stakeholders and decision makers about targets, goals, strategies, and measures. An appropriate response to climate change needs to transcend a government-policy based approach to embrace governance mechanisms that harness the creativity and advice of civil society, from business and academia to community leaders. These are essential not only to enrich the policy development and implementation process but to optimise transparency in accountability and reporting.

A robust quantitative, evidence base is required to inform sound public policy development and implementation.

Climate change is becoming an increasingly important policy driver for regional and urban economic development policies. Currently, large information gaps remain related to inter-jurisdictional comparability, common indicators and metrics to measure progress. Front and centre is the need for an evidence base to enhance the ability to identify and diffuse best practices, not only at local scale but also in terms of how national and local government partners can work better together. Strengthening empirical evidence – including through improved local inventories of greenhouse gas emissions – will advance understanding about where climate change regional and urban development practices are performing well and why, and about how national policy frameworks enable or constrain performance at sub-national scales. Few cities worldwide have real knowledge of the impact of new development on their long-term fiscal condition. Introducing qualitative assessment in cost-benefit analyses – such as the performance-based planning approach in use in the San Francisco Bay Area, United States – can be challenging but an important input for decision making.

Introduction

Climate change is one of the most pressing issues of this century. World greenhouse gas emissions (greenhouse gas) have roughly doubled since the early 1970s, reaching about 42 gigatons CO_2 equivalent (Gt CO_2eq) in 2005 (IEA, 2009). Recent OECD and IEA work suggests that if we continue on the present high emission trajectory, global greenhouse gas emissions will increase by more than 50% by mid-century, causing world mean temperatures to rise 4 to 6° Celsius (°C) above pre-industrial levels by the end of the century and more in the long term (OECD, 2009; IEA, 2009). In addition, the planet's natural system to absorb carbon will peak by mid-century and then likely weaken, possibly making climate change much more acute (IPCC, 2007a). While there is significant uncertainty about the costs of inaction, it is generally agreed that failing to tackle climate change will have significant implications for the world economy (Stern, 2007; OECD, 2009). Among the most difficult challenges presented by climate change is the expected increase in the intensity of extreme weather events, including floods and droughts, more violent storms, more intense heat waves, and escalating conflict over food and water resources.

Action on climate change must be along two broad fronts to include both adaptation and mitigation simultaneously.[1] The earlier and more cost-effective our actions to mitigate greenhouse gas emissions, the more we can do to protect the climate and limit the risk of dangerous climate change over the medium and long term. Equally, the earlier we adapt, the more we can cost-effectively protect people and infrastructure from dangerous impacts of inevitable climate change (IPCC, 2007a; Stern, 2007; OECD, 2008; Nicholls *et al.*, 2008). Adaptation will necessarily be more local than mitigation, as to be effective it will need to be tailored to local and regional contexts that drive vulnerability and adaptive capacity (IPCC, 2007b; Fuessel, 2007; Moser, 2009). There will inevitably be a long time lag between mitigation and avoided climate change so some amount of change is inevitable in the coming decades and beyond. Thus mitigation and adaptation are complementary policies and will need to advance in parallel across levels of government (Agrawala *et al.*, 2010; Fischer *et al.*, 2007; Fuessel, 2007).

Limiting long-term climate change will require broad international co-operation to reduce and reverse growing global emission trends of greenhouse gases (GHG). To date, more than 120 countries plus the European Union have associated themselves with the Copenhagen Accord, which was noted at the 15th Conference of the Parties to the UN Framework Convention on Climate Change.[2] The Accord recognises the scientific view that the increase in global mean temperatures should be kept to 2 °C or less. Implementing and going beyond the Copenhagen Accord pledges will require a broad set of policy instruments and actions across levels of government. If we want to meet the ambitious 2 °C long-term objective, existing policy frameworks will have to be strengthened and expanded. An essential component is to put a "price on carbon" so as to create market incentives to ensure that emissions are reduced first where it is cheapest to do so. OECD analysis stresses the importance of market-based mechanisms such as cap-and-trade systems, carbon tax, or both, as key elements of the national policy mix with cross-country linkages of carbon markets to help build a global carbon price (OECD, 2009). Market mechanisms are essential but insufficient on their own; they will need to be complemented by removal of subsidies to fossil fuel energy and increasing public and private investment in clean energy R&D. Moreover, as market imperfections (*e.g.* monitoring, enforcement, and asymmetric information problems) prevent some emitters from responding to price signals, complementary instruments will also be necessary, including standards (*e.g.* building codes, electrical appliance standards, diffusion of best practices) and information instruments (*e.g.* eco-labelling).

Cities have a key role to play in the global agenda for addressing the challenge of climate change. More than half of the world's population now lives in cities, a share that is expected to grow to two-thirds by 2050 (UNFPA, 2007; UN-HABITAT, 2009). As key engines of the global economy, cities are responsible for the bulk of national output, innovation and employment, and they constitute the key gateways of transnational capital flows and global supply chains (OECD, 2006; OECD, 2008). Accordingly, cities account for a great majority – between 60 to 80% – of worldwide energy use and account for a roughly equivalent share of global greenhouse emissions. Projections indicate that this trend will continue as urban populations grow. Cities can in principle use energy in a more efficient way than more dispersed areas because of reduced costs and economies of scale; however, this depends on urban design and form. Chapter 1 analyses the relationship between cities and climate change and shows that it is not cities, or urbanisation *per se*, that contribute to greenhouse gas emissions, but rather the way in which people move around the city, the sprawling growth patterns they adopt, the way in which people use energy at home and how buildings are heated and cooled that make cities the great consumers of energy and polluters that they are. Cities' emissions can thus vary greatly depending on lifestyles, spatial form, public transport availability and the sources of their energy.

Climate impacts specific to urban areas are discussed in Chapter 2. If urban growth and development patterns are contributing to the increase in GHG emissions, urban population and infrastructure is also increasingly at risk to detrimental effects of climate change. The fixed or long-term nature of urban infrastructure already in place, and the long lead times for planning new urban infrastructure, render it complex to address the impacts of rising temperatures and sea levels as well as changing precipitation patterns that climate change will bring, particularly given the uncertainties of local and regional climate predictions. Although it is well understood that climate change will have impacts on urban infrastructure and populations in developed and developing countries (Bicknell *et al.*, 2009; Wilbanks *et al.*, 2007), adaptation policies at the local level have lagged behind mitigation actions. Decisions are partly complicated by the "newness" of the adaptation challenge, and the lack of pre-existing networks of decision makers or institutions that operate at relevant scales across overlapping or co-located jurisdictions to address vulnerability to climate change (Cash *et al.*, 2006; Corfee-Morlot *et al.*, 2010; Moser, 2006 and 2009). Furthermore, a large share of the world's urban centres are located in low-lying coastal areas which are particularly vulnerable to storm surge and water-related calamities, increasing the risk to property, livelihoods and urban infrastructure (McGranahan *et al.*, 2007; Hanson *et al.*, 2010). Adapting to climate change will require significant public investment, for example, to address increases in the risk of flooding, storms, heat extremes, drought and water scarcity. Disruption in infrastructure systems can clearly create inefficiencies and cascading systemic effects, which in turn and will slow down economic progress, imposing costs on the local and national economy (Ruth, 2006; Hallegatte *et al.*, 2010). Inaction now will only further increase the costs of climate change damage, as well as the need for more costly adaptation measures in the future.

The benefits of implementing urban policies to tackle climate change are examined in Chapter 3. For example, analysis conducted for this study shows that the traditionally perceived trade-off between economic growth and achieving mitigation objectives observed at a macroeconomic level can be alleviated when urban policies, such as densification or congestion charges, are introduced. This is the result of a computable general equilibrium model (IMACLIM-R) that incorporates an urban module and draws on data from the *OECD Metropolitan Database*. Under a policy scenario where national emission reduction strategies are implemented, the aggregate mitigation costs can be reduced if economy-wide environmental policies are complemented by urban policies, such as congestion charges or increasing spatial density. This is due to complementarities with other policy objectives, such as lower local pollution and health benefits, and the enhancement of city attractiveness and competitiveness through lower local pollution levels. The chapter also discusses other types of local benefits of climate change policies, including quality of life, cost savings and increased efficiency, energy security, and infrastructure improvements.

How cities develop is part of the climate problem, but it can also be part of the solution. While the international community has been struggling to agree on common objectives and targets to fight global warming, a growing number of cities and regions have taken initiatives to reduce their energy use and GHG emissions and to begin to adapt to climate change. Cities and regions in many OECD countries have key responsibilities in the urban sectors that can provide valuable strategies for fighting and adapting to climate change, including policies that affect transportation and the built environment. With the help of strategic planning tools, policies on the local level can be a focus for complementary policy packages that bring together territorial strategies and sectoral policies. Chapter 4 reviews policy tools to address climate change at the local level in the sectors of land-use zoning, natural resources, transportation, building, waste and water. The question of effective urban policy packages intersects with the concept of urban density, a major driver of CO_2 and N_2O emissions. This chapter also assesses different characteristics of densification policies and their effectiveness in meeting environmental goals whilst ensuring that cities remain attractive in the long term.

Environmental policies that do not also support growth will not be sustainable over the long term. Chapter 5 discusses the role of cities in contributing to a new global green growth model at a time when governments must reduce their carbon footprint while pursuing economic growth and job creation. The chapter highlights the main policy areas through which city and regional governments can contribute to green growth objectives, including developing and maintaining green public infrastructure, improving the eco-efficiency of production, boosting demand by fostering the greening of consumption preferences and facilitating green innovation. Although tools for assessing the effectiveness of such policies in reaching their objectives of job creation and output growth need to be developed, the chapter provides an analytical framework that can orient future research on this crucial issue.

As cities and national governments cannot act alone to effectively tackle climate change, a framework for understanding the linkages across multiple levels of government and with the private sector and non-governmental stakeholders is needed. Chapter 6 proposes a multi-level governance framework that explores these linkages between national, regional and local policies to address climate change. Such a framework identifies vertical governance between different levels of government, as well as horizontal governance across multiple sectors at the same government level, as well as with non-governmental actors. It considers the question of "what is good practice?" in the areas of multi-level governance and climate change.

Each stage of the local policy-making process presents an opportunity to incorporate climate change priorities, agenda setting, policy design, implementation and policy evaluation. Chapter 7 discusses these opportunities, and the issues for horizontal co-ordination they raise. Co-ordination across city departments as well as across municipalities in the same metropolitan region is needed to implement climate policies cross-sectorally. Co-ordination among cities and surrounding municipalities is especially crucial given that many urban initiatives to mitigate and adapt to climate change require changes that are broader than just one city's jurisdiction. While some municipal governments have led the way on co-ordinating climate change policy at the metropolitan regional level, greater incentives and effective co-ordination mechanisms are needed. Regional initiatives can have a broader impact on climate priorities given their scale and potentially greater access to funding and technical expertise.

Multi-level governance is a critical issue for national governments, the large majority of which have agreed to work together to reduce greenhouse gas emissions and to adapt to inevitable climate change. Chapter 8 reviews local-national interactions and co-ordination in the development of climate policy, thus focusing on the vertical dimension of climate governance. A key issue for national policy makers is what they can do to empower cities to become more effective in the design and implementation of policies for mitigation and adaptation to climate change and to take advantage of the opportunities to learn from city-scale experimentation and action. These include policies driven from the top by national or regional governments as well as the bottom-up innovation of local policy approaches that can subsequently be scaled up to regional or national responses. A hybrid of the two frameworks provides top-down incentives and guidance while leaving room for city-level adaptation and innovation. In some cases, this includes partnerships within the private sector. Climate priorities also call on national governments to integrate mitigation and adaptation goals into national regional development policy frameworks, although only a few countries can provide successful models for climate-sensitive national regional policy.

Measures to reduce greenhouse gas emissions and adapt to expected climate change impacts will put additional pressure on city budgets and increase the need for additional public resources. Chapter 9 discusses opportunities to reform existing revenue sources as well as new forms of financing for urban climate change initiatives. A number of existing fiscal instruments and incentives already at cities' disposal, including taxes, fees and grants, could be considered as instruments for achieving climate change and urban sustainability goals. Carbon markets and access to financial capital may emerge as promising new funding sources, particularly if they are adapted to the multi-sectoral reality of urban development projects.

Looking ahead, new institutions are needed to enable national governments to facilitate capacity building and decision making at the local level. City authorities are also in a unique position to effectively engage local stakeholders and to design and implement locally tailored responses to climate change. Chapter 10 reviews key institutional priorities for greater engagement of local decision makers, the private sector and civil society stakeholders in developing local knowledge to address climate change. Key among these is the need to harmonise greenhouse gas emission inventory and reporting protocols to allow cities to monitor and compare progress in reducing emissions with other cities nationally and internationally. This is a key first step in enabling cities to participate in international carbon markets. In addition, regional science and policy networks would allow for the interchange between expert climate information and local knowledge of opportunities for reducing emissions and vulnerabilities to climate change. Finally, urban climate policy networks are considered as a means to provide a forum for national, regional and local officials, researchers, and stakeholders to establish a common understanding about targets, implementation strategies and monitoring.

Notes

1. The IPCC (2007b) defines adaptation as "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects". Mitigation means implementing policies to reduce greenhouse gas emissions and enhance carbon sinks.
2. As of May 2010, 42 industrialised (Annex I) countries have pledged quantified economy-wide emissions targets for 2020 and 36 developing and rapidly industrialising (non-Annex I) countries have pledged mitigation actions under the Copenhagen Accord. Collectively these pledges, if fully implemented, are estimated to reverse emission trends but to be insufficient on their own to put global emissions on pathway to limit average global temperature rise to 2 °C (OECD, 2009 and 2010).

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PART I

Trends

PART I

Chapter 1

Urbanisation, Economic Growth and Climate Change

This chapter analyses the relationship between cities and climate change and shows that it is not cities, nor urbanisation per se*, that contribute to greenhouse gas emissions, but rather the way in which people move around the city, the sprawling growth patterns they adopt, the way in which people use energy at home and how buildings are heated and cooled that make cities the great consumers of energy and polluters that they are. Cities' emissions can thus vary greatly depending on lifestyles, spatial form, public transport availability and the sources of their energy.*

Key points

Cities are major contributors of CO_2 emissions

- Roughly half of the world's population lives in urban areas, and cities consume a great majority – between 60 to 80% – of energy production worldwide and account for a roughly equivalent share of global CO_2 emissions. Greenhouse gas (GHG) emissions in OECD cities are increasingly driven less by industrial activities and more by the energy services required for lighting, heating and cooling, electronics use, and transport mobility.
- Growing urbanisation will lead to a significant increase in energy use and CO_2 emissions, particularly in non-OECD countries in Asia and Africa where urban energy use is shifting from CO_2-neutral energy sources, such as biomass and waste, to CO_2-intensive energy sources.

How cities grow and operate matters for energy demand and thus for greenhouse gas emissions

- Energy use and related CO_2 emissions are driven by how much energy is required to light, heat and cool buildings as well as to operate home appliances and office equipment, by how electricity is generated and by the energy used to move around the city and its peripheral areas.
- Urban density and spatial organisation are key factors that influence energy consumption, especially in the transportation and building sectors. Rapid urbanisation over the last half-century has been accompanied by urban sprawl, with urban land area doubling in the OECD and growing by a factor of five in the rest of the world. The expansion of built-up areas through suburbanisation is still growing in most OECD metropolitan areas.
- Increasing spatial density of urban development could significantly reduce energy use in urban areas and CO_2 emissions. Lower energy consumption is correlated with higher urban density.

Energy sources and technology choices also matter

- The greenhouse gas emissions impact of energy consumption depends not just on how much is consumed, but also on the energy source, and the mode of power production.
- Technology also matters: urban areas relying on inefficient or wasteful energy technologies contribute more greenhouse gas emissions than those that consume the same amount from more energy efficient sources.

There is an increasing recognition of cities and urban regions' role as key engines of economic growth, job creation and innovation – as well as their role as the major contributors to global warming. Higher concentrations of population are generally linked with higher energy use, which is one of the main drivers of greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2) emissions. This worldwide trend will only be reinforced as growing urbanisation – particularly in non-OECD countries – results in increased overall energy demand, and therefore increased GHG emissions. However, cities present great opportunities for reducing countries' contributions to climate change. In OECD countries, where urbanisation is already well advanced, the main drivers of GHG emissions are energy consumption patterns, including how people move around metropolitan regions and the amount of energy they consume for daily home and work activities. Urban density and spatial organisation are key factors that influence energy consumption, especially in the transportation and building sectors. This chapter discusses the relationships between urbanisation, economic concentration, energy use and GHG emissions in OECD countries and provides the main rationale for taking action at the urban scale: urban structure and form do matter for climate change.

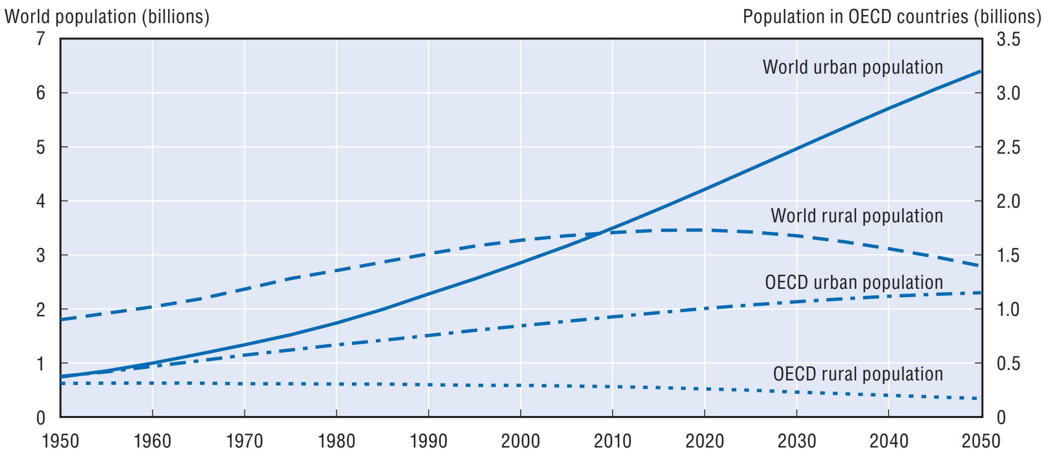
The worldwide urbanisation process

Urbanisation is a global phenomenon and is expected to continue for decades to come (OECD, 2006; UN, 2008). According to the United Nations, roughly half of the world's population lives in urban areas,[1] and this share is increasing over time, projected to reach 60% by 2030 (Figure 1.1). However, although urbanisation growth within the OECD is still ongoing, most of the urban population growth up to 2030 will occur in developing countries (Figure 1.2). Developing countries are projected to have urban growth rates roughly double those of OECD countries in the 2005-30 timeframe (UN, 2008). China, for instance, which is already the largest urban nation in the world, will see its current urban population rising from 600 to 900 million by 2030. As of 2015, the newly added urban population will be larger than the total population of many OECD countries, such as Germany, Japan, Mexico and France (Kamal-Chaoui in OECD, 2008a). Though the pace of urban growth will be highest in smaller towns and cities in countries in Africa and Asia, the proportion of the world's population living in so-called megacities, or urban centres with more than 10 million people, is also predicted to rise to 12% in 2025, from about 9% today, and the number of megacities will rise from 19 to 27 (UN, 2008).

World urbanisation trends are now catching up with the transformations that have already taken place in OECD countries over the last century. OECD countries have already experienced urbanisation: by 1950, urban populations in the OECD were greater than rural

Figure 1.1. **Urban and rural population in the world and the OECD**

Absolute population numbers

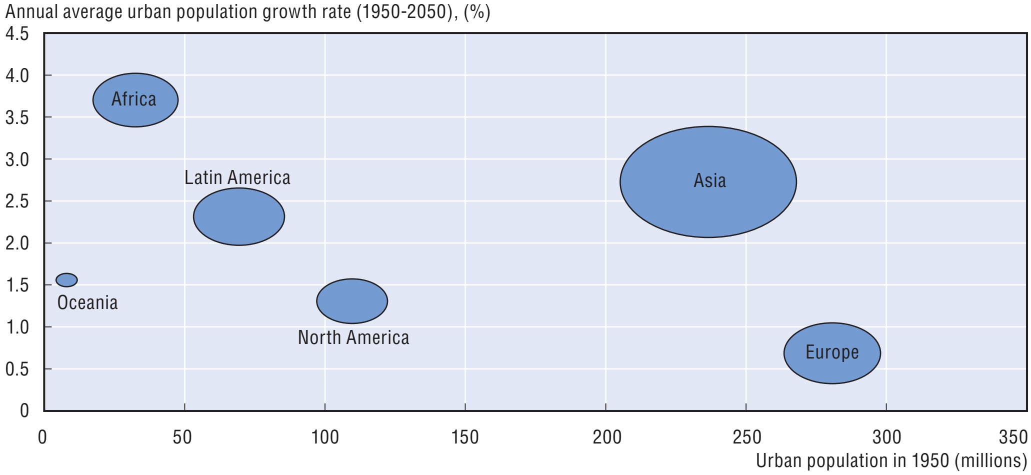


Source: Own calculations based on data from the *UN Population Database* (2009).

StatLink http://dx.doi.org/10.1787/888932341974

Figure 1.2. **Trends in urbanisation by continent**

Urban population and growth (1950-2050)



Notes: Urban areas are defined according to the *UN Population Database* which takes into account each country's own definition of urban. Bubble size depicts population size in 2010.

Source: Own calculations based on *UN Population Database* (2009).

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populations (Figure 1.1). That same milestone occurred in the global urban population in 2006. In many ways, OECD countries have been coping for more than half a century with the challenges brought about by an increasing urban population. If global urbanisation in the first half of the 20th century took place predominantly in European cities, population size has made Asia the continent with the highest urban population in the world today (Figure 1.2). Africa is also experiencing significant transformations, as it is home to some of the fastest-growing cities. The UN forecasts a decline in rural population after 2020, while among OECD countries the rural population has shrunk throughout the second half of the 20th century. The UN expects urban population to grow steadily both worldwide and in OECD countries (albeit at a slower pace). By 2050, 70% of the world's population – and 86% of the population in OECD countries – will live in urban areas.

There is no agreed-upon definition of an urban area; therefore a number of methods exist to analyse trends in urban areas. In this report, three units of analysis referring to urban areas are used:

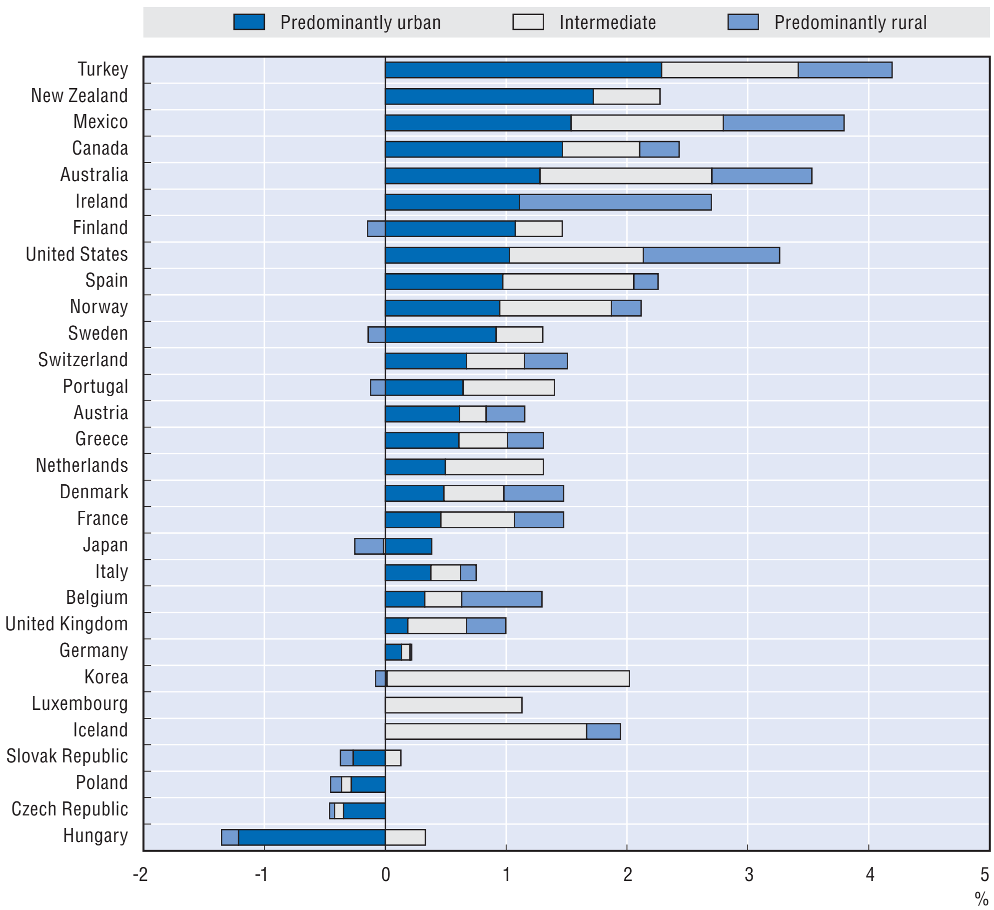
- **Urban areas.** These refer to urban areas as they are defined by the national authorities of each country. Data are often made readily available by national statistical institutes based on a single-county or municipality-level unit of analysis. However, often these urban areas are too small or too large to account for cities. This definition is used in particular when referring to UN data.
- **Predominantly urban areas.** These are defined using the OECD regional typology and employed throughout this report. They are regions where the population living in high-density areas (150 inhabitants per km^2) represents at least half of the population in that region. Although predominantly urban areas are also based on administrative areas, they are larger than a single municipality. The OECD has been able to produce comparisons across regions and countries using predominantly urban areas, but they remain too large for medium-sized cities in some cases and too small for metropolitan areas.

- **Metropolitan areas (functional areas).** These refer to commuting areas as defined in the *OECD Metropolitan Database*, which takes into account population density, net commuting rates and type of region. These are typically large cities comprised of a number of administrative and adjacent areas where economic relations are intense. Metropolitan areas are typically defined as concentrations of population and economic activity that constitute functional economic areas covering a large number of authorities (OECD, 2006).

In the OECD, urbanisation is on the increase in almost every country. Taking into account predominantly urban areas in the OECD as defined by the OECD regional typology,[2] today more than 53% of the total population is living in urban areas; this number rises to almost 83% if we include intermediate regions,[3] less densely populated areas characterised by systems of medium-sized cities. Over 1995-2005, population growth in OECD countries has been more dynamic in predominantly urban areas and intermediate areas than in predominantly rural areas. Only two countries (Belgium and Ireland) show stronger demographic expansion in predominantly rural areas (Figure 1.3). What is more,

Figure 1.3. **Population growth in OECD regions**

Annual population growth rates by type of region (1995-2005)



Notes: In some cases like Korea, intermediate regions' growth can be accounted by for growth in cities of a smaller size in wider areas that are considered to be intermediate. For instance Gyeonggi-do is an intermediate region that surrounds the Seoul area almost entirely; given that there has been considerable business growth outside the administrative area of Seoul after the deconcentration policy, it is possible that part of that growth has gone to Seoul's suburbs located in Gyeonggi-do.

Source: Own calculations based on data from the *OECD Regional Database*.

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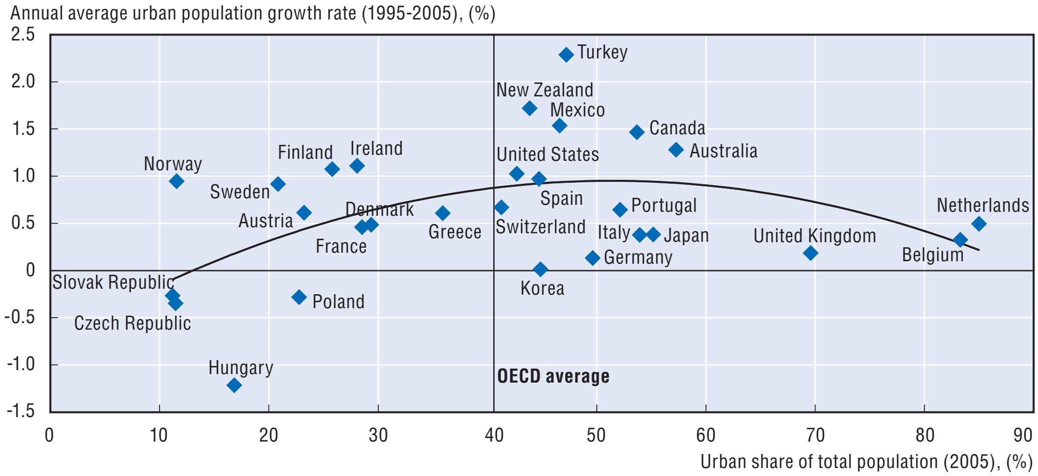
with a few exceptions in Eastern European countries, all OECD member countries have had positive urbanisation growth rates between 1995 and 2005. If predominantly urban areas are taken into account, all countries with urbanisation shares higher than the OECD average are becoming increasingly urbanised (Figure 1.4, see quadrant 1 located above right). As a result, the OECD population is becoming increasingly concentrated in a few places (Figures 1.5, 1.6 and 1.7).

Over 70% of people in the OECD who live in predominantly urban areas are in areas of more than 1.5 million people. In fact, urban populations locate increasingly according to city size. Thus, the share of total urban population living in smaller cities (between

Figure 1.4. **Urbanisation in OECD countries**

Urbanisation levels and growth according to predominantly urban areas (1995-2005)



Notes: Urban share of total population by country refers to population in predominantly urban regions as a proportion of total population. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban regions in those countries.

Source: Own calculations based on data from the *OECD Regional Database*.

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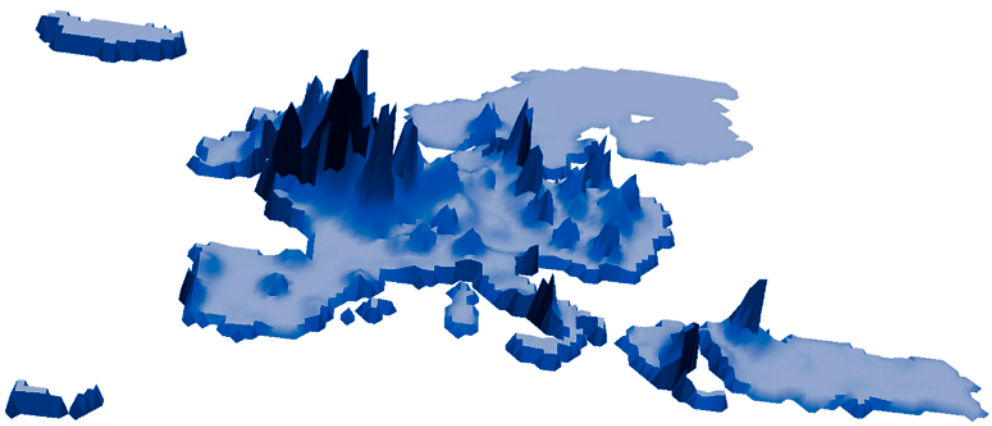
Figure 1.5. **Urban concentration in Europe**

Population density at TL3 level (inhabitants per km^2) in European countries (2005)

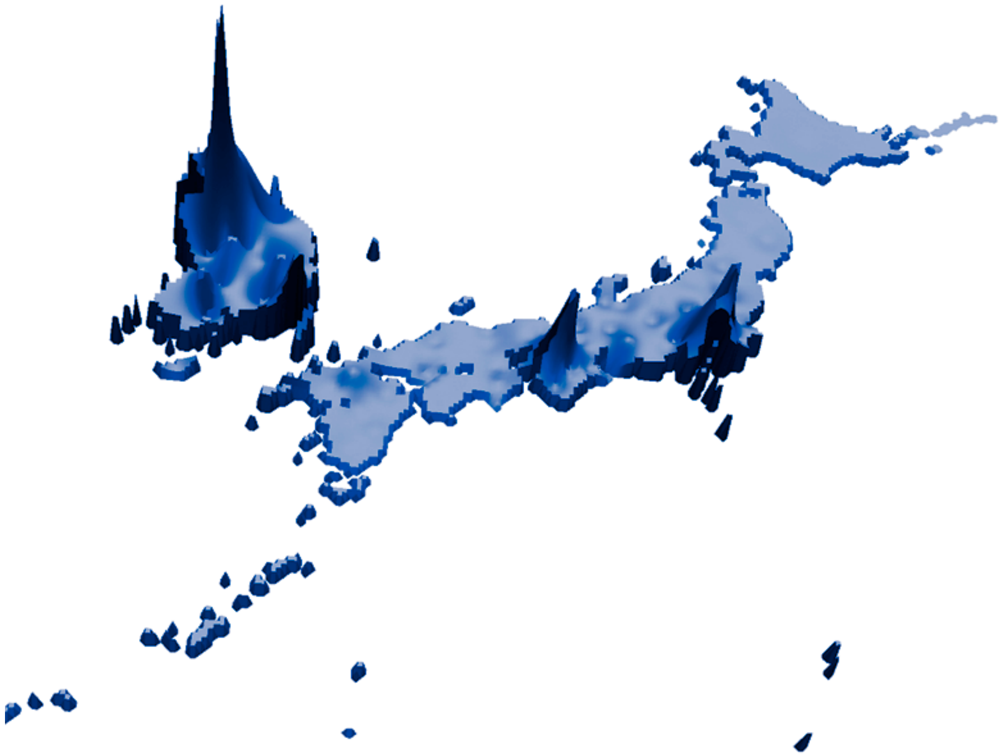


Note: OECD regions are classified at two levels: Territorial Level 2 (TL2) and Territorial Level 3 (TL3).

Source: Own calculations based on data from the *OECD Regional Database*.

Figure 1.6. **Urban concentration in Asian OECD countries**

Population density at TL3 level (inhabitants per km^2) in Japan and Korea (2005)



Note: OECD regions are classified at two levels: Territorial Level 2 (TL2) and Territorial Level 3 (TL3).

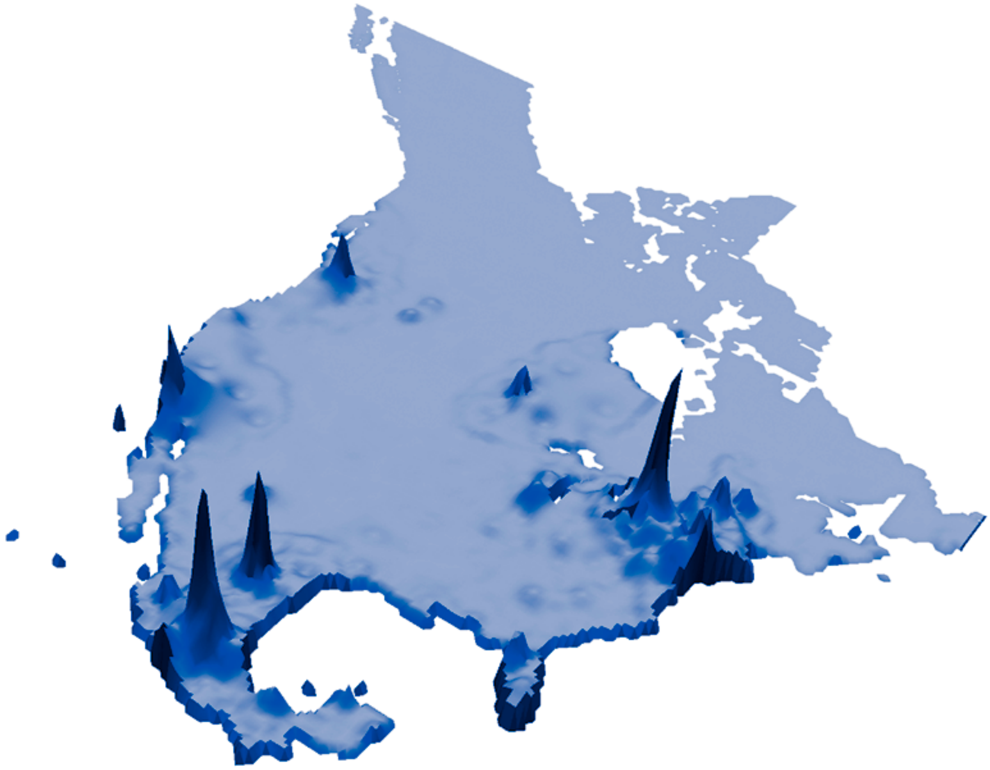
Source: Own calculations based on data from the *OECD Regional Database*.

100 000 and 500 000 people) is lower than the population living in any other type of city, and smaller cities also grow more slowly (0.4% annually on average). Medium-sized cities (between 500 000 and 1 million people) grow faster than smaller cities but more slowly than larger cities (Figure 1.8).

Trends among metropolitan regions in the OECD show similar results. In some cases, a single metropolitan region accounts for nearly half of the national population. Seoul, Randstad and Copenhagen represent between 44 and 48% of their respective national populations. With a few exceptions, namely Berlin, Manchester, Cleveland, Birmingham, Budapest and Pittsburgh, metropolitan areas in the OECD have experienced an increase in population between 1995 and 2005 (Figure 1.9). On average, OECD metropolitan areas have been growing at an annual pace of almost 1% since 1995, but cities such as Phoenix, Atlanta and Toronto have observed growth rates several times the average and in many others such as Ankara, Miami, Guadalajara and Washington, metropolitan population expansion has grown at least twice as fast as the average. Madrid, Seoul, Sydney and Mexico City also have experience above-average population increases.

Figure 1.7. **Urban concentration in North America**

Population density at TL3 level (inhabitants per km^2, 2005)



Note: OECD regions are classified at two levels: Territorial Level 2 (TL2) and Territorial Level 3 (TL3).

Source: Own calculations based on the *OECD Regional Database*.

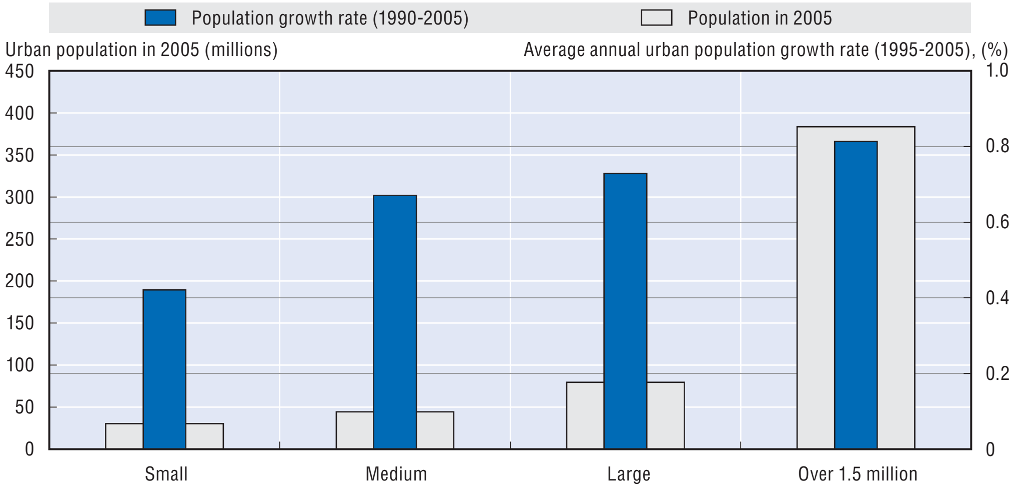
Cities and economic concentration

Urban areas are home not only to concentrations of people, but also to economic density and productivity. This is often the reason for a pooled labour market that increases the possibility of skills-matching between workers and firms. Firms also agglomerate, seeking to reduce risks of contract defaulting, as they have access to a wider set of skills and can establish linkages with suppliers and buyers. Cities are also often where knowledge spillovers take place, benefiting not only the city but also the wider regional area. Thus, in approximately half of OECD countries, more than 40% of the national GDP is produced in less than 10% of all regions, which account for a small share of the country's total surface and a high share of the country's population (OECD, 2009a).

Urbanisation is part of the development process and is generally associated with higher income and productivity levels. In OECD countries, higher urban population shares are associated in most cases with higher per capita GDP than their national average (Figure 1.10). In part, such higher per capita GDP can be attributed to metropolitan areas. In many OECD countries, one single metropolitan area produces one-third (*e.g.* Oslo, Auckland, Prague, Tokyo, Stockholm, London, Paris) to one-half (*e.g.* Budapest, Seoul, Copenhagen, Dublin, Helsinki, Brussels) of the national GDP (Figure 1.11). Thanks to the benefits of agglomeration economies, most OECD metropolitan regions with more than 1.5 million inhabitants feature a higher GDP per capita, a higher labour productivity and

Figure 1.8. **Urbanisation and city size**

Urban population and growth according to population size of predominantly urban areas (1995-2005)



Notes: This analysis was carried out using only predominantly urban areas. Small cities are predominantly urban areas with populations between 100 000 and 500 000 people. Medium-sized cities are predominantly urban areas with populations between 500 000 and 1 million people. Large cities are predominantly urban areas with populations between 1 and 1.5 million people.

Source: Own calculations based on the *OECD Regional Database*.

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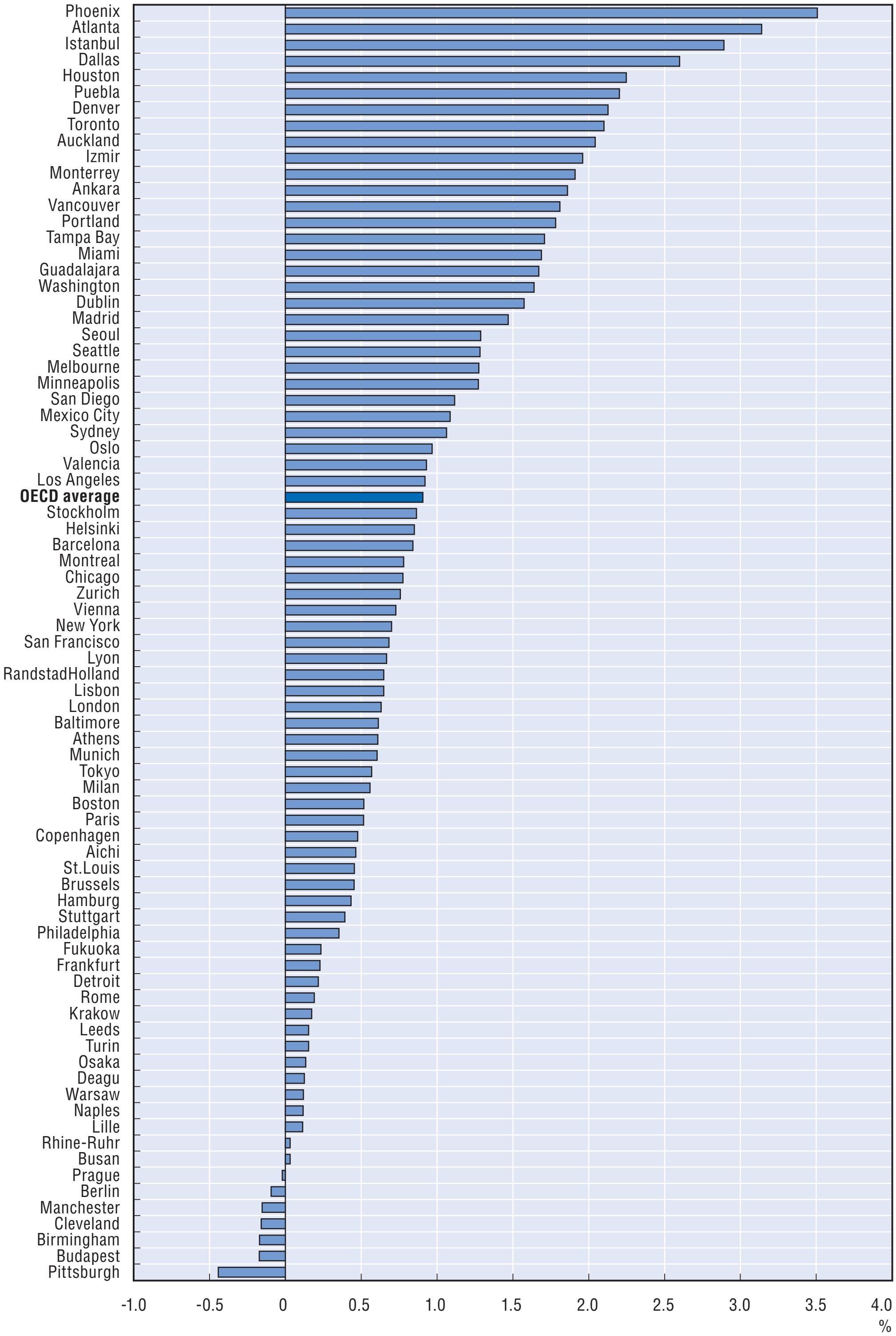
higher employment levels than their national average. Disaggregating GDP into four main factors reveals that, for the most part, higher income in metropolitan areas can be attributed to higher labour productivity levels (Figure 1.11).

However, the effect of labour productivity can be nuanced – or aggravated – by demographic or labour-market factors. In particular, the size of the pooled labour market (working-age population as a proportion of total population) and the way in which labour markets function (depicted for instance by employment rates) are important factors in determining how GDP in metropolitan areas diverges from the national level. Their effect is such that most metropolitan areas are probably held back by labour market-productivity relationships. The highest GDP levels relative to national GDP can be found in metropolitan regions, such as Warsaw, Monterrey, Washington DC and Paris, due to a great extent to labour productivity. Metropolitan regions, however, can also be held back by poorer performance – when compared to the national level – in labour market indicators such as participation rates. The size of the labour market is thus a relevant factor in determining agglomeration and performance of metropolitan regions. At the other end of the ranking, metropolitan regions with below-national-average GDP levels, such as Daegu, Naples or Berlin, are lagging behind precisely due to lingering productivity, participation and employment rates, and are only marginally helped by demographics (Figure 1.11). However, mid-ranking metropolitan regions, such as Chicago, Hamburg or Puebla, are mostly being held back by the size of the labour market.

Trends in urbanisation and population concentration are closely linked with concentration of economic activities and production (OECD, 2009b). Concentration of population in predominantly urban regions has also produced economic agglomeration. For instance, in Europe, economic activity concentrates around population centres (Figure 1.12). In Japan and Korea, economic density is evident in Osaka, Seoul and Tokyo

Figure 1.9. **Population growth in OECD metropolitan areas**

Average annual growth rates (1995-2005)



Note: The period of growth in the case of Auckland is 1996-2005.

Source: Own calculations based on data from the *OECD Metropolitan Database*.

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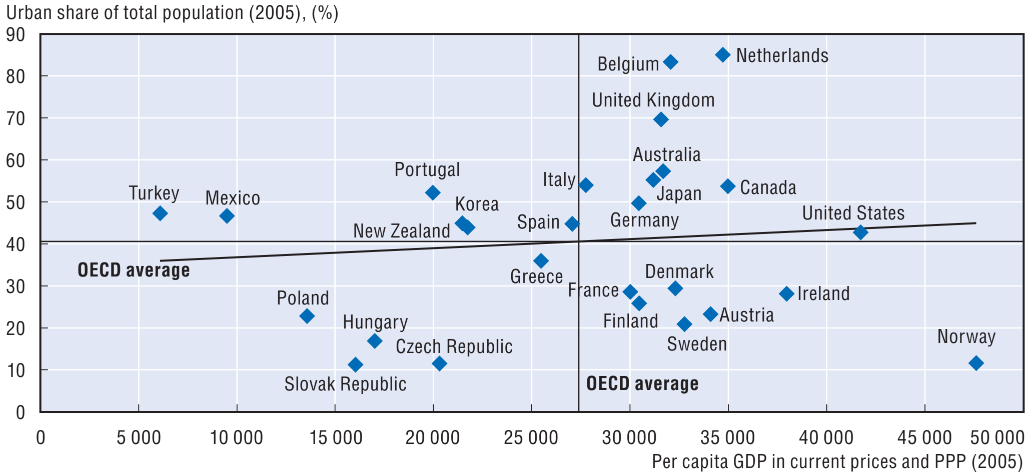
Figure 1.10. **Urbanisation and income**

Urban share of total population and per capita GDP in OECD countries



Notes: Urban share of total population by country refers to population in predominantly urban regions as a proportion of total population. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* does not identify predominantly urban regions in those countries. Switzerland was not included as GDP figures at sub-national level in that country are not available. Mexico's per capita GDP data refer to 2004; New Zealand's per capita GDP data refer to 2003; Turkey's per capita GDP data refer to 2001.

Source: Own calculations based on data from the *OECD Regional Database*.

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(Figure 1.13). Such agglomeration effects are fuelled by higher wages that can be paid due to higher productivity levels that in turn attract more workers so that centripetal forces are set in motion.

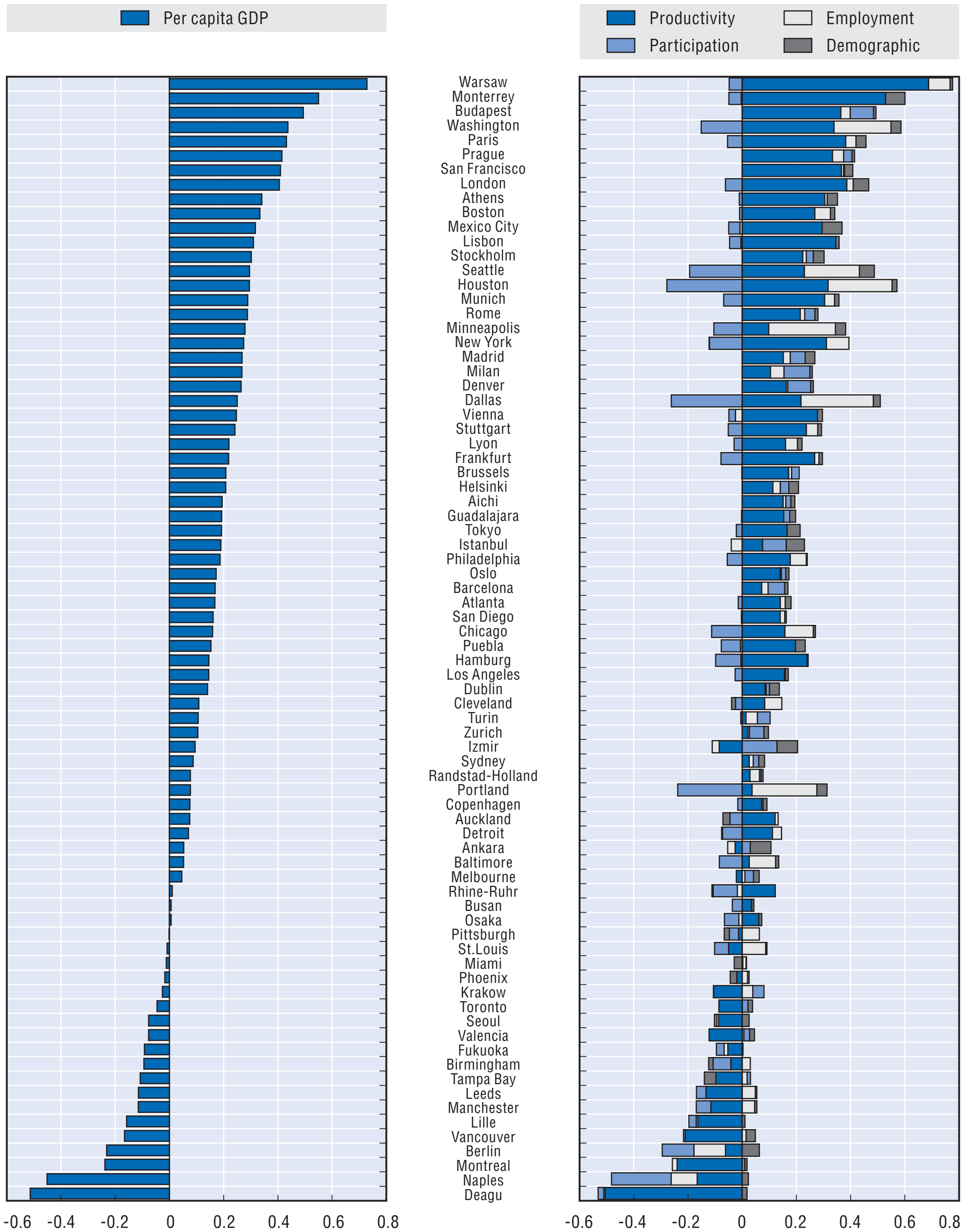
However, the benefits associated with economies of agglomeration are not unlimited. Cities can reach a point where they no longer provide external economies and become less competitive (OECD, 2009b). One of the main explanations of such mixed outcomes is linked with the existence of negative externalities, including congestion and other environmental costs such as high carbon-intensities and/or high vulnerability to climate change (these can be thought of as centrifugal forces). Negative externalities associated with large concentrations in urban areas raise the question of whether the costs borne by society as a whole are becoming unsustainable. As externalities, these negative attributes are not internalised by firms and households, and may only show up as direct costs in the long term. They include, for instance, high transportation costs (*i.e.* congested streets) and loss of productivity due long commuting times, higher health costs, higher carbon emissions and environmental degradation. Taking into account the costs and the benefits of agglomeration, it has been argued that urban concentration may entail a "privatisation of benefits and socialisation of costs" (OECD, 2009a).

Economic growth, energy use and greenhouse gas emissions

Cities use a significant proportion of the world's energy demand. Cities worldwide account for an increasingly large proportion of global energy use and CO_2 emissions. Although detailed harmonised data are not available at the urban scale, a recent IEA analysis estimates that 60-80% of world energy use currently emanates from cities (IEA, 2008a). This can be attributed, in part, to changes occurring in urban areas in emerging and developing countries, including increased economic activity. As countries urbanise, they tend to shift from

Figure 1.11. **Factors determining per capita GDP differentials**

Labour productivity, employment and participation rates, demographic factors among OECD metropolitan regions with respect to their national average (2005)



Notes: Per capita GDP can be disaggregated into four components: productivity, employment, participation and demographic. The demographic component represents the size of the pooled labour market of each metropolitan region compared to the national average. Labour market pool is calculated as the proportion of the working-age population over the total population. Australia, Germany and US data refer to 2004; New Zealand data refer to 2003; Switzerland data refer to 2002; Turkey and Mexico data refer to 2000.

Source: OECD Metropolitan Database (2009).

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Figure 1.12. **Economic concentration in Europe**

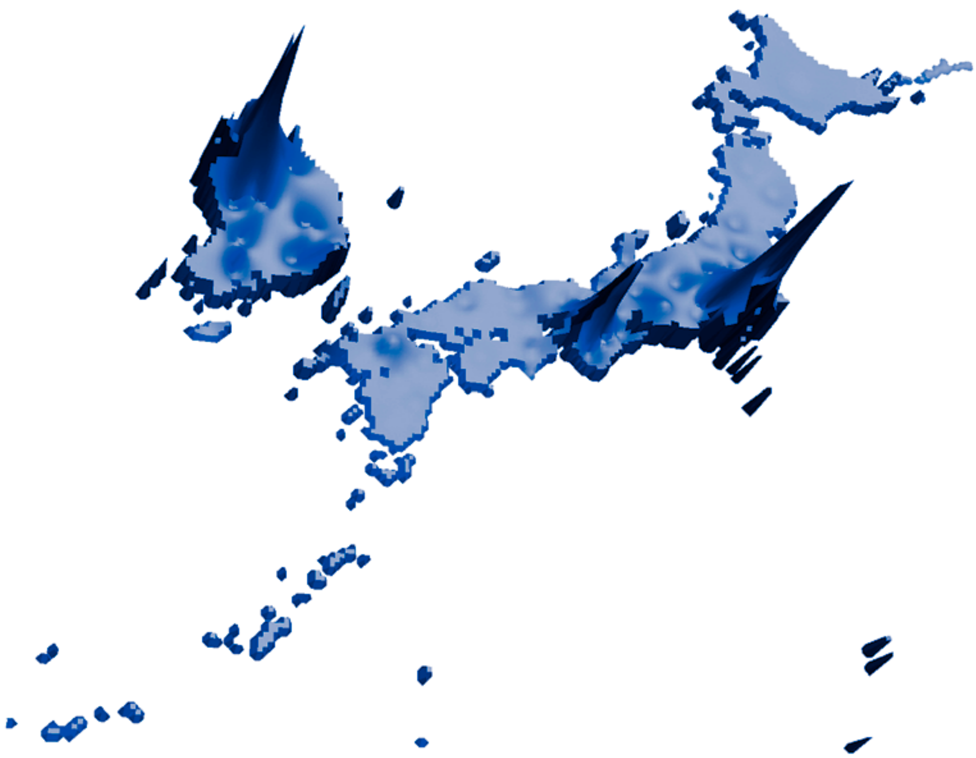
Economic density at TL3 level (GDP per km^2, 2005)

Note: OECD regions are classified at two levels: Territorial Level 2 (TL2) and Territorial Level 3 (TL3).

Source: Own calculations based on data from the *OECD Regional Database*.

Figure 1.13. **Economic concentration in Japan and Korea**

Economic density at TL3 level (GDP per km^2, 2005)



Note: OECD regions are classified at two levels: Territorial Level 2 (TL2) and Territorial Level 3 (TL3).

Source: Own calculations based on data from the *OECD Regional Database*.

CO_2-neutral energy sources (biomass and waste) to CO_2-intensive energy sources, leading to an increasing proportion of CO_2 emissions from cities (Jollands in OECD, 2008a). Cities (including towns) currently use over two-thirds of the world's energy, an estimated 7 900 Mtoe in 2006, even though they only account for approximately 50% of the world's population.

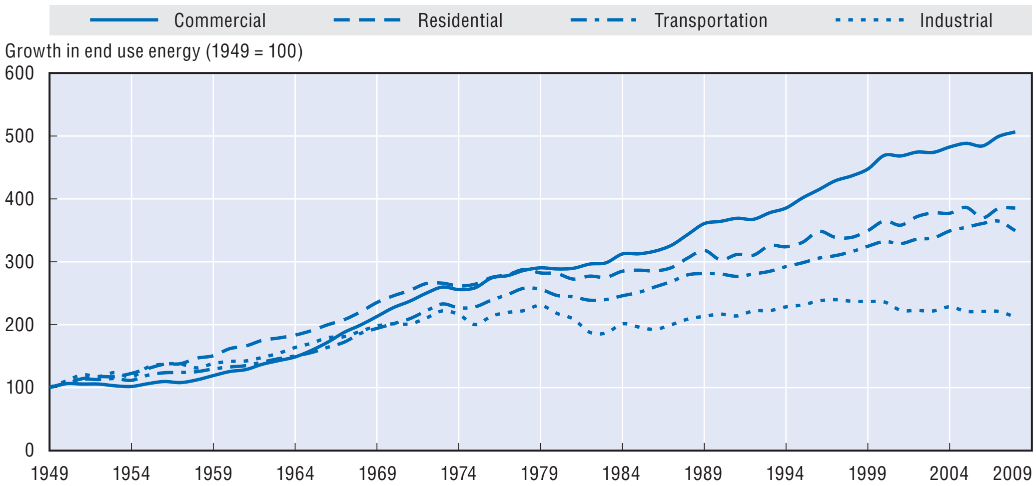
Projections indicate that cities are likely to increase their share in the total world energy consumption. By 2030, cities are expected to account for more than 60% of the world's population and 73% of the world's energy use, or more than 12 400 Mtoe in energy (IEA, 2008a). Of the global energy use projected by 2030, 81% is expected to come from non-OECD countries. US cities will likely account for 87% of US energy consumption in 2030, compared with 80% in 2006. Urban areas in the European Union will likely account for 75% of EU energy consumption, up from 69% in 2006. Cities in Australia could experience an increase from 78% to 80% of national energy consumption during the 2006 to 2030 period, and Chinese cities could account for 83% of national energy consumption compared with 80% today (IEA, 2007).

Cities contribute to climate change in three main ways: through direct emissions of GHGs that occur within city boundaries; through the GHG emissions that originate outside of city boundaries but are embodied in civil infrastructure and urban energy consumption; and through city-induced changes to the earth's atmospheric chemistry and surface albedo.

- **Direct GHG emissions** include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions from energy conversion, CH_4 emissions from the landfill decomposition of municipal solid waste, CH_4 and N_2O from anaerobic decomposition and nitrification-denitrification of nitrogen during wastewater treatment, CO_2 emissions from waste incineration, fluorocarbon (HFC, PFC) and sulfur hexafluoride (SF_6) emissions from refrigerants, semiconductor manufacturing and insulators, and CO_2 and N_2O emissions from rural-urban land conversion.
- **Embodied GHG emissions** include GHG emissions embedded in the energy required to produce the concrete, steel, glass, and other materials used in civil infrastructure, the CH_4 and N_2O emissions used to provide the food consumed by urban residents, and the CO_2, CH_4 and N_2O emissions from rural power plants and refineries that generate energy for urban consumption.
- **Changes to atmospheric chemistry and surface albedo** include the direct and indirect GHGs that result from changes in atmospheric composition and surface reflectivity. For instance, the IPCC estimates that tropospheric ozone (O_3), a secondary pollutant commonly found in cities, is the third most important GHG behind CO_2 and CH_4 (IPCC, 2007). Carbon monoxide (CO), an indirect GHG produced predominantly from mobile sources in cities,[4] lengthens the atmospheric residence time of CH_4.

Although cities' impact on the earth's climate is diverse and complex, GHG emissions from direct energy use increasingly account for the bulk of cities' climate impact in OECD countries. In other words, GHG emissions in OECD cities are increasingly driven by the energy services required for lighting, heating and cooling, appliance use, electronics use, and mobility. Industrial energy use and GHG emissions (including GHG emissions embodied in building materials) appear to have become less significant. In the US, for instance, industry's share of total energy use fell from a peak of 48.4% in 1955 to a low of 31.4% in 2008,[5] and growth in industrial energy use has essentially remained flat since the late 1970s (Figure 1.14). The importance of energy use as a source of GHG emissions is more obvious; fossil fuel energy systems accounted for an estimated 85% of US GHG emissions in 2007 (EPA, 2009).[6, 7]

Figure 1.14. **US energy consumption by sector (1949-2008)**



Source: OECD, based on US Energy Information Administration (2009), "Energy Consumption by Sector", *Annual Energy Review* 2008, Report No. DOE/EIA-0384, *www.eia.doe.gov/emeu/aer/consump.html*.

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There are three main categories of final urban energy use: electricity, thermal energy, and transportation energy. These three forms of energy are not exclusive (Table 1.1). Electricity is used to a limited extent for water and space heating, and to a lesser but increasing extent for transportation. Oil, predominantly used as a feedstock for transportation fuels, is also used sparingly for electricity generation and heating. For the purpose of matching goals with appropriate strategies, it is important to keep these different types of uses in mind. Energy efficiency that reduces electricity demand, for instance, does not directly reduce exposure to oil price volatility because so little oil is used to generate electricity. The intensity of energy demand at certain periods, known as peak demand, may also be stronger in cities, which in theory could reduce opportunities to make use of renewable energies. However, in practice, this is not a significant obstacle to renewable energy production because of new technologies that can manage loads.

Table 1.1. **Categories of urban energy use**

Type	Main energy sources (% total)	Main use
Electricity	Coal (41%), nuclear (27%), natural gas (17%), oil (5%).[1]	Lights, appliances, electronics, industrial motors.
Thermal energy	Natural gas, oil, electricity (n.a.).[2]	Space heating, water heating, cooking, industrial process heat.
Transportation energy	Oil (97%).[3]	Vehicles, transit systems (mobility).

1. Percentages are for all OECD countries.
2. Thermal energy sources are difficult to isolate, but natural gas is typically the dominant source of space and water heating in OECD countries. In the US, for instance, natural gas accounted for 76% of residential and commercial primary energy consumption in 2008, most of which was for space and water heating.
3. Percentage is based on US data .There are no recent estimates for the composition of transportation energy use for OECD countries; we use the US as a proxy here, and argue that this percentage is representative of typical OECD countries.

Source: Percentages for electricity energy sources are from IEA (2007), *Key World Energy Statistics*, OECD, Paris. US sectoral data are from EIA website, "Energy Consumption by Sector", online at: *www.eia.doe.gov/emeu/aer/consump.html*.

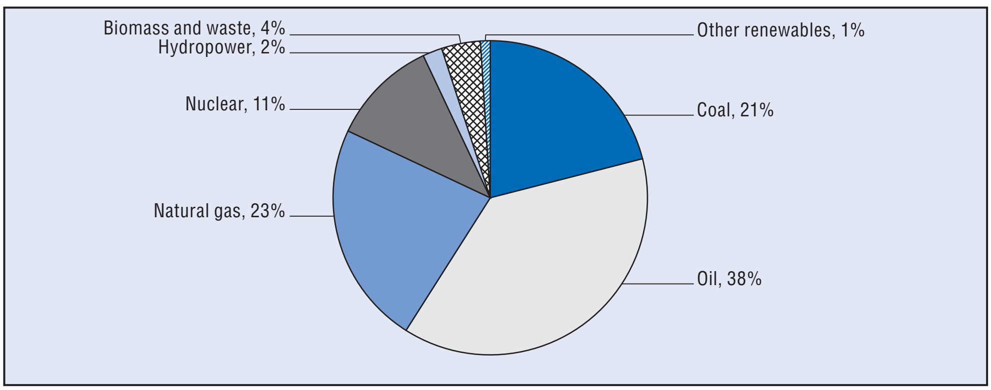
Many cities have undertaken inventories of their GHG emissions, but comparisons among cities are difficult. There is currently no single protocol ranking for assessing urban areas' per capita GHG or CO_2 emissions, making comparisons across cities impossible. Cities have taken different approaches in defining what sectors to include, in establishing the geographic boundaries of the area included, and have aggregated data in different ways. Additional urban GHG inventory differences include:

- different definitions of the urban area (*i.e.* by the larger metropolitan region, by city limits, or by another unit);
- choice of inventory years presented;
- inventory scope (*i.e.* whether or not more than city-owned operations are reported, and whether indirect emissions are included); and
- methodological issues.

Comparable GHG inventories and indicators at city-scale would be valuable because they would allow cities to manage emissions in their urban areas and enable national and international policy makers to properly target and assist city authorities to act (Chapter 10).

Energy consumption is often used as an indicator of GHG emissions generally, and CO_2 emissions in particular, but the relationship is not direct. Energy consumed in cities, be it in the form of electricity, oil or gas heat, or fuel, is produced from a variety sources, each with a different climate footprint (Figure 1.15). Some sources, such as hydropower, nuclear, solar, and wind energies produce no or minimal GHG emissions. Fossil fuel sources – coal, oil, and natural gas – do contribute to GHG emissions, but to different degrees; for example, coal contributes more GHG emissions in the power sector than natural gas (IEA, 2009). The efficiency of energy production is another determinant of the degree to which energy consumption contributes to GHG emission. Some energy is always lost between production and end use, but the amount lost (often dependent on infrastructure quality) varies greatly depending on the efficiency of production and quality of transmission infrastructure. Urban areas relying on inefficient or wasteful energy sources contribute more GHG emissions then than those that consume the same amount from more efficient sources. OECD countries face a challenge in moving to low-emissions urban energy production. In 2005, fossil fuels accounted for 83% of primary energy use in

Figure 1.15. **Total energy consumption in OECD countries (2007)**



Source: IEA (2009), Energy Statistics Division historical data, © OECD/IEA, Paris.

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OECD countries. Renewable energy, alternatively, accounted for less than 5%. The shares of oil and natural gas in total primary energy consumption in OECD countries also illustrate the importance of thermal and transportation energy in OECD countries.

The impact of energy consumption on GHG emissions depends not just on the amount consumed, but also on the GHG intensity, or GHG emissions factor, of all the activities involved in processing and producing it. When total life-cycle emissions, such as resulting from the extraction, processing, and transporting of fossil fuels, were taken into account in an inventory of 10 large cities,[8] the intensity of GHG emissions was 7-24% greater than that for end-use activities only (including energy production and air and sea activities outside of city boundaries) (Table 1.2). For example, Cape Town's per capita electricity consumption is lower than that of Geneva, but the GHG intensity of its electricity supply is significantly higher, due to South Africa's use of coal for 92% of its electricity generation and Geneva's reliance on hydropower. Thus, an important distinction must be made between urban inventories that capture emissions from city energy consumption and those that capture total life-cycle emissions associated with a city's energy supply (Kennedy *et al.*, 2009).

Table 1.2. **Total GHG emissions, including end-use, life cycle, and within city measures, for ten world cities**

	Emissions within city[1]	Emissions from end-use activities[1, 2]	End-use emissions including life-cycle emissions for fuels[1, 2, 3]
Bangkok	4.8	10.7	Not determined
Barcelona	2.4	4.2	4.6
Cape Town	Not determined	11.6	Not determined
Denver	Not determined	21.5	24.3
Geneva	7.4	7.8	8.7
London	Not determined	9.6	10.5
Los Angeles	Not determined	13	15.5
New York City	Not determined	10.5	12.2
Prague	4.3	9.4	10.1
Toronto	8.2	11.6	14.4

1. Figures indicate global warming potential, expressed in carbon dioxide equivalents (t eq CO_2) per capita.
2. Includes activities occurring outside city boundaries (*e.g.* from power generation, air and marine activities).
3. Includes upstream emissions such as those caused by the extraction, processing, and transporting of fossil fuels.

Source: Kennedy, Christopher *et al.* (2009), "Greenhouse Gas Emissions from Global Cities", *Environmental Science and Technology*, Vol. 43, No. 19, American Chemical Society, Washington, US, pp. 7297-7302.

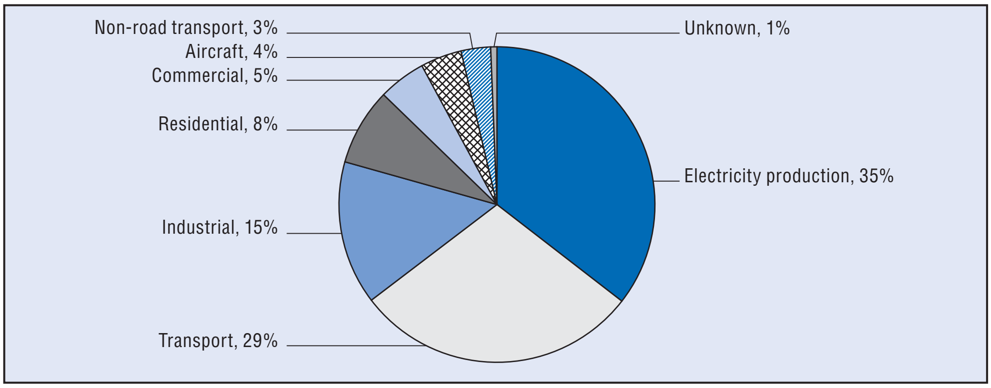
StatLink http://dx.doi.org/10.1787/888932342639

The urban form matters – the impact of sprawl

Energy use, and thus carbon emissions, are chiefly driven by how electricity is produced, the uses of such energy in households and the way in which people move around the city. Roughly two-thirds of all emissions in the United States come from electricity and road transport activities in urban and intermediate regions, with an additional one-quarter produced by industrial and residential uses (Figure 1.16). Predominantly urban regions home to the largest cities and intermediate regions that contain medium-sized cities are responsible for more than half of those emissions. They are also likely to be responsible for some emissions in rural areas, as consumers of electricity produced in rural regions. Therefore, policies that induce households to use energy more efficiently, including through building codes and policies that favour reduced commuting journeys and public transportation (*e.g.* spatial densification and congestion charges), might be useful in stimulating changes in the amount of carbon emissions.

Figure 1.16. **Carbon emissions in US cities**

Produced in predominantly urban areas by type of activity (2002)



Source: Own calculations based on data from the Vulcan Project (2009). The Vulcan Project is a NASA/DOE-funded effort under the North American Carbon Program (NACP) to quantify North American fossil fuel carbon dioxide (CO_2) emissions at space and time scales much finer than has been achieved in the past.

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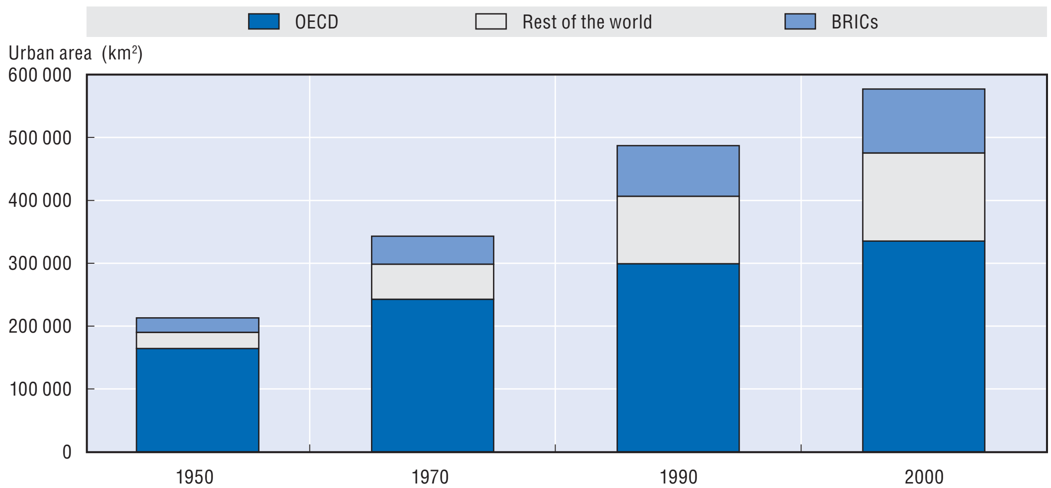
The form of urbanisation matters for energy demand and thus for GHG emissions. Population growth in OECD metropolitan areas has meant an expansion of developed areas through suburbanisation. Suburbanisation and urban sprawl has been important in the OECD, but has recently been more so for the rest of the world. Urban land area in the OECD has doubled in the second half of last century, but has experienced a fivefold increase over the same period in the rest of the world (Figure 1.17). In fact, in the vast majority of OECD metropolitan regions, the suburban belt grows faster than the core (Figure 1.18). In only 15% out of 78 metropolitan regions in the OECD, the core has seen population expansion increase faster than the suburbs. In a number of these cases, the core has benefited from both favourable economic conditions (*i.e.* lower land prices at the core) and/or intended policies in order to regain population at the core. For example, in Copenhagen, inner-city

Figure 1.17. **Urban sprawl**

Trends in urban land expansion in the world and the OECD



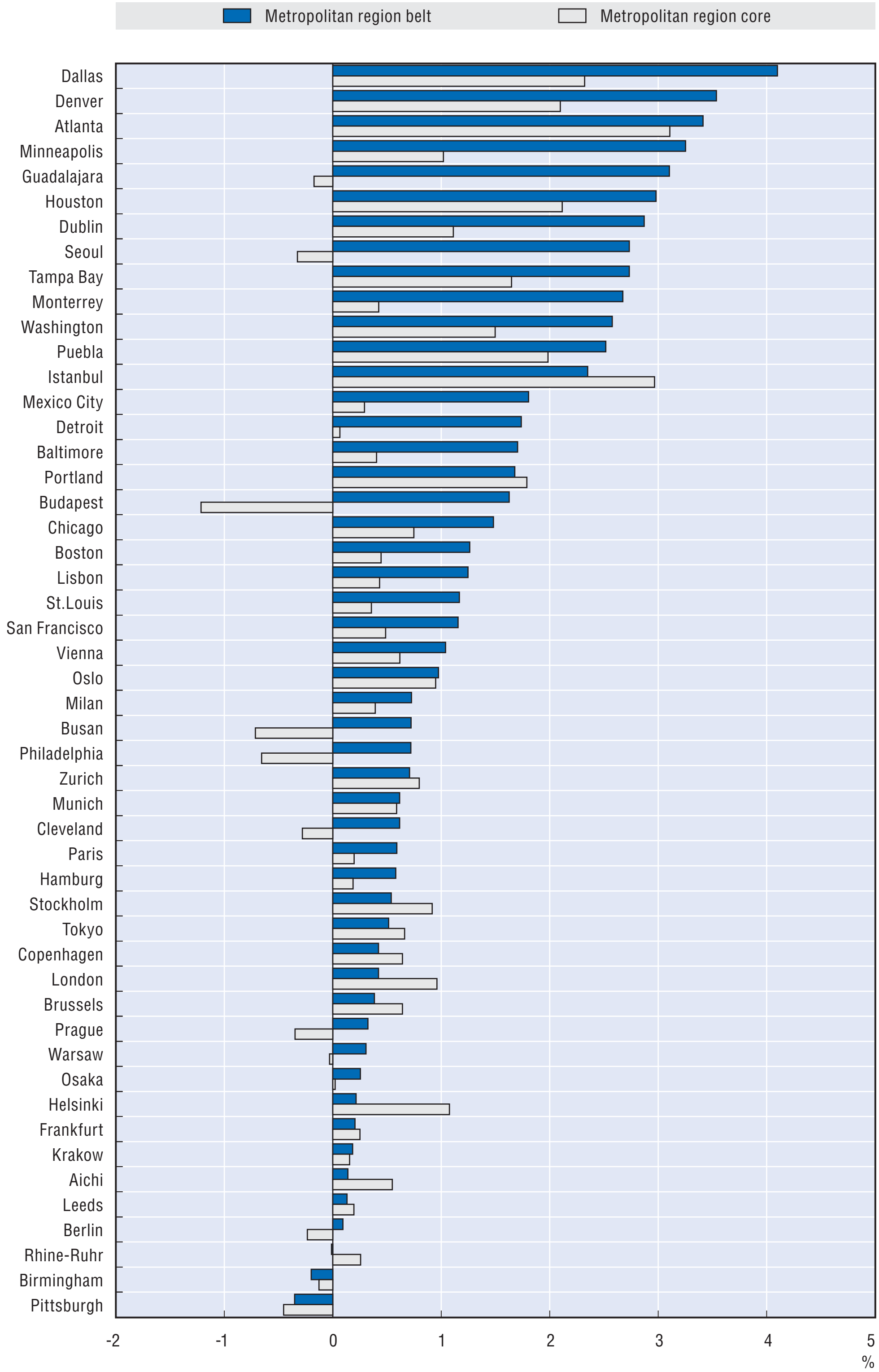
Note: BRIC countries refers to Brazil, Russian Federation, India and China.

