WORLD ENERGY COUNCIL
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For sustainable energy.

Energy and Urban Innovation

World Energy Council

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Foreword and Acknowledgements

This report deals with the energy-related challenges that cities, particularly large and "mega-cities", will face during the coming decades. It analyses the technical and policy actions that must be taken if we want to meet these challenges, and the role energy companies can play in designing and implementing efficient solutions. The report is business and policy oriented.

It results from a twofold process:

- A bottom-up process in which WEC members carried out case studies on a comprehensive set of large to "mega" cities, both in the developed and emerging world.
- A survey of the literature by a writing team headed by the study director.

As study director, it is my great pleasure to acknowledge precious contributions by:

- Our chairman **Anil Razdan**, who gave us challenging intellectual orientations at the beginning of the study, helped us with his outstanding knowledge of the issues at stake, particularly in the emerging world, and took care of a very comprehensive case study of the city of Delhi.
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And last but not least…

The writing team (also listed below), a "dream team" indeed, I have had the chance to gather and work with. The outstanding competencies of the senior members and the enthusiasm, availability, efficiency and knowledge of the junior members made it a real pleasure to perform the task assigned to us by WEC.

Paris, July 2010
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Study Director

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Executive Summary

Introduction

This report outlines the energy-related challenges that cities, particularly large and “mega-cities”, will face during the coming decades. It analyses the technical and policy actions that must be taken to meet these challenges and the role the energy industry and business can play in designing and implementing efficient solutions. The report is the result of a bottom-up process in which World Energy Council members carried out case studies on a comprehensive set of large to “mega” cities, both in the developed and emerging world. It is complemented by an extensive literature study.

An expanding number of large cities face significant energy-related challenges now and in the future**. Technical and policy actions must be taken in order to meet these challenges.** In this context, energy companies play a crucial role in the design and implementation of efficient solutions. The report studies the growth, development, and energy-linked issues of large cities; develops concepts for a secure and sustainable energy supply and distribution system, including transportation; and recommends norms and the necessary steps to ensure sustainability. Cities studied include Tokyo, Mexico City, Delhi, Toronto, Shanghai, Cape Town, London and Paris (a comparison), and the San Francisco Bay Area. The report contains data, facts, analysis, and proposals concerning: urbanisation and the challenges for a sustainable energy supply (Chapter 1); assessments of the potential and costs of innovative urban technologies (Chapter 2); and descriptions of the “policy packages” aimed at overcoming the problems associated with cities (Chapters 3 to 5).

Rapid urbanization of the world population, already taking place, will be a widespread and strong trend during the coming decades. In the next 20 years, the equivalent of seven cities with ten million people will be added every year. This is partly driven by people’s general preference to be in a city slum rather than in a remote rural area, as the city provides more economic opportunities and better health and education benefits. The effect of this migration is complemented by a rapid urban population growth in many cities. As a result, cities concentrate a large part of a nation’s population and contribute disproportionately to the national and world economy.

At the city level, local authorities have options to reduce greenhouse gas (GHG) emissions. They can target the emissions over which they have direct control as an organizational entity (energy use in public buildings, public transport fleet, etc.). They can use their capacities and policy levers to reduce the GHG emissions stemming from those socio-economic activities over which they have administrative influence. Local authorities generally have significant direct and indirect influence over policy areas such as land-use zoning, transportation, natural resources management, building efficiency, waste and water services.

Even without anthropogenic climate change, the rapid urban growth in emerging and developing countries, mainly in the South, is a massive sustainability challenge and involves bringing urban services to all, as well as dealing with local pollution of air and water, and the production of solid waste. On the other hand, the mature and more slowly growing cities of the developed world, mostly in the North, need policies to retrofit existing buildings, reshape development to stop urban sprawl, and use a more systemic approach to energy networks. Cities, particularly coastal, also have to anticipate their adaptation to the effects of climate change.

Technology solutions

Many energy technologies which can improve the energy sustainability of mega-cities and smaller cities are found on the energy-demand side. **There are many mature technical solutions. The main difficulties lie in their adoption.** These mature technological solutions have costs that are well documented in many different geographic, social and political contexts. Nevertheless, there is the potential for these costs to decrease through incremental innovation and economies of scale. Technical solutions that are already mature for buildings include insulation, heat pumps and high efficiency gas boilers. Bus rapid transit (BRT), metro rail, tramways, and hybrid cars can move people and goods. Solar photovoltaic, energy from waste, and combined heat & power can be locally used to generate energy. Yet costs and potentials vary widely and there are no "best solutions" for all cities. In implementing technologies, consideration needs to be given to building stock, climate, urban shape, cultural behaviour, and financing possibilities.

Technology adoption is always a big challenge anywhere. Economic maturity (i.e., profitability within existing regulations and fuel prices) is never enough for a sustainable technology to be widely and rapidly adopted. Difficulties in adoption are rooted in immature and imperfect markets (inadequate workforce education, absence of competition between firms), in transaction costs, and in coordination problems and lack of planning. Institutional innovations to support the adoption of existing technologies (coordination of actors, education, market transformation, investment mechanisms, financing schemes, etc.) are therefore as important as purely technical innovation efforts.

Research, development and demonstration (RD&D) is still required to lower the cost and enhance the social acceptability of many "urban" energy technologies. In particular, RD&D is needed in the areas of high-temperature heat pumps, solar photovoltaic collectors, batteries for hybrid and electric cars, design concepts for electric cars, innovative insulation materials, multifunctional building materials (e.g., integrating cost-effective photovoltaic electric generators), lighting, domestic appliances, IT equipment and, more generally, RD&D focused on information technologies, which will become pervasive in cities. Although not only an urban problem, technical innovations are also needed in sustainable energy supply, notably in the "greening" of electricity generation.

Policy solutions

The challenges are to provide energy to all, to combat energy poverty, and to shape the rapid growth of cities in emerging countries and reshape

Cities should be given the power to experiment.

existing "rich" cities in order to curb GHG emissions and local, energy-related pollution. In doing this, **the strength of market forces on the land and building markets, as well as on the city's labour market, must not be underestimated. But urban planning at the appropriate stage is always an absolute necessity.** While there is no "ideal" city form, density thresholds do exist. There are, for example, robust density thresholds (50-150 inhabitants/ha), below which mass transportation systems are simply not economically feasible.

Policies are always packages of measures. It is not enough for technically and economically mature solutions to be available "off-the-shelf". Policy action plans are always a complex package of public investment, private investment and technical, institutional (to coordinate different types of actors), regulatory and financial measures. **Regulations must always be combined with incentives, information and other actions, aimed at improving market efficiency.**

Since providing energy to all, combating energy poverty, curbing GHG emissions and local, energy-related pollutions do not only depend on municipal and local policies, coherence across levels of government is required, with a clear distribution of tasks. Before defining local policies, an assessment of the jurisdictional capacity to act of local authorities is needed, followed by a shift of capacity to act towards the most appropriate policy level, if necessary. At the very least, a clarification of the responsibility among actors for each topic is needed. In many cases, cities should be allowed increased jurisdictional capacity to act on a number of energy-based issues. In particular, cities should be given the power to experiment. Everywhere, **cities must strongly improve their capacity for coordination, including internal coordination among municipal services, coordination between adjacent municipalities, and Public Private Partnerships (PPPs).**

The main outcome of PPPs is in transferring technologies and management efficiency to public services or dispersed small private businesses, to improve the overall efficiency of the process. PPPs also allow leveraging private-sector capital. However, even if they can greatly help, they generally cannot by themselves solve the financing problems of extending the basic services to the poor and curbing the GHG emissions. Public money is still needed. In any case, PPPs require a clear and stable legal and regulatory framework as well as setting up independent regulatory authorities, and substantial investment in social and human capital within the public administration.

Investment

Ambitious programmes to curb energy related pollution are often costly. In most cases, these imply large investments to substitute technical capital to replace fossil fuels and/or unskilled labour, but also complementary (as large if not larger) investments in human and social capital. Without the latter, the best technical solutions will fail. The ability to invest is therefore a strong constraint, contrary to the claim that there still exists everywhere a large potential of emission reduction whose cost is negative. Such a claim tends to neglect the transaction costs and the investments in social and human capital needed to

The challenges can be met with a package of technical, institutional, policy and financial measures. Regulations must be combined with incentives, information and other actions, aimed at improving market efficiency.

achieve the required institutional changes. From this point of view, **it would be fair to differentiate the burden between developing, emerging, and rich cities, and ask less of poorer cities.** For example, it is possible that urban governments in developing countries could be asked to choose Bus Rapid Transit (BRTs) over metro systems, since the former are much less capital intensive, although they emit more.

There are ways to increase the funds available to a municipality, particularly in the South:

- Increase land and properties taxes in a progressive way;
- Tax the capital gains on land and buildings streaming from public investments and regulation changes (both imply the setting-up of a minimal land registry and monitoring of the property market);
- Use of carbon finance, in order to sell emission rights to parties in the North, and, more generally, to benefit from future North-South transfers aimed at lowering the cost of curbing emissions and sharing responsibilities;
- Charge users the full cost of urban services.

However, the dilemma on tariffs and subsidies is still pending. The main idea of the 1990s, that the customer must pay the full cost of the urban services, has proved difficult to implement in the early part of the twenty-first century. **It is now clear that services for the poor will have to be subsidized for a long period of time if access rates are to improve rapidly.** In theory, these subsidies should take the form of budgetary transfers to the poorest, with the market price set at full cost in order to deliver the right economic signal. This kind of budgetary transfer is often difficult to implement, so that current practice of subsidizing energy prices indiscriminately for both rich and poor is usually the norm.

Conclusions

Instruments available to local-level governments include direct policy actions, enabling different groups involved in the policy process, as well as providing the information necessary to foster behavioural change by consumers. Policies instituted should be packages of measures. It is not enough for technical solutions to be available if no one can afford them. Strong and early public intervention is required to meet the challenges of urban development. And objectives must be kept simple and stable.

The challenges can be met with a package of technical, institutional, policy and financial measures. Regulations must be combined with incentives, information and other actions, aimed at improving market efficiency. Policies dealing with funding and financing cannot be separate from policies for design and/or implementation. Governance and accountability with appropriate targets must go hand in hand. Sustainability policies must be part of a coherent policy framework. Finally, regulations must be based on long-term and stable objectives, not short-term ones.

Chapter 1: The Energy Challenges of Urbanization

1.1 An Urbanizing World

1.1.1 Three Billion New Urban Dwellers by 2050

In 2008, for the first time in history, the proportion of the world's population living in urban areas reached 50% (Figure 1). If current trends continue it will rise to 60% by the year 2030.[1].

However, urbanization does not have the same meaning for developing and developed countries. While developed countries had already reached the 50% level in the 1950s, developing countries still concentrate most of their population in rural areas and will take approximately a decade to reach the same level. Least-developed countries where most of the population still lives in rural areas face the fastest urbanization rates in the near future.

Furthermore, in the next decades, the absolute growth of the urban population will be substantial. Since 2007 and looking forward to 2050, the world population growth will be around 2.5 billion, with cities absorbing around 3.1 billion inhabitants.[2] These projected figures indicate that not only will urban areas absorb all of the expected growth, but they will also draw a portion of the rural population.

1.1.2 Demographic Growth and Rural Migrations

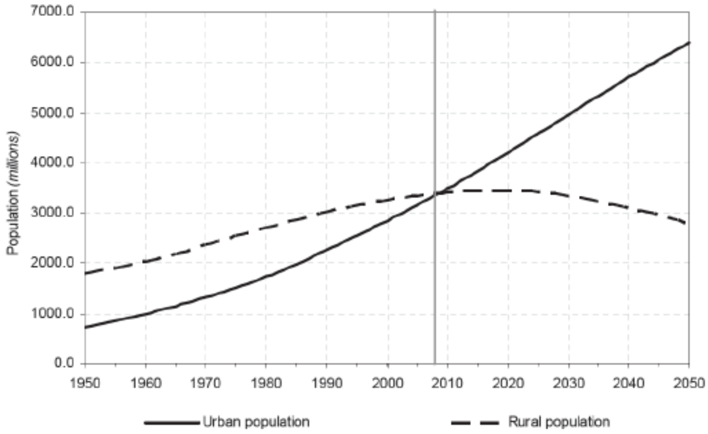
Urbanization is the result of "natural increase" of urban population, migration from rural areas and changes in city boundaries. The latter, even if it is not the result of absolute population growth, is very important since it is essential for the coordination of public policies and urban planning. In the early stages of urbanization, rural migration is the principal source of urban growth. This is because fertility rates tend to decline in urban areas and population growth due to migration is higher than that due to the natural increase of urban population. Nevertheless, recent estimates suggest that the main cause of today's urbanization is not migration but natural increase. According to the UN, out of 60 million of new urban population, 36 million are born there, 12 million are due to the reclassification of rural areas into urban areas, and the remaining 12 million corresponds to migrants.[3] In general terms, this implies a significant change in political attitude towards urban growth. It suggests that: governments are no longer concerned with keeping the rural poor from coming to the city (a policy that is still applied in most developing countries), nor are they focused on keeping control of (or adapting to) natural urban growth.

1.1.3 Urbanization Yesterday and Today

The speed with which people are moving into cities has scarcely changed since the end of the nineteenth century. The increase of urban population was 7.7% in 1880-1900 for developed countries, and was 7.1% for developing countries in the period 1985-2005.[4] Moreover, urban growth rates are expected to slow to around one to two per cent. However, there are some marked changes in

[1] UN-Habitat, 2009.
[2] UN, 2007.
[3] UNPF, 2007.
[4] World Bank, 2008.

Figure 1
Urban and rural population of the world 1950-2050
Source: UN 2007



i) the patterns of urbanization; and ii) the volume of people flowing into the cities.

Patterns of urbanization have changed markedly even in the last four decades: advances in medicine have led to higher survival rates leading to a longer-lived population, while transports cost have declined, leading to a more mobile population. Since the 1970s, railroad-freight costs have been reduced by half, maritime freight by almost 70% and road-transport costs by about 50%, despite the augmentation of energy and wage costs.[5] As a result, the area of interaction of cities today is not only limited to their nearby environment but extends to the whole world.

Nowadays, migration is not only fuelled by economic signals (for example, the wage differential between rural and urban areas), but by other factors such as environmental degradation, climate change, decreased productivity in agriculture, rural overpopulation and violent conflicts. Some examples of these factors include the 1.5 million people in Colombia forced to leave rural areas in the short period between September 1995 and June 2003 because of the activities of rebel groups; In India, in 2008, 46% of rural-to-urban migrants were households who owned less than 0.01 hectares of land—insufficient for subsistence. Unfortunately, there are also increasing numbers of "climate-change refugees"; it is estimated that, over the next 50 years, 20 million Bangladeshi will join their ranks, displaced by flooding.[6]

The volume of people moving to cities means that by 2030, almost all global demographic growth will occur in cities of developing countries, with the total population of these cities doubling from two to four billion people.[7] Accommodating two billion inhabitants in urban areas means building the equivalent of seven, new, ten-million-person cities each year, representing the equivalent of seven Shanghais or Jakartas, or ten Londons. This type of urban growth is unprecedented: for example it took 130 years for London to grow from one to nearly eight million inhabitants, although the same demographic leap has taken only 45 years for Bangkok, 37 years for Dhaka and 25 years for Seoul.[8] Cities in the developing world will require an increase of approximately 39,000 new dwelling units every day during the next two decades in order to cater to population growth alone.[9] Urban infrastructure (mass transportation, electricity and water distribution, etc.) and housing, which normally take years or decades to construct or reconfigure, are especially vulnerable to these demands.

Furthermore, recent evidence suggests that the urbanization occurring in developing countries is not always coupled with economic growth. Asia and Africa, despite following the same urbanization

[5] World Bank, 2008.

[6] Forero, 2003; NSSO, 2008; Karim, 2008.
[7] UNPF, 2007.
[8] UN-Habitat, 2004a.
[9] UN-Habitat, 2002.

path, have had divergent paths of economic growth. Fay and Opal find that urbanization does not stop during economic downturns.[10] In their study, out of 187 countries reporting annual negative growth over a period of five years, 183 experienced positive urbanization rates. In fact, the prime determinant of whether urbanization increases rapidly or not is not whether income growth is positive or negative, but whether the level of urbanization in the country is high or low. Countries in Africa and South Asia still have a long way to go and will continue to experience rapid urban growth rates. Conversely, Latin American countries, which already have up to 80% of their population living in urban areas, will experience smaller rates of urban growth.

1.1.4 Is Rural Migration Good?

As the most visible cause of urbanization, migration has been at the centre of urban policies for decades. For example, China had (and retains) strict regulations that block migration to urban centres, while India continues to support strict land regulations that make urban life inaccessible for many. However, these kinds of policies may generate unwanted economic and social side effects. A recent study of Chinese cities shows that more than half of them (63%) are significantly undersized because of mechanisms to control migration; moreover, the welfare losses (in terms of GDP performance) of being undersized are considerable.[11] In Indian cities, because government is unable to control migration directly, around 24% of city dwellers live in slums.[12]

While controlling urbanization through migration restrictions has been one of the main policies for tackling the "urban growth problem", the scientific community has attained a certain degree of consensus on the benefits and disadvantages of urbanization. Among other things, rural to urban migration allows the diversification of risk, and contributes to rural development by reducing poverty in rural areas and increasing productivity.[13] But it can also be seen as exacerbating negative impacts on the environment (relating to water-use, biodiversity, air pollution, etc.), as well as lessening citizen welfare through the saturation of urban infrastructure and the concentration of unwanted social disruptions (crime, violence, etc.). Urbanization, even when not playing a role in economic development, can be used to promote better health and education if well managed. Moreover, as the latest World Bank, *World Development Report*, for 2009, states, late developers face a different world, since cities are more populous and markets are more international. City governments can draw on more tools and greater shared knowledge (learning from others), i.e. international urban conferences, use of geographical information techniques for planning and technological advances in transport, etc.

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[10] Fay and Opal, 1999.
[11] Au and Henderson, 2005.
[12] NSSO, 2001.
[13] A person of the household goes to the city to find a job while the household stays in the rural area, diversifying the sources of revenues.

1.1.5 Is There an Optimal City Size?

During the Industrial Revolution, the urbanization of developed countries followed an increase in agricultural productivity, coupled with the continuous industrialization of their cities. The former fed the non-agricultural population in the cities, while the latter meant that industries absorbed unskilled migrants in their production lines. At the same time, the concentration of inhabitants within cities allowed human capital to grow. Agriculture flourished in response to the numerous innovations that developed as a result, such as the use of tractors and the rotation of cultures. As cities expanded and countries developed, the idea emerged that urbanization came with growth. By concentrating in urban areas, industries could gain from “agglomeration economies”.

Agglomeration economies were first described by Marshall as arising from labour market interactions, from linkages between intermediate and final goods suppliers, and from knowledge spillovers. Duranton and Puga reclassify these as “sharing, matching, and learning” mechanisms: cities allow industries and their inhabitants to share indivisible goods (roads, common transportation), find and match their skills more easily and learn from each other, improving productivity.[14]

Nevertheless, as cities grow, the gains due to agglomeration economies are accompanied by losses due to negative externalities. Traffic congestion, various kinds of air, water and soil pollutions, social segregation, and the explosion of slums have led to the understanding that there may be a trade-off between agglomeration economies and congestion effects. However, the literature has so far agreed on the point that there is not a single, optimal city size, but many and various. Furthermore, empirical data suggest that the balance between agglomeration economies and congestion effects has remained constant for large periods of time (explained by Zipf’s rank-size rule).[15] With dominating positive or negative net agglomeration externalities, the growth of the *ensemble* of largest cities should be above or below that of smaller cities, which is however not the case. Because agglomeration economies and negative externalities depend on variables like the structure of production and urban form or density profiles, each city has its pseudo-optimal size. And since urban planning can influence many of these variables directly or indirectly, urban policies can change optimal sizes. For instance, improving the public transport system can increase the labour market size and reduce local air pollution at the same time.

1.2 Mega-cities

1.2.1 Mega-cities Among Cities

The urbanization process is clearly visible in the rise of the number of cities and their increasing

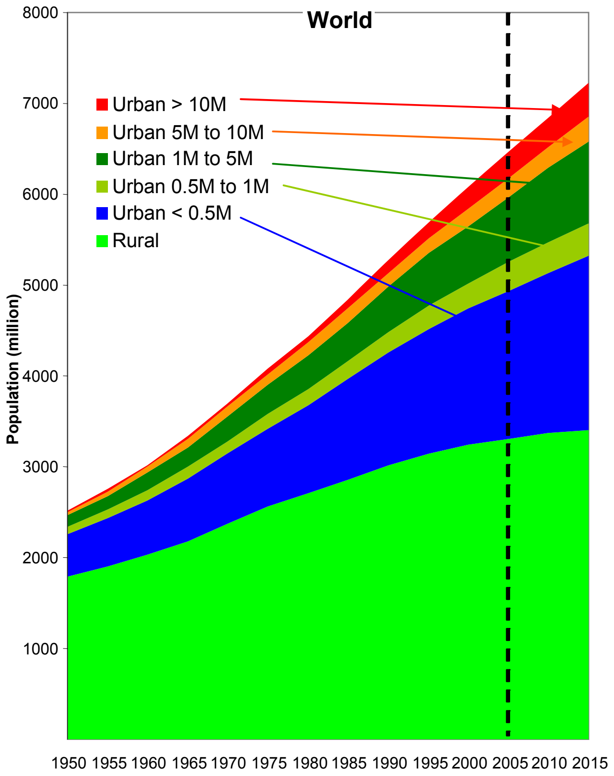
[14] Marshall, 1890; Duranton and Puga, 2003.