Source: OECD (2008), *Environmental Outlook to 2030*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/888932342183

Figure 1.18. **Suburbanisation in OECD metropolitan regions**

Population growth in metropolitan region's core and belt compared (1995-2005)



Note: For US metropolitan regions, core-base counties were used to identify metropolitan statistical areas' cores.

Source: Own calculations based on data from the *OECD Metropolitan Regional Database*.

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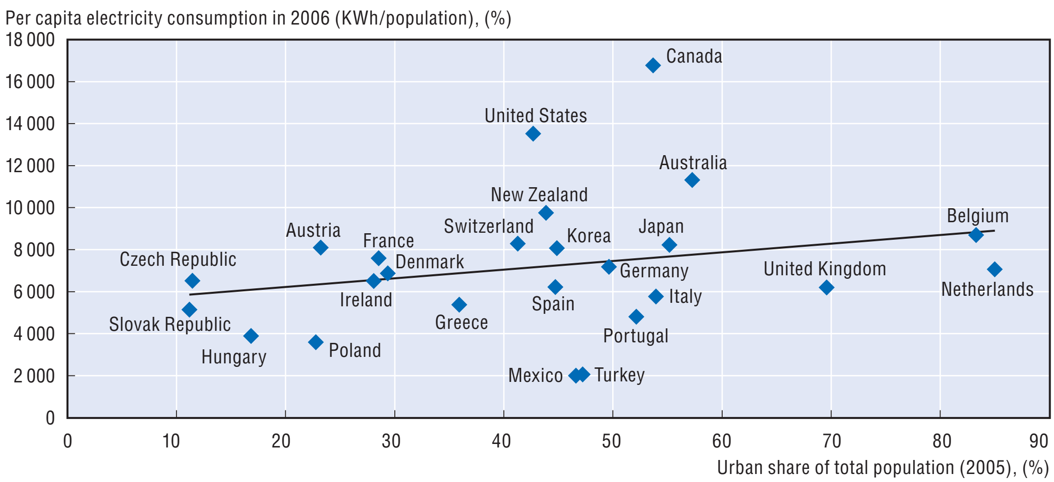
neighbourhoods have been improved through the 1997 *Kvarterloft* programme that promoted citizen and private-sector participation and the Urban Renewal Act of 1998. Both initiatives promoted quality of life in urban areas through densification, regeneration, and traffic and environmental planning (OECD, 2009c). In other cases, such as Tokyo, the process of gentrification coincided with a fall in housing prices in the urban core after the housing bubble burst in the early 1990s (An, 2008).

Increasing density could significantly reduce consumption of electricity in urban areas. Where increased urbanisation (estimated in terms of predominantly urban areas) has led not only to demographic and economic agglomeration, but also to higher levels of electricity demand, densification tends to decrease electricity demand. In general, the more urbanised a country becomes, the higher the demand for electricity (Figure 1.19). However, not all urban areas demand electricity in the same way and lifestyles in different cities can make a big difference. As density increases in urban areas, per capita electricity demand decreases (Figure 1.20). For instance, Japan's urban areas are around five times denser than Canada's, and the consumption of electricity per person in the former is around 40% that of the latter. If we take countries in the same geographical context with similar heating needs such as Denmark and Finland, the proportions are quite similar. Denmark's urban areas are denser than Finland's by a factor of four, and people there only consume around 40% of the electricity consumed by the Finns.

Not surprisingly, density emerges as a crucial element to reduce carbon emissions. Urbanisation greatly increases carbon emissions (Figure 1.21) Germany has almost twice the urban population of France, and German cities have twice the pollution levels as those in France. However, not all urban areas pollute equally. As density increases, CO_2 emissions from transport go down (Figure 1.22). Austria's urban areas are more than four times denser

Figure 1.19. **Urbanisation and electricity consumption**

Urban population shares and electricity consumption

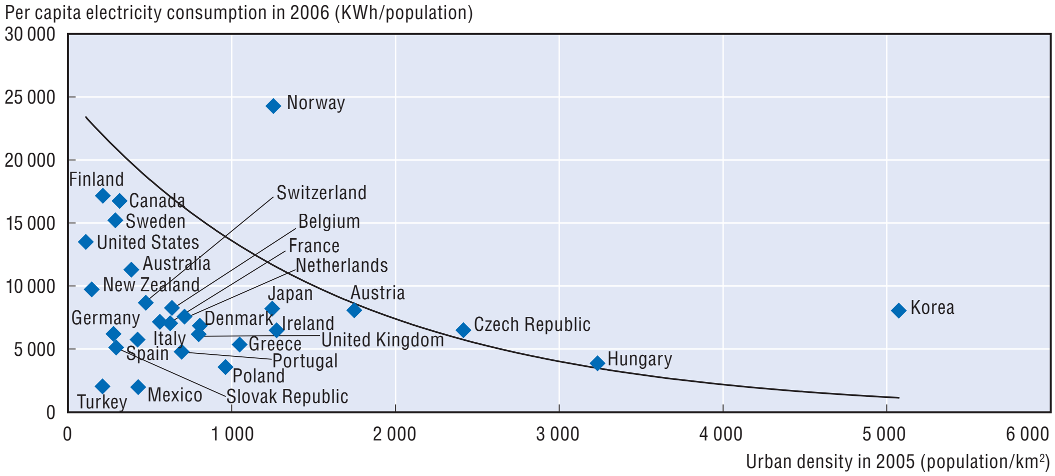


Notes: Urban shares were calculated on the basis of predominantly urban areas. Finland, Norway and Sweden were taken out of the sample since they were considered to be an outlier. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban areas in those countries.

Source: Own calculations based on data from the *OECD Regional Database* and IEA (2009), *Energy Balances in OECD Countries*, © OECD/IEA, Paris, p. 183.

StatLink http://dx.doi.org/10.1787/888932342221

Figure 1.20. **Urban density and electricity consumption**



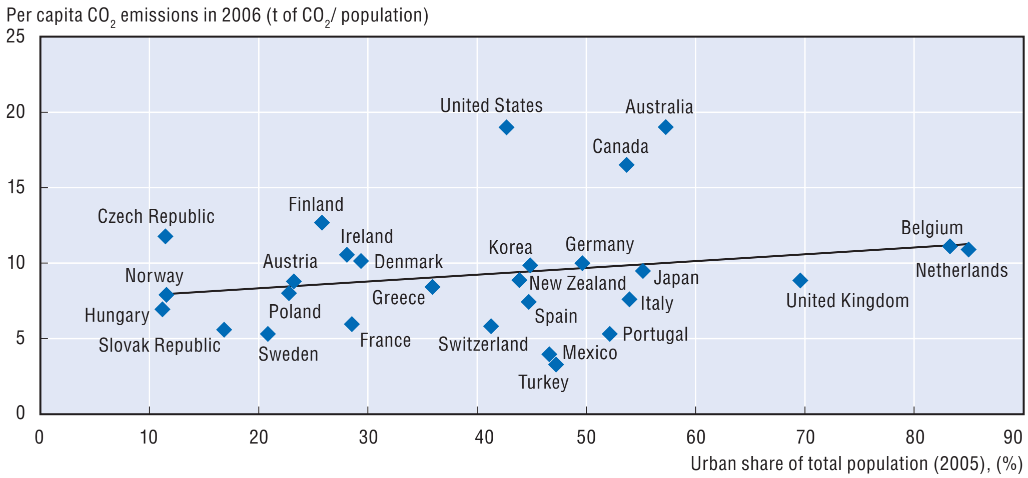
Notes: Urban density is calculated on the basis of predominantly urban areas. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban regions in those countries.

Source: Own calculations based on data from the *OECD Regional Database* and IEA (2009), *Energy Balances in OECD Countries*, © OECD/IEA, Paris, p. 183.

StatLink http://dx.doi.org/10.1787/888932342240

Figure 1.21. **Urbanisation and carbon emissions**

Urban population shares and CO_2 emissions



Notes: Urban shares were calculated on the basis of predominantly urban areas. Finland, Norway and Sweden were taken out of the sample as they were considered outliers. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban regions in those countries.

Source: Own calculations based on data from the *OECD Regional Database* and IEA (2008), *CO_2 Emissions from Fuel Combustion*, © OECD/IEA, Paris, pp. 37 and 49.

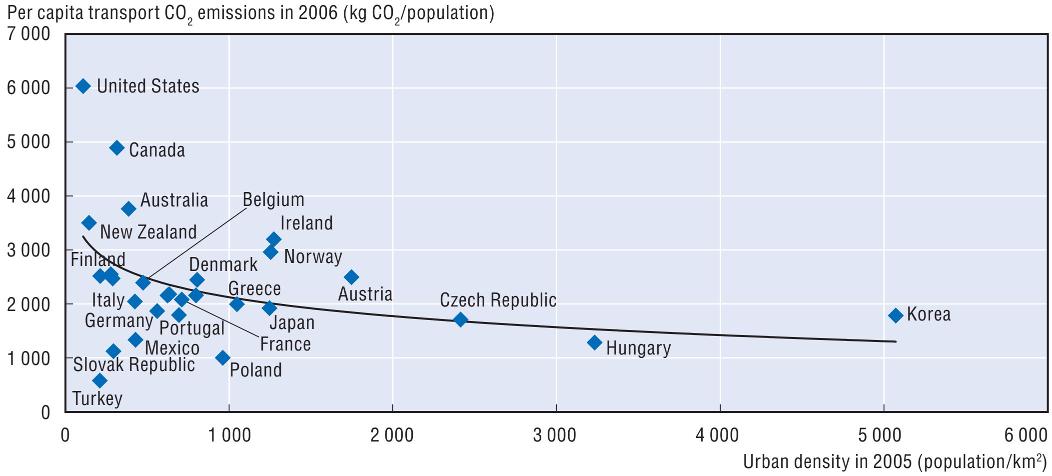
StatLink http://dx.doi.org/10.1787/888932342259

than Australia's, and generate only 60% of the amount of CO_2 emissions per capita that Australia's urban areas generate. Therefore, while urbanisation levels might bring about an expansion in carbon emissions, these are reduced with higher density (Figure 1.23).

Lifestyles, in particular the way in which people commute, are also crucial in the generation of CO_2. As urban areas become denser and rely more on public transport, carbon emissions are reduced. Not surprisingly, among OECD member countries, North American countries produce 50% more CO_2 emissions than the Europeans; while European countries

Figure 1.22. **Urban density and carbon emissions in transport**

Per capita carbon emissions produced by transport activities and urban density

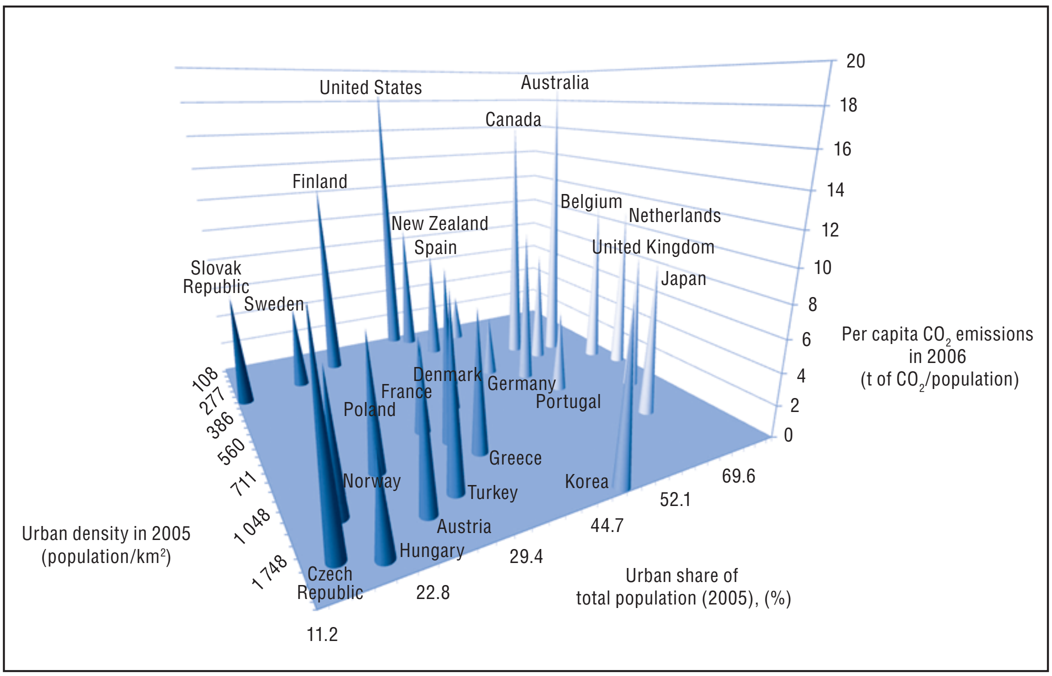


Notes: Urban density was calculated on the basis of predominantly urban areas. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban regions in those countries.

Source: Own calculations based on data from the *OECD Regional Database* and IEA (2008), *CO_2 Emissions from Fuel Combustion*, © OECD/IEA, Paris.

StatLink http://dx.doi.org/10.1787/888932342278

Figure 1.23. **Urbanisation, density and carbon emissions**



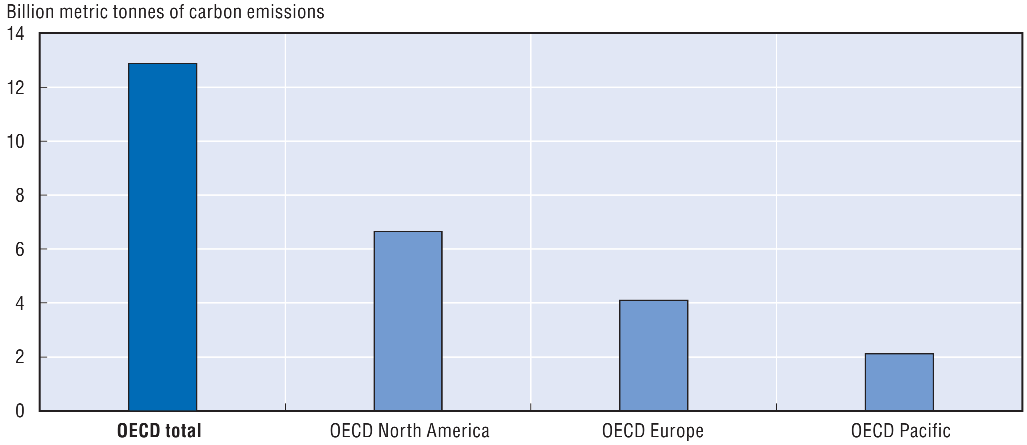
Notes: Urban density and urban share were calculated on the basis of predominantly urban areas. Iceland and Luxemburg were not included in the sample as the *OECD Regional Database* identifies no predominantly urban regions in those countries.

Source: Own calculations based on data from the *OECD Regional Database* and IEA (2008), *CO_2 Emissions from Fuel Combustion*, © OECD/IEA, Paris.

StatLink http://dx.doi.org/10.1787/888932342297

pollute twice as much as the Asian countries (Figure 1.24). Similarly, not all cities in the same country have the same lifestyles nor do they contribute to carbon emissions in the same way. Although the United States is the OECD country with the most flows of carbon emissions, internally cities like Los Angeles are noticeable for the concentration of CO_2 emissions (Figure 1.25). Even smaller cities like Houston produce much more CO_2 than New York – the largest city in the country. The Toronto region is one of the metropolitan regions in North America with the highest share of public transit (around 23% in 2006) only surpassed by New York. The public transit share of the Toronto region is comparable to those of many

Figure 1.24. **CO_2 emissions in the OECD**

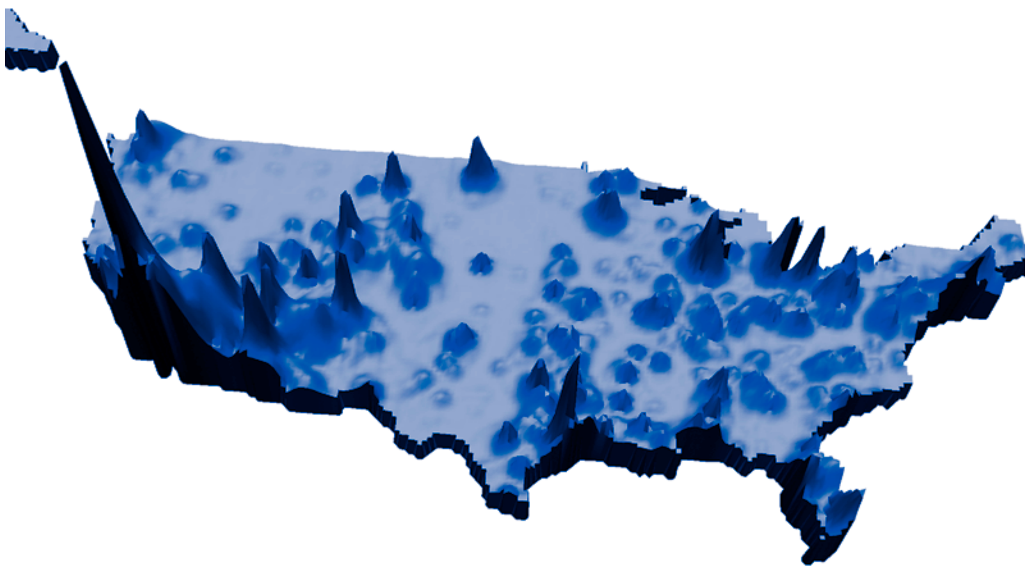


Source: IEA (2008), *2006 CO_2 Emissions at National Level*, *www.iea.org/Textbase/stats/index.asp*.

StatLink http://dx.doi.org/10.1787/888932342316

Figure 1.25. **Concentration of carbon emissions in the United States**

CO_2 emissions at county level (2002)



Source: Own calculations based on data from the Vulcan Project (2009) and the OECD typology of regions. The Vulcan Project is a NASA/DOE-funded effort under the North American Carbon Program (NACP) to quantify North American fossil fuel carbon dioxide (CO_2) emissions at space and time scales much finer than has been achieved in the past.

European metropolitan regions, such as London, Munich and Amsterdam, but falls well below public transit shares in Japanese cities like Tokyo. Despite the high use of public transit within the North American context, the Toronto region has one of the highest rates of car use among OECD metropolitan regions (71% in 2006) (OECD, 2009d). European metropolitan regions have been able to lower car use through a more extensive use of public transit, as well as development of other transportation modes including walking and cycling.

Notes

1. This refers to the population living in areas classified as urban according to the criteria used by each country (*UN Population Database*, 2009).
2. Throughout the document OECD definition of urban and rural refers to predominantly urban and predominantly rural regions. The former refers to regions in which the share of population living in rural local units is below 15%; the latter refers to regions in which the share of population living in rural local units is higher than 50%. In order to classify regions as predominantly urban or predominantly rural it is necessary to define local units within each region to their degree of rurality. A local unit is therefore rural if its density is lower than 150 inhabitants per km^2.
3. Intermediate regions are those with a share of population living in rural local units between 15% and 50%.
4. In the United States, for instance, the EPA reports that as much as 95% of the CO in typical cities comes from mobile sources. See *www.epa.gov/oms/invntory/overview/pollutants/carbonmon.htm*.
5. Energy Information Administration (EIA) website, "Energy Consumption by Sector". See *www.eia.doe.gov/emeu/aer/consump.html*.
6. This estimate was made by summing all emissions from coal, natural gas and petroleum extraction, distribution and conversion in the EPA's GHG emissions inventory.
7. The EPA GHG inventory includes CO_2, CH_4, N_2O, HFCs, PFCs and SF_6, but does not include gases whose radiative forcing properties are more uncertain, such as O_3. The IPCC estimates the radiative forcing of tropospheric O_3 at + 0.35 [–0.1, +0.3], which, at the high end would make tropospheric O_3 more important than CH_4 (IPCC, 2007). An increase in the importance of O_3 would not change the importance of energy systems; fossil fuel combustion accounts for about half of global NO_x emissions (Brasseur *et al.*, 2003), and NO_x is one of two precursors to tropospheric O_3 formation.
8. Bangkok, Barcelona, Cape Town, Denver, Geneva, London, Los Angeles, New York City, Prague and Toronto (Kennedy *et al.*, 2009).

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PART I

Chapter 2

Climate Change Impacts Specific to Urban Regions

This chapter discusses climate impacts specific to urban areas. If urban growth and development patterns are contributing to the increase in GHG emissions, urban population and infrastructure are also increasingly at risk to detrimental effects of climate change. The fixed or long term nature of urban infrastructure already in place, and the long lead times for planning new urban infrastructure, renders it complex to address the impacts of rising temperatures and sea levels as well as changing precipitation patterns that climate change will bring, particularly given the uncertainties of local and regional climate predictions. Furthermore, a large share of the world's urban centres are located in low-lying coastal areas which are particularly vulnerable to storm surge and water-related calamities, increasing the risk to property, livelihoods and urban infrastructure. Although it is well understood that climate change will have impacts on urban infrastructure and populations in developed and developing countries, adaptation policies at the local level have lagged behind mitigation actions.

Key points

Coastal cities are particularly vulnerable to climate change

- Many of the world's largest cities are located in coastal areas and this increases their vulnerability to rising sea levels and storm surge, presenting unprecedented risk to livelihoods, property, and urban infrastructure. Port cities most vulnerable to coastal flooding are located in both the most rapidly developing countries such as India and China (*e.g.* Kolkata, Shanghai, Guangzhou) and in wealthier countries such as the United States (*e.g.* Miami, New York City), the Netherlands (*e.g.* Rotterdam, Amsterdam) and Japan (*e.g.* Tokyo, Osaka), with the estimates of exposure and vulnerability varying depending upon the metric used (*i.e.* population or built infrastructure assets).

Cities and poor populations are particularly vulnerable

- Heat waves will be more intense in urban areas compared to rural areas due in part to urban heat island effects, which are exacerbated by large amounts of concrete and asphalt and excess heat from equipment such as air conditioning. Average annual temperatures tend to be 3.5 to 4.5 °C higher in cities than rural areas, and this difference is expected to increase by 1 °C per decade (up to a difference of 10 °C in large cities).
- Poor populations, often concentrated in cities in both rich and poor nations, are among the most vulnerable to climate change in part because they tend to settle in sub-standard housing and in more vulnerable areas, and because they lack the resources to quickly and effectively protect themselves from extreme weather patterns and shifting climatic conditions.

Rising sea levels, more extreme storms and flooding, and extreme heat events: just as cities and metropolitan regions contribute to climate change in specific ways, they are also vulnerable to potential climate change impacts in specific ways. Climate impacts will result from global climate change, but how climate change impacts individual metropolitan regions will vary. Some effects of climate change are reasonably predictable (*e.g.* melting of glaciers, changes in global mean temperatures), while others are not (*e.g.* frequency and magnitude of extreme weather events). In addition, many impacts, including sea level rise, heat waves, droughts, spread of invasive species and disease, will vary with local conditions. This chapter will assess urban-level impacts caused by storm events including coastal flooding and extreme precipitation, as well as heat extremes and urban heat island effects, and increased drought and water scarcity. Adaptation measures to address these potential impacts are often slow to develop, impeded by the uncertainty about the nature and timing of the impacts and the need for tailored regional and local analysis of specific contextual issues. Indeed climate change impacts will vary by metropolitan region due to many factors, including local geography, population size and composition, spatial development pattern, economic profile and degree of existing development among other factors (Hunt and Watkiss, 2010; Hallegatte and Corfee-Morlot, 2010). However, failure to adapt in a timely manner can increase the costs of climate change damage and as well as those of future adaptation measures.

Urban climate impacts and vulnerabilities

Certain characteristics particular to cities render them more vulnerable to climate change impacts than less-urbanised areas. Urban areas' dependency on complicated and extensive networks for transportation, communication and trade, the high density of built infrastructure and the existence of urban poor in often informal settlements, for example, are key factors raising their vulnerability to climate change, including extremes (Bicknell *et al.*, 2009; Wilbanks *et al.*, 2007). *Functioning* urban infrastructure and a healthy environment not only provide the urban population with the necessary structure for carrying out economic and social activities, but are also prerequisites for ensuring the competitiveness of a city. Physical infrastructure, such as transportation, energy and communications infrastructure, and social infrastructure, such as health, governmental and educational services, are strongly interdependent in urban areas (Hitchcock, 2009), and vulnerable to the non-linear disruptive effects that can result when critical temperature, wind or water exposure thresholds are surpassed. Urban centres may also be particularly vulnerable to some of the distributive impacts of climate change, as income disparities tend to be greater in cities and cities tend to be home to large concentrations of poor or elderly citizens. Climate change impacts in areas outside of cities may also contribute to a rise in rural-urban migration, which would further increase the concentration of poor citizens vulnerable to climate change.

Cities' stability and prosperity rely on vast networks of infrastructure that provide essential services – solid waste disposal; wastewater treatment; transportation; water, energy and sanitary provisional systems. However, environmental impacts are dynamic. Not only do they often exhibit non-linear and cumulative effects, but they can reach ecological thresholds[1] and result in the irreversible loss of environmental values[2] (OECD, 2008a). Disruptions in infrastructure systems create inefficiencies and slow down economic progress, imposing costs on the local and national economy. For example, large portions of mass transportation systems and road networks, which are critical to cities' productivity, communication and competitiveness, can be cut off or shut down due to flooding in key locations (Box 2.1). Urban infrastructure is not typically designed to handle extreme events, particularly in developing countries (Hallegatte *et al.*, 2010). Temperature extremes and less predictable precipitation cycles will likely require key infrastructure (*e.g.* for energy production or transport) to be replaced or repaired more frequently and may reduce their operational capacity (*e.g.* blackouts or service interruptions), if infrastructure design does not take potential climate variations into account (Mansanet-Bataller *et al.*, 2008; Cochran, 2009). Many of the dangers of climate change can be mitigated by folding the expectation of a new climate into existing infrastructure development, although this is complicated by the dense interconnections among the infrastructures on which cities rely. It is also made more difficult by the tendency for some the information most relevant for climate decision making (*e.g.* impact of climate on local rainfall extremes) to be associated with the highest degree of uncertainty. Although urban infrastructure is an essential element in city competitiveness, cities in many parts of the world are struggling to meet the basic needs of their populations, and have limited resources to devote to adapting to climate (Ruth, 2006; Ruth *et al.*, 2006).

Adaptation is also made difficult by the fact that modifications to urban infrastructure and the built environment are expensive and occur incrementally over long periods of time. For instance, transportation and flood control infrastructure can be built to withstand a wide range of extreme weather events, but such infrastructure generally lasts decades, heightening the need to incorporate extreme climate scenarios into current infrastructure

Box 2.1. **Climate change, transportation and flood risk**

The City of New York's airports, as well as many of its power plants and waste transfer facilities, are at sea level and/or on waterfront sites. The subway system and subterranean water and sewer systems were designed for current sea levels. A Category III hurricane would flood all the tunnels leading out of New York, as well as the city's airports, requiring the emergency evacuation of up to 3 million people (City of New York, 2007).

The Thames Barrier, which protects London from high seas, was raised only three times in its first six years of operation, but was been raised 56 times between 2001 and 2007. Flash floods caused approximately 600 flooding incidents in the London Underground between 1992 and 2003. A single 2002 flooding incident in the Borough of Camden caused traffic disruptions amounting to losses of at least GBP 100 000 per hour's delay on each main road affected, without counting the costs of infrastructure damage. A recent report concluded that significant changes to current drainage systems would be needed to maintain current service levels in the event of even a small increase in storm rainfall (Mayor of London, 2007).

Source: City of New York (2007), "PlaNYC: A Greener, Greater New York", April, *www.nyc.gov/html/planyc2030/downloads/pdf/full_report.pdf*; Mayor of London (2007), "Action Today to Protect Tomorrow: The Mayor's Climate Change Action Plan", Greater London Authority, February, London, *www.london.gov.uk/mayor/environment/climate%1echange/docs/ccap_fullreport.pdf*.

design and planning. Vulnerability to storm and hurricane risks can be reduced through spatial planning and land management, but land-use changes occur over decades and urban buildings typically last 50 to 100 years, if not longer. As a consequence, urban adaptation options often must be anticipated by at least decades to be effective (Nicholls *et al.*, 2008). Current adaptation efforts are challenged by the uncertainty about the nature of future climate change impacts especially given that adaptation costs are immediate while benefits are delayed and based on present assumptions of climate impacts (Hallegatte *et al.*, 2008). Adaptation to the most catastrophic events possible would require costly investments while running a strong risk of being unnecessary (Jones, 2004) at the least, and could potentially contribute to greater climate change damage by offering a false sense of security that puts larger population at risks if impacts exceed expectations (Nicholls *et al.*, 2008).

Poor populations in both rich and poor nations are expected to be the most vulnerable to climate change in part due to the lack of resources and capacity to respond in a timely manner or to adapt or to move to less vulnerable areas (Corfee-Morlot *et al.*, 2010). As the 2005 Hurricane Katrina in the United States demonstrated, climate extremes may hit wealthy nations but can still fall the hardest on the poor, who lack the resources to respond quickly and effectively to protect themselves from extreme weather patterns (Mathew, 2007). The urban poor may also be more exposed to flooding, since they are likely to occupy the cheapest land, sometimes illegally, or reside in floodplain areas such as the Dharavi slums in Mumbai (Sherbinin *et al.*, 2006; Ranger *et al.*, 2010), Dakha (Alam and Rabbani, 2007) or the New Orleans' 9th Ward. They are also more vulnerable as they may use cheaper materials to build dwellings, often violating building or safety codes. This may increase vulnerability to storms or natural disasters as was shown by the collapsed structures from Hurricane Mitch (1998). Where a city's low level of development does not allow for expensive infrastructure investments or institutional capacity to protect the population adequately, a vicious cycle of vulnerability and poverty may result (Ibarrarán *et al.*, 2009). Climate change can also have a disproportionately more severe impact on other more vulnerable members of the urban population, such as on women, the very young, the elderly and people whose health is already compromised (Ruth and Ibarrarán, 2009).

Local strategies to reduce GHG emissions can also contribute to urban inequality. For example, the swift application of a transportation tax could have redistributive effects in urban areas by placing a larger burden on residents living farther from city centres, including those who have located there because affordable housing is unavailable closer; the impact may be lessened through a more incremental approach. Rising energy costs may incentivise behaviour that reduces GHG emissions, but higher costs leave those with little income to invest in energy efficiency measures exposed to higher energy prices. On the other hand, as the poor spend a greater share of the income on energy costs, they can disproportionately benefit from energy-efficiency programmes (Hallegatte *et al.*, 2008). Further, given their disproportionate vulnerability to climate change impacts, mitigation policies' benefits may outweigh their costs to poor residents however these benefits accumulate only in the long term. Climate change can also impact cities by increasing rural-urban migration. A decrease in income in the agricultural sector due to a climate-related decrease in production could lead agricultural workers to migrate to the city in search of work. Rapid and unmanaged growth in urban populations can strain the availability of housing and basic infrastructures (particularly water and sanitation), increasing the potential for negative health impacts and vulnerability to natural disasters (Hallegatte *et al.*, 2008).

Coastal flooding risks

Cities are highly concentrated in coastal zones, which puts a large portion of the urban population at risk from rising sea levels and intensifying storm surges. Mean sea level has risen on average 1.3-2.3 millimetres per year over the last few decades (1963-2003) with the average rate almost doubling in the last decade of this period; the IPCC expects sea levels to rise 18-59 centimetres by 2100 (IPCC, 2007a).[3] Peak sea levels, which are most relevant for coastal planning as they characterise storm surges, may be rising even faster. Rising sea levels are a critical issue for major cities, particularly in developing countries (Table 2.1). Even in Europe, 70% of the largest cities have areas that are less than 10 metres above sea level (McGranahan *et al.*, 2007). Projected sea level rise is also associated with significant

Table 2.1. **Cities are highly concentrated in coastal zones**

Share of urban settlements whose land area intersects the Low Elevation Coastal Zone (LECZ), by urban settlement size (2000)

Region	< 100 K (%)	100-500 K (%)	500 K-1 M (%)	1-5 M (%)	5 M+ (%)
Africa	9	23	39	50	40
Asia	12	24	37	45	70
Europe	17	22	37	41	58
Latin America	11	25	43	38	50
Australia and New Zealand	44	77	100	100	n.a.
North America	9	19	29	25	80
Small island states	51	61	67	100	n.a.
World	13	24	38	44	65

Source: McGranahan, G., D. Balk and B. Anderson (2007), "The Rising Tide: Assessing the Risks of Climate Change and Human Settlements in Low Elevation Coastal Zones", *Environment and Urbanization*, Vol. 19, International Institute for Environment and Development, London.

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loss of land in coastal regions due to erosion. For example, a 0.3 metre sea level rise in the United States, which is on the low end of IPCC projections (0.2 to 0.6 metres), would erode approximately 15 to 30 metres of shoreline in New Jersey and 60 to 120 metres in California (Ruth and Gasper in OECD, 2008b; Ruth and Rong, 2006). Adaptation measures to combat sea level rise will be necessary because of the lag time between slowing down warming and slowing down the effects on glaciers. Even under scenarios where emissions are eliminated, sea level rise continues well after temperature has stabilised (Ruth and Gasper in OECD, 2008b; Nicholls *et al.*, 2008).

Recent OECD work demonstrates that a 50-cm sea level rise, factoring in socio-economic development, could result by 2070 in a tripling of the population at risk of coastal flooding and a tenfold increase in the amount of assets exposed, or from 5% of 2008 GDP to 9% of 2070's GDP (Figure 2.1). About two-thirds of the increase in population exposed to coastal flooding is due to the socio-economic factors that drive coastal settlement, while the remaining third is expected to result from climate change and land subsidence. Port cities most at risk for coastal flooding are located both in rapidly growing developing countries such as India and China (*e.g.* Kolkata, Shanghai, Guangzhou) and in wealthy countries such as the United States (*e.g.* Miami, New York City), the Netherlands (*e.g.* Rotterdam, Amsterdam) and Japan (*e.g.* Tokyo, Osaka) (Nicholls *et al.*, 2008). While adaptation in the form of coastal protection (dykes) is likely to be cost-effective, such adaptation efforts can also incur costs in the form of negative side effects. For example, coastal infrastructure to protect the city against storm surge, such as sea walls, can damage local landscapes, ecosystems and beaches, which may result in a reduction in tourism. Fisheries industries may also suffer as infrastructure to reduce coastal flooding can damage coastal ecosystems, on which 90% of fish species depend during at least one stage of their life cycle (Hallegatte *et al.*, 2008).

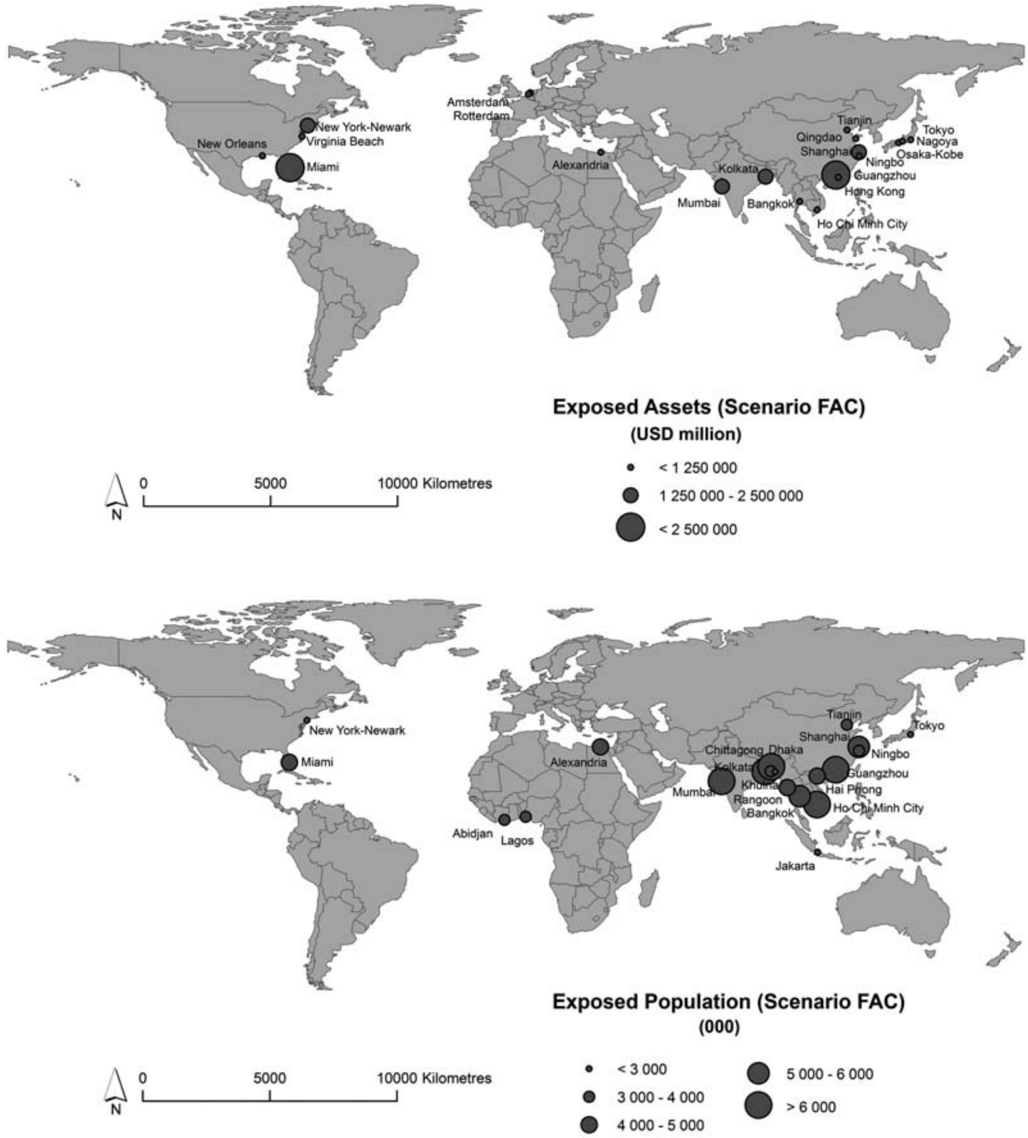
Precipitation and storm impacts

More frequent storm events caused by climate change can result in hydrological changes that stress the capacity of drainage infrastructures, sewage systems and water treatment facilities in cities (Ruth and Gasper in OECD, 2008b; Hallegatte *et al.*, 2010). The increasing frequency of severe weather events, combined with sea-level rise, can cause sanitation problems if urban infrastructure is ill-equipped to accommodate a sudden influx of water (Ruth and Gasper in OECD, 2008b; Rose *et al.*, 2001). Heavy precipitation events wash urban pollutants into rivers and lakes, and can reduce water quality in reservoirs by increasing turbidity (Ruth and Gasper in OECD, 2008b; Frederick and Gleick, 1999; Miller and Yates, 2006). As intense precipitation occurs more often, urban planners will have to confront multi-faceted problems of controlling and managing precipitation inflows and protecting existing water supplies. Urban runoff and failures of combined sewer overflows and municipal sewer plants can all introduce pathogens into water systems that pose a variety of health risks; documented cases globally range from wound infection to kidney failure (Ruth and Gasper in OECD, 2008b; Nuzzi and Waters, 1993; Rose *et al.*, 2001).

Aside from extreme storms, changes in precipitation patterns will be critical. Scientists expect a general trend of increasing precipitation in middle latitudes and decreasing precipitation near the equator, but the effects will be highly variable on the local scale, and the technology to predict them accurately does not yet exist (Ruth and Gasper in OECD, 2008b; IPCC, 2007b). There is also recent evidence that local precipitation

Figure 2.1. **Top 20 port cities' exposed assets (a) and exposed population (b)**

Future scenario with socio-economic development, subsidence and climate change



Note: Note the different scales in the key.

Source: Nicholls, R. *et al.* (2008), "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes", *OECD Environment Working Paper Series*, No. 1, OECD, Paris.

rates may be impacted by urbanisation and that historically arid regions may experience an increase in storms. For example, an analysis of arid regions revealed a statistically significant increase in precipitation in Phoenix, Arizona, and suburbs during its urbanisation period, compared to its pre-urbanisation period. This study also noted increased variability in precipitation for this region and for Riyadh, Saudi Arabia (Ruth and Gasper in OECD, 2008b; Shepard, 2006).

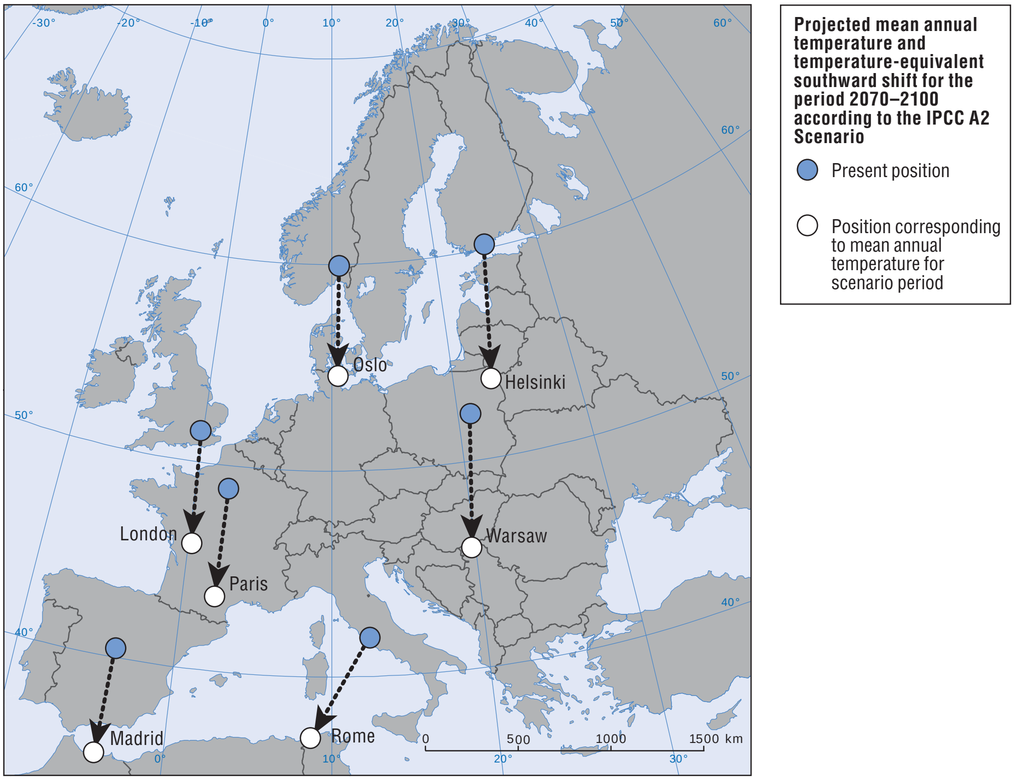
Floods are one of the most costly and damaging disasters, and will pose a critical problem to city planners as they increase in frequency and severity. The frequency and severity of flooding has generally increased in the last decade compared to 1950-80 flood data, along with the frequency of floods with discharges exceeding 100-year levels (Ruth and Gasper in OECD, 2008b; Kron and Berz, 2007) More frequent severe precipitation events are predicted to cause a greater incidence of flash flooding and urban flooding (IPCC, 2007c). There is a need to evaluate existing infrastructure for treating and transporting water and to better understand how the existing systems can handle excess precipitation or an influx of seawater. The City of London Corporation, for example, has identified "hot spots" vulnerable to flooding, where it plans to install new sustainable drainage system and invest in maintenance to accommodate the expected rise in the volume of precipitation (Kamal-Chaoui in OECD, 2008b). OECD (2008a) reported a wide range of estimates for the costs of adapting urban water infrastructures from a variety of empirical studies, on the order of hundreds of millions to billions of dollars per year. In sub-Saharan Africa, adaptations in urban wastewater treatment systems (new and existing facilities), could cost USD 2 billion to 5 billion per year, while in Toronto, Canada, similar improvements were valued at around USD 9 billion annually (Ruth and Gasper in OECD, 2008b). In addition to the obvious structural damages and loss of life that they can cause, floods can short-circuit transformers and disrupt energy transmission and distribution, paralyse transportation, compromise clean water supplies and treatment facilities, and accelerate spread of water-borne pathogens (Ruth and Gasper in OECD, 2008b; Ruth and Rong, 2006; IPCC, 2001a). Socio-economic models of future flood damage in cities (*e.g.* Boston, Massachusetts; London) independently predict vast increases in spending in response to damages resulting from climate change in the absence of adaptive infrastructure changes (Ruth and Gasper in OECD, 2008b; Kirshen *et al.*, 2005; Hall *et al.*, 2005; and Choi and Fisher, 2003).

Heat impacts and heat-island effects

Cities will not only face risks from floods and rising sea levels, but also significant increases in temperatures and the frequency of heat waves. According to the IPCC A2 scenario, average annual temperatures projected for the period 2070-2100 indicate that urban population in European cities will feel as if the weather of the city had moved southwards. London will feel more like Bordeaux, Paris much more like Marseilles and Madrid and Rome will be as hot as North African cities (Figure 2.2). However, these changes could be even more acute if action is delayed. With atmospheric GHG concentrations already at around 430 ppm CO_2, delaying action could raise GHG stock levels beyond 500 ppm in less than 25 years (Dietz and Stern, 2008). The implication is that such levels increase significantly the chances of a three-degree increase in global mean temperature.

Heat waves are likely to increase in severity and duration in the future, contributing to heat mortality in both developed and developing countries. These increases will likely be more strongly felt in urban areas, as cities tend to have higher air and surface temperatures compared to rural areas. This is known as the urban heat island (UHI) effect, which is due to combined effects of structural interference with thermal radiation, low albedo of impervious surfaces and reduced transport of water into the atmosphere, known as evapotranspiration (Ruth and Gasper in OECD, 2008b; Oke, 1982). The UHI effect is suspected of warming urban areas 3.5-4.5 °C more than surrounding rural areas and this differential is expected to increase by approximately 1 °C per decade (Voogt, 2002). The temperature differences between urban and surrounding rural areas can reach up to 10 °C for large urban agglomerations. The built environment, including buildings and roadways

Figure 2.2. **Apparent southward shift of European cities due to climate change (2070-2100)**



Source: Hiederer *et al.* (2009) in EEA (2009), *Ensuring Quality of Life in Europe's Cities and Towns*, EEA Report, No. 5/2009, EEA, Copenhagen.

that absorb sunlight and re-radiate heat, combined with less vegetative cover to provide shade and cooling moisture, all contribute to cities being warmer and susceptible to dangerous heat events.

The UHI effect can have negative public health effects in urban area as the impacts of heat waves can be worse in urban areas. For example, in the 2003 European heat wave that is estimated to have caused 70 000 victims (Robine *et al.*, 2008), a higher percentage of the causalities in France came from urban areas (Hallegatte *et al.*, 2008). Increasing temperatures can affect mortality in a number of ways, including heat-induced mortality, famine, exacerbation of non-infectious health problems and spread of infectious disease (Ruth and Gasper in OECD, 2008; Seguin and Berry, 2008; Costello *et al.*, 2009). Climate change can also exacerbate the effects of urban air pollution. UHI effects can generate changes in local atmospheric cycles. Changes in solar influx and chemical composition of near-ground air masses can cause formation of photochemical smog and reduce air circulation, which would otherwise diffuse the concentration of air pollutants (Hallegatte *et al.*, 2008). Warmer temperatures due to climate change and UHI effects, all other things held constant, may increase concentrations of conventional air pollutants, such as ozone and acid aerosols, as well as emissions of particulates and allergens (Aron and Patz, 2001). Moreover, higher temperatures due to climate change may actually make it more difficult to control the formation of some pollutants, such as ozone, which can exacerbate chronic respiratory diseases and cause short-term reductions in lung function (Bernard *et al.*, 2001).

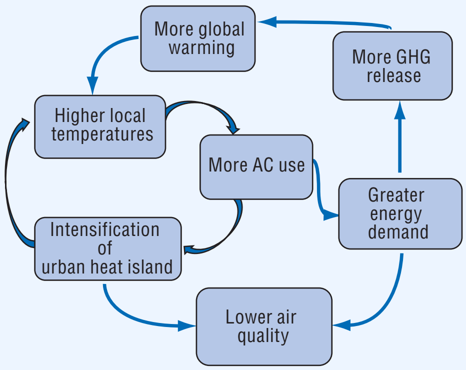
One study estimates these effects in the New York metropolitan area to increase mortality rates in the 2050s due to ozone-related acute climate change impacts alone (Knowlton *et al.*, 2007).

By aggravating heat-related climate change impacts, UHI effects are likely to increase future energy demand (Box 2.2) (Ruth and Gasper in OECD, 2008b; McPherson, 1994). In the United States, for example, an estimated 3% to 8% of annual electricity use is required to offset UHI effects (Ruth and Gasper in OECD, 2008b; Grimm *et al.*, 2008). Adaptation to rising

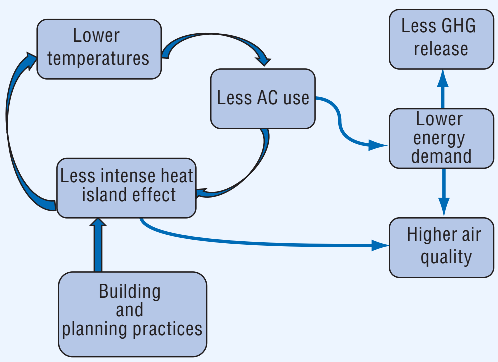
Box 2.2. **The urban heat island effect**

The built environment, which is concentrated in cities, reflects less sunlight, absorbs more heat and retains it longer than vegetation does. In addition, the concentration of energy use leads to a concentration of waste heat. Because of this, cities are consistently several degrees warmer than their surroundings, particularly at night. This exacerbates higher temperatures due to global warming, and participates in several feedback cycles with it.

The vicious cycle of business as usual:



A more virtuous cycle of mitigation and adaptation can be activated by policies that limit the urban heat island effect, such as green roofs, tree cover and permeable and light-coloured surfaces:



Source: OECD (2008), *Competitive Cities and Climate Change: OECD Conference Proceedings*, Milan, Italy, 9-10 October 2008, OECD, Paris.

temperatures by increasing air conditioning can also further increase UHI effects. For instance, massive air conditioning has been shown to increase UHI effects up to 1 °C (Hallegatte *et al.*, 2008).

Effects of increased drought and water scarcity

Climate change may intensify competition for water. Cities generally rely on their immediate surroundings for water. While the effect of climate change on the water resources of a particular city cannot be predicted at present, the competition for water can be expected to intensify in the areas that become dryer than they are now. Since current water management systems are designed for historical weather patterns, some adjustment will probably be required in most places (Hitz and Smith, 2004). Areas most likely to be affected include those that rely on snow melt for water over the course of the summer, since winter snow packs in most places will decline (IPCC, 2001b). This will exacerbate the pressure on water resources caused by rising population and affluence (AAAS, 2006) and require revision of urban water supply strategies (Box 2.3). As much as 50% of the urban population in Asia and Africa already lacks adequate provision of water and sanitary services (Ruth and Coelho, 2007). Drinking or recreational water can be contaminated by sewage backup, and microbial/chemical agents and biotoxins can be introduced into the water supply. Urban nitrogen pollution is a common characteristic of cities that further stress hydrological cycles and the clean water available. Saltwater intrusion of groundwater and surface water is a critical problem that reduces the availability of potable water and can spread harmful pollutants through urban water systems. Cases of saltwater intrusion are nearly ubiquitous among coastal cities, documented in diverse environments including the eastern United States, the coast of Thailand, as well as both Chinese and Vietnamese deltas (Ruth and Gasper in OECD, 2008b; Nicholls *et al.*, 2008). Costs of desalination are high, at approximately USD 1.00 per m^2 to generate potable water from seawater, USD 0.60 per m^2 to convert brackish water and USD 0.02 per m^2 for freshwater chlorination (Ruth and Gasper in OECD, 2008b; Zhou and Tol, 2005).

Box 2.3. **Barcelona's response to drought**

Barcelona experienced a major drought after two consecutive autumns of insufficient rainfall in 2006 and 2007. The situation was so bad that the city had forecast a possible interruption of the water supply to households and was forced to launch a series of emergency plans to safeguard supplies of drinking water. The city developed a water supply strategy for the period up to 2030, based on diversification of sources, including targeting consumption savings through publicity campaigns, free distribution of water-saving devices and time restrictions on some ornamental and recreational use; recovery of local aquifers, using new pollution-control technologies, to decrease dependency on river water; water purification of around 290 hectometres of water for the whole metropolitan area; plans for an extension of networks for the transport of purified water; and the opening in 2009 of a desalination plant (although the city recognised this technology entails high energy consumption). Barcelona is also extending its current network of 11 rainwater reservoirs to 17 by 2011, which will raise the city's collection capacity by 83%.

Source: OECD (2008), *Competitive Cities and Climate Change: OECD Conference Proceedings*, Milan, Italy, 9-10 October 2008, OECD, Paris; Mayol, I. (2008), presentation at the OECD conference, "Competitive Cities and Climate Change", 9-10 October 2008, Milan, Italy.

Higher air temperatures and more frequent droughts can cause increasing demand for household and industrial use of water in urban areas (Ruth and Gasper in OECD, 2008b; Wilbanks *et al.*, 2007). Although modelling evidence has not shown these increases to be dramatic, effects may be exacerbated, as population growth is concentrated in cities (Ruth and Gasper in OECD, 2008b; Protopapas *et al.*, 2000). Increases in temperature vary significantly by region, making it difficult to predict impacts on a given area based on global or broad regional estimates of temperature change. Modelling estimates for the United States have suggested large costs to meet increasing demand as temperature rises through 2060, while studies on Greece have predicted decreasing costs under certain climate change scenarios (Ruth and Gasper in OECD, 2008b; Morrison and Mendelsohn, 1998; Cartalis *et al.*, 2001). Regional variation has proven significant at the state level in the United States, emphasising the need for understanding not only the potential regional effects of climate change, but also the differences in manifestation of these impacts for various urban sectors (*e.g.* waste management, manufacturing and services) (Ruth and Gasper in OECD, 2008b; Sailor, 2001).

The costs of urban inaction

Most of the discussion of climate change impacts in the urban environment has focused on storm and flood-related damages, heat impacts, water use, and human health and welfare; however it is important to consider explicitly how current and potential changes directly and indirectly impact local economies. Economic impacts can determine future capacity to adapt and cope with the aforementioned issues associated with change. Direct costs from climate change impacts can be staggeringly high, especially when related to natural disasters and sea level rise (Box 2.4). Shoreline retreat in the United States costs between USD 270 billion to 475 billion per metre climb in sea level; analogous costs in developing nations can amount to one-third of annual GDP (Ruth and Gasper in OECD, 2008b; IPCC, 2001a). Flooding is one of the most expensive disasters, with a single flood causing England, for example, to spend GBP 1 billion to repair damages in 2000 (Ruth and Gasper in OECD, 2008b; Zoleta-Nantes, 2000).

Box 2.4. **The high costs of storms**

In developing countries, storms are currently the costliest weather events, as evidenced by research from the insurance sector. For example, the Association of British Insurers (2005) estimated a 75% increase by the 2080s in the costs of insured damage due to severe hurricanes in the United States, and a 65% increase for Japan. Nordhaus (2006) estimated that, given a doubling in CO_2-equivalent, the annual average cost of hurricane damage in New Orleans and Miami, United States, could increase by USD 8 billion at 2005 incomes (0.06% of GDP). City-specific storm risk assessments are rare. One study of New York City estimated damages of approximately 0.1% of annualised Gross Regional Product (GRP), and for one event the probable maximum loss was estimated at 10-25% of GRP (Rosenzweig and Solecki, 2001).

Source: Hunt, A., P. Watkiss and OECD (2010), "Climate Change Impacts and Adaptation in Cities: A Review of the Literature", OECD, Paris; ABI (Association of British Insurers) (2005), *Financial Risks of Climate Change*, *www.abi.org.uk/Display/File/Child/552/Financial_Risks_of_Climate_Change.pdf*; Nordhaus, W.D. (2006), *New Metrics for Environmental Economics: Gridded Economic Data*, Yale University, produced for the Global Forum on Sustainable Development on the Economic Benefits of Climate Change Policies, 6-7 July 2006, Paris; Rosenzweig, C. and W.D. Solecki (2001), "Global Environmental Change and a Global City: Lessons for New York", *Environment*, Vol. 43, No. 3, pp. 8-18.

Indirect impacts can hinder local economic activity. Economic impacts can have rebound effects in the job market and reduce tax revenue. These stresses on the local economy may limit investment opportunities and deplete funds for infrastructure innovations, leaving cities more vulnerable to future change (Ruth and Gasper in OECD, 2008b). Ripple effects from outside the city can also result in costs that are felt throughout the region or at national level. Decreases in productivity or income outside the city may lead to a decrease in demand and an increase in import prices that could in turn affect the profitability of many economic sectors in the city and the income of city inhabitants, as well as food security (Hallegatte *et al.*, 2010; Ranger *et al.*, 2010).

Some economic loss will come in the form of "hidden" costs, such as the costs of rerouting traffic, lost productivity, provision of emergency and continued aid, relocation and retraining, lost heritage, and urban ecosystem damage. In addition, higher risk and uncertainty stemming from global climate change imposes additional costs on the insurance, banking, financing and investment industries (CIER, 2007). In general, these costs will hit cities and their competitiveness. Because of the difficulty of estimating the value of non-market entities and services, costs of lost ecosystems and cultural heritage as well as health-related impacts are often ignored in economic studies. However, they may constitute a significant portion of the total damages associated with climate change impacts. If climate change adds to such burdens and other "hidden" costs – increased health care expenses, lost productivity and retrofitted infrastructure – it can only compromise cities' competitiveness.

Since emissions and pollution today will have an enduring effect far into the future, the temporal difference in value of money should be considered. It is generally agreed that costs and benefits incurred today have a greater value than those incurred in the future because of the opportunity cost of capital. The difference in the value is measured by the discount rate. Its precise size, however, is uncertain, and researchers may attribute different rates to it depending on their purpose or preference (OECD, 2008a). Putting off adaptation may increase future costs by increasing insurance rates. In reaction to the increased risk, many insurance companies are paying particular attention to their potential exposure to the effects of climate change and are considering raising their premiums. Already Swiss Re, one of the world's largest re-insurers, requires companies to disclose their climate strategy as part of its Directors and Officers Liability insurance application. In 2008, Ernst and Young identified climate change as the top strategic risk for the industry (Kamal-Chaoui in OECD, 2008b).[4]

Notes

1. Impacts may increase sharply once a particular level (threshold) of environmental pressure is exceeded.
2. While some environmental impacts are potentially "reversible" (allowing for the restoration of environmental conditions to their prior state), there are many areas in which this is not the case (once degraded, environmental values are lost permanently).
3. The IPCC notes however that… "sea level projections do not include uncertainties in climate-carbon cycle feedbacks nor do they include the full effects of changes in ice sheet flow, because a basis in published literature is lacking" (IPCC, 2007a). Taking these effects into account could lead to much higher projections.
4. See: *www.ey.com/Global/assets.nsf/International/Industry_Insurance_StrategicBusinessRisk_2008/USDfile/Industry_Insurance_StrategicBusinessRisk_2008.pdf*.

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PART I

Chapter 3

Economic Benefits of Climate Action: The Urban Dimension

This chapter examines the benefits of implementing urban policies to tackle climate change. Findings from a computable general equilibrium model (IMACLIM-R) that incorporates an urban module and data from the OECD Metropolitan Database *demonstrate that the traditionally perceived trade-off between economic growth and achieving mitigation objectives (observed at a macroeconomic level) can be alleviated when urban policies are introduced. Under a policy scenario where national emission reduction strategies are implemented, aggregate mitigation costs can be reduced if economy-wide environmental policies are complemented by urban policies, such as congestion charges or increasing spatial density. This is due to complementarities with other policy objectives, such as lower local pollution and health benefits, and enhancement of city attractiveness and competitiveness through lower local pollution levels. The chapter also discusses other types of local benefits of climate change policies, including quality of life, increased efficiency, energy security, and infrastructure improvements.*

Key points

Urban policy can contribute to least-cost national CO_2 emissions reduction targets and mitigation strategies

- Findings from a computerised general equilibrium model (IMACLIM-R) with an urban module demonstrate that urban policies can lead to a reduction of total OECD global energy demand and, consequently, of CO_2 emissions at relatively low cost.
- Under a policy scenario where national emission reduction objectives are implemented, the aggregate mitigation costs can be reduced if economy-wide environmental policies are complemented by urban policies, such as congestion charges or increasing spatial density.
- The lower tradeoffs between economic growth and environmental priorities at the urban level may be due to complementarities of policies observed only at the local scale.

The costs of delaying action on climate change may be high, while some urban climate policies may be "no-regret" policies

- While climate change mitigation and adaptation policies require significant investment, delaying action can increase future costs and limit future options for adapting to climate change impacts or reducing emissions in cities.
- Beyond direct costs of climate change in urban centres, the economic impacts of climate change can have positive rebound effects in the job market and reduce tax revenue.
- Some urban climate policies may be no-regret policies as they can provide co-benefits that offset their cost. These include public health benefits, cost savings from reduced energy use and increased efficiency, energy security, and improved urban quality of life. These additional non-climate benefits may also help to explain the lower tradeoffs and synergies between economic growth and greenhouse gas emissions reduction at the metropolitan level.

Simultaneously addressing stabilisation of the climate and economic growth has become a challenging task for the international policy community. This apparent trade-off has been so far discussed in two ways. The first is to measure economic growth in a way that integrates the degradation of environmental assets into the calculation of GDP. The second is to take into account the discounted long-term economic benefits of climate stabilisation, by avoiding extreme future adverse events. Both approaches entail significant measurement and valuation problems. However, findings from a regional growth model disaggregated at the metropolitan level, presented in this chapter, show that the trade-off between economic growth and climate policy can actually be lower when local dimensions are taken into account. Namely, policies to reduce traffic congestion and increase urban density can have a significant effect on national GHG emissions levels while allowing the local economy to grow. Also, adaptation and mitigation policies can provide important benefits in the form of reduced energy costs, increased local energy security and improved urban health. This is particularly important for city and regional governments, which can be sensitive to immediate price increases and investment costs in exchange for the less-tangible and longer-term benefits of addressing global climate change.

Effects of urban policies on global energy demand and carbon emissions

A Computable General Equilibrium (CGE) model has been used to simulate a world economy divided into macro-regions in economic interaction with OECD metropolitan areas. More precisely, this modelling exercise has been carried out by employing the spatialised version of the IMACLIM-R CGE framework (Crassous *et al.*, 2006). IMACLIM-R allows simulating the interactions between changes in energy consumption, carbon emissions and economic growth, given a set of policies and other exogenous factors (Box 3.1).[1] Two types of urban policies are explicitly explored: *i)* urban densification;[2] and *ii)* congestion charges (see also Chapter 9). The results suggest that densification policies would increase people's propensity to use public transport, from 12.9% in the baseline scenario to 14% by 2050 with densification policies. As a consequence, the volume of private transport falls across the

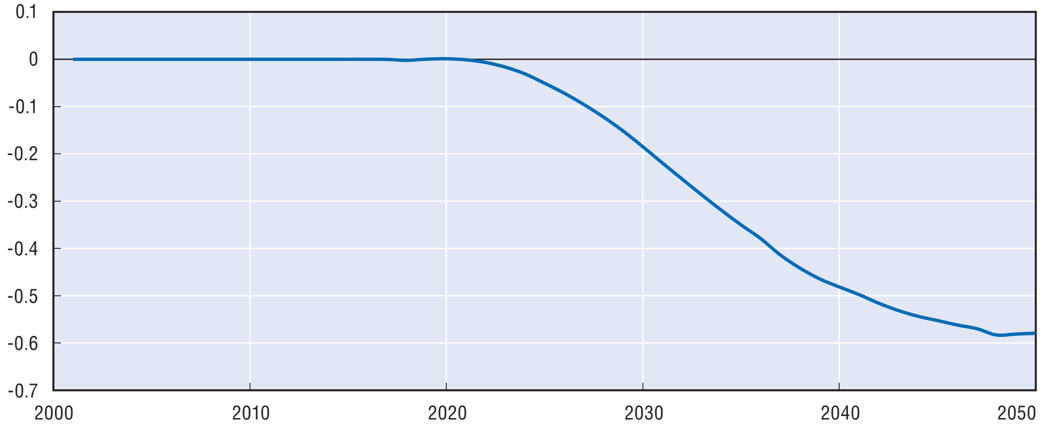
Box 3.1. **A CGE model of metropolitan economies**

The impact on climate change of policies at the metro-regional scale can be modelled using a general equilibrium approach that takes into account most of the factors that influence the way in which an economic system works. In particular, computable general equilibrium (CGE) models can be used in order to simulate a world economy divided into countries and groups of countries, multiple sectors, and production and consumption functions. The approach taken in this chapter involves the use of IMACLIM-R model (Crassous *et al.*, 2006; see Annex 3.A1 for details). The global CGE model employed in this chapter has been enriched by a metropolitan module representing the metropolitan economies and their interactions with the macro-level (Grazi and Waisman, 2009). This module was calibrated on the *OECD Metropolitan Database* and is consistent with the assumptions in the OECD ENV-Linkages model.

The model is based on the comparison of two scenarios: one without policy changes, the so-called *baseline scenario* (BS), and a *climate policy scenario*. The comparison of these two scenarios for each period enables quantification of the magnitude of the policies' impact. Two particular local policies have been tested to explore possible impacts on the economy and on carbon emissions: densification policies and congestion charges. The densification policy can be interpreted as an indirect form of intervention whose primary effect is to reduce individuals' dependence on private transport for commuting. Densification is the increase in the number of inhabitants living in a given territorial unit, for instance, the number of inhabitants per km^2. In analysing where an economy chooses to locate and what determinants impacts its distribution across available agglomerations, the metropolitan module in the IMACLIM-R model draws on the new economic geography approach (Krugman, 1991). The static urban agglomeration structure is described in the model by three main determinants: locally available active population, labour productivity, and urban density. Data are taken from the *OECD Metropolitan Database*. The long-run mechanism through which firms (and people consequently) agglomerate is driven by an agglomeration-specific attractiveness index that encompasses three main factors: the rate of capital return, the expected volume of production and the change in absolute number of firms. Firms therefore are attracted by cities with higher capital returns (determined by labour productivity), an increase in the size of markets (given by the expected volume of production) and the presence of other firms (so that they can establish backward and forward linkages). The model also allows for migration of people among regions and cities following firms' investment decisions. Higher-productivity cities will be able to offer higher wages and thus attract workers and skills, which completes the agglomeration cycle. Higher wages are assumed to be a compensation for workers as they need to cope with the external costs of the agglomeration, namely commuting, housing costs and local pollution.

Figure 3.1. **Energy demand with a densification policy**

Per cent difference in total OECD demand (densification *vis-à-vis* baseline scenario)



Note: The line shows the difference between demand of energy once cities are denser and the baseline scenario (or business as usual).

Source: Simulations from IMACLIM-R model based on the *OECD Metropolitan Database*.

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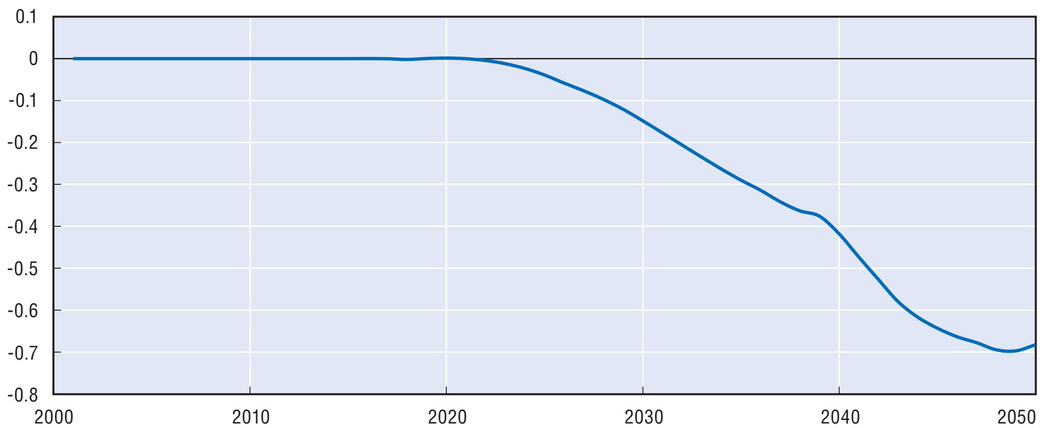
OECD, implying a decrease in the demand for oil. If cities were to become denser, total OECD energy demand would decrease from 2020 on, and would reach 0.6% less compared to the baseline by 2050 (Figure 3.1). This is in line with previous evidence that urban form affects individuals' travel behaviour and consequently global environmental quality (Grazi *et al.*, 2008). A similar result is obtained if congestion charges only are applied.

Following the implementation of densification and congestion charges, carbon emissions are reduced relative to the baseline, following a similar pattern to the one of energy demand from 2020 on (Figure 3.2). We consider the introduction of a local tax on the use of private vehicles by individuals for commuting purposes. This takes the form of a toll road of the type already implemented in some metropolitan regions (London and Stockholm

Figure 3.2. **Carbon emission reductions with a densification policy**

Per cent difference in total emission reductions in OECD (densification *vis-à-vis* baseline scenario)



Source: Simulations from IMACLIM-R model based on the *OECD Metropolitan Database*.

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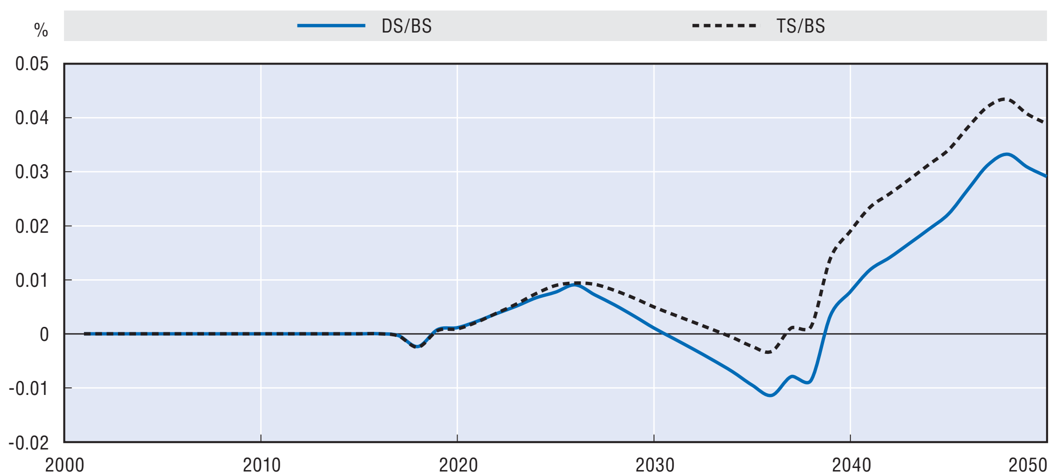
among others).[3] Revenues from the toll road tax can be used to finance metropolitan region densification plans, thereby lowering the cost of densification. The fact that many city or metropolitan governments have the capacity to implement such a tax *and* decide how revenues will be spent contributes to the effectiveness of urban-level policies. At the national level, responsibility for transportation, land-use and tax collection would likely reside in separate government institutions, *e.g.* the Ministries of Transport, Housing and Territorial Planning, and Treasuries.

Environment and economic growth at the urban scale: From trade-offs to policy complementarity

Densification and congestion charges are not the only effective tools to reduce energy demand and carbon emissions; however, they are important as it can be demonstrated that they do not have a detrimental effect on long-term economic growth.[4] More specifically, the model generates three adjustment phases in economic growth, over time. First, an initial minor and short-lived economic expansion exists with both policies in almost the same pattern until 2025, mainly driven by lower fuel prices as demand for oil falls. Second, economic growth becomes mildly negative after 2030 (Figure 3.3). As fuel prices fall, people find it less costly to drive again and so they increase their demand for oil and prices start to rise again, bringing about a short-lived economic contraction. Finally, a more important expansion of economic activity – more so under the congestion charges scenario – becomes possible around 2038 since the new increase in oil prices tends to accelerate technical change and thus spurs innovation and economic growth.

Figure 3.3. **Economic growth with local policies**

Changes in GDP comparing densification and congestion charges *vis-à-vis* baseline scenario



Note: DS refers to Densification Scenario; BS refers to Baseline Scenario; TS refers to Tax Scenario (in turn refer to the application of congestion charges).

Source: Simulations from IMACLIM-R model based on the *OECD Metropolitan Database*.

StatLink http://dx.doi.org/10.1787/888932342373

Underlying these results is the fact that technology-support policies embodied in the IMACLIM-R model can reduce and even offset the economic cost of curbing carbon emissions. In this regard, the discussion on how to address the climate change problem has mainly focused on the economic impact of carbon abatement. The latter has been estimated at 1 to 3% – depending on the discount rate used – of reduction in world GDP (*cf.* Stern, 2007; OECD, 2009). However, the OECD (2009) acknowledges that the perceived trade-off between economic growth and mitigation policies is lower if technology-support policies are considered: first because technology-support policies may help address innovation failures and boost economic growth; second because these policies postpone emission cuts until technologies become available and therefore reduce the impact on economic growth (OECD, 2009).

In other words, the prospects of economic growth can actually be improved by providing incentives to innovation and growth. Emission reduction targets implied by climate policy bring about the need to improve processes and change products in a way that allow firms to comply with such regulations. Firms are then obliged to invest in improving their processes; many will fail to do so and perhaps be driven out of market, but many others may find new ways of doing things and in the long run such innovation bursts will lead to greater economic progress. OECD (2009) shows that R&D policies and technology adoption incentives are better suited than price and command-and-control (CAC) instruments for correcting specific innovation and technology diffusion failures that undermine the creation and diffusion of emissions-reducing technologies.

Assessed at the regional or local level, policies to reduce carbon emissions are less opposed to economic growth than policies designed at the aggregate level. As mentioned previously, cities are major contributors to climate change through energy demand and on-road transportation; thus local authorities can play a part in reducing such demand and emissions by inducing changes in the way people live and commute in urban areas. Moreover, policy tools at the disposal of cities' authorities are effective in tackling emissions by avoiding costs that are generally assumed at the macro level. Local policies that change commuting patterns – and there could be other policies to reduce emissions that are not explored in the model, such as building codes – can effectively reduce carbon emissions and, in the long run, boost economic growth through innovation. The reason for this lower trade-off lies in the fact that more complementarities among policies and economic activities can be observed at the local than at the aggregate or national level.

To illustrate the combined effect of climate and urban policies, an emission reduction scenario was simulated in the CGE model at 450 ppm CO_2eq (IPCC Scenario III, see Box 3.2).[5] In terms of carbon abatement, this scenario corresponds roughly to more than a 30% reduction in world carbon emissions by 2050, compared with the baseline (from above 30 to less than 20 $GtCO_2$). In the OECD, the abatement is even bigger in relative terms (Figure 3.4). The associated GDP losses could represent up to one-third of a percentage point for the OECD (Table 3.1).

For the group of OECD countries, it was possible to simulate the combined effects of implementing both a carbon price and urban spatial policies. Under the 450 ppm target, the gains from urban policies are relatively mild, although positive. If a more demanding target, such as 410 ppm, were to be reached,[6] the complementarity between the two policies would be sizeable (around 0.3% of OECD GDP, when a strong discounting rate is used). The global GDP losses under the 410 ppm climate policy scenario range from 3% to greater than 4% of GDP. Although it could not be simulated at this stage due to lack of data, it is likely that urban policies implemented at a global scale could generate much larger benefits.

Box 3.2. **Emission targets and modelling of climate policy**

When carbon emission targets set to avoid serious climate change (*e.g.* limiting global warming at 2 °C) are compared with those considered in energy economics literature on mitigation scenarios, substantial discrepancies emerge. So far, most model assessments of mitigation costs have considered stabilisation levels of atmospheric greenhouse gas concentrations above 500 ppm CO_2eq (*e.g.* Stern (2007) focuses on mitigation scenarios aiming at 500 to 550 ppm CO_2eq). Although such stabilisation levels are likely to be insufficient for keeping warming below 2 °C (Meinshausen, 2006), they are used as a benchmark for climate-energy modelling exercises: out of 177 mitigation scenarios considered in the IPCC AR4, only six were grouped in the lowest stabilisation category (corresponding to 445-490 ppm CO_2eq, which is consistent with a medium likelihood of achieving the 2 °C target).

The rationale behind the limited number of studies considering reduction targets that are consistent with the 2 °C target is that such low stabilisation can only be attained under a number of restrictive assumptions: *i)* a high degree of flexibility of substitution within the energy economic system; *ii)* a broad portfolio of technology options (including bioenergy, other renewables and carbon capture and storage); *iii)* a full and immediate participation in a global mitigation effort; and *iv)* the necessity of generating negative emissions.

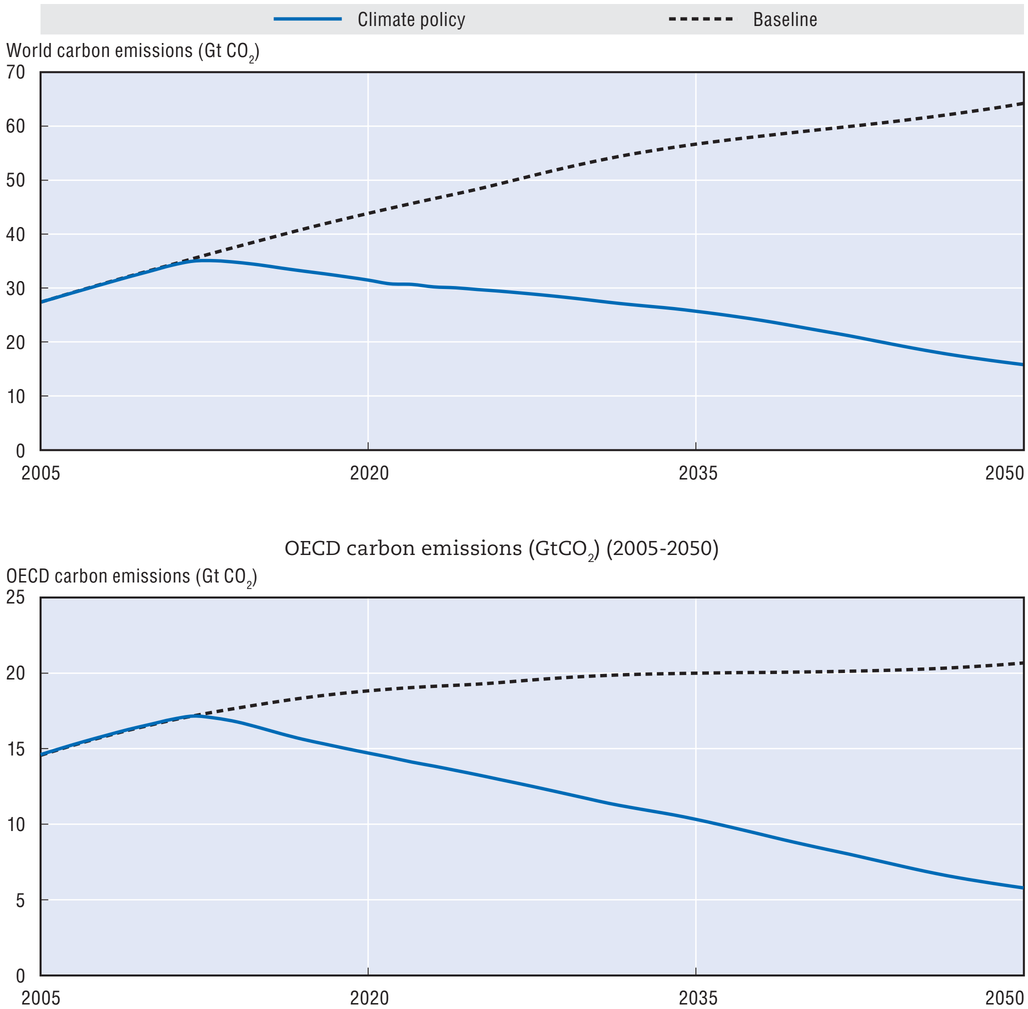
Going beyond the alleviation of carbon abatement costs, there are complementarities between carbon emission reductions and economic growth that can be found at the urban level, for instance with regard to attractiveness. Using the attractiveness index that is at the heart of the agglomeration dynamics in the spatialised version of IMACLIM-R model, it can be seen that a group of highly attractive metropolitan regions are associated with high levels of carbon emissions stemming from commuting, such as Los Angeles, New York, Seoul, Tokyo or Toronto. In contrast, a number of metropolitan regions combine relatively low emission levels per automobile and high attractiveness (*e.g.* Auckland, Madrid and Sydney) (Figure 3.5). Commuting modes could therefore be at the heart of carbon emission patterns, implying that a more intensive use of public transport may contribute significantly to reducing GHG emissions and pollution while increasing local attractiveness.

In this context, low pollution and GHG emission levels will increasingly be a factor driving the attractiveness of urban areas. In the next two decades, cities that could become more attractive will do so while also curbing local pollution. According to the results of the CGE model, and if current trends are sustained, cities that could experience improvements in attractiveness by 2030 include Ankara, Auckland, Barcelona, Krakow, Lille, Melbourne, Montreal, Monterrey, and Toronto; they will do so while also trimming down local pollution (Figure 3.6). Conversely, metropolitan regions could lose attractiveness if they continue to pollute, as in the cases of Chicago, Los Angeles, New York, Osaka, Paris, Philadelphia, Seoul and Tokyo, if current trends continue.

Assuming local pollution is related to attractiveness, and the latter associated to population and firm creation, higher incomes, productivity and wages, then an environmental policy at the local level could generate economic gains. In particular, changing the urban structure by increasing cities' density and intensifying the use of public transportation may induce both improvements in attractiveness – and therefore economic performance – and in cities' responsiveness to climate change. As will be developed below, densification policies to respond to climate change can take the form of removing tax and development disincentives

Figure 3.4. **Trends in carbon emissions under a 450 ppm urban climate policy scenario compared with the baseline**

World carbon emissions ($GtCO_2$) (2005-2050)



Source: Simulations from the IMACLIM-R model.

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in the urban core, actively pursuing compact spatial form, and increasing mass transit networks and urban amenities in areas targeted for higher-density growth. These issues should be at the heart of the ongoing debate about a green growth strategy.

Other benefits of urban climate policies

Additional local benefits resulting from emissions reductions and climate adaptation policies may also be partly responsible for a potential positive relationship between economic growth and GHG emissions reduction at the metropolitan regional level. These benefits can be grouped into four categories:

i) Public health improvements.

ii) Cost savings and increased efficiency.

iii) Energy security and infrastructure improvements.

iv) Improved quality of life.

Table 3.1. **GDP changes under implementation of alternative climate policy packages**

OECD

Discount rate (%)	Stabilisation target: 450 ppm (*IPCC scenario III, 2007*)		Stabilisation target: 410 ppm (*IPCC scenario II, 2007*)	
	Carbon price (%)	Carbon price + Urban spatial policy (%)	Carbon price (%)	Carbon price + Urban spatial policy (%)
1	–0.05	–0.04	–0.91	–0.85
3	–0.16	–0.15	–0.84	–0.67
7	–0.34	–0.33	–0.72	–0.37

World

Discount rate (%)	Stabilisation target: 450 ppm (*IPCC scenario III, 2007*)	Stabilisation target: 410 ppm (*IPCC scenario II, 2007*)
	Carbon price (%)	Carbon price (%)
1	–0.88	–4.16
3	–1.01	–3.62
7	–1.15	–2.95

Notes: For a given discount rate *r*, GDP losses are actualised starting from 2010, year at which the urban densification policy is expected to be set in place.

Actualised GDP losses are computed by making use of the standard formula: $\sum_{t=2010}^{2050} \frac{GDP_t}{(1+r)^{t-2010}}$

Note that with high discount rates both losses and gains, in the long term, yield low discounted values. In a scenario in which losses take place at the beginning of the period and gains at the end (such as in Figure 3.3) then the discounted cumulated losses are higher than the discount rate.

Source: Calculations based on the IMACLIM-R model.

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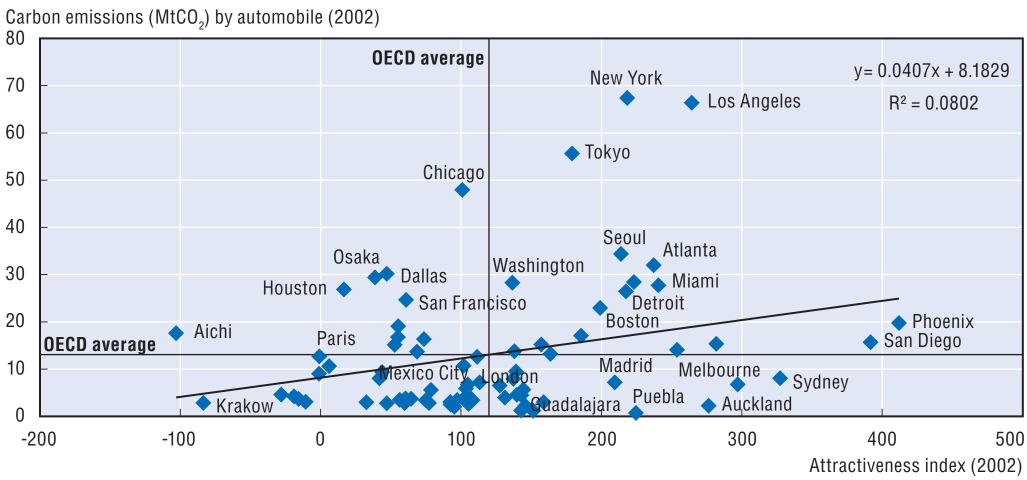
Figure 3.5. **Attractiveness and carbon emissions related to automobiles across metropolitan regions**



Source: Calculations based on the IMACLIM-R model and *OECD Metropolitan Database*.

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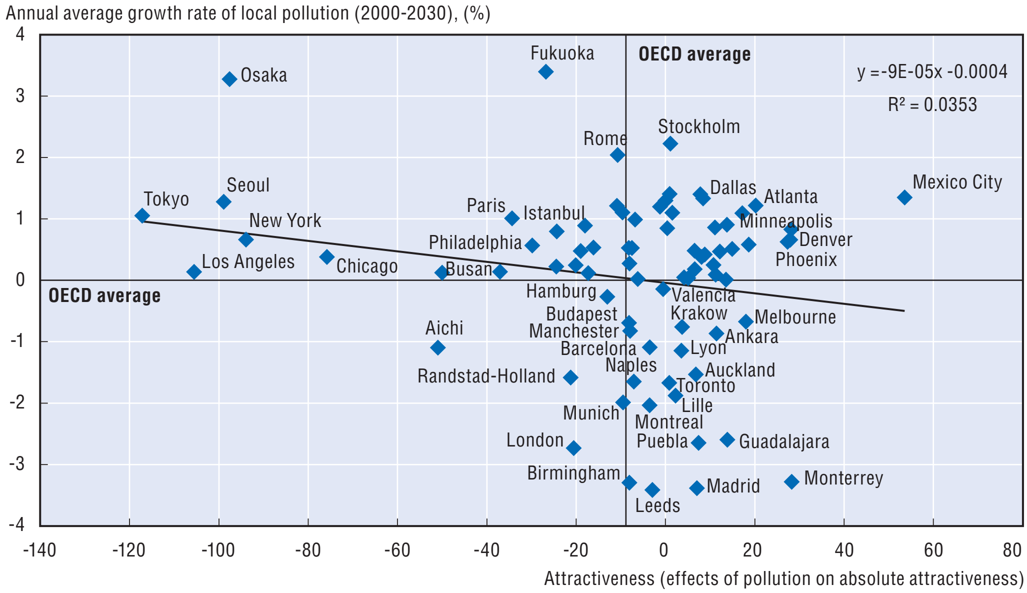
Each of these categories of benefits represent gains beyond those directly related to reduced GHG emissions or protection against climate change impacts. Table 3.2 provides an overview of some of the main co-benefits of mitigation policy in urban areas. The non-climate benefits of certain climate change policies are strong enough to warrant their implementation regardless of their impact on mitigating or adapting to climate change. In these cases they are considered "no-regrets" strategies (Hallegatte *et al.*, 2008).

Figure 3.6. **Changes in attractiveness and local pollution emissions across metropolitan regions**



Source: Calculations based on the IMACLIM-R model and the *OECD Metropolitan Database*.

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Table 3.2. **Related aims and co-benefits of sector policies to reduce GHGs at urban scale**

Sector	Climate policy aims and benefits	Other (non-climate change) benefits
Electricity production and industrial energy use	Encourage energy efficiency and fuel switching from coal and oil to low or no-emission energy sources, such as combined heat and power, renewable energy to reduce CO_2 emissions.	Improve urban air quality and limits regional SO_x and NO_x air pollution, preserve water quality, increase energy security, all of which can deliver local benefits.
Residential and commercial energy: buildings, office equipment and appliances	Lower energy use in housing and household services, reduce CO_2 emissions.	Lower investment costs for energy suppliers and possibly smooth load; lower operating costs for commercial entities and consumers and avoids regional air pollution from (unnecessary) electricity and/or heat generation; improve comfort and affordability; raise energy security.
Transport	Raise the efficiency and emission performance of vehicles and manage demand by encouraging use of less carbon-intensive modes of transport (*e.g.* public transit and bicycling), reduce CO_2 and possibly other GHG emissions.	Lower congestion in cities and reduce harm to human health from urban air pollution; lower dependency on oil imports to raise energy security. However, co-costs may also exist *e.g.* increased diesel fuel use lowers CO_2 but increases particulates, which have human health risks; also catalytic converters lower NO_x emissions but raise N_2O and CO_2 emissions.
Waste	Minimise waste, increase recycling and material efficiency in production and packaging, reduce CH_4 emissions.	Limit needs for costly and unsightly landfilling; improve economic performance.

Source: Hallegatte, S., F. Henriet and J. Corfee-Morlot (2008), "The Economics of Climate Change Impacts and Policy Benefits at City Scale: A Conceptual Framework", *OECD Environment Working Paper Series*, No. 4, OECD, Paris.

Mitigating greenhouse gas emissions provides public health benefits by reducing many dangerous air pollutants (OECD, 2008a), making improved public health an important co-benefit of efforts to reduce GHG emissions in metropolitan regions. Indeed, reduction in urban air pollution is an important component ofmany national estimates of climate change mitigation co-benefits (Cifuentes, 1999; Davis *et al.*, 2000; and Kunzli *et al.*, 2000). GHG emissions reductions may benefit human health to such a degree as to offset in large part the local costs of emissions reduction (OECD, 2001; Davis *et al.*, 2000; and IPCC, 2007).

Policies to reduce GHG emissions through increasing energy efficiency can also result in widespread benefits by significantly reducing energy costs for business, consumers and governments. Initiatives to improve building energy efficiency are examples of no-regrets strategies because the energy savings achieved can compensate for the initial investment costs in as little as a few years (Hallegatte *et al.*, 2008). Policies to reduce the amount of energy already going to waste in public buildings can therefore be cost-neutral if their implementation costs are compensated over time.

Both mitigation and adaptation policies can improve the security of local infrastructure and public services. Policies to mitigate greenhouse gases improve national security through reducing dependency on foreign energy sources and by reducing the risks involved in transporting highly combustible fossil fuels around the world (Schellnhuber *et al.*, 2004). Adaptation measures can also improve the security of an area's energy supply. For example, improving the resilience, efficiency and redundancy of energy supply networks protects against interruptions in electricity service during extreme heat events and also reduces the risk of shortfalls (peak demand outstripping supply) or intentional attacks on the system. Similarly, some infrastructure to protect coastal cities from storm surge and flood risks can be economically justified even at current sea levels (Hallegatte *et al.*, 2008).

Many of the measures that mitigate climate change and that help adapt to its effects also make cities more liveable and therefore potentially more competitive. For instance, cities that reclaim land in flood plains as part of adaptation plans can make this land available to the public as parks or recreational land. This provides an amenity to residents, removes buildings and other infrastructure from flood plains, reduces the urban heat island effect, helps control downstream flooding, provides habitat for animals, and limits water pollution by slowing storm water runoff into large bodies of water. Efforts to reduce personal vehicle use and increase use of mass transit can improve public safety and reduce traffic congestion and noise (Hallegatte *et al.*, 2008).

Adaptation to climate change and mitigation of climate change can also be complementary strategies. Adaptation focuses on expanding the ability to cope with changes in climate, whereas mitigation focuses on reducing the amount of change through reducing emissions or removing greenhouse gases from the atmosphere through sequestration. In choosing a portfolio of mitigation and adaptation measures, it may be necessary to make investment trade-offs between them. However, adaptation and mitigation can go hand in hand, for example when developing a decentralised energy system based on locally available energy sources. Here, GHG emissions may be lower, as may be the vulnerability to large-area outages from severe weather impacts.

Synergies between policies to reduce GHG emissions and adapt to expected climate change impacts are particularly important at the urban level. For example, efforts to reduce building energy demand for cooling can also reduce urban heat island effects and prevent electricity shortfalls and blackouts during extreme heat events. On the local level, adaptation and mitigation policies are deployed through the same policy sectors, including land-use planning, transportation, and building sectors, as opposed to the global scale, where mitigation and adaptation goals are designed separately. This synergy presents opportunities to design urban mitigation and adaptation policies within a consistent framework (Hallegatte *et al.*, 2008).

Notes

1. The baseline scenarios for both the IMACLIM-R and the OECD ENV-Linkages models, were made consistent through comparable exogenous assumptions on demographic trends, labour productivity, GDP trends (as a proxy for the intensity of economic activity), fossil energy prices, energy intensity of the overall economy and carbon tax trajectories.
2. Densification indicates policies that increase the number of people per km^2 in a given urban area. These include restrictive and enabling policies. The former actively pursue densification through policies such as green belts, whereas the latter are those that allow activity to be drawn to the core, such as public transportation systems or the elimination of distortions in the market such as taxes for deconcentration.
3. Such a road toll reduces average rather than marginal commuting costs by car (see Henderson, 1974, for the underlying economics of road pricing mechanisms).
4. Note that, in the IMACLIM-R model, the explicit representation of technologies through reduced forms of technology-rich bottom-up sub models allows for an explicit description of agents' decisions that drive the pace and direction of technical change. Moreover, consumption and investment choices in IMACLIM-R are driven by agents' imperfect foresight and explicit inertias on the renewal of equipments and technologies. The combination of these two features is the underlying explanation for moderate carbon abatement costs in IMACLIM-R's policy scenarios when compared to those in other general equilibrium models.
5. Note that a 450 ppm CO_2 scenario roughly corresponds to a 530-550 ppm of all GHG scenario.
6. This is the result for the OECD using the highest discount rate (7%) It is the difference between –0.72% with carbon prices alone and -0.37% with densification added.

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ANNEX 3.A1

Computable General Equilibrium Model of Cities and Climate Change: IMACLIM-R and OECD Metropolitan Database

The model and methodology

Approach and capabilities of the model

Our methodology is based on a model that takes into account patterns in OECD metropolitan regions and the feedback mechanisms that can take place between cities and more aggregate dimensions of the economy. Thus, the *OECD Metropolitan Database* is used to model the behaviour of cities through a general equilibrium model that allows for the interaction of such metropolitan regions and the national macroeconomic activity as well as carbon emissions affecting climate change. Understanding those feedback mechanisms is crucial to better inform on long-run trends of aggregate indicators of local and global economic development that are relevant for policy scenario analysis.

The model that is described in this paper yields information on the spatial and economic dimensions of the metropolitan regions such as: *i)* the social and economic aspects of the spatial structure of the metropolitan regions; *ii)* supply-side behaviour of the metro-regional economies; and *iii)* demand-side behaviour of the metro-regional economies. These dimensions of the urban economy allow the construction of an attractiveness indicator for metropolitan regions; differences in such attractiveness will determine the long-run spatial and economic development patterns of the 78 metropolitan regions, largely based on firms' migration decisions.

This model also has the capacity to predict the potential impacts of certain policies at the metropolitan region scale on energy consumption, carbon emissions and economic growth. Our analysis aims at comparing the impact of alternative policy measures at the metro-regional level on core economic and environmental variables. In terms of policy implications, the lessons emerging from the comparative analysis could provide useful information on the potential impact of alternative settings on carbon emissions. The modelling analysis can also be seen as a useful base for further studies of OECD metropolitan regions. To the best of our knowledge, studies combining the theoretical modelling approach and the empirical dynamic computable general equilibrium technique to the relationship between spatial development of metropolitan regions, location choices, energy consumption pathways and climate change are not available.

The model

In our model, the world is composed of many macro-regions each of which can be seen as a mass of metropolitan regions. We assume that each metropolitan region is monocentric and axi-symmetrical spreading along an one-dimensional space $x \in [-d; d]$, where d is the overall city size. Consistent with the traditional approach to urban and regional economics since von Thünen (1966), the central business district (CBD), situated at the origin $x = 0$, is the location where firms choose to distribute once they locate in the metropolitan region. All economic activities take place in the j-CBD, whereas the urban population is distributed within circular peripheral areas surrounding it. In our economy three types of decision makers exist: governments, producers, and consumers. We assume that the government chooses housing policies that maximise the utility of the representative consumer. Profit-maximising firms do not consume land, while utility-maximising workers do. Urban workers settled at a certain point x of d consume $\lambda_j(x)$ units of land and commute a distance x to the CBD. The number of urban workers L_j is given by:

$$L_j = \int_{0 \le x \le d} \frac{\mathrm{d}x}{\lambda_j(x)} \qquad (1)$$

At land market equilibrium, workers are indifferent between any x-location around the CBD of metropolitan region $j \in J$. This comes down to assuming that all people living inside each peripheral ring at each point x face identical external costs. More specifically, the interplay between different commuting costs (based on the distance between each individual's residential place and the CBD, where jobs and all varieties of the differentiated goods are available) and housing costs (being heterogeneous the value and the consumption of land throughout the periphery) are homogenous within each peripheral ring.

Governments own the available land and determine the spatial distribution of housing supply. Hence, heterogeneity of density within the metropolitan region does not result from households' preferences over the available land but is rather exogenously set. We take the trend for the density function $\lambda_j(x)$ as given and choose a power functional form for the sake of simplicity.

$$\lambda_j(x) = \lambda_j^* x^{\xi}, \text{ with } \quad 0 \le \xi \le 1 \qquad (2)$$

[1]

As in Murata and Thisse (2005), each urban worker supplies one unit of labour. Considering unitary commuting costs $\theta_j \ge 0$ in the iceberg form in line with Samuelson (1954),[2] the effective labour supply of a worker living in the urban area at a distance x from the CBD is:

$$s_j(x) = 1 - 2\theta_j x, \text{ with } -d_j \le x \le dj \qquad (3)$$

Condition: $\theta_j \le \frac{1}{2d_j}$ ensures positive labour supply. The total effective labour supply throughout the urban area is therefore:

$$S_j = \int_{-d_j \le x \le d_j} \frac{s_j(x)}{\lambda_j(x)} \mathrm{d}x = \frac{2d_j^{1-\xi}}{\lambda_j^*(1-\xi)} \left(1 - 2\theta_j \frac{1-\xi}{2-\xi} d_j\right) \qquad (4)$$

whereas the total potential labour supply is given by:

$$L_j = \int_{-d_j \le x \le d_j} \frac{1}{\lambda_j(x)} \mathrm{d}x = \frac{2d_j^{1-\xi}}{\lambda_j^*(1-\xi)} \qquad (5)$$

Letting w_j be the wage rate firms pay to workers to carry out their activity within the j-urban area, commuting costs CC_j faced by one worker in the metropolitan region j result from the losses of effective labour. Combining (4) and (5), we obtain:

$$CC_j = \frac{\left(L_j - S_j\right) w_j}{L_j} = \frac{2}{\lambda_j^* \left(1-\xi\right)} \frac{1-\xi}{2-\xi} \theta_j d_j \tag{6}$$

We normalise at zero the rent value of the land located at the edges of the city: $R_j(d_j) = 0$. Given that all urban workers are identical from a welfare perspective, using (3) the value of commuting costs $2\theta_j x$ and rent costs $R_j(x)$ is the same throughout the urban city. Precisely:

$$2\theta_j d_j w_j + \lambda_j(x) R_j(x) = s_j(d_j) w_j + 0 = s_j(-d_j) w_j + 0 = (1 - 2\theta_j d_j) w_j \tag{7}$$

From (7), the equilibrium land rent is simply derived, as follows:

$$R_j(x) = \frac{2\theta_j \left(d_j - |x|\right)}{\lambda_j(x)} w_j \tag{8}$$

In order to understand how the land rent is distributed among urban workers by the local government, we first calculate the aggregated land cost by integrating $R_j(x)$ over distance x that represents the available urban land, and then divide the resulting figure by the labour force that is active in the city:

$$RC_j(x) = \frac{\int_{-d_j \le x \le d_j} \lambda_j(x) R_j(x) \frac{1}{\lambda_j(x)} \mathrm{d}x}{L_j} = 2\theta_j w_j \frac{1}{2-\xi} \tag{9}$$

Combining (6) and (9) gives $\frac{CC_j}{RC_j} = 1-\xi$ which determines the distribution of external costs over commuting and housing: the lower ξ, the more commuting costs are relatively important. From each labourer's income, an amount: $CC_j + RC_j = ECL_j$ is deduced as compensation to live in the urban area. This amount is expected to affect consumers' purchasing power Υ_j.

Consumption

We consider a macro-regional economy to be comprised of a mass of metropolitan regions (labelled $j = [1; J]$), including two sectors, one composite sector D of the IMACLIM-R manufacturing-plus-service type taking place in a j-metro-regional agglomeration, and one traditional sector F that is active in the non-metro-regional land. We assume that the many firms of the manufacturing-plus-service type produce each one variety (labelled $I = [1; N]$) of one type of the differentiated good q under increasing returns to scale. Therefore, the number of available varieties in each metropolitan region j, $n_j \in N$, is equal to the number of firms that are active in the same metropolitan region. The traditional good is produced under Walrasian conditions (constant returns to scale and perfect competition) and can be freely traded across metropolitan regions. At any time, by assuming the well-known iceberg structure for transport costs (Samuelson, 1952), any variety of the composite good can be traded between two regions. Transportation costs are zero for intra-regional shipment of both goods. We extend the standard NEG literature (Krugman, 1991) by tracking bilateral flows for the mass of metro-regional agglomerations, so that a quantity $c_{jk}(i)$ of a variety produced in metropolitan region j is consumed in k and purchased at a price p_{jk}. We define a price index P_j of the composite good available in j in order to be able to treat the various products as a single group.

$$P_j = \left[\int_{i=1}^{n_j} p_{jj}(i)^{1-\varepsilon} \mathrm{d}i + \int_{k \neq j} \int_{i=1}^{n_k} p_{kj}(i)^{1-\varepsilon} \mathrm{d}i\mathrm{d}k \right]^{\frac{1}{1-\varepsilon}} \tag{10}$$

Here $\varepsilon > 1$ is the elasticity of substitution between varieties. The economy employs a unit mass of mobile workers L wherever they are employed. Workers (L) are both input production factors and output end-users. Given a certain net income Υ_j, individuals should decide allocating over the consumption of the above described differentiated good D (produced in the metropolitan regions), and a "traditional" good F (freely traded and purchased at a homogenous price p_F). We consider that households that reach identical welfare levels and bare identical external costs ECL_j stemming from being located in the j-metropolitan region (see equation [7]). Given individual's utility U_j defined over the disposable income Υ_j for consumption in each j, welfare maximisation behaviour imposes:

$$max\ U_j = U_j[D_j(\Upsilon_j), F_j(\Upsilon_j)] \tag{11}$$

For the sake of simplicity, we choose a Cobb-Douglas functional form for the utility function:

$$U_j = (D_j)^{\beta}(F_j)^{1-\beta}(Z_j)^{-\zeta} \tag{12}$$

where, $Z_j = k_j Q_j = k_j n_j q_j$ captures the negative environmental externalities associated with production Q_j via a j-specific coefficient k. The intensity of the environmental burden is measured by the parameter ζ. Price and utility homogeneity throughout the j-metropolitan region impose that aggregate consumption of the composite good is independent on the distance x from the j-core. The constant-across-metropolitan region sub-utility from aggregate consumption of all the varieties composing the manufacturing good is:

$$D_j = \left[\int_{i=1}^{n_j} c_{jj}(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i + \int_{k \neq j} \int_{i=1}^{n_k} c_{kj}(i)^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}i\mathrm{d}k \right]^{\frac{\varepsilon}{1-\varepsilon}} \tag{13}$$

The representative consumer has to satisfy the following budget constraint:

$$\int_{i=1}^{n_j} p_{jj}(i) c_{jj}(i) di + \int_{k \neq j} \int_{i=1}^{n_k} p_{kj}(i) c_{kj}(i) \mathrm{d}i\mathrm{d}k = \Upsilon_j \tag{14}$$

where Υ_j is the net disposable income for consumption, already discounted from external costs for workers ECL_j (see equation [7]). Maximising utility given in (12) subject to (14) gives the aggregate demand in metropolitan region j for the variety i produced in metropolitan region k:

$$c_{kj}(i) = L_j \Upsilon_j \frac{(p_{kj})^{-\varepsilon}}{(P_j)^{1-\varepsilon}} \tag{15}$$

Production

All firms producing in a given metropolitan region j incur the same production costs and rely upon the same capital and labour as spatially mobile input factors. We consider labour as subject to external economies of scale resulting from improved production process through some metropolitan region-specific technology spillover, as follows:

$$l_j = \frac{l_{j,0}}{n_j^{\alpha}} \tag{16}$$

where l_j is the effective unitary labour input requirement for production, n_j is the given number of active firms in region j, α is a parameter that captures the non linearity of the external agglomeration effect (Fujita and Thisse, 1996; Grazi *et al.*, 2007), and $l_{j,0}$ is the agglomeration-specific unitary labour input requirement for production in absence of agglomeration effects ($\alpha = 0$).

Due to the fixed input requirement, the amount of productive capital in metropolitan region j, X_j is proportional to the number of domestic firms, n_j:

$$X_j = xn_j \quad (17)$$

Firms of the above type find it profitable to join a certain metropolitan region j to benefit from a specialised labour market. This brings about differences in terms of labour productivity between producing inside and outside the metropolitan region. To avoid all firms concentrating in the same place because of absent specific differentiation, we introduce inherent reasons for differential location choices. We therefore assume that firms choose to locate according to the trade-off between production benefits and costs that are specific of the metropolitan region j. Concerning the former, they take the form of heterogeneous labour productivity across different metropolitan regions (that is $l_j \neq l_K$), whereas the latter (*i.e.* production costs) are indirectly captured by the different labour costs (namely, the wage rate w_j) firms face across the different metropolitan regions to compensate workers for the metropolitan region-specific external costs. Letting r_j and w_j the unitary returns of, respectively, capital X_j and labour l_j, the total cost of producing q_j for a firm $I \in n_j$ in region j is expressed as:

$$TC(i) = r_j x + l_j w_j q_j(i) \quad (18)$$

Given its monopoly power, it is clear that each firm acts to maximise profit:

$$\pi_j(i) = p_j q_j(i) - [r_j x + l_j w_j q_j(i)] \quad (19)$$

In order to integrate the spatial dimension into the model, trade is allowed between the metropolitan regions. We use the iceberg form of transport costs associated with trade of composite goods (Samuelson, 1952). In particular, if one variety i of manufactured goods is shipped from metropolitan region j to metropolitan region k, only a fraction will arrive at the destination, the remainder will melt during shipment. This means that if a variety produced in location j is sold in the same metropolitan region at price p_{jj}, then it will be charged in consumption location k at a price:

$$p_{jk} = T_{jk} p_{jj} \quad (20)$$

where $T_{jk} > 1$ captures the trade cost from metropolitan region j to metropolitan region k.

As already mentioned, the freely tradable traditional good F is produced under constant returns to scale and perfect competition. Letting r_F and w_F be the unitary returns of, respectively, capital X_F and labour l_F, the total cost of producing q_F for a firm settled outside the metro-regional area is expressed as follows:

$$TC_F = (r_F X_F + l_F w_F] q_F \quad (21)$$

In such a perfectly competitive market, the price of the traditional good is obtained directly from marginal production costs:

$$p_F = r_F X_F + l_F w_F \quad (22)$$

Short-run market equilibrium

Given n_j firms operating in the metropolitan region j, the labour-market equilibrium condition posits that the total labour effectively supplied S_j (see equation [4]) is equal to the total labour requirements by production $l_j n_j q_j$:

$$S_j = L_j\left[1-2\frac{1-\xi}{2-\xi}\theta_j d_j\right] = l_j n_j q_j \tag{23}$$

where, we recall, d_j is the size of metropolitan region j, θ_j is the unitary commuting cost in metropolitan region j and $n_j q_j$ is the total domestic production of the composite good.

Moreover, the market clearing condition imposes that all that is produced by firms is also consumed by individuals. Hence, production size $q_j(i)$ of a firm located in region j is as follows:

$$q_j(i) = c_{jj}(i) + \int_{k\neq j} T_{jk} c_{jk}(i)\mathrm{d}k \tag{24}$$

For the sake of simplicity and without loss of generality we consider that all varieties are identical. This allows us to drop the notation i for the variety in the remaining analysis. In particular, the price index in (10) can be re-written as: $P_j = \left[n_j p_j^{1-\varepsilon} + \int_{k\neq j} n_k \left(T_{kj} p_k\right)^{1-\varepsilon}\mathrm{d}k\right]^{\frac{1}{1-\varepsilon}}$

By plugging (15) into (24), we obtain the equilibrium production of one firm operating in metropolitan region j.

$$q_j = L_j \Upsilon_j \frac{\left(p_j\right)^{-\varepsilon}}{\left(P_j\right)^{1-\varepsilon}} + \int_{k\neq j} T_{jk} L_k \Upsilon_k \frac{\left(T_{jk} p_k\right)^{-\varepsilon}}{\left(P_k\right)^{1-\varepsilon}}\mathrm{d}k \tag{25}$$

As a consequence of profit maximisation behaviour, firms will enter and exit the manufacturing sector until the point at which profits are zero, as an equilibrium condition of monopolistic competition. Therefore, by substituting (25) into (19) and setting $\pi_j = 0$, the return to capital r_j at equilibrium is straightforwardly obtained:

$$r_j = \frac{\left(p_j - l_j w_j\right) q_j}{\chi} \tag{26}$$

Recalling that p_j is the price of a variety i that is both produced and sold in metropolitan region j, under the Dixit-Stiglitz monopolistic market we see that a profit-maximising firm sets its price as a constant mark-up on variable cost by assuming a constant elasticity of substitution (CES), $\varepsilon > 1$:

$$p_j = \frac{\varepsilon}{\varepsilon-1}\frac{\partial TC_j}{\partial q_j} = \frac{\varepsilon}{\varepsilon-1}\frac{l_j w_j}{n_j^{\alpha}} \tag{27}$$

All varieties are sold in the metropolitan region at the same price and no trade costs occur to spatially differentiate the market value of a given variety. It is worth describing what we consider as the wage rate w_j. In our spatial economy, a fraction of the whole available land hosts metro-regional activities. The equilibrium on workers' migration imposes that the utility level *per unit of labour* reached by living within the j-metropolitan regional area is identical to the one achieved within the k-one. This is because certain beneficial effects are expected to be homogeneously faced by individuals as they decide to enter the metro-regional market.

Workers will chose to enter the metro-regional market if the utility they reach there is at least equal to level of (unitary, per unit of work) utility in the outside area, u^*.

$$\frac{\left(D_j\right)^{\beta}\left(F_j\right)^{1-\beta}\left(\kappa_j n_j q_j\right)^{-\delta}}{l_j n_j q_j} = u^* \tag{28}$$

Our model allows for income distributional effects and assumes that all revenues produced in metropolitan region j are redistributed locally. In other words, the aggregate revenue in metropolitan region j, $L_j Y_j$ equals the sum of total wages $l_j w_j n_j q_j$ and return to capital $r_j X_j$: $L_j Y_j = l_j w_j n_j q_j + r_j X_j$:[3]

Utility maximisation under the Cobb-Douglas specification in (1) leads to the following identities between prices and quantities for the two market goods: $P_j D_j = \beta Y_j$ and $p_F F_j = (1 - \beta) Y_j$. Substituting the two identities into (28) gives the equilibrium wage rate for a worker in metropolitan region j:

$$w_j = u^* \frac{\varepsilon - 1}{\varepsilon \beta^{\beta} (1-\beta)^{(1-\beta)}} P_j^{\beta} p_F^{(1-\beta)} \left(\kappa_j n_j q_j\right)^{\delta} \tag{29}$$

The long-run model

This chapter extends the short-run model so as to address dynamics over time and ensure analytical consistency for inclusion in the IMACLIM-R framework as a specific module accounting for the spatial organisation of the economy at the urban scale. Dynamics in our modelling framework are carried out in two steps.

Spatial disaggregation

We consider the IMACLIM-R static equilibrium at time t. At this time, macroeconomic information at the macro-regional and national levels are disaggregated into a combination of local urban economies where the interactions between economic agents occur in the form developed in the previous sections.

In each metropolitan region j at time t, a fixed number of profit-maximising firms $n_j(t)$ sets prices $p_j(t)$ and quantities $q_j(t)$ to meet households' demand for the composite good D, according to (25) and (27). Labour requirement for production drives population distribution $L_j(t)$ and metropolitan region size $d_j(t)$ through relations (23) and (5), respectively. Consistency between descriptions of the economy at the metro-regional and macro-regional or national scales requires ensuring that the average value of each spatially disaggregated (*i.e.* metro-regional) variable equals the value of the corresponding aggregate (macro-regional) variable resulting from the IMACLIM–R equilibrium.

Firm mobility

The second step of the module describes firms' location decisions and induced changes in the spatial distribution of firms and productive capital in the national economy. Metropolitan regions differ in labour and infrastructure endowments, captured in the model by labour productivity l_j and unitary commuting costs θ_j, respectively. These j-specificities act as constraints on production expectations (through [18]) and expected capital returns (through [26]), and hence influence the attractiveness of metropolitan regions for productive investment. The attractiveness of metropolitan regions ultimately affects the migration decisions of firms.

Location decisions across the set of available metropolitan regions at time t are taken by firms on the basis of an index of relative attractiveness $a_j(t)$ that accounts for the capital return investors expect to receive from investments in a given metro-regional market. This reflects the active role of shareholders who want to maximise the return to capital, which is *a priori* a cost to firms. The relative attractiveness $a_j(t)$ helps determine the stable spatial distribution of firms across the available metropolitan regions at equilibrium time $t + 1$, $n_j(t + 1)$.

Two types of firms base their location decisions on $a_j(t)$: the existing firms at previous equilibrium time, and the newly created firms. For each of the two groups of firms we are able to establish the stable number of firms at a given equilibrium time.

i) First, consider the case of two metropolitan regions labelled j and k, with $j, k = (1; 2)$; $j \neq k$. For a generic old j-firm (that is a firm coming from previous equilibrium time and settled in metropolitan region j), the magnitude of the incentive to migrate to k depends on the relative attractiveness of metropolitan region j:

$$m_{j \to k} = \pm \left| a_k(t) - a_j(t) \right|^{\gamma_1} \left(\frac{1}{\delta_{jk}} \right)^{\gamma_2} \left| \frac{1}{l_k(t) - l_j(t)} \right|^{\gamma_3} \quad (30)$$

where δ_{jk} is the distance between the metropolitan regions j and k, $l_k(t)$ measures the productivity of labour in metropolitan region k, and γ_1, γ_2, γ_3 (such that $\gamma_1, \gamma_2, \gamma_3 > 0$ and $\gamma_1 + \gamma_2 + \gamma_3 = 1$) represent the measurement of the relative migration incentive of, respectively, attractiveness, distance, and labour productivity.

Equation (30) writes that a generic j-firm is encouraged to move to k from metropolitan region j if condition: $a_k(t) - a_j(t) > 0$ is verified (as this ensures $m_{j \to k} > 0$). The magnitude of this incentive is a function of: *i)* the difference in relative attractiveness between metropolitan regions; *ii)* the physical distance δ_{jk} between them; and *iii)* the absolute difference between metropolitan regions in the structure of production, as captured by the labour productivity term $l_k(t) - l_j(t)$. Extending (30) for a more generic application, in which many alternative metropolitan regions are spatially available, the incentive to move to an metropolitan region j from any other k (with $j, k = (1; J)$ and $j \neq k$) is derived as follows:

$$M_j = \mu^M \int_{k \neq j} m_{j \to k} \mathrm{d}k \quad (31)$$

where μ^M is a parameter that homogenises the units of measurement.

ii) Consider now the case of new firms that are created at the equilibrium time t. They spatially sort themselves across the J metropolitan regions according to the value of relative metro-regional attractiveness. The number of firms created in metropolitan region j is proportional to the emerging force E_j:

$$E_j(t) = \mu^E a_j(t) \quad (32)$$

where μ^E is a parameter that homogenises the units of measurement. Given the economy size at time t, the total number of firms in metropolitan region j at the equilibrium time $t + 1$ results from the interplay between firms' migration decisions from other metropolitan regions and entry of new firms:

$$n_j(t+1) = n_j(t) + M_j(t) + E_j(t) \quad (33)$$

The absolute attractiveness $A_j(t)$ of a j-metropolitan region is given by the absolute variation of firms between consecutive equilibria, $n_j(t+1) - n_j(t)$, so that:

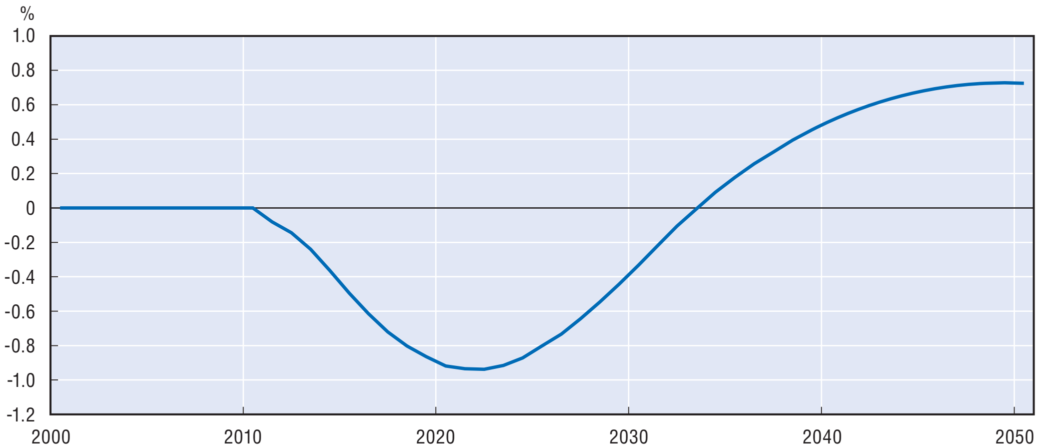
$$A_j(t) = M_j(t) + E_j(t) \quad (34)$$

Main results of the model with a climate policy only

Considering the evaluation of possible impacts of local policies, it is important to bear in mind the impacts that a carbon policy alone might entail without the urban module in the IMACLIM-R model. The results in terms of cost effects of implementing a single carbon tax can be expressed as the ratio of GDP under the carbon tax compared to the baseline scenario (no carbon tax). In the first 20 years of the carbon tax implementation period the OECD economy faces significant, yet temporary, losses with respect to the baseline (in which no tax is put into operation). This is due to the initially strong increase of the price of carbon, which tends to accelerate technical change despite the inertias characterising the renewal of production equipment, technologies and infrastructure. By 2032, the improvement of energy efficiency confirms to be highly beneficial for economic activity, especially because it renders the economy less vulnerable to oil shocks. This is captured by a rapid increase in GDP (Figure 3.A1.1).

Figure 3.A1.1. **Economic impact of a climate policy alone using the baseline scenario**

Ratio of OECD GDP under climate policy to OECD GDP under baseline scenario



Source: Calculations based on *OECD Metropolitan Database* and IMACLIM-R.

StatLink http://dx.doi.org/10.1787/888932342449

Notes

1. Condition $\xi \geq 0$ ensures that $\lambda_j(x)$ is an increasing function, so that the empirical evidence of higher population density in the centre of the city is captured. Condition $\xi \leq 1$ is necessary to have population convergence in (1).
2. Considering different unitary commuting costs θ_j across the agglomerations captures the specificities of each agglomeration in terms of modal shares and transport infrastructures.
3. Note that implicitly, this expression means that the housing rents are also redistributed across households, as they do not appear in the income formation.

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PART II

Competitiveness Policies

PART II

Chapter 4

The Urban Policy Package

While the international community has been struggling to agree on climate change targets and co-ordinated approaches to fight global warming, and many national governments have begun to act, a growing number of cities and regions have also taken initiatives to reduce their energy use and GHG emissions and to begin to adapt to climate change. Cities and regions in many OECD countries have key responsibilities in the urban sectors that can provide valuable strategies for fighting and adapting to climate change, including policies that affect transportation and the built environment. With the help of strategic planning tools, policies at the local level can establish complementary policy packages that bring together territorial strategies and sectoral policies. Chapter 4 reviews policy tools to address climate change at the local level in the sectors of land-use zoning, natural resources, transportation, building, waste and water. The question of effective urban policy packages intersects with the concept of urban spatial density, a major driver of CO_2 and N_2O emissions. This chapter also assesses different characteristics of urban densification policies and their effectiveness in meeting environmental goals whilst ensuring that cities remain attractive in the long term.

Key points

Cities have key competencies to act on climate change and can serve as policy laboratories for innovative responses to climate change

- Urban decision makers determine or influence public transportation systems, the built environment, renewable energy and energy efficiency policies and measures. They also oversee the sustainability of public service delivery. Cities and metropolitan region authorities are thus well positioned to develop policy and programmatic solutions that best meet specific geographic, climatic, economic and cultural conditions. Urban authorities are equally well placed to develop innovative policy solutions that, if successful, can be scaled up into regional or national programmes, thus acting as a testing ground for national pilot programmes on the urban level.
- Urban governments are taking serious action on climate change – even in the absence of national policies – through local regulations, urban services, programme administration, city purchasing and property management, and convening of local stakeholders. While some local and regional governments have taken action independently, others have benefited from guidance provided by networks of local governments and transnational networks. Important opportunities exist where cities are purchasers or service providers (water services system, capture of methane gas from landfills for energy…), but many city authorities could still make greater use of their regulatory authority to achieve climate goals.

Systematic, multi-sectoral strategic planning is required to exploit synergies between climate and other urban policy goals

- Effective climate policy packages seek complementarities among and within urban sectors to implement policies that enhance each other's effectiveness. For example, land-use zoning policies that allow for higher densities and greater mixing of residential and commercial uses can enhance transportation climate goals by reducing trip distances and frequency (and hence emissions associated with transportation) while strategic mass transit linkages can attract development and promote compact growth. Important opportunities also exist at the urban level to develop and exploit adaptation and mitigation win-wins.
- Successful policies for compact cities rely on strategic urban plans. While the higher residential densities targeted by these policies have the most direct effect on greenhouse gas emissions, transportation linkages – particularly between employment centres and residential zones – are crucial to ensuring that increases in density translate into reductions in personal vehicle use. Mixed land uses in urban neighbourhoods and high quality urban services and amenities, including open space, are also crucial to the long-term attractiveness and effectiveness of compact cities policies.
- Long-term strategic planning needs to take into account interaction between urban development and vulnerabilities to climate change. Cities and urban planning provide a key entry point to act on the adaptation agenda and reduce vulnerabilities. However, adaptation is made difficult by the fact that modifications to urban infrastructure and the built environment may be expensive, especially if not designed up front, as land-use and infrastructure changes occur only over decades and urban buildings typically last 50 to 100 years or longer. As a consequence, urban adaptation options often must be anticipated by at least a few decades to be effective. A risk management strategy that has both near and longer term co-benefits is likely to be most attractive given inevitable resource constraints.

Many cities and metropolitan regions in the OECD are taking action on climate change – even in the absence of national policy or commitments – not only out of recognition of cities' contributions to and risks from climate change, but also of the opportunities to achieve synergies and lower the potential tradeoffs between economic growth and environmental priorities. As primary locations of energy consumption, cities are searching for ways to lessen their impact on and prevent damage from climate change while also remaining economically competitive. Cities and regional governments – both small and large – are well positioned to tackle certain types of climate policies, particularly those relating to spatial development and the built environment, transportation, natural resources management, and urban utilities. How can urban areas maximise the impact of their climate activities while minimising abatement costs? This chapter discusses opportunities to most effectively apply urban resources to address climate change by prioritising: *i)* policies that are natural extensions of existing modes of urban governance; and *ii)* packages of complementary policies. This is followed by a consideration of the underlying impact of urban spatial development decisions on future energy demand and preparedness for climate impacts. Opportunities to apply long-term strategic planning to future GHG emissions and adaptation scenarios are then presented.

Urban governance and policy complementarities

A key indication of urban areas' increasing interest and sense of responsibility in responding to climate change is the proliferation of local climate plans, strategies and policies in recent years. Many cities across the OECD have identified opportunities for mitigation and adaptation activities and have implemented them through locally tailored and often innovative programmes. Cities have also set targets for greenhouse gas (GHG) reductions, some beyond national commitments, or in the absence of national action. They include for instance, London, which in its Climate Change Action Plan, established in March 2007, calls for a 60% reduction from 1990 to 2025; New York's "A Greener, Greater New York campaign", set up in April 2007, calling for a 30% reduction from 2005 to 2030, and Tokyo's Climate Change Strategy, established in June 2007, calling for a 25% reduction from 2000 to 2020. Through the US Mayors' Climate Protection Agreement, more than 1 000 mayors have agreed to meet or exceed Kyoto Protocol targets even though the US government has not ratified the Protocol.[1] While some local and regional governments have taken action independently, others have benefited from guidance and/or support provided by networks of local governments as well as, in some instances, from their national or regional governments (see Chapter 8). These include the Nottingham Declaration in the United Kingdom (signed by 300 local authorities)[2] and transnational networks such as ICLEI, the METREX $EUCO_2$ 80/50 project, and the EU Covenant of Mayors.[3] Urban climate action has also developed in response to national government mandates, such as Japan's Act on Promotion of Global Warming Countermeasures, which requires local governments to formulate climate change action plans.[4]

The context for urban policy making and programme implementation often involves multiple levels of governance. Cities often need to collaborate with other cities and higher levels of government – as well as private sector and non-governmental stakeholders – to gain the authority, technical expertise, community support and funding needed to establish and achieve their climate policy goals. This can require vertical co-ordination among local, regional and national governments, and horizontal co-ordination among the range of agencies engaged in climate policy within a local government, as well as among the local governments within a region (see Chapter 7). In some cases, the role of local governments is to administer national programmes or apply for and redistribute national funding. In other cases, urban areas act independently of outside programmes and may even innovate policy solutions that later get scaled up to the regional or national levels.

Urban areas in general engage in at least four modes of governance through which they can design and implement climate change policy responses. These (adapted from Kern and Alber in OECD, 2008 and Bulkeley and Kern, 2006) are:

i) **Self-governing: the municipality as consumer.** Sub-national governments can limit their own consumption and ecological footprint through municipal operations management, including such efforts as promoting the energy efficiency of municipal buildings and the greening of public transport vehicles.

ii) **Governing by provision: the municipality as provider.** Governing by provision is accomplished by influencing infrastructure development, programme administration and service delivery in the provision of urban services (*e.g.* transportation, water, electricity, public housing, natural resources management, etc.).

iii) **Governing by authority: the municipality as regulator.** Local governments may enact regulations to curb CO_2 emissions or adapt to climate change impacts if they have legal jurisdiction over relevant policy areas such as energy (*e.g.* through building codes), urban transport, land use, waste and other natural resources (*e.g.* wetlands and parklands management).

iv) **Governing through enabling: the municipality as a facilitator.** The municipality can facilitate co-ordination with private and community actors, such as by establishing public-private partnerships for the provision of services and infrastructure.

These modes of urban governance point to opportunities for local policy action on climate change in key urban sectors: land-use zoning, natural resources management, transportation, building, and to a lesser extent renewable energy and urban utilities (waste and water services). Self-governance particularly affects the GHG emissions and climate vulnerabilities of government-owned or managed infrastructure, buildings, property and natural resources. Governance through service provision shapes GHG emissions generated by mass transit networks, waste collection, water provision, and, in some cities, energy delivery, as well as these services' vulnerability to climate-related disruptions. City and regional regulations allow urban governments to meet climate policy goals by mandating, prohibiting, or attaching costs to activities related to land use and development, vehicle use, building energy efficiency, generation and use of renewable energy, and waste generation and management. Their proximity and familiarity with local business and interest groups puts urban governments in a position to inform and enable efforts by the local private sector, civil society organisations and individual residents to reduce GHG emissions and prepare for climate change impacts.

City and regional governments may more easily identify and combine complementary climate policies within and across sectors than higher levels of government, given the interconnectedness of urban policy sectors. The existence of a policy complementarity signals a benefit in the form of the return generated when one policy is enacted along with another (De Macedo and Oliveira Martins, 2006). Identifying the impact and benefits that policy sectors can have on each other is essential to designing policy packages that enhance the effectiveness of each individual policy. Some urban sectors are particularly interlinked to others, and thus can enhance or undermine the effectiveness of other sectoral policies. As Table 4.1 and Figure 4.1 present, land-use zoning, *i.e.* the decisions

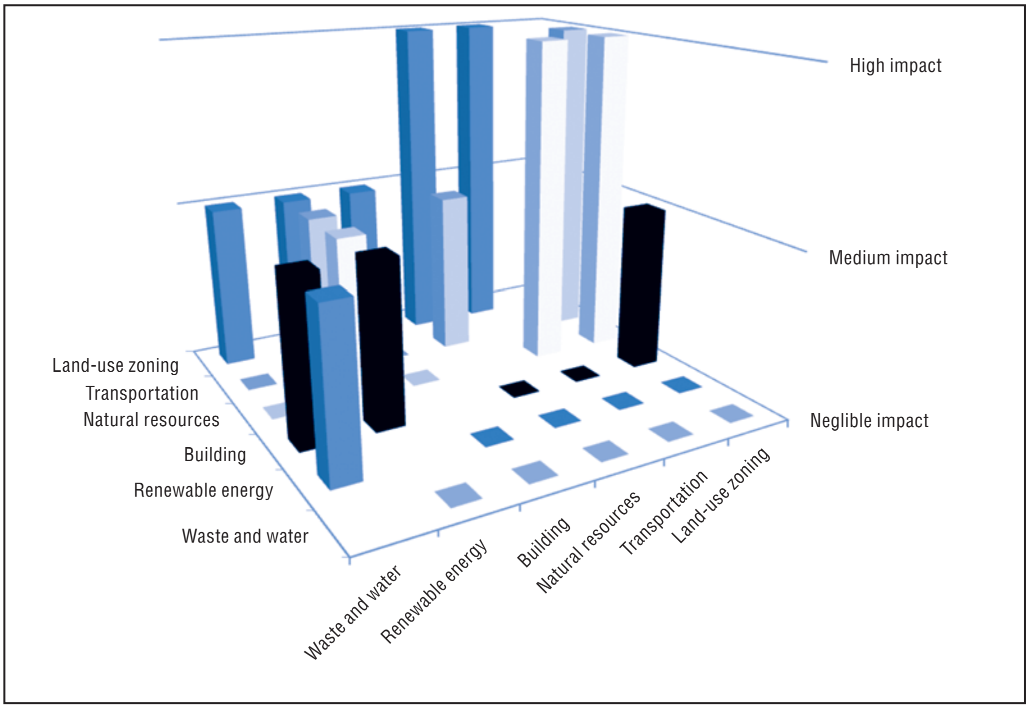
Table 4.1. **Urban sectoral interactions: Potential for climate policy complementarity and tradeoffs**

Impact → (reads horizontally)	Land-use zoning	Transportation	Natural resources	Building	Renewable energy	Waste and water
Land-use zoning *Land-use zoning determines the density, height of buildings, and proportion of undeveloped land on each property.*	–	Segregation of land uses impacts travel distances and frequency; transit-oriented development zones encourage use of mass transportation.	Zoning designates natural resource areas that may be set aside to reduce vulnerability to flooding or urban heat island effects.	Zoning impacts placement and density of buildings, which in turn impacts building energy efficiency and vulnerability to flooding and urban heat effects.	Zoning density can constrain on-site renewable energy production but can also increase efficiency of service delivery.	Zoning density can determine the efficacy of delivery of waste, recycling and composting services; and the energy required for and efficacy of delivery of water services.
Transportation *Transportation policies determine the development and extension of road and mass transportation networks.*	Transportation infrastructure policies shape demand for land and acceptance of density increases.	–	Transportation systems impact natural resource and preserved zones.		Transportation policies can require renewable energy sources for mass transportation systems.	
Natural resources *Natural resource policies determine which areas are preserved from development and what uses are acceptable on them.*	Natural resource policies determine the limits of developed land-use zones and can improve quality of high-density zones.	Natural resource policies affect the placement of road and mass transportation infrastructure.	–		Natural resources endowment makes certain renewable energies possible.	
Building *Building policies, including building codes, affect building materials, construction types, and other physical conditions.*	Building codes can increase acceptability of high-density zones by requiring design features to improve quality of high-density structures.			–	Building codes can require the on-site generation of renewable energy.	Building codes can require design and building materials that produce less construction waste and reduce water consumption in buildings.
Renewable energy *Renewable energy policies can increase on-site renewable energy production and share of energy produced by renewable sources.*					–	Renewable energy production can involve high water consumption.
Waste and water *Waste policies determine the means and extent of waste disposal. Water policies determine service extent, pricing, and water sources.*						–

Note: Policy sectors with no shading demonstrate highest impact. Policy sectors with shading demonstrate lower impact. Policy sectors with dark blue demonstrate negligible or no impact.

regarding the location and density of residential, commercial, industrial land uses, among others, has the widest influence on other sectors. Transportation policies are also interlinked with land-use zoning, natural resources management and use of renewable energy, as they affect the amount and type of energy required to travel between activities within a metropolitan region as well as the impact and vulnerability of transport infrastructure relative to the surrounding environment. Policy complementarity within

Figure 4.1. **Urban sectoral interactions: Impact on other sectors' climate policies**



StatLink http://dx.doi.org/10.1787/888932342468

each sector is also crucial, and more easily co-ordinated at the urban scale. For example, transportation polices to limit personal vehicle use are enhanced by policies to increase mass transportation options, two areas where municipal governments often have the authority and capacity to act.

Land-use zoning policies

Land-use zoning policies have a wide-ranging, long-term and yet underlying effect on sectoral policies to address climate change. Spatial planning affects the placement of the built environment, and therefore the distances required for urban travel, the energy required to heat and cool buildings, and the vulnerability of the built environment. Urban master plans and land-use zoning policies determine the set of land uses that are allowed in a particular zone – at the most basic level these include residential, commercial, industrial, open space and mixed uses – and the degree to which land uses are separated from one another. These decisions shape the built environment and determine long-term travel patterns, building placement, access to amenities and exposure to natural hazards. This section presents the impact of land-use zoning policies on other sectoral climate change policies; the following section discusses the impact of density and "compact city" policies.

Land-use zoning policies impact transportation GHG mitigation policies by determining the degree of segregation among land uses and therefore the energy required to travel between home, work, shopping and other activities. The degree to which these uses may be segregated varies with how restrictively zones are defined. For example, German residential zoning is often more flexible than its American counterpart, as it allows for doctors' offices, hostels, small hotels, and multi-story apartment buildings to be co-located, while most residential zones in the United States are restricted to single-family dwellings (Buehler *et al.*, 2009). The establishment of mixed-use zones, which allow for the development of a combination of business and residential uses, is one way of providing alternatives to segregated zoning. However, where mixed-use zones are not the norm, such as in the United States, they are typically only applied in specially designated districts where their impact is limited (Hirt, 2007).

Land-use zones that allow for transit-oriented development can facilitate increased use of public transportation (Hankey and Marshall, 2010; Ishii *et al.*, 2010). While it may not change trip distances or frequencies, it can decrease the distances between mass transit stations and residences, places of work and retail. The City of Toronto has created policies to encourage or require mass-transit oriented development, in addition to policies to facilitate density in the urban core and mixed-use (residential and commercial) development.[5] The City of Toyoma, Japan, is pursuing transportation-oriented growth by concentrating city functions such as residential, commercial, business, and cultural facilities along a newly established light rail line, built over an underused long-distance rail line (Mori in OECD, 2009b). Arlington County, Virginia, promotes transit-oriented development around the light rail system by providing density credits that allow for higher density buildings, increasing parking requirements and improving infrastructure around transit stations. As with mixed-use zones, transit-oriented development zones are often exceptions to traditional land-use zones and therefore can be limited in their reach. Comprehensive reform may require an overhaul of residential zoning codes to systematically allow non-residential uses rather than the piecemeal designation of mixed-use zones (Hirt, 2007).

Land-use planning tools also have a fundamental impact on natural resource management. They present a primary means for cities to adapt to potential climate change impacts, including reducing vulnerability to flooding and other extreme weather events (Wilson, 2006). Local government disaster management plans are being updated to take into account potential impacts and vulnerability assessments. The Finnish cities of Espoo and Helsinki have mandated that new planned areas be 2.6 metres above sea level, and that the lowest floor level of new buildings be 3 metres above sea level (Voutilainen, 2007). Planners in the United States have introduced the concept of "rolling easements", hich could be used to discourage development of coastal areas by granting a public right-of-way to a narrow portion of coastal property, which migrates inland as the shore erodes. This prevents coastal land owners from erecting structures to block sea level rise and transfers the impact of sea level rise to the private land owner (Titus and Narayanan, 1996). The most immediate impact of the policy would be to discourage new coastal development in areas vulnerable to coastal flooding (US Global Change Research Programme, 2009). In urban areas in developing countries, the process of integrating adaptation into development policies generally involves combining two separate but linked processes: *i)* understanding the nature of local climate risks and choosing targeted adaptation options; and *ii)* formulating and implementing development policies that are beneficial to adaptation (OECD, 2009c) (Box 4.1).

Land-use policy can also support building policies that increase energy efficiency. Residential zones restricted to single-family dwellings, common for instance in the United States, can greatly restrict the availability of multi-family and row housing, both of which typically are more energy efficient per capita than detached single family dwellings. Land-use policy tools that promote multi-family or compact housing zones can also facilitate the use of district heating and cooling systems by allowing service to a greater number of customers in a given area than would be possible in a single-family residential zone. Land-use policies can also aim to reduce urban heat island effects, as the cities of

Box 4.1. **Integrating adaptation into development planning**

Donors and international agencies can support the development of climate change adaptive capacity within urban settings through the development planning process in a number of ways. They could:

i) Review sectoral priorities in light of climate change, such as drawing the attention of partner governments to the urgent need to increase funding for infrastructure, as the deficits in urban infrastructure provision and maintenance are serious constraints to adaptive capacity.

ii) Explore different options for channelling funds and stakeholder engagement to build local adaptive capacity (*e.g.* by supporting municipal infrastructure funds).

iii) Support decentralisation processes that transfer authority to elected local governments. Support for decentralisation should be coupled with efforts to enhance local government capacity to take up the responsibilities afforded by decentralisation.

iv) Increase support to civil society organisations. Because these organisations interface most directly with communities, they represent a key constituent in local-level adaptation.

Source: OECD (2009a), *Integrating Climate Change Adaptation into Development Co-operation: Policy Guidance*, OECD, Paris.

Stuttgart, Freiburg and Mannheim, Germany have demonstrated. These policies include regional plans that provide minimum standards for open spaces, including a minimum width of 500 metres for “green corridors” and 250 metres for “green breaks”.[6]

Many metropolitan regions have used land-use planning to create “sustainable neighbourhoods” or “eco-neighbourhoods” that combine transportation, natural resource preservation, building, energy, waste and water policies to respond to climate change and reduce the urban environmental footprint. Common principles include increasing energy efficiency and renewable energy generation, using sustainable building materials, and reducing personal vehicle use. The most notable “eco-neighbourhoods”, either completed or currently under development, are located in western and northern Europe, including in Sweden (Bo01 and Augustenborg in Malmö and Hammarby Sjöstad in Stockholm); Finland (Viiki in Helsinki); Germany (Vauban and Rieselfeld in Freiburg; Kronsberg in Hanover); Denmark (Vesterbro in Copenhagen); the Netherlands (Leidsche Rijn in Utrecht); and Great Britain (BedZED in Beddington, zero-carbon communities [Box 4.2]). However, eco-cities are also under development in Korea, China and Abu Dhabi. Residential density varies among sustainable neighbourhoods projects, although most could be described as low-rise high density; towers or high-rise apartments are rare. Sustainable neighbourhoods shape development beyond residential density; cars may be restricted or prohibited (such as in Vauban) and waste collection policies that are more restrictive than elsewhere in the city may be imposed.

Transportation policies

Transportation is a key sector for reducing GHG emissions, while transportation infrastructure is also vulnerable to climate change impacts in key ways. The transport sector is a significant and growing contributor to GHG gas emissions. Transport activity is responsible for 13% of all anthropogenic emissions of GHG gases and 23% of world CO_2 emissions from fossil fuel combustion – this share rises to 30% in OECD countries. In most countries, transport CO_2 emissions are growing faster than total CO_2 emissions: CO_2 emissions from fuel

Box 4.2. **The United Kingdom Eco-Town Programme**

The United Kingdom Government's eco-town programme has been developed as a response to the challenges of climate change, the need for more sustainable living, and an acute shortage of affordable housing. The plans are for five eco-towns by 2016 and up to 10 by 2020, as part of larger plans to build three million homes by 2020. Eco-towns will be new settlements of between 5 000 and 20 000 homes, with good links to existing towns. At least 30% of the new homes will be affordable housing, and all new buildings across the developments are expected to be zero-carbon and to promote sustainable and healthy living.

In July 2009 the Government announced the locations of the first four new eco-towns. They are Rackheath (Norfolk), north-west Bicester (Oxfordshire), Whitehill Bordon (East Hampshire) and the China Clay Community near St. Austell, Cornwall. Plans at the four confirmed sites are proposed or supported by local authorities. The developments – which will include 4 000 homes on a disused airfield at Rackheath and 5 000 in the Cornwall eco-town – must still go through the planning process. Construction is expected to be underway by 2016. A second wave of at least six eco-towns is planned. The government is making up to GBP 5 million available for councils to conduct further planning work on these proposals.

Source: Thorpe in OECD (2009b), *Green Cities: New Approaches to Confronting Climate Change, OECD Workshop Proceedings*, conference held 11 June 2009, Las Palmas de Gran Canaria, Spain.

combustion in OECD countries grew 17% from 1990 to 2005, while transport CO_2 emissions grew by 30% over the same period (ITF, 2008). Transportation infrastructure is also vulnerable to climate change impacts such as flooding and high temperatures. Public transportation systems are at risk for flooding due to storms and rising sea levels, particularly in – but not limited to – coastal areas. Heat extremes can also damage roadways, bridges, and rail lines that were designed for lower maximum temperatures.

The urban transportation sector presents key opportunities for national, regional, and local governments to reduce GHG emissions and adapt to expected climate change impacts. Key transportation policies to reduce GHG emissions or adapt to climate change impacts aim to:

i) increase use of public transportation systems;

ii) decrease personal vehicle use and manage traffic demand;

iii) support non-motorised means of travel (*e.g.* pedestrian or bicycle);

iv) increase vehicle fuel efficiency and use of alternative fuels;

v) prevent disruptions to transportation system due to flooding; and

vi) prevent disruptions to transportation system due to extreme temperatures.

Local and regional governments deploy policy tools to meet these goals in their capacity as regulatory authorities, managers of public transit systems and road networks, purchasers, and enablers of local non-governmental action. National governments may deploy policy tools through local governments by regulatory mandate, funding or incentives. A key distinction should be made between policies that impact accessibility, or the ability for people in urban areas to gain access to employment, retail, services and activities, and policies that impact mobility, or the ability to travel a given distance. Policies to reduce GHG emissions from vehicles may reduce mobility by discouraging personal vehicle use and increasing mass transit use, while land-use policies to increase proximity to urban amenities and a mixture of commercial and residential land uses can improve accessibility.

Local governments can discourage personal vehicle use by using their authority to regulate vehicle circulation, parking and speed limits, but alternative transportation modes must be provided to maintain cities' competitiveness. Measures to discourage personal vehicle use include restrictions on personal vehicle use in designated zones or during certain times of day, increased parking fees or reduced parking spaces, and reduced speed limits in certain zones. These restrictions are most likely to be applied in central business districts and regional employment or retail centres (Cambridge Systematics, Inc., 2009). Restrictive policies should target zones that strongly attract employees or consumers and therefore can compete with areas that are more easily accessible by personal vehicles. Policies to discourage personal vehicles should be combined with policies to increase mass transit service, quality and multi-modal linkages to maximise both policies' effectiveness (ECMT, 1995). Local governments can also promote the co-benefits of such restrictions, which include reduced congestion, increased walkability, and increased safety, to gain support from local stakeholders for such reforms. As a self-governing entity, cities can also encourage through incentives, or in some cases require, city employees to restrict personal vehicle use.

As providers of public transit, local and regional governments can increase the use of public transit systems by focusing on improving quality, increasing linkages with multiple modes, expanding service and increasing efficiency of operation to lower consumer costs and increase attractiveness. For example, in recent decades there has been a growing focus on better management and expansion of existing public transport networks in order to improve their quality and reliability (Poudenx, 2008). Public transit agencies can increase quality through measures such as physical improvements to make the system more attractive and feel safer, and improvements to better communicate service times and delays to customers (ECMT, 1995). For example, many local transportation agencies, including those in Stuttgart and Paris, have implemented real-time signage systems to communicate expected arrival times to mass transit customers. The City of Beijing aims to achieve a 40% share of public transport use, which would build on an increase in market share from 30% to 39% over 2005-08, by expanding public transit service, improving quality and providing linkages to other travel modes (Liu *et al.*, in OECD, 2009b). Local governments could do more to prioritise demand-side policies to improve management, regulation, information and pricing. To improve linkages between multiple modes of travel, multiple local agencies often need to co-ordinate service delivery, which requires effective regional co-ordination on transportation planning.

Improvements to the public transit system need to be carefully planned to provide attractive alternatives to personal vehicle travel and to maximise co-benefits while minimising potentially negative impacts. Increasing the use of public transit systems provides important co-benefits, but does not guarantee a reduction in personal vehicle use. Actually reducing personal vehicle use requires service expansion and improvements that present viable alternatives to personal vehicle travel. By reducing time and costs spent on travel, an expansion of public transportation systems can make areas of economic or social activities more accessible thereby increasing the market size for related goods and services; make industrial activities more productive and competitive; and connect previously isolated consumers to the public transportation market. The expansion, operation, and maintenance of transport infrastructure are also regional jobs providers (OECD, 2002). Routes must be carefully planned to target concentrations of employment, retail and social activities and residential neighbourhoods, without increasing demand for undeveloped land. Public transportation system expansion can create winners and losers, both in terms of social classes and economic activities, by making some activities more accessible but not serving others. Expanding services can also result in higher property rents in newly served areas. Noise and other potential environmental impacts, such as pollution from buses, may aggravate discrepancies in pollution and other environmental hazards depending on the location and concentration of expanded services (OECD, 2002).

Local governments can use their authority over the design and management of a city's road system to increase the share of non-motorised means of travel, particularly biking and walking. Local governments can eliminate traffic lines lanes or use "traffic calming" strategies, such as replacing intersections with traffic rotaries and enlarging sidewalks, to both discourage driving and encourage foot travel. Local governments can also make structural improvements to encourage travel by bicycle. While city-operated shared bicycle rentals, such as Paris' Vélib', Rio de Janeiro's Samba and Montreal's Bixi have been highly promoted for their potential to reduce GHG emissions, the corresponding efforts to facilitate bicycling, including the creating of protected bicycle lanes and clear signage of bicycle routes, may have a more significant impact on the attractiveness of bike travel.

In their capacity as purchasers and regulators, local governments can increase city-owned vehicle fuel efficiency, although their impact may be limited. Many cities have included policies requiring the purchase of hybrid or alternative-fuel buses and other vehicles in the local government fleet. The City of Toronto, for example, has established the Green Fleet Plan, which has already resulted in an over 10% reduction in emissions from use of the city's 4 000 vehicles.[7] While it is simpler for local governments to influence their own purchases than those of their residents, governmental fleets seldom constitute more than 1% of GHG emissions within most jurisdictions. Climate policies that focus on reducing government-owned vehicle emissions are therefore not a substitute for comprehensive approaches to urban transport emission reductions. Regulations to lower and strictly enforce speed limits and prevent engine idling, both of which increase fuel efficiency, may be more effective in reducing GHG emissions reductions than other regulatory policies such as those that discourage personal vehicle use through parking and driving restrictions (Cambridge Systematics, Inc., 2009; Ewing *et al.*, 2008). However, the average optimal speed for fuel efficiency in most cars may be higher than typical city speed limits, making it difficult for urban areas to realise GHG emissions reductions through speed restrictions. Local governments may have greater opportunities to enact policies to restrict engine idling, because these regulations are most easily incorporated into existing enforcement of parking restrictions.

Local governments can also decrease personal vehicle use by enabling alternatives through programme co-ordination and technical assistance. Cities can facilitate the use of alternatives to personal vehicle use through programmes such as the City of Toronto's Smart Commute Programme, in which the city works with large employers to develop plans that encourage their employees to utilise alternate forms of transportation.[8] Some cities have also begun to provide shared-car services through concessionaries, including the City of Hanover. While cities influence individuals indirectly when they work with employers to create employee travel plans, Cambridge Systematics, Inc. (2009) estimated that employer-based commute strategies (including vanpools, employee parking pricing and tele-work policies) can result in an up to 1.7% reduction in baseline GHG emissions, similar to their estimates for congestion pricing. The actual impact of employer-based strategies on GHG emissions depends of course on the scale at which they are implemented (Cambridge Systematics, Inc., 2009).

Cities can also take the lead on promoting use of renewable fuels for transportation and discouraging fossil fuel use by increasing the share of renewable energy used for mass transit systems (Box 4.3) and supporting the development of new technologies (see Chapter 7 example of development of the Philias low-emission public transport vehicle assisted by the Samenwerkingsverband Region in the Netherlands). Others provide funding, such as the City of Paris' programme providing EUR 400 to purchasers of electric motorcycles (City of Paris, 2009a).

Box 4.3. **Calgary's electric light rail powered by wind**

The City of Calgary's light rail transit system, the C-train, with electric drive motors powered by overhead electric wires, transports around 200 000 passengers daily. Strong westerly winds coming from the Rocky Mountains led to the development of a twelve 650 kW turbine wind farm to the south of Calgary. Changes in the regulations that govern the sale of electricity in Alberta now allow anyone to buy electricity from companies producing wind power. A partnership between the city, the local energy supply company ENMAX Power Corporation and Vision Quest Windelectric Inc. resulted in the City of Calgary announcing the Ride the Wind!™ programme in September 2001. The council took the decision to buy commercial wind power as the primary source of the C-train's electricity at an additional cost of around CAD 0.005 per passenger trip. The greenhouse gas emissions from operating the train are now effectively zero. This was the first light rail system in North America to, in effect, run on wind power. A high speed train between Calgary and Edmonton is now under evaluation and could theoretically also be powered by renewable electricity.

Source: IEA (2009), *Cities and Towns and Renewable Energy – YIMFY: Yes In My Front Yard*, © OECD/IEA, Paris, Box F, p. 92.