15 Gabaix, 1999; Zipf’s rule: with dominating positive or negative net agglomeration externalities, the growth of the *ensemble* of largest cities should be above/below that of smaller cities. Evidently, *individual* cities can forge ahead or fall behind the overall distributional pattern of aggregate uniform urban growth rates as outlined by the rank-size rule.

Figure 2

Distribution of Global Population between Urban and Rural Areas

Source: UN 2004b



size. While in 1975 there were around 179 cities with more than one million inhabitants, in 2007 the total had increased to around 430.[16]

As shown in Figure 2, most of the urban population still lives in small- or medium-sized cities. Only 4% of the urban population currently lives in "mega-cities", defined by the UN as urban agglomerations of more than ten million inhabitants. Nevertheless,

although small- and medium-sized cities have the largest share of the urban population, mega-cities tend to attract the most public attention. This is unsurprising: these cities are cultural, political and economic centres, with global renown. They provide the most obvious example of our urbanizing world, and demonstrate most clearly the advantages and disadvantages of life in the city. In addition, in many developing countries, a large share of the national population is concentrated in the largest city, which in many cases happens to be the capital. This is particularly apparent in Latin America, where there are 13 countries, in each of which 20% or more of the country population is concentrated in the country's largest city. Mega-cities also contribute disproportionately to both national and world economies. A recent study shows that the largest 100 cities of the world (in terms of population), contain only 9% of the global population, but account for 25% of global GDP. Furthermore, the 30 largest cities contain only 4% of the total global population, but produce 16% of global GDP.[17]

1.2.2 Mega-cities in the Developing World

The number of mega-cities has increased considerably following developing world urbanization. Between 1975 and 2010, the number of people living in mega-cities rose from 53.2 million to 318 million. In 1950, there were only two mega-cities, Tokyo and New York; by 2025 the number of mega-cities is expected to rise to 27. While most mega-cities are growing slowly, some are experiencing explosive growth. The population of Shenzhen (China) grew more than 10% per year between 1975 and 2005. Dubai (Arab Emirates), Lagos (Nigeria) and Dhaka (Bangladesh)

[16] UNPD, 2007.

[17] PWC, 2008.

Figure 3

The growing number of mega-cities in developing countries

Source: UN 2007

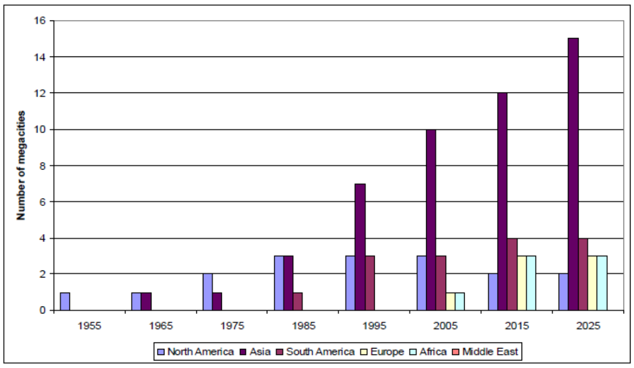


Figure 4

Basic services in selected mega-cities

Source: UN-Habitat 1993 and 1998

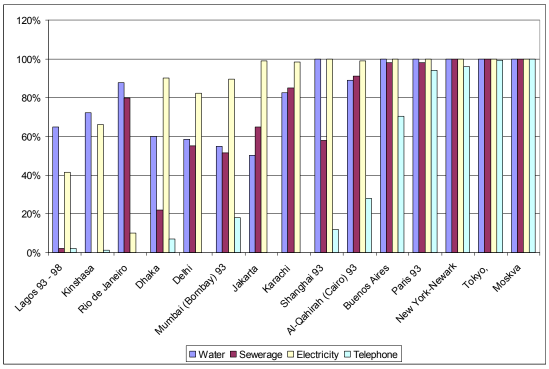


Table 1

Mega-cities 2010 and 2025

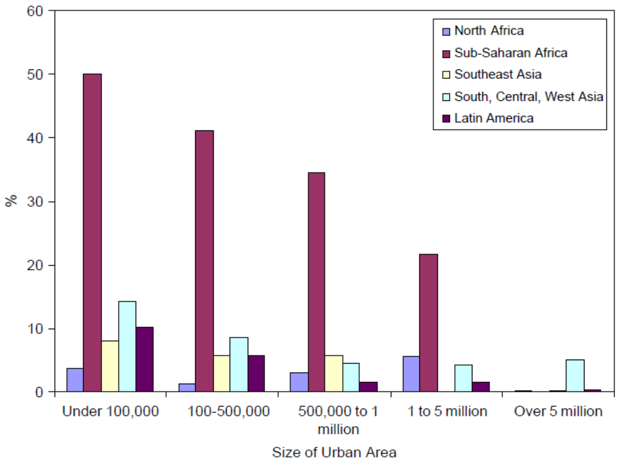
Source: adapted from UN 2007

City	Country	2010		2025		Growth (2010-2025)
		Population	Rank	Population	Rank	% Per year
Tokyo	Japan	36.1	1	36.4	1	0.06%
Mumbai (Bombay)	India	20.1	2	26.4	2	2.09%
Sao Paulo	Brazil	19.6	3	21.4	5	0.61%
Mexico City	Mexico	19.5	4	21.0	6	0.51%
New York-Newark	USA	19.4	5	20.6	7	0.41%
Delhi	India	17.0	6	22.5	3	2.16%
Shanghai	China	15.8	7	19.4	9	1.52%
Kolkata	India	15.6	8	20.6	8	2.14%
Dhaka	Bangladesh	14.8	9	22.0	4	3.24%
Buenos Aires	Argentina	13.1	10	13.8	16	0.36%
Karachi	Pakistan	13.1	11	19.1	10	3.05%
Los Angeles	USA	12.8	12	13.7	17	0.47%
Cairo	Egypt	12.5	13	15.6	13	1.65%
Rio de Janeiro	Brazil	12.2	14	13.4	18	0.66%
Beijing	China	11.7	15	14.5	15	1.60%
Manila	Philippines	11.7	16	14.8	14	1.77%
Osaka-Kobe	Japan	11.3	17	11.4	22	0.06%
Lagos	Nigeria	10.6	18	15.8	12	3.27%
Istanbul	Turkey	10.5	19	12.1	20	1.02%
Moscow	Russian Fed	10.5	20	10.5	23	0.00%
Paris	France	10.0	21	10.0	27	0.00%
Kinshasa	Dem Rep. Of Congo	9.1	22	16.8	11	5.64%
Jakarta	Indonesia	9.7	23	12.4	19	1.86%
Guangzhou (Guangdong)	China	9.4	24	11.8	21	1.70%
Lahore	Pakistan		-	10.5	24	-
Chennai (Madras)	India	-	-	10.1	26	-
Shenzhen	China	-	-	10.2	25	-

Figure 5

Percentage of households lacking piped water, flush toilet and electricity by size of urban and geographic region

Source: Cohen 2006



experienced rates around 5% for the same period. In fact, most mega-cities seem to follow a similar growth pattern: rapid and explosive growth for a couple of decades, followed by a diminution and stabilization of the growth rate. Thus, around the world, some mega-cities, such as Kinshasa and Karachi, are at a point of rapid expansion, while others, such as Tokyo and Buenos Aires, present insignificant or even negative rates of population growth (Table 1).

Figure 3 and Table 1 show how mega-cities were at first concentrated in Europe and North America, while in recent years, they are increasingly developing in Asia and Africa. It is no surprise that in 2025 Asia will have 15 mega-cities, out of a total of 27, since it accounts for more than half of the world's population. However, Africa's mega-cities are experiencing higher growth rates and will probably face the biggest challenges since, as we saw above, in this region urbanization is not always accompanied by economic growth.

The variety of demographic growth rates and levels of wealth among mega-cities means that they provide very different kinds of housing for their inhabitants, with many lacking very basic amenities (Figure 4). In Luanda, Maputo and Kinshasa two-thirds of the residents cannot afford to buy the food they need to survive.[18]

1.2.3 Mega-cities are Better Prepared

Evidence suggests that although mega-cities face "mega" challenges they seem to be more capable of responding to their inhabitants' basic needs than are smaller cities. Figure 5 shows bigger cities are, on average, better serviced than smaller ones. This difference can be explained, in part, by the fact that in smaller cities, local authorities find it more difficult to attract the support of central government or international agencies in order to finance basic infrastructure growth.

This report will focus on the energy challenges of mega-cities. However, while the (population >ten million) threshold is rather conventional, we do not restrict our analysis to ten million+ cities because this statistic generally depends on a particular definition of "city" boundaries (Box 1). Therefore, we also use case studies of cities like Cape Town, Toronto, and the San Francisco Bay Area, which are not strictly mega-cities, but which we think experience the same challenges that other "regular" mega-cities experience on their continents. Furthermore, the expansion of the analysis to medium or small cities can identify technical or political innovations that might be suited to larger cities.

[18] Davis, 2006.

Box 1: What are the boundaries of a “city”?

The definition of urban areas is never simple—and sometimes puzzling. Some countries use administrative benchmarks; others use population density or the composition of economic activity; still others do not distinguish between rural and urban areas. These differences introduce serious problems for identifying urban populations, estimating growth, and making international comparisons. It is probably the main cause of evident differences perceived in urban indicators worldwide. For instance, in identifying a single city, some approaches identify those areas that have a single administrative entity, while others include metropolitan areas that contain a group of urban agglomerations. The differences are obvious: Mumbai alone (Greater Mumbai) has a population of 11.2 million, while the whole Mumbai Metropolitan Area is said to reach 18 million. The problem of urban area definition and determination of city boundaries is more evident in mega-cities because, during their growth process, they usually merge with nearby villages or cities without merging authorities. In order to avoid confusions, throughout this document city boundaries will be specified when referring to a given city. See also the Case Study on Delhi in Annex 1.

1.3 Energy for Mega-cities

1.3.1 Collecting Data on Energy Use

According to the World Energy Outlook 2008, cities represented two-thirds of global energy consumption in 2006. This proportion is expected to grow to almost three-quarters, by the year 2030.[19]

Energy data at the urban scale is rare and when available, it is generally hard to uncover the methodology used to collect it—although it is clear that many different approaches are used (Box 2). The divergence of energy data, alongside the difficulties of establishing the boundaries of cities (Box 1), together present the biggest obstacles to the compilation of benchmark comparisons between cities. Recognizing the lack of available information at the urban scale, a Global City Indicators Program was launched in 2009 by the World Bank and UN Habitat. The programme aims to establish a set of indicators, assembled using a globally standardized methodology, and to publish results that can be accessed freely via the web (Box 2).

Box 2: Urban energy use and city indicators

The urban share in current world energy-use varies as a function of: the boundaries of: the energy system, in terms of spatial scales (cities vs. agglomerations, see Box 1); the definitions

[19] IEA, 2008.

of energy systems (final commercial energy, total final, and total primary energy); and the boundary drawn to account for embodied energy in goods and services imported into, but also exported from, a city. The direct transfer of national energy reporting formats to the urban scale is often referred to as a "production" approach. It contrasts with a "consumption" accounting approach that pro-rates associated energy uses per unit of expenditure with urban consumer expenditures. This accounts for energy uses irrespective of their form (direct or embodied energy) or location (within or outside a city's administrative boundary).

According to Pachauri, the energy consumption of Indian households is evenly divided between direct and indirect energy.[20] Results from an analysis of household energy use in the Netherlands also point in the same direction: 46% of the total average energy requirements was direct (natural gas, electricity petrol), and 54% was indirect (consumer goods and services).[21]

According to IIASA both approaches provide valuable information, and should be used as complementary tools to inform urban policy decisions.[22] However, in order to be useful, urban studies need to adhere to much higher standards of clarity, carefully documenting the terminology, methodology, and underlying data used.

Responding to the lack of comparable indicators between urban areas, the World Bank recently launched the Global City Indicator program. This uses 22 "themes" to measure a range of city services and quality of life indicators in the urban context. The themes are grouped into two categories:

- The *City Services* category comprises themes evaluating the public services provided by local authorities. It includes Education, Recreation, Governance, Social Services, Transportation, Wastewater, Energy, Fire and Emergency Response, Health, Safety, Solid Waste, Urban Planning, and Water
- The *Quality of Life* category assesses a range of indicators that contribute to the overall quality of life within an urban area, but are not the direct responsibility of any local service provider. These comprise: Civic Engagement, Economy, Shelter, Subjective Well-Being, Culture, Environment, Social Equity, and Technology and Innovation.

For more information, see the Global City Indicators Facility.

1.3.2 Drivers of Energy Consumption

Four key drivers influence the final consumption of urban energy:

1. The level of economic development and the distribution of income

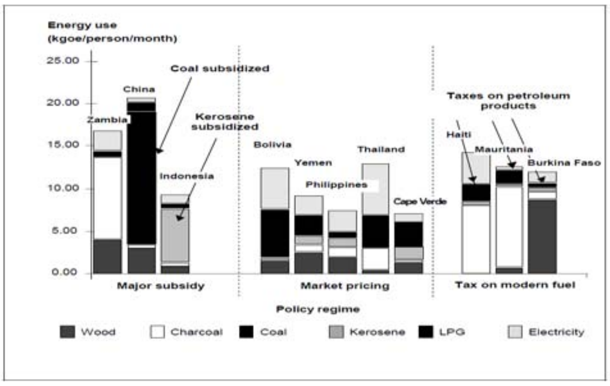
2. Urban form and density profiles

[20] Pauchauri, 2002.
[21] Vringer *et al.*, 1995.
[22] IIASA, 2010.

Figure 6

Energy use vs. government policy (ESMAP2008)

Source: Komives et al. 2005



3. Culture and climate

4. Demographic growth, transition and age structure

Public policies at various governance levels can generally influence the direction of the first two drivers, but this is not the case with the other two drivers. Below we discuss all four drivers in more detail.

On the production side, a range of drivers may be relevant (for example, culture) but three key drivers influence the primary energy mix:

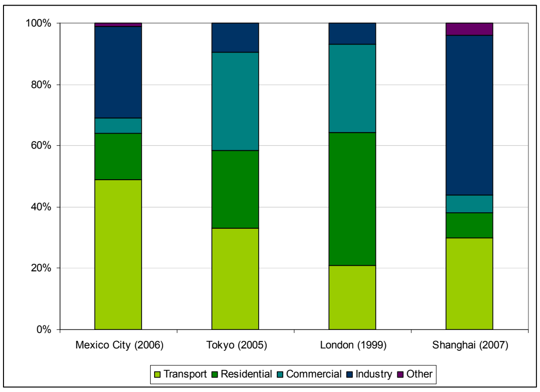
1. National policies
2. Resource availability
3. Levels of development

Petroleum-rich countries, like Mexico or Iran, meet the bulk of their final energy needs with fossil fuels—and will probably continue to do so. Countries lacking a large-scale energy resource, such as France, have established national energy policies to attain higher energy independency through the development of nuclear electricity. Germany has recently moved away from nuclear energy and developed considerable renewable energies due to the opposition of the population to nuclear power generation. This example illustrates how culture and non-governmental organization can play a significant role in influencing energy policies.

Figure 7

Energy used by sector in different cities. Mexico, Tokyo, London, Shanghai

Source: Ciudad De Mexico, 2006 and Tokyo Metropolitan Government, 2007



1) Level of economic development and distribution of income

As cities shift from earlier development stages to higher development levels, household energy consumption tends to shift from the use of traditional biomass fuels to more modern forms of energy (LPG and electricity). According to Barnes *et al.*, this transition follows a three-stage process.[23] Initially, wood fuel is the predominant energy source, but as deforestation advances and wood becomes less available, the energy source passes to a second stage of transition fuels, such as charcoal and kerosene. Finally, the third stage occurs as markets develop and incomes rise as evidenced through large-scale switching to LPG and electricity. The length of each of the stages, according to Barnes *et al.*, is not only influenced by local characteristics (nearby forests, climate, etc.) and development stages, but also by national policies concerning the relative prices of final energy (Figure 6). By imposing taxes or creating subsidies, governments may increase or diminish the speed with which households pass from traditional fuels to modern forms of energy. Furthermore, if a modern distribution system is discriminatory (for example, not available in informal settlements) or unequal across a city, transition may be delayed or partial.

The level of development of a country can also have a major influence on the consumption of energy between sectors (Figure 7). Typically,

[23] Barnes, *et al.*, 2005.

Figure 8
Energy use transition
Source: IEA, 2002

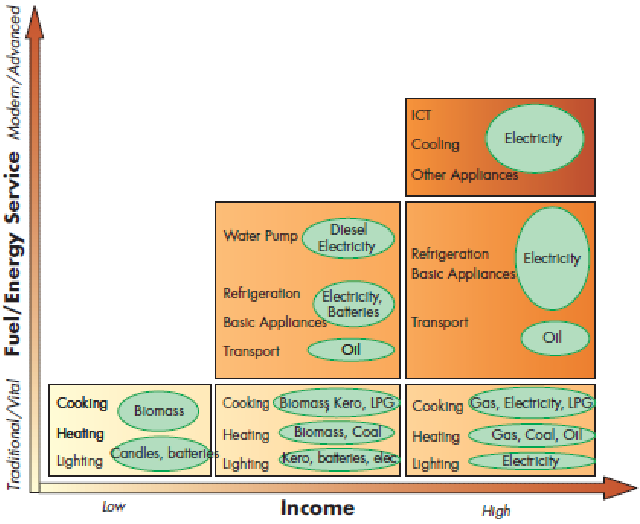
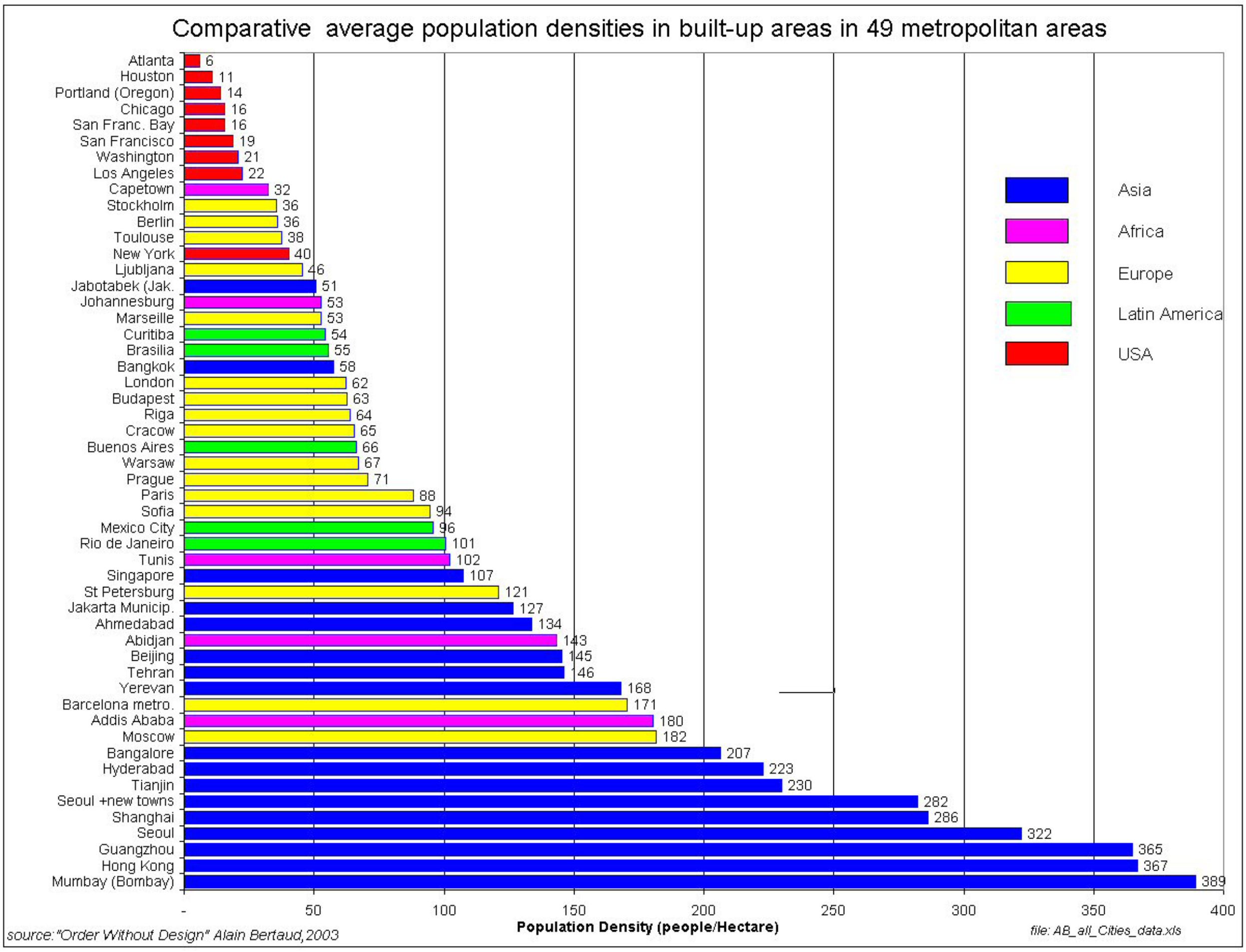


Figure 9
Average population densities in built-up areas in 46 Metropolitan areas
Source: Bertaud, 2003



developed countries have service-oriented economies, while those of developing countries are still supported by industry. The share of energy used in each sector varies considerably between mega-cities. While Shanghai is highly industrial, the share of energy consumed by the industrial sector in London and Tokyo is very small. By contrast, the energy used in the "commercial" sector is relatively high in London and Tokyo.