Reducing infrastructure vulnerability to climate change impacts poses a key challenge for local and regional transportation authorities. Preventing disruptions due to flooding is chief among these concerns. It is vital for cities to clearly assess and plan for sea-level rise, storm-surge and other storm impacts that exceed existing 100-200-year plans. Below-ground transportations systems are particularly susceptible to water damage. Effects from extreme temperatures can also disrupt mass transit systems if they exceed the heat thresholds for which roadways and public transportation systems have been designed. Currently, most transit system agencies have not yet started making improvements to infrastructure, although some cities have developed plans for protecting underground transit systems from coastal flooding. Concern about climate change impacts is also beginning to shape future infrastructure development. For this reason, nationally funded local infrastructure projects in Switzerland have to comply with climate change standards mandated by the Swiss Federal Department of the Environment, Transport, Energy and Communications.[9] While adaptation plans and taking climate change impacts into account in new infrastructure are important steps, system-wide vulnerability assessments and large-scale retrofitting are needed to respond to impacts that are expected to exceed existing worst-case infrastructure planning scenarios.

An assessment of local initiatives that aim to reduce personal vehicle use, increase use of non-motorised travel, and adapt to anticipated climate change impacts should take into consideration policy complementarity, the scale of policy impact and the opportunities for co-benefits. Policies to lower speed limits, prohibit idling and enable employer-based commute plans are easily implementable on a wide-scale on the local level and have demonstrated significant impacts on GHG emissions. Policies to increase demand for public transportation through improvements to quality, communication and linkages, and physical improvements to calm traffic and ease bike and foot travel may require additional investment but can provide important co-benefits in the form of reduced congestion, decreased pollution, increased health, and reduced time and cost associated with local or regional travel.

Transportation policies can enhance policies in other sectors as well as within the transportation sector. Transportation policies can be designed to support strategic territorial plans by prioritising service in compact and high density zones. Transportation policies also have an impact on land-use zoning policies and natural resource policies as transportation networks can increase the value of the properties they serve and can improve the perceived quality of high density developments. On the flip side, expansions in road and rail services can also lead to demand for suburban land, which can increase urban sprawl and put pressure on urban natural resources. However, these measures can provide co-benefits in the form of a wider set of sustainability objectives, such as congestion mitigation, improved air quality and better accessibility. Taking advantage of policy complementarity requires transportation decision making to become more multi-sectoral and to co-ordinate with other local and regional, and in some cases national policy makers.

Natural resources and environmental management

Local governments can accomplish climate goals in their roles as land owners and land managers of a range of infrastructure and environmental services. These include planning and managing parks and other outdoor spaces, and providing other protective natural infrastructure. Natural resource policies can be applied to reduce energy demand, absorb CO_2, and protect against climate impacts. Natural resource policies can also enhance the effectiveness of land-use zoning policies by improving the quality of high-density areas through provisions of green space. Natural resource policies, and in particular wetland protection and urban forestry programmes can also play an important role in adaptation by providing natural buffers for storms, in addition to mitigation benefits by removing CO_2 from the atmosphere.

Local governments are making use of their jurisdiction over environmental features within their boundaries to protect developed land from potential climate change impacts. For coastal cities, public investment for flooding protection is a primary adaptation tool. Examples include Venice (Box 4.4), New Orleans, Helsinki and Rotterdam. These investments are not without controversy, however, as they can lead to the destruction of ecological resources in order to protect the built environment. Parks and natural spaces can also be used as an adaptation measure, by planning new parks in areas that are most vulnerable to flooding. A number of cities and regions including the City of Dresden, Germany, and the Dolnoslaskie Region, Poland, are implementing adaptation programmes to prevent flooding, minimise and manage rain water and storm water.[10] Through national hydraulic engineering and forestry legislations, the Swiss federal government is providing funding at the canton level for protective measures against natural hazards, which is matched by funding from cantons, municipalities, and infrastructure owners.[11] Other cities are increasing their capacity to assess potential impacts. The coastal city of Shenzhen, China, has developed a network of 2 000 automatic meteorological data collection stations, to provide a monitoring range of 250 km (OECD, 2010a). Because environmental zones do not often fall within city boundaries, adaptation planning and management often requires horizontal co-ordination with multiple local governments within the same region as well as vertical co-ordination with regional and national governments.

Box 4.4. **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 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 Safeguard 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 defense, recovery and re-qualification 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 salt marshes and sandbars have been reinstated and protected.
- 35 km of industrial channels and five former landfills have been protected.
- 100 km of embankments have been raised.
- 45 km of beaches have been rebuilt and 10 km 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 cm, which could occur over the next 100 years. Even when the dams are up, the port's operations will still be ensured, thanks to the construction of a large shipping lock at the mouth of the lagoon.

Source: OECD (2010b), *OECD Territorial Reviews: Venice, Italy*, OECD, Paris; Paruzzolo in OECD (2009b), "Green Cities: New Approaches to Confronting Climate Change", *OECD Workshop Proceedings*, conference held 11 June 2009, Las Palmas de Gran Canaria, Spain.

The natural environment of the urban landscape is also often included in climate plans as a means of absorbing CO_2 and reducing overall urban GHG emissions, as well as reducing potential urban heat island effects. The City of New York's PlaNYC Climate Plan includes a goal of planting an additional one million trees by 2030, and filling all available spaces for trees. The plan sets a goal of planting 23 000 additional trees annually (City of New York, 2007). Sejong City, a new city in Korea that will be completed by 2014 with an expected population of a half million by 2030, plans to reduce average city temperatures by 2.5 °C by devoting over half of its total surface area to parks, greenbelts and waterfronts and operating a water circulation system that draws on natural water resources (Sejong City, 2009). Tokyo has initiated policies to support greening projects that include tree-lined streets and rooftop greening. In São Paulo, the development of Linear Parks along waterways has served to minimise flooding effects, reduce water pollution, and absorb CO_2 by planting of more than half a million trees in over four years (Sobrinho in OECD, 2009b).

Building policies

Energy demand from buildings represents a significant share of cities' energy-related emissions in OECD countries; at the same time, the built environment is also vulnerable to climate change impacts. The share of energy demand from residential and commercial buildings can be much higher in cities than in worldwide figures. For example, GHG emission from buildings in the City of New York were estimated to account for 79% of the city's total emissions in 2005 (City of New York, 2007). While contributing to climate change, the built environment is also vulnerable to anticipated climate impacts, including urban heat-island effects, flooding, and related extreme weather events. Building location and design can add to the negative outcomes of urban heat-islands. The increased frequency and severity of flooding will threaten buildings that were located in areas previously believed to be at lower risk of flooding. Urban planners, architects, engineers and urban policy makers are now in the position of dealing with the dual challenges of designing and constructing urban zones that both curb energy consumption (and thus GHG emissions) and can cope with future climate change impacts.

National, regional, and local governments can deploy a range of building policies to assist local authorities, reduce GHG emissions and adapt to climate change impacts. Building policies that regularly demonstrate GHG emissions reductions aim to:

i) increase building energy efficiency through design, placement, construction materials and retrofitting with energy-saving devices; and

ii) increase local share of renewable and captured energy generation.

These measures all have the potential to reduce CO_2 emissions from building heating and cooling while simultaneously providing co-benefits in the form of reduced energy prices for energy consumers, reduced risk of blackouts during extreme heat events, and health benefits associated with reducing air pollution from unnecessary electricity and heat generation. In addition to this, building policies for adaptation aim to:

i) adapt to flooding and extreme storm events by requiring minimum ground clearances; and

ii) reduce urban heat island effects by requiring or encouraging "cool roofs".

Regional and local governments often implement these tools in their capacity as regulators of building codes, providers of building services, fiscal authorities, building and property owners, and enablers of local non-governmental action. National governments deploy these tools through local governments by regulatory mandate, subsidies, incentives and technical assistance.

As illustrated in Table 4.1, building policies impact or benefit other sectoral policies to a lesser extent than, for example, land-use zoning policies. However, they can enhance other sectoral policies in a few key ways. Design requirements, such as minimum setbacks from the street, can increase quality of residential development and therefore the acceptability of increased multi-family zones and higher residential density in land-use zoning plans. Building policies can require or encourage on-site generation of renewable energy in new developments, which can enhance renewable energy policies. Building policies can also contribute to water and waste policies by requiring or encouraging water conservation as well as designs and building materials that produce less construction waste.

Building codes are the primary means for increasing building energy efficiency in new buildings. Through building design and placement criteria, they can require reducing the demand for energy to light, heat and cool buildings. Their regulatory approach can be seen as an effective way for achieving a given goal of energy efficiency of new buildings (OECD, 2003). For example, because they are applied equally to owner-occupied and rented buildings, they can pre-empt the disincentive that owners and renters of rented buildings face in making energy efficiency investments.[12] They can also facilitate the meeting of specific targets. For example, the City of Shenzhen became in 2006 the first Chinese city to establish building energy efficiency regulations, and has since set targets of 20% energy reductions for retrofitting existing buildings and 50% reductions for new construction (OECD, 2010a). On the other hand, the effectiveness of building codes is often constrained in several ways. First, as building codes typically apply only to new construction and renovations, their benefits are only felt over the long-term (IEA, 2005). Second, while most of the OECD countries now include national energy efficiency requirements in their building codes for all new buildings, city or regional building regulations to apply more stringent efficiency standards often apply only to projects over a certain size.[13] Third, due to strong opposition of stakeholders, it is often difficult to set energy efficiency requirements strict enough to effect significant reductions in GHG emissions or real protections against climate change impacts (OECD, 2003). Fourth, building codes may discourage innovation because developers rarely have an incentive to exceed efficiency standards (IEA, 2008a). Performance-based codes, which set a total requirement for the building based on the supply of energy or the resulting environmental impact, may provide more incentives for innovation, but require a comprehensive and reliable method for calculating the energy performance of a building (IEA, 2008a). Finally, and perhaps most importantly, the effectiveness of building codes can vary significantly due to difficulties and resulting differences in compliance and enforcement (UNEP, 2007).

While some local authorities have added their own energy efficiency standards to their building codes, these can often be limited in their scale, impact and implementability, and therefore may be well suited to a package of national building codes and programmes. National building energy efficiency standards can reduce the risk of regional competition based on building codes and could potentially result in more uniformly strict standards across cities. National regulations can even take the lead in place of local policy, if ambitious goals are set. In Germany, it is now national policy for new construction of commercial buildings to attain a minimum performance of 110 kWh per m^2. Beyond codes, building-related policies afford a wide array of opportunities for collaboration among multiple levels of government (Box 4.5).

Supporting building retrofitting or the installation of energy-efficient technologies can be an effective instrument for local governments to reduce GHG emissions from existing buildings. The City of Berlin has pioneered a model for improving energy efficiency in buildings in which the city project-manages the retrofit of public and private buildings by contracting with energy service companies to implement efficiency retrofits to achieve an average of 26% reduction of CO_2 emissions (C40 Cities, 2009); the City of Toronto has provided technical support for owners of large facilities to retrofit their buildings for energy efficiency through its Better Buildings Partnership and Sustainable Energy Funds.[14] The benefits of such projects are greatest where heating and cooling loads are high. While retrofit programmes present an opportunity to have an impact on the energy demand of the built environment, governance of such programmes can be more complicated. Building

Box 4.5. **Multi-level governance building efficiency programmes**

- **The Crown Energy Efficiency Loan, in New Zealand,** is a financial instrument to assist central and local government agencies to implement energy efficiency projects. It complements the 2007 National Energy Efficiency and Conservation Strategy, which required 10% improvement in in-house energy efficiency in central and local government over five years. Local authorities and other public agencies borrow funds from the government which are repaid over five years; ideally, loan repayments are structured such that the energy cost savings exceed the cost of the loan repayments. The Crown Energy Efficiency Loans finance energy efficiency measures previously recommended by audits carried out by independent energy experts, and are allocated based on the project's cost effectiveness, projected CO_2 emissions reductions, contribution to renewable energy, potential for replication by public and private sectors, and co-benefits. As of June 2008, loans exceeding USD 23 million have been granted to 230 projects to achieve estimated cost savings of USD 60 million and reductions in CO_2 emissions of nearly 23 000 tonnes per year – the equivalent of taking 6 500 cars off New Zealand roads.
- **The Low Income Retrofitting Project, in Greece,** is an initiative of the national government in co-operation with municipalities to improve energy efficiency in homes built before the 1980s for families with incomes of less than EUR 60 000 a year. The national government works with national associations of private businesses and the local community (municipalities and directly with private business) to identify and inform low-income households about this project. The project focuses on increasing energy and cost savings through projects by increasing the energy efficiency of insulation, windows, and heating, and by installing solar collectors and cool roofs. The Ministry of Development created an agreement with national business associations to freeze the costs of these services for two years. The programme is evaluated through an "auto-verification" scheme in which the associations must evaluate whether their industry members are implementing technologies that meet the national standards – which can result in a conflict of interest.
- **Upper Austria's Regional Market for Third-Party Financing** (TPF) links municipal and private energy efficiency projects with financing in order to remove the barrier of high upfront investment costs. This programme originally linked municipalities with investors interested in financing energy efficiency renovations in public buildings, and was later expanded to link building, lighting and renewable energy projects in the public and private sectors with energy financing. TPF projects look to Energy Service Companies (ESCOs) to provide pre-financing energy-conservation schemes. ESCO guarantee that energy costs will be reduced by a certain percentage after energy improvements are made. Subsequent energy savings are then used to cover investment costs over an agreed pay-back period (typically 10 to 15 years). Out of eleven participating ESCOs, two are publicly owned; the rest are private. ESCOs are responsible for financing energy-saving measures as well as implementation, operation and maintenance. Municipalities enter TPF projects on a voluntary basis and are responsible for collecting all relevant data prior to setting up the project. Depending on the status of the owner, the regional government may fund the upfront investment costs for energy performance contracts up to 12% in the case of private owners, and up to 20% for municipalities. The upper limit in both cases is set at EUR 100 000 per project. Funding comes on top of other State (Upper Austria) subsidies. The budget comes from the broader climate change programme of Upper Austria.

Source: IEA (2009), *Innovations in Multi-level Governance for Energy Efficiency: Sharing Experience with Multi-level Governance to Enhance Energy Efficiency*, IEA, Paris, pp. 56, 103 and 114.

retrofits are less well suited to implementation through building codes; uniform performance requirements in building codes could be too burdensome for some existing buildings, and may be more appropriate for policy instruments such as public-private partnerships and grant programmes. They also require a good monitoring system and a competitive energy performance contracting industry (IEA, 2008a). Energy efficiency technical assistance programmes are a key vehicle for national assistance on the local level. Public-private partnerships can also result in the construction of buildings that are energy efficient by design, such as in the case of the Kronsberg Passive House Estate in Hannover, Germany.[15]

Building retrofitting, or the installation of energy-efficient technologies in local government-owned properties have become widely adopted into local climate action plans (Wheeler, 2008), and are often easier to implement than policies for private buildings. Depending on the scale of the intervention, self-governing and purchasing policies can have a wide impact on city building efficiencies; they can also serve as a model for privately funded energy efficiency projects. These projects can require co-ordination among multiple local government agencies. For example, cities in Japan provide matching funds to public schools that have made energy efficiency improvements, in the amount of half of the projected annual cost savings (Sugiyama and Takeuchi, 2008). Many governments have undertaken retrofitting local street lighting, including Graz, Austria, Gwalior, India and Stockholm, Sweden. While not typically subject to building policies, efficient street lighting programmes reflect the focus on improving the energy efficiency of government-owned properties. In the case of Graz, investments were pre-financed and refinanced from the energy cost savings, which are paid off over 15 years, while in Stockholm an investment in light-emitting diode (LED) traffic signals is expected to pay off within 10 years (IEA, 2008b).

Programmes to require or enable use of renewable or captured energy sources in buildings can have a large-scale effect on demand for low-emissions energy sources. Barcelona's "Solar Thermal Ordinance", which requires all new buildings and major renovations to use solar thermal collectors to supply at least 60% of the energy used to heat water, led to similar ordinances in over 60 other Spanish municipalities. In the Greater London area, building codes requiring renewable energy generation have expanded to communities across the United Kingdom (Box 4.6). District heating and cooling systems, which capture heat produced in energy generation to heat or cool water for all buildings connected to the systems, have the added benefit of being able to be applied incrementally at appropriate scales. Moreover, given that district energy systems connect to both new and existing buildings, they are an effective way of altering the energy demand of the existing building stock. One of the earliest district heating systems, in Copenhagen, provides 97% of the city's total heating needs. The cities of Stockholm, Sweden and Mannheim, Germany provide other examples of district heat generation, including through the use of biofuels. The City of Toronto, Canada, has enabled the creation of a district cooling system by establishing a corporation that has connected most of the major downtown office buildings to a deep lake water cooling system and which has resulted in a significant decrease in electricity demand for air conditioning.[16] Regulatory changes requiring buildings within a designated zone to connect to the system allow district heating and cooling projects to realise energy efficiency gains for a large number of energy consumers. For example, MVV Energie in Mannheim, Germany, makes more money selling hot water than it does electricity, due to the efficiencies of its system. However, potential price inefficiencies may exist if the projects receive significant government subsidies (Agrell and Bogetoft, 2005).

Box 4.6. **The Merton Borough initiative**

Known as the "Merton Rule" after being first introduced by the London Borough of Merton in 2003, it is a prescriptive planning policy regulation that requires developers of all new buildings in the district to plan to generate at least 10% of their predicted future total annual energy demand (for heating, cooling and electrical appliances) using renewable energy equipment that is integrated into the building design or located on site. Acceptable systems include solar PV panels, solar water heaters, ground source heat pumps (for heating and cooling space and heating water), and biomass from residues and energy crops. Energy arising from direct combustion or fermentation of domestic or industrial organic wastes is not permitted due to the possible problems of local pollution, odours, etc.

The concept was deemed to be successful and has since been taken up by the Greater London Council and many other municipalities across the United Kingdom. Each municipality can vary the details and thresholds outlined in the regulations to suit their local conditions. For example, variations in the original 10% demand level have ranged between 5% and 20%. The most commonly accepted threshold for implementation of the regulation is a development of more than 10 dwellings or non-residential developments with floor areas greater than 1 000 m^2, but other thresholds exist. The regulation also serves to encourage the energy efficient design of buildings, and to give consideration to their layout and orientation on site, since having to provide 10% energy demand from renewables is more cost-effective at lower levels of demand. In cases where the incorporation of renewable energy equipment could make a new building development unviable, for example it is not possible to mount solar panels or wind turbines on a roof, a waiver can be sought by the developer. When given sufficient grounds, the regulation may not be enforced. The energy use of the buildings is subsequently monitored to ensure the target is being met.

Note: See website for more information: *www.merton.gov.uk/living/planning/planningpolicy/mertonrule.htm.*

Source: IEA (2009), *Cities and Towns and Renewable Energy – YIMFY: Yes In My Front Yard*, © OECD/IEA, Paris, Box G, p. 97.

Local governments face the challenge of revising local building regulations to address potential climate change scenarios, particularly those that expose the built environment to flooding and extreme storm events. Building codes that require minimum floor height requirements in new developments located in areas at risk for flooding and extreme storms represent an underutilised adaptation opportunity. Building codes are however not sufficient to address flood vulnerabilities because they typically only affect new construction and major renovations. They therefore must be combined with additional flood mitigation measures, such as retrofitting and infrastructure investments.

Local governments can also address the threat of increased urban heat island impacts by implementing building codes that require "cool roofs". Cool roofs may be painted white or composed of materials that allow them to reflect sunlight and minimise the amount of heat they absorb, which makes them well suited to warm climates but could work against efforts to reduce heating energy consumption in colder climates. Building codes that mitigate urban heat islands provide co-benefits by reducing the demand for energy to cool buildings. As cool roofs reduce cooling bills, they provide an economic incentive; however, like other energy efficiency measures, the upfront investment may need to be surmounted by local governments.

Renewable energy policies

Some cities and regions have undertaken the provision and production of renewable energy, in addition to pursuing goals of increasing renewable energy consumption through land-use zoning, transportation, natural resource and building policies. Local governments can develop their own sources of renewable energy by capturing and converting energy from one or more renewable energy sources that exist in many cities and towns (IEA, 2009a). A distinction can be made between distributed energy options (*e.g.* rooftop solar or solar water heaters) and centralised power production. Cities are generally better placed to incentivise distributed energy technologies, in part through zoning laws such as Barcelona's Solar Thermal Ordinance, as discussed earlier, Cities can also use their self-governing authority to purchase renewable energy for city or regional operations (IEA, 2009a).

Some cities in the OECD, such as the City of Los Angeles, own and operate power-generating facilities, which provides them with more options for increasing local use of renewable energies. The city's *GreenLA Climate Action Plan* sets targets for the Los Angeles Department of Water and Power (LADWP) to increase its renewable fuel sources to 20% by the end of 2010 and to 35% by 2020, in part by developing four new renewable energy projects. These new projects build on CO_2 reductions of 3% achieved over 2004-08, which resulted in an estimated reduction of 524 000 metric tonnes of CO_2 (City of Los Angeles, 2008). The City of Seoul, Korea, aims in its new climate change master plan to expand its renewable energy share from 1.5% in 2007 to 20% by 2030, with nearly half of this share to come from hydrogen energy (Seoul City Government, 2009). Cities and regions that are not municipal power producers can still use their regulatory authority to remove obstacles to local renewable energy production and their self-governing authority to purchase renewable energy for city or regional operations (IEA, 2009a).

Renewable energy policies can be enhanced or undermined by other sectoral policies, particularly in the areas of land-use zoning, transportation and building. Renewable energy production can also have a negative impact on adaptation activities by increasing demand for water: a range of renewable energy producers, including solar farms, biofuel refineries and cleaner coal plants, consume significant amounts of water to produce energy. For example, some local water authorities in California have denied permits for potential renewable energy developments based on their high projected water demand (Woody, 2009).

Urban utilities

Waste policies

While urban waste contributes to climate change through methane (CH_4) and to a lesser extent CO_2 released by landfills and emitted by waste incinerators, heat and energy capture from waste incineration can provide an efficient energy source. Methane, which represents the largest share of GHG emissions produced by the waste sector (IPCC, 2007), presents a key concern for local GHG emissions reduction efforts because CH_4 has a significantly greater impact on climate change than CO_2 emissions and continues to be released for decades after waste disposal. Outdoor burning of waste, more common in cities in developing countries, contributes to air pollution and poses significant health risks (IPCC, 2007). Waste processing and transfer facilities in coastal areas are also at risk from rising sea levels and more severe storm events.

Local governments can reduce GHG emissions from the waste sector through policies that aim to reduce waste quantities and increase the net energy efficiency of incinerators. Local governments can deploy these policy tools in their roles as regulators, waste service providers, and enablers of efforts to reduce waste consumption. National governments can provide technical and financial assistance for energy generation programmes and set standards for incinerators. Co-benefits to reducing waste and improving incineration technologies include reduced air pollution, resource consumption and reduced landfill impacts on water quality.

Local governments can reduce the quantity of waste that ends up in landfills by providing recycling and composting services and setting fees to discourage waste. Many cities divert waste from landfills through recycling and composting programmes. The City of San Francisco's recycling and food composting efforts have allowed it to divert from landfills 70% of all waste consumed (Kamal-Chaoui in OECD, 2008).[17] The actual amount of non-recyclable and non-compostable waste provided to collectors can be reduced through incentives in the waste collection rate structure. The City of Zurich restricts the amount of waste that residents can generate, and sets fees for additional amounts. Local governments also have opportunities to reduce waste by improving waste management systems. To meet its target of recycling 35% of the waste stream in 2009 and 51% in 2011, the province of Rome, with financial support from the Lazio region, provides economic grants to municipalities in its jurisdiction to establish waste collection systems that enable them to quantify individual household waste and thereby create fiscal incentives for waste reduction recycling (Kamal-Chaoui in OECD, 2008). Waste quantities can also be reduced through education campaigns, which are already common in many urban areas in OECD countries. In order for efforts to reduce the amount of non-recyclable and non-compostable waste through fees or information to be effective, they need to be coupled with collection services that offer recycling and composting for a wide range of consumer waste products. The EU Landfill Directive requires reductions in the volume of biodegradable municipal waste it sends to landfills.

Local government agencies that use waste as an energy source can increase the net energy efficiency of incinerators and reap economic benefits from energy savings. Even when incinerators do not generate energy, they emit a significantly smaller amount of GHG emissions than landfills. The amount of other pollutants they emit depends greatly on their cost and design; many European countries have adopted stringent emission standards for incinerators (IPCC, 2007). Cities are also capturing methane gas from landfills to be used as a source of energy. The City of Monterrey, Mexico, which has been active in generating electricity by harvesting methane, used public and private funds to construct a seven-megawatt energy plant that captures and converts enough landfill gas into electricity to power the city's light-rail transit system and its streetlights (Kamal-Chaoui in OECD, 2008). In China, the City of Guangzhou in Guangdong province has undertaken one of the largest landfill energy capture projects, which is expected to generate more than 50 GWh of electricity, or enough for 30 000 households (OECD, 2010a). Other cities investing in landfill methane gas capture include Amman, Jordan (Freire in OECD, 2009b), Christchurch, New Zealand and Nelson, New Zealand.[18]

The waste services sector provides an opportunity for local governments to reduce GHG emissions economically because they can build on services they already provide and capitalise on economic benefits. Policies to reduce waste through expanding recycling and composting services and raising the price of non-recyclable waste recycling programmes 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 at either landfills or incinerators (Morris, 2005). It is therefore important that policies to support waste-to-energy capture do not compete with recycling programmes. Policies that support waste incineration and landfill gas capture complement recycling and composting policies by increasing the energy efficiency of disposal of non-recyclable or non-compostable waste. Incineration or landfill programmes that capture heat and energy can reduce net GHG emissions while offering economic benefits.

Water policies

While many cities do not prioritise urban water policies as part of their climate policy goals, they deserve attention because water service provision both consumes energy and is also vulnerable to climate change impacts such as increased droughts and rising sea levels. Water service provision contributes to GHG emission because of the energy demanded by water treatment, pumping and other water provision activities. For example, approximately 5% of all the electricity used in California is related to water provision, while an additional 15% is related to end uses of water, such as heating and pressurising (California Natural Resources Agency, 2008). Local governments respond to a variety of climate change impacts scenarios with four key water policy goals that aim to:

i) reduce water consumption;

ii) reduce energy demand of water delivery systems;

iii) prevent water system infiltration due to flooding; and

iv) prevent water system disruption due to drought.

Policies that encourage or require technological improvements, among others, can reduce the amount of energy required to provide water and reduce water consumption to better adapt to the risk of less available water due to climate change impacts.

Climate change requires changes in local water management to anticipate shifts in demand, and to confront the potential reduction of water availability and quality. Smart water policies that help achieve water conservation and efficiency goals include proper pricing of water to encourage waste reduction, financial incentives for low-flow appliances, proper design of subsidy and rebate programmes, new state and national efficiency standards for appliances, education and information outreach, water metering programmes, and more aggressive local efforts to promote conservation. Local and regional governments can enact regulations to increase the use of recycled water. For example, more than 40 000 homes in Melbourne, Australia, are required to use Class A recycled water, metered and delivered separately in a distinctive purple pipe, rather than potable water for toilet flushing, washing cars and watering outdoor landscaping. More could be done to drive better environmental performance in new housing through demand management. Best practices involve developing policy tools that give water efficiency equal priority to energy efficiency. This raises issues of funding and whether it is appropriate for customers to finance widespread improvements to the housing stock through water charges.

Empirical evidence emphasises that using prices to manage water demand is more cost-effective than implementing non-price conservation programmes, and they also have advantages in terms of monitoring and enforcement. Water supply managers are often reluctant to use price increases as a water conservation tool, however, and often rely instead on non-price demand management techniques, such as the adoption of specific technologies (*e.g.* low-flow fixtures) and restrictions on particular uses (*e.g.* lawn watering).

On average, in the United States, a 10% increase in the marginal price of water can be expected to diminish demand in the urban residential sector by about 3-4%. A recent study of 12 cities in the United States and Canada suggests that replacing two-day per week outdoor watering restrictions with drought pricing could achieve the same level of aggregate water savings, along with welfare gains of approximately USD 81 per household per summer drought (Mansur and Olmstead, 2007). Toronto's WaterSaver Program helps businesses that use a lot water to identify areas that may be "wasting" water and offers solutions and cash incentives. Industrial, commercial and institutional facilities that successfully reduce water use can receive a rebate (CAD 0.03 per litre of water saved). The programme allows Toronto to buy back water or sewer capacity that has been freed up by participants who have reduced water use in their operations (Raissis in OECD, 2009b).

Cities have also begun incorporating adaptation strategies into their water supply planning processes. New York City has started to adapt its water supply, drainage, and waste water systems to account for climate change and sea level rise. The City of Crisfield, United States, has incorporated sea level rise and storm surge into its comprehensive plan and is using land elevation to guide future land use planning. Many other cities are assessing vulnerabilities of water supplies. In the East of England plan (one of nine Regional Spatial Strategies in England), clear policy guidance on water planning is incorporated at the regional level to inform the next stage of the spatial planning hierarchy (Hickey in OECD, 2009b).

Adaptation and mitigation policies in the water sector are interconnected: Increased water shortages increase the energy required to provide water, as water scarcity can require greater pumping and greater travel distances from water source to consumer. Desalinisation, a possible solution for water scarce areas, requires a significant amount of energy. Policies to reduce consumption complement adaptation policies by reducing vulnerability to fluctuations in water availability and the need for energy intensive delivery methods.

Key urban policy packages

As national, regional, and local governments seek climate change policy packages that maximise their impact on GHG emissions and reduce their vulnerability to climate change impacts, a focus on policies that fit best with urban modes of governance and that enhance other climate policies is warranted (Table 4.2). City and regional regulatory authority is an important governance mode for implementing mitigation and adaptation policy tools across urban sectors, particularly as relates to the goals of reducing travel distances, discouraging personal vehicle use, increasing building energy efficiency and reducing vulnerability to storm, flooding and extreme heat impacts. Many cities display however a reluctance to make full use of their regulatory authority in the face of potential political, private sector and public opposition. Notable exceptions include Barcelona's Solar Thermal Ordinance and San Francisco's recent introduction of mandatory recycling (Kern and Alber in OECD, 2008; Partin, 2009). Service provision is another key means of implementing climate change policy goals, particularly those related to increasing mass transit use, providing renewable energy, district heating/cooling and waste-to-heat initiatives, and managing the urban environment to reduce the risk of flooding and other climate impacts. The impact of policies implemented through self-governance tend to be more limited in scope, but environmental management policy tools for adaptation and installation of energy efficiency technologies in city-owned buildings can have a large impact when

Table 4.2. **Policy tools for local-level action on climate change**

Policy goals	Policy tools	Policy sector	Purpose	Mode of governance	Complementary with policy tools that
Reduce trip lengths	Restructure land value tax to increase value of land closer to urban core, jobs, or services.	Land-use zoning.	Mitigation.	Regulatory.	Increase mass transit use.[1]
	Mixed-use zoning to shorten trip distances.	Land-use zoning.	Mitigation.	Regulatory.	Discourage vehicle use.[1] Support non-motorised means of travel.
Increase mass transit use	Transit-oriented development zones.	Land-use zoning.	Mitigation.	Regulatory.	Increase mass transit use.[1] Discourage vehicle use.[1]
	Restructure land value tax to increase value of land served by public transportation.	Land-use zoning.	Mitigation.	Regulatory.	Increase mass transit use.[1]
	Tax-incentives to developers near public transportation.	Land-use zoning.	Mitigation.	Regulatory.	Increase mass transit use.[1]
	Improve quality of public transportation.	Transportation.	Mitigation.	Service provision.	Discourage vehicle use.[1]
	Provide linkages with multiple modes of travel.	Transportation.	Mitigation.	Service provision.	Discourage vehicle use.[1] Support non-motorised means of travel.[1]
	Expand mass transit service.	Transportation.	Mitigation.	Service provision.	Discourage vehicle use.[1]
	Employee transport plans.	Transportation.	Mitigation.	Facilitative.	Improve quality of public transportation. Provide linkages with multiple modes of travel. Expand mass transit service.
Discourage vehicle use	Traffic calming (*e.g.* reducing lane width) to discourage driving.	Land-use zoning.	Mitigation.	Regulatory/service provision.	Improve quality of public transportation. Provide linkages with multiple modes of travel. Expand mass transit service.
	Driving and parking restrictions in certain zones.	Transportation.	Mitigation.	Regulatory.	Improve quality of public transportation. Provide linkages with multiple modes of travel. Expand mass transit service.
Support non-motorised means of travel	Traffic calming and increasing bike lanes.	Transportation.	Mitigation.	Regulatory/service provision.	Discourage vehicle use.[1]
Increase vehicle efficiency and alternative fuels use	Special parking privileges for alternative fuel or hybrid vehicles.	Transportation.	Mitigation.	Regulatory.	Driving and parking restrictions in certain zones.
	Purchase of fuel-efficient, hybrid, or alternative fuel vehicles for city fleet.	Transportation.	Mitigation.	Self-governance.	–
Increase building energy efficiency	Zoning regulation to promote multi-family and connected residential housing.	Land-use zoning.	Mitigation.	Regulatory.	Increase attractiveness of higher density developments through policies tools that: ● Increase neighbourhood open space. ● Improve quality of public transportation. ● Provide linkages with multiple modes of travel. ● Expand mass transit service. Tree-planting programmes.
	Energy efficiency requirements in building codes.	Building.	Mitigation.	Regulatory.	Co-ordination of public-private retrofitting programmes. Stringent enforcement policies. National building codes.
	Co-ordination of public-private retrofitting programmes.	Building.	Mitigation.	Facilitative.	Energy efficiency requirements in building codes.
Increase local share of renewable and captured energy generation	Building codes requiring a minimum share of renewable energy.	Building.	Mitigation.	Regulatory.	Technical support to developers and property owners.
	District heating and cooling projects.	Building.	Mitigation.	Regulatory/service provision.	Remove regulatory barriers to requiring connection to district heating/cooling system.
	Waste-to-energy programmes.	Waste.	Mitigation.	Service provision.	Strictly regulate incinerator emissions. Remove recyclables from waste stream.

Table 4.2. **Policy tools for local-level action on climate change** *(cont.)*

Policy goals	Policy tools	Policy sector	Purpose	Mode of governance	Complementary with policy tools that
Reduce vulnerability to flooding and increased storm events	Zoning regulation to create more open space.	Land-use zoning.	Adaptation	Regulatory.	Zoning regulation to promote multi-family and connected residential housing.
	Retrofitting and improvements to mass transit systems to reduce potential damage from flooding.	Transportation.	Adaptation.	Service provision.	Improve quality of public transportation. Provide linkages with multiple modes of travel. Expand mass transit service.
	Designation of open space as buffer zones for flooding.	Natural resources.	Adaptation.	Regulatory.	Zoning regulation to create more open space. Zoning regulation to promote multi-family and connected residential housing. Building codes requiring minimum ground clearance.
	Building codes requiring minimum ground clearance.	Building.	Adaptation.	Regulatory.	Designation of open space as buffer zones for flooding.
Reduce urban heat-island effect and vulnerability to extreme heat	Retrofitting and improvements to mass transit systems to reduce potential damage from extreme temperatures.	Transportation.	Adaptation.	Service provision.	Improve quality of public transportation. Provide linkages with multiple modes of travel. Expand mass transit service.
	Tree-planting programmes.	Natural resources.	Mitigation and adaptation.	Self-governance.	Increase attractiveness of higher density developments through policies tools that: ● Increase neighbourhood open space. ● Improve quality of public transportation. ● Provide linkages with multiple modes of travel. ● Expand mass transit service.
	Building codes requiring design materials that reduce heat-island effects.	Building.	Mitigation and adaptation.	Regulatory.	Energy efficiency requirements in building codes.
	Building codes requiring "green roofs" with vegetation or white surfaces.	Building.	Mitigation and adaptation.	Regulatory.	Energy efficiency requirements in building codes.

1. Denotes complementarity with all policy tools listed under a policy goal.

applied widely. Public information campaigns can enhance a number of other policy tools, including those that can benefit most from targeted climate-related information. However, as the impact of urban facilitative activities is diffuse, it is hard to measure.

Policies that enhance each other when applied concurrently should also be considered as top priority policies. Land-use zoning policies that allow for higher densities and greater mixing of residential and commercial uses can enhance transportation climate goals by reducing trip distances and frequency, protect natural areas that act as buffer zones against climate impacts, decrease building energy demand, and increase efficiency of urban services delivery. Other sectors, in turn, can enhance the quality of densification policies and lessen their potentially negative impact on adaptation measures. The expansion of mass transportation and non-motorised travel options can provide benefits that outweigh the disadvantages of high residential density, while natural resource policies can enhance the quality and availability of open spaces within densely developed areas. Building design policies can enhance the quality of the densely built environment while reducing climate vulnerability through minimum ground clearances and design features to reduce urban heat island impacts.

Policy complementary within sectors is also important for enhancing policy effectiveness. Transportation policies to increase the quality and availability of public transportation, bicycle, and foot travel make policies to discourage or restrict vehicle travel and circulation more politically feasible. For example, congestion fees for driving during peak hours worked well in

London because they were combined with improvements in management of the road network and substantial enhancements in bus service. In the building sector, local government co-ordination of public-private partnerships to provide energy efficiency retrofitting programmes complement energy efficiency codes that affect only new development and major renovations. Waste policies to promote both waste-to-energy incineration and the collection of recyclables can enhance rather than undermine the economic viability of recycling programmes while diverting waste from landfills. Policies to reduce water consumption can increase local resilience to drought while lowering energy demand for water service provision and the development of energy-intensive water sources in response to water scarcity.

Density and spatial urban form in combating climate change

The urban policies discussed above intersect with the question of urban density. Many cities have begun pursuing policies to increase the density of residential neighbourhoods and favour concentration at the centre of the urban agglomeration as a means to facilitate the mitigation and adaptation measures discussed above. The questions of whether to densify development and which spatial development patterns to pursue have come to the forefront of local long-term planning concerns. Compact cities and sustainable neighbourhoods have been presented as models of development patterns that can address climate challenges and long-term resource, economic, and social sustainability. However, questions remain about the effectiveness of these spatial urban forms in meeting environmental goals and in attracting residents over the long term.

In determining whether and how to incorporate climate policies into spatial urban form and density decisions, city and metropolitan governments face a number of questions:

i) How to define density in order to set priorities for compact development?

ii) Which spatial development patterns best contribute to GHG emissions reductions, climate change adaptation, and efficient resource use?

iii) How can spatial planning reduce the energy required to travel between home, jobs, and activities?

iv) What impact does compact development have on economic growth?

v) How can challenges to urban quality of life, housing affordability, and urban attractiveness be overcome?

These questions require consideration of the potential impact on GHG emissions and climate change vulnerability, but also on economic growth, long-term resource sustainability, affordability, and urban quality of life.

The concept of the "compact city" as a spatial development strategy has become popular in many OECD countries, particularly in Europe and Japan. The European Commission encourages European cities to move towards more compactness, on the basis of environmental and quality of life objectives (Commission of the European Communities, 1990). The British government has made urban compactness a central element of its sustainable development policy (United Kingdom Department of the Environment, 1994) and the Dutch government has taken similar action (Sorensen *et al.*, 2004). Most recently, the Japanese government has introduced the concept of "Eco-Compact City" as one of its top-priority urban policies (Ministry of Land, Infrastructure, Transport and Tourism, 2009). The compact city strategy aims to intensify urban land use through a combination of higher residential densities and centralisation, mixed land uses, and development limits outside of a designated area (Churchman, 1999). Compact cities also typically involve concentrations of urban services and transportation options and high degrees of land-use planning controls (Table 4.3) (Neuman, 2005).

Table 4.3. **Compact city characteristics**

● High residential and employment densities.
● Mixture of land uses.
● Fine grain of land uses (proximity of varied uses and small relative size of land parcels).
● Increased social and economic interactions.
● Contiguous development (some parcels or structures may be vacant or abandoned or surface parking).
● Contained urban development, demarcated by legible limits.
● Efficient urban infrastructure, especially sewerage and water mains.
● Multi-modal transportation.
● High degree of accessibility: local/regional.
● High degree of street connectivity (internal/external), including sidewalks and bicycle lanes.
● High degree of impervious surface coverage.
● Low open-space ratio.
● Unitary control of planning of land development, or closely co-ordinated control.
● Sufficient government fiscal capacity to finance urban facilities and infrastructure..

Source: Neuman, M. (2005), "The Compact City Fallacy", *Journal of Planning Education and Research*, Vol. 25, No. 1, Sage, London, pp. 11-26.

While some associate compact cities with high-density development, the concepts are distinct. Compact development prioritises development close to and radiating from an urban core, where the definition of high-density development is based primarily on the concentration of dwelling units, regardless of proximity to an urban core or urban amenities. In some metropolitan regions, compact development may apply to polycentric development, where two or more cities in a region share complementary functions (Nordregio, 2005), in which case compact development strategies radiate from each urban core.

Impact on urban amenities and services

As illustrated in Chapter 1, dense and compact development emerges as a crucial strategy to reduce GHG emissions. Policies to increase residential density in urban areas, whether or not they are part of a compact cities or sustainable neighbourhoods strategy, have been credited with providing benefits such as reduced GHG emissions from travel, increased efficiency and reduced costs of public services provision, and increased protection of agricultural land and open spaces (Churchman, 1999). Higher residential densities may also facilitate many of the urban policies to reduce GHG emissions and adapt to climate change impacts. For example, dwellings that are adjacent rather than stand alone are more insulated and therefore require less energy for heating and cooling. Mass transport networks and public utilities benefit from economies of scale in denser areas, which can facilitate expansion of mass transit and reduction of personal vehicle use. Compact development can provide the economies of scale required to make district heating and cooling projects economically viable, and reduce the energy required to provide water, wastewater, and waste services. Higher-density development can also result in the preservation of key open spaces critical for climate change adaptation, such as flood plains or buffer zones for coastal flooding. Estimates of the effect of compact growth scenarios on US national GHG levels range from 1% (US National Research Council, 2009) to 10% (Ewing *et al.*, 2008), but further research is needed to understand the impact of a range of spatial development scenarios on future greenhouse gas emissions.

The impact of density on urban economic and social priorities is even more diverse and complex. On one hand, high-density residential areas have been associated with a more economically efficient use of high-priced land and a greater mix of housing types, which may facilitate a more diverse mix of residents than areas dominated by single-family housing (Churchman, 1999). On the other hand, policies to promote high-density residential development have also attracted criticism, in particular for their potential impact on residents' quality of life, access to open space, housing prices, and responsiveness to market demand. High residential densities can lead to increased traffic congestion and pollution, which can be exacerbated by a lack of trees or vegetation. The value of land may also rise significantly as a result of high-density developments, which can discourage the preservation of open space and limit residents' access in high-density areas (Churchman, 2003). The increase in land values also can result in the exodus of low-income and even middle-class residents from high-density areas with valuable amenities such as proximity to the urban core, open space, and mass transit. If increases in urban density are accompanied by efforts to reduce pollution or otherwise improve the urban environment, wealthier households may move in, driving up rents and benefiting landlords at the expense of existing tenants, as demonstrated in a study of California cities (Banzar and Walsh, 2006). Higher housing prices and smaller dwelling sizes, both associated with high-density areas, may lead families with children to leave for areas with lower prices, larger dwellings, or opportunities for outdoor space. This can lead, in turn, to economically and socially homogenous high-density areas. Further research is needed to clarify the relationship between high residential densities and neighbourhood demographics.

Building design and availability of neighbourhood amenities affect residents' perceptions of high-density developments' advantages and disadvantages. In determining urban quality of life, residents' perceptions of density, or perceived density, may be as important as real measures of residential density (Churchman, 1999). For example, in the Netherlands, 10 dwelling units per net hectare is considered low density and 100 units per hectare high density, while in Israel, 20 to 40 dwelling units per net hectare is considered low density, and 290 units per hectare is considered high density. While high-density developments are often associated with high-rise towers, low-rise buildings can also achieve relatively high densities. For example, a study of Toronto, Canada, identified net densities of 120-230 dwelling units per hectare in areas of buildings up to five stories (Churchman, 2003). Urban amenities, such as open space, mass transit service, shopping areas and cultural activities, can all serve to lessen the potential impacts of high-density developments on quality of life. For example, a study of neighbourhood satisfaction in central Dublin found that density itself was less important to perceived quality of life than management of the physical environment (*e.g.* litter, pollution, greenery), noise and traffic congestion, and access to open space, children's facilities, quality food stores and secure parking (Howley *et al.*, 2009). However, while building design and amenities may increase high-density areas' attractiveness, they do not address the issue of potentially rising housing prices.

Spatial policy tools for low-carbon development

A focus on spatial compactness or density to increase urban growth's responsiveness to climate change and sustainability may be limiting if it does not take into account the climate impact of urban activities (Neuman, 2005). Metropolitan regions must be able to respond to rapid growth and demand for undeveloped land. To effectively reduce GHG emissions, it is critical for spatial policy tools to reduce distances between residential, employment, shopping, and leisure activities, which is not necessarily achieved by increasing residential densities alone. As was discussed in the section on land-use policies, Transportation and resource efficiency, and open space preservation can be facilitated by spatial development that is planned to maximise transportation linkages, prioritise areas adjacent to public utilities services, and preserve open space. The Île-de-France region provides a key example of combining these elements in a long-term master plan (Box 4.7).

Box 4.7. **Île-de-France's regional master plan to become the first "Eco-Region"**

Where and at what density future construction should take place in Paris and the surrounding Île-de-France region, and how this will impact climate change goals, are key questions for the revision of the Île-de-France Regional Master Plan.

The new SDRIF (Master Plan for the Île-de-France region) continues past practices of targeting polycentric development in the region, but also emphasises the importance of a compact region and places new attention on the historically dense urban core of the agglomeration. With the goals of limiting traffic and curbing urban sprawl, the SDRIF encourages higher density in existing urban spaces and prioritises development in areas served by public transportation. As a prescriptive land-use document in particular, it reworks the map of constructible land, seeks minimum densities for new urbanisation, and places conditions on the urbanisation of certain areas.

As density is only sustainable if it translates into urban spaces with a high quality of life, the revision of the SDRIF aims for urban "intensity", or the linking of dense neighbourhoods to quality public transportation, parks and open spaces, services, and jobs. To maximise opportunities for quality densification:

- The general map of the SDRIF, which must be respected by local plans, identifies preferential sites for densification, often to optimise planned public transport links.
- The rules expressed in the SDRIF's text make it compulsory for all municipalities to increase their local average densities.
- Other elements of the SDRIF set expectations for densification of districts around existing and planned public transport stations (express railway, metro, tram).
- To balance plans to reduce the expansion of urbanised land, the SDRIF requires new districts to meet higher minimal housing densities than currently in practice.

The counterpart of this *ville compacte* is the plan's strong effort to preserve and mobilise the region's open spaces, whose various economic, environmental, and public uses are now better acknowledged. This includes the strengthening of a network of green spaces that runs through the central agglomeration and the creation of "biological corridors" in the outer areas of the region.

Box 4.7. **Île-de-France's regional master plan to become the first "Eco-Region"** *(cont.)*

Finally, the new SDRIF continues longstanding efforts to develop the metropolitan area around a network of strong, structured urban centres. The plan's transportation programme plays a key role in this effort as it will help structure the region's urban core and give a boost to the new dense neighbourhoods called for in the SDRIF. In addition to reinforcing the region's historically "radial" transportation system, which spans outward from Paris, the new SDRIF calls for a number of new high-capacity lines running around the Parisian centre.

Source: Fouchier in OECD (2009b), *Green Cities: New Approaches to Confronting Climate Change, OECD Workshop Proceedings*, conference held 11 June 2009, Las Palmas de Gran Canaria, Spain.

A number of policy tools exist to facilitate compact development, through mixing land-uses, improving mass transit services and providing urban amenities. These include reducing existing regulatory barriers to more compact development, including barriers to mixed-use, transit-oriented and brownfields development, accompanied by fiscal reform that internalises environmental and public services costs incurred by new development and concentrates urban amenities and services in priority growth areas. A primary strategy for promoting more compact urban development is to reform land-use policies that restrict opportunities for high-density development. Zoning and other land-use controls impose an "implied zoning tax" that discourages new housing construction (Glaeser and Gyourko, 2003). Floor-area-ratio restrictions, restrictions on units per acre, and height restrictions all can restrict compactness policies. Zoning reform and incentives to increase mixed-use developments, which combine residential and non-residential land uses, can reduce the length and frequency of personal vehicle trips. Mass transit use is facilitated not only by increasing density but also by ensuring service to key employment centres, even those located away from residential neighbourhoods or on the urban periphery. Transit-oriented developments, which often include mixed-use elements, and mass transit connections to key employment and residential areas are needed to reduce personal vehicle use and can function even in the absence of high-density policies.

Many policy instruments to reduce urban sprawl, which is characterised by low density, segregated land uses whose outward expansion is unchecked and may "leap" over undeveloped land (Burchell *et al.*, 2002) may result in higher residential densities within the urban area, but also achieve goals related to increasing the use of mass transit, improving accessibility of the urban environment, and increasing urban amenities such as nearby open space (Table 4.4). Land-use policies such as urban growth boundaries and development incentives can actively promote denser urban development. However, while more compact development is achieved, negative impacts on property values can have perverse effects on the value of land outside urban growth boundaries. Less restrictive approaches also exist. In Germany, for example, new development is restricted to land immediately adjacent to already developed land (Buehler *et al.*, 2009). Local governments can also promote densification by allowing developers to exceed zoning regulations if they meet other climate policy goals. Given the tendency for higher housing prices closer to urban cores, it can often be relevant to keep some land for future infrastructure, including through tools such as land banks for affordable housing, urban amenities, and infrastructure.

Table 4.4. **Policy instruments to manage urban sprawl**

Policies for managing urban growth	Policies for protecting open space
Public acquisition Public ownership of parks, recreation areas, forests, environmentally sensitive areas, etc.	**Public acquisition** Public ownership of parks, recreation areas, forests, environmentally sensitive areas, etc.
Regulation Development moratoria, interim development regulations. Rate of growth controls (such as building permit caps), growth-phasing regulations. Adequate public facility ordinances. Up-zoning or small-lot zoning, minimum density zoning. Mixed-use zoning. Transportation-oriented zoning. Greenbelts. Urban growth boundaries. Urban service boundaries. Comprehensive planning mandates (master plans).	**Regulation** Subdivision exactions. Cluster zoning (incentives often provided). Down-zoning or large-lot zoning. Exclusive agricultural or forestry zoning. Mitigation ordinances and banking. Non-transitional zoning. Concentrating rural development.
Incentives and fiscal policies Development impact fees. Real estate transfer tax. Split-rate property tax. Infill and redevelopment incentives. Brownfield redevelopment. Historic rehabilitation tax credits. Location efficient mortgages. Priority funding for infrastructure in city centre.	**Incentives and fiscal policies** Right-to-farm laws. Agricultural districts. Transfer of development rights. Purchase of development rights, conservation easements. Use-value tax assessment. Circuit breaker tax relief credits. Capital gains tax on land sales.

Source: OECD adaptation based on Bengston, D.N. *et al.* (2004), "Public Policies for Managing Urban Growth and Protecting Open Space: Policy Instruments and Lessons Learned in the United States", *Landscape and Urban Planning*, Vol. 69, pp. 271-286.

Strategic urban planning for climate change

Long-term strategic planning needs to take into account urban areas' contributions and vulnerabilities to climate change. As urban areas have shifted towards the concept of urban governance, which involves managing and co-ordinating public and private interests, future growth and development decisions are no longer made solely by a central authority. Strategic planning – determining future action, identifying implementing roles, and monitoring and evaluating the outcomes (see Steiss, 1986) – has been increasingly used to co-ordinate diverse priorities and contributions from multiple levels of government, non-governmental stakeholders and the private sector. The basic principles of strategic urban planning are to observe urban dynamics, land and house prices and understand the reasons why key stakeholders intervene in urban development processes; establish a consensual long-term vision and translate it into specific goals, define and prioritise required actions to achieve those goals given local capacity to act and power structures; and manage linkages among sectoral policies and uncertainty. The tools for flexible and strategic public intervention that can be used to incorporate climate change responses into long-term growth plans typically include:

i) analyse urban emissions drivers and urban vulnerabilities;

ii) identify local capacity to act;

iii) model long-term implications of policy options; and

iv) assess costs and benefits and cost-effectiveness.

To plan long-term reductions of urban areas' contributions to climate change, it is critical to inventory sources of GHG emissions. Scenarios to predict future GHG emissions are needed to identify policy priorities and choose among policy options. Analysing the drivers of GHG emissions involves identifying energy-consuming activities, the modes through which those activities take place, the energy intensity of the activities and the GHG emissions intensity of the energy sources consumed. Many cities have begun to inventory their emissions sources, however, the need exists for harmonisation of tools.

Climate change impacts are often localised, thus effective responses require region-specific assessments of local vulnerabilities. Vulnerability assessments model potential local damage in scenarios of flooding, rising sea levels, heat extremes, and other expected climate change impacts. Many urban areas are beginning to undertake these assessments, including the Washington DC/Northern Virginia region (Box 4.8). However, they are costly and require scientific expertise that may not be readily available to urban governments. This points to a role for national governments to foster science-policy capacity building and information to improve local understanding about how climate change will affect cities.

Box 4.8. **The Sustainable Shoreline Community Management in Northern Virginia project**

To support the development of a regional climate change adaptation plan for Northern Virginia, United States, the Northern Virginia Regional Commission embarked on a three-year effort to develop a plan for sustainable shoreline and near-shore restoration, protection, revitalisation and community development along the region's tidal waters. Through the Sustainable Shoreline Community Management in Northern Virginia project, the local governments in Northern Virginia are able to addresses coastal hazards and sea level rise preparation in a collaborative manner.

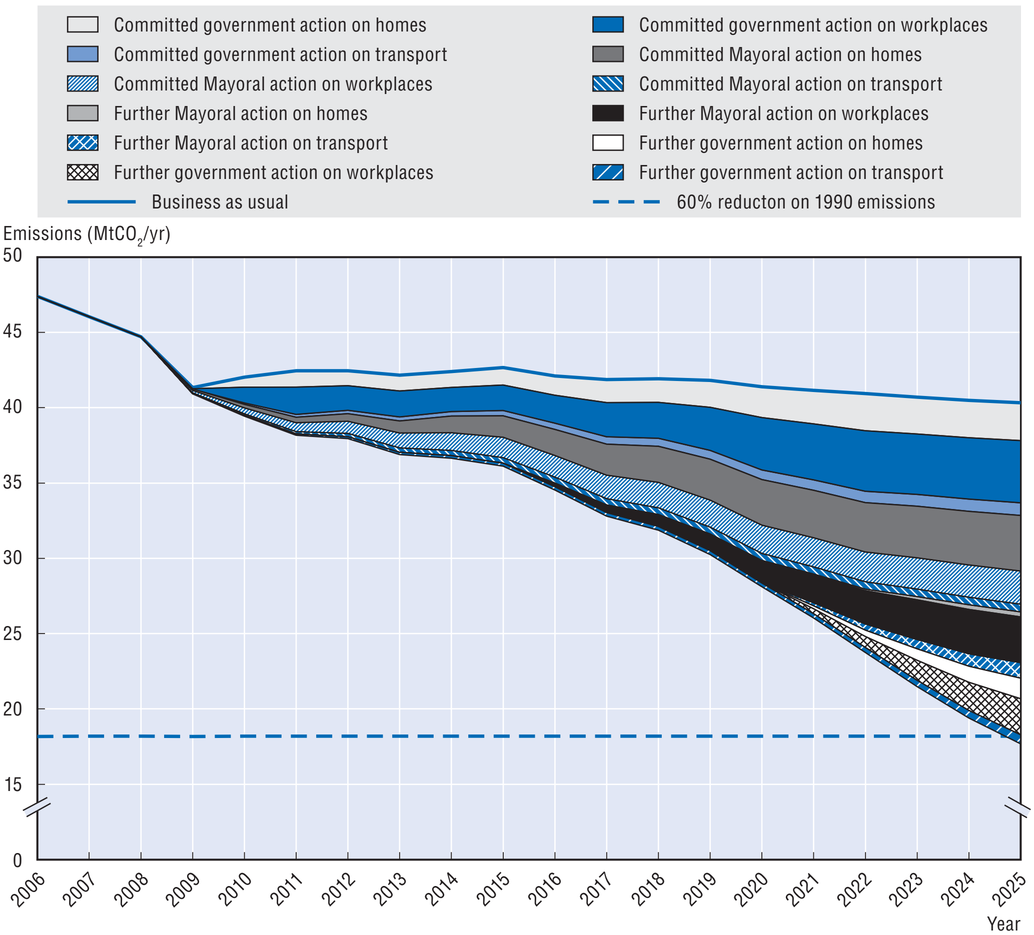
This plan focuses specifically on impacts due to sea level rise and storm surge and is funded in part by the Virginia Coastal Zone Management Programme through a grant sponsored by the National Oceanic and Atmospheric Administration. Phase I, of this three-year, three-phase project, includes an inventory of existing data resources and policies to determine the natural and man-made resources at risk, identify data gaps, and understand current local shoreline management regulations. A workgroup consisting of representatives from local, state, and federal governments, colleges and universities, and other stakeholders assists in highlighting and collecting relevant data including policies, land use, and natural resource information. Phase II will focus on filling data gaps, identified through Phase I of this project, and producing a report and maps of areas at risk of sea level rise and other climate change impacts.

Source: Grape in OECD (2009b), *Green Cities: New Approaches to Confronting Climate Change*, OECD Workshop *Proceedings*, conference held 11 June 2009, Las Palmas de Gran Canaria, Spain.

An assessment of local capacity to respond to urban contributions and vulnerabilities to climate change is critical to planning future responses. Understanding local capacity allows local authorities to identify what they are capable of accomplishing alone and what may require the involvement of other levels of government or of non-governmental stakeholders. For instance, a city may have direct control of the local electric or gas utility, and therefore a say in pricing policies or the fuels used to generate power, but may have much more limited control over another sector such as public transport planning. Assessing capacity to act can be challenging, but some cities are forging ahead. Wedge analysis and stakeholder mapping are two types of tools to assess local capacity to act. For instance, the Greater London Authority has assigned responsibility for different initiatives proposed in its climate action plan to Mayoral and governmental authority (Figure 4.2), as well as the contribution to greenhouse gas targets of different types of energy reductions (Figure 4.3). To understand GLA's ability to influence the emissions associated with buildings around London, the mayor's team also developed an influence "hierarchy" examining different factors that could potentially affect buildings-related emissions, and the mayor's influence over these factors (Lefèvre & Wemaere, 2009).

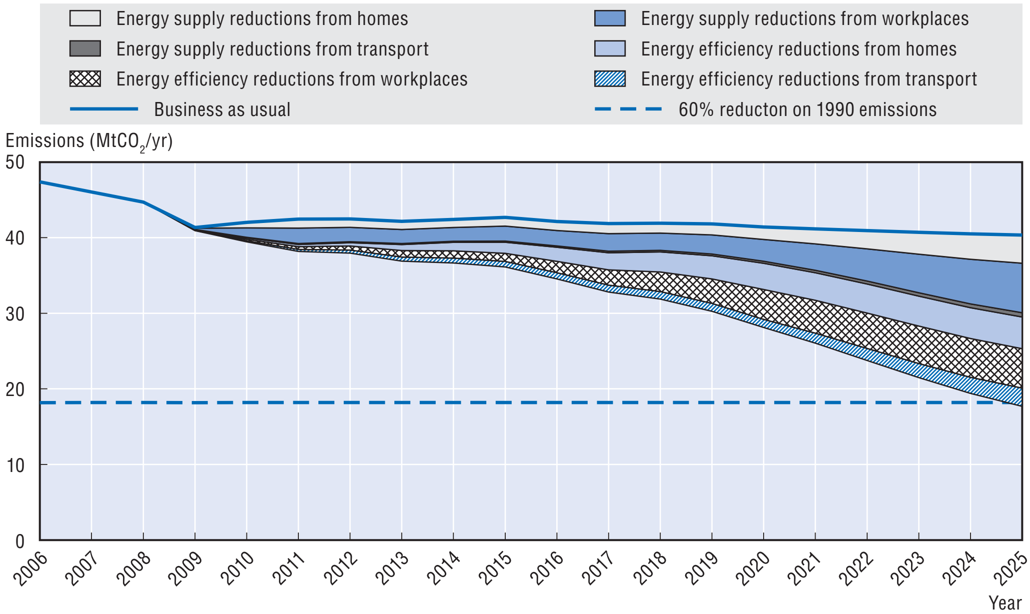
Modelling the impact of policy options on future GHG emissions and climate vulnerabilities is a key step in understanding policy opportunities and tradeoffs. Because of the complexity of the interrelations between the drivers of spatial organisation processes within a city, the empirical prediction of the multiple impacts of various combinations of urban policies is a difficult task. Given the various trade-offs that sustainability requires, it is necessary to also find a way to quantitatively assess the impacts of policy on the welfare of different population categories, productivity, energy consumption, and GHG emissions. Strategic planning processes can be significantly facilitated by long-term prospective methods that are able to forecast the effects of urban policy alternatives on urban spatial

Figure 4.2. **Projected CO_2 emissions reductions in London (2008-2025)**



Source: Greater London Authority (2010), "The Mayor's Climate Change Mitigation and Energy Strategy (Public Consultation Draft)", GLA, London.

Figure 4.3. **Breakdown of projected reductions in London's CO_2 emissions by energy efficiency and energy supply savings (2008-2025)**



Source: Greater London Authority (2010), "The Mayor's Climate Change Mitigation and Energy Strategy (Public Consultation Draft)", GLA, London.

organisation. Current models are driven mainly by transport scenarios and estimate through quantitative assessment their consequences on various sustainable parameters, such as different population categories, congestion, energy consumption, GHG emissions, etc. One example, the TRANUS model, which integrates transport and land-use scenarios, has been implemented both in northern cities (Baltimore, Sacramento, Osaka, Brussels, etc.) and southern cities (São Paulo, Mexico City, Caracas, Bogotá, etc.). Models that go beyond transportation-based scenarios, and which also take climate change impacts into account, are needed to better inform policy options.

Tools to assess costs and benefits and inform cost-effectiveness planning also play a key role in strategic planning. Policies, plans, and projects tend to be assessed on short-term financial returns, or on an economic valuation based narrowly on a structured cost-benefit analysis, from the perspective of a limited range of stakeholders or project objectives. Few cities worldwide have a real understanding of the impact of new development on their long-term fiscal condition. Decisions are dominated by immediate capital costs, despite the fact that often over 90% of lifecycle costs for typical infrastructure are expended during operational maintenance and rehabilitation. At the same time, most government budgets do not account for ecological assets, the services they provide, and the economic and social consequences of their depletion and destruction. Introducing qualitative assessment in cost-benefit analyses can be challenging; one example is the performance-based planning approach in use in the San Francisco Bay Area, United States, to help the Metropolitan Transportation Commission focus on sustainable measurable outcomes of potential investments and the degree to which they support stated policies (Chapter 7, Box 7.4).

While the requirement for cost-effectiveness should probably be proportional to the environmental ambitions (similarly for social initiatives), the economic dimension of the problem is rarely seriously considered. For instance, few local climate action plans are currently based on a serious economic analysis of the possibilities and constraints of the proposed measures. The cities of London and New York are exceptions. Energy-economy or sectoral energy models have made it possible to simulate different policies and especially to build sets of Marginal Abatement Cost Curves (MACCs).[19] These mechanisms are highly efficient tools for analysing different aspects of climate policies, particularly by seeking to reduce the global cost through levelling, to a certain degree, the marginal costs of sectoral initiatives. These mechanisms can provide the required support to develop a methodology for defining and prioritising actions to be initiated, based on technical-economic criteria. The different actions required can then be organised to build a cost-effective programme (Lefèvre and Wemaere, 2009).

Notes

1. As of August 2010, 1 044 US mayors have signed the agreement. See *www.usmayors.org/climateprotection/list.asp*.
2. See *www.energysavingtrust.org.uk/nottingham*, accessed 18 November 2009.
3. ICLEI's Cities for Climate Protection was one of the first networks established, and counts over 680 cities as members from over 30 countries worldwide (*www.iclei.org/climate-roadmap*). The EU CO_2 80/50 project, organised by METREX: The Network of European Metropolitan Regions and Areas, targets a reduction in GHG emissions by its member cities of 80% below 1990 levels by 2050 (*www.eurometrex.org/ENT1/EN/Activities/activities.asp?SubCat1=EUCO2*). The Covenant of Mayors is a commitment by signatory towns and cities to exceed EU CO_2 emissions reduction targets (*www.eumayors.eu/*).
4. From response to the OECD "National-Local Climate Change Governance Practices Questionnaire" by Naoto Nakagawa, Japanese Ministry of Foreign Affairs, 10 August 2009.
5. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009.
6. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Klaus Elliger, City of Mannheim, Germany, 12 August 2009.
7. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009.
8. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009.
9. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Barbara Jeanneret, Swiss Federal Statistical Office, 17 August 2009.
10. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Wolfgang Socher, City of Dresden, Department of Urban Ecology, 26 August 2009, and by Maciej Zathej, Dolnoslaskie Region, Poland, Regional Bureau of Spatial Planning, 28 August 2009.
11. From response to the OECD "National-Local Climate Change Governance Practices Questionnaire" by Barbara Jeanneret, Swiss Federal Statistical Office, 17 August 2009.
12. Known as a "principal-agent" problem, owners of rented buildings have little incentive to make investment because they usually do not have to pay the energy bills, and renters do not have incentive, either, because they are not likely to benefit from the investment over the long term. Under such circumstances, economic instruments and information tools may not function effectively (OECD, 2003).
13. For example, the City of Boston approved a green building zoning code in January 2007 that requires all construction projects exceeding 50 000 square feet to be designed and planned to meet the US Green Building Council's (USGBC) LEED "certified" level standards (City of Boston Redevelopment Authority). The Flemish Climate Policy Plan for 2006-2012 sets out comprehensive requirements for new or significant additions to dwellings, schools and offices, as well as major renovations of schools and offices exceeding 3 000 m^3 (Flemish Ministry of Public Works, Energy, Environment and Nature, 2006).
14. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009.

15. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Astrid Hoffmann-Kallen, Ute Heda and Rainer Konerding, City of Hannover, Climate Protection Unit, 1 September 2009. See also *www.passivhaustagung.de/zehnte/englisch/texte/PEP-Info1_Passive_Houses_Kronsberg.pdf*.
16. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009.
17. The South Waikato Region, New Zealand; Christchurch, New Zealand; Dolnoslaskie Region, Poland; Darmstadt, Germany; and Toronto, Canada, also provide examples of composting (responses to the OECD "Local Climate Change Governance Practices Questionnaire" by James Piddock, South Waikato District Council, New Zealand, 29 July 2009; by Tony Moore, Christchurch City Council, New Zealand, 3 September 2009; by Maciej Zathej, Dolnoslaskie Region, Regional Bureau of Spatial Planning, 28 August 2009; by Günther Bachmann, City of Darmstadt, Department of Economy and Urban Development, 21 August 2009; and by Mark Bekkering, City of Toronto, Environment Department, 11 August 2009).
18. From response to the OECD "Local Climate Change Governance Practices Questionnaire" by Tony Moore, Christchurch City Council, New Zealand, 3 September 2009; and by Debra Bradley, Nelson City Council, New Zealand, 3 September 2009.
19. "Marginal Abatement Cost Curves (MACCs) provide an assessment of the level of emissions reduction which a range of measures could deliver at a given point in time, against a projected baseline level of emissions. They show how much CO_2 each measure could save (the level of abatement potential) and the associated cost per tonne of CO_2" (United Kingdom Committee on Climate Change, 2009).

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PART II

Chapter 5

Contribution of Cities to a Green Growth Model

Environmental policies that do not also support growth will not be sustainable over the long term. Chapter 5 discusses the role of cities in contributing to a new global green growth model at a time when governments must reduce their carbon footprint while pursuing economic growth and job creation. The chapter highlights the main policy areas through which city and regional governments can contribute to green growth objectives, including developing and maintaining green public infrastructure, improving the eco-efficiency of production, boosting demand by fostering the greening of consumption preferences and facilitating green innovation. Tools need to be developed for assessing the effectiveness of such policies in reaching their objectives of job creation and output growth and the chapter provides a first step through an analytical framework that can orient future research on this crucial issue.

Key points

Cities and regions could play a key role in fostering the green growth agenda

- Cities and regions can promote green growth through many levers, including the creative use of procurement; better screening of investments in infrastructure, transport, communication networks and utilities; financial and tax incentives; partnerships and regulation of energy suppliers; and consumer awareness and training programmes for green jobs.
- Cities also have significant opportunities to lead by example. An effective green growth strategy for cities should search for employment gains in the short-to-medium term through targeted investments, and should pursue systemic changes in the way cities function and grow over the long-term.

Cities and regions can help create stronger markets for renewable energies and energy-efficient products and services and promote eco-innovation

- Feasible options for local public investment that can reduce emissions and sustain employment include improving the energy efficiency of buildings through retrofitting and selective public purchasing; integrating environmental targets in transportation and planning and increasing the share of renewable sources in energy supplies, through distributed technologies or centralised utilities. The employment benefits of energy efficiency at the local level are largely the result of multiplier effects, as households and businesses shift expenditures from a capital-intensive sector (energy) to more labour-intensive sectors (*e.g.* local services).
- Cities can also be effective in greening industrial production by developing one-stop support services for green industry start-ups; enabling existing businesses to reach energy conservation goals; providing training tailored to local labour market needs; and by developing awareness programmes to raise consumers' preferences for green products.
- Cities can also play an enabling role, through well-designed support for R&D and for industrial and public research collaboration in eco-innovation clusters.

A fundamental question that metropolitan regions face is how to pursue economic growth and job creation while preventing environmental degradation and unsustainable use of natural resources. The challenge for cities and regions is to identify the mechanisms for increasing economic growth through policies addressing urban sustainability – in other words, how to achieve green growth. The OECD defines green growth as "a way to pursue economic growth and development, while preventing environmental degradation, biodiversity loss and unsustainable natural resource use". Green growth involves a paradigm shift in the way public policy for economic growth is conceived at all levels of governance, and calls for a better integration of national, regional, and local policies and stronger links with non-public actors, including the business sector and civic organisations.

City and regional governments will play an essential role in developing and deploying the green growth agenda. In fact, while the main financial inputs to green growth strategies since the 2008-09 global economic crisis have come from national stimulus packages, city and regional governments will have great responsibilities for implementation. This requires the development of a coherent multi-level governmental strategy to identify policies which are more likely to support the growth of the new green industries as well as the greening of production and consumption at the regional and local levels. City and regional governments can help manage the transition to greener growth by:

i) Facilitating job creation, through:

- investments in greener infrastructure, procurement and service provision;
- integrated urban energy management strategies, including technical support to start-ups in the renewable sector and energy conservation measures in the industry;
- information and incentive programmes targeting private demand for green products and services; and

ii) Fostering systemic changes in the medium-long term through eco-innovation, co-operation in green research and development (R&D), education and training, and green clusters.

Shifting away from carbon-intensive industries will offer new opportunities in terms of employment development. Many governments have highlighted the job potential associated with the green investments made as part of the fiscal stimulus packages and some of the official estimates are presented in the OECD Green Growth Strategy Interim Report (Box 5.1). A well-designed strategy at the city or regional level can support the growth of the new green sectors, through incentives and regulatory changes, while managing trade-offs throughout the adjustment process. In addition, raising the environmental awareness of urban residents will be critical to generate sufficient demand for green products and services. Cities can also raise the growth potential of the clean-energy economy in the longer term through supporting innovation. This will primarily require the development of local networking platforms for eco-innovation, in partnership with private sector researchers and universities.

Facilitating job creation through green growth: The role of cities and regions

City and regional economies function as catalysts for green markets through investments in greener infrastructures and buildings, policy interventions in the domains of renewable energy and energy efficiency, and awareness programmes for green consumers. The associated green industries are characterised by their relative novelty and by their close link with environmental policy and regulation. These industries can improve sustainability by producing goods and services to measure, prevent, and limit environmental risk while minimising pollution and resource use (ECOTEC, 2002). The European Commission's Environmental Policy Review concluded that eco-industries are an engine for growth, expanding at around 5% per year, with the expanded world market for environmental goods and services estimated at over EUR 500 billion (European Commission, 2004). We can distinguish five main categories of green industries relevant to cities and metropolitan regions:

i) Renewable energy and energy efficiency.

ii) Transportation efficiency, new modes of transport and substituting transport.

iii) Green manufacturing, construction and product design.

Box 5.1. **The new green wave in economic policy**

The environmental goods and services sector is increasingly seen as a promising business opportunity. "Greening the economy" is becoming a pressing issue in many countries, mainly in the context of the implementation of international commitments such as the Kyoto Protocol or the Millennium Development Goals. In the midst of the global crisis, the growing policy consensus on the opportunity of combining economic recovery with economic greening is leading to the development of green growth strategies both at the global and national levels. The OECD Declaration on green growth was signed by all 30 OECD member countries at the time, plus Chile, Estonia, Israel and Slovenia, at the Meeting of the Council at Ministerial Level, 24-25 June 2009. It invites OECD to develop a Green Growth Strategy that brings together economic, environmental, technological, financial and development aspects into a comprehensive framework. According to recent estimates (HSBC, 2009), South Korea has invested the highest portion – 81% of its total recovery package – in clean energy (renewable energy, energy efficiency, and public transport). China, France, Germany and the United States also rank high with 38%, 21%, 13% and 12%, respectively, of their total packages focused on clean energy. The Korean green growth strategy also includes three action plans for "greening" industrial production: *i)* expand the green industrial complex, such as resource recycling and IT-based industries (green industrial complexes with circulation facilities for energy recycling are expected to expand from 5 in 2009 to 10 in 2013 and 20 in 2020); *ii)* enhance green partnerships (1 500 firms expected to participate in the partnerships by 2013); and *iii)* disseminate green business structures for enhancing exports of green products (green product share in export value expected to rise to 15% by 2013) (PCGG, 2009). It is estimated that Korea's "Green New Deal" will create 960 000 jobs from 2009 to 2012 (OECD, 2010)

The role of regions and cities in green stimulus plans has been acknowledged in different stimulus packages. The American Recovery and Reinvestment Act includes USD 3.2 billion to fund the Energy Efficiency and the Conservation Block Grants (EECBG), a programme conceived by the Conference of Mayors to implement climate change mitigation strategies in cities. The European Commission announced in March 2009 an investment of EUR 105 million in projects under the EU's Cohesion policy, representing about a third of the overall regional policy budget. A large part of this package (EUR 54 billion) is designed to help member states comply with EU environmental legislation. Improvement of water and waste management alone accounts for EUR 28 billion of the total.

Source: HSBC (2009), "A Climate for Recovery: The Colour of Stimulus Goes Green", HSBC Global Research, *www.globaldashboard.org/wp-content/uploads/2009/HSBC_Green_New_Deal.pdf*; UNESCAP (2008), "The Green Growth Approach for Climate Action", background paper for the 3rd Policy Consultation Forum of the Seoul Initiative Network on Green Growth, 18-20 September 2008, Cebu, Philippines; OECD (2009a), *Policy Responses to the Economic Crisis: Stimulus Packages; Innovation and Long-Term Growth, OECD*, Paris; OECD (2010), *Interim Report of the Green Growth Strategy: Implementing our Commitment for a Sustainable Future*, OECD, Paris.

iv) Waste and pollution control and recycling.

v) Environmental analysis, training and consulting.

For each of the five categories, several sub-sectors can be identified. In urban areas, this translates into a wide array of job offers (Table 5.1). Job-creation programmes at the city and regional level include a variety of instruments, ranging from purchasing and pricing policies, to financial incentives and tax exemptions, to one-stop-shop services for green businesses and training programmes for the labour force.

Table 5.1. **Green firms and green jobs**

Category	Sectors	Examples of jobs
Renewable energy	• Hydroelectric. • Solar PV. • Solar thermal. • Geothermal. • Wind. • Bioenergy. • Combined Heat and Power (CHP).	• Energy engineers. • Electrician and plumbers installing the systems. • Mechanics building the infrastructure. • Renewable energy plant operators.
Transportation efficiency	• Urban Public transport. • Railways. • Urban cycling amenities.	• Public transport drivers and employees. • Bus retrofitters. • Builders of rail networks, tramways and bicycle paths.
Green manufacturing, construction and product design	• Retrofitting. • Energy efficient building materials. • Building maintenance and contracting. • Domestic and office equipment and appliances. • LED (light emitting diodes). • Cleaner coal technologies. • Biodegradable products. • Hybrid vehicles.	• Engineers and scientists working on energy efficiency improvements (efficient lighting, smart metering, low energy monitors, advanced and efficient production processes…). • Chemists developing environmentally friendly packaging, cleaning products and sprays. • Employees of firms producing green building materials (alternative cement, recycled wood…).
Waste and pollution control and recycling	• Mobile and stationary air pollution source controls. • Water conservation and reuse. • Pulp and paper recycling. • Aluminium recycling. • Electronic recycling.	• Workers employed for renewing water infrastructure. • Hazardous material removal workers. • Recycling plant engineers and operators.
Environmental analysis, training and consulting	• Landscape. • Public administration. • Specialised consulting and marketing. • Green venture capital and other financial services.	• Energy contractors. • Specialised consultants. • Trainers. • Marketing specialists. • Green-civil engineers. • NGOs.

Investments in greener infrastructure and greener service provision

In their self-governing role, city and regional governments can directly increase demand for green products and services through their purchasing choices and their management of existing and new infrastructure (Box 5.2). These local-level activities can foster the enabling environment needed to transition to a green economy as the impact of policy interventions can be closely monitored and evaluated, providing useful feedback on could be applied to higher levels of government. There is considerable room to improve the environmental sustainability of the urban infrastructure through greener investments by replacing dwindling raw materials with suitable waste products, by using improved materials to extend infrastructure service life and energy efficiency, and by introducing performance-based design and specifications or sustainable structural shapes, including reusable building components.

It is still not clear whether local governments will be able to rely on larger budgets for their own investments in infrastructure in a post-crisis context. The crisis has put serious pressure on local budgets, by raising the demand for social welfare services and reducing revenues from taxes. Public investment is often the first expenditure that is cut by city and regional governments in financial stress (OECD, 2009b). It is important to address these liquidity constraints, through direct transfers or through the establishment of public funds encouraging action by sub-national governments, so that profitable investments in greener infrastructure are not delayed. Green infrastructure funds can be particularly effective in

Box 5.2. **Fiscal stimulus for investments in infrastructure: Examples from OECD countries**

Most OECD and non-OECD economic stimulus packages contain a focus on improving national infrastructure – mostly through public works. The government of Australia launched an USD 800 million Community Infrastructure Programme that will fund local governments to build infrastructure such as town halls, local libraries and sporting facilities. Only in Australia, USD 8.4 billion will be spent on regional highways and country roads, and USD 3.2 billion in regional rail networks over six years. Japan has offered a subsidy to municipalities of JPY 4 billion to repair and earthquake-proof public facilities. Canada has assigned CAD 6.4 billion to renew infrastructure in partnership with provinces and municipalities. At the regional level, Ontario announced an investment of USD 622 million in housing in the 2009 Provincial Budget. The investment is expected to rehabilitate 50 000 social housing units, build 4 500 new affordable housing units and is estimated to create 23 000 jobs province-wide over the course of the programme. Moreover, the Federation of Canadian Municipalities (FCM) is endowed with CAD 515 million to accelerate projects such as construction of schools, water and waste-water projects and critical community services infrastructure.

Source: OECD (2009a), *Policy Responses to the Economic Crisis: Stimulus Packages; Innovation and Long-Term Growth*, OECD, Paris.

raising the environmental value of infrastructure investments, as financing can be made conditional on transparent criteria or scores (use of improved materials, energy efficient design), and because they create incentives for the creation of public-private partnerships. Enhancing the local ownership of large infrastructure projects can improve the quality of public spending. The main reason for this efficiency gain is that local governments usually know best what the most urgent needs are and can therefore target the provision of public infrastructure to these needs. Larger projects might require greater co-ordination among interested cities, as joint production of neighbouring jurisdictions can ensure economies of scale in the delivery of infrastructure services and reduce free-riding problems. In this scenario, green infrastructure funds can facilitate co-operation among relevant parties by establishing a common agenda and providing clear evaluation criteria.

Purchasing policies of cities and regional governments in the infrastructure domain can strongly boost the market for climate friendly products and services. Having the capacity to plan and responsibility over infrastructure, transport, water, energy, waste and public buildings, city and regional governments authorities are uniquely placed with procurement to implement effective climate mitigation and adaptation actions. City governments can use their large market power and market engagement to bring new technologies on the market. Several experiences show that sustainability concerns can be successfully integrated into urban procurement practices through innovative tools (*e.g.* life cycle costing),[1] and institutional solutions. As discussed earlier, Berlin has a pioneering programme whereby public retrofitting tenders include a requirement for average CO_2 reductions of 26%: within this programme 1 400 buildings have already been upgraded (Hidson, 2009). The city of Helsinki established a Procurement Centre, charged with developing operational models for managing markets through systematic dialogue with businesses. The centre is defining environmental criteria for different product groups and co-ordinating training programmes to raise awareness among procurers. Co-ordination in procurement among cities is important, both from a cost-efficiency and from a market-stimulus perspective. On the cost efficiency side, joint procurement can effectively bring down the costs through economies of scale in purchasing. On the market stimulus side, co-ordinated action can magnify the signal sent to the market.

While there is no clear consensus on what actually is a good green investment, experts have drawn up sets of criteria to assess the effectiveness of the green investment measures and have come up with similar results that apply equally well to national and local projects. Edenhofer and Stern (2009) and Bowen *et al*. (2009), for instance, suggest that investments should meet the following criteria:

- Timeliness in decision and implementation.
- Potential long-term social returns (with respect to climate change objectives).
- Positive "lock-in" effects from investment in long-lived low-carbon capital stock.
- Likely extent of job creation and size of the domestic fiscal multiplier.
- Use of under-utilised resources.
- Time-limitedness: the extent to which spending is likely to be shifted forward in time, reducing necessary spending later on.

Among the pre-conditions for effectiveness, participatory processes and stakeholder involvement, as well as an engaged local leadership, are particularly important for investments undertaken at a regional or urban scale.

The most obvious option for a shovel-ready, local green investment to re-employ displaced workers or create new jobs is a large-scale building retrofit programme. Jobs can be created immediately to repair or replace deteriorated assets, with no new plans, environmental impact statements, or land acquisition,. Further, the technology to reduce energy consumption in buildings already exists and simply needs to be deployed. Regional and city governments must resist the temptation of focusing on new construction projects as the primary means for reducing energy demand from buildings, as retrofitting the existing stock is generally a more efficient and a more labour-intensive activity. Current practice in retrofit programmes makes possible a considerable reduction in building maintenance costs and investments in the repair and replacement of worn-out elements. Finally, retrofitting public-owned residential complexes has the important complementary benefit of increasing the market value of dwellings, making residential areas more attractive. The city of Freiburg, Germany, has pursued this strategy by allocating a budget of EUR 2 million to the renovation of the city's old and historical buildings. This has included the non-intrusive, strategic installation of 180 solar PV panels on the tiled roof of the old City Hall.

In recent years, several local governments in OECD and non-OECD countries have already opted to invest in renewable energy, resource-saving, recycling activities and green area management in order to spur job creation (IEA, 2009). These activities include projects linked with waste treatment systems (Oslo), brownfield redevelopment (Toronto), water supplies (Amman), care of green areas and landscape (São Paulo), development of products and energy efficient technologies for use in their own buildings (Hamburg), as well as in public transport (Calgary) and local schools (Bristol). Many examples exist of community owned solar photovoltaic installations (Toronto Solar Neighbourhoods), wind farms (Sams´ø), biodiesel vehicles (Halifax), hydrogen vehicles and related infrastructure (Reykjavik, Fukuoka, Seoul), or biogas-fuelled buses (Stockholm). These public projects have the common characteristic of seeking the participation of private business partners.

Recycling is one of the most dynamic drivers of environmental-friendly employment creation. In the recycling sector, private companies are taking the lead in launching new investments and up-scaling existing ones, the role of city governments being more one of improving the business environment (through initial grants for factory facilities, land-use regulations and one-stop services to reduce unnecessary red tape). The example of Kitakyushu City is illustrative of the tremendous employment opportunities that strategic waste management and recycling can open in a globalised economy (Box 5.3).

Infrastructure enabling intra-urban mobility is crucial for agglomeration economies to produce their effect. More compact, connected cities can improve their environmental effectiveness through combined investments in transportation networks and ICT. There are important complementarities between these two investments. Both respond to the need of improving connections between people and businesses, reducing costs of commuting and information transfers. Besides their productivity, quality of life and ecological footprint benefits (saving time, money and energy), investments aimed at reducing mobility costs within the cities can have important benefits in terms of spatial equity, breaking the physical disconnection from jobs that exacerbate unemployment in poorest neighbourhoods. Concerning transportation networks, the "New Mobility" models experimented with in both developed (*e.g.* Toronto, San Francisco, London) and developing countries (*e.g.* Cape Town, Chennai, Bangalore) search for better integration of different transport modes around hubs: these hubs are dynamic centres for service provision, generating new employment opportunities in entertainment, recreation, dining, banking, commerce, and community services. Integrated urban strategies for sustainable transportation can serve as incubators for important innovations, providing the necessary framework for evaluating the costs and benefits of new technologies with wide industrial applications, like hybrid engines, hydrogen fuels and sensor networks.

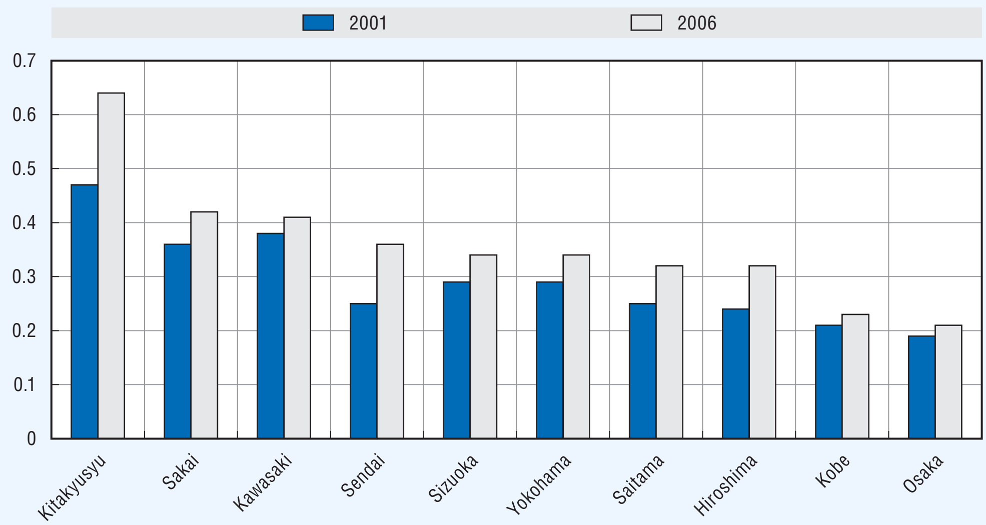
Several countries are investing to generate rapid shifts in the installation and use ofinformation and communication technology (ICT) equipment, including energy, water and traffic congestion management technologies. There is increasing evidence of the positive effects of ICT on productivity growth in OECD countries (OECD, 2003; Crandall *et al.*, 2007).[2] ICT is a significant contributor to energy efficiency through the innovation process, or the substitution of a new technology for an old one, which brings with it a lower level of energy consumption and/or resource use. Given the significant environmental benefits (*e.g.* energy savings from transportation substitution, "dematerialisation" and smart building) and the employment effects in the short-term (*e.g.* new construction sites for broadband deployment) and medium-to-long-term (*e.g.* creation of new business and jobs, higher productivity and better market access for existing firms), it makes sense for cities to invest more resources in green ICT infrastructure. Regulatory reforms, reducing barriers to entry and investment by new service providers, are critical to sustain private investment in broad-band networks. First-movers in ICT network investments seem to enjoy significant benefits. The Paris suburb of Issy-les-Moulineaux, by providing superior broadband infrastructure, a business-friendly climate and innovative e-services, has managed in less than a decade to radically change its industrial structure, reducing local unemployment to virtually zero.[3] Korean municipalities are particularly active in the deployment of ICT technologies as a means of enhancing energy efficiency of urban infrastructure. The Gangnam-gu district of Seoul, home to corporate headquarters, multinationals and IT venture firms, adopted a carbon mileage system and is now pioneering innovative service provision via wireless networks.

Box 5.3. **Strategic urban economic policy in the recycling sector, Kitakyushu City's example**

The recycling sector yields great potential for employment creation and re-employment of displaced workers, in particular in cities with an industrial history. Kitakyushu City, Japan, once the capital of steel and chemical industries, overcame severe pollution and sought out the growth potential in the recycling sector. Kitakyushu City launched the Eco-Town project in 1997 and has now many recycling companies, which handle sludge and waste materials produced as by-products of industrial production processes.. In attracting recycling companies, local government emphasised the cheap and vast land available away from residential districts, abundant industrial water from the ocean, subsidies for factory facilities, accumulated human capital and manufacturing sectors, and clustering of related recycling companies. Local government also facilitated companies' establishment in the Eco-town through one-stop support services. As of 2008, 26 companies and 17 research institutions were in operation, and employing 1 352 people (see Figure 5.1 for Japan below).

Figure 5.1. **Percentage share of recycling sector employees among total employees in 2001 and 2006**

Top 10 ranking



Source: Ministry of Internal Affairs and Communications, enterprise statistics.

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According to a public opinion survey in 2007, an increasing number of citizens in Kitakyushu City recognise the recycling sector as one that contributes to the environment, partly due to the government's encouragement of public involvement. Residents' support of the recycling industry is a big attraction for a sector that is often exposed to an attitude of "not in my back yard".

Globalisation is opening new windows of opportunity for Kitakyushu City. For example, China has gradually increased the need for recycling due to serious water contamination and inappropriate waste disposal. Kitakyushu City has begun environmental co-operation with Chinese cities, including Dalian City since the 1990s, Quingtao City since 2007 and Tianjin City since 2008. Kitakyushu International Technology Cooperation Association (KITA), a public education institution for environment policies and technologies, has taught over 5 000 people from 130 countries from 1980-2008. The City aims to link environmental co-operation with development of environmental business. In this way, Kitakyushu City's environment strategy is deeply embedded in the economic growth strategy.

Source: Bank of Japan, Kitakyushu subsidiary (2008), "Recycling Industry in Kitakyushu City", *www3.boj.or.jp/kitakyushu/sonota/kitarecycle.pdf*, accessed 2 October 2009; OECD (2009c), *OECD Territorial Reviews: Trans-border Urban Co-operation in the Pan Yellow Sea Region*, OECD, Paris.

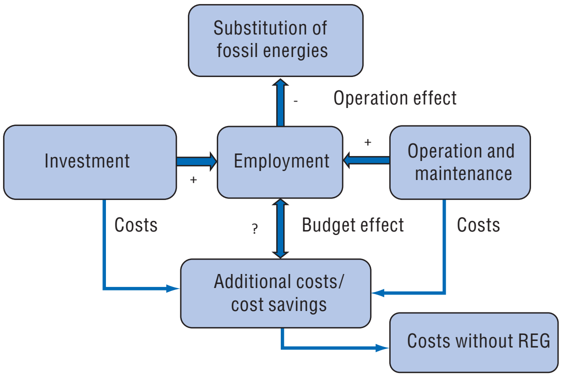
Increasing the environmental sustainability of public infrastructures generally implies higher fixed costs. However, the range of economic benefits that must be accounted for in cost-benefit analyses is wide and may not be properly identified in current cost-benefit analysis assessments. First of all, there are important multiplier effects generated along the value chain.[4] For example, the US Department of Commerce's Bureau of Economic Analysis (BEA) estimates that across the United States, for each additional dollar's worth of output from the water and sewer industry in a year, the dollar value of the increase in output that occurs in all industries is USD 2.62 in the same year. Moreover, raising energy efficiency and investing in new energy infrastructure and smart grids can also raise regional energy security, by reducing exposure to highly volatile fossil fuel prices and enabling improved grid management, thereby reducing the likelihood of blackouts.[5] Rightly accounting for these complementary benefits in urban investment strategies requires new tools and dedicated investments in training and human capacity. The introduction of enabling technologies (ICT and nanotechnologies) can significantly increase the economic and environmental efficiency of the new infrastructure and network investments (OECD, 2009d). Moreover, contracting issues and corruption must be addressed. Public sector wages would need to be closer to private sector wages to avoid cost over-runs and maximize efficiency in output delivery.

Urban energy management strategies for employment creation

In the wide spectrum of urban green growth policies, particular attention should be paid to Renewable Energy (RE) generation and Energy Efficiency (EE) for local energy provision. In fact, these are areas with relevant synergies between environmental impacts and employment generation, requiring capacity to act at the local level. Renewable energy initiatives in city and regional climate action plans are often focused around distributed energy technologies, such as rooftop solar photovoltaics (PV) and solar water heaters, which cities are more able to deploy directly.[6] Energy efficiency initiatives are "no-regret measures", as in addition to climate change-related impacts they generate additional benefits in the form of cost savings. The substantial local-level investments that adapting to climate change will require in the energy sector, such as increasing the heat-resistance of transformers and wiring, will produce sustained public demand for specialised and semi-skilled jobs.[7] The private sector will receive a boost from investments in the energy sector as they are increasingly realised through public-private partnerships. However, the net employment effect of investments in the energy sector, and in renewable energy in particular, are difficult to assess in the short-medium term, as some jobs will be lost in carbon-intensive sectors as others are created in low-carbon sectors (Figure 5.2).

Raising the share of renewable energy can be attractive from the perspective of generating employment because new investments in renewable technologies are generally more labour-intensive than investments to expand fossil fuel-based energy generation. In addition, the impact on local employment tends to be higher as the demand for system installers and maintenance engineers is more likely to draw from the local labour pool. A distinction here is needed between large scale, centralised renewable energy utilities, and small scale, decentralised utilities. The latter, distributed solar PV in particular, have higher labour intensity as a result of the fragmentation (number of systems required to achieve the needed capacity) and of the labour-intensive installations. Installing a large 100 MW solar PV array in the desert requires significantly less labour than installing 100 MW of 4 kW residential rooftop PV systems (*i.e.* 25 000 systems). There are also significant differences across renewable

Figure 5.2. **Employment effects of renewable energies**



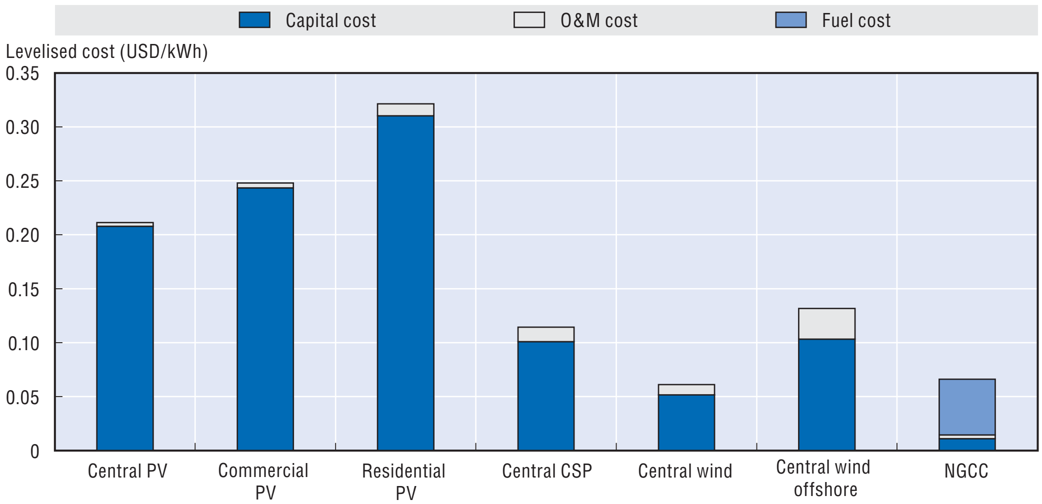
Source: Bremer Energy Institute (2006), "Renewable Energies – Environmental Benefits, Economic Growth and Job Creation", *www.estif.org/fileadmin/estif/content/press/downloads/060506_Bremer_insitute_impact_jobs_renewable_energies.pdf.*

technologies, in particular concerning labour demands for maintenance and operation of the facilities. Kammen *et al.* (2006) estimate that installing 1 MW_a of wind turbine capacity creates an estimated 0.7-2.9 times as much permanent employment *vis-à-vis* a comparable natural gas combined cycle (NGCC) power plant; installing 1 MW_a of rooftop solar PV creates an estimated 7.8 times more employment than a NGCC power plant.[8]

The numbers from different sources show that the renewable energy industry has already reached a noteworthy size, with about 200 000 jobs in the EU in 2003 (European Commission, 2004). While the majority of jobs in the fossil fuel industry are in fuel processing, a relatively capital-intensive activity, the majority of jobs created in the renewable energy industry are in manufacturing and construction.[9] In all renewable energy sectors, costs have fallen dramatically due to improved technologies.[10] However, renewables are not yet cost-effective compared to conventional energy sources, as they require more inputs – both in terms of capital and labour – for a given amount of output. Renewable installations are in fact more short-lived (on average 25 years *versus* 40 years for coal and gas), and have a lower capacity factor (operating on average 25% of the time, with respect to about 80% for fossil fuel plants). Again, there are large differences in costs across technologies. To summarise: *i)* distributed generation is currently more expensive than centralised generation; *ii)* residential PV is more expensive than commercial PV; *iii)* PV is more expensive than solar thermal; *iv)* solar is more expensive than wind; *v)* onshore wind can be cheaper than natural gas (Figure 5.3).

Whereas renewable energies' higher current cost relative to fossil fuels may increase city and regional governments' net expenditures, energy efficiency can be cost-effective now. For instance, recent empirical analysis for California suggests that, at USD 0.027-0.034/kWh, the average resource costs of energy efficiency are still well below the cost of generation and are significantly below the cost of distributed renewable energy (Shin, 2009). In addition to direct savings, energy efficiency allows households and businesses to shift expenditures from a low value-added, capital-intensive sector (energy) to higher value-added, labour-intensive sectors (*e.g.* energy efficiency services). For cities, expenditure shifting has the added benefit of redirecting expenditures from energy, whose revenues are likely to be re-invested outside the city, to sectors that are more likely to be local (*e.g.* services). Income that remains local is more likely to be reinvested in the local economy, producing local multiplier effects that have a positive impact on growth.[11]

Figure 5.3. **Estimated levelised cost of generation, various technologies**



Note: NGCC is combined cycle natural gas and central CSP is concentrating solar power.

Source: Levelised costs are early 2009 estimates based on Kahrl, F., W. Tao and D. Roland Holst (2009), "Municipal Climate Policies: Scope, Economics, and Institutions", Center for Energy, Resources, and Economic Sustainability, University of California, Berkeley.

StatLink http://dx.doi.org/10.1787/888932342487

Tax incentives to encourage residents and corporations to use renewable energy or adopt energy efficiency systems and equipment can be effective in raising the demand for clean energy and achieving the critical market size to support local or regional investments. Market access in the energy sector is still severely constrained, especially for small and medium enterprises (SMEs). Direct purchasing of renewable electricity, biofuels and of renewable equipment, possibly jointly by several municipalities, can be useful to support the growth of energy efficiency or renewable energy SMEs. Regulations imposed by cities can complement national and regional standard setting (*e.g.* Renewable Portfolio Standards and Energy Efficiency Resource Standards), encouraging the local generation and deployment of renewable energy. Access to funds for new projects in renewable energy often proves difficult due to the lack of available and adapted financing resources. Soft loans and guarantees provided by city or regional governments can be thus highly attractive for renewable energy project developers.

Fixed price systems ("feed-in tariffs") have played a decisive role in attracting renewable energy investment in European regions. Through feed-in tariffs systems, producers of renewable energy feed solar electricity into the public grid and receive a premium tariff per generated kWh, reflecting the benefits of renewable electricity compared to electricity generated from fossil fuels or nuclear power. While the first programmes were financed through government budgets, it is more and more the case that utilities pay a premium tariff for renewable electricity, and then pass on this extra cost, spread equally, to all electricity consumers through their regular electricity bill. Feed-in-tariffs operate over a fixed period of time, reducing uncertainty in anticipated revenues. The first two cities to adopt a local feed-in tariff in the United States were Gainesville, Florida, and Los Angeles, both in 2008. Feed-in tariffs to promote solar energy have been implemented in several German cities, following the positive experience of the "solar city" of Freiburg (Fitzgerald, 2009). The conditions for feed-in tariffs need to be set through a co-ordinated effort of national and local governments, as feed-in tariffs can turn out to be a competitive disadvantage for some cities or regions. Cities and regions can also consider the implementation of least-cost-planning (LCP) and integrated resource planning (IRP) in order to support energy saving technologies. These mechanisms oblige the utilities to verify whether investment in renewable energy (or reduction of consumption) is feasible when they intend to substitute or extend their existing production capacities.

When considering the employment effects of energy policies, possible adjustment costs should not be ignored. As a result of climate policies, jobs will be lost in carbon-intensive sectors directly affected by regulations and standards (for example, in decommissioned fuel and coal power plants). Further jobs will be lost along the value chain: for example, contraction in demands for coal-fired power generation will lead to upstream job losses in the mining industry. Regional economies face two main dangers when exposed to aggressive price measures and environmental regulations for business: *i)* industry downsizing due to adjustment costs; and *ii)* relocation of footloose industries. First, manufacturing firms might be unable to adjust in the short term to a rise in input prices caused by greater reliance on renewable energies or compliance with new environmental regulations. Difficulties in adjusting can result in sizable losses in employment.[12] Second, national or regional differentials[13] in the effective price of power and regulation might induce relocation of industries, and multi-nationals in particular, towards localities with looser environmental regulation (*pollution haven hypothesis*). Industries most likely to locate in pollution havens are not necessarily those labelled “the dirtiest” industries but rather more “footloose” industries such as electronic and appliance manufacturers.[14]

The possible employment costs of climate policies for regional economies mentioned above, either in the form of profit losses for business or leakage effects, should be weighed against potential productivity gains achievable in the longer run. Innovative firms capable of investing in and adopting clean energy technology are likely to see their input costs decrease over time relative to those businesses not adjusting, as coal and oil are likely to become relatively more expensive in the coming years. While it is still early to draw conclusions, anti-carbon regulations might spur a process of creative destruction that could be ultimately beneficial to regional productivity and innovation. The argument is that the need to adopt energy-saving technologies with wide-ranging applications will trigger in the longer term a process of technology diffusion, adaptation and experimentation, with significant spillovers on regional productivity growth (Fankhauser *et al.*, 2008). In the short-medium term, there is scope for regional economic policies aimed at minimising potential employment losses. These will take the form of services reducing the costs of energy conservation and pollution reduction measures, and local labour market policies facilitating the absorption of laid-off workers in the expanding green industries.

City and regional capacity building programmes for management can lead to wider and less costly adoption of conservation measures. Increasing evidence shows that better managed firms are significantly less energy intensive (Bloom *et al.*, 2008).[15] Local or regional one-stop-shop agencies for business support should acquire specialised skills in order to advise firms on the most cost-effective ways of reducing emissions. Their role would consist mainly in enabling businesses to reach conservation goals at lower costs, for example through sustainability audits. They might also engage in demonstration projects for new equipment, in partnerships with manufacturers and academia (OECD, 2009e).[16] In Canada, programmes such as the Eco-Efficiency Partnership in British Columbia, the Eco-Efficiency Centre in Nova Scotia and the EnviroClub of Quebec are good examples of approaches to improving simultaneously the environmental performance and the competitiveness of local SMEs. The "Chicago Industrial Rebuild Program" assists facilities in securing financing to implement recommended improvements. An interest-free loan is available to participants who purchase "green" or renewable power. Nearly half of the metal casting industry in Chicago participated in the city-funded assessments. If all recommendations are implemented, it is estimated to generate over USD 5 million in cost savings, 10-25% in energy savings and reduce air pollution by 1 000 US tonnes per year.

Finally, greater eco-efficiency can be a source of employment for the local workforce and business opportunities for firms, which can realise profits by exchanging waste and energy. Recently, eco-industrial parks and regional eco-industrial clusters have been integrated into several regional and national economic development plans. At the heart of these initiatives is the argument that industry can mimic natural ecosystems, shifting from the current wasteful linear model of production to a circular model, where wastes are converted into new inputs and energy cascaded through the local industrial network (Gibbs, 2008). Kalundborg in Denmark is the most well-known example of the economic gains that can be achieved by developing waste and energy exchanges in an eco-industrial park. The diverse firms in the eco-park of Kalundborg utilise each other's surplus heat and waste products, with annual estimated savings of USD 12-15 million (Tudor *et al.*, 2006). Several other eco-industrial parks have followed this successful model and provide examples of how efficiency and sustainable use of resources can be integrated into business development programmes (*e.g.* Styrian recycling network in Austria, Rotterdam Harbour and Industrial Complex in the Netherlands, Londonderry industrial park in New Hampshire, and Guigang Eco-Industrial Park in China). It is difficult to plan effective eco-industrial systems from scratch. However, local governments can facilitate their development. Japan's Eco-Town programme is an example of a large-scale public programme seeking to maximise business and resource-saving opportunities generated by the proximity of industrial and urban areas. It launched 61 innovative recycling projects, which successfully contributed to raising industrial productivity and generating employment, while improving environmental amenities (Van Berkel *et al.*, 2008).

Greening preferences to raise the size of green markets

While public investment can sustain the development of the green economy in the earlier phase, its long-term health will crucially rely on the dynamism of demand from private consumers. Private customers' willingness to pay a premium for products and technologies that reduce GHG emissions and resource use (*i.e.*"green products") will impact the extent to which newer and better products will be offered for sale. Identifying policy instruments able to affect preferences for green goods in a cost-efficient manner is a crucial challenge for urban green policy. There is significant heterogeneity in the willingness to pay for green products, and individual and community characteristics can explain why we observe a high concentration of demand in particular cities or regions (Kahn and Vaughn, 2009).[17] Lack of customer education on renewable energy is one of the most serious barriers for retail green power products (Wiser *et al.*, 1998). Cities in OECD and in some non-OECD countries are increasingly raising local awareness through consumer education programmes, eco-standards and eco-labelling, and best-practice demonstration sites. It makes sense to develop and implement these programmes locally, as research has shown that mass information (*e.g.* international labels) are easily ignored, while local and targeted information seems to more effectively to raise demand (OECD, 2008a). While these initiatives have yet to be rigorously assessed, it is increasingly clear that systemic changes in consumption habits are critical for raising market penetration of green goods and services.

Relying on voluntary contributions from customers, through utility green pricing programmes, can be highly effective to support higher levels of local investment in renewable energy. Participating customers in green pricing programmes typically agree to pay a premium on their electric bill to cover the incremental cost, for the utility, of providing additional renewable energy. The number of these programmes has increased steadily in recent years: to date, more than 750 utilities in the United States offer a green pricing option.[18] Green pricing programmes involving voluntary contributions from private citizens and from corporations are proliferating in many other OECD countries.[19] A review of the experience of green pricing programmes in the United States until 2000 concludes that success, in terms of consumers' participation and increases in supply capacities, is determined by: product design (*e.g.* multiple products to appeal to different market segments), value creation (*e.g.* participation raises personal recognition and civic pride), product pricing (*e.g.* premiums are cost-based and transparently invested in new renewable energy development), and programme implementation (*e.g.* how the product is marketed) (Swezey and Bird, 2001). The development of marketing capacity at the city level, in particular, seems to be a crucial element behind impressive capacity developments, such as the City of Palo Alto's 100% renewable energy optional programme.[20]

Local and regional government can go a long way to increasing local green consumption by financing arrangements reducing the upfront cost hurdles and unit costs of distributed energy technologies. For example, the City of Berkeley's Financing Initiative for Renewable and Solar Technology (FIRST) programme reduces these hurdles by providing loans to homeowners to purchase and install solar photovoltaic systems at interest rates and payback periods similar to those for home mortgages. Borrowers repay the city through an additional, transferrable tax added to their annual property taxes.[21] Berkeley FIRST also illustrates the limitations of funding mass residential PV system at the city level, as the city's first round of funding provided USD 1.5 million for only 40 homes; expanding the programme to reach 1% of the city's housing stock would require USD 17.5 million in capital, equivalent to 5.4% of the city's total budget for fiscal year 2009.[22] In addition, the concern that this and other Property Assessed Clean Energy (PACE) programmes could contribute to the inability of some homeowners to repay their mortgage highlights the need for policy coherence from multiple levels of government (Zimring and Fuller, 2010). For solar water heaters, low interest, long-term finance can make them cash flow positive in the first year. These financing arrangements primarily concern new homes, as solar water heaters are integrated into the mortgage. Incentives programmes are also being developed to retrofit existing houses with solar water heaters. The California Public Utilities Commission (CPUC) developed a state-wide Solar Hot Water incentive programme. The proposed incentive amount for residential SWH systems is expected to be about USD 1 500 per system on average.

City and regional programmes to raise awareness of the value of green products aim to overcome information failures. Information on the quality and character of green services and goods can be quite technical and difficult to obtain, leading individuals to inadequately perceive the risks implied by climate change and unsustainable resource use. Local programmes investing in information and communication technologies (ICT) can significantly lower the information asymmetries that often lead to non-economic behaviours in energy consumption and cost. An example is the provision of new smart metres that display and record real-time energy consumption data and analyse electricity demand patterns to encourage changes in energy usage. Recent research at the MIT Portugal

Program has shown that smart metres produced energy savings of up to 20% for households in Lisbon.[23] City-level demonstration projects, even of a limited scale, have been very effective. A multi-year survey in the city of Blacktown, Australia, shows that awareness of the Blacktown Solar City project grew to 44% two years after its initiation. Of the people surveyed, 91% had switched to energy-saving light bulbs, 73% had chosen an appliance because of its energy rating, 42% had installed insulation to reduce energy use, 30% had signed up for green electricity and 5% had installed solar panels during the two years of the project's implementation.[24] This demonstrates the potential impact of government information campaigns, coupled with wide technology deployment (*e.g.* roll-out of smart metres), on local and regional green spending and energy efficiency.

Systemic changes through regional eco-innovation

As argued by Schellenber *et al.* (2008) there is a "*dilemma – a 'Gordian Knot' – at the heart of any effort to deal with global warming. If policy makers limit greenhouse gases too quickly, the price of electricity and gasoline will rise abruptly, triggering a political backlash from both consumers and industry. But if policy makers limit greenhouse gases too slowly, clean energy alternatives will not become cost-competitive with fossil fuels in time to prevent catastrophic global warming*". Innovation, by cutting down the costs of green product and technologies, can be the stroke that will cut the knot. Green innovation can be defined as innovations in environmentally responsible products and services that are both sustainable and contribute to reducing the impact of GHG emissions upon the environment.

Large cities and metropolitan areas have a very important role as centres of innovation (OECD, 2008a). The size and compactness of urban centres generate opportunities for enhanced information flows: as Glaeser *et al.* (1992) put it, "intellectual breakthroughs must cross hallways and streets more easily than continents and oceans". The mobility of workers through sectors, firms and space may be an additional way of spreading innovation that is facilitated by proximity. Most importantly, the availability of a large and diverse pool of labour is a crucial competitive advantage of cities in attracting innovation activities. The processes by which innovation unfolds in cities are mutually reinforcing. The concentration of knowledge creation in cities attracts skilled, entrepreneurial and creative individuals, whose location choices in turn contribute to producing innovation (OECD, 2009f).

The importance of size and density as "pull factors" for knowledge industries and creative individuals does not mean that green innovation will only happen in large urban centres. The green economy is in fact a vast mosaic of differentiated products and services, requiring very diverse labour and capital inputs. There are many latent opportunities for small and medium-sized cities to raise their competitive position in the green markets. These opportunities need to be fed by dedicated investments in knowledge creation. A notable example comes from Århus, Denmark's principal port city, which has been successful in linking university research with both spin-off firms and larger, indigenously established firms involved in "green innovation" (Cooke, 2008).

Most innovation activities seem however to take place in larger urban areas (OECD, 2009f). Innovative activities are not distributed evenly within countries; some areas are highly innovative while others produce little or no technical and organisational innovations (OECD, 2009f). Innovation tends to be "spiky" among cities as well: some cities have a lot of it, some have very little. The analysis of patterns of concentration and specialisation of

Table 5.2. **Top innovators in renewable energy, counts of patents by region (2004-07)**

	Wind		Solar		Hydropower		Geothermal		Biomass	
		Patents		Patents		Patents		Patents		Patents
1	Ost-Friesland (DE)	340	San Jose-San Francisco-Oakland (US)	323	Ostwurttemberg (DE)	28	Aichi (JP)	21	Oxfordshire (UK)	148
2	Los Angeles-Long Beach-Riverside (US)	129	Los Angeles-Long Beach-Riverside (US)	191	New York-Newark-Bridgeport (US)	28	Los Angeles-Long Beach-Riverside (US)	19	New York-Newark-Bridgeport (US)	142
3	Tokyo (JP)	81	Tokyo (JP)	151	Isère (FR)	22	Stuttgart (GE)	14	Cleveland-Akron-Elyria (US)	135
4	Navarra (ES)	81	Boston-Worcester-Manchester (US)	148	Los Angeles-Long Beach-Riverside (US)	22	Houston-Baytown-Huntsville (US)	14	San Jose-San Francisco-Oakland (US)	128
5	Berlin (DE)	64	Detroit-Warren-Flint (US)	141	Sydney (AU)	19	Atlanta-Sandy Springs-Gainesville (US)	13	Cheshire (UK)	62
6	Schleswig-Holstein Mitte (DE)	58	Sydney (AU)	139	Linz-Wels (AT)	18	Aachen (DE)	13	Rheinpfalz (DE)	53
7	Osaka (JP)	58	Munchen (DE)	137	Rogaland (NO)	18	Zug (CH)	12	Houston-Baytown-Huntsville (US)	50
8	Seoul (KR)	49	Washington-Baltimore-N. Virginia (US)	129	Melbourne (AU)	16	Hamburg (DE)	10	Philadelphia-Camden-Vineland (US)	41
9	Fyns amt (DE)	47	Melbourne (AU)	94	Philadelphia-Camden-Vineland (US)	16	Industrieregion Mittelfranken (DE)	10	Unterer Neckar (DE)	30
10	San Jose-San Francisco-Oakland (US)	43	Kyoto (JP)	87	Osaka (JP)	15	Greater Vancouver (CA)	10	Berkshire (UK)	29

Source: Data are extracted from the OECD REGPAT data set. Counts of patents are weighted according to the methodology described in OECD (2008), "The OECD REGPAT Database: A Presentation", *OECD STI Working Paper*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/888932342696

innovative activities is important for understanding the regional dimension of green growth. While predominantly urban regions, as defined by the OECD regional typology, have produced between 2004 and 2006 an average of 106 patents in the green technology classes above, intermediate urban regions have produced on average only 30 patents, and predominantly rural areas only 10.[25] This evidence is in line with the findings of Bettencourt *et al.* (2007), who show that new patents are granted disproportionately in larger urban centres and argue for the presence of increasing returns in innovation activity with respect to population size.

Why should cities and regions bear the costs of inventions while they could free-ride on knowledge developed elsewhere? The case for localised investments in green innovation rests on three main assertions:

- innovation activity should be tailored to the local milieu, as geographical and historical differences are important for innovation dynamics;
- regional policies are effective in supporting the development of new applications for the technologies of innovative firms; and
- significant constraints limit international and within-country technology transfer and deployment.

There is a strong awareness that knowledge creation and learning is critical to the competitive advantage of firms and cities. The availability of "knowledge systems" capable of producing new learning is particularly crucial for the development of green industries, where costs are constantly pushed down through innovative processes and technologies. The dynamism of a local knowledge system has deep roots in the economic history of each territory: regional development is in fact based around path-dependent processes of learning, institution building and resource accumulation. Yet, local innovation policies can produce systemic improvements in the quality of the system. Two major roles for cities can be identified:

i) a facilitator role for information sharing, through support to formal inter-organisational networks, and through the facilitation of informal knowledge spillovers; and

ii) an enabler role, through the identification of priority areas for investment in science, technology and development and well-designed support for R&D and education.

Widening and generalising access to knowledge through public-private partnerships and networking platforms for eco-innovation is a policy target within the reach of city and regional governments. Knowledge Transfer Networks (KTNs) are set up and funded by government, industry and academia. They bring together diverse organisations and provide activities and initiatives that promote the exchange of knowledge and the stimulation of innovation. KTNs in the field of eco-innovation have been initiated by regional development agencies in the United Kingdom. A major review of the KTNs in the United Kingdom showed that 75% of business respondents rated KTN services as effective; 50% developed new R&D and commercial relationships with people met through these networks; and 25% made a change to their innovative activities as a result of their engagement within KTN (OECD, 2009c). The Lahti Cleantech cluster in Finland encouraged innovation and development of environmental technologies by bringing together small and large enterprises, educational organisations and regional authorities. As a result, 170 new jobs have been created, 20 new clean-tech companies have set up in the Lahti region and the project has attracted more than EUR 30 million in total investment.[26] The London Hydrogen Partnership is working to bring the hydrogen technology forward in the capital so as to improve energy security and air quality, reduce greenhouse gases and noise, and support London's green economy.[27]

Research and Development (R&D) activities are at the core of environmental innovation and are necessary for the development of new environmental technologies (OECD, 2009c). There are few data and assessments on public and private expenditure for R&D programmes targeting environmental technologies and products. Cities and regions can be innovative by promoting pilot, small-scale R&D projects within a framework that clearly specifies targets, outputs and indicators so as to allow monitoring and evaluation. Successful projects can qualify for access to other sources of financing and could provide large benefits through replication in other cities. Well-designed public technology infrastructures can leverage new private investments in R&D. Examples of this type of technology infrastructure include the development of joint research projects between public and private laboratories (Co-operative Research and Development Agreements, CRADAs, and publicly sponsored Research Joint Ventures, RJV), and Small Business Innovation Research Awards. In the Rhône-Alpes Region of France, regional and national investments in R&D were instrumental to the development of the Tenerrdis competitiveness cluster, which is promoting scientific collaboration to develop clean technologies applied to construction, transport and energy production.

Tenerddis brings together 185 stakeholders, who developed, between 2005-08, 226 R&D projects, for a total of EUR 440 million of investments, of which EUR 200 million came from public funding.[28]

Universities can facilitate local knowledge exchange – the local "buzz" – and become effective pipelines of information exchange with national and global markets. Universities can effectively contribute to the creation of local knowledge hubs for green technology by:

- educating people (training graduates and continuing education);
- increasing the local stock of codified knowledge (patents, publications);
- providing public space for local and global exchange (hosting forums, meetings and conferences; networks of alumni, faculty exchanges); and
- problem-solving (contract research, incubation services, co-operative research with industry).

There is great potential in university involvement in green technologies, but efforts for consolidation of this involvement are just emerging. There is increasing empirical evidence that partnerships raise the innovative outputs of both firms and universities (OECD, 2009c). The competences in wind engineering and wind energy at the Danish Technological Institute and at Ålborg and Århus Universities have been essential for the development of the Danish wind energy clusters (Cooke, 2008). Targeted public financing aiming at boosting the innovation capacity (and thus the competitiveness) of local green firms can use local, public research facilities as a means of leverage. In particular, innovation vouchers, which provide financing for university-industry collaborations, can be effective at promoting the transfer of knowledge between the research and the business community.[29]

It is increasingly important to generate incentives to speed up the move of environmental technologies from the laboratory to the market. This will be mainly done by increasing and focusing sponsored research projects on environmental technologies and by increasing the density of institutional and informal linkages between business and universities. Local governments have now more autonomy in this regard. One result is that city and regional governments now strongly encourage universities to open technology transfer offices (TTOs) and technology licensing offices (TLOs), whose activities are focused on translating research findings into practical application for the benefit of the general public. Investments for consolidating these efforts are warranted, as TTOs and TLOs are often small and lack capacity, and can therefore be ineffective. An effort to strengthen and consolidate, particularly in fields where the technologies are new, is recommended. A recent case study on the Kitchener and Guelph metropolitan areas about 100 km west of Toronto (Bathelt *et al.*, 2008), shows that a significant number of firms related to information technology have been successfully launched since the 1970s around the activities of the University of Waterloo.

Local and regional governments can support private innovation by supporting the activities that follow the research and development of new environmental technologies. These activities can be summarised in five stages: demonstration, verification, commercialisation, diffusion and utilisation. Private R&D expenditures in green innovations might be in fact limited given the novelty and complexity of the market for environmental products, and the associated difficulties in making new products known and properly valued. Local governments can take the forefront by promoting environmental technology verification schemes, supporting the development of marketing tools (websites, targeted conferences, mailing lists), financing and disseminating results of demonstration tests, and removing regulatory barriers to the implementation of these technologies.

Notes

1. Life cycle costing (LCC) is a structured approach that can be used to produce a spend profile of the product or service over its anticipated life-span. The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options. See *www.ogc.gov.uk/implementing_plans_introduction_life_cycle_costing_.asp*.
2. ICT is a *general purpose technology* that changes the way firms produce goods and services – for example, through just-in-time manufacturing, supply-chain management, and electronic commerce – thereby enhancing the quality of other factor inputs such as labour and non-ICT capital. Crandall, Lehr and Litan (2006) find that employment in both manufacturing and services industries (especially finance, education and health care) is positively related to broadband penetration. One percentage point increase – equal to roughly 3 million lines – is associated with nearly 300 000 more jobs, assuming that the economy is not already at full employment.
3. Today, more than half of the 1 500 companies in Issy are in the ICT sector, including Cisco Systems' European headquarters, Hewlett Packard, Orange Internet, Sybase, Canal+, and Microsoft Europe.
4. For example, the US Department of Commerce's Bureau of Economic Analysis (BEA) estimates that across the United States as a whole, for each additional dollar's worth of output of the water and sewer industry in a year, the dollar value of the increase in output that occurs in all industries is USD 2.62 in the same year.
5. Following the energy crisis in 2000-01, the Energy Action Plan of the California State government, optimising energy conservation and building new generation facilities, was effective in eliminating outages and excessive price spikes (Roland-Holst, 2008).
6. Distributed resources are those located near the point of use (*e.g.* energy efficiency, rooftop solar water heaters, or municipal transportation plans), and centralised resources are those generally located far from the point of use (*e.g.* large-scale wind farms, gasoline and other transportation fuels, or regional development plans).
7. As discussed above, these strategies emphasise the "hardening" of system assets such as power generation facilities or transmission and distribution grids. They include the use of higher temperature-rated transformers and wiring, and the construction of flood-prevention berms around power plants (Mansanet-Bataller *et al.*, 2008). They also involve more "soft" approaches, focused on managing risk and specific climate change impacts without making extensive (or expensive) capital improvements. Soft strategies include adjusting reservoir release policies to ensure sufficient summer hydropower capacity, shading buildings and windows, or using high-albedo roof paints and surfaces (Hill and Goldberg, 2001).
8. MW_a refers to "average installed megawatts de-rated by the capacity factor of the technology" (Kammen *et al.*, 2006). In this analysis, the authors control for both the different capacity factors and lifetimes among different generating technologies.
9. Estimates for the share of installation jobs in total PV employment ranges from 15% (Singh and Fehrs, 2001) to 70% (Solar Technologies FZE website, *www.solartechnologies.net/sg_part5.html*), although lack of specificity in these estimates makes them difficult to compare. See also Grover (2007) and NCI (2008) for other estimates.
10. Investment costs for wind power have declined by approximately 3% each year over the last 15 years. For solar photovoltaic cells, unit costs have fallen by a factor of 10 over the past 15 years. The price of solar photovoltaic continues to decline 20% for every doubling of capacity (Van der Zwaan and Rabel, 2004).
11. See O'Sullivan (2000) and Shaffer *et al.* (2004) for lucid descriptions of multiplier processes at the sub-state level.
12. Firms can take two measures to mitigate the environmental burden of production: cleaner production and end-of-pipe technologies. Cleaner production reduces resource use and/or pollution at the source by increasing the efficiency and improving the design of production methods to reduce risks to the environment and human health, whereas end-of-pipe technologies curb pollution emissions by implementing add-on measures.
13. There are important within-country differences in the price of energy. In 2006, the average price of electricity in 106 US. cities was USD 0.073 per kWh. In the same year, however, it varied from USD 0.036 per kWh in Omaha, Nebraska, to USD 0.195 per kWh in New York City (Bae, 2009).

14. Recent research on a cross section of countries (Kellenberg, 2009) shows that the enforcement of environmental policy is more of a deterrent to inward investments than the level of the regulation itself. This might indicate that even if political co-ordination leads countries or regions to agree on common level of regulations, the playing field might still not be level due to strategic local enforcement behaviour.

15. According to the OECD programme on "Firms, Innovation and the Environment" (Johnstone, 2007), the frequency of inspections (regulatory oversight) is found to have a positive effect on the designation of an individual as being responsible for environmental matters and on the comprehensiveness of environmental management.

16. The provision of technical assistance should be carefully designed to build capacity within the firm, rather than substitute for it. Indeed, OECD studies (Johnstone, 2007) show that technical assistance has a consistently negative impact on the implementation of environmental management. This might be explained by publicly provided technical assistance crowding out internal management practices.

17. Individuals look at their local environment when making consumption choices. The spatial clustering of purchases of hybrid vehicles and of LEED registered buildings in the United States provides insight into the role of imitation in preferences. Kahn and Vaughn (2009) find that initial hybrid penetration in California occurred predominantly in census tracks with greater than average environmental preference, as measured by the percentage of registered green party voters.

18. See US Department of Energy's website for an overview of green power markets, at *http://apps3.eere.energy.gov/greenpower/markets/index.shtml*.

19. In Europe, green power purchasing and utility green pricing have existed since the late 1990s, and have achieved good results in particular in the Netherlands, Finland, Germany, Switzerland, and the United Kingdom. In Japan, there were an estimated 60 000 green power consumer-participants by early 2005. Green power in Japan initially developed through voluntary community organisations, like the Seikatsu Club Hokkaido.

20. Palo Alto Green (PAG) is the City of Palo Alto's 100% renewable energy optional programme open to all residential and commercial customers. The programme has about 20% of the customers involved, with residential customers making up on average 95% of the mix and the commercial customers at 5%. The residential sales account for roughly 60% of the programme sales with commercial and governmental making up the rest. However, starting with July 2008, both the City of Palo Alto (CPA) and the Regional Water Quality Plant (RWQCP) are increasing their commitment to buy renewable energy equal to 30% of their total usage, a tenfold leap from the previous 3% of total usage purchases (source *www.cityofpaloalto.org/environment/default.asp*).

21. To raise funds for the project, the city of Berkeley created a special tax district and issued bonds on future tax revenue from the special tax district. For further details on the Berkeley FIRST programme, see *www.ci.berkeley.ca.us/ContentDisplay.aspx?id=26580*.

22. In 2000, Berkeley's housing stock was 46 875 houses (*http://quickfacts.census.gov/qfd/states/06/0606000.html*). The city's budget was USD 321 million in FY09 (see *www.ci.berkeley.ca.us/ContentDisplay.aspx?id=31028*).

23. See *www.mitportugal.org/ses/research-projects.html* and the OECD research on ICT and climate change at *www.oecd.org/sti/ict/green-ict*.

24. For details on the Australian Solar City Program, see *www.environment.gov.au/settlements/solarcities/index.html*. See also the OECD Green ICTs publication at *http://oecd.org/dataoecd/3/7/44001912.pdf*.

25. This result is only descriptive and must not be interpreted as causal evidence of a link between urbanisation and green innovation. For recent evidence arguing for the existence of a causal relation between urban size and innovation activities, see Bettencourt *et al.* (2007).

26. For more information on the Lahti and the other clean-tech clusters of Finland (Kuopio, Oulu, Uusimaa), see *www.cleantechcluster.fi/en/*.

27. The partnership, established in 2002, aims to maintain dialogue among all sectors/actors relevant to the hydrogen economy, prepare and disseminate relevant materials, provide a platform for funding bids and initiation of projects (see *www.london.gov.uk/lhp/about/index.jsp*).

28. See *www.tenerrdis.fr/en*.

29. An Innovation Vouchers Subsidy Scheme was introduced for the first time by the Dutch Ministry of Economic Affairs and then experimented with in several OECD countries. Innovation vouchers were proposed as a key instrument for facilitating university-SME collaborations by Terry Cutler in the report for the Review of the Australian National Innovation System (Cutler and Company Pty Ltd., 2008), In Cutler's proposal of a voucher programme, each voucher would be worth up to USD 15 000 and would be used to fund collaboration between the small firms and a public sector research organisation. The programme would link 5 000 firms per year with public research agencies at a cost of USD 5-75 million per year. The voucher programmes can be easily scaled-down at the sub-national level, targeted on energy efficiency innovations and applied by municipal departments in charge of innovation and business support.

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PART III

Governance

PART III

Chapter 6

Multi-level Governance: A Conceptual Framework

As cities and national governments cannot act alone to effectively tackle climate change, a framework for understanding the linkages across multiple levels of government and with the private sector and non-governmental stakeholders is needed. Chapter 6 proposes a multi-level governance framework that explores these linkages between national, regional and local policies to address climate change. Such a framework identifies vertical governance between different levels of government, as well as horizontal governance across multiple sectors at the same level of government, including engagement with non-governmental actors, and governance across and between cities or territories. It lays out a framework to explore, "what is good practice?" in the area of multi-level governance and climate change, laying out a number of sub-themes and questions for investigation in Part III of the book.

Key points

Multi-level governance provides a conceptual framework for understanding and addressing climate change adaptation and mitigation policy issues

- A multi-level governance framework provides a means to understand the complex web of interactions between different level of governments, non-state and non-governmental actors, all of whom are contributing to action on climate change today.
- Multi-level governance may help to overcome some of the many obstacles to effective design and implementation of climate policies. Tools for multi-level governance – in the form of vertical and horizontal co-operation – may help to narrow the "policy gap" among levels of government and promote implementation of stated policy goals and plans.
- The chapter provides a framework to examine and identify good practice with multi-level governance for climate change. This framework is used as a starting point for the chapters that follow in Part III of the book.

A multi-level governance framework provides a starting point for understanding how central governments and other public and private actors interface to design and implement policies from international to national and local levels of action (Hooghe and Marks, 2003). This has been widely developed and used by the OECD to assess the performance of co-operative frameworks in nations as well as metropolitan and rural regions (*OECD Territorial Reviews*). Regardless of the constitutional form of government, multi-level governance calls for a narrowing or closing of the policy "gaps" among levels of government via the adoption of tools for vertical and horizontal co-operation. The OECD framework endorses, for example, the use of performance indicators, a variety of forms of fiscal grants or financing mechanisms, and the use of contracts between levels of government (OECD, 2005; 2007; 2009a). These tools help improve co-ordination among stakeholders and build capacity in particular at the sub-national level (OECD, 2009b). This approach is currently being applied to enhance an integrated approach of water policy (OECD, 2011 forthcoming).

Multi-level governance also provides a flexible conceptual framework to understand the relationships between cities, regions and national governments across mitigation and adaptation policy issues as well as across a widening range of non-state and non-governmental actors[1] (Marks, 1993; Betsill and Bulkeley, 2004; Bulkeley and Schroeder, 2008; Corfee-Morlot, 2009). Public interest in climate change in the 1980s may have emerged initially through international and national science-policy interactions (Corfee-Morlot *et al.*, 2007), however it has become increasingly evident that regional and local policy decisions are also essential in the design and implementation of mitigation and adaptation strategies. This is because greenhouse gas emissions are the result of actions or processes that occur in a given place and, while national and international policy frameworks can mandate and co-ordinate action, a multitude of local-level actions will ultimately be needed to alter future emission pathways over the long term. Also climate change impacts are felt locally; thus adapting to climate change will also require a wide variety of regional and local changes. As with climate mitigation, adaptation may be guided through nationally led mandates, but its implementation will be inevitably local in character. Of course, key information and specific knowledge gained from local experimentation can also contribute to the design of climate policy at the central level (OECD, 2007, 2009c and 2009d).

Much analysis of climate change policy has taken an international regimes-based approach and focused on the establishment of international treaties as a main driver of change (Haas *et al.*, 1993; Paterson, 2008; Young, 1989). However, examining the political economy of climate change policy through a multi-level governance approach helps to break down state-centric understanding to better characterise the relationships between different actors horizontally across and vertically between different levels of government and governance. The multi-level relationships on climate policy will involve different configurations of actors and priorities depending on the scale and scope of decision making.

Any multi-level governance framework will encompass at least two different dimensions of action and influence and both warrant attention: the first is the vertical dimension across scales or levels of governance and the second is the horizontal dimension of governance (Bulkeley and Betsill, 2005; Hooghe and Marks, 2003; OECD, 2006).

The vertical dimension of multi-level governance recognises that national governments cannot effectively implement national climate strategies without working closely with regional and local governments as agents of change. On the other hand, to take action, cities cannot be effective and do not operate in isolation from other parts of government. Local governmental authority to act in areas related to climate change is often "nested" in legal and institutional frameworks at higher scales (Dietz *et al.*, 2003; Hooghe and Marks, 2003). For example, while regional and local policies determine the specific details of land use, human settlement patterns and transportation planning, the space for action and potential for change is usually limited by national development paths, national policies and technical standards and national budgets and funding priorities (Sathaye *et al.*, 2007). This suggests that action at local scale may enable or constrain what is possible nationally and *vice versa*, highlighting a two-way relationship between local and national action on climate change. Economic aspects are also key. In particular, externalities and spillovers of local policies are often used as a key argument for supporting improved co-ordination between levels of government and the search for a "relevant scale" for allocating public responsibilities and resources.

On the horizontal axis, there is increasing evidence of multi-level patterns of governance and transnational networks on climate change and other global environmental issues where actors work across organisational boundaries to influence outcomes. Within the multi-level regulatory framework, learning, information transmission and co-operation also occurs horizontally with linkages increasingly being forged between cities, regions and national governments (Bulkeley and Moser, 2007). At the sub-national level, some of these horizontal relationships have been created through formalised information networks and coalitions acting both nationally and internationally, including ICLEI's Cities for Climate Protection, the Climate Alliance, the C-40 Large Cities Climate Leadership Group, the US Mayors Climate Protection Agreement, among others.[2] These groups have given an institutional foundation to concerted effort and collaboration on climate change at city level (Aall *et al.*, 2007).

Horizontal co-ordination at the local level is not just about international associations of local authorities. Above all, it concerns different forms of co-ordination among local jurisdictions that belong to the same urban metropolitan area or the same rural area or between urban and rural areas. Urban regions are characterised by a strong institutional fragmentation while many strategic decisions need to be made, and services provided, at this level (OECD, 2006). This element is very important for urban development policies in general and environmental issues in particular. Speaking about the "horizontal dimension" of multi-level governance is also very often associated with the need for improving co-ordination across line ministries at the central level for dealing with cross-cutting policies, which is particularly the case on environmental issues. On issues of climate change, cities and other local governments hold the unique potential to work closely with local constituencies to develop visions of the future that match the needs of these constituents while also addressing climate change (Brunner, 1996; Cash and Moser, 2000; Moser and Dilling, 2007).

Horizontal governance patterns also include the notion of issue-based governance[3] where often overlapping jurisdictions address key issues separately and in parallel with other decisions on other pieces of the climate change puzzle (Hooghe and Marks, 2003; Gray, 1973). These may include a range of policy issues with significantly earlier and deeper historical foundations than climate change, *e.g.* in the areas of energy efficiency, air pollution or water management, where there may be separate instruments or mechanisms (Corfee-Morlot, 2009). Instruments may include joint powers agreements, separate commissions, regional councils or boards, annexation, metropolitan districts, metropolitan governments, tax-base sharing and redistributive grants, and informal co-operative mechanisms (OECD, 2006; Walker, 1987). Horizontal governance activities thus increasingly also include giving "voice" or influence in the policy dialogue process to business, research and environmental non-governmental organisation.[4] One prominent example of this is the broad evidence of non-governmental actors in a range of activities related to climate policy from the generation of ideas to formulate policy to a "watchdog" role to assess how well policies are performing with respect to the stated goals of policy (Gough and Shackley, 2001; Levy and Newell, 2005; Weiss and Jacobson, 1998).

Local-scale action allows for an interface between experts and local stakeholders to build understanding about how climate change may affect local development choices and how those choices will affect the future climate. However for this to be possible, a number of different pre-conditions must hold: the existence of some autonomy in regional strategic planning as well as the institutionalisation of a dialogue with private (citizens, associations, firms, and other relevant local stakeholders). Through this type of local deliberative exchange, social norms may evolve, for example about how climate protection fits with visions of future development; this can make it possible to garner bipartisan political support for policy reforms and action.

In adaptation local actors should both benefit from and shape adaptation decision making at other levels in order to ensure successful adaptation action. Lessons and experiences with adaptation at the local level must feed into higher levels of decision making to make sure that local strategies remain relevant and appropriate, and provide a basis for transferring knowledge to other sectors and communities. Effective communication channels, institutions that support innovation and experimentation, and meaningful participation from community-level actors are central to achieving this objective (OECD, 2009e). Inevitably local action on climate change will facilitate identification of specific obstacles to action and enable the design of targeted solutions to overcome these, whether the solutions are grounded in local or higher levels of action.

Key obstacles to the effective design and implementation of policies at local level are varied, ranging from issues of authority to problems of resources and capacity. In particular there may be a lack of devolved authority in many relevant areas from buildings to transport. There may also be political tension between national and local policy priorities and different preferences for change. There may be overall failure to diffuse incentives for change through the market system, with climate change being dealt with in only a narrow way through a sub-set of policies targeting a limited range of actors or investments. This will slow change and limit the cost-effectiveness of climate policy initiatives across levels of government. There will also be a need to consider the legal and regulatory frameworks at the disposal of sub national governments and to examine how these can be aligned to integrate climate change considerations. Last but not least there may be the lack of co-ordination among line ministries taking purely vertical approaches to cross-sectoral policies that can require co-design or implementation at the local level.

Methodology and key questions to structure the analysis

There is therefore a need to consider city-scale action on climate change within a multi-level governance framework and within this to focus on the question of: What is good practice? In particular, the analysis that follows examines general recommendations that could help governments strengthen multi-level governance of climate change. This is examined in four parts (corresponding to the chapters that follow):

i) How is climate policy playing out across local levels or horizontal levels of governance? Is it working well and if so why?

ii) What are different national-local linkages or vertical governance approaches to deliver GHG mitigation and/or climate adaptation? What are the key institutional models and within these features of "good practice"?

iii) What are the main financial instruments and tools available to local governments to address climate change action and how to these link up to other levels of government?

iv) What are the key tools for good multi-level governance of climate change? Are they in place and effectively functioning to support cost-effective local decision making on climate change? If not, what is needed to ensure that appropriate tools will be put in place?

Overall, it is useful to probe the notion of "good practice". This chapter of the book begins to review and test the usefulness of a number of principles or criteria for good practice that can be broadly drawn from previous OECD work in the fields of environmental and regional/urban development policy respectively, and from the brief literature review included here. These principles include (see also Beck *et al.*, 2009 and Kivimaa and Mickwitz, 2006):

- **Ensure participatory governance and strategic planning at relevant scale:** Does the policy framework stimulate reflection and understanding across a broad cross-section of local stakeholders about how climate change and climate protection and policy will affect the local communities and development and help to shape a way forward to integrate climate protection and resilience into urban development planning? How is citizen engagement and participatory development included in the approach to climate policy design?

- **Provide an analytical foundation for short and long-term planning:** What internal as well as external "know-how" exists on climate change mitigation and adaptation issues and is adequate use made of available resources? Are research efforts relevant to local policy, *i.e.* is it sufficient, tailored to regional or local questions and in an accessible form to support sub-national decision making? Are planning structures in place to incorporate long-term issues raised by climate change research?
- **Deliver cost-effectiveness and economic efficiency:** Will the policy(ies) or planning practice(s) lead to least cost investments to achieve a given climate goal/target?Does the policy mix rely upon an appropriate mix of instruments, including market to guide private investment to least-cost outcomes? To what extent are direct as well as indirect impacts (costs and benefits) of climate change policies as well as both mitigation, adaptation and risks of inaction considered in the design of policies?
- **Encourage experimentation and innovation, particularly at local and regional levels of governance:** How can national governments encourage experimentation and learn from such experience? How can the unique opportunities for local scale innovation be incentivised and monitored to draw lessons either to improve policies in other local context or more broadly diffused through regional or national policy frameworks?
- **Address distributional consequences and procedural equity:** How will the policy(ies) affect the poorest in the targeted community? Does it lead to good access to information and decision making across all segments of the targeted population?
- **Establish a long-term planning horizon:** Climate change action planning is a project that unfolds over the long term. It therefore demands continuous commitment and political vision. How can policies and practices be designed that transcend the political cycle and embody a long-term, future-oriented vision?
- **Deliver policy coherence:** How do we align incentives in a pro-active manner to deliver climate protection and resilience, working both vertically across levels of government, and horizontally across different actors and issues within a given scale of governance. Have the potential contradictions and synergies between the aims related to climate change mitigation and adaptation and other policy goals been assessed? Have there been efforts to minimise contradictions and exploit and expand on synergies? Has there been an effort to integrate climate change action to be compatible with other policy priorities?
- **Conduct monitoring, reporting and evaluation:** Are there clearly-stated evaluation and reporting requirements for climate change mitigation and adaptation policies to allow performance assessment (including deadlines) *ex ante*? To what extent has performance assessment occurred? Have indicators been defined, followed up and used to assess performance?

Some of these principles may be more important and practical to pursue at one scale *versus* another – *e.g.* equity and participatory governance practices may be more meaningful at local scales of decision making than for national policy and decision making. With respect to coherence, a positive outcome will depend upon local contexts and starting points and must be assessed by looking at the balance of outcomes across new actions to address climate change and pre-existing incentives and outcomes in related areas (*e.g.* urban development plans, transport and/or energy policies). Feasibility of any multi-level governance proposal or action is also to some extent going to be determined by whether the new action can be well integrated into existing practices in related areas.

Notes

1. The word "state" here refers to nation-states – not to be confused with sub-national regional or state government authorities. Overall, many have argued that the authority of (nation-)state actors is considerably weaker today than it has been in the past on issues of public concern (Sathaye *et al.*, 2007). These patterns put emphasis on "governance" rather than on "governments" as a centre for social research on global environmental change and decision making.
2. For example, ICLEI's Cities for Climate Protection network has been extensively analysed in the literature (Aall *et al.*, 2007; Betsill and Bulkeley, 2004, 2006; Lindseth, 2004). One of the first networks established, it counts over 680 cities as members from over 30 countries worldwide.
3. An example of issue-based governance is where an institutional structure is in place to govern water resources, or air quality at regional scale covering one or more municipalities.
4. These are also fondly known as BINGOs, RINGOs and ENGOs, representing business and industry, research and environmental non-governmental organisations, respectively.

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PART III

Chapter 7

Local and Regional Governance

Each stage of the local policy-making process presents an opportunity to incorporate climate change priorities, agenda setting, policy design, implementation and policy evaluation. Chapter 7 discusses these opportunities and the issues for horizontal co-ordination that they raise. Co-ordination across city departments as well as across municipalities in the same metropolitan region is needed to implement climate policies in a cross-sectoral manner. Co-ordination among cities and surrounding municipalities is especially crucial given that many urban initiatives to mitigate and adapt to climate change require changes that are broader than just one city's jurisdiction. While some municipal governments have led the way to co-ordinate climate change action at the metropolitan regional level, greater incentives and more effective co-ordination mechanisms are needed. Regional initiatives can have a broader impact on climate priorities given their scale and potentially greater access to funding and technical expertise.

Key points

Climate priorities still need to be integrated in each stage of the urban policy-making process: agenda setting, policy design, implementation and policy evaluation

- While city leaders have begun to incorporate climate change mitigation priorities into city policy agendas, driven by the social, environmental and economic potential benefits of action, urban-level adaptation strategies are rare and need more attention.
- The policy design stage represents an opportunity for cities to better enable action from individuals and the private sector in climate policy design. However, urban climate policies are often developed outside of an integrated urban planning framework, thereby favouring short-term responses and hampering long-term systematic approaches, such as those designed to address sprawl.
- Key barriers to climate-integrated policies are a lack of appropriate climate governance institutions or necessary authority, insufficient expertise, and a lack of funding or central government support. Relatively few urban climate policy evaluations have been conducted, and measuring progress remains a challenge for many cities.

When climate policies spill over city borders, inter-municipal action is needed

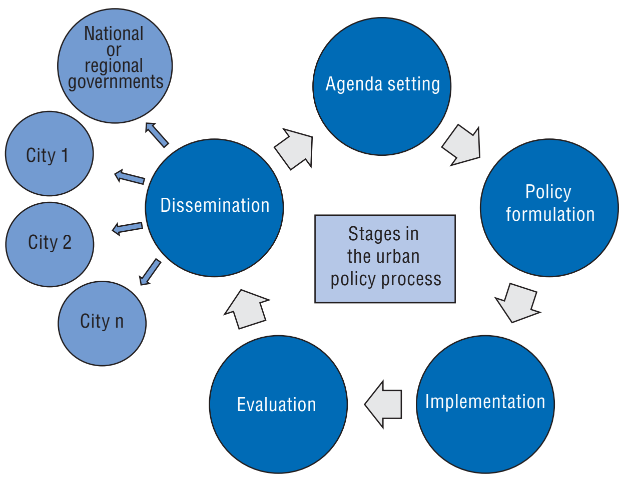
- In many cases, the administrative structure of urban climate policy governance does not fall precisely within cities' actual boundaries, so that carbon-relevant functions, economic interchanges, flows of materials and energy, and transportation between activities and households in the city's core area and localities overlap across multiple municipalities.
- Co-operation with other local governments is often hindered by an absence of regulatory frameworks to guide inter-municipal initiatives. Metropolitan regions that provide models of successful climate policy co-ordination among municipalities are often endowed with an inter-municipal collaborative framework or benefit from technical infrastructure that transcends city borders.
- Regional approaches to climate change mitigation and adaptation can broaden the impact of urban actions. At the regional level, greater technical and financial capacity, and environmental know-how may exist than within individual cities or towns, and larger-scale responses can link policies and programmes that would otherwise operate in isolation.

The increasing number of urban responses to climate change highlights the need for horizontal co-ordination across multiple levels of governance: among city or regional departments; among multiple municipalities within the same region; and among governmental, private sector and civil society stakeholders. Opportunities – and challenges – for incorporating climate change mitigation and adaptation policy goals exist at each stage of local policy processes. How can cities and metropolitan regions best incorporate climate policy goals in their policy-making frameworks and improve opportunities for co-ordination on climate policy across sectors, municipalities, and stakeholders? In this chapter, we discuss the means by which city and regional governments develop and implement policies to mitigate their impact on climate change and adapt to its effects. We first consider each stage of the policy process and explore the obstacles local and regional governments face at each stage of the policy process. Then, we discuss issues related to urban and regional governance which typically hinder policy development and implementation in urban areas, before touching on opportunities for intermunicipal and regional co-ordination.

The public policy process: The planning behind climate change action plans and policies

Though local and regional governments across the world have elaborated a wide variety of climate change actions and plans, the development and implementation of these often follow a common policy-making continuum. To better analyse the policy process, this chapter will employ a simplified Stages Heuristic framework (Jones, 1970; Anderson, 1975; Brewer and de Leon, 1983). According to this framework, the stages of policy making can be divided into roughly four stages:[1] agenda setting; policy formulation and approval; implementation; and feedback evaluation, which may result in the dissemination of ideas and replication elsewhere. Climate change policy making will be analysed at each one of these distinct phases, while also highlighting relationships between phases. The policy process stage framework, which is discussed in more detail below, offers an opportunity to both better understand how climate change policies are being made at a local level, to identify and address the most severe obstacles that arise in each phase. In so doing, this chapter helps answer two questions proposed by this paper: *i)* "How is climate policy being designed, implemented and evaluated within and between levels of government?"; and *ii)* "How could multi-level climate policy designs be improved?".

Figure 7.1. **Stages in the public policy process**



Agenda setting

There are several motivations and drivers behind sub-national actions and strategies. In many cases, political leadership has been the most important factor in developing climate action plans. This often requires a legal mandate. For instance, in London, under the Greater London Authority Act 2007, the mayor was given a "new statutory duty to contribute towards the mitigation of, or adaptation to, climate change in the UK" (GLA, 2007). This legal requirement to address climate change provides a platform upon which to build future strategies. A drawback of politically driven climate plans is that they are often limited by the supporting politician's term in office.

Support from the business sector and general public provides another driver for the adoption of a climate change action plan. This support may take the form of a positive climate of public opinion or a lack of overt opposition from key interest groups. For instance, the City of London Corporation has played a role in developing and representing business interests in carbon markets. In other cities, policy networks and research groups have been critical to launching a climate agenda, a theme that will be more fully explored later in this paper.

A triad of reasons motivate local governments and regions to act on climate change. These include growing concern among local leaders about the long-term human health or social and environmental effects of inaction as well as the possibility to piggy-back climate change onto more urgent local agendas such as improved local environments and liveability of cities. Beyond a range of negative local public health and environmental deterioration risks emanating from climate change there are potentially large co-benefits to be reaped from both mitigation and adaptation action (see Chapter 3). Key areas include reduced air pollution and congestion in urban areas with subsequent benefits for human health and liveability of cities.

More recently, economic motivation has gained importance through the promotion of energy independence and security, especially in the context of increasing oil prices and diminishing resources. Improving energy efficiency through replacement of lighting, building retrofits and insulation have been identified as the most cost-effective means for reducing greenhouse gases (McKinsey and Company *et al.*, 2007). In most cities and regions, there is still tremendous room for energy-efficiency improvements, through better insulation of the existing housing stock, use of fluorescent light bulbs in place of incandescent ones, capturing waste heat from industrial activities, reducing the number of unnecessary miles travelled, decreasing waster and increasing resource efficiency in local industries.

There is also a growing recognition that the greening of cities can lead to new jobs. The argument is that the economic benefits associated with a large number of mitigation activities (energy efficient devices, green building, etc.) act as an incentive to generate new technologies and new consumer markets in urban areas. A study conducted by the UNEP/ILO (2008) suggested that a silver-lining in the climate change story will be the creation of millions of new green jobs in green manufacturing, green construction, and green energy. The report predicted that in Germany environmental technology will quadruple over the coming years, reaching 16% of manufacturing output by 2030 and employing more people than the auto and machine tool industries combined. Following this momentum, in the United States, the Governor of the State of Washington and legislative leaders announced a comprehensive legislative package, the "Green Jobs and Climate Action Plan" which includes targeted investments in energy efficiency and clean energy sources that will create new jobs for the region. This builds upon previous efforts, such as Vienna's adoption in 1999 the city's climate protection programme (KLIP) as a framework for its eco-business plan[2] or the Kitakyushu Eco-Town in Japan (OECD, 2009a).

Local governments face several obstacles when determining climate change policy priorities. The first type of obstacle is legal-related. Questions over jurisdiction can hinder efforts to mitigate the full range of a city's climate impacts. Second, local-level policy making has also tended to overlook the need for adaptation policies. Third, cities may or may not have full control over a number of key areas of decision making. Ongoing debates over concurrent or overlapping mandates continue to hinder policy making. In the United States, state and local governments continue to debate the interpretation of authority to promote growth-control and land-use measures. Richardson *et al.* (2003) argue that local authorities in the United States too conveniently hide behind an obscure 19th century ruling of the Supreme Court (the "Dillon Rule" which established a legal tradition of conservatively and cautiously interpreting local government authority) to escape culpability for deploying land-use and growth control strategies that are necessary to address climate change (Richardson *et al.*, 2003). He notes that the "Dillon Rule" does not preclude strong action by local authorities when addressing the necessary land-use and growth-management strategies.

Climate change policy making has been characterised by a lack of focus on adaptation issues. Indeed, to date, existing climate change action plan focus on mitigation. In the United States, only a handful of cities (New York, Seattle, Portland, Boulder) and states (Oregon, Washington State) incorporate both adaptation and mitigation in their responses to climate change. Mexico City has only recently incorporated adaptation actions in its portfolio of mitigation actions.

The successful integration of adaptation into local development processes depends on a number of enabling conditions. There needs to be broad and sustained engagement with and participation of local stakeholders, including local governments, communities, civil society and businesses. Local authorities need to adopt a collaborative approach where local actors are seen as legitimate decision-making agents. In addition, there needs to be greater awareness raising and targeted messaging on climate change, as local actors need to know why they might have to take different decisions or call on different or additional resources in shaping their livelihoods. Furthermore, appropriate information needs to be gathered and used to inform local-level adaptation decisions (OECD, 2009b).

A lag in attention to adaptation in local climate plans may be because it requires a larger upfront research effort, presumably to be sponsored by the public sector and engagement of actors around a relatively new set of issues (*e.g.* water planning for and understanding of future trends that break from past trends). However, at least initially adaptation can be sensibly advanced through the integration of concern about climate risk into normal development planning and investment (OECD, 2009b). Mitigation policy, by comparison, is often connected to a number of pre-existing regulatory frameworks where government action is already well established, *e.g.* in the areas of energy efficiency and waste management, and incentives for the private sector to increase investment. Moreover, mitigation and adaptation actions can have either synergistic or contradictory effects. For instance, expanding the use of conventional air conditioning to adapt to higher extreme temperatures in cities is likely to drive up the use of energy and the emission of GHG. In contrast, better insulated buildings will both lower the need for air conditioning, energy demand and emissions while helping people to live with the more extreme temperatures that climate change will bring.