A comparison between poor and rich households in terms of energy demand reveals how the poor usually pay higher shares of their income to fulfil their energy needs, while also having a poorer energy mix.[24] Furthermore, as households climb the social ladder, they tend to buy more appliances and increase electricity consumption (Figure 8). In terms of indirect energy, richer households usually consume more, because they own bigger houses and more vehicles, and buy more goods. An analysis of energy consumption in Sydney found that, although direct energy consumption also increases with income, this occurs at a much slower rate than indirect energy.[25]

2) Urban form and density profiles

Urban density is a controversial indicator as there are many ways to measure it, and consequently multiple ways in which it can be used in urban policy design. As Bertaud suggests, one relevant standardized measurement of urban land consumption is indispensable in addressing the issue of sprawl.[26] Land consumption (area of land per person) is usually measured by its inverse population density (number of people per unit of land). Density is often measured as population divided by an administrative boundary, for example municipal limits. However, this measure of density is not very useful as municipal limits may include a large amount of vacant land or even bodies of water. Therefore, a relevant way to obtain a meaningful measure of density is to divide population by the built-up area consumed by urban activities, where "built-up area" is defined as including all uses, with the exception of contiguous open space larger than four hectares, agricultural land, forests, bodies of water and any unused land.

A comparison between the built-up densities of 48 cities around the world, presented by Bertaud and Malpezzi, shows differences between cities of several orders of magnitude (Figure 9).[27] However, it is still possible to see a correlation between the density of a city and its location on a continent: US cities have the lowest densities; African, European, and Latin American cities have medium-range densities; Asian cities have high densities. This suggests that densities may be strongly influenced by institutional factors—not a surprising conclusion, as urban densities are largely influenced by real-estate markets, and therefore by consumer trade-offs between commuting distance and land area consumed. The way households make these trade-offs is clearly influenced by institutions, historical factors and urban policies implemented over the long term.

[24] Komives *et al.*, 2005.
[25] Lenzen *et al.*, 2004.
[26] Bertaud, 2003.
[27] Bertaud and Malpezzi, 2003.

Figure 10

Urban density and transport-related energy consumption

Source: Newman and Kenworthy, 1999

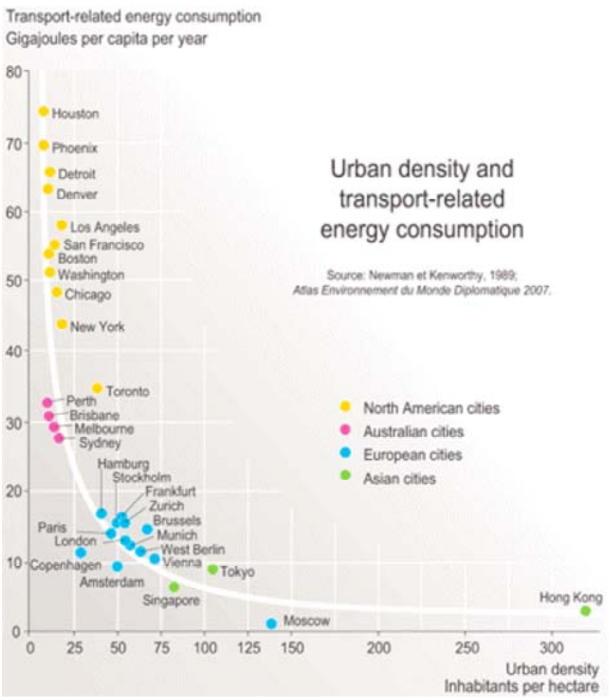


Table 2

Typology of cities based on the average metropolitan density and transport

Source: Newman and Kenworthy, 1999

*IMT: individual motorised transport. PT: public transport. NMT: non-motorised transport Density: number of inhabitants and jobs per hectare of net urban area (without green spaces or water)

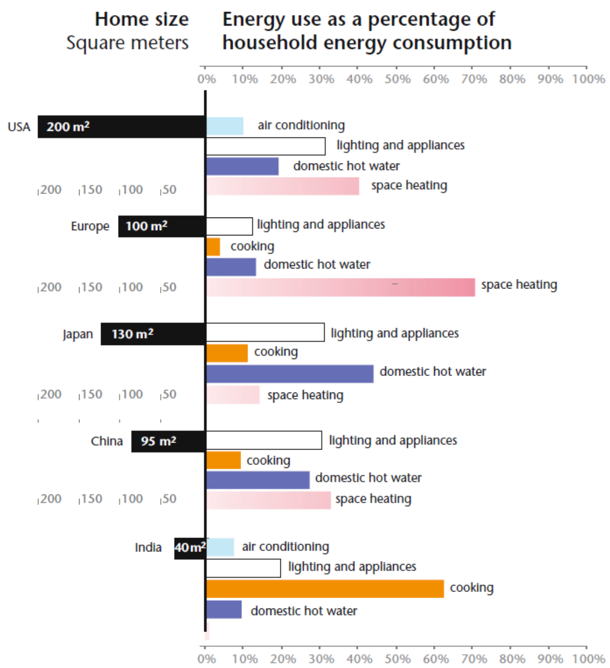
Overall urban density	**Low** < 25 inhab/ha	**Intermediate** 50–100 inhab/ha	**High** > 250 inhab/ha
Modal split	IMT: 80% PT: 10% NMT: 10%	IMT: 50% PT: 25% NMT: 25%	IMT: 25% PT: 50% NMT: 25%
Automobile usage (km/person/year)	> 10,000		< 5,000
Public transport use (trips/person/year)	< 50		> 250
Fuel consumption in transport (MJ/head/year)	> 55,000	35,000–20,000	< 15,000
Representative examples	North American and Australian cities	European cities	Asian cities

More importantly, as Bertaud emphasizes, the cities shown in Figure 9 are all reasonably successful cities.[28] Some may be better managed than others, but the great majority constitute the prime economic engine of the country to which they belong. This would suggest that, given the wide range of densities encountered, there is no “right”, “manageable” or “acceptable” range of densities *per se*. None of the cities shown in Figure 9, which collectively represent about 250 million people, can be said to have a density that is too low or too high and is hindering development or manageability.

However, even if there is a wide variation of density levels that can ensure the economic efficiency of cities, the consequences for both environment and social cohesion can vary considerably. Research by Newman and Kenworthy on car dependence

[28] Bertaud, 2003.

Figure 11
Household energy consumption and space consumption
Source: WBCSD 2009a



and sustainable urban development stresses the strong correlation between average urban densities, the modal distribution of displacements, and the energy consumption of urban transport (see Figure 10).[29]

The correlation between the average urbanisation density of residents per hectare and the consumption of energy per person is strong: R^2 = 0.86. This is due to the fact that density is strongly correlated to the modal distribution and the intensity of automobile usage (Table 2).

Thus, metropolitan areas with low densities are almost completely dominated by car usage and the total transport energy consumption is substantial (often more than 65,000 MJ/person/year). Cities with high densities have a more balanced tri-modal split, distinctly in favour of public transport (between 40 and 60% of journeys taken), and total transport energy consumption is four to seven times less than in cities with low densities. The extreme example of this category is Hong Kong. European cities occupy an intermediate position in terms of urban density: between 40 and 120 (residents + jobs) per hectare net. However, in these cities, while the modal split is more balanced it remains markedly in favour of cars, which are undergoing continuous growth in low-density suburbs. In *intermediate* density cities total transport energy consumption is usually two to four times less than in cities with low densities.

Urban form also has an influence on other types of energy consumption. Having a compact city reduces the street length of infrastructure facilities, such as water supply and sewage lines, reducing the energy need for pumping. However high-rise buildings demand the installation of vertical transportation systems, which increase electricity demand. Moreover, while compact cities might have less transport-related energy consumption they are more likely to experience a temperature increase due to heat island effects, which at the same time can generate higher demand for air conditioning. In terms of energy systems, district cooling and heating systems are usually more effective, as density is higher, but the potential for natural lighting is generally reduced, increasing the need for electrical lighting. Dense cities might also

[29] Newman and Kenworthy, 1999.

reduce the area available for collection of solar energy.[30]

In conclusion, it is widely agreed there is no theoretical or practical argument for defining an “optimal“ form or density for a city. However, research has identified some size and density thresholds that provide useful guidance for urban planning. The importance of these urban size/density thresholds extends to other structures. These include, on the one hand, specialized urban infrastructures like opera houses or underground transport networks, which are, as a rule, economically infeasible with fewer than 1 million potential users. They also include, on the other hand, public transport and energy networks (e.g., cogeneration-based district heating and cooling), whose feasibility, both for decentralized and highly centralized, distributed “meso”-grids, is framed by a robust density threshold of between 50-150 inhabitants/ha (5,000-15,000 people per km^2).[31]

3) Culture and Climate

Climate and culture are two other factors that reveal differences in energy demand between cities. For instance, many of the cities that experience tropical climes have little annual variation in temperatures and so no need to heat space, while cities located in areas with extreme temperatures normally need both heating and cooling. Unander et al. explore the question of climate and energy use and find that, although differences in climate do translate into considerable variations in residential energy demand, the most important component driving residential energy demand is the size of the home.[32] A recent study, carried out by the WBCSD reveals considerable differences in energy use and house size between several countries (Figure 11).[33]

A comparison between Europe and Japan, who have similar climates, reveals the importance of culture. In Japan, households tend only to heat the room(s) in use, while European households tend to heat all rooms. The structure and materials used for construction also play an important role in energy consumption and efficiency. Both of these depend highly on a city’s culture and history, as well as nearby available resources. Cultural preferences might also explain differences in energy consumption in the transport sector. In Europe, more people cycle in the north than in the south, mostly due to cultural reasons. Compared to other variables influencing urban energy demand, culture and climate are probably the least influenced by public policies.

4) Demography

Finally, changes in urban energy demand also depend on demographic growth and transition. In cities where the population is aging, the number of trips to work or to school might be reduced. Population growth is also translated into higher absolute energy demand. Some studies reveal that

30 Hui, 2001.
31 IASA, 2010; It needs to be emphasized that such density levels of 50-150 inhabitants/ha certainly do not imply the need for high-rise buildings, since these density levels can be reached by compact building structures and designs, traditional as well as new, including town- or terraced houses, which still allow for public, open, green spaces.

32 Unander *et al.* 2004.
33 WBCSD, 2009a.

the size of the city seems to play a role in the energy mix. While in small cities it might be easy to obtain wood from surrounding forests, as city size increases the impact on the surrounding environment is higher. A study of 45 cities in the developing world indicates that small cities have lower levels of connection to electricity than bigger ones and higher use of low-efficiency fuels.[34]

1.3.4 Energy Poverty: Visions from North and South

Energy is an essential part of our lives. We need it to cook, to cool or heat our houses and to commute to work or school. However, energy—while coming in different packages and forms—is not always affordable or accessible to all. Some households living in informal settlements may find it difficult or impossible to get access to electricity, given their illegal status, while others may have access, but be unable to afford available energy services to heat their houses in winter to an acceptable temperature. Both examples represent different forms of energy poverty.

Defining energy poverty, like defining poverty itself, is not an easy task. This is because, first, it means introducing a threshold of what is considered to be acceptable; and second, given the diversity of energy sources and uses, it is difficult to introduce a global concept of basic energy needs. For instance, households living in tropical weather do not usually need to heat space, while heating is one of the main energy services required by those living in northern regions. To date, three different methodologies exist to measure energy poverty. The first considers energy-poor households as those *who spend more than a given percentage of their income (or total expenditure) on energy services*. The second is based on engineering estimates and considers energy poor households as *those unable to satisfy minimum needs in relation to direct energy required* (Box 3). The third uses energy services, not direct energy use, to define energy poverty.

Box 3: Defining energy poverty

The following three methodologies have been proposed:

1) Energy-poor households are those spending more than a given percentage of their income (or total expenditure) on energy services. In its simplest form, affordability is expressed as the share of energy payments in total household income, but it can also be expressed in reference to total household expenditure.[35] Although there is no universal benchmark, around 25% of household expenditure for electricity heating and water seems to be an acceptable threshold. A 10% threshold has been commonly agreed in the case of electricity.

2) Energy-poor households are those that cannot have the direct energy required to satisfy basic needs. Energy poverty is calculated based on engineering estimates to determine the direct energy required to satisfy basic needs. This method has been used by a

[34] Komives *et al.*, 2005.

[35] EBRD, 2005.

Table 3

Percentage of the population with access to electricity

Source: IEA, 2002

	Water supply[a]		*Sanitation*[a]		*Electricity*[b]	
	Urban	*Rural*	*Urban*	*Rural*	*Urban*	*Rural*
East/Southeast Asia	92 (*70*)	69	71	35	99	81
South Asia	93 (*53*)	80	64	23	68	30
Sub-Saharan Africa	82 (*39*)	46	55	26	51	7
Middle East/North Africa	96 (*92*)	78	90	56	99	77
East Europe/Central Asia	98 (*98*)	78	93	64	N/A	N/A
Latin America	96 (*95*)	69	84	44	98	51
OECD	100 (*100*)	94	100	92	100	98

number of authors.[36] Krugman and Goldemberg et al. indicate that requirements of direct primary energy per time unit to satisfy basic needs are about 500 watts per person. However, this type of calculation presupposes a number of elements, such as the type of energy consumption equipment, its size, efficiencies, and intensities of use. Additionally, it assumes a definition of basic needs that can vary between climate regions, age, and seasons, etc.[37]

3) Energy poverty in terms of access to energy services: the United Nations estimates that minimum needs for energy services (lighting, cooking, etc.) correspond to about 50 kilograms of oil equivalent (kgoe) of annual commercial energy per capita.[38] This calculation is based on the idea that households are not actually looking for electricity or fuel, but for the energy services provided by them: heat supplied to a room, light for studying, and heat for cooking. The main downfall of this method is that obtaining the data to carry out this type of analysis can be quite difficult.

The most used definition of energy poverty is the first one (share of income spent in energy services) but the idea of energy poverty changes from one country to another. While in developing countries, energy poverty is generally linked to lack of access to modern energy sources, in the United Kingdom energy poverty is known as fuel poverty and is generally related to households that have difficulties heating their dwellings during the winter season. In France, energy poverty is known as précarité énergétique and comprises three criteria: social, energy and technical. An energy-poor household in France is a household that has low income, and usually lives in low-energy efficient buildings or in buildings with technical disabilities such as high degradation or bad construction).[39]

What is considered to be an essential energy need is not just dependent on climate and urban structure: differences between definitions may also be shaped by cultural influences. In England, the minimum temperature inside a house, below which a household is considered as fuel poor, is 21°C. Scotland uses a higher temperature of 23°C in the living rooms for elderly (60+ yrs), disabled and infirm households. Furthermore, most energy poverty calculations only consider housing-related energy expenses, and do not include transportation-related energy. If the latter is included, the number of energy-poor households is higher. For instance, in France 7.5 million households spend more than 10% of their revenue on energy services, including transportation, while only 1.6 million are considered as fuel poor on the basis of their incapacity to keep their houses warm.[40]

What is the magnitude of energy poverty in cities? Empirical evidence (Table 3) suggests that both in developed and developing countries, cities have more access to modern energy than rural areas,

[36] Revelle, 1976; Bravo, 1979; Krugman and Goldemberg, 1983.
[37] Pachauri, 2002.
[38] UN, 2005.
[39] ANAH, 2009.
[40] EPEE, 2006a.

Figure 12
Energy expenses of households in France as a percentage of net salary
Source: INSEE, 2006

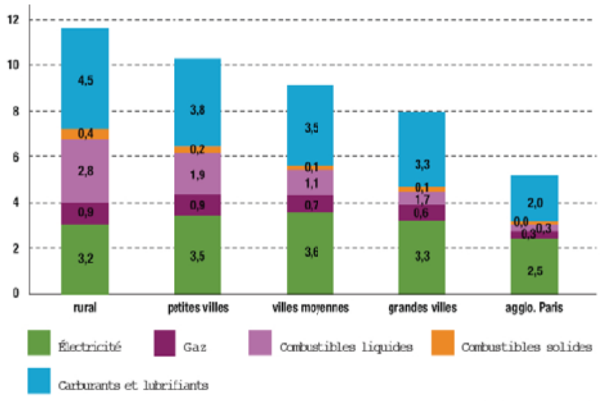
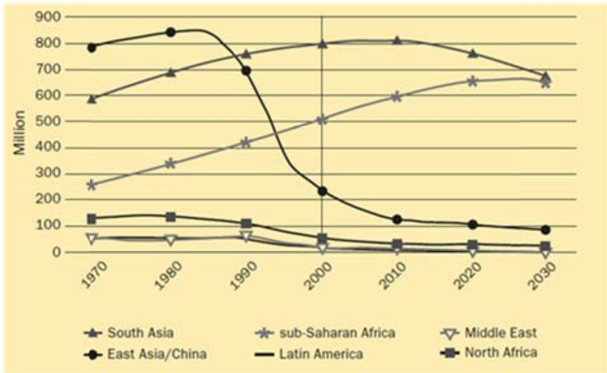


Figure 13
Number of people (actual and projected), without electricity, by region
Source: IEA, 2002



and that bigger cities seem to have higher connection rates.[41]

For developing countries, both France and the UK show how cities do better in terms of energy poverty than rural areas. In France, big cities do better than smaller cities, and the average amount spent on electricity does not change significantly when comparing rural and urban areas or small and big cities (Figure 12). In the UK, differences between the energy consumption of rural and urban areas is partially explained by the fact that rural areas have lower levels of energy efficient houses.[42]

Energy poverty in developing and developed countries as well as the relative new concept of “mobility poverty” will be discussed in the following subsection.

1. The energy poor: developing countries

In developing countries, energy poverty is generally related to the population’s lack of access to modern energy sources (LPG and electricity). The use of less efficient fuels can have negative effects on health (indoor pollution), and does not necessarily mean paying less. In fact, a study carried by Pachauri *et al.* suggests that households depending on energy sources that include less efficient fuels tend to pay more per unit of useful energy than those that use more efficient energy forms (Table 4).[43]

In general, in most developing regions, access to electricity has improved considerably, but some regions still have a long way to go (Figure 13). The disparity in access to electricity between regions can be transposed when comparing rural and urban areas, or when comparing the poor and the rich in urban areas.

Furthermore, for those living in an informal settlement, gaining access to legal electricity usually requires attaining increased security of tenure. In some cases, electricity bills are used as proof of eligibility for slum dwellers to benefit from slum-upgrading policies. In other cases, electricity bills can be useful to gain access to other services or products (portable phones, for example), or might improve access to employment.
Unfortunately, providing basic services to informal settlements is in many cases avoided by local governments, who may see the provision of services as a partial formalisation of the settlement. A United Nations report (2005) further explains how electricity services can remain inaccessible for slum dwellers, given a number of factors, including lack of street addresses and/or formal housing registration, and tariff structures and payment mechanisms that are not adapted to the capacities of local households.[44] Chapter 3 of this report explains how electric companies and local governments are trying to expand energy services

[41] Komives *et al.*, 2005.
[42] Snodin, 2008.
[43] Pauchauri, 2002.
[44] Modi, *et al.* 2005.

Table 4

Fuel costs per unit end-use and useful energy

Source: Pachauri et al. 2002

URBAN India	Energy Expenditure (Rs. per Year)	Energy Expenditure as a Percentage of Total Household Expenditure (%)	Price per Unit end-use Energy (Rs per kWh)	Price per Unit Useful Energy (Rs per kWh)
Biomass	1328	9.4	0.14	0.68
Biomass & Kerosene	1185	8.8	0.08	0.37
Biomass & Electricity	1261	8.4	0.09	0.34
Biomass, Kerosene & Electricity	1595	8.7	0.09	0.33
Kerosene & LPG	2145	6.6	0.22	0.43
Kerosene, LPG & Electricity	2427	7.5	0.18	0.32
Electricity & LPG	2528	7.1	0.21	0.33

Table 5

Electricity access by quintiles

Source: Komives et al. 2005

City (Country)	Year	Total (%)	Poor (%)	Quintiles				
				1(%)	2(%)	3(%)	4(%)	5(%)
Greater Buenos Aires (Argentina)	2002	100	98	97	99	100	100	100
Urban (Bolivia)	1999	99	97	97	97	100	100	100
Bogota (Colombia)	2003	100	99	99	100	100	100	100
Urban (Tamil Nadu-India)	2001-2002	92	84	78	90	95	96	98
Urban (Maharashtra-India)	2001-2002	90	88	83	93	89	90	94
Urban (Delhi-India)	2001-2002	92	90,3	86,6	91,1	93,2	91,6	94,3
Urban (Albania)	2002	99,9	99,8	99,6	100	99,8	100	100
Urban (Bulgaria)	2003	99,9	99,5	99	100	100	100	100
Urban (Georgia)	2002	100	100	100	100	100	100	100
Urban (Turkey)	2002	99,9	99,8	99,5	100	100	100	100
Urban (Rwanda)	2000-2001	32	12,8	4	21,7	28,6	45,3	60,8
Urban(Yemen)	2003	90,1	86,1	80	92,1	89,5	93,7	95,2
Manila (Philippines)	1997	90,3	81,5	75,2	87,8	92,9	96,9	98,8
Urban (Vietnam)	1998	98,4	96,5	94,9	98,1	99,4	99,8	100

to the poorest by adapting these structures and mechanisms.

2. The energy poor: developed countries

The extent of energy poverty can be considerable, even in developed countries. In 1996, the UK counted 6.5 million fuel-poor households.[45] While the proportion has been reduced considerably since then, by 2003 there were still 2 million households in this category. If the UK's energy *poverty* definition is extended to the United States, the number of households in fuel poverty is around 15.9 million.[46]

Table 6 shows that the magnitude of energy poverty in developing countries can be significant, and touches a particular population. For all of the cases studied, low income households and households on tenant basis are overrepresented when compared to their proportion of the total population. In the case of the United States and the UK, fuel-poor households tend to be less energy efficient than other households, and the elderly are more likely to be among the energy poor.

The European Fuel Poverty and Energy Efficiency project showed similarities between the factors effecting fuel poverty in the five countries involved in the study (Belgium, France, Italy, Spain and the United Kingdom).[47] Three main causes of fuel poverty were identified:

1. Low incomes: the poor have a higher probability of being in fuel poverty. In most

[45] Spending more than 10% of their income on fuel in order to heat the home to an adequate standard.