Policy formulation

The development of local policies and action plans typically involves the establishment of an expert body or commission composed of stakeholders and policy leaders who meet to discuss goals, potential areas of action, priorities, implementation strategies and monitoring mechanisms. These commissions are sometimes limited to talk shop places where ideas circulate; when they are more linked to the decision-making process, they tend to follow a more closed process. Sector-specific working groups are usually established as well for areas such as transportation, energy, housing, waste management and forestry. These working groups may first engage in a "shared diagnosis"[3] of climate change mitigation and adaptation issues, to support subsequent policy formulation. To maximise the potential for useful input and to involve the public in decision making that will affect them, many commissions draft plans with active participation from stakeholders – from industry, NGOs, academia, government, homeowners, and the like. This may be done through workshops, lectures, public hearings, or written comments on draft plans of action. In Seattle, the mayor appointed a "Green Ribbon Commission on Climate Protection". The Commission, which brought together leaders from Seattle's business, labour, non-profit, academic and government sectors to develop local solutions, developed a report and recommendations for local action. This included a metrics sub-committee to develop measures to indicate if Seattle is making progress in meeting its goals and sub-committees for energy, transportation, outreach, and freight. The sub-committees benefited from the work of an earlier commission that had conducted the city's first greenhouse-gas emissions inventory (Box 7.1).

Prioritisation of actions depends on time horizons, *i.e.* strategies must be matched to the time period targeted in the action plan. For instance, the Northwest region of England developed a Climate Change Action Plan for 2007-09 and thus was restricted to actions that could be taken over a three-year timeframe. Priority therefore was placed on those actions

Box 7.1. **Decision criteria used by Seattle's Green Ribbon Commission**

In coming up with recommendations for Seattle's Climate Action Plan, the Green Ribbon Commission followed a series of **decision criteria**:

- **Greenhouse gas (GHG) reduction potential over time:** Does the action avoid, reduce or sequester GHG emissions in Seattle (without exporting GHG emissions elsewhere)? Can the GHG emissions reductions from the action be measured? If so, what are they? Does the action provide near-term reductions (*i.e.* before 2012)?
- **Feasibility:** Do cost estimates appear to be reasonable compared to estimated GHG reductions? Is the action technically feasible/how easy is it to implement? Is the action legally feasible? Will the action require new legislation? Has the action been tried successfully elsewhere? Are there likely partnerships that will enhance programme implementation?
- **Catalytical potential:** Is the action likely to influence others to take action (*i.e.* the multiplier effect) and/or does the action result in GHG reductions outside of Seattle? Is it transferable outside Seattle to other jurisdictions, businesses, etc.? Is it compatible with or does it enhance the effectiveness of other policy initiatives? Does it have ancillary economic and/or environmental benefits (*e.g.* reduced air pollution, job creation, keeping dollars within the region, etc.)?

Source: Seattle Climate Change Action Plan, *www.seattle.gov/climate/criteria.htm*.

that were likely to have the biggest impact on reducing greenhouse gas emissions in the short term. Local and regional governments trying to determine which strategies to prioritise often emphasise policies that are politically feasible, financially sound – in terms of "bang for the buck" and will have the largest emissions reductions (Gallivan *et al.*, 2007). Through this process, policy makers determine areas where actions can be taken with multiple benefits. A few governments establish criteria for prioritising greenhouse gas reduction actions. The Darebin City Council in Australia, for instance, provides a useful set of criteria for considering timeframes, benchmarks and methods to allocate resources (Box 7.2). However, in general, prioritisation is not clear-cut and local and regional plans include an impressive list of actions, as Wheeler (2008) pointed out for the United States.

Box 7.2. **Darebin City Council's criterion list for prioritising greenhouse gas reduction actions**

The Darebin Council in Victoria, Australia, has decided as part of its greenhouse gas reduction objectives, that the purchase of renewable energy through the Australian GreenPower programme would be one of the simplest and most effective means of achieving large scale emission reductions, but requires ongoing annual expenditure. Criteria for prioritising greenhouse action within existing Council Buildings include: *i)* payback within 15 years; *ii)* proposals with larger emission savings to be prioritised; *iii)* where projects have a similar greenhouse impact, projects with the shortest payback period to be prioritised; *iv)* maintenance issues including costs or savings to be considered; *v)* aim for at least 10% of the project budget for the facility to be allocated to Ecologically Sustainable Development (ESD) initiatives with a priority given to energy efficiency, then water consumption, materials, etc.; *vi)* design for Greenhouse Neutrality – the cost of achieving greenhouse neutrality for the life of the building to be considered and capital and operating opportunities and costs to be compared (*i.e.* the operating cost of buying 100% GreenPower and offsetting gas emissions for the life of the building); and *vii)* large construction projects (more than AUD 1 million) to have an ESD consultant appointed (in consultation with Council's ESD Officer) and have electrical and mechanical services reviewed by Council's Energy Efficiency Consultant.

Finally, as part of the formulation process, city and regional governments may also develop measurable and verifiable benchmarks against which environmental progress – positive or negative – can be assessed. One of the first tasks is developing a greenhouse gas inventory that identifies emissions from the transport sector, household and commercial energy use, land clearing, waste disposal, and other sources of emissions. Technical expert committees can play a critical role in helping to determine a range of tools to assess performance. As noted in Chapter 10, additional tasks may include setting up systems for developing greenhouse gas inventories.

A main obstacle for policy formulation is that policies have often been developed without an integrated urban planning framework. Many actions seem to be selected on an *ad hoc* basis according to the feasibility to implement short-term visible actions rather than clear criteria that establish priorities to obtain effective results. Were climate change goals and recognition of long-term risks of climate change fully integrated into urban development plans, the prospects for effectiveness of "climate change" actions would be improved. In particular local authorities might achieve a better balance between mitigation and adaptation, reduce unintended negative consequences of those actions, and better link urban development objectives with climate change actions. Climate change actions are thus not solely linked to the environment but should be an integral part of urban development strategies. Yet in many cities there is a lack of integration of climate policy into urban planning. For example in Japan, Sugiyama and Takeuchi (2008) found that climate change is treated as a distinct policy issue, rather than one whose solution will require integration of climate change awareness into all policy areas, ranging from transport, to finance, education, and zoning. Integrated planning schemes would be able to better address urban sprawl, which as mentioned in the introduction, is an indirect contributor to CO_2 emissions.

A crucial prerequisite for the creation of climate-proofed urban infrastructure is the implementation of integrated land use and transport policies that allow for compact cities to develop with clusters of high-density nodes. This requires first developing an integrated urban planning framework, as land use and zoning may exacerbate or limit the exposure and vulnerability of urban dwellers and infrastructure to the growing threat of climate change. Many of the principles which had begun to be integrated into land use and transport planning, *e.g.* mixed-use development, reducing the need to travel, etc., have the potential to reduce emissions, but local climate strategies are not well integrated into the existing planning tools. Indeed, few cities have integrated land-use planning and transport into other climate related actions. A few pioneering cities, though, could inform the next generation of climate change action planning. In the United States, the municipality of Santa Cruz has incorporated climate change strategies into general plans. Others like Chicago, Denver, Las Vegas, have included climate change plans, though often with a loss of focus on climate change *per se* (Wheeler, 2008). The City of Madrid's "Plan for Efficient Use of Energy and Climate Change Prevention" (2008) has developed a comprehensive approach addressing urban planning, transport, building, and water and waste management.[4] Correspondingly, urban planning tools, such as zoning and building codes, also need to be adapted to the long-term prospects of climate change.

Implementation

Local governments' capacity to implement climate change policies and action plans is closely linked with their regulatory modes or urban governance. As discussed in Chapter 4, at least four modes of urban governance can apply to sub-national government (adapted from Kern and Alber in OECD, 2009a and Bulkeley and Kern, 2006):

i) Self-governing: the municipality as consumer.

ii) Governing by provision: the municipality as provider.

iii) Governing by authority: the municipality as regulator.

iv) Governing through enabling: the municipality as a facilitator.

The institutionalisation of local climate policies and strategies within local administration and their integration with other sectoral plans is a key issue for the implementation of local climate action. Cities have created a range of institutional mechanisms to implement climate-related policies. The City of Zurich, for instance, created a special unit for environmental protection in charge of supervising the city's climate policy with cross-departmental tasks within the city administration. This special administrative unit is responsible for assessing every planned development and construction project in terms of its climate impacts and the departments responsible for the implementation of such developments need to account for the results of this assessment.[5] Other responses to integrating climate change into urban governance include the creation of a unit in charge of climate change policy within each climate-relevant department, a climate-policy steering group,[6] a climate protection co-ordination group, or an over-arching unit with appropriate competences for mainstreaming climate change policy. In San Francisco, the Office of Climate Protection Initiatives is funded to co-ordinate the multiple climate initiatives undertaken by several programmes, lobby for climate protection legislation at the federal level, and work with local private companies, for example, to encourage the use of vehicles that run on biodiesel. Progress made so far has been significant: the city has a 70% recycling and composting rate, the strongest green building standards for new buildings in the United States, and the largest local financial rebate for solar installations.[7]

However, most cities do not pursue such a systematic and structured approach and, instead, prefer to concentrate competencies for climate change policy in an environment department or agency. Traditionally environmental departments have been weaker politically and less resourced than other departments in sub-national administrations. For example, this is the case in approximately two-thirds of German cities (Kern *et al.*, 2005). This may lead to co-ordination and integration problems if the environmental agencies do not have the power nor necessarily the competence to implement comprehensive or sectoral policy. In Johannesburg, for instance, semi-privatisation within the local authority created a silo effect, fragmenting communication between different agencies, utilities and the city administration (Holgate, 2007). Although climate change policy affects a variety of sectors or departments within the local administration (such as administrative units dealing with finances, procurement, urban planning, economic development and education), in many cities expertise on these questions is still concentrated in the environmental department. In other words, in the majority of cases, climate-related issues are not taken into account when climate-relevant decisions are taken outside the environmental department.

Implementation obstacles

The analysis of existing local climate change plans shows an important implementation deficit. Many early greenhouse gas emission targets established at the local levels were not met. Most local and regional plans have been established with insufficient attention to which policies and measures would be necessary and how to assure implementation of policies once introduced. Very few jurisdictions have issued progress reports or evaluations. Several reasons are being advanced for this implementation deficit:

- *Institutional blockage within local administrations.* In the United States, many individual states have established ambitious plans, but implementation has proven problematic. Barry Rabe (2009) notes that in New Jersey, implementation of the 2000 Sustainability Greenhouse Gas Action Plan was hampered by lack of a governing structure that could co-ordinate, monitor, and control the actions of so many different departments and agencies involved in climate mitigation activities therefore there was no entity capable of managing and co-ordinating the different interests and priorities of the relevant departments. In a similar vein, in New York City, assigning the responsibility to realize energy savings to one entity has facilitated monitoring and increased the transparency of project spending. The New York City Division of Energy Management (DEM), which has the specialised technical knowledge to identify energy efficiency opportunities in the city's buildings but does not manage or operate any of them, is responsible for implementing the City's policy to reduce energy use in public buildings 30% by 2017. In order to ensure that the equipment installed in these buildings are properly used, DEM is required to work with the building operators and engineers in the project design and construction phases (New York City Mayor's Office of Long-Term Planning and Sustainability, 2010). This co-ordination increases the operators' capacity to use the equipment properly and ensures that the new equipment will meet the needs of the building's users.

- *Insufficient capacity and expertise.* The lack of technical expertise in planning authorities to deal with climate change-related issues has been recognised as a main obstacle, particularly in cities in emerging economies like Johannesburg (Holgate, 2007) and Mexico City (Molina and Molina, 2004) as well as more advanced cities like London (Bulkeley and Schroeder, 2008a). In this context, the need to involve all relevant government stakeholders in the agenda setting and formulation stages spills over into the implementation phase. Their experience defining and developing climate policy increases their capacity to successfully implement the policy, as it relates to their responsibilities.
- *Lack of appropriate funding.* A key obstacle to implementation stems from the reality that most existing plans do not mention specific needs for funding and many local governments do not have the capacity to include funding requirements in their climate change programme. The lack of appropriate funding also explains why certain cities do not always integrate all major emissions sectors into their action plans. The City of Los Angeles climate plan, for instance, largely ignores the costly transport sector, although it is responsible for around half of emissions in the city. Due to differences in financing structures, some local governments shoulder greater financial burden than others to fund climate change plans. While US cities such as Portland, Seattle, Denver and Chicago can share the financial burden of expanding the public transport system with the state government, local governments in California must generate 90% of funding for transport infrastructure from their local revenues (Bulkeley and Schroder, 2008b).
- *Lack of devolved authority or appropriate responsibility.* As mentioned in the agenda setting section, in many OECD countries, local authorities lack sufficient jurisdiction over matters that greatly affect their greenhouse gas emissions. These include energy policies (particularly national electrical grid development and maintenance), funding for transportation development, maintenance and operations, taxation and revenue generation authority. Some competencies might not be under the responsibility of the appropriate scale of intervention. For instance, waste management in London falls under the responsibility of local borough councils which prevents the Greater London Authority, which covers an area closest to the functional area, to use waste in the provision of energy. On the other hand, while decentralisation is often advocated as the solution to reinforce implementation capacity, it has in some cases led to a paradox whereby more responsibilities are delegated to local authorities, while they lack financial resources and even the decision-making power to undertake effective policies. That being said, the experience in many countries suggest that municipalities do not fully exploit their authoritative powers and are reluctant to apply authoritative modes of governing through regulatory measures and strategic planning (Kern in OECD, 2009a).

Within metropolitan regions, empowering sub-local units with important climate-related powers raises the complexity of co-ordination. To again draw from the experience of Greater London, the City of London has faced difficulties in establishing relationships with the 33 local or borough councils that are contained in the Greater London area. Local councils are driven by their responsibilities in relation to performance indicators and local agreements, in which climate change play a minor role, are signed directly with the central government and. Only 23 have signed the national Nottingham Declaration for Local Councils and only six have a climate change action plan. With the exception of providing directions to local level planning and through the development of public transport, there are few direct means through which the Mayor, the GLA and the London Development Agency can affect action at the local level. Even in relation to planning, the Mayor's powers are limited to providing direction for Local Development Frameworks which must generally conform with the London Plan. This issue is particularly acute for waste management, which is under the responsibility of local councils (Bulkeley and Schroeder, 2008a).

- *Lack of support from central governments.* This also often impairs the effectiveness of sub-national climate change policies. The actual response of local governments varies considerably due to national programmes, as well as legislative, regulatory and policy frameworks which support local initiatives. National policy and measures with respect to planning (*e.g.* improving the energy efficiency standards of new buildings) and business (*e.g.* carbon reduction commitment) are important drivers for action among actors. The absence of appropriate regulation in key areas, particularly with regard to energy generation and supply, is perceived as a major obstacle. In its 2007 climate change action plan, London admits that central government support is needed to achieve half of its ambitious goal of a 60% reduction in CO_2 by 2025 (GLA, 2007).

Policy evaluation

Relatively few evaluation frameworks have been employed to measure the outcomes of climate policy at local scale. This may be due to the fact that the most aggressive policies have only been recently launched. One exception may be found in Newcastle, Australia, which has created the world's first and only device, known as a greenhouse gas "speedometer",[8] that monitors and reports the city's consumption of electricity, gas, liquid fuels, waste to landfill, water consumed, trees planted and the resultant equivalent in tonnes of carbon dioxide expended. The electronic billboard includes a 500-megawatt electricity metre in the town square, updated hourly from data sourced directly from the energy providers in the 15 electrical zone substations that power the city. The device has demonstrated that if the city had continued business as usual, it would have increased its greenhouse gas emissions in 2008 to around 20% to 35% above the 2000 level. In addition, the 250 council-owned and operated facilities that fuel the city have managed to reduce electricity consumption by 40% compared with 1995 levels, and water consumption by 25%, thanks to an action-based research programme and the establishment of a rating system. In the absence of large-scale national funding, the city has entered into a public-private partnership with 12 foundations (Together Today PPP). This has proved essential for bringing together those who need low-carbon products and services and those who supply them.

With respect to mitigation, it is common to observe cities in the OECD that rely on the development of aspirational goals as the indicators of progress rather than the development and attainment of actionable mitigation and adaption targets that are quantifiable and verifiable (Wheeler, 2008). This is reflected in the litany of cities which have adopted climate change mitigation goals but are unable to fulfil their targets, or develop meaningful performance measures linking, for example, energy management and emissions reductions. The landscape is full of sub-national governments unable to tie quantifiable mitigation targets with large-scale applications of energy efficient buildings, building retrofits, renewable energies, and transit-oriented development.

With respect to adaptation, analyses of impacts and adaptation options at a city-scale level, and relevant decision making, is at a very early stage. Within the last decade, a number of OECD country cities have undertaken multi-sectoral analyses of potential climate change impacts, including London, New York, Boston, Hamilton and Wellington (Hunt and Watkiss, 2010). There are very few detailed studies and these studies are largely qualitative in nature. One exception is the cost-effectiveness analysis in a study undertaken in Boston. Further work is needed to advance understanding of the costs and benefits of adaptation options at local scale.

A main obstacle to policy evaluation is linked to the difficulties in developing performance benchmarks and creating a monitoring system to assess policy performance. As mentioned, ideally these elements are designed in the policy formulation stage in a co-operative, inclusive manner. As will be developed in Chapter 10, concerning aggregate GHG emission performance at urban scale, standardised greenhouse gas emission inventory and standard reporting protocols for cities would also help cities to achieve their goals, to measure the progress and compare the cost-effectiveness of actions by sector and to become potential actors in the carbon market which could open the way for new sources of funding for city-scale mitigation efforts.

Following evaluation, some policy ideas are disseminated and replicated elsewhere and might even create a feedback loop that informs a change in the original policy itself. However, many other useful policies live and die within a city's borders, although they may present useful solutions for other local governments. Although dissemination is not a central component of the policy process, and may arise unexpectedly, it can be an important outcome of the local policy process, as it can inform future agenda setting and actions beyond the city or local boundaries. Studies on "policy transfer" on multiple scales, from the global to the local, illuminate how policies are reshaped and adopted following their dissemination (Cook, 2008; Evans, 2004).

Collaboration between municipalities and regional government

Inter-municipal action to combat climate change

A lack of horizontal collaboration among municipalities within urban regions can be an obstacle to actions to combat and adapt to climate change throughout the policy process. In many cases, the administrative structure of governance does not fall precisely within metropolitan regions' actual boundaries, so that carbon-relevant functions, defined economic interchanges, flows of materials and energy, and transportation between activities and households in the city's core area and neighbouring localities overlap across multiple jurisdictions. This requires that city officials engage in the sometimes challenging task of co-operation with other local governments.

Inter-municipal co-operation within metropolitan areas has been identified as a key obstacle for well-functioning and competitive metropolitan regions (OECD, 2006). The series of OECD Metropolitan Reviews pinpoints in particular how the integration of spatial and transport planning creates institutional structures capable of ensuring urban sustainability. The co-ordination of transport offers particular potential given that between 30 and 40% of total CO_2 emissions in cities in the ITF/OECD area are generated in the transport sector (Crass in OECD, 2009a). The European Commission's Green Paper on Urban

Transport as well as the International Transport Forum highlight how improvements in inter-municipal collaboration can help tackle congestion, air pollution, health problems, noise, and greenhouse gas emissions.

Ultimately, metropolitan areas endowed with an existing inter-municipal collaborative framework or administrative unit level at the appropriate scale would be better positioned to deal with the issue of institutional fit in the field of climate change. The underutilised inter-municipal co-ordination tools within metropolitan areas may pose serious problems for adaptation policies, which typically need to be developed and implemented at a regional scale (*e.g.* for example water management systems and precautionary flood-protection measures along rivers).

Successful mitigation policies also often depend on technical infrastructure, which transcends city borders, *e.g.* power distribution and transmission infrastructure. The lack of institutional fit with carbon-related issues has been identified as a key priority to effectively implement the climate change strategy in Mexico City. Although a few examples exist of climate change action plans at the metropolitan level, most notably in London, Hanover, and Portland, collaborative inter-urban frameworks for climate change policies and strategies are the exception, not the rule.

Box 7.3. **Cases of metropolitan co-ordination for climate change action planning**

London: In London, the creation of the Greater London Authority in 2000 with a directly elected assembly and mayor provided the opportunity to address climate change at the London-wide scale. Planning responsibility allows the mayor to promote the use of on-site renewable energy generation (micro-generation) and Combined Heat and Power (CHP). In the first term of the mayoral mandate, the Greater London authority formed the London Energy Partnership. This was followed by the introduction of the congestion charge and the approval of policies for addressing the emissions of new development. This momentum led to the development of a Climate Change Action Plan and the creation of the London Climate Agency in 2005 to deliver the policy framework (Bulkeley and Schroeder, 2008a).

Hanover: The German metropolitan region of Hanover, a metropolitan region with about four million inhabitants, benefits from a regional approach to mitigation and adaptation strategies. The Regional Climate Protection Agency (Klimaschutz-Agentur Region Hannover) co-ordinates all climate protection activities throughout the region. In the meantime, the regional association of local governments and Hanover county have been transformed into a new authority covering the metropolitan region, *i.e.* "Hanover Region" (Region Hannover), and major competences have been transferred to this body.

Portland: Metro Portland (Oregon), which serves the city of Portland, three counties and 25 cities in the region, is in charge of maintaining the Portland area urban growth boundary and is also responsible for the region's transportation system. This is crucial to avoid urban sprawl and is, therefore, a key element of the regional mitigation efforts. The city of Portland was the first city in the United States to put a local climate action plan in place. In 2001 Multnomah County followed Oregon's lead and developed a regional strategy (Local Action Plan on Global Warming) covering the city and the county. This strategy includes 150 short- and long-term measures with the overall goal of reducing CO_2 emissions by 10% by 2010 (Ekelund and Sigurdson, 2007). Portland, like Hanover, is governed by an elected regional body, which may explain the strength of its regional collaboration (OECD, 2006).

Beyond inter-municipal co-operation in one geographic area, some local governments have participated in resource-pooling strategies that have achieved significant savings through co-ordinated action, such as projects to purchase energy-efficient products for common use. For example, the Clinton Foundation has helped organise a "Purchasing Alliance" for green cities that collectively negotiates discounted pricing agreements for a range of energy-efficient products. The Clinton Foundation, along with ICLEI and other groups, have also created similar networks for cities to pool know-how to reduce policy development costs and create uniform environmental monitoring frameworks. In Europe, regional energy agencies, which are partially funded by the EU offer guidance and services on energy and transport policy to some 260 local and regional agencies. However, in most cases decision making remains the prerogative of local governments and the influence of these international or transnational networks is limited, in particular if their funding is not ensured in the medium and longer term.

Regional strategies and actions

Regional approaches to climate change mitigation and adaptation can provide a scaling-factor that can make structural changes possible that would be unattainable on a purely local basis. At the regional level, greater technical and financial capacity, and environmental know-how may exist than within individual cities or towns. Regions can also develop strategies that can link policies and programmes that would otherwise operate in isolation (*e.g.* connecting initiatives in urban and rural areas). By achieving levels of scale not possible at the local level, regional strategies have the potential to make larger contributions to greenhouse gas emissions reductions. Thus, whereas an individual city might be able to think of ways to improve energy efficiency in housing within existing structures, at the regional level it may be possible to consider urban planning strategies that will result in not only more efficient housing designs and standards, but also where houses are built and their relationship to the regional environment.

Many examples of regional climate and energy initiatives provide insight into cross-cutting climate solutions. For example, various communities in and around the industrial region of Eindhoven, the Netherlands came together to build upon their regional strengths in technological research and development in an effort to meet three interlinked goals: a cleaner environment, preserving jobs, and building a technology for the future (Broaddus, 2007). The Samenwerkingsverband Region of Eindhoven was at the centre of the development of the low-emission public transport vehicle, the Philias – an advanced, guided bus that is controlled by a magnetic system built into the road – and that connects various communities within and around Eindhoven to major regional facilities, including the airport.[9] The San Francisco Metropolitan Transport Commission offers an equally powerful example of regional action to enact the infrastructural and technological changes necessary to "green" transportation structures, improve connections within and between urban areas, and limit emissions from transport through the introduction of low emission and alternative fuel vehicles. This kind of larger structural transformation requires substantial co-ordination among land use planners, technical specialists, engineers, conservation experts, and administrators at the local, regional, and in some cases, the national level (Box 7.4).

Box 7.4. **Transportation 2035 Plan for the San Francisco Bay Area**

San Francisco Bay's Metropolitan Transport Commission issued the draft "Transportation 2035 Plan: Change in Motion" in December 2008 for public review and comment. The plan is built on the 3-E principles of economy, environment, and equity. It was two years in the making and based on widespread public input that was obtained through a regional forum, workshops, telephone surveys, on-the-street surveys, focus groups (including in low-income areas), and consultations with tribal, federal, and state resource agencies.

Given that transport-related emissions account for 50% of the Bay's greenhouse gas emissions, the plan sets out the goal of reducing transportation-related emissions by 40% below 1990 levels by 2035, cutting congestion by 20%, reducing daily vehicle miles travelled per person to 10% below 2006 levels, and reducing by 10% the share of low-income residents' household earnings consumed by transportation and housing. Proposed ways of achieving this goal include smart growth policies, reduced congestion through improved and more effective infrastructure (freeway ramp metering, changeable freeway message signs, co-ordination of traffic signals along adjacent arterials, carpool lanes), expanded transit service, bike lanes, high speed rail, high occupancy toll lanes, express bus service, a carbon or vehicle-miles travelled tax, incentives to channel new housing and jobs into existing communities and the urban core.

Source: Metropolitan Transportation Commission (2008), "Transportation 2035 Plan for the San Francisco Bay Area", Metropolitan Transportation Commission, Oakland, CA, United States.

Notes

1. Note this framework is slightly adapted particularly to include a dissemination option.
2. The plan was introduced to help enterprises operate and generate profits through eco-friendly practices that benefit both the environment and the economy. Five hundred and twenty-seven enterprises have participated to the Eco-business plan, implementing more than 9 000 environmental projects. The eco-business is now being implemented in other cities like Athens, Greece.
3. In France, this process, known as *diagnostic partagé*, commonly comes at the start of the development of an Agenda 21 framework at the local level to help determine which sustainable development issues to address.
4. This strategy has paid off as Madrid has managed to reduce GHG emissions by 15% over the period 1990-2004, while Spain as whole registered a rise of 47%. Madrid's City Council, exceeding Spain's commitment, released a Plan for the Sustainable Use of Energy and the Prevention of Climate Change last year, promising a 14% reduction of GHG based on 2004 values over the period from 2008-2012. The city has developed its public transport network in recent years, pledged to make municipal transport vehicles environmentally friendly by 2011 and has actively exploited new sources of energy, including the generation of electric power through waste incineration, biogas from landfills and sludge drying. It has also embarked on the renovation of its public lighting system and encouraged a steady rise in the incorporation of solar-powered heating systems in newly constructed and renovated buildings (whose number has increased sevenfold since 2003). In collaboration with the city's economic and social stakeholders represented in the Pro Clima Madrid Forum, a platform that includes all its major private companies, Madrid is promoting biofuel supply networks and an incentive scheme for clean motor vehicles.
5. To guarantee that this model works properly requires, first, strategic plans comprising sectoral targets, policies and measures (such as the combination of a general master plan for the environment and a specific master plan for energy in the city of Zurich); and, second, a project-based approach which prevents departmental segregation.
6. California is moving toward the idea of cross-institutional networks. This is being done, in part, through the Climate Action Team that is charged with co-ordinating action among different departments, actors, and interests (Rabe, 2009; Corfee-Morlot, 2009). The Climate Action Team is composed of members of the California Environmental Protection Agency (CalEPA), the Business, Transportation and Housing Agency, the Department of Food and Agriculture, the Resources

Agency, the Air Resources Board, the Energy Commission, and the Public Utilities Commission. The Secretary of the CalEPA heads up the team. The Climate Action Team is required to report on their progress towards meeting the statewide greenhouse gas targets.

7. San Francisco also has a bus fleet that runs entirely on electricity or biofuels, a taxicab fleet 80% of whose vehicles will be green by 2012, and among the highest levels of bicycle commuting in the United States. These programmes, plus the attempt to purchase clean and green energy for the city's electricity grid, have resulted in an independently verified 6% reduction of greenhouse gas emissions below 1990 levels.
8. *www.newcastle.nsw.gov.au/environment/climate_cam/*.
9. Philias Bus Rapid Transport Eindhoven, Part I, video, *www.youtube.com/watch?v=StN-4xdzhz4*.

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PART III

Chapter 8

Local-National Climate Policy Linkages

Chapter 8 reviews the vertical dimension of climate governance, focusing on local-national interactions and co-ordination in the development of climate policy. Multi-level governance is a critical issue for national governments, the large majority of which have agreed to work together to reduce greenhouse gas emissions and to adapt to inevitable climate change. A key issue for national policy makers is what they can do to empower cities to become more effective in the design and implementation of policies for mitigation and adaptation to climate change and to take advantage of the opportunities to learn from city-scale experimentation and action. These include policies driven from the top by national or regional governments as well as from the bottom by local policy approaches and innovations that may subsequently be scaled up to regional or national responses. A hybrid of the two frameworks provides top-down incentives and guidance while leaving room for city-level leadership and innovation. Partnerships with the private sector are shown to be an important feature in hybrid frameworks. Climate priorities also call on national governments to integrate mitigation and adaptation goals into national regional development policy frameworks, although only a few countries can provide successful models for climate-sensitive regional development policy.

Key points

There is no "one-size-fits-all" framework for national policy to incentivise and guide local action or for national-local co-ordination

- National-local governance on climate change can be driven from the top by national or regional authorities, grow from the bottom up as local policy innovations provide models for regional or national action, or feature a hybrid of both approaches.
- Nationally led "top-down" approaches may mandate or strongly recommend a specific set of policy actions at local scale, such as in the case of Norway or China. "Bottom-up" frameworks are initiated at local level and often emerge where policy authority is highly decentralised (*e.g.* in the US) and strong national policy does not exist, allowing for greater experimentation and innovation. Hybrid approaches exist where national governments work closely with cities to stimulate two-way learning and where there are features of both top-down incentives and bottom-up leadership and initiative, and may also encourage public-private partnerships to promote action on climate change; examples include Brazil, Japan and Sweden.
- Eventually national-local linkages can enhance opportunities to learn from one city to another as well as for successful policies to be identified and possibly replicated across regional or national scales.

National governments play a key role in supporting and removing barriers to greater urban governance and enhancing cities' capacity to act on climate change issues

- National governments can empower local authorities, leverage existing local policy experiments, accelerate policy responses and learning, foster resource mobilisation and help engage local stakeholders.
- Strong national targets for adaptation and greenhouse gas emission reduction can help prevent regional competition based on environmental regulations and even promote a "race to the top" through proper incentives. Identifying national policies that conflict with or prevent local climate action, such as through a regulatory impact assessment process, is an important way national governments can improve the alignment of national policies with local climate goals, plans and policies.

National regional development frameworks could be strengthened to better integrate climate change considerations

- Very few OECD countries are applying a "climate change lens" to the implementation of regional spatial or economic development policy frameworks. Instead, regional development policies are typically applied independently of national sectoral strategies to address climate change. Alignment of incentives across sectoral and cross-sectoral policy areas is required to deliver policy coherence and to integrate climate change into regional and territorial development planning.

Main rationale for local-national policy linkages

These are several broad reasons for national governments to better engage with local governments and stakeholders on the issue of climate change. First local authorities serve as a vehicle for the implementation of nationally driven policies, to ensure that the mandates outlined at national scale are actually carried out and deliver meaningful results at local scale. Second, through local policy and urban planning reforms, local governments may be able to build resilience to climate change into urban infrastructure and development patterns. Third, urban scale action may be important in its own right and able to provide a means of social and technical innovation that is not possible at broader scale, ultimately providing a vehicle for learning and broader dissemination where successful innovations occur. In this way, experimentation and learning at the local and sub-national level can provide essential experience and, when successful, lead to bottom-up diffusion of approaches between cities and regions as well as to influence national and even international levels of actions (Bulkeley and Betsill, 2005; Corfee-Morlot, 2009; Newman *et al.*, 2009).

With respect to adaptation, local level decision making is particularly important for at least three reasons. First, climate change impacts are manifested locally, affecting local livelihood activities, economic enterprises, human health, etc. Second, vulnerability and adaptive capacity are determined by local conditions. Regional or national vulnerability indices often mask the dramatic variations in vulnerability at local levels. Third, adaptation activities are often best observed and implemented at the local level. Decisions about livelihood strategies and investments drive adaptation. Local monitoring and evaluation of how policies, programmes and projects are supporting adaptation are essential as they also provide a basis for learning, adjusting and eventually scaling up actions that are successful (Bicknell *et al.*, 2009; OECD, 2009a).

Local action will also provide essential insights for understanding the political economy of climate change policy. It will provide a vehicle to identify how incentives and interests interact at different levels of governance, to observe and understand direct local costs and benefits of action, including local co-benefits, and the local winners and losers of any particular set of policy choices. The evidence or perceptions of who wins and who loses, and the weight of co-benefits associated with any set of climate policies may significantly differ at local scales compared to aggregate nation-wide experience. This can open a range of opportunities for local action that may not exist at broader scales.

From a national government perspective therefore, it is useful to focus on how to design national policies to better empower and enable local governments and stakeholders to address climate change through everything from day to day decisions about household and consumer choices, to broad urban planning decisions with long-term implications for climate change vulnerability and emissions intensity of urban development (see Chapters 1 and 2). National policies may aim to exploit the opportunity for national authorities to learn in parallel with local communities about the range of policy options at hand and their performance in different local contexts, thus providing an essential testing ground for policy.

Beyond understanding of costs and benefits of action, Table 8.1 highlights three different clusters of drivers that shape approaches to climate policy at different scales of action (Betsill, 2001; Carmin *et al.*, 2009; Moser, 2009; Schreurs, 2008):

i) Government functions and roles.

ii) Key actors and institutions.

iii) Tools for decision making.

Table 8.1. **Climate change and multi-level governance: Key actors, functions and tools at different scales of action**

	Local/city	Sub-national regions (*e.g.* states or provinces)	National	International
Government functions and roles	• Implement local decisions as foreseen under national or regional law. • Where authority exists – act autonomously, *e.g.* through land use planning, decisions on local infrastructure (*e.g.* local roads, urban planning and zoning, flood control, water supply, local parks/reserves/green-spaces, sanitary waste). • Identify local priorities – enhance local/regional understanding working with local actors. • Raise awareness, create deliberative "space" for decision making. • Develop locally adapted policies and measures, *e.g.* public private partnerships and local public procurement policies.	• Implementation of national laws, standards. • Regional climate policy framework – near and long-term targets – regional strategic orientation. • Regional laws and policies in key climate-related sectors (*e.g.* energy, air pollution, water). • Regulate performance in key sectors where permitted by national law to do so (*e.g.* building or appliance standards). • Prioritise and set out time frames for regional action (*e.g.* by sector). • Provide incentives, funding and authorisation to enable local action on climate change. • Risk characterisation at regional scale; definition of risk management rules or guidance, funding, and principles. • Establish a monitoring system to track GHG emissions and policy performance over time. • Fund core analytic inputs to facilitate regional and local decision making. • Ensure that decision makers have the tools, information and appropriate institutional context to deliver good decisions.	• National climate policy framework – near and long-term targets – strategic orientation for policy. • National laws, policies and standards in key climate-related sectors (*e.g.* energy, air pollution, water). • Regulate performance (*e.g.* building or appliance standards). • Prioritise and set out time frames for national action (*e.g.* by sector). • Infrastructure funding and authorisation for construction (*e.g.* national roads, sitting power or transmission facilities, water supply and quality, parks or reserves). • Establish a national inventory system and build understanding of nation-wide mitigation opportunities and their costs. • Risk characterisation at national scale; definition of risk management rules or guidance, funding, and principles. • Monitor performance of climate policies – national scale. • Fund core analytic inputs to facilitate sub-national (regional and local) decision making. • Provide regions, local governments with tools and support to make good decisions (*e.g.* inventory methods).	• Set out timeframe and priorities for co-operative action, collaborative framework to guide national action. • Provide seed resource to support action. • Monitor and peer-review and where appropriate, compliance assessment (*e.g.* FCCC). • Facilitate sharing of experience between nations.
Key institutions or actors	• Public: city, county or other public authorities. • Private sector: local industry and business, tourists, households. • Local environmental or consumer organisations. • Local and regional experts.	• Public: state or provincial governmental authorities. • Semi-autonomous public or public-private institutions (*e.g.* school boards or issue-based commissions). • Private sector: regional industrial federations; major corporations. • Environmental organisations. • Academic networks, universities. • Worker unions.	• Public: national governmental authorities. • Semi-autonomous public or public-private institutions (*e.g.* school boards or issue-based commissions such as for water or air pollution management). • Private sector: national industrial federations; major corporations. • Environmental organisations. • Academic networks, universities. • Worker unions.	• Public intergovernmental organisations and institutions. • Private: multi-national companies (*e.g.* insurance, energy, telecommunications). • Major environmental and development non-governmental organisations (*e.g.* WWF, Greenpeace, WRI, Red Cross, etc.).
Tools for decision making	• Deliberative or participatory policy processes (perhaps linked to ongoing policy processes, *e.g.* urban planning and infrastructure decisions). • Local GHG inventories – standardised and linked with national inventory methods. • Urban vulnerability mapping or risk assessment (*e.g.* flood risk and key infrastructure).	• Funding for research. • Regional climate modelling – building on national research. • Impact science – regional centres of expertise. • Policy research – regionally tailored. • Harness academic resources and facilitate networks. • Regional GHG inventories. • Project funding structures to support regional and urban scale action.	• Funding for research. • Climate modelling – national research (*e.g.* NOAA, UK Hadley Centre). • Support for impact science – regional (sub-national) centres of expertise. • Policy research – including support for regionally tailored research. • Harness academic resources and networks. • National GHG inventories. • Project funding structures to support urban scale action.	• Funding for research. • International research collaboration and science-policy networks (*e.g.* IPCC). • Harmonised GHG inventory methods. • Harmonised reporting systems (*e.g.* FCCC) to provide oversight for international carbon markets.

How each of these different clusters join up to work together across scale will determine the boundaries for decision making and alter the outcomes at any particular level.

With respect to the first cluster – government functions, responsibilities and roles – there is significant variation across scale and different opportunities and challenges at each level, which will also vary by national institutional context. For example, local governments typically have some autonomy over urban planning and land use decisions or on public transport priorities, but they may not have any of the responsibility for provision of key transport infrastructure such as roads. The division of authority in key areas such as infrastructure (roads, parking, public transport systems, and buildings) or even service provision (water, energy, waste management) will define the potential for local governments to act. The "nested" institutional structures of government decision making on issues central to climate change, underscores the need for linked up policy frameworks that address climate change across levels of government (Dietz *et al.*, 2003).

On the second cluster, institutions and actors at each level of government are important as they largely determine both the resources available to support climate decisions and the politics of decision making (Hooghe and Marks, 2003). At a national scale, national governments (both the legislative or parliamentary and administrative branches) are responsible for large public budgets to support public action, whereas public resources are typically much more constrained at local scale. As such, there is much greater flexibility at national scale to shift significant resources to finance new policy initiatives such as on climate change. Other types of human or expert resources may also be more readily available at national or regional scale than at local scales to support climate decision making, for example through public university systems or national research institutes. Even if the resources are made available to support local decision making, the challenge will be to build capacity to exploit these wisely and to build a local knowledge base that informs decision making. In many cases, obstacles can derive either from the lack of devolved responsibility or excessive decentralisation without commensurate financial tools and/or lack of appropriate capacity at the sub-national scale.

A look across the diversity of actors playing into climate decision making at different scales also suggests that the politics of climate change may be more tractable at the local scale. This is because there will necessarily be a narrower set of local interests than at broader levels of decision making. At national levels, policy makers are faced with trying to ease the transition for all business sectors in the nation that are set to lose due to climate policy, while at local levels in many instances there will be a narrower subset of these interests to deal with and interests may more easily align to experiment with pro-environmental stance. This provides some opportunities for stronger or at least more experimental, pro-environmental action at local levels than at national levels of decision making.

Another institutional issue is the ability for strategic policy development at any one level to incite climate-friendly investment and behaviour. At national level an important factor is how national governments handle design and implementation of climate change policies. For example the diffusion of responsibility in one or several departments will matter given that line ministries that address sectoral issues have multi-level governance practice built into their mandates. There is also a need for focused attention to building capacity throughout levels of government to undertake pro-active assessment of the costs and effectiveness of policy options in the areas of mitigation and adaptation. This will take some training but also access to standardised tools and up to date information in each area. Within this, national governments will need to take some responsibility for decentralising understanding and building ownership and responsibility throughout government as well as across stakeholder communities. This task will be facilitated by the creation of economic and financial incentive mechanisms that serve to make the costs and the risks of climate change apparent in day to day market transactions. Where markets are not present or well-functioning, there is a need for different types of instruments, perhaps in the form of direct public financing to alter outcomes.

Finally on the third cluster, tools for decision making may also vary across levels of decision making. At the international level, for example, governments have worked collaboratively to design and implement markets for emission reductions. This rests upon the use of harmonised carbon market instruments (*e.g.* typically national emission trading programmes in OECD countries) and greenhouse gas reporting instruments (*i.e.* standardised inventories and registry tools). At national level on mitigation, such instruments are used to guide private sector investment to least-cost outcomes. Additionally, it can be argued that a key tool is centralised (national or regional) support programmes aiming to finance local action on climate change. Similarly at the local scale, key tools include also internationally harmonised accounting or inventories of GHG as well as the use of open, consultative practices to generate ideas and support for local action.

Institutional models: Local-national co-operation on climate change

A review of practice across a range of OECD and emerging economy locations (Brazil, China, South Africa) reveals that there are various types of institutional models influencing or guiding policy action on climate change across levels of government. These include: *i)* nationally or regionally led enabling frameworks with predominant influence moving through national policy to influence local action; *ii)* bottom-up or more autonomous locally- or regionally-led action that in turn may influence national action; and *iii)* a hybrid approach showing features of both and sometimes encompassing strong public-private interactions. Each of these is discussed in turn in the following sections.

Table 8.1 provides an overview of a number of examples that demonstrate these different models and types of influences highlighted below.

Nationally led – "top-down" enabling frameworks

A main institutional approach to incentivise local action that is observed in many countries is a centralised enabling framework. Such a framework uses national policy to require that local and/or regional authorities to take climate change into account at local level. In this model, central governments can develop a variety of different policies that can serve to assist local governments to contextualise national (or regional) policies and priorities as well as assist local governments to develop the competencies necessary for municipalities to take further action on their own. Local governments have an important implementation role to play if national emission reduction and adaptation targets and goals are to be met. A first order issue for national governments is to understand exactly how best to clarify goals in local contexts and to work with local governments on implementation. Beyond the essential role in implementation, there is a need to document experience and monitor progress at local level, not least to understand at national scale and further within the context of international obligations, to what extent progress is being made to mitigate and adapt to climate change.

As noted in Chapter 7, four different modes of governing climate change pertain at local levels: self-governing municipal operations (*e.g.* municipal buildings or vehicle fleets); provisioning (in terms of public services, *e.g.* in the water, waste or energy area); regulating; and enabling. Local governments also face a number of implementation barriers in their efforts to advance climate change response. For example, in both mitigation and adaptation policy areas, city authorities often find their ability to act constrained as emissions sources or different aspects of land-use planning fall outside of their jurisdiction. In these cases national approaches and regulations are essential to spark action, giving a mandate or at least a framework within which cities can act.

At a minimum, national policies will be essential to establish broad, cross-sectoral price signals to guide investment to climate-friendly outcomes, for example through a tax on carbon or establishment of national cap-and-trade regulations. More targeted, sector specific national policies or regulations may also be needed, for example, to encourage large-scale investment in energy conservation and fuel switching (Betsill, 2001; OECD, 2009b). Additionally, national policies can also help to ensure that climate policy within countries is not confined to a few front-runner municipalities, but is rather integrated into the functioning of urban areas across the country (Aall *et al.*, 2007). Centralised frameworks therefore can ensure that a few "best practice" examples do not distract attention from the importance of pushing the majority "business as usual" municipalities into taking action (Aall *et al.*, 2007).

In a similar manner, national policies targeting local authorities may also take different forms, ranging from regulation or requirement that local authorities take certain actions to enabling. However many of the examples examined relate to enabling policies or frameworks where mandated approaches play a role but the general framework is one that leaves wide latitude to local authorities to taper local policies on climate change to local contexts.

One of the earliest examples of a national enabling policy framework on climate change at urban scales can be found in **Norway**. In June 1998, the Norwegian parliament passed the Government White Paper on the Kyoto Protocol, introducing local climate policy as an explicit policy area. Using the White Paper as a base, the Minister of the Environment issued a circular in September of the same year requesting municipalities to develop local climate plans aiming at reducing carbon emissions and increasing sequestration through forestry projects. These plans were to be developed in partnership with the country and regional government authorities. To support the development of these plans, a local climate policy programme was established in 2000 by the Ministry of the Environment aiming to allocate NOK 7 million (USD 1 million) to stimulate action. With these funds, 26 projects were supported involving 37 of 435 municipalities and 8 out of 19 counties. In addition to financial help, a web-based information source and emissions calculation tool was put in place by the national government (Aall *et al.*, 2007). In the development of climate plans, national financial support appears to have been a key catalyst as only one municipality was reported to have taken action without grant support. However, while plans have been established, a problem is that implementation appears to have stalled as funding has not been available to municipalities to support the implementation of the programmes (Aall *et al.*, 2007).

In **China**, the central government's National Climate Change Policy co-ordinating Committee, an inter-ministerial committee, is responsible for policies addressing climate change. However the division of labour between national and local levels of the organisation is difficult to establish. Moreover, laws are formulated in a way to let local administrations interpret them to their own advantage. China's central government is aware of the need for regional governance in climate change and has recently signed contracts on energy efficiency and pollution reduction targets with provincial level officials and is currently looking for a new approach in the energy sector (Yuan, 2007). The central government's new preoccupation with environmental issues, combined with the annual performance review of the local leaders, may provide a means for the central government to put additional pressure on local and regional governments to achieve local emission reductions and increase energy efficiency. The central government is now looking at voluntary agreements as a substitute for top-down, nationally led policies (Yuan, 2007), as shown in the example of Nanjing (Box 8.1).

A number of other countries have also established national programmes to assist local level governments in the development and implementation of climate policies. For example, in **France**, the *Agence de l'Environnement et de la Maîtrise de l'Énergie*, an inter-ministerial agency focused on environment and energy research and policy, has developed a funding programme to assist municipal areas with the development of a *Bilan Carbone* emissions inventory. The ADEME provides expert input as well as financial support, being able to cover in certain cases up to 50% of the cost of emission inventory development.

In **Portugal** and the **United Kingdom**, a number of central policies and programmes have been established to assist local governments. In the United Kingdom, these include the use of Regional Development Agencies to foster regional approaches (see below), as well as the Carbon Trust and Energy Savings Trust, which are also helping to pilot energy savings programmes across England's core cities to develop management plans. On the issue of adaptation, the UK Climate Impacts Programme is active to generate local and regional knowledge about climate change and to build capacity at this scale to enable timely and cost-effective adaptation. In Portugal, the project "Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures" (SIAM) brings together scientists from various disciplines to advance research on climate change and disseminate knowledge. The Portuguese political response to climate change is translated into the National Programme to Climate Change, as a central government plan, conceived on a sector basis. This establishes a framework for the action of local authorities, including more recently the National Adaptation Strategy to Climate Change. Several local communities have started to take action in public transportation, infrastructure design, energy efficiency measures, land use planning and zoning, waste and green procurement programmes. As an example of good practice, Sintra (nearby Lisbon), is the first Portuguese municipality to adopt a climate change adaptation strategy, designed in collaboration with the SIAM team.[1]

Learning from the "bottom up" – from cities and regions to national action

A second model of multi-level climate governance is "bottom-up" where regional or local authorities are encouraged or allowed to go beyond national requirements or incentives to independently act to address climate change, either as an active part of national policy or in the absence of national policy. In this model, learning and experience acquired through successful local programmes diffuses to inform and steer policy making at regional or national levels of government. Inevitably both directions of influence – top-down and bottom-up – co-exist to shape action and policy across levels of decision making, such as in the case of the **city of Portland** and the **State of Oregon** in the **United States** (Box 8.2 and Figure 8.1).

Box 8.1. **Nanjing, China: Voluntary agreements as a substitute for top-down policies**

China is the biggest CO_2 emitter in the world (IEA, 2007). Economical problems related to climate change prompted the Chinese government to put energy efficiency at the top of their agenda. In 2007, The World Bank estimated that the cost of inaction to China's economy (*i.e.* health, energy efficiency, and building degradation) totalled around USD 100 billion annually, or 5.8% of China's GDP (World Bank, 2007). China is rapidly urbanising, having reached an urbanisation rate of 35% in 2000. Although coal heating systems are gradually pushed back in major Chinese cities, vehicle emissions are becoming the biggest sources of urban emissions. In Beijing alone, air pollution have become one of the leading causes of deaths and its cost is estimated from 7.5% to 15% of the city's GDP (Creutzig and He, 2009). China's 11th Five Year Plan, 2006-10 sets a target for energy intensity reduction. Structural problems however make implementation at the local level difficult, as Chinese implementation of top-down policies is typically very weak (Teng and Gu, 2007; Eichhorst and Bongardt, 2009).

In this context, the city of Nanjing has developed incentives to encourage effective participation at the local level. Nanjing is one of the most developed cities of China and has been referred to as the "Chinese Environmental Model City". Like every other Chinese city, it has a local Environmental Protection Bureau (EPB) responsible for implementation of national energy, environmental and climate policies at local level (Teng, Gu, 2007). In 2002, Nanjing EPB launched a voluntary energy efficiency programme with local state-owned companies.* The initial assessment phase has been funded by the European Union through the Asia Pro-Eco Programme, in a project called "Feasibility Study on Demonstrating Voluntary Approaches for Industrial Environmental Management in China". From 2002 to 2006, EUR 53 million were invested (European Commission, 2009). In March 2008, the voluntary agreement was signed between Nanjing Environmental Protection Office and targeted companies. These agreements included a 5% reduction of emission intensity of between 2007 and 2009 (Yuan, 2007), but also the opportunity for firms to share knowledge and know-how on specific issues with public authorities (Eichhorst and Bongardt, 2009). Incentives were provided to participating companies. Grants were largely supported by Nanjing EPB through revenues generated by a pollution tax (Yuan, 2007).

The Nanjing case shows that voluntary agreements can complement national measures and create incentives for public participation.

* The entire power sector in China is state-owned.

Source: Creutzig, F. and D. He (2009), "Climate Change Mitigation and Co-benefits of Feasible Transport Demand Policies in Beijing", *Transportation Research Part D: Transport and Environment*, Vol. 14, No. 2, pp. 120-131; Eichhorst, U. and D. Bongardt (2009), "Towards Cooperative Policy Approaches in China – Drivers for Voluntary Agreements on Industrial Energy Efficiency in Nanjing", *Energy Policy*, Vol. 37, Elsevier, London, pp. 1855-1865; European Commission (2009), *Actions to Support Asia's Environment*, available at *http://ec.europa.eu/europeaid/where/asia/regional-co-operation/environment/index_en.htm*, accessed 16 April 2009; IEA (2007), *World Energy Outlook*, OECD/IEA, Paris, France; World Bank (2007), *Cost of Pollution in China: Economic Estimates of Physical Damages*, World Bank, Washington DC; Teng, F. and A. Gu (2007), "Climate Change: National and Local Policy Opportunities in China", *Journal of Integrative Environmental Sciences*, Vol. 4, No. 3, pp. 183 seq.

There are a number of other examples of note in the United States as well as in Spain, both of which have a decentralised approach to governance. In turn this allows experimentation and room for innovation for those states and cities with the resources to do so. The **State of California** is notable for example; its leadership on air pollution control issues has provided a foundation of knowledge, experience and political will to support its recent actions to address climate change – action that is out in front of actions taken by the

Box 8.2. **Portland, Oregon: Green building multi-level governance**

Portland, Oregon has long been a leader in the United States on green building innovation. Portland's efforts, dating back to 1994, to aggressively develop a green building sector and innovation has had a direct influence on state-wide policy. Interestingly, the effort was begun by a volunteer citizen group, which was created to inform city council decisions concerning sustainable development and commissioned a planning process to explore the potential for a local green building technical assistance programme. It grew into a Green Building programme which is a partnership of development-related city government functions and local organisations. The programme today focuses on policy development, demonstration projects, technical assistance, education and financial incentives (City of Portland Bureau of Planning and Sustainability, 2009a). It is funded through local residential and commercial solid waste fees, and grants. The Portland programme also includes a Green Investment Fund, which is operated in partnership with the Oregon Energy Trust. Over the last six years, the Fund has provided over USD 2.5 million in funding to residential, commercial, industrial and innovation projects; 70% of the grants are financed by the City of Portland and 30% by Oregon Energy Trust (EDAW, 2008).

At regional scale across the state of Oregon, there is also movement to require that new and renovated buildings achieve high levels of energy efficiency. The Oregon Building Code Division established a building code requiring that new and refurbished building meet environmental and energy efficiency performance criteria in its 2008 edition (Oregon Housing and Community Services, 2009). Following these regional measures, several green building firms in Portland indicated that the demand for their services outside the region of Portland was increasing significantly (Allen and Potiowsky, 2008). To continue leading in the green building field, the City of Portland's Bureau of planning and sustainability recently proposed a building code that goes beyond the State standards (City of Portland Bureau of Planning and Sustainability, 2009b).

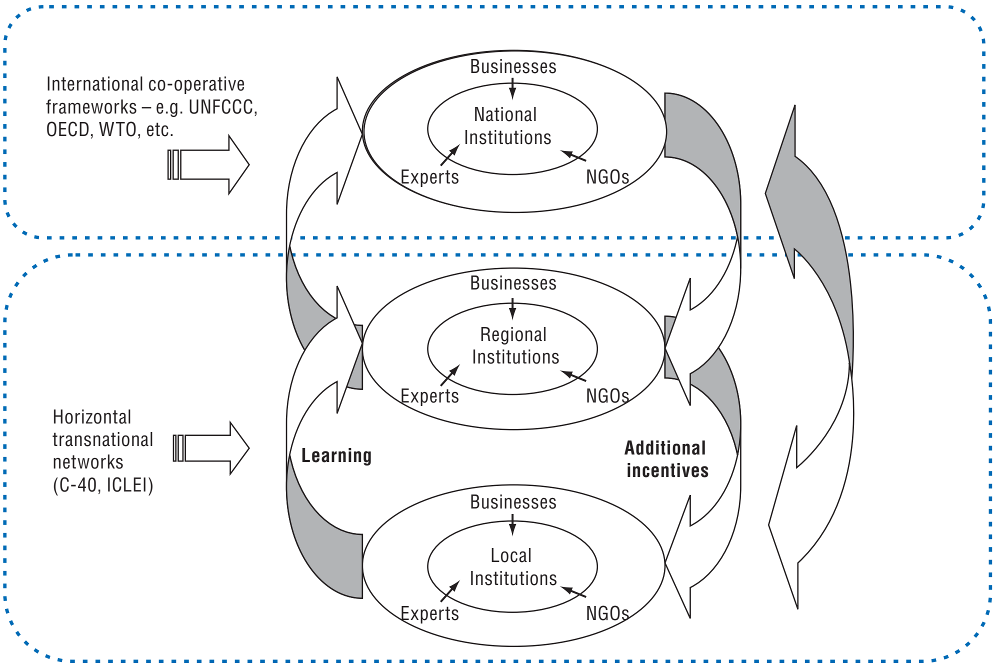
The state-wide building code is part of a suite of mitigation actions reported in the State of Oregon climate change plan, which was adopted in 2004 (State of Oregon, 2004). In addition, in 2007, the Oregon government created the Oregon Built Environment and Sustainable Technologies Research Center (BEST), therefore acknowledging the need for a sustained governmental policy support in the green building sector and the competitiveness of the national sustainable market (Allen and Potiowsky, 2008), It aims to develop, transfer and commercialise the results of university led research by creating new companies, services and products and to foster industry-university collaboration (Oregon Best, 2008).

Another important institutional actor is the Oregon Housing and Community Services (OHCS) which is responsible on one hand for the interface between regulators and regulations and on the other for citizens and stakeholders. It is promoting green building awareness through regional workshops and publications (Oregon Housing and Community Services, 2009). National incentives are also in place to stimulate green building practices: the Oregon Business Energy Tax Credit and the State Loan Program are often defined as key ingredients in the Oregon's leadership in the green building sector (Allen and Potiowsky, 2008).

The local motivation to create the green building programme in Portland is to develop and maintain a local/regional competitiveness around a new green pole of economic activity. In 2007, the City of Portland had the highest number of LEED certified buildings in the United States, and was attracting firms and qualified workers from around the country (Allen and Potiowsky, 2008). The Portland experience has provided an important foundation on which to draw insights for broader diffusion through a state-wide effort to regulate building energy performance and move towards green buildings more broadly across the state. The State of Oregon now has a comprehensive web of institutions designed to ensure green building excellence across the state. Beyond demonstrating the two-way influence between local and regional policy, this example also shows how participatory local policy processes, with broad stakeholder engagement, can lead to innovative policy and economic change.

Source: Allen, J.H. and T. Potiowsky (2008), "Portland's Green Building Cluster: Economic Trends and Impacts", *Economic Development Quarterly*, Vol. 22, No. 4 Sage, London, pp. 303-315; City of Portland Bureau of Planning and Sustainability (2009a), *The City of Portland's Green Building Program*, homepage of City of Portland, available at *www.portlandonline.com/osd/index.cfm?c=41481*, accessed 22 March 2009; City of Portland Bureau of Planning and Sustainability (2009b), *City of Portland Proposed High Performance Green Building Policy*, homepage of City of Portland, available at *www.portlandonline.com/OSD/index.cfm?c=45879*, accessed 22 March 2009; City of Portland Bureau of Planning and Sustainability (2009c), *Green Investment Fund*, homepage of City of Portland, available at *www.portlandonline.com/OSD/index.cfm?c=42134*, accessed 22 March 2009; EDAW (2008), *Case Study: Portland Green Investment Fund*, City of Seattle, Seattle; *Green Building Source Guide*, OHCS, Portland; Oregon Best (2008), *An Economic Engine for Oregon*, homepage of Oregon Best, available at *http://oregonbest.org/*, accessed 23 March 2009; Oregon Housing and Community Services (2009), *Building Codes Division: Green Building Services*, homepage of OHCS, available at *www.cbs.state.or.us/external/bcd/programs/green.html*, accessed 20 March 2009; Oregon Housing and Community Services (2002), *Green Building Source Guide*, OHCS, Portland; State of Oregon (2004), "Oregon Strategy for Greenhouse Gas Reductions: Governor's Advisory Group On Global Warming", State of Oregon.

Figure 8.1. **Multi-level governance framework for cities**



US national government (Corfee-Morlot, 2009; Hanemann, 2008). Other states have also been active (Pew Center, 2010; Rabe, 2004). Also at the local level, **New York City** has become a leader on the issue of adaptation and mitigation. This is due in part to ongoing support from a strong network of academic and government practioners, working together to advance understanding and support decision making (Hunt and Watkiss, 2010; Rosenzweig *et al.*, 2007; see also Box 8.3).

In Spain, the state government of **Catalonia** supports cities in its region, notably in the Barcelona metropolitan area to understand and act upon climate change in the context of sustainable urban development (Laigle, 2009). Since the end of the 1970s, Spain has become one of the most decentralised countries in Europe. Each autonomous government, the *Generalitat*, has negotiated its constitution with the federal State of Spain. Regional governments now bear the legislative and executive power in many areas. As a State-level authority, the *Generalitat* has the mission to manage land use planning, economic development, transportation as well as health and environmental issues. The *Generalitat* also manages the territorial planning and infrastructure development, urban centres and suburb organisation, and the distribution of economic activities. *Comarcas* are smaller territorial inter-municipal entities determined by the areas of urbanisation and economic development. Their mandate is to manage services defined by the *Generalitat*. They provide legal and technical assistance to small municipalities. There are 7 *comarcas* in the Barcelona Metropolitan Region. Finally, municipalities manage the urban planning of cities and adjacent area (Laigle, 2009).

The Catalan Office of Climate Change is the Government of Catalonia's main vehicle for advancing mitigation and adaptation to climate change. It aims to co-ordinate local actions and local GHG reduction policies in Catalonia, to work with different sectorial actors (*i.e.* public and private actors in transport, buildings and waste), to project future climate scenarios, and to provide support for the scientific community to better understand the

Box 8.3. **New York City: Bottom-up policy making driven by climate change risk**

With over 8.3 million inhabitants, New York City is the largest city in the United States. Like other coastal cities in the world, New York City will be dealing with more frequent climate events by the 2050s. Temperature in New York are forecast to rise by 1.5° to 3 °F (0.5°-1.5° Celsius) by the 2020s and by 3° to 5 °F (1.5°-2.5° Celsius) by the 2050s (NPCC, 2009). Many problems are associated with this temperature rise (*i.e.* drought, heat waves, precipitations), however one of the most challenging concerns stemming from climate change is sea-level rise, with water levels expected to increase from 4 to 12 centimetres by 2020, and by 30 to 56 centimetres by the 2080s (Mehrotra *et al.*, 2009). For New York City, coastal storms and flooding will lead to several infrastructural problems including street, sewer and low-level infrastructure flooding, bacteria and parasite problems in potable water reservoirs.

Decisions taken now in the field of infrastructure will greatly affect the quality of life of those citizens in decades to come. As in many field, environmental management in the City of New York deals with a much bigger region. For example, the NYC water system is made up of 18 storage reservoirs, 3 controlled lakes, 210 miles of aqueducts, 2 balancing reservoirs, distribution facilities and tunnels and over 6 200 miles of distribution mains (Rosenzweig *et al.*, 2007). In dealing with climate, New York City decision makers necessarily have to work with actors at several scales (*i.e.* state and local agencies and stakeholders).

The NYCDEP Climate Change Program is designed for decision makers to have better tools for dealing with climate impacts, adaptation, review, and monitoring. In 2004, the NYCDEP launched the Climate Change Task Force to ensure that NYCDEP's strategic planning was taking into account the potential effect of climate change on New York City's water infrastructures (City of New York, 2009). Later, in 2008, NYC Office of Long Term Planning and Sustainability created the NYC Climate Change Adaptation Task Force. The mandate of the task force is to support municipal decision making by developing a risk management plan, by evaluating climate change impacts and by developing mitigation and adaptation strategies. The Climate Change Task Force also has a mandate to co-ordinate scientific research across the research community as well as input from social researchers and other experts (Rosenzweig *et al.*, 2007; City of New York, 2009). Finally, by working with researchers, the NYCDEP aims to improve its regional climate modelling therefore reduce uncertainties in climate projections and improve infrastructure and investment planning

For example, it has worked with Columbia University's Center for Climate Systems Research (CCSR) to develop an analytical framework which divides adaptation challenges into management, infrastructure and policy categories assessed by time-frame (CCSR, 2009; City of New York, 2009). NYCDEP is also a member of other relevant research networks, *e.g.* the EU CLIME (Climate and Lake Impacts in Europe) project aiming at developing integrated regional water quality models to increase knowledge about climate change impacts on local watersheds (Mehrotra *et al.*, 2009; CCSR, 2009).

Source: CCSR (2009), *Climate Impacts*, homepage of Center for Climate Systems Research, available: *http://ccsr.columbia.edu/cig/index.html*, accessed 21 July 2009; City of New York (2009), *PLANYC: Progress Report 2009 – A Greener, Greater New York*, New York City, New York; Mehrotra, S., C.E. Natenzon, A. Omojola, R. Folorunsho, J. Gilbride and C. Rosenzweig (2009), "Framework for City Climate Risk Assessment", paper presented at the Fifth Urban Research Symposium, 28-30 June 2009, Marseille, France; NPCC (New York City Panel on Climate Change) (2009), *Climate Risk Information*, NPCC, New York; Rosenzweig, C., D.C. Major, K. Demon, C. Stanton, R. Horton and M. Stults (2007), "Managing Climate Change Risks in New York City's Water System: Assessment and Adaptation Planning", *Mitigation and Adaptation Strategies for Global Change*, Vol. 12, pp. 1391-1409.

impacts of climate change (Government of Catalonia, 2008). The mission is to develop and apply climate change mitigation and adaptation policies. It depends on the Directorate for Environmental Policies and Sustainability and is financed by the Department of the Environment and Housing. In 2007, the Office was funded at a level of EUR 1 million to work towards its mandate. The Office also supports information sharing through the Catalan Network of Cities and Towns towards Sustainability.

In 2007, the Catalan Office of Climate Change, the Sub-Directorate General of Environmental Information and Education organised the Catalan Convention on Climate Change with the support of the Directorate General of Citizen Participation. Catalan citizens were highly involved by the Convention and contributed to its final product. Private sector stakeholders, scientists, county councils and provincials councils also have participated in the process. The Convention ended in 2008 with a preliminary draft of the Catalan plan to mitigate climate change. The 2008-12 Catalan Plan to Mitigate Climate Change identifies measures needed to achieve targets defined in the European Union Emissions Trading Directive as well as ideas that came out of the Convention. It includes a programme of actions aimed at driving research, awareness-raising and participation. Projects launched by the plan include express buses, the anaerobic digestion of liquid manure and methane capture. The plan also contains elements for adapting to climate change. For example, the government of Catalonia is studying and measuring the possible impacts of climate change in the Ebro Delta (Government of Catalonia, 2008).

Other countries with decentralised climate policy initiatives include Canada (on both mitigation and adaptation at state or regional government level), Australia (*i.e.* on adaptation) and New Zealand.

Hybrid models

A third hybrid institutional model can also be identified where national and/or regional governments on the one hand, are working closely with local authorities on the other hand, to encourage experimentation and innovation at the local level to respond to climate change, and ultimately to identify successful lessons for broader diffusion elsewhere.

In **Sweden**, responsibility for climate-related risks and physical planning lies with municipalities. The central government, however, has a long tradition of establishing policy directives and mandates for municipalities to align local policies with national objectives (Nykvist and Whitmarsh, 2008). Within this system, the municipalities are often provided with substantial financial, legal and professional resources. Stemming from a tradition of centralised support to municipalities to stimulate local environmental initiatives, the Swedish central government developed the KLIMP climate investment programme to assist cities in climate change programme implementation. Attributed through a competitive process, eligibility for KLIMP grants requires that cities develop a climate strategy including main and intermediate objectives, locally adapted policy measures as well as strategies for follow-up and evaluation. Depending on the projects, funding provided by the central government covers between 25% and 85% of the costs, placing the responsibility for the remainder on the municipalities themselves (SEPA, 2004; Kern and Gotelind in OECD, 2008). Between 2003 and 2008, approximately 126 climate investment projects in several cities, representing an investment of EUR 214.9 million over this period, resulted in an estimated 1.1 billion tonnes of CO_2 reduction per year (SEPA, 2009).[2] An initial analysis of those projects related to mitigation suggests that funded projects focused primarily on energy (52%) with another 25% addressing transportation issues (Storbjörk, 2007).

The parameters of the KLIMP programme have evolved with better understanding of climate change as well as increased emphasis placed on adaptation. The 2007-08 funding cycle attempts to press municipalities to see climate change in the broader context. As part of this effort, the Värmland region, consisting of 16 municipalities, has created an energy office as common information and support resource which has served as an important partner with smaller municipalities in developing grant applications and programmes. While pure educational aspects can be part of submitted projects, applications must include clearly visible and tangible measures and investments (Storbjörk, 2007).

Table 8.2. **Overview of Swedish National Local Climate Programme**

Programme/administering organisation	Objectives	Implementing organisation	Type of actions	Targeted population	Funding source/annual budgetary costs
KLIMP/Swedish EPA 2003/08	• Stimulating investments that can lead to the reduction of greenhouse gas emissions. • Strengthening local climate work and co-operation between national and local actors. • Collecting and disseminating knowledge and experience of climate investments to encourage climate work in other parts of the country.	Swedish Investment Support Council.	• Provide grants to local governments for cities to outsource private energy companies. • Promote energy efficient investments to reduce emissions and dependence on markets.	Local decision makers.	Swedish EPA. EUR 214.9 million/5 years.
LIP/Swedish EPA 1996/2002	• Speeding up the transition of Sweden to an ecologically sustainable society. • Helping to raise employment levels.	Swedish Investment Support Council.	• Reducing GHG emissions. • Attributing grants in areas where environmental needs of muncipalities are the greatest and where municipalities are most able to make improvements.	• Municipalities. • Local companies. • Local organisations.	Swedish EPA. EUR 576 million/6 years.

Finland also has also created a specific institutional mechanism to assist cities and regions to develop capacity, design and implement locally tailored climate policies. These are Regional Environment Centres (RECs) and permit authorities, which have an important role in the regional/sub-national collection of information on environmental issues. They are also involved in land use planning, environmental education and campaigns to reduce greenhouse gas emissions (Ministry of the Environment, 2009). Jointly with permit authorities, the 13 RECs make decisions on environmental permits for large and medium-sized enterprises. Their mission and goals are defined by the Ministry of the Environment. However, RECs also prepare regional programmes providing guidance on environmental and land use planning. These are voluntary guidelines for cities to follow and they are influencing how cities are addressing the issue of climate change. Finland also has a number of other innovative national institutions that are facilitating research, commercialisation and information to consumers on innovative technologies and practices, *e.g.* in the area of energy efficiency. Two complementary national public-private organisations are developing knowledge on climate change and sharing the information with stakeholders, industries and decision makers. Motiva Oy is a non-profit company funded and directed by the Ministry of Employment and the Economy. It provides information on the impact of energy conservation and renewable energy sources to energy users from the industry, commercial, public and household sectors (Motiva Oy, 2008). TEKES is the National Technology Agency in Finland. It is the main source of public financing for clean technology innovation and is also an expert organisation that conducts research on innovation (TEKES, 2008). TEKES partners with the business community and researchers to develop and finance industrial R&D projects as well as projects in universities and research institutes in the area of climate-friendly technology. On adaptation, in 2005, *Finland's National Adaptation to Climate Change* was submitted to the parliament as a part of Finland's National Energy and Climate Strategy. The strategy outlines knowledge on projected climate impacts, and defined measures to improve Finland's climate adaptation capacity for adapting to future climate change. Ministries are responsible for the implementation of the National Adaptation Strategy (NAS), but the NAS recognises the importance of regional and local level actors such as Regional Environment Centres and municipalities (Swart *et al.*, 2009).

Climate change may have dramatic effects on water supply in some already arid parts of the world. This is expected to be the case in **South Africa**. Although many challenges exist, there is now strong national and regional support for cities to act on and take measures to handle climate related events, such as for the city of Cape Town (Box 8.4). Drivers for these actions are mainly governments at local and national levels and non-governmental organisations or agencies (Hunt and Watkiss, 2010).

In **Japan**, environmental and energy policies are considered to be national government competencies, however national government can delegate its authority to governors and mayors to implement national laws and regional and local governments can develop their own policies and measures whenever the central government does not act in the climate change sector (Sugiyama and Takeuchi, 2008). The Kyoto Protocol Target Achievement Plan, introduced in 2005 and revised in 2008, aims to stimulate municipal and regional initiatives in the energy efficiency, transport and regional planning sectors (Government of Japan, 2008). It also encourages the use of JI and CDM to achieve low carbon objectives at local scale. Throughout Japan, local and regional governments implement and monitor their own climate action plan. Monitoring of municipal plans is often done by monitoring groups which include local stakeholders and decision makers (Sugiyama and Takeuchi, 2008). In addition, several Japanese examples exist where regional and local governments are putting climate change regulations in place. Kyoto has required a labelling system informing consumers about the environmental impact of their air conditioning appliances and televisions. The success of the Kyoto labelling policy led to a similar nationwide effort in 2008. Tokyo has introduced a mandatory cap-and-trade system in Japan as part of its climate change strategy[3] (City of Tokyo, 2008, and Box 8.5).

Other local governments develop their own actions in the promotion of energy efficiency. Osaka, Wakayama and Ube are among cities operating "fifty-fifty" programmes jointly with public schools and energy service companies. In this type of programme, public schools receive a subsidy equal to half of the money they have saved by reducing their consumption of electricity, fuel and water (Sugiyama and Takeuchi, 2008). For example, Ube City promotes a fifty-fifty programme calculated on the basis of the city's budget for these costs over the previous two years. Other local governments provide subsidies for the

Box 8.4. **Cape Town, South Africa: Linking local water planning to national infrastructure investment**

South Africa has experienced a robust growth from 2004 to 2008, however, both high unemployment and outdated infrastructure continue to constrained growth. Further, the global financial crisis has considerably slowed South Africa's economy in the second half of 2008. South Africa began to experience electricity and water shortages as state services suppliers suffered problems with ageing plants, necessitating cuts to residents and businesses in the major cities. A lot of South Africa is already suffering from unimproved water sources, only poor water quality can be accessible in some parts of the country, thus contributing to a range of health problems. As the frequency of extreme water events increase with climate change, more people are likely to suffer from water problems (Boko *et al.*, 2007).

At the urban level of climate governance, the supply of water services will be a particular challenge as is demonstrated by the case of the City of Cape Town. The Integrated Water Resource Planning Study in the City of Cape Town recognises the need to adopt an integrated water resource planning approach to address the effects of stresses on the supply of water (Mukheibir and Ziervogel, 2007). In 2004, the City of Cape Town created a better water conservation plan by introducing a long-term sustainability strategy; this complements the pre-existing water demand management strategy developed by the City of Cape Town in partnership with the national department of Water Affairs and Forestry. The plan introduces adaptation measures such as water pricing, restriction, leak reduction and pressure management (Mukheibir and Ziervogel, 2007). In 2006, the city developed a comprehensive framework to address climate change, which included alternative approaches to implement and finance mitigation and adaptation investments. Climate change adaptation and mitigation have also benefited from locally driven non-governmental organizsations formed during the apartheid (Hunt and Watkiss, 2010).

At the national level, infrastructure provisioning and service delivery is a key linkage with local water planning and provisioning; this is mostly part of the Reconstruction and Development Program (RDP) which recently laid out the Government's economic and social growth vision respect to the environment (Mukheibir and Ziervogel, 2007). Since 2004, in order to better adapt municipal and regional infrastructures to climate related events, the South African Government has emphasised investment in urban infrastructure as a key objective in the country's growth and social development when creating the National Spatial Development Perspective (NSDP). The NSDP ensures that investments made in public infrastructures meet their target in areas where it is the most needed (Swilling, 2006). The major sources of funding are the Industrial Development Corporation (IDC), the Development Bank of Southern Africa (DBSA) and state-pension funds (PIC) in South Africa.

Source: Boko, M., I. Niang, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda (2007), "Africa", *Climate Change 2007: Impacts, Adaptation and Vulnerability*, contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by M.L. Parry, O.F. Canziani, J. Palutikof, P.J. van der Linden and C.E. Hanson, Cambridge, UK, pp. 433-467; Hunt, A. and P. Watkiss (2010), "Climate Change Impacts and Adaption in Cities: A Review of the Literature", *Climatic Change: Special Issue on Cities and Climate Change*, Springer Netherlands, in press; Mukheibir, P. and G. Ziervogel (2007), "Developing a Municipal Adaptation Plan (MAP) for Climate Change: The City of Cape Town", *Environment and Urbanisation*, Vol. 19, No. 1, pp. 143-158; Swilling, M. (2006), "Sustainability and Infrastructure Planning in South Africa: A Cape Town Case Study", *Environment and Urbanization*, Vol. 18, No. 1, Sage Publications, pp. 23-50.

Box 8.5. **Tokyo, Japan: Implementation of a mandatory cap-and-trade system**

Tokyo, the world's largest city, is responsible for administering a jurisdiction of 12 million inhabitants. In 2007, the City of Tokyo took the lead in regulating municipal emissions by introducing the first mandatory cap-and-trade system in Japan as part of its climate change strategy (City of Tokyo, 2008; World Bank, 2009). Even though the national government has considered introducing a national emission trading system (ETS), it has not advanced at the national level in part because of the strong pressure from national industries (Sugiyama and Takeuchi, 2008). Starting in 2010, the Tokyo cap-and-trade system will target 1 255 private organisations from the industrial and commercial sectors. Office buildings, factories, department stores, hospitals and hotels are covered by the Tokyo ETS which is the first ETS in the world to target such companies. The ETS cap will be established according to Tokyo's own emission reduction target, a 25% reduction by 2020 from the 2000 level (Tokyo Metropolitan Government, 2007). Tokyo ETS was approved by business groups, companies, NGOs and Tokyo's Chamber of Commerce and Industry during a vast public consultation (City of Tokyo, 2008). Monitoring and reporting will be done every year. Important lessons can be learned from Tokyo's experience in climate action, particularly in the city's engagement with stakeholders and partnering with private firms and developing joint initiatives (World Bank, 2009). These include the time taken by local administration to formulate and explain proposed measures, receive feedback and gain project acceptance, and finally creation of a mechanism that obliges or encourages stakeholders to engage climate action.

Source: City of Tokyo (2008), *Introduction of Tokyo's Mandatory Cap and Trade System*, Tokyo Metropolitan Government; Sugiyama, N. and T. Takeuchi (2008), "Local Policies for Climate Change in Japan", *Journal of Environment and Development*, Vol. 17, No. 4, Sage, London, pp. 424-441; Tokyo Metropolitan Government (2006), "Environmental White Paper 2006", available at *www2.kankyo.metro.tokyo.jp/kouhou/env/eng/environment07.html*; Tokyo Metropolitain Government (2007), *Tokyo Climate Change Strategy*; World Bank (2009), *Cities and Climate Change: Sharpening the Tools of Diagnosis and Dialogue*, World Bank, Washington DC.

installation of energy efficient equipment. The City of Kyushu in the Saga prefecture promotes a programme for photovoltaic electricity and pays JPY 40 per kilowatt/hour to the producers (Japan for Sustainability, 2008).

Another type of hybrid model has also emerged where the private sector is central and increasingly active to steer action through international or national carbon markets. These markets were created in part under the Kyoto Protocol as a tool for national governments to achieve aggressive mitigation targets in the 2008-12 timeframe. In this market led example, there are top-down and bottom-up governmental as well as local private sector influences. This model may also be considered to be form of public-private partnership or "PPP" model of multi-level action on climate change. Action in **São Paulo**, **Brazil** clearly demonstrates a PPP type of institutional model where a growing number of sub-national initiatives – both at state and local levels – are being taken with the support of the national policy framework on climate change (Box 8.6).

Incorporating climate change into existing national, regional and urban development frameworks

A main challenge for national climate strategies is how they are integrated within existing regional and urban development policies frameworks that most OECD countries have had in place now for decades.[4] A brief review of practices in OECD highlights the following trends.[5]

Box 8.6. **São Paulo, Brazil: A hybrid PPP institutional model**

Brazil has a higher per capita emissions ratio than the emerging countries average, the country is currently ranked 6th in cumulative country emission (Stezer, 2009). With respect to GHG emissions, the country sees the Kyoto Protocol and its mechanisms as the most appropriate instrument for the reduction in GHG emissions (Embassy of Brazil in London, 2007). As a non-Annex I party to the UNFCCC, Brazil has no national target for emission reductions. On the other hand, Brazil is one of the countries which has been active CDM projects (Puppim de Oliveira, 2009). A growing number of initiatives are being taken at sub-national levels, such as for the city and state of São Paulo.

The State of São Paulo is the most populous state in Brazil with 98% of its population living in urban areas. The State is responsible for 25% of the country's emissions and figures among the 40th largest source of CO_2 emissions in the world. The State and the City of São Paulo both have, in principle, the authority to legislate on environmental protection and pollution control. Transnational networks of non-state actors first played an important role in the creation of a state-level climate change framework in the 1990s (Setzer, 2009). In the early 2000s, the City of São Paulo, started considering climate change policies in part as possible solutions for local air pollution; local and regional GHG emissions reduction legislation could be justified by their economic and public health benefits (Setzer, 2009; Puppim de Oliveira, 2009). In 2002, the City of São Paulo published its Agenda 21, greatly focused on climate change. In 2003, the municipality joined ICLEI's Cities for Climate Protection (CCP), a campaign promoting local climate change policy making (ICLEI, 2007). Through the CCP programme, São Paulo completed an inventory of its emissions, which showed that land transportation (48.6%) and landfills (23.5%) were the main sources of the city's GHG emissions. In 2005, the State of São Paulo and the State of California signed an agreement on technical co-operation between the two states. Recognising the need to act in climate change related sectors, the agreement also acknowledge the potential economical gains in working on emissions offset programmes through Kyoto Protocol's CDM.

The city then developed several initiatives to mitigate GHG emissions centring on the use of CDM. The Bandeirantes Landfill Gas to Energy Project (BLFGE) was implemented by the City of São Paulo jointly with local private company Biogas Ambiental, and in co-operation with German Bank KGW and private firm Van der Wiel and Arcadis (Netherlands) (UNFCCC, 2005). The project generates energy from the landfill methane emissions. From 2004 to 2010, the BLFGE project will have contributed to a reduction of 7 500 000 tonnes of GHG (UNFCCC, 2005). The project has already reduced GHG emissions by 11% in the City of São Paolo (Cunha and Rei, 2006). In 2006, São Paulo City Hall obtained BRL 34 million (USD 16 million) from the sale of carbon credits generated by the CDM project were sold, invested in social projects in the area of the landfill and also on climate change mitigation (Puppim de Oliveira, 2009).

São Paulo City Hall also acted in transport and building sectors. Specifically, the city introduced hybrid buses in the municipal transportation service with financing help from the GEF and started a programme of automobile inspection and traffic restriction during the rush hour (Puppim de Oliveira, 2009). In 2007, the City of São Paolo passed a solar energy bill, now used as model by more than 50 other Brazilian cities (Cunha and Rei, 2006). The bill mandates, among other things, buildings with more than three bathrooms (homes, apartments, service or industrial buildings) to use passive solar heating systems. Expected impacts are 3 400 tonnes CO_2 reduction and 8.7 million kWh of energy saved per year.

In 2009, São Paulo became one of the first cities in the developing world to implement a city wide plan to fight climate change, which aims at reducing GHG emissions by 30% of 2005 levels by 2012 through several measures comprehensively focused on transportation, renewable, energy efficiency, waste management, construction and land use. The bill also considers adaptation measures, as it encompasses public health, education and defence measures. Implementation will be enforced through a compulsory city wide GHG emissions inventory to track emission reductions every five years, with incentive mechanisms for the private sector. Financing mechanisms will include allocations of the Special Environment and Sustainable Development Fund finances, vesting authorities to implement incentives and fees and a system of payment for preservation of ecological services for properties owners.

Source: Embassy of Brazil in London (2007), *Climate Change Policy*, available at *www.brazil.org.uk/environment/climatechange.html*, accessed 30 April 2009; ICLEI (2007), *Local Renewables Model Communities Network in Brazil – REDE ELo*, homepage of ICLEI, available at *www.iclei.org/uploads/media/ELo_Brazil_Bali_LR2007.pdf*, accessed 27 April 2009; Puppim de Oliveira, J.A. (2009), "The Implementation of Climate Change Related Policies at the Sub-national Level: An Analysis of Three Countries", *Habitat International*, Vol. 33, No. 3, pp. 253-259; Stezer, J. (2009), *Subnational and Transnational Climate Change Governance: Evidence From the State and City of São Paulo, Brazil*, London School of Economics and Political Science, London; UNFCCC (2005), *Project Design Document Form (CDM PDD): Bandeirantes Landfill Gas to Energy Project (BLFGE)*, UNFCCC; Cunha, K.B. and F. Rei (2006), *Sub-national Climate-friendly Governance Initiatives in Developing World: A Case Study of State of São Paulo, Brazil*, Institute for Energy and Environment, São Paulo.

Table 8.3. **Frameworks and institutional models of multi-level governance on climate change**

Location and implementing institutions	Type of initiative	Incentives for local action	Programme(s)	Key actors	Monitoring and assessment	Outcomes
United States: Oregon; Portland: • City of Portland. • State of Oregon.	Locally or regionally led.	• Regional competitiveness and economic pole.	**Green Building Program** • Technical assistance. • Grants from residential and commercial waste tax. **Green Investment Fund** • Subsidy on exemplary projects. **Building Code**	***i)* Policy advocate** • Citizen advisory group. • Municipal bureaus. • City of Portland. • State of Oregon. ***ii)* Targeted audience** • Technology suppliers and certified green buildings providers. • Waste managers. • Consumers/buyers.	**Green Investment Fund** • 5% of total fund used by Portland Office of Sustainable Development to monitor programme.	**Participation of State-level institutions** • OHCS. • Creation of Oregon BEST in 2007.
China: National government.	Nationally led.	• Economic incentives. • Environmental problems.	Enabling local and regional voluntary agreements.	***i)* Policy advocate** • National government. • International community/EU. ***ii)* Targeted population** • Municipalities. • State-owned energy producers. • Businesses in building and energy sector.	Regional and National Environmental Protection Agency.	• Empowered Regional Environment Protection Bureaus. • Chinese "Environmental Model Cities". • EU – Asia Pro-Eco programme in China (voluntary approaches in environmental industrial management).
Japan: • National government (enabling). • Regional and local authorities.	Hybrid.	• National enabling legislation for local and regional governments. • Inaction in GHG reduction policy making.	**Among others** • Tokyo ETS. • Kyoto Labelling System. • Regional and municipal emission targets. • Saga feed-in tariffs.	***i)* Policy advocate** • National policy makers. • Local and regional policy makers. • Local and regional public institutions. ***ii)* Targeted audience** • Businesses. • Industries/factories. • Energy producers. • Consumers.	**Local action plans** • Yearly or periodic sectoral reviews done by monitoring group. **Tokyo ETS** • Monitoring and reporting every year. **Fifty-fifty programmes** • Municipalities and energy producers.	• National implementation of eco-labelling programme building on Kyoto local experience. • GHG emission reductions from regional and municipal actions.

Table 8.3. **Frameworks and institutional models of multi-level governance on climate change** *(cont.)*

Location and implementing institutions	Type of initiative	Incentives for local action	Programme(s)	Key actors	Monitoring and assessment	Outcomes
Finland: ● National government (enabling). ● Regional and local authorities.	Hybrid.	● European commitment to the Kyoto Protocol.	**Information development and exchange** ● MotivaOy. ● Tekes. **Sub-national actions** ● AFLRA. ● ICLEI CCP.	***i)* Policy advocate** ● Stakeholders. ● Public administration. ***ii)* Targeted audience** ● Researchers. ● Businesses. ● Communities. ● Consumers.	**Ministry of Employment and Economy** ● TEKES. ● MOTIVA OY. **Municipalities** ● AFLRA.	● Regional and municipal action coherent with national objectives. ● Regional and municipal GHG emissions reports. ● Regional and municipal climate change action plans.
Sweden: Swedish Investment Support Council.	Hybrid.	● Speeding up the transition of Sweden to an ecologically sustainable society. ● Helping to raise employment levels.	**National investment programme** ● LIP (1996-2002). ● KLIMP (2003-08).	***i)* Policy advocate** ● National government. ***ii)* Targeted population** ● Municipalities. ● Energy producers.	**Swedish EPA** ● The Agency re-evaluates the grants according to reported mitigation performances.	● 3% reduction in GHG annual national emissions.
Brazil: São Paulo: City of São Paulo, State of São Paulo, international and national private sector.	Hybrid/PPP.	● Local air pollution (transport emission reduction). ● National/regional economic benefits from international agreements.	● Landfill emission reduction projects. ● Transport emission reduction. ● Development of a new-model vehicle emission standards (PROCONVE). ● Solar Energy Law (2007). ● São Paulo State Climate Change bill (2009). ● São Paulo City Climate Change Policy 14.933 (2009).	***i)* Policy advocate** ● Local and state authorities (Municipal committee for climate change and eco-economy, State Forum for Climate Change and Biodiversity). ● International CDM project partners (public/private). ● ICLEI. ***ii)* Targeted population** ● Energy consumers. ● Car and property owners.	**Local emission inventory** ● City of São Paulo. **GHG reduction under CDM projects** ● PPP monitoring.	● Economic benefits from CDM reinvested in social and climate policies. ● GHG emission reduction. ● State participation in climate policy making.

Within the OECD, application by national governments of regional policy using a "green" lens, or the pursuit by central governments of climate change strategies using a regional development policy filter, is uneven. Japan and Korea currently appear to have developed the most comprehensive of approaches to green regional (urban) development strategies of the OECD countries (Box 8.7). More generally:

- Only a minority of OECD countries is applying a climate change lens to the implementation of regional/territorial/spatial economic development policy frameworks. What appears to be the norm are the parallel application of regional development policies on the one side, and the pursuit of targeted sectoral strategies directly or incidentally addressing climate change. In most cases these are decoupled from each other.
- Sectoral strategies may be applied without regard for regional or local strengths and assets. A regional development policy lens may not be used at all when designing sectoral strategies to address climate change.
- Cross-sectoral, holistic regional approaches to address climate change by central governments appear to exist in only a few instances, *e.g.* in Japan, Korea and Sweden. In most countries, a significant coherence/co-ordination challenge exists in the

Box 8.7. **Regional policy and climate change: Examples from a selection of OECD countries**

In **Japan**, the central government is currently pursuing a "Compact City" urban greening policy because of the positive externalities on the environment. Reduced greenhouse gas emissions is a positive outcome of Japan's strategies to affect a modal shift away from private motor transport in its urban agglomerations, whose main aim is to reduce congestion and costs to business activity and productivity. Under the Compact City policy framework, the central government is focusing on generating a more compact urban structure with its 2006 revisions to its *City Planning Act*. These revisions introduce measures to control sprawl through more stringent land-use planning and development regulations. A related initiative, the Comprehensive Urban Transport Strategy, aims to ensure that citizens in urban areas can live with less dependence on the automobile, by targeting investments at light rail/light rapid transit and by zoning to combine functional activities related to commerce, housing and industry around light rail stations. Under this strategy, city administrations are encouraged to modify their own transportation initiatives to favour public transport over road construction, with assistance from the central government. At the same time, as a means to promote a "race to the top", the Japanese government has introduced the recognition of an "Environment-Friendly Model City" as a means to share best practices relating to the promotion of compact urban form and lower GHG emissions among urban centres across Japan. The first urban centre to receive the designation was Kitakyushu-city in 2006.

What **Korea** calls its "Korean-Style New Deal" to address the current economic crisis aims to contribute simultaneously to creating new jobs and respond to climate change. The project aims to support the construction sector in supplying energy-saving, eco-friendly "green" homes and building transfer nodes for low-carbon, mass-transit infrastructure such as high-speed rail. The government of Korea has explicitly underscored in its "New Deal" that it seeks to counter the conventional view that economic growth conflicts with environmental protection. On the contrary, a principle at the core of its approach is the synergy between economic growth, job creation and environmental protection and enhancement.

Australia has identified climate change adaptation and mitigation as its top emerging issue for regional policy design and implementation. Indeed, as part of its regional policy framework Australia has recently introduced a Climate Change Action Fund to assist regions and communities in adjusting to a low-pollution future as well as a Carbon Pollution Reduction Scheme for Australian households.

Box 8.7. **Regional policy and climate change: Examples from a selection of OECD countries** *(cont.)*

In **France**, the current round of regional development plans (CPER, *contrats de plan État-Régions*) for 2007-13 now contains a carbon-neutrality objectives: any infrastructure project financed under a CPER that leads to the generation of emissions (a highway, for example) must be offset by other projects that will reduce emissions (like public transit, for instance). The French government's national climate change framework is also being planned using an urban lens: the *Grenelle de l'Environnement* provides for the extension of the existing climate-energy plans, the strengthening of environmental assessment components in urban planning, and the inclusion of anti-urban-sprawl objectives, measures to limit greenfield development and the development of eco-friendly districts/neighbourhoods in urban planning approaches. In light of pending legislation in the Grenelle II process, the voluntary nature to date in France of local-scale greenhouse gas inventories will be modified. Article 26 of the Grenelle II text lays the groundwork for mandatory GHG inventory reporting for urban areas greater than 50 000 people, public entities larger than 250 employees and private entities with more than 500 employees. The required inventories for urban areas are to be used in the development of a *Plan Climat* (Climate Action Plan) and are equally required for cities larger than 50 000 people.

Austria has identified climate-change adaptation and mitigation as a top emerging challenge in implementing its regional policy framework. In the **United Kingdom**, within the framework of Regional Development Agencies, a new performance framework for local authorities incorporating climate objectives, as well as new local transport legislation, which gives more authority to municipalities in transportation policy.

The **Czech Republic** has identified as a top-emerging issue for its regional policies the improvement of the economic and environmental potential of its regions, the revitalisation of its decaying districts and the sustainable development of its rural areas, while **Germany** will focus part of its regional policy approach to implementing the EU cohesion policy on reconciling climate-change objectives with its goals for regional economic growth. **Greece** also identifies climate change as a key emerging issue in its regional development policy framework.

The **European Union** itself, under the French presidency in 2008, expressed the need to incorporate a territorial-based approach to climate change, to mainstream climate-change issues in spatial development policies at all levels of government in the Union and to integrate risk-management considerations into spatial development policy, including risks to the environment.

In **North America**, the three central governments of Canada, Mexico, and the United States have to varying degrees adopted elaborate climate-change strategies. Each also has in place long-standing regional development policy frameworks. That said the links between the two are tenuous; at best, they are sectoral and uneven.

In **Canada**, infrastructure investment policies focus to a significant degree on green infrastructure initiatives from public transit to water, wastewater and solid waste and community-based renewable energy systems. Infrastructure investments reflect regional circumstances, especially in programming that requires the support (and investment) of the provincial government for a project in a given region to receive federal funding. Federal infrastructure programming is implemented outside the regional development policy framework, even if it is often delivered regionally through the federal Regional Development Agencies. Federal sectoral support in areas that affect climate change, such as support for eco-friendly housing projects or for new technologies for energy generation, for example, are also applied a-spatially across Canada, outside the country's regional economic development policy framework.

In **Mexico**, the federal government explicitly recognises the link between urban competitiveness and urban attractiveness and liveability, including environmentally friendly urban development. Indeed, the government goes further, basing policy directions on the premise that in the future, urban competitiveness will constitute the outcome of the adoption of climate-change policies and strategies. Through its Ministry of Social Development, the government is pursuing its urban development policy framework using a climate-change lens, with a focus on public transport corridors and urban mobility, maximising urban public green space and more effective waste disposal technologies to reduce GHG emissions.

implementation of the various climate-change and regional development spatial plans: little if any co-ordination exists between the various scales of regional and local planning instruments.[6]

- The most effective cross-sectoral strategies appear to be those where climate change mitigation and adaptation is seen to be a potential source of regional economic development/growth. By contrast, strategies based on adding a "green" component in a more isolated manner to sectoral regional development policy drivers (for example, infrastructure development), seem less likely to successfully sustain regional economic development and tackle climate change over the longer term. This assumes that national governments accept that economic development and environmental sustainability are not an either/or proposition but rather are synergistic.

As climate change becomes an increasingly important policy driver for central governments, and especially in the context of the 2008-09 economic crisis, a robust quantitative, outcomes-driven evidence base is required to inform sound public policy development and implementation aimed at sustainable regional economic development. Currently, large information gaps remain across the OECD membership related to inter-jurisdictional comparability, common indicators and metrics to measure success and perhaps most importantly time-series data to measure the impact of cross-sectoral climate-change strategies on regional economic development and *vice versa*. Strengthening empirical evidence will advance understanding about what climate change regional and urban development practices are performing well and why and support the sharing of lessons learnt between member countries.

The OECD (2009) *Policy Guidance on Integrating Climate Change Adaptation into Development Co-operation* suggests an integrated approach to adaptation. This guidance describes core decision making and policy processes as well as key actors at each level of governance. It also describes the governance architecture and steps within the policy cycle relevant to each level. It identifies particular *entry points* along the cycle where consideration of adaptation could be incorporated. These entry points provide opportunities for the identification, integration and implementation of measures and investments specifically designed to enable and support adaptation but which had not been envisaged in the initial plan, programme or project (OECD, 2009c).

Addressing national barriers to local action

Beyond specific programmes that have been developed to promote climate change action at the local level, municipal governments can be restricted by existing policies. Pre-existing policies, many of which have been in place for decades, were developed before climate change emerged as a significant issue. Across a number of countries, local level officials have indicated that national policies can reduce their capacity to act in a number of areas. For example, in Norway, local municipalities have reported that large-scale flood defence schemes have undermined their ability to develop more robust, locally calibrated systems. In the United Kingdom, local authorities note that short-term budget cycles pose significant difficulties in the development of long-term initiatives. Further, at the EU level, relatively "static" biodiversity protection requirements have made it difficult for some areas to implement managed retreat adaptation as a preferred management policy (Urwin and Jordan, 2008).

In a top-down and bottom-up analysis of policies in the agriculture, water and nature conservation sectors in the United Kingdom, Urwin and Jordan (2008)[7] revealed a number of synergistic as well as antagonistic interplays between national polices which often served to constrain local action on climate change. Table 8.4 presents those policies identified by local-level officials as being antagonistic to the implementation of adaptation policies.

Table 8.4. **Examples of antagonistic interplays among adaptive sectoral policies with respect to adaptive responses: A bottom-up perspective**

Sector	Adaptive response	Dissonant policy	Reason for antagonism
Water resources	Ensure future water security.	ODPM's "Sustainable Communities" initiative.	Development in water scarce areas will exacerbate problems of water supply.
		Planning Regulations 1999 No. 3280 (UK).	Water companies not a statutory consultee regarding proposed new developments.
		2003 Water Act (UK).	Time-limited licences increase uncertainty in future planning for water companies.
	Demand-side management.	1999 Water Industry Act (UK).	Lack of compulsory metering.
		2000 Building Regulations (UK).	Water efficiency measures not statutory requirements for new developments.

Source: Urwin, K. and A. Jordan (2008), "Does Public Policy Support or Undermine Climate Change Adaptation? Exploring Policy Interplay across Different Scales of Governance", *Global Environmental Change*, Vol. 18, No. 1, Elsevier, London, pp. 180-191.

The policies highlighted typically apply to specific sectors, however it can be expected that policies from other areas, which traditionally have not integrated environmental nor climate considerations, could provide the wrong incentives for investment, leading to mal-adaptation or mal-mitigation. It may be an impossible task for central policy makers to alter and re-evaluate every counterproductive policy that could create antagonistic interplay, especially given that there is a variety of competing policy priorities. However there may be some key actions that can assist with comprehensive alignment across policies. For example, in the case of new policy in the United Kingdom, one suggestion from Urwin and Jordan is to incorporate climate change issues directly into mandatory regulatory impact assessment (2008). In any case, working directly with municipal authorities in this process will be important as they may be in the best position to experience first-hand the obstacles, as well as the benefits, that interplay can create (Urwin and Jordan, 2008).

Specifically on the issue of adaptation, the OECD has advanced the notion of applying a *climate lens* in development planning. A climate lens is an analytical tool to examine a strategy, policy, plan, programme or regulation. The application of such a climate lens at the national or sectoral level involves examining: *i)* the extent to which a measure – be it a strategy, policy, plan or programme – under consideration could be vulnerable to risks arising from climate variability and change; *ii)* the extent to which climate change risks have been taken into consideration in the course of the formulation of this measure; *iii)* the extent to which it could increase vulnerability, leading to mal-adaptation or, conversely, miss important opportunities arising from climate change; and *iv)* for pre-existing strategies, policies, plans and programmes which are being revised, what amendments might be warranted in order to address climate risks and opportunities (OECD, 2009a). Thus while this is largely a forward looking set of recommendations, there is also value to screening pre-existent policy and plans for consistency with climate change objectives.

Summary points

This chapter addresses particularly the question of how to design national policy frameworks to support local level innovation and action to mitigate and adapt to climate change. It underscores a variety of institutional and economic factors that shape decision making on climate change across levels of government. These include not just the costs and benefits of action or the co-costs and benefits but also what the roles and responsibilities, formal functions and legal authority at different levels of government; it also includes who the main actors are, and what financing and other tools are available to support decision making.

The examples explored here highlight a variety of institutional models that national-local linkages on climate change may take. National enabling policy may mandate or strongly recommend a specific set of policy actions at local scale, as in the case of the required development of local climate plans in Norway or in China. We refer to this model as a top-down or nationally-led policy framework. A second model is bottom-up or locally led, where independent local action generates innovative ideas or policies that are tested and refined locally and, if successful, later used as a template for broader action at regional or national scale. This is shown to exist, for example, in the United States, where there is currently a weak national policy framework for climate change. A third model is referred to as "hybrid", where national (or regional) governments work closely with local governments to stimulate two-way learning. This is the case of the Swedish KLIMP funding programme; they can provide a voluntary framework to incentivise action by offering funding or support for activities. In the Swedish case, local communities compete with each other for central funding of mitigation or adaptation options where key disbursement criteria are based on expected performance and local implementation/evaluation plans. The example of Japan illustrates an even more decentralised approach where enabling legislation explicitly recognises and calls on local government to act. In this context, there is room for innovation at the local level; some practices, such as the use of energy labelling, were initiated and tested locally before being diffused more broadly. Yet without a strong national policy framework to ensure broad incentives and implementation of key actions, these examples may remain isolated. Another is example of a hybrid model is found in São Paulo where local and national governments work closely with private sector actors to facilitate action at local scale, for example through the use of offset mechanisms in the international carbon market (*i.e.* JI or CDM).This chapter has also reviewed how regional economic development policy at national level is being advanced with use of a "green" lens, or alternatively the pursuit of national climate-change strategies using a regional development policy filter. A "paradigm shift" is required to move away from perceiving growth and sustainability as an either/or proposition to defining the two policy objectives as linked and mutually reinforcing. This paradigm shift is already happening in many centres of responsibility across national governments. At issue, however, is whether national governments accept this premise generally and most importantly whether within national governments each responsibility centre with authority over issues related to climate change and regional economic development fully understand and act upon the need for change. What follows from this is the challenge of intra-governmental co-ordination and coherence in developing and implementing cross-sectoral approaches aimed at pursuing regional development objectives using a climate-change or more broadly a sustainability lens. Recent work at the OECD has also called for the use of a "climate lens" in development planning and this approach could usefully be applied to urban and regional development planning more generally.

Finally this chapter addressed the question of incentives for action across levels of government, demonstrating how a large number of pre-existing policies may incite mal-adaptation or mal-mitigation, working counter to any progress made in more targeted climate policies. To ensure progress in the aggregate, across the entire socio-economic system in any one nation, this calls for more systematic, integrated or comprehensive efforts to align incentives across sectoral and cross-sectoral policy areas to reflect climate change objectives and deliver policy coherence.

Overall the examples in Chapters 7 and 8 suggest that some principles for good practice are more easily advanced at lower rather than higher levels of governance, or at least require the engagement of local authorities to ensure delivery and effectiveness (Table 8.5). For example, the engagement of local governments may democratise and increase citizen engagement in climate change activities. City authorities are in a unique position to engage local stakeholders and design locally tailored responses to climate change. They may also be better situated than national governments to confront many of the difficult challenges related to adaptation, including managing flood risk, water stress, or the "climate proofing" of urban infrastructure. With respect to mitigation, local authorities may be better placed than national governments to reduce GHG emissions from some key sources such as waste and transport, and deliver a range of co-benefits to local citizens. However they can be supported by specific central government policies that encourage them to experiment with innovative solutions that could, if they provide good results, be implemented in other places. Urban and territorial development policies may also offer particular opportunities to address climate change. Strengthening multi-level governance approaches is therefore key to delivering both low-carbon and climate-resilient development in the future.

Table 8.5. **National *versus* local strengths putting principles of good governance into practice**

Principles of good governance	Local/regional or smaller scale	National or higher level
Ensure participatory governance and strategic planning	✓✓	✓
Provide an analytical foundation for short and long-term planning	✓	✓✓
Deliver cost-effectiveness and economic efficiency	✓	✓✓
Encourage experimentation and innovation	✓✓	✓
Address distributional consequences and procedural equity	✓✓	✓
Establish a long-term planning horizon	✓	✓✓
Deliver policy coherence	✓	✓
Conduct monitoring, reporting and evaluation	✓	✓

Notes

1. Section contributed through written comments from the government of Portugal, delegation of OECD, in June 2009.
2. It is important to note that KLIMP programme builds on a predecessor programme LIP, which targeted sustainable development from 1998 to 2003. This earlier programme is also estimated to have achieved significant CO_2 reductions, estimated to be 1.5 million tonnes CO_2 per year in this period.
3. The Tokyo Climate Change Strategy aims at reducing Tokyo's GHG emission from the 2000 level by 25% by 2020. See *www.kankyo.metro.tokyo.jp/kouhou/english/pdf/TOKYO%20Climate%20Change%20Strategy%202007.6.1.pdf*.
4. See *www.oecd.org/gov/regionaldevelopment*.

5. These are the findings from the answers to the questionnaire and the discussion that followed at the OECD Ministerial Meeting on Regional Development, 30 March 2009. These were compiled by Adam Ostry, Chair of the OECD Working Party on Urban Areas.
6. These include the regional (CEPR) and the local development plans (PLU – *Plans Locaux d'Urbanisme*), the Territorial Energy and Climate Plans (PECT – *Plans Énergie-Climat Territoriaux*), the Territorial Coherence Plans (SCOT – *Schémas de Cohérence Territorial*), the Urban Transport Plans (PDU – *Plans de Déplacement Urbains*) and the Urban Planning and Sustainability Plans (PADD – *Projets d'Aménagement et de Développement Durable*).
7. This is a study reviewing the United Kingdom Climate Integration Programme (CIP).

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PART III

Chapter 9

Financial Instruments and Funding New Expenditure Needs

Measures to reduce greenhouse gas emissions and adapt to expected climate change impacts will put additional pressure on city budgets and increase the need for additional public resources. Chapter 9 discusses opportunities to reform existing sub-national and national revenue sources as well as new forms of financing for urban climate change initiatives. A number of existing fiscal instruments and incentives are already at cities' disposal, including taxes, fees and grants, and these could be considered as instruments for achieving climate change and urban sustainability goals. Carbon markets and access to financial capital may emerge as promising new funding sources, particularly if national and international policy makers decide to adapt them to better accommodate the multi-sectoral nature of many urban mitigation projects.

Key points

Climate change puts additional pressure on city budgets

- Local governments in OECD countries are already responsible for 70% of public investment and 50% of public spending in environment, as they are responsible for a range of sectors that impact environmental sustainability and greenhouse gas emissions, sometimes as the sole authority, but more often in partnership with other levels of government. Cities will need additional revenue sources to finance low GHG emission development, notably new mass transit solutions, energy-efficient building retrofits and climate-resilient protection for the built environment.

Local fiscal instruments and incentives at the disposal of cities could be "greened" to achieve urban sustainability goals, including climate change targets

- Local revenue sources are not neutral: their provenance, rates, exemptions and composition all impact the price citizens and firms pay for certain goods and services, such as urban transportation options, land development and housing. There is room for greening sub-national taxes, especially those that have an impact on the city's built environment, transport and energy, such as property taxes and transportation taxes. Currently, some sub-national taxes in certain countries promote urban sprawl, especially where city revenue depends in large part on land sales. Cities and metropolitan areas could make more use of fees and charges as instruments to influence behaviour and thus mitigate climate change. As congestion charges, development charges, value-capture taxes, and other revenue sources confront users with the real costs of their choices, these instruments could reduce the inefficient use of resources and limit sprawl.

Urban areas should leverage existing financial instruments and explore complementary new instruments

- The budget pressures caused by climate change might require cities to exploit new financial instruments, *e.g.* increased access to capital markets or potentially new carbon finance mechanisms. Increased access to carbon markets could aid cities in seeking additional and complementary financing. However the CDM mechanism may need to be re-tooled to facilitate urban access to it, particularly for multi-sectoral urban mitigation projects.
- National governments could play a key role in greening urban finance, by re-designing sub-national taxes and grants to sub-national governments, especially those that have an impact on the city's built environment, transport and energy. Intergovernmental grants could take environmental indicators into account to compensate local governments for the external benefits of their environmental expenditures.
- A comprehensive greening of urban finance would also increase the coherence between urban finance and urban planning frameworks to enhance urban sustainability and contain outward urban growth. Carbon taxes and climate change levies, although occasionally introduced at the local level (*e.g.* Boulder), may be more suitable instruments for the national or supra-national level rather than the city or regional level, as they could distort competition between regions.

Climate change creates new challenges for urban finance: it necessitates a greening of existing financial instruments, and put additional pressure on city budgets, which creates the need for additional resources. Existing financial instruments that could be made more sustainable are taxes, fees and grants; they could be "greened" by providing more incentives for compact development and reduction of activities leading to GHG emissions. Additional pressure on city budgets could result from adaptation and mitigation policies, as well as rises in the price of fossil-fuel energy sources. Carbon finance mechanisms and increased access to capital markets are potential additional sources of financing for cities.

Financial instruments and incentives

Fiscal instruments and incentives already at cities' disposal could be considered complementary instruments for achieving urban sustainability goals, including climate change targets. Local revenue sources are not neutral: revenue sources, rates, exemptions and composition all impact the price of certain goods and services for citizens and firms, such as urban transportation options, land development and housing. As citizens and firms are in most cases price elastic (at least to a certain extent), these price-related mechanism will be able to influence the behaviour of citizens and firms. A key challenge for sustainable urban finance is thus to combine revenue-raising capacity with the introduction of fiscal incentives that stimulate sustainable development. In addition to the access to revenue sources needed to implement adaptation and mitigation measures, an important part of the behavioural changes needed for sustainable urban development could be stimulated by incentives mechanisms that internalise externalities and put a price on behaviours that contribute to GHG emissions and unsustainable resource use. The financial instruments that form part of cities' climate change plans express this search for revenue sources that stimulate sustainable development (Table 9.1). These incentive mechanisms could be introduced in the three main city's revenue sources: taxes, fees and grants.

There is a huge variety of urban finance practices available from which cities could learn. The composition of revenues varies across OECD cities: for example, in a selection of 18 OECD cities, revenues from grants from national or regional governments range from 5% to almost 70%, and a similar range applies to tax revenues (Figure 9.1). The introduction of incentives for sustainable urban development could be considered for these traditional city revenue sources: grants, taxes and fees. At the same time, this variety means that there are few universal recipes that could apply to all metropolitan regions. Particular fiscal instruments and incentive mechanisms will be more or less effective in cities according to their specific revenue composition and local conditions.

Taxes

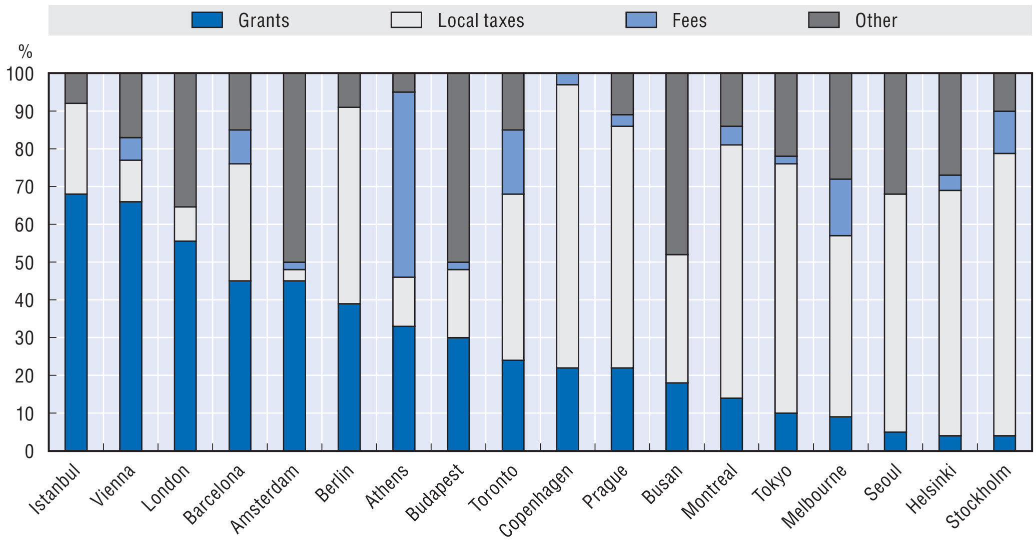
Urban taxation is a potentially powerful tool for stimulating sustainability for two reasons. First, tax revenues provide more than half of the revenues for many OECD cities and could thus be considered the most important revenue source for cities. Second, the urban tax most often used in OECD countries is the property tax, which has a direct relation with land use and the built environment, which is responsible for a large part of cities' GHG emissions (Figure 9.2). Income tax, another large local tax resource – although less frequently used – is less directly related to the environment.

Table 9.1. **Financial instruments in selected city's climate change plans**

City	Financial/fiscal instruments
Paris	• Innovative financial partnerships needed between national, regional and local governments in renovation of buildings. Involve banks for attractive interest rates and adjust loan repayment charges to the cost effectiveness of the energy-saving work. • Voluntary fund to finance sustainable development projects in tourism. • Total cost-based accounting method. • Tax credit in property tax for energy-saving renovations (from 2008). • Energy-saving certificates or projects set up by the *Caisse des Dépôts et Consignations* buying emission reductions and selling on international carbon market. Carbon credits; finance social housing. • Discount rates in parking tariffs for small and electric vehicles. • Shifting burden to eco-taxes: transferring TIPP (Interior Tax on Petroleum Products) to STIFF (regional transportation public authority), raising Versement Transport (tax collected from companies to fund public transport), transferring FARIF (*ad hoc* fund devoted to public land banking) to local authorities. • Tariff-based incentives for waste recycling. • Fines for energy suppliers that do not save energy, giving them an incentive to partner with local authorities by financing part of investments. • Performance information (*Bleu budgetaire*).
Mexico City	• Additional resources from sale of GHG emission reduction credits.
London	• Introduce carbon pricing; host carbon-trading markets. • Carbon pricing for transport: charge cars to enter in the central business area on the basis of their carbon emission levels. • Become world leader in financial development on climate change: carbon emission trading, green funds, pricing climate change risks, financing climate change research. • Lobby the national government to change vehicle charges in different Vehicle Excise Duty bands. • Support borough-based carbon pricing initiatives: permit-parking charges on the basis of CO_2-emissions.
Tokyo	• Climate Change Fund. • Examine the introduction of Energy Efficiency Promotion Tax System.
Philadelphia	• Systems benefit charge for demand side management programmes by local utilities. • Update pricing of parking.
Austin	• Development of carbon offset credits.
Toronto	• Investigate road pricing in the Greater Toronto Area. • Financial incentives to use public transit.
Portland	• Public utility charges funding energy conservation programmes. • Support extension of the State Business Energy Tax Credit.
Los Angeles	• Increase of LA Department of Water and Power rebates for energy efficient investment by customers.
San Francisco	• Expand transportation impact fee assessment to all the downtown commercial space. • Increase Gas Tax. • Investigate congestion pricing and cordon tolls. • Consider charging market rates for parking permits; differentiate parking rates based on vehicle size. • Collecting parking lot taxes from hotels. • Differentiate vehicle registration fees based on vehicle size or emissions. • Promote bridge toll waivers for alternative fuel vehicles. • Commuter tax benefit programmes for city and county employees. • Reduce city permit fees for solar energy. • Provide differentiated rates for waste recycling.
Seattle	• Road pricing. • Parking tax: implementation and increase. • Consider open-space impact fee.
Stockholm	• Congestion charge.

Note: The elements in the table have the common characteristic of being mentioned in the city's climate change plan, but express a large heterogeneity, as they refer to measures already implemented as well as projected plans and principles.

Figure 9.1. **Main revenue sources of selected cities within the OECD**



Note: Demarcation of the cities refers to municipal boundaries (except for Melbourne, which refers to the city centre). Financial year: Tokyo, Seoul, Budapest (2003), Istanbul, Toronto, Prague, Barcelona, Copenhagen (2004), Athens, Berlin, Helsinki, Melbourne, Stockholm (2005), Amsterdam, Vienna (2006).

Source: OECD (2006), *Competitive Cities in a Global Economy*, OECD, Paris.

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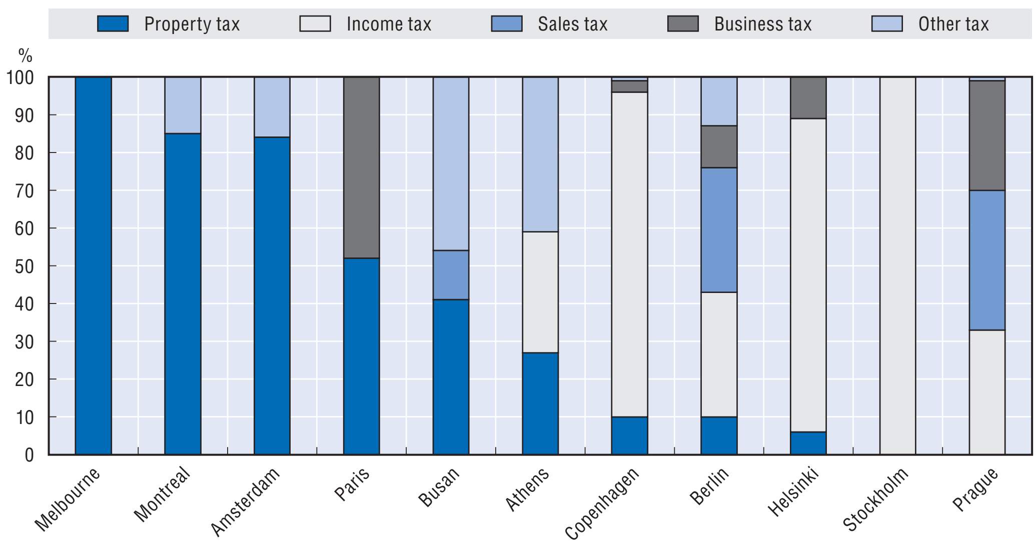
Figure 9.2. **Main taxes of selected cities within the OECD**



Source: OECD (2006), *Competitive Cities in a Global Economy*, OECD, Paris.

StatLink http://dx.doi.org/10.1787/888932342544

Over the last decades, several OECD countries have "greened" their taxation system, but this has taken place mostly at the national level rather than sub-nationally. In order to improve environmental conditions, many OECD countries have introduced environmental taxes, such as carbon taxes (*e.g.* Sweden since 1991), climate change levies (*e.g.* United Kingdom since 2001) and other similar fiscal instruments aimed at stimulating environmental sustainability. Some countries, such as the Netherlands, have made greening of their tax system an explicit policy goal, and introduced comprehensive reform of the tax system.

Attention by policy makers and researchers has been mostly focused on greening taxation at the national rather than the sub-national level. There is however room for greening sub-national taxes, especially those that have an impact on the city's built environment, transport and energy, such as property taxes and transportation taxes, as will be discussed below.

Carbon taxes, and climate change levies, are almost always introduced at the national level, as they would distort competition between regions. One of the exceptions is the carbon tax introduced in the City of Boulder (Colorado, United States) which is low enough not to have a negative impact on the city's attractiveness for citizens and companies, but arguably not high enough to have a substantial impact on reducing carbon emissions (Box 9.1). In order for the carbon tax to have a real impact on reduction of carbon emissions, it would in many countries have to increase the price of carbon significantly, especially since price elasticity is relatively low in the short term. To avoid distortions to competitiveness, supra-national co-ordination might be necessary.

Box 9.1. **Carbon tax in the City of Boulder, United States**

In order to finance its Climate Change Action plan, the City of Boulder introduced a local carbon tax in 2006, thereby becoming the first local government in the United States to introduce such a tax. The tax base for the tax is residential and commercial electricity consumption, and the tax generates up to USD 1.6 million annually through 2012 – when the tax is set to expire. The tax was approved by referendum in 2006. The budget estimates were broken down by sector expenditures, such that the residential sector contributes 58%, the commercial sector contributes 39% and the industrial sector contributes 3%. The City Council set the first year tax at a maximum rate of USD 0.0022 per kWh for residential customers; USD 0.0004 per kWh for commercial customers; USD 0.0002 per kWh for industrial customers. The average household will pay USD 1.33 per month and an average business will pay USD 3.80 per month. In subsequent years, the City Council has the authority to increase the rates as needed to fund the Plan, as it may be amended, to a maximum rate of USD 0.0049 per kWh for residential customers; USD 0.0009 per kWh for commercial customers; and USD 0.0003 per kWh for industrial customers.

Source: Koehn in OECD (2009), *Green Cities: New Approaches to Confronting Climate Change, OECD Workshop Proceedings*, conference held 11 June 2009, Las Palmas de Gran Canaria, Spain.

Taxes impacting land use and the built environment

The property tax, the primary source of local tax revenue in many OECD cities, is sometimes skewed in favour of single family houses, discouraging compact city development. Multi-family rental housing in the United States, for example, bears an effective tax rate (tax divided by property value) that is considerably higher than the rate for single-family owner-occupied housing: at least 18% in 2001 (Goodman, 2006). The higher tax rate for apartments observed in the national totals holds for 10 of the 12 states that are identified in the Residential Finance Survey data. One of the explanations is the explicit policy of sub-national jurisdictions to tax apartments more heavily than single family houses: apartments are often classified as commercial real estate rather than as housing and many local governments tax commercial property at a higher rate than residential real estate. In other instances, such as in Illinois since 2004, jurisdictions have capped taxes or tax increases for single-family houses without setting corresponding caps for apartments. Another explanation is that some jurisdictions value owner-occupied houses by sales prices and apartments by rental revenue or net operating income (IAAO, 2000). Implemented like this, the residential property tax promotes low-density development and disproportionally burdens lower-value properties. A similar bias in the property tax system towards single family homes exists in other OECD cities (*e.g.* Toronto), but the inverse also occurs. For example, housing co-operatives, offering housing options in multi-apartment buildings representing around one-eighth of the dwellings in Greater Copenhagen, are not subject to the municipal property tax, in contrast to other less compact dwelling types, such as single family houses (Skatteministeriet, 2008; Andersen, 2007). Other provisions related to the property tax can also have an impact when they provide more incentives for dwelling types that are denser, such as rental housing or social housing: *e.g.* the property tax rate for owner-occupied housing in Sweden is twice as high as for rented properties (Birgersson and Turner, 2006).

In addition, as most property tax systems tax land and structures on the land at the same rate, they provide limited incentives to develop undeveloped land within cities. Distortions created by the property tax may result in the inefficient spatial expansion of cities, which makes the tax one possible cause of urban sprawl (Brueckner and Kim, 2003). Sprawl is stimulated when it is more beneficial for developers or other actors to develop on undeveloped land outside of cities rather than within cities. Placing proportionally higher taxes on land than on built structures would make it more costly to hold on to vacant or under-utilised, centrally located sites. Reducing the tax burdens on development and redevelopment of urban land could facilitate revitalisation and the replacement of obsolete buildings in older central cities. More compact development can be stimulated by introducing a form of land taxation such as a split-rate property tax. The key characteristics of such a tax, applied in Sydney; Hong Kong, China; the US cities of Pittsburgh and Harrisburg and other cities within OECD countries such as Denmark and Finland, is that land value is taxed more heavily than the buildings on the land, thereby providing an incentive to develop it. This is in contrast to the conventional equal-rate system that applies the same tax rate to land and to build structures on it.

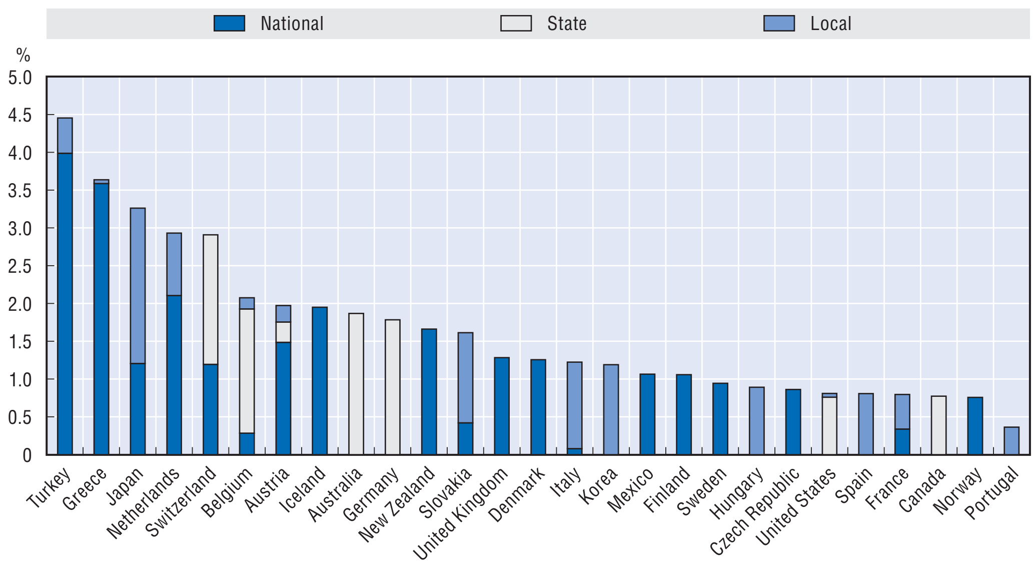
Some cities have introduced property tax reform to favour compact development. Through differential taxation, a special area tax could be applied on suburban properties or use a set of cascading taxes that gradually increase as one moves away from the city centre towards the periphery. A relatively simple form of such a tax might be a higher standard property rate for suburban inhabitants or preferential rates for multiple dwellings. Although the introduction of such a tax could be politically difficult to implement, there are cities that have introduced a tax along these lines. The City of Austin, United States, has for example introduced a special transportation levy on all city utility bills, based on the estimated average number of daily trips made by individuals residing in different types of property. The levy averages USD 30-40 per year for a typical household, but differentiation takes place according to housing type (Litman, 2009). Depending on local circumstances, such a tax could have social consequences if lower-income groups have difficulties finding affordable housing in city centres and are dependent on car use, which might already be taxed in other ways.

Taxes impacting transportation

Cities in the OECD have overall limited fiscal incentives in place for reducing car use. Car users are in many cases not charged for their use of the road network, non-residential parking is free in many cities, and personal income tax regulation often favours automobile use over transit, as the costs of owning, operating and parking a car are in many cases deductible for firms and individuals, whereas transit benefits for employees are not. Companies in OECD countries often provide subsidies (frequently stimulated by fiscal arrangements) to their employees for their individual motorised transport and free company parking, rather than for public transportation. In many non-OECD countries, such as India, Indonesia and Egypt, fuel subsidies provide further disincentives for the reduction of car use. They are usually provided by central governments, but mostly benefit the urban population in these countries. Some cities and regions have introduced motor vehicle or fuel taxes, although this remains a predominantly national tax in most OECD countries (Figures 9.3 and 9.4). In Canada, for example, excise taxes on gasoline and diesel are collected by both federal and provincial governments, as well as by some select metropolitan regions (Montreal and Vancouver), with combined excise taxes up to CAD 0.305/litre in Vancouver. Similar effects on fuel consumption could be attained by a pay-as-you drive insurance, although such schemes have not been introduced yet (Parry, 2005).

In some metropolitan regions, transportation-related taxes are used to fund metropolitan transit. A local tax that is frequently used to finance public transportation is the value capture tax. The base for a value capture tax is an increase in property values arising from public infrastructure development. This increased value results from the increased desirability of the location, better access, and the potential for higher rents, increased resale value and higher-density development. Value capture taxes can be imposed or can take the form of a negotiated agreement; they may be levied as an ongoing annual charge or as a one-time tax. Value capture taxes have been used to finance transport infrastructure in cities as different as Hong Kong, China; Miami; Milan and Bogotá. A value capture tax can only be applied when the property value increase can be unambiguously attributed to infrastructure investment. Value capture taxes are less useful when property taxes are assessed on a yearly or regular basis,

Figure 9.3. **National, state and local motor vehicle taxes in unitary OECD countries (2006)**

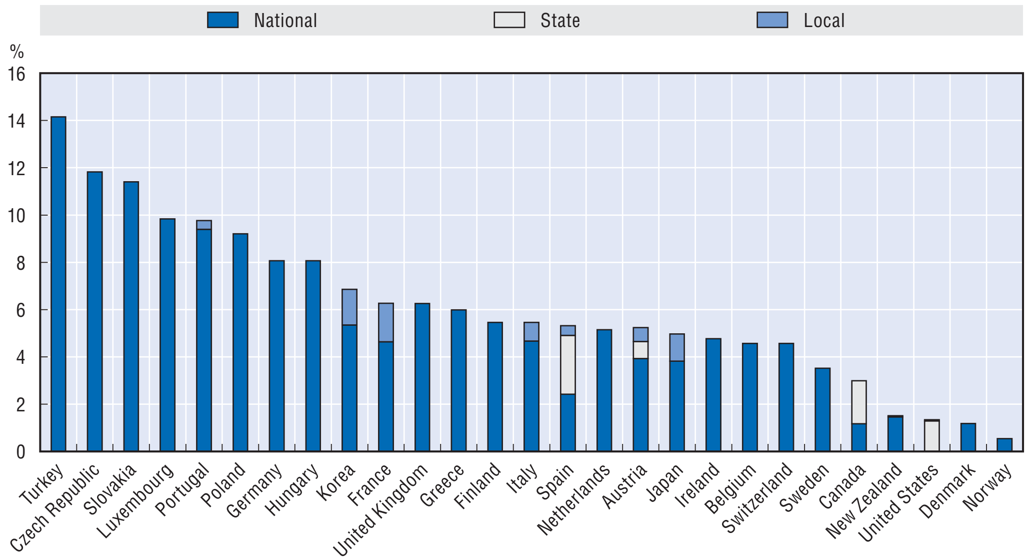


Note: Tax revenues as share of total government revenues (central and local).

Source: *OECD Revenue Statistics Database.*

StatLink http://dx.doi.org/10.1787/888932342563

Figure 9.4. **National, state and local fuel taxes in unitary OECD countries (2006)**



Note: Tax revenues as share of total government revenues (central and local), including petroleum excise taxes.
Source: *OECD Revenue Statistics Database.*

StatLink http://dx.doi.org/10.1787/888932342582

since the annual assessment captures any increases in the property value that might result from public infrastructure investment; this does however not take place in most OECD countries. In addition, some metropolitan transit authorities dispose of tax income, an example of which is the *versement transport* to finance metropolitan public transport in France. This tax is collected from companies employing nine or more people, as a surcharge on salaries at a rate that may vary between 1% and 2.2%, and is earmarked for public transport at the discretion of the metropolitan transit authority. These revenue sources, although not uncontroversial, complement other public transportation fees and provide a substantial part of revenues for metropolitan public transport (around 70% of the income for STIF, the metropolitan transport authority of the region Paris Île-de-France).

Fees and charges

Fees and charges could be effective instruments in a variety of areas to signal the higher cost of internalising environmental externalities, including in the sectors of transport, land development, waste and water. Fees and charges are ideal for funding local services where specific beneficiaries can be identified and non-payers excluded. Fees are particularly effective when they recover full costs and when fees are paid according to individual or household use, as these give residents incentives for more efficient use of resources. Fees have been applied to land use and the built environment, transport, urban water provision and waste disposal.

Fees and charges impacting land development and the built environment

Development charges could be used to cover the costs of urban sprawl, but much depends on their design. Development charges are levied on developers to provide funding for the infrastructure needed to provide services to the developed area. They are in principle good instruments for compensating for the costs of sprawl, as long as they take into account real costs and as long as charges for single detached homes are considerably larger than those for apartments. This, however, is not always the case. In Toronto, for example, area-specific charges could give developers incentives to develop compactly, but municipalities in the Toronto metropolitan area have not widely used them: most development charges are applied using a uniform rate for the whole municipality (OECD, 2009a). This means that the costs for the municipalities are equalised over the various development projects being undertaken in the municipality. Although this minimises the risk of conflicts with developers, the disadvantage is that the development charge does not have a direct relation to the costs of providing services to new developments, and therefore does not provide an incentive to developers to develop compactly. Other impediments to internalising the costs of sprawl could be the limited amount of cost categories than can be recovered via development charges. More efficient use of the development charges would imply charging a fee to developers that closely resembles the real and full costs for building and providing the infrastructure to a particular area. The effects of development charges on social equity appear ambiguous. On the one hand, low-income families might try to find affordable housing far from the city centre; internalising the costs of sprawl could raise the price of this housing so that it becomes unaffordable to these groups. On the other hand, development charges can include a partial subsidy to finance social housing inside the development area; countries like France and the United Kingdom impose a percentage of social housing in new developments.

Several cities depend on land sales for a large part of their revenues, which also can create incentives for urban sprawl. This is the case with the metropolitan cities in Guangdong province in China. The contribution of land sales to local revenue has been estimated to be 55% in the City of Guangzhou in 2006 and around 80% in the City of Shenzhen throughout the 1990s (Tian and Ma, 2009; Peterson, 2006; OECD, 2010). Although these could be valuable instruments to capture land value increases and to finance infrastructure, in practice local governments in China have been so motivated to generate revenues from land sale and leasing that they have generated an oversupply of land for construction. This has stimulated sprawled development and loss of cultivated land in the whole of China. Similar dynamics, although less extreme, are at work around other metropolitan regions in the OECD. Municipalities in the peri-urban fringe of many German agglomerations compete with each other by developing new land to attract inhabitants and companies, thereby bringing in gains that are used to finance public services. This dynamic is made possible by municipal autonomy in land-use planning and large demand for undeveloped land; the result is an undermining of sustainable planning principles.

Brownfield or infill development in many OECD metropolitan regions usually offers fewer benefits to developers. It also takes more time to complete, and so occurs less frequently unless specifically stipulated by local governments. Suburban municipalities have thus actively pursued the development of previously undeveloped land, or greenfields. Because suburban municipalities typically have a greater supply of greenfields, they can be more attractive to developers and can benefit from the revenues and revenue bases brought in by greenfield development. However, greenfield development does not take into account the costs of sprawl, given that other actors are responsible for much of the transport infrastructure to connect newly developed land and bear the brunt of the resulting vehicle congestion and travel-related air pollution.

Fees and charges impacting transportation

The congestion charge has in some OECD metropolitan areas contributed to the reduction of GHG-emissions. This instrument is similar to toll roads in that it charges for road use, but differs in that it charges exclusively or more intensely during peak traffic periods. Some congestion charges have to be paid when entering a certain delineated area within the city (cordon-based charges), whilst others charge according to kilometres travelled within an area. Examples of the first type of congestion charge are functioning in London and Stockholm, whereas an area-based charge is in operation in Singapore. The congestion charges also vary according to technology, tariffs and design, including differentiation to time of the day and other criteria (Table 9.2). Some of these initiatives (Singapore, Milan) are designed to tax higher-polluting vehicles more heavily, whereas other systems do not differentiate according to vehicle type. Congestion charges have been observed to reduce CO_2 emissions from transport up to 19.5% (in London), as well as emissions of other air pollutants (Beevers and Carslaw, 2005). These beneficial effects on emission reductions could lead to the reduction of traffic volumes, shifts in transit modal shares and reduction of congestion responsible for a considerable part of GHG emissions. In some cases, the receipts from the congestion charge are used to finance urban public transport; this is the case in London. Congestion-charge technology can be costly and charges could be subject to the risk of "rebound effects" (with more people willing to take the car if congestion charges manage to actually de-congest traffic) if not accompanied by other policies, such as parking fees.

Alternative effective measures are high occupancy toll (HOT) lanes. HOT lanes make use of the infrastructure provided by high occupancy vehicle (HOV) lanes introduced in many OECD countries. HOV lanes are highway lanes on which only vehicles with a minimum number of occupants (usually two or three) are allowed to drive, in order to promote car pools. In the United States, several of these HOV lanes have been found to be ineffective, because car pooling did not have a wide appeal. In order to use their excess capacity, several HOV lanes instituted in the United States are being transformed into HOT lanes on which vehicles with less than the minimum number of occupants are permitted if they pay a toll. Assessments of the effectiveness of these HOV lanes are mixed, considering the relatively high costs for collecting tolls.

Other similar options include parking fees and taxes. Parking fees and taxes are price-elastic, and there is ample evidence that they are effective in reducing car trips and decreasing the car share in the modal split. Parking charges have led to a 12% decrease of vehicle miles of commuters in US cities, a 13% point reduction of car shares in modal splits in British cities, a 20% reduction in single car trips in Ottawa and a 38% increase of car pooling in Portland (Shoup, 1997; Bianco, 2000; Dasgupta *et al*., 1994; Wilson and Shoup, 1990). Parking fees could be differentiated in order to make them more effective. A parking surcharge might be levied on drivers who arrived at parking garages during the morning peak hours, and spatially differentiated parking fees could rival time-differentiated congestion fees (Arnott *et al*., 1991). The cost per minute associated with metre parking is however nominal in most cities. Some cities make use of congestion pricing for parking. For the most part, however, this takes the form of making parking cheaper in spaces further away from the high-demand areas. There are also other arrangements in place. Los Angeles has an area (Venice Beach) where the rates on the metres charge depending on the time of day. New York City has a congestion pricing programme for commercial parking

Table 9.2. **Main urban congestion charges in operation and their environmental outcomes**

	London	Stockholm	Singapore	Milan	Durham (UK)
Introduced	2003.	2006.	1975. 1998 (2nd generation).	2008.	2002.
Maximum tariff	GBP 5. GBP 8 from July 2005.	SEK 20 highest tariff.	USD 3, later USD 5.	EUR 10.	GBP 2.
Differentiation by	Single rate for vehicles entering central London between 7-18.30.	Time of day.	1975-98: Single rate entering the Central Business District during 7.30-10.15 am. 1998: Differentiation by vehicle type, time of day and location.	Vehicle emission standards. Type of vehicles. Resident or not.	Single rate between 10 am and 4 pm Monday-Saturday.
Area	21 km^2.	36 km^2.	7 km^2.	8 km^2.	
CO_2 emission reduction	19.5% reduction. GDP 2.3-2.5 million in CO_2-emissions saved.	36 000 tonnes a year (13% reduction).		9% reduction (150 000 tonnes).	
Other environmental effects	12% reduction of NO_x-emissions in charging zone. 12% reduction of PM_{10} emissions in charging zone. 15% reduction in vehicle km. 12% traffic reduction. Reduction of 211-237 million vehicle distance. Reduction of 35% in pollution. Total environmental benefits: EUR 4.9 million per year.	8.5% reduction of NO_x. 14% reduction CO. 13% reduction of PM_{10}. Avoidance of 27 premature deaths. 22% reduction of vehicle passages in charging area.	75% reduction of car traffic in the morning peak; in 1992 car volume was still at 54% of the pre-1975 level. Drop of car share in modal split from 48% to 29% immediately after introduction. 1998 model: Elasticity of passenger car –0.106 in their restricted zone, –0.21 in the short run, –0.30 in the long run. Reduction of 15% of daily traffic volumes.	19% reduction of PM_{10}-emissions (EUR 3.3 mn). 37% reduction of NH_3-emissions. 11% reduction of NO_x-emissions. Traffic reduction: 14.4%.	Reduction of 50-80% of number of vehicles.
Period	2002-03.	January-July 2006.		January-December 2008.	

Source: Beevers, S. and D. Carslaw (2005), "The Impact of Congestion Charging on Vehicle Emissions in London", *Atmospheric Environment*, Vol. 39, pp. 1-5; Transport for London (2004), *Congestion Charging – Update on Scheme Impacts and Operations*; Prud'homme, R. and J. Bocarejo (2005), "The London Congestion Charge: A Tentative Economic Appraisal", *Transport Policy*, Vol. 12, pp. 279-288; Johansson, C.L. Burman and B. Forsberg (2008), "The Effects of Congestions Tax on Air Quality and Health", *Atmosperic Environment*, Vol. 42, pp. 1-12; Lundqvist (2008), "Can Congestion Charging Support Sustainable Development of Metropolitan Areas? – The Case of the Stockholm Trial on Congestion Charging", paper presented at 47th Annual Meeting of the Western Regional Science Association, Hawaii; Olszewski, P. (2007), "Singapore Motorisation Restraint and its Implications on Travel Behaviour and Urban Sustainability", *Transportation*, Vol. 34, pp. 319-335; Olszewski, P. and L. Xie (2005), "Modelling the Effects of Road Pricing on Traffic in Singapore", *Transportation Research*, Vol. 39A, pp. 755-772; Menon, A. (2000), "ERP in Singapore – A perspective One Year On", *Traffic Engineering and Control*, Vol. 41, pp. 40-45; Willoughby, C. (2000), "Singapore's Experience in Managing Motorization and its Relevance to other Countries", *Discussion Paper*, No. TWU-43, TWU Series, The World Bank, Washington DC; Milan Municipality (2009), *Monitoraggio Ecopass, Gennaio – Dicembre 2008*, Agenzia Milanee Mobilità Ambiente; Santos, G. and G. Fraser (2006), "Road Pricing: Lessons from London", *Economic Policy*, Vol. 21, pp. 263-310.

that involves a graduated fee depending on how long the vehicle remains parked (de Cerreño, 2004). These kinds of arrangements allow the price of parking to better reflect demand; as such they can reduce parking congestion and thus vehicle use.

Grants

Ecological goods and services are often public goods with important spillover effects, which might necessitate intergovernmental grants in order to internalise externalities. Non-excludability and positive spillover effects frequently lead to under-supply and scarcity of environmental goods and services, and thus to misallocation. This misallocation can to a limited degree be avoided by planning and law, as these mechanisms are less able to ensure an environmentally sound allocation of resources. In addition, ecological endowment and fiscal capacities for nature conservation are often distributed unequally among regions, requiring some form of fiscal transfers to prevent certain regions from being responsible for nature preservation without having the means to finance it.

The need for intergovernmental grants is linked to the expenditure assignments in specific countries or regions. Discovery and dissemination of basic knowledge about environmental harm and the effectiveness of various policy instruments, as well as policies tackling trans-boundary environmental problems and pollutants, such as sulphur dioxide, carbon dioxide and ozone, are in many instances assigned to central government levels, as their spatial externalities would lead to under-provision at the local level. In contrast, environmental policy associated with more localised characteristics, such as land use, soil contamination, water resources and nature conservation, have lower probabilities of cross-boundary spatial externalities, and would thus be better suited for assignment to lower levels of government. In cases where environmental policies with large spillovers are assigned to local governments, intergovernmental grants could make sense in order to compensate local governments for the external benefits of its expenditures.

Specific grants are in many cases used to internalise positive externalities. A large variety of *Länder* in Germany provide conditional grants for ecological functions, ranging from sewage disposal, water supply, waste disposal and remediation of contaminated sites to landscape maintenance and water conservation schemes (Ring, 2002). Although the allocation of some of these environmental grants is criteria-based, many specific grants for environmental goals are allocated to a limited set of projects on the basis of a competitive process. A different category of grants is formed by payment schemes for environmental services provided by farmers and other landowners, as they are usually directly paid to the service provider by the national and supranational (EU) governments – and in some cases (*e.g.* Austria) even local governments.

General grants, however, rarely use ecological indicators, although there are some exceptions. In Germany, a few states (*e.g.* Saarland) have included ecological functions, such as those related to natural hot springs and damage from mining, as a basis for calculating the fiscal need in determining fiscal transfers from *Länder* to local governments (Ring, 2002). The Portuguese fiscal transfer scheme rewards municipalities for designated Natura 2000 sites and other protected areas within their territories, as these represent 5% of the allocation criteria of general grants to municipalities (Prates, 2007). In Brazil, a variety of states have introduced environmental criteria to allocate state tax shares to local governments via the green ICMS (Box 9.2).

Introduction of ecological indicators in general grants is considered in several countries. The German Advisory Council on the Environment has since 1996 called for the integration of ecological indicators into intergovernmental fiscal transfers, which has resulted in a number of detailed studies for implementation, for example financing on the basis of improvements for local nature and wildlife, or on the basis of "nature points" valuating activities to improve nature protection (Perner and Thöne, 2005). The incorporation of biodiversity per standardised area has been suggested for the general grant system in Switzerland, providing more biodiverse cantons with relatively more fiscal transfers (Köllner *et al.*, 2002). In India, the 13th Finance Commission advised that 7.5% of fiscal transfers to states and territories be based on the criterion of forest cover; in this proposed formula the states and territories with lesser forest cover area would receive fewer lump-sum transfers, while the others would gain according to their forest cover area (Kumar and Managi, 2008).

Box 9.2. **Environmental indicators in tax shares to local governments in Brazil**

The tax on the circulation of goods and services (ICMS) is a value-added tax collected by state governments, and part of these revenues must be redistributed among municipalities. Three-quarters of this redistribution is defined by the federal constitution, but the remaining 25% is allocated to each state's legislation. The state of Paraná was the first Brazilian state to introduce the ecological ICMS (ICMS-E) in 1992, followed by the states of Minas Gerais in 1996, and several other states including São Paulo in 1996 and Rio de Janeiro in 2009. The ICMS-E was introduced against the background of state-induced land-use restrictions (protected areas) for several municipalities, which prevented them from developing land and generating value added, without being compensated for these restrictions: in the municipality of Piraquara, for example, 90% of the municipal territory was a designated protected area for conserving a major watershed to supply the Curitiba metropolitan region with drinking water (May *et al.*, 2002).

Depending on the different states, the share of the ICMS allocated on the basis of ecological indicators ranges from 0.5% in São Paulo to 13% in Tocantins. Rio de Janeiro started with 1% in 2009, which will be gradually increased to 2.5% in 2011. Although the states have different systems in place, there are many commonalities in the allocation mechanism. The revenues are allocated according to the ecological index of a municipality, which is based on the total area set aside for protection, in relation to the total area of the municipality. The protected areas are weighted according to the different categories of conservation management, with weights ranging from 1.0 (for ecological research centres and biological reserves) to 0.1 (for special local areas of tourist interest, and buffer zones). Some states, such as Paraná, have included an evaluation of the quality of the protected areas in the calculation of the ecological index. The quality of the protected area is assessed by regional officers of the state environmental agency on the basis of physical quality, biological quality (fauna and flora), quality of water resources, physical representativeness, and quality of planning, implementation and maintenance.

Evaluations of in Paraná and Minas Gerais show that the introduction of the ICMS-E has been associated with the creation of new protected areas and have improved environmental management and quality of these areas. In Paraná, the total area measured in conservation units increased with 165% between 1992 and 2000; the increase in Minas Gerais was 62% over 1995-2000 (May *et al.*, 2002). The ICMS-E has also improved relations between protected areas and the surrounding inhabitants, as they start to see them as an opportunity to generate revenue, rather than an obstacle to development. The ICMS-E has built on existing institutions and administrative procedures, and thus has had very low transaction costs (Ring, 2008).

Source: Ring, I. (2008), "Integrating Local Ecological Services into Intergovernmental Fiscal Transfers: The Case of the Ecological ICMS in Brazil", Land Use Policy, Vol. 25, pp. 485-497; May, P. *et al.* (2002), "Using Fiscal Instruments to Encourage Conservation: Municipal Responses to the 'Ecological' Value Added Tax in Paraná and Minas Gerais, Brazil", in S. Pagiola, J. Bishop and N. Landell-Mills (eds.), *Selling Forest Environmental Services: Market-based Mechanisms for Conservation and Development*, Earthscan, London.

Introduction of ecological indicators in general grants might entail a shift of transfers from urban to rural areas. Model calculations of a fiscal transfer system in which biodiversity indicators would be incorporated show that fiscal transfers would change relatively in favour of non-urban cantons, although the changes would be limited compared to the actual situation in 1999, due to small regional differences in biodiversity status and low transfer sums use in the model in order to provide realistic scenarios (Köllner *et al.*, 2002). Model calculations show that incorporation of protected areas within the fiscal transfer system in Saxony (Germany), along the lines of the ICMS-E in Brazil, would lead to higher transfers to rural communities, as they would be compensated for the ecological functions they perform for urban areas and the rest of the country (Ring, 2008).

As general grants in many cases compensate for cost differentials between localities, there would be a need to develop indicators that reflect costs for ecological public functions. There are different methodologies that could be used in developing these criteria. A grant for environmental management in Queensland (Australia) has been allocated according to a environmental needs index, constructed through a multi-analysis criteria analysis (MCA) approach, using 29 different criteria that were selected and weighed by a group of decision makers (Hajkowicz, 2007). Although it provided a structured approach for achieving equalisation of environmental funds, it could create problems related to objectivity and transparency. An alternative approach to inform the allocation of fiscal resources for the environment across regions is environmental valuation, *e.g.* in the form of damage cost assessment, hedonic pricing and contingent valuation. Although valuation could provide a powerful tool to inform fiscal equalisation of environmental funds, it is rarely used, perhaps because they are relatively costly.

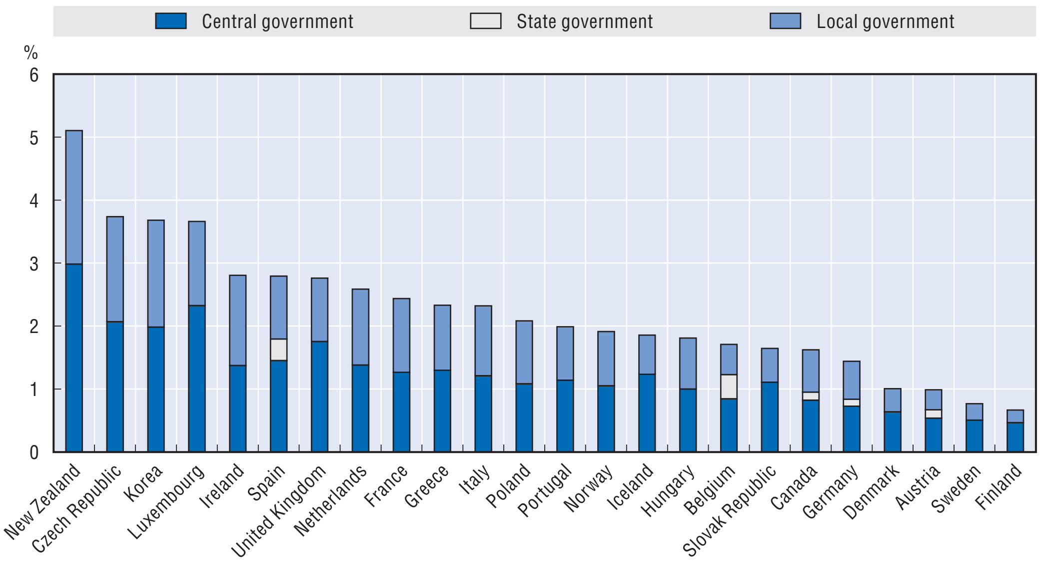
New urban expenditures and new funding sources

Measures to reduce GHG emission and adapt to expected climate change impacts will put additional pressure on city budgets and increase the need for additional resources. Three forms of upward pressures on city budgets can be anticipated: costs related to adaptation, costs related to mitigation and costs related to price rises in carbon-related energy sources. The costs of adaptation are uncertain, but could be substantial. Many cities are exposed to the risks connected to climate change; these risks could entail huge casualty rates and damages. Some cities have set out adaptation strategies that require additional investments, for example to increase shock resistance of buildings and to facilitate evacuation of water in case of flooding. In addition, cities might try to insure some of their key assets, but insurers will provide climate change insurance only with a high mark-up rate due to considerable uncertainties about possible impacts of climate change. Mitigation also often requires public investments; a considerable extent of these would appear to be necessary in order to realise the GHG reductions announced by several cities in their climate change plans. Although investment in climate change and urban sustainability policies can produce co-benefits, such as increased accessibility and greater attractiveness of the city, these investments will present an additional burden on most cities' budgets. A third source of pressures on city budgets are costs related to carbon-related energy sources. Several city expenditure items are energy-intensive, in particular basic services such as garbage collection and disposal, street lighting, water supply and bus transportation. This might become problematic when energy prices rise, as anticipated in energy forecasts.[1]

Cities are responsible for large parts of government expenditure, including expenditures for the environment, transport and buildings. This is the result of decades of fiscal decentralisation, which have increased the average share of sub-national expenditures in OECD countries to 33% in 2005 and have made sub-national governments responsible for almost 70% of total investment spending, which is particularly important for climate change. Following this decentralisation tendency, cities are now responsible for a range of sectors that impact environmental sustainability and GHG emissions, sometimes as the sole authority, but more often in partnership with other levels of government. For example, local governments in many OECD countries are responsible for amounts of public spending on environmental protection (which includes waste management, waste water management, pollution abatement, protection of biodiversity and landscapes, and R&D on environmental protection) that are almost similar to that of their respective national governments (Figure 9.5). Transportation is in many OECD countries a shared responsibility, with local governments taking care of local infrastructure, regional governments for regional infrastructure and national governments for national infrastructure. Similar shared responsibilities can also be found with respect to the built environment and land use. Debates on environmental federalism have showed that local governments can play an important role in environmental policies, especially when they are able to internalise externalities.

Figure 9.5. **National and sub-national expenditures on environmental protection in OECD countries (2005)**

Per cent of total government spending



Source: *OECD National Accounts Statistics Database.*

StatLink http://dx.doi.org/10.1787/888932342601

Through these responsibilities for spending, cities have in many instances the capacity to influence local circumstances. Although local governments act sometimes as agencies for higher governments, which does not give them much leeway to adapt programmes to local circumstances, fiscal decentralisation has in most cases gone hand-in-hand with the transfer of responsibility for policy instruments to local governments. Cities have over the last decades seen increased budgets and discretion in how to use these instruments. In order to fund new expenditures connected to climate change, cities would benefit from increased access to carbon finance and capital markets.