[46] Power, 2006.

[47] EPEE, 2006b.

Table 6
Energy poverty in developed countries

Source	Country	Definition of Energy Poverty	Energy Poor Households	Who is the Energy Poor?			
				Income	Energy Efficiency	Status Tenure	Other
POWER (2006)	USA	10% energy burden	15,9 million (2005)	36% had incomes higher than the Federal Poverty Guideline Only 15% were receiving any combination of income support or non-cash assistance	Energy poor households use 13% more btus per heated sq.ft	Half own their home	39% are 65+
BOARD-MAN (2010)	UK	10% energy burden	2 million (2003)	90% of fuel poor are within the lowest 30% of incomes	Only 1% of fuel poor households among ABC Energy performance certificate (8%) for all households	30% live on social housing and 14% more on rental status	50% are 60+
EPEE (2006b)	BEL-GIUM	Three criteria: (1) Capacity to pay to keep one's home adequately warm (2) Leaking roof, damp walls/floors/ foundation, or rot in window frames or floor (3) Arrears on utility bills (electricity, water, gas)	240,000 to 650,000 households according to criteria (2005, pg13)	17% of fuel poor households belong to first decile		44% are tenants even though they represent 31% of Belgian household	10% single parent families (5% of Belgian households)
EPEE (2006b)	SPAIN	Three criteria: (1) Capacity to pay to keep one's home adequately warm (2) Leaking roof, damp walls/floors/ foundation, or rot in window frames or floor (3) Arrears on utility bills (electricity, water, gas)	0,5 to 2,6 million according to criteria	18% fuel poor households belong to the first decile and 53% to first 3 deciles		20% are tenants although they represent 7% of Spanish households	24% single people (16% of Spanish households)

cases it involves households that receive social security payments, work part-time or are in debt.

2. Low thermal efficiency of dwellings: energy-poor households have, on average, less efficient houses. The proportion of housing stock built below thermal regulations differs from one country to another, since thermal-efficiency regulations were established at different times in each of the countries concerned.[48] Low-performance dwellings usually have defective insulation (windows, roof, walls), humidity, and no central heating systems. Households must choose between heating their dwellings and risking not being able to pay, or not heating their dwellings and risking their health.

[48] Introduction of thermal regulations: Spain (1980), France (1974), Italy (1973), UK (1965 effective since 1974), Belgium [Flanders (1992), Brussels (1999), Walloon (1984)].

3. The energy price: over the last decade, gas prices have strongly increased, while electricity prices have remained stable for most of the decade with a slight increase over the past two years.

3. Mobility poverty: some elements

Mobility poverty is a type of energy poverty that has only recently gained attention. The WBCSD suggests that development in the transportation sector in Sao Paulo, Bangalore, Dar es Salaam and Shanghai has mostly favoured those in middle or upper classes.[49] As in many developing countries, new transport infrastructure in cities has favoured the construction of new roads or investment in new metro systems. The construction or expansion of roads generally favours those who have the means to buy motorized vehicles, while punishing non-motorized mobility modes (due to the addition of dangerous roads, the rupture of sidewalks, etc.). The concentration of investments in new metro systems as a strategy for better mobility can also have side-effects on those in the bottom deciles of income distribution, who normally commute by bus, as Metro tickets are generally more expensive.

Four elements are at the core of mobility poverty in mega-cities:

1. As cities grow they become less well adapted for non-motorized commuting. This is exacerbated if cities are not sufficiently multifunctional, so that households are not able to fulfil their needs near their place of living, and non-motorized and almost free modes of commuting are not sufficient. In such cities, public transportation is needed to assure mobility.

2. Cities that favour cars are less adapted for non-motorized commuting. Roads generally disrupt non-motorized modes of transport. If government responds to the need for mobility by building more roads, the poor are excluded because they usually cannot buy motor vehicles. Furthermore, once roads have been constructed and motorized modes of transport favoured it is very difficult to reconcile efficient and viable public transport systems, which then have to compete with private vehicles, (e.g. splitting road space).

3. Bus networks do not receive sufficient investment, in comparison to greater investment in more modern and expensive public transport systems, which are expected to produce profits. In Shanghai, as the new metro network is expected to be profitable, fares will be well beyond the reach of a large share of the inhabitants of the city.

4. Public transport is often, but not always, expensive. In Bangalore, 50% of the population spends more than 24% of their income on transportation, while in Shanghai the minimum two-way ticket on the metro costs 18% of the daily income of

[49] WBCSD, 2009b.

low-income households. An increase in the cost of public transportation might be the result of a strategy to improve quality of service in order to gain new clients that previously used private motorized vehicles.

These four factors constrain mobility either because the cost of commuting is too high or the time spent commuting is too long. Together, they generate an inequality of access to mobility. The consequences of poor mobility can be dramatic for the economic development of a city. A good transport network serves as a means to ensure prosperity through the economic gains offered by the city's agglomeration economies (big job market, proximity between industries). A bad transport network can exclude a part of the active population, especially those belonging to the lowest income deciles; it can generate congestions and local pollution, and increase poor energy efficiency.

1.3.5 The Energy Challenges in Mega-cities

The main challenges mega-cities are facing can be defined according to the three elements of sustainable development, economic, social and environmental factors:

1. Economic factors

Given their economic weight in their respective countries, a major challenge for mega-cities is to preserve high competitiveness in an increasingly globalized world. Considering, on the one hand, both global energy constraints and the issues presented by climate change, and, on the other hand, mega-cities' large energy consumption, the management of energy demand is indeed crucial. Furthermore, to avoid disruptive blackouts and shortages, infrastructure must be retrofitted, and new solutions implemented. The reliability and efficiency of the electricity network is a crucial point for many developing-country cities. The transportation sector is also seen as very important. Large congestions, due to transport system failure, can affect competitiveness and pose a significant problem; examples of this situation can be seen in Bangalore or Sao Paulo.[50]

2. Social factors

Today, organization mostly occurs in developing countries, and, on many occasions, is absorbed by the informal sector. In this way, cities have the potential either to integrate or to separate, and this is a key point for mega-cities. While developed-world cities need to maintain their current living status, the challenge for developing-world cities is to improve quality of life for all, tackling poverty and reducing inequality, while avoiding spatial segregation. Although mega-cities offer innumerable opportunities for their citizens, the high concentration of people may generate more stress for individuals, and quality of life may actually be diminished, when compared to that in smaller cities.

[50] One recent study estimated that traffic jams cost the New York City area $13 billion every year (Mayor's Office of Long-Term Planning and Sustainability, City of New York 2007), and $2,4 billion in lost of productivity for Sao Paulo (WBCSD, 2009b).

3. Environmental factors

Given their high concentration of population in a relatively small geographic area, mega-cities tend to have a negative impact on the surrounding environment, generating unsustainable activities, and creating irreversible environmental impacts. Even when the consumption per capita of natural capital remains low, the absolute consumption may exceed carrying capacities. There are disadvantages that arise from so many people living so closely together ("agglomeration diseconomies"), such as water and soil pollution. Indoor and outdoor air pollution may also be very significant, especially in mega-cities located in developing countries. For example, 12.6% of the premature deaths in Jakarta are said to be related to air pollution causes.[51] In fact, out of 18 mega-cities studied by Gurjar *et al.*, five are classified as having "fair" air quality, while the rest are labelled "poor".[52] According to this study, based on a multi-pollutant index, Dhaka, Beijing, Cairo and Karachi appear to be the most polluted mega-cities.

Since cities around the world emit around 75% of the GHGs and host 50% of the world's population, they need to be at the core of climate change mitigation and adaptation policies. Therefore actors located in cities, including mega-cities, will have to shoulder a large part of the mitigation efforts aimed at reaching the "factor 2" global reduction in carbon emissions, and the "factor 4"reduction in the rich countries by 2050. In terms of adaptation to climate change, mega-cities also face big challenges: out of the world's 27 mega-cities in 2025, 15 are coastal cities. For the others, such as Delhi, climate change is likely to aggravate serious water shortage problems. Climate change is not only a challenge for some mega-cities; it may in fact be a menace.

Energy is always central in these sustainability challenges are:

- Ensuring access to modern energy services for all the urban population
- Ensuring sufficient resources to meet energy demand
- Tackling climate change and other environmental problems as well as social inequalities.

We need to make a clear distinction between emerging, rapidly growing mega-cities of the South and mature and richer cities of the North. The main global challenges may be similar, but there are also more city-specific challenges, and differences in the means available to design, finance and implement ambitious policies.

Even if anthropogenic climate change were not an issue, the rapid growth of mega-cities in the emerging and poor countries would remain a massive sustainability challenge. The investment in technical capital (e.g., buildings, networks), as well as social capital (institutions and governance), and human capital has to be very large in order to make the city work for all, and still curb local pollution. This is particularly difficult when the financial resources of states and local governments remain limited. As a result, in Business as Usual BAU scenarios, a large part of the population will live in

[51] Bart, 1994.
[52] Gurjar *et al.*, 2007.

informal settlements for many decades. Without drastic policy changes, these settlements will, in most cases, remain as they are now: synonymous with energy, water and, often, transportation poverty. As far as climate change is concerned, the main challenge for the fast growing mega-cities of the South is to control their territorial expansion by stopping urban sprawl, staying dense and mixed, diminishing the use of personal cars and investing in efficient mass transportation networks with good connectivity.

The mature and slowly growing cities of the North also have to drastically change their policies in order to reduce their emissions. This can largely be done by: retrofitting existing buildings; reshaping the city so as to stop the tendency to urban sprawl in the suburbs; favouring the use of mass transit systems, low or zero emissions vehicles and non-motorized transport (e.g., walking and cycling); promoting a more systemic approach of energy networks (e.g., cascading and recycling) and greening their energy mix.

In the following chapters available technical solutions will be presented along with the “policy packages” necessary to achieve energy management at a local scale and the institutional issues needed to scale-up action plans. The report will not deal systematically with what mega-cities can do to adapt to climate change. Instead, it will focus on three main areas:

- Combating energy poverty
- Greening the energy mix
- Climate change mitigation actions

Empirical evidence is favoured and most of the information is based on actual policy packages or technical solutions implemented or planned by real cities.

Chapter 2: Technical Solutions

2.1 Existing Technologies: Cost and Potential

2.1.1 Introduction and Methodology

The objective of Chapter 2 is to review existing technologies that can allow cities to reduce their energy consumption and/or CO_2 emissions while respecting sustainable development conditions. Thus, when analysing a specific technology, we looked at its capacity to decrease energy consumption, its capacity to decrease GHG emissions (better efficiency or energy source change) and its interactions with the city system and its population. Moreover we are only interested in those technologies that are especially urban (e.g., public transport, district heating, etc.), and those that could be efficiently implemented by local actions (e.g., retrofitting buildings, lighting). Other technologies that have no specific link to the local level, such as carbon capture and storage were not studied.

The London Action Plan begins with the quite surprising idea that "it's not a question of technology—in all sectors except aviation the technologies we need to deliver this scale of emissions reduction are already available or well on the way to commercialisation."[53] However, the emphasis tends to remain on the "new": we were promised that the green revolution would come from the development and commercialisation of new technologies; similarly, new technologies are often presented as our main hope for tackling energetic and climatic challenges. But as the London Action Plan emphasises, many useful technologies are indeed available now. The primary challenge for cities is about finding the right one and being able to implement it properly. Depending on a city's situation, some solutions will be better suited than others. With the present abundance of solutions to save energy and reduce emissions, it is not an easy task to identify the best-adapted solution. Yet considering the money required and the path dependencies often encountered in urban areas, it is essential to make informed choices.

The effective use of new technology to reduce energy and CO_2 costs depends on many factors, including: the precedent technology used and its efficiency; the behaviour of users and their willingness to modify this (the "rebound effect"); the context (e.g., energy mix and its evolution, the climate); political efficiency and the level of implementation; the market structure (e.g., concurrence level, information); and he economic hypotheses used (e.g., energy price, discount rate). All of these factors may well differ between cities.

This chapter tries to give a rigorous assessment of existing technologies, and provide some guidelines for identifying the best technology for particular circumstances. It does not attempt to identify

[53] London Action Plan, p20, 2007.

solutions for each city; rather, it aims to try to help the reader identify where possible solutions might be found. Our approach here is not to give exhaustive potentials and costs for each technology, but to describe indicative potentials and costs, to explore possible trade-offs between different technologies, and to try to explain the contexts of their implementation. This chapter will also touch on other aspects of implementation, which will be treated in more depth in the following chapter on policies and governance.

2.1.2 Transportation

Transportation modes, or systems, can be considered as fully sustainable if they are safe, comfortable, environmentally friendly, available (i.e., in the case of public transport, not too far away, and frequent), affordable (notably for low-income individuals), and, do not generate congestion. No transportation mode is fully sustainable, but, compared with the present situation, some technologies can improve such a system.

Transportation modes may have characteristics that are explicitly contradictory from the point of view of sustainable development. For example, motorized two-wheelers use less energy than cars, but are much less safe. Sometimes these contradictions are implicit: for example, a metro is much more expensive than a Bus Rapid Transit System (BRT), hence it may simply not be affordable from an investment point of view. For this reason, a very limited number of metro lines are built in some mega-cities. From a user's point of view, metro tickets are too expensive for the poor.

Some fundamental characteristics of transportation modes depend heavily on where they are used (e.g., congested city centres versus suburbs), and how they are used (e.g., driving style and, above all, occupancy rate). For electric vehicles, emissions of pollutants "from the well to the wheel" will also depend on the methods of electricity production. There are also very significant cost differences according to the places where transportation modes are produced and used: for example, cars or buses cost less in countries where average income is low (and possibly technical and safety specifications less demanding); a bus driver is paid much less in these countries than in richer countries. For all these reasons, this chapter will discuss the questions and issues around "rich" countries (US and Canada, Western Europe and Japan) separately from those relating to emerging and developing countries.

Sustainability in transport

Sustainability in transport has different aspects (social, economv, and environmental) that often cannot be entirely fulfilled. A large bus network with high frequency is favourable to social equity, but may not be cost efficient. It could imply a low occupancy rate and thus high GHG emissions per user. A modern system, fast and efficient, but expensive, could improve average mobility and emissions rates, but exclude poor populations and reduce their mobility. Technology alone is not sufficient to provide improvements in all the dimensions of a sustainable transport system, as efficient urban planning is often required as well.

Figure 14

Amount of space required to transport the same number of passengers by car, bus or bicycle

Source: Poster from Planning office, Münster, Germany

1) Developed countries

In mega-cities, walking and bicycling can be used only to a certain extent, as the city is often spatially vast. Nevertheless, since walking is cheaper than any other mode of transportation, and cycling is the second cheapest, people in developed countries walk and cycle less than in developing countries. As an example, in the Paris agglomeration, people walk only 0.6 km on average per trip, and cycle only 2.0 km. An electric bicycle (electricity-assisted pedalling) is an improved technology that may expand the range of bicycle travel (2 → 5-10 km), and make it available to less active and elderly people. These bikes typically cost €1,000 (Paris subsidizes the equivalent of 25% of this cost) with an electric consumption around €0.08 /100 km. Considering the success of e-bikes in Chinese mega-cities, large increases could happen in many other mega-cities. Nevertheless, bicycling remains a potentially dangerous way of travelling: it is better if speeds are limited for e-bikes (25 km/h in Europe), and, above all, if adapted infrastructures are built, such as cycle lanes and parking systems.

It is worth noting that in Île de France (Paris region), half of all car trips are less than 3 km, for an average of 6.5 km.[54] As seen in Figure 15, the reduction potential of this kind of trip is quite significant. Indeed, the Figure shows that the car is an important modal choice for these short trips. If a large number of these car trips were replaced by cycling, significant energy and CO_2 reduction could be achieved.

An example from the greater Lyon Area, which is a large city, but not a mega city: if all trips greater than 3 km were replaced by cycling (50%) and public transport (50%), 88,000 tCO_2/year could be saved, compared with 2.2 million tCO_2, total for transport in the greater Lyon Area.[55]

In some mega-cities where the use of cars is restricted, motorized two-wheelers may play a significant role, with a negative impact on noise and local pollutants (especially if they use two-stroke engines). To avoid these inconveniences, electric scooters can be an option and may have a large potential, since scooters are usually used for quite small trips. In developed countries, most electric bicycles and scooters use modern batteries (NiMH or Li).

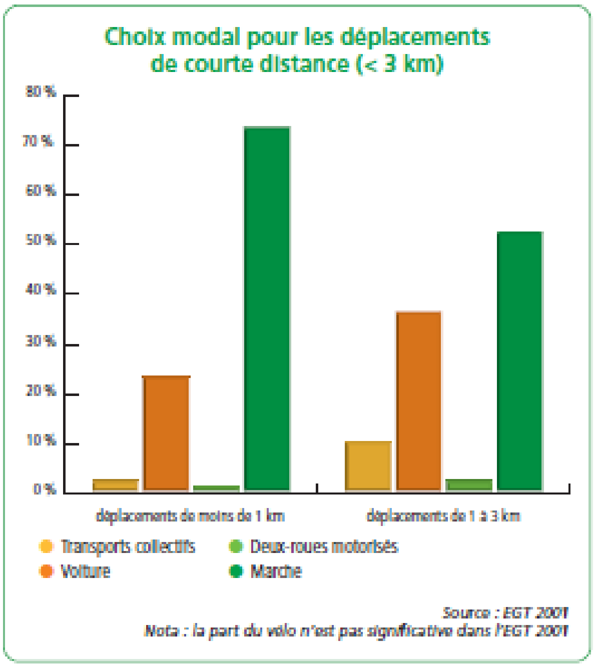
[54] Stif, 2009; picture from PDU, 2009 ; région Île de France; IAU, 2008.

[55] Calculus by the author; EMD 2006 of Lyon, RATP for car emission rate.

Figure 15

In the Ile de France (Paris region), half of all car trips are less than 3 km, for an average of 6.5 km

Source: EGT, 2001



Bicycle-hire schemes also increase the use of bicycles in two ways. First, owing to information technologies such schemes can be very practical and convince many people of their use. Secondly, it can have a catalyst effect on cycling in the city: for one hired-bike on the road there will be two or three private bikes.[56] This being said, the potential for energy savings and CO_2 mitigation remains relatively small. Since average trip length is generally long in a mega-city, cycle modal share in terms of travellers per km will stay quite low (although, as noted, electric bicycles could change this for the better). A positive impact could be the capacity to relieve transport systems dedicated to short routes, such as buses, during rush hour.

In rich countries, "typical" cars use a significant amount of energy in urban areas (typically some 8 to 15 litres /100km), and emit local pollutants, such as NOx and particles; increasingly stringent regulations lower these emission levels (SO_2 has already been almost eliminated). Moreover, cars usually transport around one person on average. However, there are some encouraging developments. For example, cars using LNG or LPG reduce the emission of local pollutants. "Improved" cars, such as hybrids, use less energy: As a thermal motor works more or less constantly, they also generate fewer pollutants. Typical gasoline consumption for these vehicles is between 4 litres /100 km and 5 litres /km, hence between 90 and 120 g CO_2/km (rounded numbers). The cost of hybrid cars is higher than for traditional cars by several thousand Euros; some governments subsidize part of the cost difference. In London, this kind of car is allowed to enter the city centre without paying the so-called "congestion charge" (urban toll). Car-pooling is another way to reduce energy consumption, emissions and cost per passenger. Local authorities can encourage the development of such schemes, for example, by introducing a reserved lane on freeways, as in some parts of the US (in California, Georgia and Texas). The development of information technologies could also facilitate the required coordination between offer and demand of car sharing.

Bus transportation is the cheapest public transportation system, in terms of investment costs. A standard bus can transport up to 100 persons

[56] Greater Lyon Area, Paris Municipality

(albeit not very comfortably), may cost some €250,000 and may use some 50 litres/100 km of diesel, emitting around 1.3 kg CO_2 per vehicle-kilometre. But these latter figures vary greatly according to where the bus is used and how many times it stops. Additionally, the average occupancy of a bus may be quite low, if it offers relatively frequent stops even during low traffic periods. As a consequence, of these two parameters, buses often have relatively high CO_2 emissions/ passenger-km. As an example, in the case of buses travelling in downtown Paris, this number reaches 120; in the suburbs it goes down to 89 g.

Hybrid buses (similar to hybrid cars) are deployed in small numbers in some mega-cities. London is one of the most advanced cities in that respect: by 2012, all new London buses will be hybrid buses. According to their proponents, energy savings may reach some 20-30%. The cost of this type of bus is not yet well-known, because of the small number currently in use. An articulated bus can cost €100,000 more than a conventional bus, but it can carry 50% more passengers, and consumes only 30% more energy, hence it is clearly more efficient on lines with a sufficiently high traffic level. Of course, it can only travel on routes where all streets are broad enough. An "extreme" version is the bi-articulated bus with a higher capacity and still better efficiency. It is not frequently used in developed countries, where local authorities prefer to build more capital-intensive systems (tramways and metros). In developed countries, staff costs are by far the most important operational expenditure (in some places, these are ten times energy costs).

Bus Rapid Transit systems (BRTs), using articulated or bi-articulated buses and a wholly dedicated infrastructure, are quite rare in developed countries, although the cost of this infrastructure is much less than for a tramway (maybe €2-5 million /km, compared to at least €20 million /km). A tramway can be twice as long as a bi-articulated bus and therefore have twice its capacity, for a cost that is six times higher; it also has a much longer life. It is likely that tramways are much more frequently found than BRTs because tramways are seen by the population as superior—no local pollution, more comfort, less noise. This in turn encourages local authorities to implement both the building of a tramway line and some kind of urban restructuration. The energy consumption of a tramway is much less than for a bus, and so are its emissions of any kind, even if it uses electricity produced with coal. However, tramways offer frequent stops and therefore a relatively low operating speed (15-20 km/h), making it less attractive for long trips.