Carbon finance

A variety of financial instruments have been developed to create a market for carbon emissions and carbon offsets, which cities can use as a supplementary revenue source. Cap-and-trade schemes have been put in place in different countries (Australia, New Zealand, parts of the United States), at the European level (EU Emissions Trading Scheme) and at the global level, following the Kyoto Treaty. Cities participate in some of these GHG markets (such as the voluntary Chicago Climate Exchange). The City of Tokyo is planning to implement a GHG cap-and-trade system in 2010. While some cities have experience in trading schemes for local pollutants (Los Angeles, Chicago, Santiago) (Box 9.3), due to the global nature of GHG emissions it is more challenging to situate a city cap-and-trade within a broader GHG mitigation strategy. Certain cities, such as London, have explicitly defined emissions trading as a business opportunity that would increase their metropolitan competitiveness (City of London, 2006). In addition, cities could earn supplementary revenues from the two mechanisms that the Kyoto protocol put in place to create carbon offsets, the Clean Development Mechanism (CDM) for developing countries (non-Annex I countries) and Joint Implementation (JI) for developed countries (Annex I countries), both certified and issued by the UNFCCC.[2] CDM allows developed countries to purchase carbon credits from emission reduction projects in developing countries, and JI from emission projects in other developed countries. In addition to this, voluntary carbon markets have been created that are unconnected to an emissions cap. In these voluntary markets, carbon offsets are verified by another carbon market standard, twelve of which are currently operational. Carbon offset markets have been promoted as an important part of the solution to the climate crisis because of their economic and environmental efficiency. Their cost-effectiveness allows for lower caps or voluntary commitments and the potential to deliver sustainable co-benefits as a by-product through technology transfer and capacity building.

Box 9.3. **Experience in metropolitan emission trading programmes for local pollutants**

Since the 1990s, a limited number of cities and metropolitan regions have introduced emissions trading programmes for local pollutants: Los Angeles in 1994, Santiago (Chile) in 1994 and Chicago in 2000. In these programmes a variety of objectives are targeted. The Regional Clean Air Incentives Market (RECLAIM) programme in Los Angeles targets reductions of NO_x and SO_x emissions, and the Emissions Reduction Market System (ERMS) in Chicago aims to reduce volatile organic materials (VOMs) emissions, whereas the emissions trading programme in Santiago focuses on total suspended particulates (TSP). At the introduction of these programmes, ambitious objectives were formulated: *e.g.* the RECLAIM programme calls for reductions of about 75% for nitrogen and 60% for sulfur oxides.

These programmes have in common the presence of an explicit or implicit cap and the possibility to trade emission credits. In the RECLAIM programme, pollution credits are allocated to each major source facility in the region, based on their historic level of emissions. Facilities are free to buy and sell these pollution credits. Each year the number of credits allocated by the programme is decreased, forcing facilities either to decrease their pollution or purchase credits from other facilities. The TSP programme in Santiago does not impose an explicit cap on emissions, but rather an implicit cap equal to the sum of the capacity permits to be distributed. The total number of permits to be distributed was estimated to be 64% of the aggregate emissions capacity prior to the programme. Sources registered and operating by March 1992 were designated as existing sources and received permits. New sources, on the other hand, received no permits, so they must cover all their emissions with permits bought from existing sources.

An important part of regional emitters are covered by these programmes. In the case of RECLAIM, this concerns a wide range of small and medium-sized stationary sources as well a few large ones, with participating facilities operating in industries as diverse as ceramics, food, furniture, glass and tiles. The number of market participants is 390 RECLAIM nitrogen-emitting facilities and 41 sulfur-emitting facilities (Schwarze and Zapfel, 2000). Public facilities (such as police and fire fighting facilities) were categorically excluded. The TSP emissions programme in Santiago covers the largest 600 stationary sources, including

Box 9.3. **Experience in metropolitan emission trading programmes for local pollutants** *(cont.)*

industrial boilers, industrial ovens and large residential and commercial heaters. These programmes are mostly implemented at the level of the metropolitan region: *e.g.* the jurisdiction of the RECLAIM programme includes the South Coast Air Quality Management District (Greater Los Angeles). The TSP emissions programme in Santiago covers, however, only the territory of the city.

Metropolitan emissions trade programmes have achieved most of their goals, although their effectiveness has been contested. Emissions in Los Angeles region fell with approximately 24% on average at RECLAIM facilities relative to counterfactual facilities (Fowlie *et al.*, 2009). In Chicago, market-wide VOC emissions were reduced by three times more than the policy goal of a 12% cap reduction. The environmental objective of the TSP-programme in Santiago, to reduce PM10 emissions from stationary sources by 50%, was met by 1998. Because industrial emissions are influenced by numerous factors, attributing changes in emissions patterns to specific policy interventions is difficult. Not surprisingly, the emissions impacts of RECLAIM *vis-à vis* the subsumed command and control rules remain controversial (Fowlie *et al.*, 2009). Part of this controversy is connected to the design of the programmes: under RECLAIM, allowable emissions have declined each year as required by regulation, but emission reduction credits were found to be initially allocated in an amount significantly inflated above actual emissions: in the first three years of the RECLAIM programme, actual industrial NO_x emissions have declined by at most 3%, while allowable emissions have been reduced on paper by about 30% (Drury *et al.*, 1999). A similar pattern (allocation of emission rights higher than actual emissions) was found in Chicago. The fact that emissions are below the cap in Chicago has been found to be primarily due to continuing and ever more comprehensive command-and-control regulation (Kosobud *et al.*, 2008).

Although the different programmes did not always manage to install completely functioning markets, the programme incentives have enabled further introduction of markets. In Chicago, there are several indications of incomplete markets: there are large volumes of permit banks, a significant number of permit expirations, and a six-year-long decline of the emission permit costs, to USD 17 per permit in 2006. This was far below estimates of the marginal control costs of reducing emissions cited in academic literature (Kosobud *et al.*, 2008). Observed prices and trading volumes in Santiago differ significantly from those predicted by numerical models of a frictionless market, with some firms relying on autarkic compliance, paying less attention to the permits market. In addition, the market has not fully developed because of transaction costs, regulatory uncertainty, and incomplete enforcement (Montero *et al.*, 2002). In the Santiago system, grandfathering the permits has created economic incentives for the incumbent sources to more readily declare their (historic) emissions in order to claim any permits. This has proved effective in helping the authority complete its inventory of sources and emissions during the early stages of the programme.

There are concerns that metropolitan emissions trading could lead to environmental "hot spots", but these claims have so far not been substantiated. Spatially sensitive pollutants like NO_x, which are prone to excessive local concentration problems ("hot spots"), call for some kind of trade restrictions. The issue of constraining the market was dealt with in the Los Angeles region by dividing the local cap-and-trade market into two zones, an inland and a coastal zone, and preventing trades from the former to the latter because of prevailing winds (Kosobud *et al.*, 2004). There are no indications of such "hotspots" in the case of Chicago: 89 out of 95 sub-areas covered by the programme revealed a decrease and only six an increase in emissions over pre-trading levels, with the sub-areas with the largest initial emissions revealing the most significant reductions after trading (Kosobud *et al.*, 2004).

Source: Drury, R. *et al.* (1999), "Pollution Trading and Environmental Injustice: Los Angeles' Failed Experiment in Air Quality Policy", Duke Environmental Law and Policy Forum, Vol. 9, pp. 232-289; Kosobud, R. *et al.* (2008), "Regulatory Conflict in the Chicago VOC Control Program", *Journal of Environmental Planning and Management*, Vol. 51, Routledge, London, pp. 561-579; Kosobud, R., H. Stokes and C. Tallarico (2004), "Does Emissions Trading Lead to Air Pollution Hot Spots? Evidence from an Urban Ozone Control Programme", *International Journal of Environmental Technology and Management*, Vol. 4, pp. 137-156; Montero, J., J. Sanchez and R. Katz (2002), "A Market-based Environmental Policy Experiment in Chile", *Journal of Law and Economics*, Vol. XLV, pp. 267-287; Schwarze, R. and P. Zapfel (2000), "Sulfur Allowance Trading and the Regional Clean Air Incentives Market: A Comparative Design Analysis of Two Major Cap and Trade Permit Programs?", *Environmental and Resource Economics*, Vol. 17, pp. 279-298; Fowlie, M., S. Holland and E. Mansur (2009), "What do Emission Markets Deliver and to Whom? Evidence from Southern California's NO_x Trading Program", *Working Paper*, No. 186, Center for the Study of Energy Markets, University of California Energy Institute, Berkeley.

Urban usage of these instruments has been marginal so far. Of the more than 2 000 CDM projects registered in March 2010, only a limited number have been urban projects. Most of these projects have targeted landfill gas or waste water treatment. There have been two urban transportation projects: the Bogotá bus rapid transit, TransMilenio, and the Delhi subway regenerative breaking system. A similar marginal number of CDM projects (0.57%) and certified emission reductions (CERs) by 2012 (0.16%) deal with energy efficiency in the urban building sector (Fenhann, 2009), such as in Khayelitsha (South Africa). In addition, some projects are implemented in other urban sectors, such as renewable energy supply electricity (Urimqi, China). JI projects have also been applied in a limited number of metropolitan regions (*e.g.* North Rhine-Westphalia in Germany and Rhône-Alpes in France). Carbon offsets realised by urban projects in the voluntary market are equally marginal.

Marginal urban use of carbon markets to raise revenue for GHG emissions-reduction projects can in part be explained by complexity and high costs involved in proving the *additionality* of projects. This *additionality* criterion is part of the Kyoto protocol to ensure that the mechanisms result in additional carbon reductions and are not used to finance activities that would otherwise also have taken place. Several mitigation efforts in cities are however notably difficult to measure, because emissions are diffuse, costly to identify and to aggregate into calculations of total emissions. CDM challenges that are particularly problematic for the urban transport sector are the definition of project boundaries, complex up-stream and down-stream leakages, the establishment of a reliable baseline, and the implementation of a reliable monitoring methodology. There are similar challenges for using CDM in the urban building sector: fragmentation and complexity of construction projects, as well as small scale and disperse emission points making the registry and the "measurable, reportable and verifiable" procedures (MRV) costly and time-consuming under the current CDM framework. Some "soft" measures taken in cities, such as optimised architecture design for passive heating or cooling, are not quantifiable in terms of GHG mitigation and thus not recognised and credited in the project provision (Cheng *et al.*, 2008).

Given these difficulties and the general lack of expertise with the carbon markets at the urban authority level, carbon finance has not been well-integrated in urban finance practice. Transport and CDM projects are generally conducted in parallel, without much interaction (Lefèvre, 2009). Cities tend to outsource CDM projects to international experts and organisations without much involvement, and the effects of CDM are rather limited on carbon emitting sources. CDM project-based design misses large GHG reduction opportunities in the transportation sector, as few projects deal with modal shift and none involve a reduction of total transportation activities. In contrast, the majority of the accepted or proposed CDM transportation projects claim their emission reductions through fuel switch, and some entail improvements of vehicle efficiency through a change in engine type or by better vehicle utilisation. Other sectors such as urban energy-efficiency are better suited for programmatic CDM, an approach through which small projects can be bundled together (*e.g.* Mexico Luz Verde compact fluorescent light bulb programme).

The possibilities for cities to use existing carbon finance instruments could be increased. Cities could work with national authorities to mention transport and buildings as key areas to reduce GHG emissions in the international negotiations, to provide a rationale to involve urban areas in market mechanisms. In order to keep transaction costs down and to take systems dimensions of urban problems into account, these actions should take the form of broad programmes rather than specific projects. In the transport sector, funding from CDM, as it is currently designed, could help to reduce public transport fares, thus increasing transit usage, and also help to finance inter-modality infrastructures, thereby facilitating modal shifts. Other CDM or JI opportunities for the urban sector would be to explore the easily attainable targets on GHG sources related to urban transportation planning, such as urban forestry, street lighting, waste energy used for transportation purposes, etc. One initiative to broaden the CDM programmatic approach to cities is under development by The World Bank using the Amman, Jordan as a pilot city. Both projects and programmatic approaches require the development of tools at an urban level to quantify emission reductions. As cities work to integrate their climate strategies with national plans, there will be a need to develop carbon emission inventories that are harmonised across cities (OECD, 2009b).

Access to capital markets

Cities have, to a varied extent, access to capital markets, but this access to capital markets might have to be increased in order to accommodate long-term climate change challenges. Larger cities especially have increasing access to international capital markets, although this aspect of their funding is still a modest proportion of the total funding and not open to all OECD cities. It occurs mostly by intermediation of a specialised body and, in all cases, the issuing community must have been subject to a credit rating carried out by a rating agency, such as Moody's or Standard and Poor's. There is a striking difference that separates Europe and North America: in Europe, investments are made largely by specialised financial institutions, such as Dexia in France and Belgium, while in the United States, a large part is provided by the bond market. This can be explained both by the absence in the United States of a financial institution specialised in financing local authorities and also the reluctance of banks to finance them. Overall, the use of the bond market is very important in the United States, and is estimated to finance between 70% and 80% of local authorities' investments.

An optimal mix of revenue sources

There is no optimal mix of revenue sources that applies to all metropolitan areas. Not only do conditions in different metropolitan areas vary hugely, but expenditure and revenue assignments differ across metropolitan areas. This implies different financing needs and different possibilities to introduce fiscal incentives. The challenge is to identify which mix of revenue sources suits which set of conditions in cities. In general, metropolitan areas can most easily influence fees and charges; have some influence over tax rates, but less on tax design; and have hardly any influence on grants from higher levels of government.

Metropolitan areas could make more use of fees and charges as instruments to influence behaviour. As they confront users with the real costs of their choices, they could reduce inefficient use of resources and limit sprawl. Fees and charges will be most effective when they cover all costs of the service provided to individual users, and less effective when costs are equalised among all users. Development charges and value capture taxes could finance the construction of new infrastructure needed to serve new suburban developments, whereas transport-related revenue sources (fuel taxes, congestion charges, parking fees) could charge for the use of the infrastructure. Fees and charges could be considered appropriate fiscal instruments regardless of specific conditions, although they are not always easy to introduce, with total or area-specific cost coverage often politically sensitive.

Transport-related revenue sources, such as parking charges and congestion charges, are inter-related and would need coherent planning. Local fuel taxes or parking charges have effects that are somewhat similar to a congestion charge, taxing car use rather than car ownership, but they are less refined instruments because they cannot be used to regulate congestion or be adjusted to vehicle emissions. Elasticities of parking charges are in many cases similar to those found for congestion charges, especially when parking charges are smartly designed. Taxes of this kind are however easier to implement than a congestion charge, because they require no investment in a charging system. Congestion charges will arguably be more appropriate for those cities whose parking fees are already high. Fiscal disincentives for car use will be more effective when alternative traffic solutions, such as public transport, are in place, which is why some metropolitan areas use these types of revenues to finance public transit.

National governments could play a role in greening urban finance, by re-designing sub-national taxes and grants to sub-national governments. Re-design of sub-national taxation could include property tax reform, in order to correct for biases towards unsustainable behaviour. In addition, governments could design grants that take environmental indicators into account in case of jurisdictional spillovers. A comprehensive greening of urban finance would also increase the coherence between urban finance and urban planning frameworks to enhance urban sustainability and to contain unlimited urban growth.

New revenue sources such as carbon offsets have so far been unconnected from more traditional revenue sources. These revenue sources, currently marginally used by cities due to a variety of constraints, provide an interesting potential revenue source for cities. These constraints should be dealt with, and the possibility of city involvement in current climate change negotiations could also be secured. There is a need to make sure that future use of these instruments by cities will be integrated within urban planning and financial frameworks, in order to avoid a situation in which these instruments finance isolated projects without connection to the larger urban sustainability agenda.

Notes

1. The ability to substitute away from using energy in providing these services is limited. For example, garbage cannot be hauled in public transport, but must instead rely upon conventional trucks until alternative technologies are available. This means that cities will have difficulties reducing their energy bills in the short term. As local government revenues are not highly sensitive to the price of energy, so there are limited fiscal gains for local governments when energy prices increase. As a result, raising energy prices that might result from climate change agreements will create an adverse fiscal shock for most local governments (Clarke Annez and Zuelgaray, 2009). This is particularly the case for cities that are mainly responsible for providing basic local services.
2. Annex I countries are Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom and the United States. See *http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php*.

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PART III

Chapter 10

Building Institutions to Enhance Local Knowledge and Strengthen Action

Looking ahead, new or reformed institutions are needed to enable national governments to facilitate capacity building and decision-making on climate change at the local level. Chapter 10 reviews key institutional priorities for greater engagement of local decision makers, the private sector and civil society stakeholders in developing local knowledge to address climate change. City authorities are in a unique position to effectively engage local stakeholders and to design and implement locally tailored responses to climate change. Key institutional shifts could include the development of a number of tools to support local decision-making. These could include standardised greenhouse gas emission inventory and reporting protocols to allow cities to monitor progress in reducing emissions in a way that is harmonised and comparable with other cities and national approaches. This is an important first step to enable cities to better access and participate in international carbon markets and to raise the visibility and credibility of urban mitigation efforts at national and international levels. In addition, regional science and policy networks can be strengthened to allow for expert climate information and local knowledge to combine to better understand how climate change will affect local areas as well as local opportunities for mitigation. Finally, strengthening urban climate policy networks may be a means to provide a forum for information exchange among city practitioners and other stakeholders, and to establish a common understanding about targets, implementation strategies and monitoring.

Key points

National governments can contribute a sound institutional foundation and knowledge base to help local decision makers engage stakeholders, and identify and carry out cost-effective actions

- Local and regional governments should be in a position to address the problems that are within their jurisdictional powers by introducing solutions they are legally and financially capable of supporting. Yet, often local governments are not provided with sufficient support from regional or national levels of government to exploit their potential as important decision makers and as enablers of local action.
- Working with sub-national and national governments, as well as with the international community on the development of a number of tools could assist cities to be more effective, such as:
  - ❖ *Harmonised greenhouse gas emission inventory and reporting* protocols for cities.
  - ❖ *Regional impact science and other policy relevant research programmes* to build analytic-deliberative capacity and support the interface between expert information and local knowledge.
  - ❖ *Urban climate policy networks,* building on regular channels of communication among national planners and regional and local government officials as well as among local stakeholders and decision-makers about targets, goals, strategies, and measures.

A robust, quantitative, evidence base is required to inform sound public policy development and implementation

- As climate change becomes an increasingly important policy driver for regional and urban economic development policies, there is a need for tools that allow inter-jurisdictional comparison, common indicators and metrics to measure progress.
- An evidence base is also needed to enhance the ability to identify and diffuse best practices, not only at local scale but also in terms of how national and local government partners and stakeholders can better work together.
- Strengthening empirical evidence – including through improved local inventories of greenhouse gas emissions and nationally funded local or regional science-policy networks – will advance understanding about where and how climate change is likely to affect regional and urban development, what practices may perform well in the face of climate change, and how national policy frameworks enable or constrain better performance at sub-national scales.

As highlighted in the introduction, a multi-level governance framework can help to accomplish an essential task to bring democracy and deliberation to the issue of how to address climate change. This includes openly acknowledging that government or other public authorities are not the only relevant actors and that it is valuable to take into account a wide range of non-state actors at different stages and scales of decision making. Building multi-level governance institutions (whether they are formal or informal) can help to bridge different perspectives amongst a variety of actors, to enhance local knowledge and understanding, and to contribute to the climate policy formulation and implementation climate change.

This is consistent with insights from social research on the need to consider the contribution of institutions as they shape individual and collective behaviour and in particular the need to create opportunities and outcomes for collective decision making (North, 1990; Ostrom, 1990). The model that emerges places some emphasis on local action to create "deliberative spaces" can raise stakeholder awareness, build trust and understanding and ultimately facilitate collective decision making and collaboration to protect common environmental resources (Ostrom, 1990; Ostrom, 2000; Ostrom *et al.*, 2002), in this case the global atmosphere.[1] In particular, the scientific complexity and uncertainty surrounding predictions of climate change at local scale requires special attention. This strengthens the argument for a more reflexive approach to climate policy decision making, one where risk management is at the centre and one that relies on multi-stakeholders at the different stages of the policy process.

Analytic-deliberative capacity and policy networks

One model of analytic-deliberative capacity that can be used to apply this concept of multi-level governance and to understand and facilitate interactions between different actors is the following:[2]

- A "**core area**" of public decision making with institutions that have formal governmental decision-making powers, *e.g.* governmental administrations, judicial system, and parliamentary bodies.
- An "**inner periphery**" operates close to the core and includes a range of institutions that have a degree of autonomy and self-governance functions. These institutions are equipped with rights and self-governance delegated by the state (*i.e.* universities, public insurance systems, professional agencies and associations, charitable organisations and foundations).
- An "**outer periphery**" of policy action, which encompasses a wider variety of "suppliers" of information and ideas for policy decisions and "customers" who are the target audience of decisions. This includes experts, businesses, and consumers as well as the media; it is the civil-social infrastructure of the public sphere.

To be legitimate, binding decisions "must be steered by communication flows that start at the periphery and pass through sluices of democratic and constitutional procedures…" (Habermas, 1998). This model of decision making emphasises the social integration function of public discourse and decisions, where the true outer periphery is part of the civil-social infrastructure of the public sphere, and where communication and local understanding is facilitated by the mass media.

In the case of multi-level governance of climate change, this model can assist the achievement of two main objectives: *i)* to support an ***analytic-deliberative exchange*** between experts, governmental partners and stakeholder to facilitated understanding of risks of and opportunities of climate change in regional and local contexts (Corfee-Morlot *et al.* in OECD, 2008; Stern and Fineberg, 1996); and *ii)* to facilitate formation of ***policy networks*** at the urban scale.

i) Regarding ***analytic-deliberative exchange***, this provides a means to "understand" climate change; as with any environmental issue, understanding is inevitably linked to scientific knowledge. However, the case of climate change may be somewhat different than many environmental problems in that it presents large scale, systemic risks that unfold over long time frames and asymmetries across geographic scales that challenge conventional decision models. Thus how climate change is framed and addressed in the public sphere will depend upon the interaction between science, the media and other socio-political processes (*e.g.* Corfee-Morlot *et al.*, 2007; Liverman and O'Brien, 2001). In this light, understanding the risks of climate change at city-scale can help cities to better work in tandem with the national government to manage national risks more efficiently, to achieve both adaptation and mitigation outcomes. Beyond the scientific issues are a range of technical issues such as understanding the sources of emissions, their magnitude and linkages to human economic activity, and thus opportunities for cost-effectively managing these emissions. Local governments have a particular role to play to build on local knowledge and create a "policy space" for a deliberative-analytical exchange to help create a climate-friendly vision of the future (Stern and Fineberg, 1996; Grindle and Thomas, 1991; Corfee-Morlot *et al.*, in OECD, 2008).

The interaction with national governments is particularly relevant in this context as they have a key role to play to enable the analytic-deliberative process on climate change at local scale. This may include ensuring that policy-relevant scientific information (*e.g.* on climate change impacts) is available and that there are regular exchanges between local decision makers and scientists. It may also include making available of standardised tools for accounting for and assessing cost-effective management of emissions.

ii) Regarding policy networks, this follows the definition of Borzel (1998) to include "a set of relatively stable relationships which are of non-hierarchical and interdependent nature linking a variety of actors, who share common interest with regard to a policy and who exchange resources to pursue these shared interests acknowledging that co-operation is the best way to achieve common goals". Applied to urban policies and politics, the concept of policy networks highlights the importance of trust, legitimacy and accountability of local institutions that goes beyond the principle of local democracy embedded in individual municipalities but rather depends on different forms of public support and participation modes of non-governmental actors at the different stages of the decision making process (OECD, 2006).

This is particularly relevant and crucial in the field of climate change for which, as mentioned in the previous chapter, public awareness and mobilisation of local "voices" constitutes a prerequisite for the adoption of actions and policies. Indeed, local government authorities cannot effectively address the massive challenges posed by climate change without widespread grassroots involvement of a wide variety of actors in civil society, such as citizens' groups, neighbourhood associations and the business sector. These non-governmental stakeholders can play key roles in both contributing to the development of sound government policies, and in ensuring that such policies are effectively implemented. They can also play the role of messengers and catalysts for community action and they can be engaged and participate in policy design and delivery. If excluded from the decision making process, they can also represent powerful obstacle for the adoption of climate change action plans and/or implementation, or limit their effectiveness.

Following this model which is based on the dual concepts of analytical deliberative capacity and policy networks formation, this chapter will first discuss different tools that national governments can develop to support local decision making. Two examples are explored: GHG inventories; and sub-national science-policy exchange. Second, the chapter turns to the role of non-state and non-governmental actors in the different stages of the policy decision-making process, from formulation to implementation and dissemination. The aim is to assess to what extent the different mechanisms can help to the formation of policy networks as an essential part of the multi-level governance process for climate change. Within this is the sphere of interaction that contributes to and promotes analytical deliberation through national and transnational networks of cities and regions. These networks are essential in identifying and disseminating relevant knowledge and best practices among sub-national governments.

Developing the toolbox to harness city-scale decision making

As noted, there are two core activities that national governments could support to help cities become more effective in the design and delivery of locally tailored policy solutions to climate change. First is the development of city-scale GHG inventories such that mitigation performance can be monitored, supported and compared across urban jurisdictions. Here both national and international attention to the challenge will be required to advance the development of the necessary tools. Second is the need for regional science-policy capacity to support timely and cost-effective adaptation at local scale; a similar need could be highlighted for regional capacity to assess the economics or costs of mitigation or adaptation policies. Progress in both of these areas could build crucial capacity at local scale to address climate change and require support from national governments.

Monitoring progress: Cities, mitigation and GHG inventories

Cities have been active in efforts to reduce greenhouse emissions for at least a decade and the level of ambition and scale of statements of intent to mitigate have grown with time.[3] However, there is a need for cities to bring rigour and structure into their efforts to measure progress in achieving their mitigation goals. While recent steps were taken by the UN and The World Bank in developing an international protocol (launched in March of 2010), we still lack harmonised, internationally accepted and widely used methods and inventory data to assess progress within and across cities.

Establishing a common set of metrics for comparison of progress across cities could raise the profile and increase the potential for urban policy to stimulate cost-effective mitigation actions. Agreement on metrics, methods and reporting frameworks for cities can establish a common language for cities to speak to each other, to measure progress and assess performance (both *ex ante* and *ex post* policy implementation), to identify and share understanding of best practices in urban-scale mitigation activities. In addition, emerging carbon markets could provide cities a starting point to leverage their otherwise limited resources. The necessity of rigour in local-scale GHG accounting is virtually incontestable given that almost any form of access to carbon-finance will require harmonised inventory methods, reporting and data sets.

There are several reasons to harmonise urban GHG inventory methods. First, a common framework will allow cities to assess progress over time as well as across locations. In turn this will allow them to compare results and cost-effectiveness of emissions reductions at the sector level – for example in the waste sector, in the transport sector or residential/commercial building energy end-use sector.[4] Furthermore, such a tool can indicate how they stack up, for example in comparison to other cities of similar wealth, population, or geographic/climate characteristics, and to understand how and why major changes in emissions occur over time. In this way, it will open new possibilities for cost-effective mitigation, as well as for collaboration and learning across location.

Second, harmonised urban inventory methods and reporting is essential to enable performance assessment and comparison across urban locations within a nation, for example, to assist national decision makers to better understand the potential for, and overall mitigation progress made, at urban scale. Harmonised urban inventory methods can also provide inputs for preparation of national inventories and emissions targets, and an information base to allow national policy makers to reward or incentivise urban-level emissions reductions.

Third and finally, with standardised local measurement approaches in place at the international level, city scale policies could lead to measurable and verifiable emission reductions that are eligible for certification and sale through existing mechanisms under the Kyoto Protocol (*e.g.* joint implementation or the clean development mechanism) or similar mechanisms that are expected for a post-2012 agreement. Although there is some progress in making national and international carbon finance available at urban scale (Bodiguel *et al.*, 2008; Roberts, 2008), much more could be done. This could open the way for new sources of funding to city-scale mitigation efforts, helping cities to exploit least cost options for reducing emissions in the coming decades.

The urban inventory challenge

The adoption of the "Global Greenhouse Gas Standard" at the World Urban Forum in March of 2010 is an initial step towards establishing an internationally-accepted local scale standard for measuring GHG-emission. However, it is useful to understand what has historically stood in the way of inventory harmonisation at urban scale. As was the case for national government, cities require solid technical input and international support to connect their inventory approaches or protocols to existing IPCC guidance and UNFCCC national reporting systems. Without these critical links to the institutional framework that has emerged to support international GHG monitoring, review and verification under the Convention, it will be difficult, if not impossible, to integrate urban-level mitigation action into emerging regulatory frameworks and markets for emission reductions.

Parties under the UN Framework Convention on Climate Change (UNFCCC) have adopted the IPCC methods as a standard framework for preparation of national inventories. National GHG inventories provide solid, comparable and verifiable emissions data at the national level to support peer-review and transparent assessment of mitigation performance under the UN Framework Convention on Climate Change and the Kyoto Protocol over time.[5] Importantly this system, when combined with other tools to ensure the quality of information and the ability to accurately track compliance and transactions, has enabled the creation of an international carbon market. That market has grown significantly in recent years, reaching a total value transacted of about USD 126 billion (EUR 86 billion) at the end of the year, double its 2007 value (Capoor and Ambrosi, 2009).

Assuming that comparability across entities is desirable, the IPCC guidance for national inventory preparation is a necessary starting point (UNFCCC, 2002). For example, in response to the need for harmonised approaches for "entity-level" reporting, the World Resources Institute and the World Business Council for Sustainable Development (WBCSD) collaborated to develop "The Greenhouse Gas Protocol", primarily for corporate use to track emissions (WRI/WBCSD). It builds on the IPCC guidance, but adapts it for use at a different level or scale of activity.[6] In recognition of the importance of the public sector and to better address their needs, the WRI/WBCSD is currently developing a *Public Sector Protocol* in co-operation with the US Logistics Management Institute (LMI), the US Environmental Protection Agency (EPA) and the US Department of Energy (DOE) (in final draft form as of July 2010). However, the approach remains constrained to tracking "entity-level" emissions.

Historically, no single protocol or set of guidelines has been adopted to harmonise compilation of data, estimation of emissions or reporting of comprehensive urban inventories including both operations-related[7] and territory-wide emissions. With neither a unilaterally accepted protocol nor the economic or financial incentives to further a harmonised approach, cities have taken different approaches to defining what sectors to include, in establishing the geographic boundaries of the area included, as well as in aggregating data. Currently, any comparison across existing city-scale inventories is hampered by the diversity of approaches, some of which are outlined briefly here.

At the local/regional level, the California Climate Action Registry (CCAR) is the first state registry to have developed a standard inventory protocol and set of methods for inventory preparation by cities building directly on the WRI/WBCSD work (CCAR, 2006). In 2006, San Francisco became the first city in the United States to submit an inventory validated with the CCAR protocol, which focuses on city operations. More recently, a number of US states have formed "The Climate Registry" which is intended to establish a harmonised system for entity level reporting across participating states and could expand the influence of the CCAR city-scale protocol.

As a transnational network, the ICLEI Cities for Climate Protection programme[8] has been active worldwide over the last decade to support mitigation action at the local level (see also below). Each of its more than 700 member local governments has committed to produce an emissions inventory using the protocols, guidelines and accompanying software developed based on the work of the WRI/WBCSD.[9] Embedded in the protocols and software are a number of inventory methods and a simple reporting structure as well as the possibility of tailoring to different national contexts. However, cities have wide choice in how they conduct inventories (geographic scope, sectors, etc.) and the ICLEI guidance points out that it is a tool explicitly developed to enable city management of emissions over time rather than to permit cross-city comparisons.[10]

There are some specific nationally led examples, such as in France the *Agence de l'Environnement et de la Maîtrise de l'Énergie* (ADEME), an inter-ministerial body working on environmental issues, has created the Bilan Carbone, an emissions accounting system developed for both corporate as well as municipal users. The tool looks at both city operations as well as emissions occurring within the geographic boundaries of cities, focusing on 10 primary emissions areas: energy generation, industrial processes, the service sector, residential, agriculture and fisheries, freight, passenger transport, construction, and waste disposal. The Bilan goes beyond direct and indirect to include the emissions associated with products consumed (*e.g.* emissions embedded in the production of cement used in city infrastructure) as well as the tourism-related air travel for destination cities. The ADEME has also established a structure both to train evaluators and to partially finance local-level inventories through grants. Developed in part by the national government, many French cities have used the Bilan Carbon to evaluate their emission levels. However, as with the ICLEI inventory tool, cities have choices in what they include in their inventory. As a result, application of Bilan Carbon leads to incommensurable results across applications.

A review of selected city inventories provides an overview of the range of technical issues embedded in the task of inventory preparation that influence comparability (see Table 10.1). Beyond differing reporting formats or inventory construction protocols, these features include:

- Different definitions of the urban area (*i.e.* is it defined by the larger metropolitan region or the city limits, or by something else).
- Choice of inventory years presented.
- Scope or boundaries of the inventory, *i.e.* whether or not more than city-owned operations are reported, and whether indirect emissions are included or not: *e.g.* treatment of electricity emissions.
- Methodological issues.

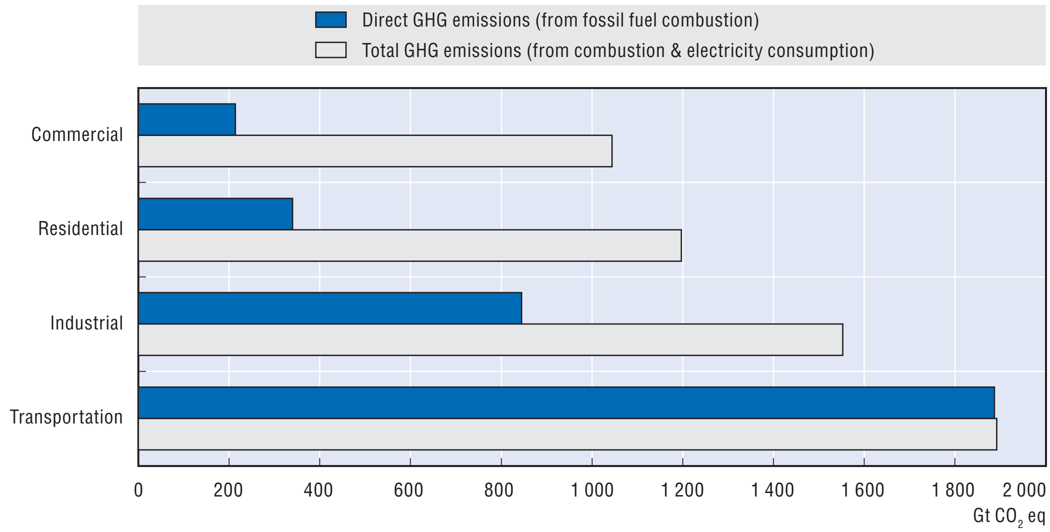
Table 10.1. **Selected city-scale GHG inventory reports: Comparison of key features**

Basic Information				Inventory				
City	Region	Population	Metro	ICLEI CCP	Data year(s)	Indirect	City Operations Breakout	Protocol
Seattle	WA	573 911	City limits	Yes	1990, 2005	Yes	Yes	GHG Protocol; IPCC National Guidelines
Vancouver	BC	2 600 000	Lower Fraser Valley	Yes	2005	No	n.a.	IPCC National Guidelines
New York	NY	18 815 988	NYC Metropolitan Region	Yes	1995, 2000, 2005	Yes	Yes	CCAP ICLEI
San Diego	CA	1 291 700	City Limits	Yes	1990, 2004	Yes	Yes	n.a.
Toronto	ON	2 503 281	City limits	Yes	2004	Yes	Yes	CCAP ICLEI
San Francisco	CA	7 264 667	County	Yes	2005	Yes	Only	CCAR
Columbia	MO	99 174	City limits	Yes	2000, 2005	n.a.	No	CCAP ICLEI
Northampton	MA	28 978	City limits	Yes	2000	Yes	Yes	CCAP ICLEI
Palo Alto	CA	61 200	City limits	No	2005	Yes	Only	CCAR
Sacramento	CA	475 743	City limits	Yes	2004	Yes	Only	CCAR
Santa Barbara	CA	90 400	City limits	No	2005	Yes	Only	CCAR
Somerville	MA	77 478	City limits	Yes	1997, 1999	Yes	Yes	CCAR

Sources: 2005 Inventory of Seattle Greenhouse Gas Emissions: Community and Corporate; 2005 Lower Fraser Valley Air Emissions Inventory and Forecast and Backcast; Inventory of New York City Greenhouse Gas Emissions; City of San Diego Greenhouse Gas Emission Inventory; *Greenhouse Gases and Air Pollutants in the City of Toronto: Toward a Harmonized Strategy for Reducing Emissions*; Annual Emission Report: City of San Francisco; City of Columbia Emissions Inventory; Executive Summary Greenhouse Gas Emissions Inventory Summer Internship (2001), Cities for Climate Protection Campaign City of Northampton; Annual Emissions Report: City of Palo Alto; Annual Emissions Report: City of Sacramento; Annual Emissions Report: City of Santa Barbara; Greenhouse Gas Emissions Inventory Report: Including Recommendations for the Emissions Reduction Plan.

A review of each of these issues in turn provides insights to the complexity of developing comparable inventories. A key issue is the geographical boundaries as well as the technical boundaries for inventories. As Diane Wittenberg, then president of California Climate Action Registry (CCAR) commented in 2006: "*The hardest part is boundaries, what's in and what's out… some of them are reporting (individual) buildings in the city, and others are skipping things like the airport. And you've got everything in between. … so we're looking forward to tightening up the way that cities are reporting*" (as cited in Corfee-Morlot, 2009). Table 10.1 considers a selected number of US and Canadian cities indicating the range of choices. Some urban areas limited their study to administrative boundaries (*e.g.* Seattle, Toronto, New York City), while others chose to include the entire metropolitan zone and/or the surrounding region (*e.g.* Vancouver, including the Lower Fraser Valley). The choice of inventory years also appears to vary widely across cities. On the scope of GHG covered, the majority of the inventories outlined in Table 10.1 take both direct and indirect emissions into consideration. Direct emissions are those produced by operations occurring within local boundaries by local activities, such as transport, commercial and residential fuel combustion, industrial production or processes as well as the treatment of waste. Indirect emissions are those resulting from energy use or imports but where the emissions occur outside local boundaries (*e.g.* electricity or steam production). Central to the question of direct or indirect emissions accounting is how to deal with the electricity sector, as most often electricity is generated outside city boundaries but largely consumed within them, *e.g.* by residential and commercial customers (Figure 10.1).

Figure 10.1. **Boundaries for GHG emissions accounting: Direct and indirect emissions (US, by sector, 2007)**



Source: Data from US EPA (2008), Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2007.

StatLink http://dx.doi.org/10.1787/888932342620

Beyond the challenge of addressing electricity emissions for urban energy use is that of how to address emissions embedded in products purchased and used in cities. These more extended analyses represent the "carbon footprint" of urban consumption activities, but go beyond the accounting of emissions within administrative geo-political boundaries, which has been adopted by the IPCC national GHG inventory guidelines (UNFCCC, 2002). Accounting for city-scale carbon footprints could be an important tool and source of information to support policies that target consumer behavioural change to limit emissions, but for consistency of reporting purposes, these emissions must be separable.

Another important boundary question is how emissions from the transport sector are accounted for. There is no harmonised approach or broad agreement on how best to allocate a share of national or regional transport activities to urban areas. A variety of different models and assumptions are possible, each with different outcomes.

Finally, there are other methodological differences associated with individual emission source categories. These include, for example, how to estimate the emission factor for electricity when emissions will vary by type of primary energy used to generate electricity? Beyond limiting the ability to compare emissions between cities, the level of aggregation and choice of methods to estimate and report emissions may alter the usefulness of the inventory for policy development. These differences suggest the urgent need for a harmonised set of methods and reporting protocols.

Towards harmonised reporting, comparable data

Groups such as ICLEI have made an excellent start on developing rigorous protocols and guidelines in co-operation with the World Resources Institute and the CCAR. In 2008, an emissions reporting protocol was developed in the United States/North America for use at the local-level in co-operation between WRI/WBCSD, the California Climate Action Registry (CCAR), the California Air Resources Board (CARB), ICLEI-US and The Climate Registry. The resulting *Local Governments Operations (LGO) Protocol* is a programme-neutral document containing general guidance on the specificities of calculating emissions from local government operations. Each of the participating entities have equally developed separate, programme-dependent supplements to be used in conjunction with the LGO Protocol.[11] Further, the above-mentioned WRI/WBCSD *Public Sector Protocol* recommends that local governments using their standard consult the *LGO Protocol*. While the protocols remains focused on operations-related emissions, a territorial-based approach is currently in discussion.

As with the challenge of developing firm-level reporting guidance – which was led by WRI/WBCSD – the tools that cities use to monitor progress will need to be linked up or nested in the IPCC national GHG inventory guidance to avoid double-counting with other local authorities or even across sectors as national governments establish nationwide policy frameworks. It will require support and resources from both national governments and the international community, including from experts engaged in the review and monitoring taking place under the Convention. While it would take time and resources to get such a system up and running, it would be a step in the right direction to empower cities in their efforts to achieve cost-effective GHG emission reductions.

As mentioned above, the most recent development in the quest towards a global local-scale inventory standard has been taken by the UN Environment Programme, UN-Habitat and The World Bank with the launch of the "Global Greenhouse Gas Standard" at the World Urban Forum in March of 2010. The launch of this programme has taken the first steps towards an internationally-accepted standard, based on both the existing WRI and ICLEI programmes. Taking a territorial approach to account for emissions from a city's energy sources, industrial production, transportation, farming, forestry and waste, among other sectors, this standard includes all six IPCC-recognised greenhouse gases. Further, it attempts to deal with a certain portion of indirect GHG emissions, including the importation of heat and electricity. However, while a key step forward, much work remains to ensure its international adoption. For example, in France where the recently voted (June 2010) Grenelle II legislation requires that local authorities in urban areas greater than 50 000 people conduct mandatory GHG inventories, no reference has been made to the Global Greenhouse Gas Standard. Thus efforts to ensure its widespread adoption will be key in ensuring international diffusion and comparability of data across regions and localities. Much may still depend on the development of incentives, such as mitigation action financing, tied to an international standard to further and ensure its widespread adoption by both national and local authorities.

Assessing regional and local impacts through sub-national science-policy exchange

A second priority for national-local collaboration is on science-policy capacity building and information. The aim of any such effort should be to establish a capacity to improve understanding about how climate change will affect cities. More detailed regional impact or risk assessments, in turn, could be expected to influence the politics of climate change from the global to the local scale (Harris, 2001; Shackley and Deanwood, 2002). Importantly, the assessment of climate impacts, vulnerability and risk at regional scale facilitates reflection about both adaptation and mitigation. That is, it supports dialogue and discussion about what types of risks are of greatest concern to affected populations and what adaptations might be most appropriate in local contexts, and it facilitates communication about what climate change is and why we need to do something about it to mitigate emissions (Corfee-Morlot *et al.*, in OECD, 2008).

Some amount of climate change is unavoidable no matter how much we mitigate. To understand and properly assess adaptation options, cities require information from scientific impact assessments to consider how climate change may play out in local contexts to impact people, urban settlements and infrastructure. What will the temperatures of the 2020s or 2030s be? How will flood risk change in the coming five years or more? And how will these climate changes interface with urban environments?

Climate science over the last decade or so has focused on large, global models that integrated different types of physical models to predict how the atmosphere will interact with oceans to change climate over time (IPCC, 2007). There is little regional information coming out of these science assessments so working at local or sub-national levels requires another layer of effort and a special set of tools to scale down or relate global change predictions to local or regional conditions (Hallegatte *et al.*, 2008). This can be done in a variety of different ways, but it takes time, expertise and money. It is research-oriented rather than policy-oriented work and organising funding and institutional capacity to make it happen in a timely manner can be difficult.

Establishing capacity to generate and use impact or risk assessment information at local or sub-national scale is a science policy exercise that presents a range of technical and procedural or institutional challenges.

On the technical issues, a recent OECD working paper proposes a framework to guide local scale impact assessment, including how global modelling results can be translated to a city scale as well as various issues in assessing climate impacts through use of a range of metrics (physical and monetary) and costs of responses under different conditions (Hallegatte *et al.*, 2010). In particular, it lays a conceptual approach to assess the avoided-impact benefits and the co-benefits of local adaptation and global mitigation (under different adaptation scenarios). Moreover, two city case studies – Copenhagen (Hallegatte *et al.*, 2010) and Mumbai (Ranger *et al.*, 2010) – have been conducted to test and refine this framework.[12] Beyond providing original and detailed assessments of climate change impacts in these locations in the 2070s/80s timeframes, these studies have also proven to be vehicles for engagement across key stakeholders in these locations. In particular, they are serving to stimulate dialogue among affected stakeholders across difficult questions such as what priorities to establish for adaptation investments given the range of possible outcomes surrounding uncertain climate projections (Hallegatte *et al.*, 2008). This highlights that procedural issues are also important, *i.e.* it is insufficient to have good scientific or technical analysis. To make good decisions requires active reflection and dialogue between expert and stakeholder communities.

On the procedural or institutional side, there is a need for active interaction between customers for information – policy makers and other decision makers – and the information suppliers, notably scientists and other experts (Stern and Fineberg, 1996). There are examples featuring state-of-the-art deliberative processes to engage stakeholders from the start to shape the framings and findings of assessments. In Canada, for example, there is now some experience with regional (sub national) participatory integrated assessment to support watershed management and climate change adaptation decision making (Cohen *et al.*, 2004; Vescovi *et al.*, 2007; Yin and Cohen, 1994). An example of multi-lateral collaboration using deliberative methods exists in the recent assessment of the Arctic region. The Arctic Climate Impact Assessment was published in 2004 and, importantly, sponsored by the Arctic Council, which represents eight member-state governments (Canada, Denmark, Finland, Iceland, Norway, Russian Federation, Sweden and the United States) and six permanent participants including two indigenous peoples' non-governmental organisations (ACIA, 2004).[13] This study was unique as it was both deliberative, employing a number of different methods to engage affected stakeholders, as well as an international process to facilitate deliberation among state actors with an interest in the region. More recently, the City of Los Angeles convened academic and environmental organisations to develop an outreach and public participation strategy for the City's Climate Program, which is based on over 150 stakeholder interviews with representatives of environmental organisations, financial institutions, business interests, media and movie industries, and youth groups (City of Los Angeles in OECD, 2009).

Policy-driven scientific efforts to predict regional climate changes are also found at local and regional scales, for example, in the United Kingdom (McKenzie *et al.*, 2006; West and Gawith, 2005) and in the United States (Hayhoe *et al.*, 2004; Moser, 2005; Parson *et al.*, 2003). UKCIP works on a contract basis with different sub-national regions or local communities. Its main source of funding comes from the *Department for Environment, Food and Rural Affairs* as well as from other contributors including the Environmental Change Institute (Oxford University) and the Government's Knowledge Transfer Partnership scheme (UKCIP, 2005). Some of the results from the UKCIP suggest that cities provide a useful spatial scale for the stakeholder engagement in decision making. In the United States, initial climate impact assessment was conducted through an extensive nationwide effort (USNAST, 2000). This national process featured a broad-based consultative process to engage local stakeholders across different regions of the United States in the preparation and vetting of these reports (Moser, 2005; Parson *et al.*, 2003). Although the national process in the United States after 2000, with the change in administration under President George W. Bush, the regional networks of people who worked on these studies have continued to support regional impact assessments in state and/or non-governmental venues (*e.g.* in the case of California, see Corfee-Morlot, 2009).

Funding for such work can and often does come at least partly from national governments, or relevant sub-national authorities, as it provides a public good that can facilitate adaptation across urban regions in an entire nation or region. Often the work can be carried out in local research centres or universities and joined up through "boundary organisations" to policy or other decision makers. Again the lead time is long, often requiring nearly a decade to build significant expertise and competence in this area, hence the need to start today.

Table 10.2 highlights a number of different institutional models that have grown up in different places around the world to provide science policy support for impact analysis and adaptation policy decision making. In looking across the organisations studied, there is broad variation in their geographic scope and proximity to "local" clients, levels and sources of funding and key roles or functions of the organisation. However, there are also a number of common features. All of them focus on the same audience, aiming to engage business stakeholders, local governmental decision makers and other local citizens. Further, the organisations have various ways of interacting with the scientific community, acting either as consumers or as suppliers (by funding) of new scientific information. But they all target the same goal, which is to facilitate stakeholder and policy decision makers' access to and understanding of scientific information. Finally, all the institutions also target use of the local scientific community to contribute relevant information, working through local, regional and national universities, and other nationally or regionally supported research institutions.

Urban policy networks and climate change

As mentioned before, local authorities cannot effectively address the massive challenges posed by climate change without the involvement of a wide range of non-public actors, including citizen's group, local NGOs and the business sector. In this respect, they contribute to policy networks formation that underlines the concept of multi-level governance at the horizontal scale. As Bestill and Bulkeley (2004) found, transnational networks of cities have also been essential in promoting policy learning and change among local actors and epitomize the multi-level nature of climate change governance contributing to global environmental governance.

The role of non-public actors in climate change

Civil society actors can broaden public participation in democratic structures and provide a voice for those who otherwise might not have a means to express their views. Civil society actors also tend to work on issues where there is a perceived gap in the work of governments. Conversely, they can also enhance and complement the work of governments. Although there is no formal role for non-state actors in international climate policy negotiations, transnational NGOs have played a role in filling in some of the adaptation gaps, both playing an important role in both assisting climate-affected communities now, while also working at the international level to promote adaptation policies and generate sources of funding for adaptation activities. In particular, civil society actors have been deepening their work with cities, by providing information clearinghouses, networking opportunities, model policies, and acting generally as co-ordinators of climate activities world-wide. Therefore, civil society actors have already carved out a role for themselves and an expansion of this work can be envisioned for the future, particularly efforts centred on adaptation. An early sign of this reconfiguration occurred in 1992 during the United Nations Conference on Environment and Development in Rio de Janeiro when 1 400 civil society representatives participated in the formal conference proceedings and another 17 000 people attended a parallel NGO Forum (McGann and Johnstone, 2005).

The strong turnout of civil society organisations in the recent UNFCC COP14 conference in Poznan illustrates the increasing participation of non-governmental organisations in climate change conferences, albeit much of it in side events. Indeed,

Table 10.2. **Institutional models for climate change information development and exchange**

Organisation	Geographic scope and key role	Clients/audience	Interaction with scientific community	Source of expertise	Lead organisation	Core funding
IRI – International Research Institute for Climate and Society	**Africa/Asia Pacific/Latin America** ● Understanding local decision process. ● Sharing climate information to meet the needs of the decision makers. ● Linking institutions and build capacities to improve climate risks management. ● Develop climate information generating tools that meet local decision makers' needs.	● Developing countries' national and multi-national decision makers. ● Developing countries' public/ private sector. ● Developing countries' citizen.	Suppliers.	● Columbia University depending on the region. ● National/local Institutions. ● NGOs. ● Research centers.	Host Institution: ● University of Columbia Funders: Public and private sectors. ● NOAA Office of Global Problems. ● Several organisations involved in project funding.	Public/private USD 9 million/year.
Ouranos	**North America/Canada/Québec** ● Develop knowledge. ● Co-ordinate multi-disciplinary initiatives. ● Help decision makers to integrated adaptation to climate change into their decision processes.	● Public and private sector decision makers. ● Local stakeholders. ● Researchers.	Suppliers.	● Federal agencies. ● Local and national universities. ● National research centers. ● Ouranos.	Funders: Public and private sectors. ● Government of Quebec. ● Valorisation-Recherche Quebec. ● Hydro-Québec.	Public/private USD 12 million/year.
PIER-EA – Public Interest Energy Research, Environmental Area	**California/United States** ● Conduct and fund research in the public interest. ● Research the environmental effects of different energy technologies used in California. ● Attract collaborators to share data and work conjointly to develop mitigation strategies. ● Develop California's capability to make informed decisions on climate change mitigation.	● Californian decision makers. ● Private sector. ● Researchers.	Suppliers.	● Federal agencies. ● California State Agencies. ● Nonprofit groups and academic. ● Private laboratories.	Host institution: ● California Energy Commission Funders: Public. ● Charge on retail electricity sales.	Public USD 6 million/year.
UKCIP – United Kingdom Climate Impact Programme	**United Kingdom localities** ● Communicate information on climate change impacts to stakeholders. ● Provide policy-making tools to decision makers. ● Establish relationships between researchers and decision makers.	● Local authorities, business, central government, voluntary organisations. ● Local stakeholders. ● Researchers.	Consumers.	● Oxford University Centre for the Environment. ● Tyndall Centre. ● Research groups within universities across the UK. ● Private laboratories.	Host institution: ● Oxford University Funders: Public and local resources. ● UK Department for Environment, Food and Rural Affairs. ● UK's Knowledge Transfer Partnership scheme.	Public/private USD 1.25 million/year.
Club ViTeCC – Villes, Territoires et Changement Climatique	**France** ● Provide information to stakeholders, institutions and private sector on their roles in climate change adaptation. ● Rethink the infrastructure-related decision-making process. ● Make scientific and technical information understandable to local decision makers and developing the proper decision tools.	● Local and regional authorities, business sector. ● Private and public sector stakeholders.	Consumers.	● Private/public services. ● National meteorological center. ● National and international Universities. ● Known local and international experts.	Host institution: ● Caisse des Dépôts. ● Météo France. ● ONERC Funders: Private/public. ● Contributions from clients.	Public/private n.a.

Source: Websites: *http://portal.iri.columbia.edu/portal/server.pt*, *www.ouranos.ca/*, *www.climatechange.ca.gov/research/climate.html*, *www.ukcip.org.uk/*; *www.caissedesdepots.fr/spip.php?article647*.

Article 7, paragraph 6, of the United Nations Framework Convention on Climate Change allows for the admission of non-governmental organisations to sessions of the Convention bodies as observers.

Although many for-profit entities have now addressed climate change through corporate social responsibility activities and/or sustainability efforts, businesses have only just begun to take an active role to establish partnerships with local governments in the climate planning process. Firms have long been widely involved in the implementation process but not so much in the early stages of policy making at the local and regional scales. The reason for this may be, in part, because although many cities around the world have established climate action plans that project the types of activities that will be needed in order to reduce GHG emissions and plan for adaptation, the implementation of these plans is still in the beginning stages.

Role of non-governmental actors in the local policy process stage framework

The involvement of the different local stakeholders is particularly important in the phases of agenda setting, policy formulation, implementation and dissemination of knowledge of the policy process stage framework.

Agenda setting

Support from the business sector and general public provides an important driver and motivation in the agenda setting for climate change action plans and policies at the sub-national level. This support may take the form of a positive climate of public opinion or a lack of overt opposition from key interest groups.

Citizens' participation in local agenda-setting has taken different forms. At the global scale, the 1992 United Nations Conference on Environment and Development gave rise to Agenda 21 (LA21), which was an initiative that not only put "sustainability" front and centre, but also provides a strong basis for understanding local democratic participation and a, "community's right (whether the community be defined as indigenous, rural, local, or other) to participate in decision making processes at the local level is promoted through themes of inclusion, local knowledge, and, tentatively, empowerment and capacity building" (Summerville, 2008). Local authorities are the lead players charged with implementing the sustainability objectives of LA21, and have used a variety of models engaging public participation. These have ranged from individual projects to larger involvement, such as the European Commission Water Framework Directive, which requires active stakeholder involvement.

In elaborating their agenda, sub-national authorities have developed different participative methodologies to guarantee that climate policies are developed with input from different types local stakeholders. The formation of policy networks and research groups has been critical to launching a climate agenda in many cities. The City of Paris for instance established thematic working groups that were given the mandate to prepare policy recommendations which were synthesised in a white book presented in January 2007 to the Council of Paris that led to an Action Plan adopted the same year.

Aside from integrating input into climate change action plans, citizens may spur action through climate litigation. This strategy has the potential to produce immediate action, while also laying the groundwork for future policy action on climate change. Using climate litigation as a tool can have one or more of the following results: clarify existing laws, challenge corporate behaviour, assign responsibility, provide opportunities for seeking damage for climate-related injuries, stimulate and inform public debate and climate advocacy (Moser, 2007). For example in Dieter Janecek v Friestaat Bayern (C-237/07 European Court of Justice 14 May 2007), Dieter Janecek, a German Green Party member living near Munich's central ring road, complained to the local authorities that particulate levels had exceeded legal limits for more than the 35 days permitted under European standards. When his request to the local authorities to draw up a local action plan to address the problem was turned down, he took his case to the ECJ. In July 2008 the ECJ ruled that European citizens are entitled to demand air quality plans from local authorities in cases there EU limits may be exceeded. While no such case has been tried in relation to climate change, it is conceivable that in the future, citizens could try to hold cities responsible for implementing climate policies and programmes. Climate change litigation, originally inspired by class action environmental law suits, has inspired some governments and/or stakeholders to use courts to facilitate environmental improvements at local scale.[14]

Policy formulation

As noted in the previous chapter, the formation of policy networks involving expert groups and commission, often organised on a sectoral-based, has been essential in the policy formulation stage.

The Climate Change Action Plan for the Northwest region of England for instance focused on the ability of regional organisations to "enable, encourage, and engage individuals, groups communities, partnerships and businesses in the move towards a low-carbon and well adapted region, recognising that regional organisations must exemplify good practice and catalyse action." It was developed with input from an advisory group consisting of experts and regional partner organisations. The consultation exercise included over 25 workshops and presentations and elicited over 130 responses from groups and stakeholders. Each action was tied to a lead organisation responsible for defining detailed steps required to deliver the action. To ensure long-term political support and focus, Guelph, Ontario, relied on working groups led by current and former mayors and council members with *ex officio* roles to co-ordinate the planning of the town's community energy plan.

A wide number of climate change planning efforts are underway to involve the private sector in climate change action planning. For example, in 2008, the Mayor of New York City announced the formation of a Climate Change Adaptation Task Force for the City, which is advised by the New York City Panel on Climate Change. This is comprised of leading experts from regional academic institutions and the legal, engineering, and insurance industries. The task force is one of the world's first municipal efforts to address climate change adaptation that includes participation of businesses alongside government, as can be seen below.

In most cases, the adoption of climate change action plan would not have been possible without the mobilisation of representatives of the business and community organisations. In Los Angeles, the plan adopted in 2007 received support from the coalition Green LA consisting of over 60 environmental and community-based organisations focussing on climate change (Bulkeley and Schroeder, 2008). It has also been supported by a large segment of the business community which were engaged in promoting green business solutions.

Implementation

Implementation cannot simply happen with the involvement of non-public actors. London's approach has been explicitly based on partnerships with the private sector, *e.g.* the London Climate Change Partnership, the London Hydrogen Partnership, and the London Energy Partnership. In the United States, more than 50 private firms are taking part in the ClimateWise Program, in which cities offer free assessment of a firm's energy, water, solid waste, transport, and recycling, and then offer guidance on becoming more efficient. The City of Chicago allocates grants for rooftop gardens and Seattle launched a programme in which businesses assess and cut their GHG (City of Chicago, 2005).

Dissemination of ideas and best practices

Many of the best policy ideas are disseminated and replicated elsewhere and might even inform a change in the original policy itself. However, many other useful policies live and die within a city's borders, although they may present useful solutions for other local governments. Although this stage is not a central component of the policy process, and may arise unexpectedly, it can be an important outcome of the local policy process, as it can inform future agenda setting and actions beyond the city or local boundaries. Civil society organisations, including industry associations, may play a key role in collecting and sharing information on climate change policy design and implementation.

A wide number of professional associations have issued guidebooks and designed training seminars to prepare urban managers to design more climate-sensitive cities. For example, the American Planning Association now includes climate change materials alongside other policy initiatives highlighted on its website, with the adoption of a new Policy Guide on Planning and Climate Change (27 April 2008). Recently (January 2009), APA released a memo that provides an overview of the ways in which energy and climate can be integrated into planning, and appears to be a document to that will launch some future work of this nature. Currently, the APA's website does now serve as a repository for information about state and local climate change initiatives, and a climate change reader for members is also available. Likewise, the US Green Building Council, a non-profit membership organisation, has provided technical education to its membership organisations. It currently has a comprehensive family of LEED® green building certification systems, educational programming, and a network of 78 chapters, affiliates, and organising groups. A wide number of initiatives in professional engineering, waste management, accounting, and public administration associations follow such initiatives.

Trans-border regional co-operation and international networks of cities

Transnational networks of local governments have formed to share strategies for combating climate change and building climate resilience in cities and regions. These networks are comprised of actors and/or institutions operating across multiple scales that involve, "regular interaction across national boundaries what at least one actor is a non-state agent or does not operate on behalf of national government or intergovernmental organisation" (Risse-Kappen, 1995). Many regions have co-operated on the transnational level to exchange policy approaches and metrics. In 1999, the Northern Virginia Regional Commission and the Verband Region Stuttgart initiated an international partnership and exchange. Numerous planning practices have diffused from Germany to Virginia through the partnership, including solar energy, storm water, transportation and open space planning policies (Medearis and Swett, 2003). In 2008, the partnership expanded its focus to include over 80 other European and North American regional councils, co-ordinated under the umbrella of the European Network of Metropolitan Regions and Areas. The partnership is unique in its problem-focused and goal-oriented efforts to identify, review, and apply innovative climate mitigation and adaptation policies among regions in Europe and the United States.[15]

The sustainability movement of the 1990s prompted the development of many large transnational networks of cities working for sustainability. From 1982 to 2004, there was a spike in the number of sustainability-related city networks, rising from 8 to 49 (Keiner and Kim, 2006). Box 10.1 profiles the climate change activities of some of the most important city networks.[16] National and transnational networks have been crucial in sharing experience, strengthening capacity-building, developing standardised methodologies and integrating cities' opinions at national and international levels. International networks of cities play a crucial role in enhancing a learning process that has resulted in the dissemination of best-practice methodologies and tools that can assist local governments to develop GHG-reduction strategies. This co-operation has produced a rich exchange of information on urban design, zoning, street patterns and public transportation that has been mirrored at the transnational level.

Beyond dissemination and best practice sharing, the transnational networks of cities have been increasingly active in the global agenda for climate change. Sub-national governments have mobilised internationally to develop/influence numerous bilateral and multi-lateral arrangements, which culminated in December 2007 with the launching of the World Mayors and Local Governments Climate Protection Agreement at the United Nations Climate Change Conference in Bali and the Local Government Climate Roadmap. Organisations participating in the Climate Roadmap process include the following partners: ICLEI, UCLG (United Cities and Local Governments), Metropolis, WMCCC (World Mayors Council on Climate Change), and C40 (Climate Leadership group). The Local Government Climate Roadmap process shadows the meetings and timetable of the UN process, and local governments have been capitalising on the momentum leading to Copenhagen to deliver their messages about local climate action. Overall, the association of local governments' networks calls for greater recognition of the cities in the next UN Framework Convention on Climate Change (UNFCC) framework. One desired outcome of this process is to politically influence climate negations during the United Nations negotiation process leading to a post-2012 climate agreement (ICLEI, 2010b).[17]

Though transnational networks seem to capitalise on the theory that higher membership rates correspond to increased bargaining power, the political benefits of these networks remain unclear. There appears to be much overlap in the types of activities that many networks are involved in, with many of the same municipal players (cities) involved in multiple initiatives. Although many key networks have come together through the Roadmap process, it is unclear to what extent these organisations are otherwise co-ordinated. Some observers have even argued that local governments have been compelled to join the CCP not only for the access to information that membership provides, but also because of the financial and political resources it affords (Betsill and Bulkely, 2004).

Summary points

Understanding climate change in a local context can highlight opportunities to maximise local benefits of mitigation and adaptation action. This will also make the issue of climate change more tractable politically. As a key tool for decision making at local

Box 10.1. **Transnational networks of cities addressing climate change**

- **ICLEI or Local Governments for Sustainability** is an international coalition of local governments committed to advancing climate protection and sustainable development. Originally named the International Council for Local Environmental Initiatives, ICLEI was founded in 1990 and now boasts membership of close to 1 200 cities worldwide, more than half of which are located in the United States. To help members achieve tangible reductions in greenhouse gas emissions and environmental impacts, ICLEI provides: tools, technical expertise, software training, policy assistance and national and international peer networks. ICLEI promotes a climate change planning process based on five milestones: calculating emissions, adopting targets, developing policies, implementing measures, and monitoring results. The organisation works through the Cities for Climate Protection (CCP) programme, which emerged as a network of local governments engaged in the international climate dialogue. When it was first founded in 1993, CCP was focused on developing energy and emissions inventory, and has evolved to include establishing and implementing GHG emission reduction targets for cities (ICLEI, 2010a; Lindseth, 2003).
- **Clinton Climate Initiative (CCI) and the Large Cities Climate Leadership Group (C40).** The Clinton Climate Initiative was launched in August 2006, and is currently working with 40 of the world's largest cities to reduce their GHG emissions (Clinton Foundation, 2009). CCI works closely with the C40 Large Cities Climate Leadership Group, serving as the exclusive implementing body of C40 works. Pledged to reduce carbon emissions and increase energy efficiency in large cities across the world, the C40 forum brings together four of the world's largest energy service companies, some of the world's largest banks, and at least 15 of the world's largest cities, to reduce energy consumption in existing buildings.* This means that CCI works with partner cities to, "develop and implement large scale projects to improve energy efficiency and directly reduce greenhouse gas emissions in buildings, waste management, transportation, outdoor lighting, ports, and other areas" (Clinton Foundation, 2009). From Seoul to Johannesburg it helps the largest cities in the world retrofit their municipal buildings, public housing and commercial buildings.
- **UCLG (United Cities and Local Governments).** UCLG is a transnational network comprised of individual cities and national associations of local governments which in total represent over half of the world's total population. Subsequently, more than 1 000 cities in 95 countries are direct members of UCLG, along with 112 Local Government Associations (LGAs). UCLG aims to be "the united voice and world advocate of democratic local self-government, promoting its values, objectives and interests, through co-operation between local governments, and within the wider international community" (UCLG, 2009). To that end, this network has taken an active role in climate change, having recently adopted the World Mayors and Local Governments Climate Protection agreement.
- **The EUROCITIES network** was founded in 1986, and now includes the local governments of more than 130 large cities in over 30 European countries. The network is poised to provide a voice for cities in EU governance structures through engagement in dialogues with the European institutions on all aspects of EU legislation, policies and programmes that affect cities. It is designed, according to one former EUROCITIES official, so that cities should "overcome their overt competitiveness" and make efforts to speak with "one voice" in order to put "more pressure on national and European institutions" (quoted in Heinz, 2005). In June of 2008, the mayors and leaders of EUROCITIES released a "Declaration on Climate Change". This document reflects the organisation's commitment to fighting climate change, and provides a framework for cities to adopt climate action plans, which are part of the suggested three-prong strategy. Guidelines for these climate action plans range from planning to reduce sprawl and increase green spaces to investing in the development of renewable energy production. Another piece of the EUROCITIES approach, as outlined in the declaration, includes integrating the concepts of the prevailing global objectives, based on input from the scientific and international policy negotiation communities, into their climate work. The third piece of the EUROCITIES approach involves measuring and reporting on GHG reductions to access the success of the climate action plans.

* C40 was founded when a group of 18 international cities met in London in 2005 to discuss collaborating to tackle climate change. The outcome of this meeting including a more formalised pledge that recognised the role and responsibility cities have in addressing climate change.

Source: Clinton Foundation (2009), "Clinton Climate Initiative", *www.clintonfoundation.org/what-we-do/*, accessed 22 January; Heinz, W. (2005), "Europe and German Cities", German Institute of Urban Affairs, Vol. 44, No. 2; ICLEI (ICLEI Local Governments for Sustainability) (2010a), "ICLEI Members", ICLEI, *www.iclei.org/index.php?id=global-members*, accessed 1 September, 2010; UCLG (2009), Local Government and Action on Climate Change in Poland, *www.cities-localgovernments.org/uclg*, accessed 11 February 2009.

scales is an exchange that allows for an interface between experts and local stakeholders, including local government, to build understanding about how climate change may affect local development choices and how those choices will affect the future climate. This is referred to here as an analytic-deliberative exchange.

This chapter calls for national governments to work with local authorities to develop tools and opportunities to use an analytic-deliberative process for decision making on climate change. A first step towards enhanced multi-level governance could include the development of better urban GHG inventory tools and capacity for local science-policy assessments. On the first suggestion, better tools for comparable emission reporting and performance assessment could expand opportunities to assess progress and learn from urban scale action, to share experience and lessons from city mitigation efforts. Making city GHG inventories comparable will require higher level agreement (*i.e.* ideally at international level) on a common format for reporting as well as on key methodological issues. Consensus will be needed on how to treat key issues such as those outlined above in a consistent manner. Even if cities are given the flexibility to construct inventories with different boundaries (*e.g.* in terms of reporting direct and indirect GHG emissions), at a minimum it will be necessary to report these in a modular manner such that comparable estimates could be constructed. Due to the high costs associated with increasing the quality of data necessary to produce strong, comparable emission inventories, it will most likely be necessary to find a middle ground, with enough detail to remain useful, but not so onerous as to make its production burdensome or financially unfeasible for local budgets. Ultimately a stronger urban inventories tool will allow cities better access to international carbon markets as a possible source of financing for local action.

A second multi-level governance priority is for national government support to local decision making through development of analytic-deliberative capacity at local scale to generate and use scale-relevant scientific information on impacts of climate change, and other policy-relevant research (*i.e.* on the technical options to adapt or mitigate and their costs). This will necessarily be part of an iterative process engaging researchers and stakeholders (including city authorities) in an ongoing exchange. Beyond engaging relevant participants, a first task is to establish a discursive process that allows ongoing exchange so that core research questions are framed with input from decision makers and decisions are made in local contexts based on the best available information from the scientific and research community. Up-to-date information on climate change impacts provides a foundation for communication about climate change with stakeholders and a means to generate understanding and concern about the issue as well as support for policy reform and behavioural change to respond. It is a means to bring the abstract and distant problem of climate change into a local context and help people – investors and consumers alike – to relate it to their daily lives so that they can think about how to address it. It provides at once a motivation for mitigation and a powerful source of information for decisions on adaptation.

A third priority is for national governments is to encourage better development of urban policy networks, and in particular the engagement of regional and local non-governmental stakeholders at various stages of the policy process to deepen knowledge, formulate and implement strategies for mitigation and adaptation that resonate from the bottom up. This will help local authorities to shape social norms through reflection about different possible urban forms and their interface with climate change. In particular, it provides a vehicle to more carefully adjust and align local frameworks to move in the right direction so that they identify where perverse incentives exist and suggest how they might be reformed. The aim is to allow for more systemic changes in urban planning and development and incentivise technology as well as behavioural change to build climate resilient, low-carbon economic growth. Strengthening inter-regional/urban and transnational policy networks might also be encouraged as another means to assist with identification and dissemination of good practice.

Notes

1. This perspective reinforces the importance of dialogic processes – of dialogue and of the notion of trust – by offering opportunities for meaningful exchange among affected stakeholders, including experts, and in so doing to build human and social capital that contributes to problem solving over time (Bohman, 1996; Dietz, 2003; Healy, 1997 and Rydin, 2003).
2. This is based on Corfee-Morlot (2009) where this is referred to as a "Habermasian model of circuits of power" (Habermas, 1998, p. 354).
3. For example, following an initiative of city of Seattle's Mayor Greg Nickels, to date more than 900 US. cities have announced plans to achieve Kyoto-like emission reductions. These ambitious goals imply bringing city emissions to below 1990 levels by 2012 (*www.seattle.gov/Mayor/Climate/*).
4. Industry emissions may vary widely from location to location or even over time within a single location, *e.g.* as industries increasingly move outside of city boundaries this may dramatically change urban emission levels. Decisions of city governments may also have little influence over industry emissions relative to large influence of local policy over residential and transport emissions. Thus special attention to this source of emissions may be warranted in the assessment and comparison of urban emission performance across cities.
5. For access to latest inventory reports and data see *www.unfccc.int* (last accessed 8 December 2008).
6. It is important to note that a number of different registries and protocols exist in the United States to serve different purposes, some of which are mentioned here. Because there is no single top-down mandatory federal system requiring entity or state-level reporting, a patchwork of state systems, some of which are mandatory, combine with voluntary reporting. For a review see Rich (2008).
7. Operations-related emissions are those that stem from the functioning of the municipality as an organisational entity. Territory-wide emissions refer to all the emissions related to the economic and social activities found on the geographic territory over which the local government exerts control.
8. ICLEI is the International Council for Local Environmental Initiatives, which now also operates a Cities for Climate Protection Campaign. See *www.iclei.org/index.php?id=800* (last accessed 12 November 2007).
9. ICLEI released in 2008 its International GHG Emissions Analysis Protocol, reviewed by UNEP, WRI, the IEA, CCAR and a number of other organisations. To facilitate the production of emission inventories, ICLEI has developed two software emission calculators, the Clean Air and Climate Protection software and the recent online Harmonized Emissions Analysis Tool (HEAT).
10. See *www.icleiusa.org/cacp* (last accessed 12 December 2008).
11. See *www.theclimateregistry.org/resources/protocols/local-government-operations-protocol/*.
12. For more information on OECD work on cities and climate change, including links to this initiative from the Governance Directorate, please visit the website *www.oecd.org/env/cc/cities*.
13. See also *www.amap.no/acia*. It is interesting to note that the report stopped short of having powerful policy recommendations in part because of reluctant state actors.
14. For example, the City of New York is part of a climate challenge against the federal government, specifically targeting the National Highway Traffic Safety Administration (NHTSA). This challenge criticises the NHTSA's treatment and reclassification of CAFÉ (Corporate Auto Fuel Efficiency Standards), which incentivise the production of larger vehicles with lower fuel efficiency. Likewise, New York City has joined Connecticut and other states in a public nuisance challenge against five of the country's highest carbon-emitting power plants. This action is part of an effort to require these plants to gradually reduce their emissions, even in the absence of federally mandated standards.
15. See the Network of European Metropolitan Regions and Areas (METREX) website for more information (*www.eurometrex.org*).

16. Other organisations include the Climate Group (*www.theclimategroup.org*), World Mayors Council on Climate Change (*www.iclei.org/index.php?id=7225*), the World Mayors and Local Governments Climate Protection Agreement (*www.globalclimateagreement.org/index.php?id=7462*), Covenant of Mayors (*www.eumayors.eu/covenant_cities/towns_cities_en.htm*), Mayors Climate Protection Center (*www.usmayors.org/climateprotection/list.asp*), Sustainable Cities: Partners in Long Term Urban Sustainability (PLUS) Network (*www.sustainablecities.net/*), Cities Development Initiative for Asia (*www.cdia.asia/about*), Asian Cities Climate Change Resilience Network (*www.rockfound.org/initiatives/climate/acccrn.shtml#4*), Oslo-Denver-Initiative (*www.ceunet.de/oslo_denver_initiative.html*), and Global Legislators Organization for a Better Environment (*www.globeinternational.org*).
17. During the recent United Nations Climate Change Conference in Poznan, Poland (COP 14), local government representatives from ICLEI presented the Local Government Climate Roadmap to United Nations officials, which included a draft text of a COP Decision on Cities, Local Authorities and Climate Change was presented by local governments to the signatories to the Kyoto Protocol.

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Cities and Climate Change

As the hubs of economic activity, cities drive the vast majority of the world's energy use and are major contributors to global greenhouse gas emissions. Because they are home to major infrastructure and highly concentrated populations, cities are also vulnerable to the impacts of climate change, such as rising sea levels, warmer temperatures and fiercer storms. At the same time, better urban planning and policies can reduce energy use and greenhouse gas emissions and improve the resilience of urban infrastructure to climate change, thus shaping future trends.

This book shows how city and metropolitan regional governments working in tandem with national governments can change the way we think about responding to climate change. The chapters analyse: trends in urbanisation, economic growth, energy use and climate change; the economic benefits of climate action; the role of urban policies in reducing energy demand, improving resilience to climate change and complementing global climate policies; frameworks for multi-level governance of climate change including engagement with relevant stakeholders; and the contribution of cities to "green growth", including the "greening" of fiscal policies, innovation and jobs. The book also explores policy tools and best practices from both OECD and some non-member countries.

Cities and Climate Change reveals the importance of addressing climate change across all levels of government. Local involvement through "climate-conscious" urban planning and management can help achieve national climate goals and minimise tradeoffs between environmental and economic priorities at local levels. The book will be relevant to policy makers, researchers, and others with an interest in learning more about urbanisation and climate change policy.

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