Metros and suburban trains cost much more (up to ten times more than a tramway for the infrastructure alone), but offer greater capacity and higher speeds, so they are better adapted to long distances. The difference between metros and suburban trains lies in most cases in the way they receive electricity: via a third rail in the case of metros (that permits smaller, less expensive tunnels) or via a catenary—and a higher voltage—for suburban trains (demanding larger tunnels, but offering higher capacity). Regenerative breaking can save 20-30% of energy consumption; this increasingly common technology will probably spread quickly. It is already used in a limited fashion in Delhi on a CDM project with

Table 7
Energy consumption per mode (bus, private car, and rail), depending on occupancy rate

Energy for urban transport in Paris (IdF)[57]	2008
Total consumption ktoe	227
Bus consumption, goe/pko	7
Bus consumption, goe/traveller/km	30
Rail consumption goe/pko	1,6
Rail consumption goe/traveller/km	6,6
Car consumption goe/traveller/km[58]	55
Emission GHG bus g CO_2eq/tra/km	104
Emission GHG rail g CO_2eq/tra/km	3,7
Emission GHG car g CO_2eq/tra/km	190
pko=if the vehicle is used at its maximum capacity	goe = gram of oil equivalent

40,000 tCO_2/year reduction for total revenue of $4 million for a ten-year period, and in Paris, Oslo and Bangkok.[59]

Finally, it is essential to keep in mind the average figure of energy consumption and CO_2 emissions of the different transportation modes (Table 7). Rail, if it is electrified (not always the case for suburban trains in some mega-cities), is clearly the most efficient means in term of energy consumption. As it can use low-carbon electricity (e.g., nuclear energy in France, and an increasing proportion of renewables in several countries) it can also be a very low-carbon mode of transportation. We see that bus efficiency depends on its occupancy rate, varying between maximal performance of 7-30 goe/pko in an average performance, which is not so different from that of the average car. To make buses more effective, bus occupancy needs to be maximized, alongside a smarter network that improves bus speeds and intermodality.

Mega-cities also play a crucial role as transportation hubs. Most of the time, the associated energy consumption and GHG emissions are not taken into account. Nevertheless, they may be very important: for example and notably air transportation (Figure 16).

Turning to the transportation of goods, the ground transportation of goods typically uses four-wheel vehicles. These, with the exception of the heaviest

[57] RATP
[58] IAU, 2007; Ratp-Ademe, 2003 .
[59] Siemens 2009

Figure 16
2006 carbon dioxide emissions in London
Source: Greater London Authority, 2007

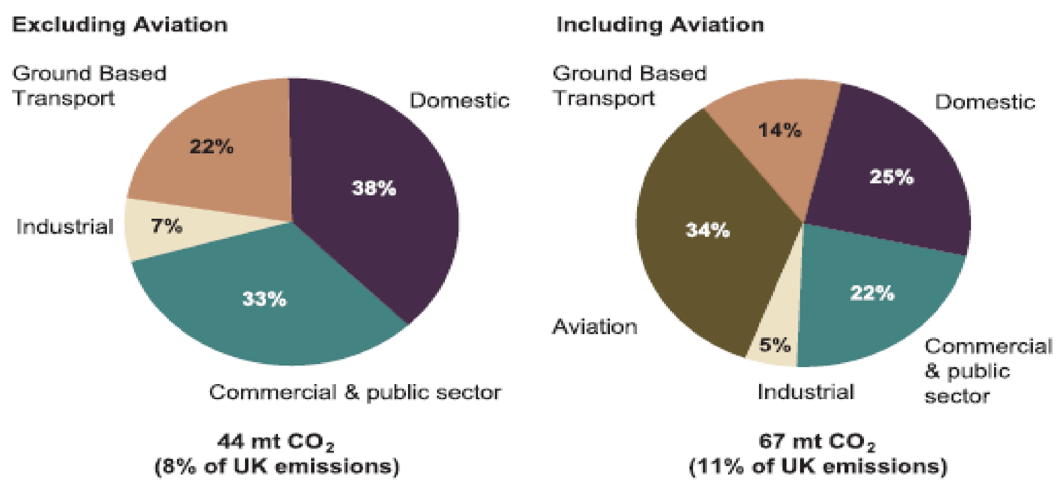


Figure 17
The new BRT in Guangzhou, China, providing a physical image of the precept "think rail, use bus"
Source: Wright and Fjellstrom, 2005, picture, from http://thecityfix.com/guangzhous-brt-revolutionizing-perceptions-of-bus-travel-in-china/

loads, can be made more sustainable using the same technologies described above.

The distribution platform may pose another problem for the sustainability of goods transportation and delivery. Is it preferable to have big commercial malls outside the city, where goods are delivered by large trucks, and then transported in customers' cars to their final destination. Or is it better to have smaller stores, served by smaller trucks, but closer to customers' homes, so that they do not have to use their cars? The available evidence seems to be in favour of the second solution—if, of course, the existing design of the city allows it.

Goods are seldom transported by trains into the centres of mega-cities; waterways, when they exist, are preferred for carrying heavy materials (e.g. for the building industry).

2) Emerging and developing countries

In emerging and developing countries, the economics of urban transportation are quite different. First of all, individuals walk or use carbon friendly modes significantly more than in developed countries, because of the prohibitive cost of other modes of transportation. The cost of individual vehicles may be somewhat lower than in developed countries, given that they are locally manufactured (by a factor of two, for a comparable vehicle). Buses are also manufactured in several emerging countries, with a similar cost ratio when compared with developed countries. Heavy infrastructure (e.g., metros or suburban trains) is capital-intensive and therefore not much cheaper than in developed countries. However, the labour costs of public transport are far lower, since the average income of the population is three to six times smaller in emerging countries, and much lower in developing countries.

These economic factors explain the broad use of motorized and non-motorized two-wheelers, and small private transport vehicles and taxis, and an occupancy rate of all kinds of vehicles that is much higher than in developed countries. However, this also means that the comfort level is much lower. In emerging countries with fast economic growth, the occupancy rate of cars has diminished quickly (by a factor of two in Shanghai within ten years), but remains higher than in developed countries. These factors also explain the generally protracted development of public transportation, which necessitates a highly capital-intensive infrastructure, such as metros and suburban trains. There are some exceptions, where a strong political will prevails or has prevailed, as in Shanghai and Mexico City.

Turning to two-wheelers, a very large number of electric bicycles and, to a lesser extent, electric scooters are used in Chinese mega-cities. These electric two-wheelers are quite cheap, but most of them have lead-acid batteries: this is sustainable if and only if these batteries are properly recycled.

BRTs have been also developed in several mega-cities in emerging and developing countries, for the economic reasons discussed above, as they can provide a high quality service with a low infrastructure cost.

In emerging and developing countries, the traffic level that would economically justify the replacement of a BRT by a tramway or a metro is much higher than in developed countries. This is because, in the comparison between a “labour intensive” technology, and a “capital-intensive” technology, the relative weight of labour costs, in general, is much lower than in developed countries. Compared with standard bus systems, BRTs also reduce emissions of local pollutants and offer a relatively high commercial speed, if there is sufficient distance between stops (a mix of “express” and “omnibus” lines can also be developed). Finally, if the frequency of (articulate or

Table 8
Comparison of transportation solutions

Technology	Context Required for Efficient Operating	Strong Points	Weak Points
Bikes/electric bikes	Bicycle lanes, inter-modality, and parking plug in infrastructure	Zero energy and CO_2/ very low energy and CO_2 Low cost	Limited range/ moderate range Possibly dangerous
Electric Cars	Plug-in infrastructure	More energy efficient than thermal cars, potentially low carbon (depending on the energy mix) No local pollution	Do not solve congestion; expensive infrastructure and vehicles
Hybrid Cars	Plug-in infrastructure if rechargeable hybrid vehicle	Lower local pollution and more energy efficient than traditional cars (even if it remains moderate, if compared with modern urban car)[60]	Extra cost; do not solve congestion
Ordinary Bus	Little congestion	Energy efficient if sufficient occupancy rate	Local pollution and CO_2 emission Slow if congestion
BRT	Traffic regulation enforcement; sufficient density	Good capacity/cost ratio	More local pollution and CO_2 emissions than tram or subway
Tramway	High density	Energy efficient Requires urban restructuring No local pollution	More expensive than BRT
Metro Rail	High density	Large capacity Energy efficient No local pollution	Expensive (infrastructure and then ticket) Long building period

bi-articulate) buses is sufficient, they can have a daily capacity similar to a metro line. However, to be efficient, they do have to run on wholly dedicated lanes, and, unlike rail systems, buses are vulnerable to increases in oil prices.

BRT projects can be difficult to implement because of a lack of traffic regulation enforcement. In Dar Es Salaam, the BRT construction has been delayed several times.[61] One problem has been the need to deal with the informal transportation sector that the project would impact. Since this informal sector

[60] Jeanneret et al., 1999.

[61] WBCSD 2009b

both provides many people in the city with their livelihoods and supplies crucial transportation needs (the BRT cannot supply all mobility needs), the new project has had to be introduced gradually, and coordinated with existing systems.

Turning to the transportation of goods: in emerging countries and even more in developing countries, a significant proportion of goods is carried by people, or on two and three wheelers (motorized or not). As a conclusion for transportation solutions, it seems clear that there is no silver bullet to save energy, limit emissions and preserve mobility (while maintaining travel-time budgets and transportation cost). Solutions for an efficient transportation system have to be found in the context of specific land use, and not focus only on technological answers. Technologies can offer cleaner and more efficient ways to transit, but, on their own, they cannot solve congestion problems, or reduce the global and increasing need for mobility. Each approach has strong and weak points, and these need to be carefully balanced to respond to the particular city context.

Box 4: Energy sustainability of mega-cities: a long-term perspective.

A fully sustainable mega-city will no longer use any fossil fuels; this long-term perspective (2050 or beyond) does not face any technical impossibility. It will rely on three types of energies:

- Fully decarbonised electricity generated using renewable energies and nuclear energy. For mobility purposes, this will be used in electrified mass transportation systems and electric (or plug-in hybrid) personal vehicles and light trucks. Electricity will also be used to heat and cool buildings, and to provide hot water, using heat pumps. Locally generated electricity will be mostly photovoltaics (PVs); its importance will vary according to the location of the city, and to its cost (low-cost PV incorporated as building materials could make a difference).
- Directly used renewable energies generated using biomass, organic waste, solar thermal energy, and geothermal energy. These will provide heat to buildings for space heating and hot water preparation. As heat cannot be transported over long distances, these energies will be locally exploited, in proportions that will vary according to local resources.
- Indirectly used renewable energies generated using biomass and organic waste. These will be used to produce synthetic biofuels for all kinds of vehicles.

Neither electricity nor renewables will be cheap. This raises the importance of good urban planning—leading to dense and mixed cities where walking and cycling will add significantly to mobility—and also well-insulated buildings.

Table 9

Insulation Cost from as study on the energy savings potential in EU member states for the EU Commission

Source: Fraunhofer-ISI, et al. (2009); AUS-LTMU et al. 2009

	Single house (120m²)	Multi-family Buildings (1400m²)
Energy consumption improvement	214 → 74 kWh/m²/a	118 → 56 kWh/m²/a
Investments (average material and labour cost in Europe)	€22,000	€143,000
Energy savings per year (0.1 €/ kWh)	€1,680	€8,680
Payback period (4%, at current energy prices)	17.5 years	25.6 years

2.1.3 Buildings

New housing

Recent European projects describe an average extra cost between 10-15% for the conception and construction of low-energy buildings (less than 50 kWh/m^2/y on average).[62] They also find declining trends for these costs, explained by the spread of knowledge and a burgeoning learning process. This means that a 5% extra cost could be possible in the near future (which is already the case in Germany).

Efficient technologies are available, but inadequate professional knowledge and lack of information means that progress is slow. Existing norms, their intensification, and the mobilisation of professionals should ensure good performance of new buildings in the near future. However, new buildings only represent a small share of the total building stock. In Europe in particular, where the renewal rate is around 1%, the main challenge is retrofitting existing buildings. Japan and the US have higher renewal rates, but today's buildings will remain the largest share of building stock over the next 30 years—so retrofitting remains the most crucial issue.

[62] Ademe-Prebat, 2009; European Commission, 2009.

Insulation in existing buildings

Thermal insulation is absolutely necessary in mega-cities with cold winters, most of which are located in developed countries or in northern China. For new buildings, it may cost anything from nothing (for standard insulation and double-glazed windows, because these features are standard, or even compulsory), to 10% of the cost of the building (for example, for reinforced insulation and triple-glazed windows).

For existing buildings with a low level of insulation, it may cost some €10,000 /dwelling, in optimal conditions—that is, if many similar dwellings are treated simultaneously, guided by a strong political will for this sector—but much more in other cases. Perhaps more realistically, a recent study carried out for the European Commission considered the costs of insulating the roof, floor and façades of a building, and gives data that allows the estimation of the payback period for this kind of retrofitting. It appears that, taking into account actual energy prices, improving insulation has quite a long payback period (see Table 9). Households might consider retrofitting a high-risk investment, especially since many countries do not offer the requisite labour quality. Nevertheless, political engagement, improvements in the retrofitting business, and increases in energy prices may reduce this payback period. For example, it is crucial to ensure that companies have properly installed insulation materials or heating devices; systematic examination and standardization may be needed in the case of new materials or devices. Better coordination among building professionals (e.g., standardization of retrofitting), a well-trained workforce, available consumer information and a comprehensive evaluation of available building stock will all be crucial for increasing the efficiency of retrofitting policies and decreasing risks for the investor. Policies are also needed to overcome split incentives between tenants and landlords.

In the case of building renovation, the variability of costs and income, can have a big impact on investment decisions. Indeed, labour costs are often as important as material costs. The investment cost for thermal efficiency in existing buildings will be very different between countries and between cities. For example in China, insulation is a great challenge, especially in Northern China. Recent renovation projects provide information about renovation prices: one project for thermal retrofitting, including housing façade renovation, heat supply system upgrades and other engineering works cost €30 /m^2; another, with only exterior insulation, cost €10 /m^2. For the latter, with a slightly inferior retrofitting price, and an adapted economical mechanism, the payback period could be about 8-12 years. Lower prices might increase the attraction of such projects, and, since coal prices are likely to increase, thermal retrofitting will be all the more profitable.[63]

Retrofitting largely depends on the mega-city context: the type of building, heating system, available private sector offer, national subsidies, energy prices and loan possibilities. In the absence of any general conclusion on the cost-effectiveness of insulation programs, the success of retrofitting projects will depend on a comprehensive and integrated policy, supported by a strong political will and efficient coordination by stakeholders.

Energy control-packages and maintenance can offer large gains at low costs. A programme led by the Berliner Energy Agency for more than ten years gives an idea of the extra cost for these energy efficiency measures: for 1,200 public buildings in Berlin, 26% energy savings were obtained using measures such as energy management, lighting retrofitting and control, heating production improvement, heating circuit and thermostat, and ventilation; for a global investment of €44 million, 180 GWh/year are saved. Through a third-party investment contract with an ESCO, the payback period has been reduced to 12 years, at no cost to the building owner.[64] This programme is described in more detail in the next chapter.

An energy audit is the first step towards energy savings, but, compared to the retrofitting cost, audit costs are quite small. A more difficult issue is the standardization of the methodology and the quality of the results. Assessment of building stock is an important step. The City of Paris (via its urban planning agency) has used infrared thermography on a large and representative sample of buildings: the results show that the importance and location

[63] Ademe, 2007.

[64] C40: Cities, 2007.

of heat loss vary significantly according to the age of the building. The resulting images have been shown to the public as part of an awareness-raising campaign.[65]

Heating and cooling devices

If electricity generation is not dominated by coal in low-efficiency power plants without carbon capture and storage, electric heat pumps (HP) are the most efficient and sustainable way of heating. Condensation boilers using natural gas are also very efficient, but they still emit CO_2, which cannot be captured due to the small size of the installation. Life-cycle management of the technology is very important, so it is important to provide as much information as possible at the point of adoption, so as to encourage the owner to choose the most efficient technology available. It is often the case that traditional technologies are chosen although better technologies are available.

Heat pumps (air-water) can be installed, instead of an old fuel boiler with, greater efficiency. Moreover, reversible heat pumps (mainly air-air) are now common and can replace electric heating and cooling systems. Air/air-heat pumps have great potential for technical improvements and probably also for improvements in efficiency. The cooling industry has a strong R&D capacity.

Ground-source heat pumps are also an interesting option. Although they can be four times more expensive than traditional options, they are only about twice as expensive as efficient gas or fuel boilers. (This said, there is variability in both price and knowledge across building firms, which can be decreased through policy packages that increase standardization, more feedback and competition).[66] This last comparison is probably most relevant, since these boilers are now becoming standard. Concerning energy consumption, heat pumps are much more efficient. On average during the year, with temperature variations, heat pumps are able to produce three times more as much heat energy than the electrical energy they consume. The payback period of the investment and the choice between technologies remain dependent on context, including such factors as the type of building, competition on the building market, public policy (for loans and subsidies), and the price of energy.

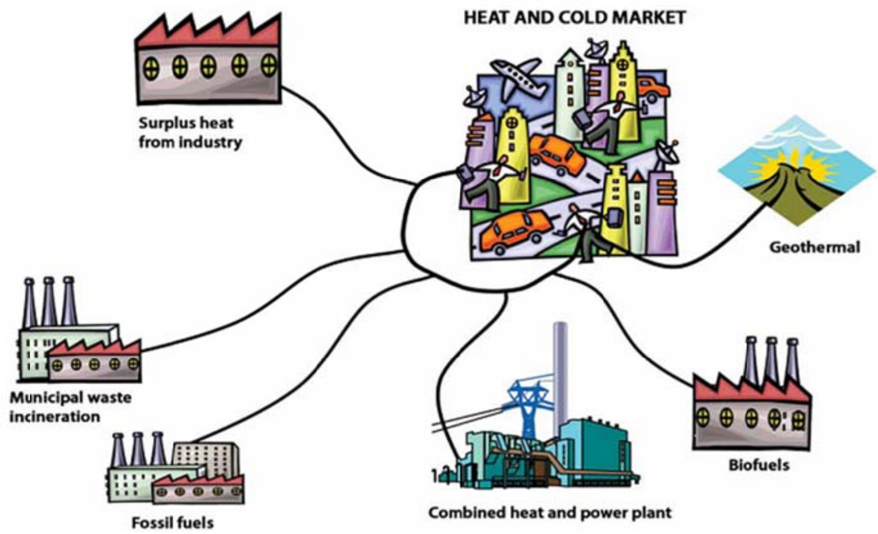
In mega-cities where summers are relatively cool, it is often possible, with good building design, not to have to use a cooling device. This cultural, rather than technological approach sets an important challenge for the conception and planning of new buildings. (When artificial cooling is unavoidable, electric heat pumps can be efficient.)

In developing-country mega-cities, cooling is an increasing issue even if current consumption is more about cooking, lighting and space heating (where heating is required). To prevent a potentially rocketing demand for electricity for cooling, better insulation and building design are needed. Consumption of energy for cooling is also (as noted above) driven by cultural behaviour: for

[65] “APUR, 2010.

[66] This applies to basic costs including equipment costs, labour and secondary cost, see Laurent *et al.* 2007 and Osso *et al.* 2007.

Figure 18
How to feed district heating?
Source: European Renewable Energy Council, EcoHeatCool project 2006



households and offices, awareness campaigns can be useful in helping to contain demand.

Heat pumps can produce sanitary hot water, but, in mega-cities with mild winters and high solar exposure, solar water heaters are a more sustainable technology. In this context, they can work with a single circuit, which is cheap, and use only solar energy. In mega-cities with less sunshine and cold winters, solar heaters need a double circuit so as to avoid water freezing. They are therefore more expensive, while solar energy provides only some 50-60% of hot water needs. A vast programme (Solar Thermal Ordinance) is being conducted in Barcelona to increase the use of this technology. In 2005, there were 31,000 m^2 of solar panels (1,600 in 2000) and the target is to reach more than 100,000 in 2010, with costs (labour and material) between 1,000 and €2,000 /m^2. In Barcelona, more than 25 GWh are saved each year. With the current energy price, the payback period is around 20 years—that is without subsidies (and subsidies are therefore useful for persuading people to get involved).[67]

Building costs

Information regarding the cost and potential is plentiful, but inconsistent, since underlying assumptions and calculations differ and are rarely explicit. Some are very optimistic and consider perfect market and perfect efficiency of technologies, in a context where there is supposed to be a sharp increase of fossil fuel prices. Others are more realistic concerning the performance of technologies and the real implementation price. However, observed cost estimates are often higher than expected because of different kinds of market failures, and real efficiency is lower.

In this chapter, an overview of technologies has been given without being overly pessimistic or optimistic. Technologies exist and can be cost-effective, and cities, in cooperation with their national governments, should try to assess the potential of their building stock, organize the market (codes, labels, information), and train the workforce. The mitigation results and the cost will largely depend on this context.

General potential

In Europe, one fourth of total primary energy supply is wasted in heat loss in the energy transformation

[67] Hypothesis: 56% covered needs, with 0.1euro/kwh, and 4% rate. Energy needs figures from AUS-LTMU, 2009.

sector.[68] (Interestingly, the magnitude of heat loss has as the final net heat demand.) It is precisely the advantage of district heating to be able to permit the use of heat sources that would otherwise be wasted (or not used): heat from Combined Heat and Power (CHP) processes, from municipal waste incineration, and industrial surplus heat, and heat from geothermal sources and biomass. Very large energy savings can be achieved in that way for many cities. In Europe, there is the potential to double the use of district heating: 2.14 EJ/year of primary energy would be saved, corresponding to the whole energy balance of Sweden.

Mega-cities context

If co-generation plants using fossil fuels offer large benefits when compared with low efficiency technologies (e.g., an old coal plant providing electricity, and an old boiler using fuel oil), these benefits are very limited if the comparison is done with "state of the art" installations, for example, CCGTs for electricity generation, condensation boilers using natural gas for heating purposes. We must assess the value of this investment in a dynamic way, since the evolution of the market can change the possible gains. There is also a trade-off between well-insulated buildings and district heating, since the efficiency potential will be lower with low-energy buildings. The saving potential of district heating will then depend on city infrastructures.

Moreover, district heating is not a fully sustainable method of providing heat if it uses fossil fuels as a primary energy supply. To take advantage of the potential of district heating, mega-cities need adapted energy and waste policies, and urban planning. CHP using sustainable fuels as much as possible has to be targeted for new investments, and should be located near the site of demand in order to improve the efficiency of district heating. Depending on the local context, cities can find combustible renewable, and organize their distribution and sale with local actors (firms, nearby agricultural activities, etc.), in order to further increase efficiency. Indeed, given their size, district heating can more easily use combustible renewables (various wastes and residues) than can households.

The cost-efficiency of any system of district heating will depend on the situation of the city in question, and whether it is possible to construct the necessary network infrastructure, as well as on the prices of crude oil and gas. The potential for doubling district heating in Europe, will depend on a total investment estimated to around €150 billion; the payback period will depend on the price of fossil fuels.[69]

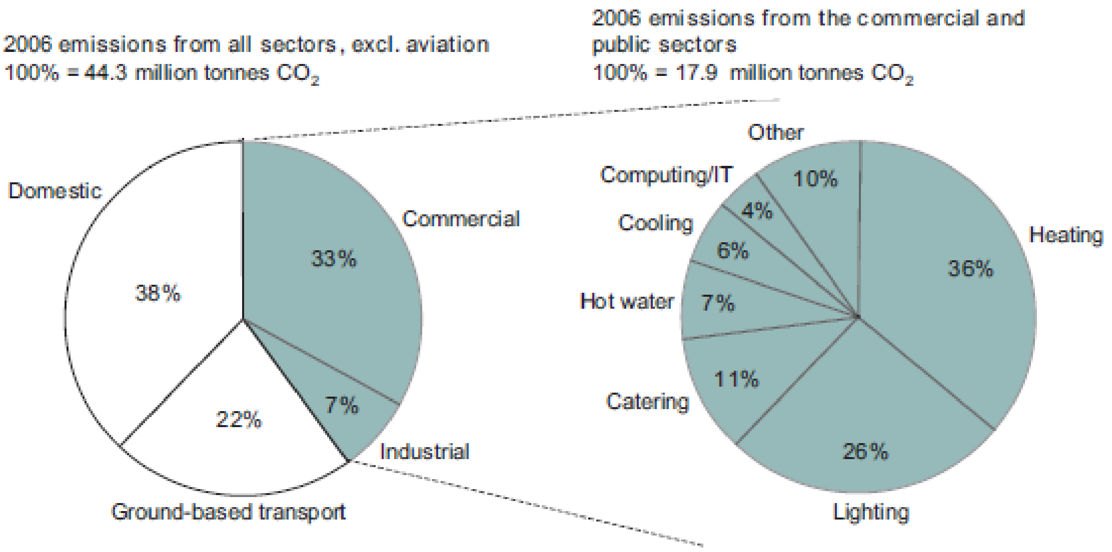
[68] The total primary energy supply 81.1 EJ, total heat loss in the energy transformation sector 23.8 EJ, heat loss in the consuming sectors 22.6 EJ, mainly in the transportation sector (Ecoheatcool 2005-6a).

[69] Investments in heat generation are neglected since electricity must be generated, waste must be incinerated in order to reduce future methane emission from landfills, and industrial processes would need heat, if no district heat were available. Cost represents heat distribution part and various heat generation facilities. See Ecoheatcool 2005-6b.

Figure 19

Offices and commercial buildings emissions, 2006

Source: London Climate Change Action Plan, 2007



In mega-cities, the density of buildings and the close presence of industry, waste treatment and electricity production could mean that a district-heating scheme could bring large energy savings. The potential will mainly depend on the infrastructure of the city and its jurisdictional capacity to develop an appropriate energy policy.

Offices and commercial buildings[70]

The increasing share of the services and sales sectors in the economy of many mega-cities means they can no longer be ignored when considering energy consumption. In London, for example, the commercial and public sectors are nearly as important as the residential homes sector for the question of CO_2 emissions.[71]

Lighting, information technology equipment and cooling consumption are particularly important for these buildings, even if heating generally retains the largest share. District heating and cooling with large centrifugal chiller heat pumps, as used in Oslo and Stockholm, can achieve high-energy efficiency in large office or commercial buildings. Such installations permit large energy-efficiency gains and CO_2 reductions. In Toronto, for example, the cooling system uses cold water from Lake Ontario to provide air conditioning to approximately 100 large office towers.

More efficient lighting and control packages and simple behaviour changes can also permit significant savings. And because office-building stock is generally more recent than housing stock and has a higher renewal rate, higher energy standards for new construction could achieve significant savings. Nevertheless, different incentives among tenants, owners, and developers can present a complex situation, and may represent a serious barrier—although city authorities can help to overcome this. Moreover, the energy bill represents, in general, a small cost compared to the global budget of an organization, and does not tend to compel attention even if it can be easily reduced. City-wide programs can be useful for several reasons, including increasing the use of audit energy performance, creating an ordinance for building standards when they are sold, transferred or renovated, and facilitating collaborations between energy service companies and large office owners.

[70] WBCSD, 2009a; London Climate Change Action Plan, 2007.
[71] London Climate Change Action Plan, 2007

Lighting

Efficient lighting can be a much more sustainable technology than standard lighting. Since the bulbs contain hazardous products, they must be recycled. Compact fluorescent lamps (CFLs) are now quite usual, as they have demonstrated not only their efficiency, but also their cost-effectiveness, since they last much longer than incandescent lamps (up to 10,000 hours). In tropical countries, where there are more cooling than heating needs, these lamps also offer the advantage that compared to conventional lighting, they reduce these needs. Nevertheless, their cost may remain an obstacle to their adoption by poor people, especially in emerging and developing countries.

To overcome this barrier many lighting programs have been and are being engaged. Mexico City distributed ten million CFLs for a global cost of €16.5 million. Since a fluorescent lamp consumes five times less energy than an incandescent bulb, it saves 270,000 tCO_2 per year for Mexico City. France did the same for its overseas territories, providing fluorescent bulbs for only one euro each. India aims to distribute 400 million CFLs through an MDP project in the next three years. It will allow the Indian population to buy these lamps for only Rs15 (€0.03). Considering the energy consumption used for lighting in mega-cities, and the efficiency gain that these examples show can so easily be achieved, municipalities could use this existing technology in a very profitable way. To have an idea of the potential, The Plan for New York 2030 project has stated that, if "all households replace 75% of their standard light bulbs with CFL bulbs, the energy savings would be enough to run all the subways and light all the stations."[72]

Light emitting diodes (LEDs) are now technically mature, as efficient as CFLs, and last much longer (up to 40,000 hours). However, they are still more expensive, so their market will be, at least for some years, mainly the commercial sector.

Cooking

Here again, there is a strong contrast between activities in mega-cities of developed countries and those in developing countries. In developed countries, natural gas is always available in mega-cities (except in high-rise buildings, for safety reasons): so people use it for cooking, or they use electricity, or a mix of the two. Induction cooking is a very efficient technology using electricity, although it is still expensive. In developing countries, people also use, in various proportions, wood, charcoal and LPG. The use of LPG is frequently subsidized, as it avoids deforestation problems linked to the use of wood or charcoal, and reduces indoor pollution. Natural gas is often absent, because the cost of a distribution network is too high. However, there are exceptions, notably in countries where there is production of natural gas. An example is Cairo: the use of natural gas has been promoted in this mega-city for sustainability reasons, notably because it is safer and cheaper than LPG (additionally, LPG distribution has used child labour).

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[72] Mayor's Office of Long-Term Planning and Sustainability, City of New York, 2007.

Appliances and consumer electronics

These devices can have extremely different electricity consumption levels: imagine the different requirements of a 20-year old refrigerator and a new one, or between a TV with a plasma-screen and a TV with an LCD-screen. In order to orient customer choices, government policy is necessary—and at a higher level than local government.

2.1.4 Information Technologies (IT)[73]

Information technologies (IT) are (or might be) present everywhere. They have been, and will continue to be, a general way to decrease energy consumption, offering a major factor in reaching more sustainable energy supply and consumption in mega-cities. They are and will be used in several domains, be it traffic regulation or energy management of buildings.

Energy savings can be achieved in different ways. Information can make energy consumption visible, making people aware of it. Moreover, by giving useful information on the service needed (transport energy, water, etc.) it allows users to choose the most desirable rather than the usual service. Real-time pricing can also offer economic incentives, allowing demand to adjust to policies across domains.

With regard to transportation systems, public transport is disadvantaged compared to private transport, since it offers less freedom and predictability. However, IT can introduce the required flexibility. Personal Travel Assistant technology could take into account personal preferences (commuting duration, route, departure time, etc.) and real-time commuting data (road conditions, weather, current capacity, etc.) to allow people better adapt their travel. Passengers can also share their information with the operating system, providing useful feedback and statistical data for planning.

IT can also help to provide a faster and universal payment system. Transport systems and payment could also be coordinated with daily services (laundry, food delivery, postal services, and other daily needs), limiting the need for transportation. Transport systems could become a hub of daily life, into which other service activities could be linked in an efficient way. Dynamic pricing for transportation systems (e.g., public transport, congestion charges, etc.) could adapt to the real-time conditions of the network, helping to limit travel congestion. Dynamic and intelligent traffic management also has prime potential: for example, through traffic light priority management, or inter-modality and transit facilitated by dynamic networks optimization. All of this could improve the performance of a public transport system. Some of these items are already partly implemented in many mega-cities in developed countries.

IT for work

An increasing share of the total workforce is employed as knowledge workers (European Union

[73] Cisco, 2009; Houghton, Reiners and Lim, 2009.

2006, 35.9%).[74] The nature of their work could offer huge opportunities for innovation and helping people to change their behaviour.

Mega-cities could see new types of office buildings called Smart Work Centres (SWCs) appear. SWCs are office centres close to residential areas; they do not belong to a specific firm, but can provide flexible capacity to individual workers or groups. The use of information technologies and SWCs can facilitate work outside the usual firm space, offering workers more flexibility and a way to use less transportation or alternate forms of transportation, such as bicycles. Employers could increase their productivity and also optimize their real estate demand. Indeed, with efficient planning, firms could avoid paying too much for space they do not always need.[75] Moreover this concept preserves the work/home boundary, which probably will remain important for most people.

These measures could not only radically modify people's mobility and daily needs, but also could largely reduce energy consumption and CO_2 emissions. However, many of these IT uses would imply profound changes in how society functions. It is therefore difficult to have an idea of either their potential or their cost. Nevertheless, perhaps more realistic IT solutions are also on the way—and offer more immediate results. These include, smart grids, smart energy controls in buildings, and intelligent transportation systems, among others.

IT for city governance[76]

Just like a company, cities need to manage their systems with speed and precision—and information technologies can help. Solutions for automating data collection and information-sharing throughout city departments can improve city governance. Indeed, once implemented, IT solutions could reduce information costs and improve the processing of information. The implementation of integrated policies that require different departments to work together could be helped by easier information sharing. Efficient instrumentation would enable cities to take better decisions and/or assess the effects of current policies.

An automatic city?

Information technologies can improve governance through better monitoring, and can help citizens to make daily choices. Nevertheless, a city cannot become an automatic system, optimized by technologies. Huge volumes of data are not sufficient: cities need meaningful and understandable data. Information technologies will not be enough to improve political mechanisms and choices, and governance remains a key issue. Moreover an ecological "big brother", where a city's

[74] epp.eurostat.ec.europa.eu/.../PGE_CAT_PREREL_YEAR_2008_MONTH_03/9-10032008-EN-BP.PDF cited in Connected and Sustainable Work, Connected Urban Development Global Conference 2008—Amsterdam, Alwood, Boorsma, Cisco Internet Business

[75] "CoreNet Global, the leading association for corporate real estate and related professionals, says that up to 60% of assigned workspaces are wasted because people are in meetings, not at their desks. This is a stunning statistic; it means that the majority of a company's largest asset class is unused." O'Donnell, and Wagener 2007.

[76] Dirks, Keeling and Dencik, 2009.

population would be constantly scanned for their environmental performance (or violations) is not desirable

2.1.5 Smart Grids

The key, but not the sole, component of a smart grid is an advanced meter used for residential, commercial and small industrial customers (Large industrial customers are already equipped with sophisticated meters). Various kinds of data are stored (e.g., electricity consumption with a high frequency or load curve, etc.) and some events (such as supply disruption) are registered. Advanced meters communicate with the grid operator, with suppliers, and with customers.

A smart grid deploys such meters and collects corresponding data and has the infrastructure to receive data.

Advanced or smart meters can provide:

- For the customer: bills based on real consumption data, as frequently as necessary ("Dumb" meters have to be read by an employee, and that costs money: hence, bills are often based on estimates, with "real" bills two times a year, for instance.) The customer may use the information provided by the meter to eliminate the least efficient appliances (like old fridges) and (if a time-of-use tariff exists) to reduce his consumption when prices are high, thus reducing his electricity bill.
- For the grid operator: lower labour costs (most operations like meter reading, service connection, and disconnection can be done remotely); a reduction of non-technical losses; and a better knowledge of his network and of the quality of supply. It can also facilitate the insertion of decentralized generation and, in the future, the optimization of the periods when PHEVs or electric vehicles will be loaded (or, possibly, unloaded).
- For the supplier: it reduces fraud, greatly reduces billing disputes, and allows the introduction of various tariff options, some of them aimed at reducing peak-load. For IT companies (such as IBM, Google, etc.) for evident reasons.
- For society as a whole: if non-efficient uses of electricity and peak-demand are reduced so are negative externalities linked with electricity generation (and specifically peak generation), such as emissions of local and global pollutants.

"Semi-smart" meters have been used for decades by some utilities, notably in Europe. Lower costs of IT and increased data storage and transmission capacities are a recent and decisive factor in favour of a generalized use of smart meters. This being said, a careful appraisal of benefits and costs has to be made before investing on a large scale—and this is also necessary because there are now various technology options. Some benefits are easy to measure (e.g., the reduction of the cost of meter reading); but some are more difficult both to evaluate *ex-ante* and to divide among stakeholders. This is the case for benefits involving a customer response, where the customer may have to buy (or rent) a device able to convey relevant information coming from the smart meter (customer surveys show that customers do not want to pay “too much” for this) and then use this information so as to reduce his electricity bill.

The unit investment cost of a smart grid can be roughly estimated to be some €100-150 /customer, if it takes place on a very broad scale and relatively quickly (e.g., over five years). Some benefits of its deployment are almost certain and easy to compute (e.g., mostly benefits for the grid operator), but their amount, compared to the initial investment, can vary according to local labour costs and pre-existing fraud levels. Benefits of this kind may typically represent some 50-60% of the initial investment; it is generally agreed that this proportion does not reach 100%, except in very specific cases.

Other benefits are much more difficult to quantify, as they will depend, among other things, on regulatory possibilities, or obligations, and customer responses. They also vary with the existing electricity generation mix. In favourable cases, the implementation of a smart grid may be very profitable (but, again, regulation and customer response are key factors in considering the distribution of these benefits among stakeholders). Pure real-time pricing of electricity would certainly increase customer response, but it might be politically difficult to implement as a compulsory feature. In-home accessories providing energy feedback and programming possibilities would facilitate savings.

Smart-grid technology may also be useful to facilitate the integration of a large proportion of small-scale, decentralized electricity generation, especially if it is intermittent, like PV.[77]

2.1.6 Greening the Energy Mix

Again, the appropriate political level is generally national. PV power plants, for instance, are more cost-effective if they are very large, and hence ground-based (although there are exceptions, mostly based on the idea that using a “free resource”, be it large roofs of commercial malls, where PV panels can be installed, or energy contained in refuse, is a good idea). Nevertheless, considering the density of energy demand in urban areas and the potential density of production, renewable sources can hardly represent a large share of total energy without a profound reduction in consumption, and/or unless PV can be incorporated in building materials in a cost-effective way.

PV energy has very specific characteristics, which make it attractive to supply electricity to mega-cities: it does not have any moving parts (hence no noise and very little risk, if properly installed), and can be installed in any quantity (from some watts to several hundred megawatts). However, it does have some drawbacks: it only works in daytime, and (in high latitudes) much more in summer than in winter, and it is still much more costly than conventional electricity sources. This second drawback has diminished with time, as PV cost reductions are quite rapid. The location of the PV

[77] IEA, 2009.

installations is significant as well. To use two examples, a large PV installation in the Paris agglomeration provides kWhs costing more than €0.30 (some five or six times more than base-load conventional generation in France); peak demand occurs during winter nights. The same installation in Los Angeles provides kWhs costing some €0.17—not very far from competitiveness with a mix of base-load and peak-load in California, where peak demand occurs during daytime in summer. In a not-too-distant future, and on the basis of economic considerations only, PV energy could contribute significantly to the electricity supply of reasonably sunny mega-cities located between latitudes of 40°N (Beijing, Southern Spain, and Northern California) and 40°S (including all Africa and most of South America).

Wind energy is almost non-existent in mega-cities for good reasons: generally speaking, cities have not been built in windy locations; moreover, buildings “break” the wind. Finally, wind turbines have moving parts—a potential source of noise and risks. Their role in mega-cities is likely to be quite limited.

Biomass can be used in district heating schemes; the sustainable character of its use as a fuel in individual boilers is more problematic in mega-cities, because of difficulties of supply, local pollution, etc.

2.1.7 Waste[78]

Waste treatment challenges differ between mature mega-cities and emerging mega-cities. In the case of the former, one strategy might be to combine limitations on waste quantity, recycling, biological treatment, and use as an energy source. The economic and climatic trade-offs between recycling and incineration are not clear. Recycling needs funds and energy to support the collecting and selection procedures. Incineration needs an expensive industrial infrastructure, but it produces saleable energy and heat: comparative costs will largely depend on the context. For example, recycling performance depends on the collection procedure used, the level of population participation, and appropriate private operators. Efficient incineration schemes need an integrated policy to proportion the infrastructure, minimize the transport, and optimize the use of the energy produced.

Biological treatment of organic waste also has many advantages: it produces biogas and a digestate, which can be sold as a fertilizer. Treatment plants can be compact and smell-less. If both a good collecting procedure and a market for the digestate exist, and if institutional framework permits the use of the products (biogas in existing networks and compost in land), it can be as cost-effective as incineration.

Methane capture in wastewater treatment plants should also be developed, although energy

[78] Prévot, 2000; Ademe 2002 and 2003; C40 Cities: Waste; McKinsey- Siemens, 2008.

amounts are much smaller. Heat pumps can also use wastewater treatment as a heat source (for example,TEPCO's has developed of a heat-pump technology-based heating and cooling system, which powers the heat pumps in Sony City, using waste heat from treated sewage water from a nearby public sewage treatment plant).[79].

For emerging mega-cities, as landfills are generally the main solution for waste, methane capture is a very good solution. It needs an investment of about $1 million per MW installed, but produces a significant amount of energy. In Sao Paulo, methane capture produces the equivalent of 7% of the city electricity consumption, and as a CDM (Clean Development Mechanism) project, $13 million is collected each year by selling the credits. When comparing incineration costs in France and methane capture, we find that methane capture is nine times less expensive in infrastructure investment for each GWh produced. Nevertheless, facing a growing volume of waste and a limited space for landfills, emerging mega-cities will increasingly need incinerators to reduce the volume of waste requiring storage. These installations should meet high emission standards for dioxin and mercury to prevent public health issues and social protests.

No city can ignore the value of its waste, in Copenhagen in 2004, for example, 39% of all waste was incinerated. The amount of heat and power generated corresponded to the consumption of 70,000 households: 210,000 MWh power and 720,000 MWh heat. Waste is an energy source, which can also be a raw material or a fertilizer.

[79]http://www.wbcsd.org/DocRoot/jTwjg3HuITGBRAGjMwkU/TEPCOSonyCity.pdf

Considering the volume of waste treated each year, cost efficiency is crucial. To choose a solution for its situation, a mega-city needs to consider itself as a system. Waste treatment depends on the management of decentralized inputs of very variable quality, induced transport, large and long-term infrastructure investments, complex public private partnership, and output (waste-treated) management. Waste treatment requires policy packages and measure instruments.

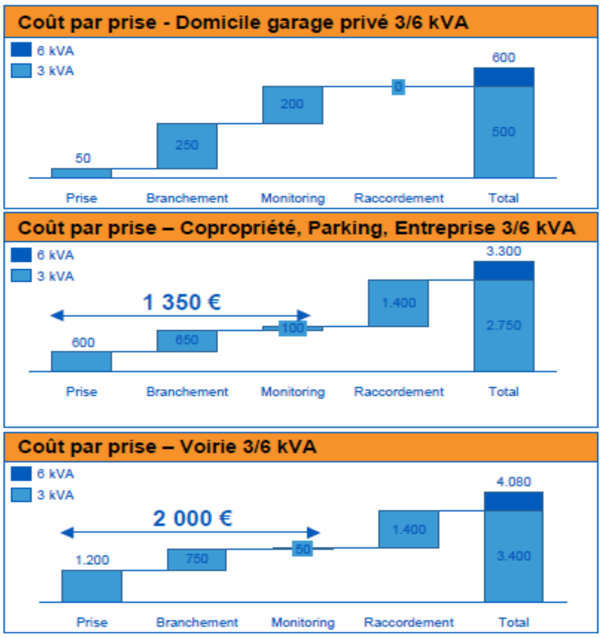
2.2 Technologies Still Needing Industrial Development

High-temperature heat pumps as substitutes for gas or fuel boilers still offer great potential for lowering costs and improving performance, which could lead to their more widespread use. Better insulation products are needed, including easily-installed, high-performance, thin products that can be used inside houses. Efficient lighting could also help to lower the cost of LEDs, which are even more efficient than CFLs.

PV will continue to benefit from cost reductions due to scale effects, as there will be a growing number of very large plants producing PV modules, and, consequently, a gradual improvement in manufacturing processes. The deployment of PV in mega-cities would be facilitated with "PV designed as a building material and architectural element that meets the technical, functional and aesthetical requirements, and cost targets"[80] The deployment of IT solutions can become much more widespread, notably in homes, if they become cheap and user-friendly.

[80] IEA, 2010.

Figure 20
Preliminary costs for the socket itself, connection, monitoring and linking to the network
Source: rDF, Legrand, DTVE



2.2.1 Electric Vehicles

Electric vehicles have existed since the very beginning of the automobile industry. Nevertheless, they have never succeeded in outdoing the popularity of the internal combustion engine because of the strength of the dominant design. All the uses associated with internal combustion engine technology, along with the criteria (autonomy), the infrastructure, and the form of cars were perfectly adapted to these engines, and not the electric ones. Development of this technology was stopped because it was necessarily judged in a context favourable to conventional cars.

However, today, the context is changing and car manufacturers are developing a new paradigm for electric cars, with new business models being developed. Urban mobility is the subject of many research projects, and electric cars are no longer conventional cars with an electric engine, but rather new products designed around specific electric engines. Today, it is not unrealistic to imagine a different electricity price for mobility, and a different congestion-charge tariff or different parking conditions for electric cars. It is worth noting that business has increased the spread of innovation, with the development of the electronic and IT sectors. This knowledge can speed the development of new business models for electric cars.

Plug-in electric vehicles (PHEVs) and electric vehicles (EVs) have become an important subject because they could eliminate local pollution in mega-cities and, provided that the generation of the electricity they use does not emit too much carbon, also reduce CO_2 emissions. However, their cost is still an obstacle to their widespread diffusion. In many rich countries, there are presently high public incentives for their adoption, but these incentives are not sustainable for governments if applied on a broad scale and for a long time period; hence costs (for batteries) have to diminish sharply and quickly.

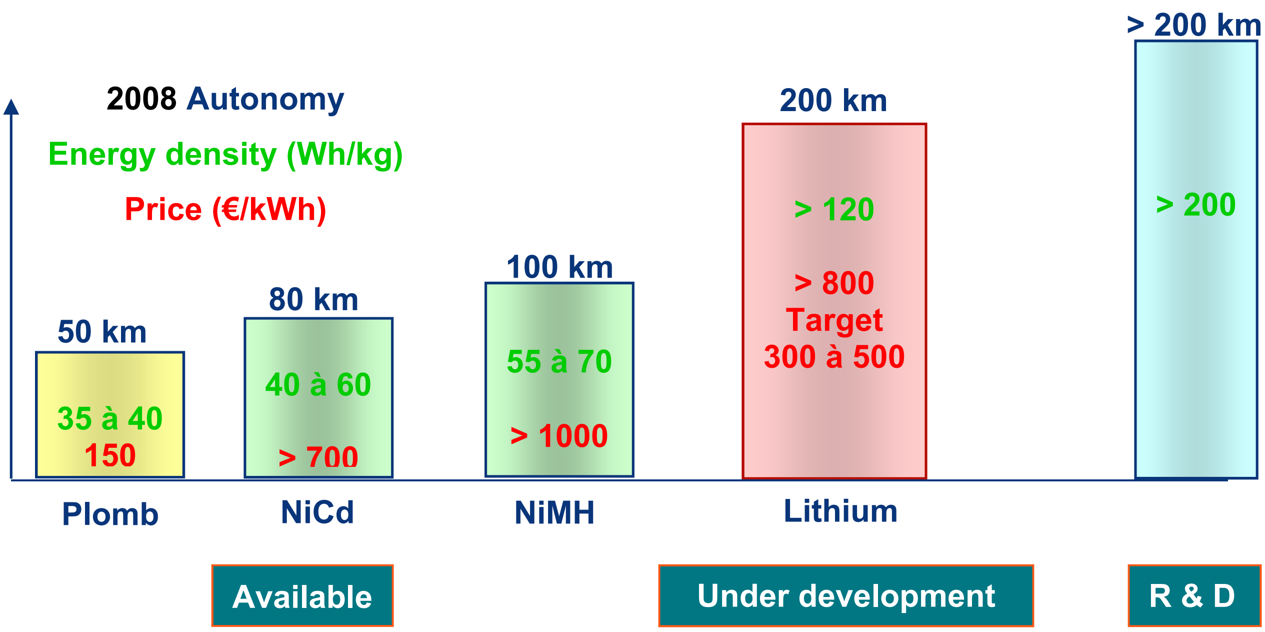
Concerning CO_2, electric vehicle emissions depend on the energy mix used for electricity production. If we take the European average of 340 g CO_2/kWh, we have around 40 g CO_2/km for a small electric car compared to 110 g CO_2/km for a small, recently produced car with an internal combustion engine.[81] If we consider that electric cars may have a big share of the market in the future, efforts to reduce the average emissions per kWh are then all the more important, since they could also reduce

[81] Figures from electric car Citroen C-Zero and Bollore Blue Car, and Peugeot 107 for the gasoline car.

Figure 21

Potential for batteries technological development in term of costs and capacity

Source: S.Lascaud R&D EDF. European Commission, 2009



transport emissions. Emissions also depend on the time chosen for recharging: peak or off-peak hours, and the implemented infrastructures.

As to the costs for the vehicles themselves, these are also significant in terms of loading infrastructures.[82] Figure 20 shows, from left to right, preliminary cost figures for the socket itself, connection, monitoring, and linking to the network. These are shown for, first, a private house—some experts consider that ordinary sockets could do the work—second, for multi-family housing, and, finally, for a socket installed along the street. Scale effects can also play a role (alongside R&D on batteries; Figure 21). For a faster 24kVA socket in the street, the estimated cost is €20,000. Another solution consists of a fast change of batteries infrastructure, which could improve the autonomy and flexibility of electric car use, but information about costs is not yet available.

Electric car deployment is a complex infrastructure issue. Global cost and efficiency will depend on the choices made for loading infrastructure. Car autonomy, CO_2 rate and the ability to be used by a smart grid (to include renewables and reduce peak-hour consumption) will depend on where and when this loading will occur—at home, in the street, or at work. Hybrid rechargeables could have an important share of the market, because they have better autonomy than electric only and currently a better global cost (because of inferior battery needs). If charging infrastructure is not quickly implemented it could disadvantage electric cars, whereas hybrid rechargeables, which can use their thermal engines, would be better adapted.

Figure 21 shows the potential for the technological development of batteries in terms of costs and capacity: figures are probably lower now, because technology evolves quickly, and could be around €10,000 per battery (i.e., probably inferior at €800 / kWh).[83] It is very difficult to gather battery price, battery capacity, and autonomy for one model, but figures will be available very soon as models become commercialized. Battery price has to be seen not only as a part of the car but also as an equivalent to fuel. Considering the price of electricity and fossil fuels, energy consumption per km could be five times less expensive for electric cars.[84] If this were the case, then the monthly package of battery service (fast-change

[82] Figures for domestic-plug and street-plug from Jehan 2009.

[83] Voisin, 2010.

[84] Calculus in a French context

infrastructure and plug-in) could be quite competitive.

Large improvements are expected in terms of autonomy and price. The standardization of batteries and plug-in features will be a key point for the efficiency and development of the charging infrastructure (with plug-in and/or fast-change batteries system).

Considering the short term, electric cars would be well adapted to second cars in urban areas, as part of car sharing, or as part of a company's fleet of cars—all these are uses where recharge can be frequent and trips are not too long. Moreover, electric cars could help the grid to include renewable energy. Car batteries can help deal with such intermittent energy sources, and therefore could have an additional economic value for electric network utility. The development of electric cars could occur concurrently with smart-grid and renewable energy development, especially when designing a charging infrastructure.

New technology or regulation?

To better assess the potential of electric vehicles versus traditional vehicles, we should take into account the improvement of thermal engines. In 2025, cars will probably have decreased their consumption of fuel, and even if electric cars emit less, the difference could be less important than expected. Electric vehicles are undoubtedly necessary—electric-vehicle development is an important way to increase competition and force improvements in thermal engines to improve—but any investment decisions could take that point into account. Strong regulation to decrease internal-combustion car consumption could also help efficiency and should be implemented. The key areas that need development, at both national and international level, are power, car size and weight, and engine technology.

2.3 Promising Research Topics

1. More research is needed on urban planning, as good urban planning is a way of having more sustainable mega-cities in the long run. Planning mechanisms will be described in the next chapter, as they usually necessitate political measures and multilevel governance.

2. Some of the technologies discussed in this chapter would benefit from more R&D. These include: high-temperature heat pumps, PV, batteries for PHEVs and electric cars, global design of electric cars, innovative insulation materials, multifunctional building materials aiming notably at integrating cost-effective PV generators, lighting, domestic appliances, and IT equipment. More generally, R&D is needed that is focused on the information technologies that will become pervasive in mega-cities.

3. Electricity storage, if it becomes affordable, will greatly alleviate many kinds of problems, including, integration of renewables, continuity of supply, and reduction of the capacity requirements to meet peak loads.

Box 5: Why is hydrogen not mentioned in this chapter?[85]

1. Hydrogen is presently manufactured, almost exclusively, using a chemical reaction called "steam methane reforming". This reaction generally uses natural gas and generates CO_2, so that this way to produce H_2 is clearly not sustainable. Alternative ways to produce H_2 exist, but they are either very expensive (electrolysis) or will not be available for many decades (for example, H_2 could be produced using the sulphur-iodine cycle, but that would require high temperature heat generated by fourth generation nuclear reactors).

2. The storage of hydrogen used in vehicles has to be done under very high pressure (up to 700 bars) or in the form of liquefied hydrogen, so as to provide a sufficient driving range; compressing or liquefying hydrogen requires much energy.

3. Fuel cells used either for stationary or mobile uses of hydrogen are either very costly or too short-lived or both.

4. Satisfactory technical solutions that do not necessitate the use of hydrogen already exist. Among these are heat pumps (in stationary applications); electric vehicles (urban and suburban uses); or PHEVs (using alternatively electricity and biofuels) for short to long distances.

5. For a "hydrogen economy" to emerge, a transportation and distribution network has to be created.

For all these reasons, the conclusions of the US Energy Information Administration, who says "that" it is highly unlikely that hydrogen FCVs (fuel cell vehicles) will have significant impacts on LDV (light duty vehicles) energy use and CO_2 emissions by 2030, can be shared. The same could be said for stationary applications.

Dynamic and Systemic

Many of the domains treated in this chapter share systemic aspects with other technologies or actions. For example, changing the transportation network has an effect on the city structure, and city structure impacts on mobility needs; implementing a new line of public transport has an impact on the occupancy of other lines; the capacity to be linked to district heating depends on the density of a city; and there is a trade-off between insulation efforts and district-heating connections. Many other examples can be found: for example, public space has to be shared between the infrastructure for bikes, buses, BRTs and electric cars; waste treatment-network efficiency depends on many aspects of the city and its population; density has an effect on heating and cooling needs.

Moreover, dynamic and track dependencies also need to be considered. The most important is the influence of urban structure on future transportation choices and energy consumption. Urban sprawl has an impact on the possible choice of transport technology, and transportation policies can have an

[85] EIA, 2008.

impact on urban sprawl (e.g., should people use cars, or a fast radial train).

Other examples: When building homes, the choice of heating system can have a deep impact on future choices (e.g., the hot water system—should it be electric, or biomass). When considering urban form or retrofitting policies, the lifetime of a building is also a key point.

Looking at waste treatment, time dependency is crucial, and policy efficiency depends on its good management: incinerators need high investment and then high use rate; landfills can deeply impact areas of the city; efficient recycling requires a well-established culture and adapted infrastructures among the population.

Systemic and dynamic aspects are often neglected, whereas they play an essential role in the success of actions for more sustainable cities: they deserve more attention.

Box 6: Compact city vs. urban sprawl

Many questions about sustainable development or technologies are raised by the following questions:

- Is the best solution urban sprawl with new technologies for cars and homes or a compact city with efficient public transport?
- From an economic point of view, is it better to invest in retrofitting buildings and high performance new homes and subsidize electric or hybrid cars, or to invest in more compact cities and very efficient public transport?

The following example may provide some useful data for energy consumption.

Imagine two four-person households, each with two working parents; one household lives in Paris, and the other in the suburbs. We will examine energy for heating and transport, since these are the variables most influenced by the differences in urban location.

Paris household:

- Average consumption for heating in a quite recently built, multi-family building in Europe: 80 kWh/m^2/an[86], housing of 70 m^2→ **480,000 goe/year.**
- In Île de France, people do 3-4 trips per day on average; average trip length for a Paris resident is 3 km (very dense area): annual distance for each parent → **3,700 km/year.**
- They use only public transport with a ratio 1/5 bus 4/5 rail → 11 goe/trav/km[87] (rail volume is five times more important than bus in traveller/km in IdF) → **80,000 goe/year.**

Suburban household:

- A passive house (a translation of the German Passivhaus, and refers to a rigorous, voluntary standard for energy

[86] Same source as for figure 6, Insulation costs.
[87] STIF 2009a; emission rates from RATP 2008.

efficiency of buildings) of 100 m^2 uses a maximum 15kWh/y/m^2 for heating (German standard) → **130,000 goe/year.**

- We consider that a Prius consumes 27 goe/trav/km, (the average consumption in IdF is 55 goe/trav/km[88]).
- Average trips for residents of the great ring of Paris is 6,3 km[89], annual distance is about **8,000 km** → 2 prius: **430,000 goe/year.**

Surprisingly, the first case and the second case have about the same energy consumption: **560,000 goe/year**. Even if figures can be discussed it is worth noting that the orders of magnitude are very similar. It is not easy, at first glance, to identify the best solution. Moreover, because of the need to deal with actual urban structures, it seems clear that cities will combine these two schemes while, in the same time, favouring more or less each way. Then which strategy should be given priority?

For the time being, the relative cost of the two schemes is difficult to evaluate. It would require a whole project applied to a particular city to determine if densification and public transport policy is more cost effective than strong thermal renovation policy and hybrid subsidies.

In light of both current urban structures and economic interests, necessary trade-offs will have to be found by cities as they develop ambitious public transport networks and hybrid and electric use. How can cities share public space and public money between the needs of these two technologies? For example, exclusive lanes for buses can limit electric car space and create congestions; the budget for public transport infrastructure can limit the budget available for electric-car subsidies and plug-in infrastructures, and *vice versa*. It could also be a situation of competition between two networks (public transport vs. plug-in infrastructure), which both require sufficient returns on infrastructure investment.

Looking for an efficient trade-off between an ambitious public transport policy and the deployment of electric or hybrid vehicles raises many questions. The answers will be of great importance for any city's future.

Turning to the calculations above, we might ask two key questions about the assumptions that underpin this exercise: i) are affordable Passive Houses available now, and ii) is it possible to use only public transport in dense areas?

With regard to Passive Houses: these may cost only 5% more when the market is well established, but are probably much more in other contexts, and performance is often lower than expected.[90] A heating consumption of 15 kWh/m^2/y is probably difficult to achieve, and 30 is maybe more realistic. Moreover, the rate of renewable building stock is very low in developed countries, while low-consumption houses have only a small capacity to reduce

[88] RATP and Ademe.
[89] IAU, 2008, pp. 54 and 79.

[90] 'In Germany, Austria, or Sweden it is now possible to construct Passivhaus buildings for costs that are no longer significantly higher than for normal standards, because of increasing competition in the supply of the specifically designed and standardised Passivhaus building products. For these countries, the extra cost of construction is generally indicated to be in the range of 4-6 % more than for the standard alternative', European Commission, 2009.

global energy consumption and CO_2 emissions in the near future.

Turning to the use of public transport for in dense areas—this is clearly possible in well-served cities like NY, London, Paris or Tokyo, but less in their periphery. Moreover one could say that it does not take into account weekend trips into the countryside by residents of compact cities, which would largely increase the global figure. However, these trips may well be taken by train, in contrast to trips made by suburban residents who own a car. Concerning car technology, it is clear that, in the future, plug-in hybrid and electric technologies could decrease CO_2 emissions even further, but the price of their deployment is still uncertain and then actual hybrid's figures were taken.

Another controversial issue is the ability to really modify the density of cities, as it seems difficult to change the urban structure of mature mega-cities in developed countries. Nevertheless, it seems that policies can be implemented to prevent further urban sprawl and modify the city structure over a longer period, particularly at the regional scale, which has the potential to limit urban sprawl. Moreover, for many growing mega-cities in the developing and emerging world, the choice between urban sprawl and compact urban area has still not yet been made. Moreover, if this calculation is done in this context, heating consumption becomes very low. Then the order of magnitude change and transport consumption become the major issue. The comparison between compact city and urban sprawl is easier: we can see that high use of public transport is required to decrease energy consumption, and this is only possible in compact cities.

The choice between compact cities and residential suburbs is also a social choice, and an individual preference. We cannot make this judgement only on the basis of energy indicators, because people do not make choices in that way—rather, they look for quality of life. This is why much needs to be done to improve quality of life in compact quarters. Since many city centres or old quarters are both dense and attractive, it does not seem impossible to reach pleasant, dense, and efficient urban areas.

2.4 Conclusion

This chapter shows that a large portfolio of options already exists for improving the sustainability of energy use by mega-cities. The largest potential can be found in i) urban form and density, with adapted public transport options, and ii) energy efficiency of buildings. These are the main challenges facing mega-cities. A third challenge, to green the energy mix, may bring interesting improvements, but offers less potential for improving the sustainability of energy use.

But the implementation of these options is generally complex. Usually they present many problems to be overcome, including information that is not widely available; split incentive or coordination difficulties (for example, in the case of buildings) blocking change; action that is costly and gains that are low or risky; a market that is not sufficiently ready or competitive to implement new technologies; lack of planning and strong public action (especially in the case of transport); and actions that are not profitable for all stakeholders.

The effective implementation and efficiency of technologies profoundly depends on associated policies. There is generally a need for public intervention, combining national policy (e.g., building codes, R & D financing, etc.); municipal policy (e.g., urban planning, traffic regulations, etc.); and private sector involvement. Local policy must also address the ways in which these technologies are used. For example, rebound effects (e.g., in heating and cooling buildings) or occupancy rates (e.g., in private cars) are often as important for the final efficiency of the technology as the technology itself.

Because policies in urban areas need to embrace both systemic and dynamic aspects, governance is key for mega-cities to meet their challenges. It is the aim of the next chapter to explain how these multi-actor interventions can be implemented at a local level.

Chapter 3: What Could be Done?

3.1 Market Forces and Planning[91]

The relationship between planning and market forces has thoroughly changed in recent decades. These changes imply some modifications in public policies affecting land use, especially to encompass objectives of sustainable development. The main development in this respect has been an important move toward deregulation and flexible planning. This progressive change differs from one country to another, but is generally implemented in most OECD countries, and also in many developing countries.

Behind this move toward deregulation rests an assumption that more flexibility in land use regulations can enhance economic development. Indeed, in several countries where planning and zoning are more rigid, regulation could constitute a hindrance to economic development. Another underlying assumption is that the increase in land supply that supposedly results from deregulation should lead to a decrease in land prices. This premise has been strongly advocated, especially in the 1970s and 1980s and was implemented in several countries, including the UK, France, Spain, and some central European countries. However, events have provided evidence that deregulation and flexible zoning do not manifestly influence the evolution of land prices. In fact, the evidence shows a series of negative consequences–for sustainability, through degradation of natural areas, social exclusion, and more generally with regard to the possibilities of using strategic planning to design a long-term vision for a territory.

Here we touch on, in part, what the legal scholar Jean Tribillon describes as "real-urbanism", in the absence of a better term.[92]

"Real-urbanism" involves deciphering the models by which urban majorities produce and reproduce their living spaces. Land and property markets, both formal and informal, are sending signals that reflect the dynamics of the urban structure, which the legislator must take into account. It is therefore important first to improve our understanding—of each city as a local context; of the phenomena of intensification (concentration and expansion); and of the dilution of urban forms. It is also essential to comprehend the effect of improvements to accessibility of rapid mass transit systems (such as heavy or light underground, Bus Rapid Transit, etc.) in the creation of new polarities. In short, we must understand the factors that determine the location of households and activities.

Tribillon also suggests that the main urban stakeholders and operators that are involved in property development should be permitted a large amount of independence: "The technician involved in town planning, together with the decision-making leader or elected official must cooperate with a third partner: the operator that builds the city and gives a real and concrete content to planning

[91] This section owes much to Lefevre , B. and Renard,V. : Financing urban sustainability policies, Background paper for OECD.

[92] Tribillon chose this term to translate the German neologism *realpolitik* (Tribillon, 2002).

Finally, the priority is not to design an ideal city but, more modestly, to redesign the forms of existing cities and thus to anticipate, encourage, and to support spontaneous urban development. Rather than seeking a static model of a sustainable urban form (Box 7), it is necessary to identify the complex pathways through which different urban forms, in relation to infrastructure, can claim sustainability.

Planners have at their disposal essentially three types of tools to help shape a sustainable urban spatial structure: i) land use regulations, part of which will be a zoning plan; ii) infrastructure investments; and iii) property taxes. The impact of these tools is indirect. The real estate market, which reacts to the constraints and opportunities provided by regulations, infrastructure, and taxation, will shape the city; the designs and blueprints of planners will not have much direct influence.[93] For this reason, spatial indicators must be constantly monitored to verify that the city is evolving in a spatial direction that is consistent with municipal objectives. Urban planning is not an exact science but advances by a process of trial and error. Monitoring the constantly evolving spatial organization of cities is therefore of utmost importance.

However, as many northern European countries have shown, it is possible to combine strong urban planning and public involvement with a free market economy. As these countries often demonstrate, there is room for public intervention, while still enjoying the efficiency advantages of free markets. In this situation, urban policies anticipate and frame market dynamics, which is the underlying principle and goal of the adoption of a strategic planning approach.

BOX 7: Looking for the ideal city

For a long time, urban experts have sought to agree on a definition for the ideal sustainable urban form. Various models of urban development have been put forward, giving priority to one or another of the three pillars of sustainability: for example, the “garden city” (Howard), the “new harmony” (Owen), the “industrial city” (Garnier), the “linear city” (Soria y Mata), the “Broadacre City” (Wright), the “radiant city” (Le Corbusier), and community and peaceful organizations such as Fourier’s phalanstery or Cabet’s Icaria, have all been proposed as models of ideal urban form.[94]

Considering the explosion in energy consumption, particularly relating to urban transport, there is a significant temptation to define an ideal urban model as one that minimizes energy requirements and GHG emissions. Planning discussions for energy-efficient urban development have been particularly lively since the 1990s, characterized by the debate between proponents and opponents of a compact city. The term “compact city” is used in the literature to bring together different approaches of urban planning, focusing on the benefits of curbing urban sprawl.

93 Bertaud, 2001.

94 Ragon, 1994.

On the one hand, the supporters of the compact city have argued that a high level of compactness, i.e., high density, in various forms, reduces the number of car trips and distances travelled.[95] High density can limit land usage through processes of urban renewal, including rehabilitation, renovation, and urban re-qualification. There are many benefits attributed to urban containment, including reduction of the costs of infrastructure, reduction of the consumption of land, preservation of habitats and landscapes of interest, and economic and social renewal of inner cities.[96] However, currently, the main objective of this policy is to reduce energy consumption and, hence, pollution. A small amount of urban sprawl makes it easier to use non-motorized and public transport, and thus allows greater mobility but also greater accessibility. High usage of public transportation limits and replaces the number of private vehicles responsible for congestion, pollution, and accidents. Due to the proximity and diversity of available facilities, the use of bicycles and walking is encouraged.

The arguments in favour of the compact city have convinced many authorities to advocate urban renewal policies, in preference to the pursuit of suburbanisation. Examples of this approach include the French law of December 13th, 2000 "Solidarity and Urban Renewal" or the implementation of the Rogers report in London, "Towards an Urban Renaissance", October 2000. The European Commission encourages European cities to move towards more compactness, on the basis of environmental and quality of life objectives.[97] The British government has made urban compactness a central element of its sustainable development policy, presented in 1994 at the United Nations Commission on Sustainable Development.[98] The Dutch government has taken similar action, and even Australian and North American authorities have attempted to reverse urban sprawl.[99]

Some authors consider that the benefits of a compact city have not yet been proven. No studies have decisively highlighted the direct and indirect costs of compactness. The concentration of several million people and associated economic activities can lead to serious problems of congestion, quality of life and access to the city for the poorest, and thus can frustrate the environmental, economic and social goals of sustainability. One of the leaders of this opposition movement, Breheny raises alarm over the fact that urban containment policies are not based on any academic certainty and highlights two key questions: what is the magnitude of energy consumption resulting from the increased decentralization of urban forms? Is this magnitude—and thus the potential reduction if decentralization can be contained—important enough to justify the introduction of policies aiming at reversing the powerful forces underlying urban dynamics?[100]

[95] We can mention among others Haugton, Hunter, 1996, Camagni *et al,* 2002, Fouchier, 1995, Newman, Kenworthy, 1999.
[96] Landscapes: Mc Laren, 1992; Council for the Protection of Rural England, 1992, 1993; Inner cities: Bourne, 1992, Robson, 1994.
[97] Commission of the European Communities, 1990, 1992.
[98] Department of the Environment, 1993.
[99] Dutch: National Physical Planning Agency, 1991; Australian: Newman 1992; North American: Wachs, 1990, Chinitz, 1990.
[100] Breheny, 1994.

He concludes his study by discussing the inconsistencies of encouraging compactness. On the one hand, the potential gain does not exceed 34% of the current energy consumption of urban transport in the United Kingdom; on the other hand, the drastic policies necessary to reverse spontaneous trends of urban decentralization in order to obtain this reduction would be too costly at economic, social, and cultural levels.

Following the reasoning of Owens, who is very active in promoting the concept of urban compactness, the response to the argument of “natural tendencies to urban decentralization” advanced by Breheny is that this viewpoint is based on two assumptions that require validation: i) these trends are the inevitable result of individual preferences; ii) the resulting urban form satisfies the aspirations of individuals.[101]

Offering an alternative to these debates, the proponents of “new urbanism” support an intermediate thesis: the model of a poly-nuclear city. In this “decentralized concentration”, the functions that are usually concentrated in the main centre are scattered into several other sub-centres, forming cores connected by effective public transportation infrastructures.[102]

The argument is that cities would function better if they provided public transport that linked them to suburbs with relatively high densities and a mixed occupation of the land.

[101] Owens, 1995
[102] We can mention among others Frey, 1999; Dutton, 2001; Beatley, 2000; Calthorpe, 1993; Jacobs, 1992; Talen, 2005; see www.newurbanism.org.

Thus, the strengthening of the “polycentric network”, with a diversification of sub-centres, is the option that attracts the largest consensus today.

POLYNET, a study conducted under the ESPON program, concludes with the advice "to be wary of the cult of polycentric consensus”.[103] This study highlights the fact that where the metropolitan area is dominated by one major centre of international level, developments in satellite cores primarily concern activities that are either specialized niches, such as the logistics around airports or enforcement activities, rather than management activities. The latter increasingly concentrate in the centres of the largest cities, as indicated by the high property prices that are willingly paid, resulting in the monopolization of these areas. POLYNET shows that the proliferation of satellite centres may lead to cross-flows in the greater metropolitan area, which do not necessarily promote a sustainable management of transportation. It also appears that the decentralisation of cities does not usually result from a coordinated policy at the greater metropolitan level, but rather from competition between the centre and its peripheries, which allows some companies to profiteer.

[103] POLYNET: Sustainable Management of European Polycentric MegaCity, Regions, INTERREG IIIB NWE programme, www.espon.public.lu/fr/ . ESPON: The Monitoring Network of European Spatial Planning, created by the European ministers of planning, was conceived as a series of studies designed to observe the European Community. After a test phase from 1998 to 2001, the first ESPON programme ran from 2002 to 2006. A new programme started in 2007 and will run until 2013; see Vandermotten, Roelandts, Cornut, 2005.

3.2 The Case for Action at the City Level

Urban areas are increasingly important centres of population, energy use and, given the relatively widespread dependence on GHG-intensive fuels, significant sources of GHG emissions. Local authorities often enjoy a range of policy competencies that give them a potentially important role in improving national policy signals and influencing behavioural changes towards low-emission development pathways. Their capacity to set local standards, influence urban planning, target infrastructure investment, deploy creative financial programs, and provide information and guidance, combined with their ability to convene and interface directly with constituencies, mean that local authorities can influence a number of barriers to GHG mitigation.

Understanding the links between the international climate regime and local mitigation policies requires an analysis of the theoretical "policy chain" that occurs, moving from "higher" to "lower" scales of government. This policy chain begins with the international framework agreements (UNFCCC, Kyoto Protocol) that currently serve to structure, at least formally, national policy on the reduction of GHG emissions. National authorities typically translate these signals into either price or regulatory policies, which are used either to reduce the quantity of an emissions-intensive activity, or to push for the adoption of less-intensive methods and technologies. However, a number of barriers, including transaction costs, market imperfections, and issues related to human understanding can limit the efficiency of these regulatory and price signals. As the signals from national policies are translated from one scale of government to another, there may also be a range of transaction costs as well as structural barriers, such as information search costs, high market entry costs, and limited access to credit. This means that the efficiency of these policy signals is reduced and the cost of achieving GHG reductions may increase.

Cities and metropolitan authorities are often well positioned to develop policy solutions that best meet local geographic, climatic, economic and cultural conditions.[104] Key to understanding how cities can improve the global efficiency of GHG mitigation policy is an analysis of the means at their disposition. Understanding their powers and duties in key sectors such as energy, transport, planning and waste have been linked to the capacity of local authorities to take action.[105] Furthermore, given their ability to influence many policies that address diffuse emissions sources, local authorities can implement both short- and long-term policies that influence emissions sectors—and often go beyond the direct influence of national governments.

Local authorities have two principal options in reducing GHG emissions. First, they can target the emissions over which they have direct control as an organizational entity, such as energy use in public buildings, public fleet, etc. Secondly, they can use their capacities and policy levers to reduce GHG emissions from activities occurring within their administrative area. In addition to direct

[104] Betsill, 2001; Bulkeley and Kern, 2006; Bestill and Bulkeley, 2007; Corfee-Morlot *et al.*, 2009, Kamal-Chaoui *et al.*, 2009.
[105] Betsill and Bulkeley, 2007.

control over emissions relating to the provision of locally provided public services, they also have significant direct and indirect influence over policy areas such as land-use zoning, transportation, natural resources management, buildings, and waste and water services.[106]

Local authorities can implement a number of policies to aid the diffusion and provision of technological and process alternatives. First, in cases where collective infrastructure is needed to provide an alternative, they can *create* the low-emission option. In order to push for the adoption of low-emission practices (updating of technologies, for example), they can establish and use strict standards for new construction and renovation, giving the necessary regulatory incentive to both the private sector and individuals to construct the necessary infrastructures and adopt appropriate technologies and processes. A range of non-punitive options is also available: for example, local authorities can use enabling policies to overcome risk-adverse behaviour. By conducting information campaigns about alternative modes of transport, for example, they may help to spur changes in behaviour.

3.3 Policy Levers Available to Local Authorities

Bulkeley and Kern have devised a classification to better understand policy approaches and instruments available to local-level governments.[107] They have proposed four categories of policies summarized (the policies are in Table 10): *self-governing*, *governing by authority*, *governing by provision*, and *governing through enabling*. This classification aids understanding of how policy measures target different sources of GHG emissions and address different types of transaction costs and structural barriers—helping to achieve desired results and incite behavioural changes in consumers as efficiently as possible.

- *Self-governing* policies apply to city operations and the ability of local/regional governments to integrate policies on energy-use, GHG mitigation and atmospheric pollution reduction policies directly into their own activities. Just like corporate entities, cities are in a position to control their own consumptions, increasing energy efficiency in city buildings and purchasing electricity and heat from low-emission sources, as well as decreasing the vulnerability of publicly owned utilities and services to changes in climate.

- *Governing by authority* is a category composed primarily of regulatory measures and binding planning documents used both to control emissions sources and to influence future urban growth. These policies are mainly available to cities that are able to regulate effectively, and their success depends on the enforcement capacity of the local government.

- *Governing by provision* is accomplished through the provision of direct services

[106] Betsill and Bulkeley, 2004, Corfee-Morlot *et al.,* 2009, Kamal-Chaoui *et al.,* 2009.
[107] Bulkeley and Kern, 2006.

Table 10

Modes of governing and local climate change mitigation policy

Source: Adapted from Bukely and Kern, 2006

Self-governing	**Governing by Authority - Planning and Regulation**	**Governing by Provision - Direct Service Provision**	**Governing through enabling**
Energy			
- Energy efficiency schemes within municipal buildings - Use of CHP within municipal buildings - Purchasing green energy - Procurement of energy-efficient appliances - Eco-house demonstration projects - Renewable energy demonstration projects	- Strategic planning to enhance energy conservation - Supplementary planning guidance on energy efficiency design - Supplementary planning guidance on CHP installations or renewable - Supplementary (private) contracts to guarantee connection to CHP or renewable energy installations	- Energy efficiency measures in public housing - Energy Service Provider/Companies - Community energy projects	- Campaigns for energy efficiency - Provision of advice on energy efficiency to businesses and citizens - Provision of grants for energy efficiency measures - Promotion of the use of renewable energy - Loan schemes for PV technology HECA report (UK)
Transportation			
- Green travel plans - Mobility management for employees - Green fleets	- Reducing the need to travel through planning policies - Pedestrianisation - Provision of infrastructure for alternative forms transport - Workplace levies and road-user charging	- Public Transport Service Provider	- Education campaigns on alternatives - Green Travel Plans - Safer Routes to School - Walking Buses - Quality partnerships with public transport providers
Planning			
- High-energy efficiency standards in new buildings - Use of CHP and renewables in new council buildings - Demonstration projects—house or neighbourhood scale.	- Strategic planning to enhance energy conservation - Supplementary planning guidance on energy efficiency design - Supplementary planning guidance on CHP installations or renewables - Supplementary (private) contracts to guarantee connection to CHP or renewable energy installations (Germany)		- Guidance for architects and developers on energy efficiency - Guidance for architects and developers on renewables
Waste			
- Waste prevention, recycling, and reuse within the local authority - Procurement of recycled goods	- Provision of sites for recycling, composting, and 'waste to energy' facilities - Enable methane combustion from landfill sites	- Recycling, composting, reuse schemes - Service provider	- Campaigns for reducing, reusing, recycling waste - Promote use of recycled products

(water, electricity, public housing, etc.). When local governments function as service providers, either through public utilities, majority stakeholders in mixed companies, or by contracting with private sector companies, they can influence public consumption and waste disposal patterns both directly and indirectly.

- Finally, policies in the category *governing through enabling* aim to assemble approaches and instruments that, through argument, learning, and incentives structures, push other actors within the community to take action. Local governments work to foster communication and learning, developing public private partnerships around different mitigation and adaptation issues, and develop incentive structures to foster action.

Box 8: Shanghai's intensive education campaign efforts

Shanghai Municipal Government has implemented measures to make the public aware of the problems relating to energy efficiency and energy conservation. Shanghai Energy Conservation Supervision Centre (SECSC), which is the first non-profit energy conservation administrative organization in China, is affiliated to the Shanghai Economic Commission. It took an active part in the dissemination of energy conservation information, good case studies, technological consultation, and energy conservation popularization and training. Shanghai is a pioneer in this public-education process, and has paired it with both regulatory and market-based efforts to expand the impact of energy efficiency policies and projects.

As shown in Table 10, local authorities have a wide range of policy options available in the energy sector. They not only have the capacity to mandate action and set standards, but can also create new offers in terms of low-emission energy services. Finally, in their capacity as enablers, local authorities can bring together different groups involved in the policy process, and provide the information necessary to foster behavioural change in consumers.

3.4 Policies as "Packages" of Measures

"Off-the-shelf" technical solutions, like those described in Chapter 2, are not enough to tackle the energy challenges in mega-cities. Both in terms of reducing GHG emissions and energy poverty, policy "packages" are needed, which coordinate actors both within and across traditional policy sectors. Given the "typical" distribution of jurisdictions and competencies, this implies coordination between different levels of government, both vertically, between national, state, and municipal levels, and within municipal levels, and horizontally, for example, between municipalities belonging to the same urban agglomeration. Secondly, it implies public private partnerships and various kinds of participation by civil society.

For example, mass transportation infrastructure policies and land-use policies have to be coordinated in order to increase the density along mass transportation lines, so as to avoid urban sprawl at the ends of lines. The effects of vested interests (such as private bus, taxi and "rickshaw" businesses) also have to be managed. Policies are more efficient if they take care of interconnectivity, emphasising walking and cycling, rather than the use of personal vehicles, as ways to connect to mass transportation.

The following sections will provide three important examples of such "policy packages": i) ways of combating energy poverty in mega-cities, in both South and North; ii) BRT networks in emerging cities, illustrated by the success story of Bogota; and iii) improvements in energy efficiency in old buildings in Europe using "third-party investment.

3.5 Policy Packages I: Combating Energy Poverty

As previously discussed in chapter 1, energy poverty is a common phenomenon in both developing and developed countries. The main causes of energy poverty are poor energy efficiency, lack of access to cheaper energy sources, and the mismatch between disposable income and cost of energy alternatives.[108] In developed countries, poor energy efficiency generates great heat loss from households, while in developing countries many households don't have access to modern energy sources (e.g., LPG, electricity) and use less efficient energy sources (e.g., wood, kerosene). Both situations may generate health problems for household members.

[108] EBRD, 2003.

According to ESMAP reducing energy poverty can improve household welfare in a number of ways[109]:

1. Improved health: reduction of indoor air pollution, safer water (boiled), and reduction of exposure to extreme temperatures
2. Security and risk reduction: fewer fires, more light at night
3. Increased education levels
4. Increased income through reallocation of the time used to procure cooking fuels
5. Boost in social status, from social exclusion to social inclusion
6. Might reduce expenses in energy (in some cases, illegal electricity is paid for at higher prices than legal electricity).

Since the main causes and consequences of energy poverty are different in developing and developed countries, energy-poverty policies for these locations will be analysed separately. Given that the main problem in developing countries is accessing modern energy sources and gaining access to legal and safe electricity, this will be the main subject of discussion. In the case of developed countries the analysis will concentrate on energy efficiency in buildings.

[109] ESMAP, 2008.

Table 11

Lessons from electrification practitioners

Source: ENSAM "meeting the energy needs of the urban poor" and USAID "transforming electricity consumers into costumers" – Sao Paulo

* cost of connection may vary according to methodology of calculation

Location	Adaptation	Subsidies or financing	Cost of connection ($US/hh)*
Manila (Philippines)	- Distribution lines brought to slum perimeter - Individual meters placed on meter walls - Households to install own wiring to reach home	- Financing offered for internal wiring	154
Cape Town (South Africa)	- Community-based distribution company - Pre-payment meters installed	- Subsidies and financial assistance for connection fees -	417
Rio de Janeiro (Brazil)	- Community agents mediated for electricity company	- Debt relief - Subsidized connection fees	226
Salvador (Brazil)	- Community agents - Replacement of inefficient lighting, refrigerator seals and unsafe inefficient domestic wiring	- Subsidies and financial assistance for connection fees - Convenient location for bill payments	350
Sao Paulo (Brazil)	- Use of non-standard technologies such as anti-theft cables, remotely controlled meters and efficient transformers	- New, efficient lights - Poorest received replacement refrigerators - Bills capped at 150 kWh for a period of 3 months	NA
Ahmadabad (India)	- Local residents to read meters	- Subsidies and financial assistance for connection fees	114

3.5.1 South: Gaining Access to Modern Energy Sources

Table 11 lists projects carried out in poor settlements across the global South, covering, the adaptation techniques used, the types of subsidies implemented and the cost of connection per household. In most of these projects the community has been involved from the beginning, and continues to have an important role in managing electricity supply and bill collection. In Manila, Philippines, distribution lines were only brought to the limits of the slums and the community was responsible for installing wiring to reach their houses; in Ahmadabad, India, local residents were in charge of reading the meters.

Some of the lessons learned from the ENSAM and USAID studies of the electrification of poor settlements include:

1. The need to involve all stakeholders (communities, NGOs, electricity companies, service recipients and intermediaries)
2. The need to adapt "traditional" ways of providing electricity services to the field, through:
    a. Technical innovation: to tackle, for example, narrow streets, or electricity theft
    b. Payment innovations: new forms of payment or tariffs (access and/or consumption subsidies)
    c. Organisation innovation: direct involvement of communities

Examples of electrification in developing countries show how fuel poverty in these cities is, in many cases, the consequence of political and institutional barriers, rather than affordability problems. In informal settlements, energy poverty is only another form of exclusion from urban services: inhabitants are usually denied access to improved water services, sanitation, health care, etc. Therefore combating energy poverty in informal settlements usually needs to be preceded by a

Figure 22

Existent policies in the European Union to tackle fuel poverty

Source: EPEE, 2009a

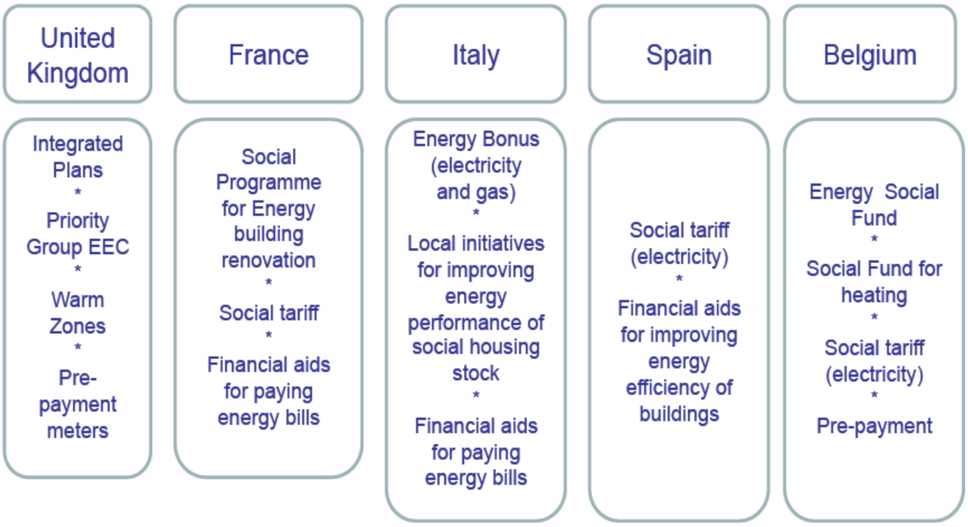


Figure 23

European "good practices" to tackle fuel poverty in Italy (I), Spain (S), United Kingdom (UK), Belgium (B) and France (FR).

Source: EPEE 2009b

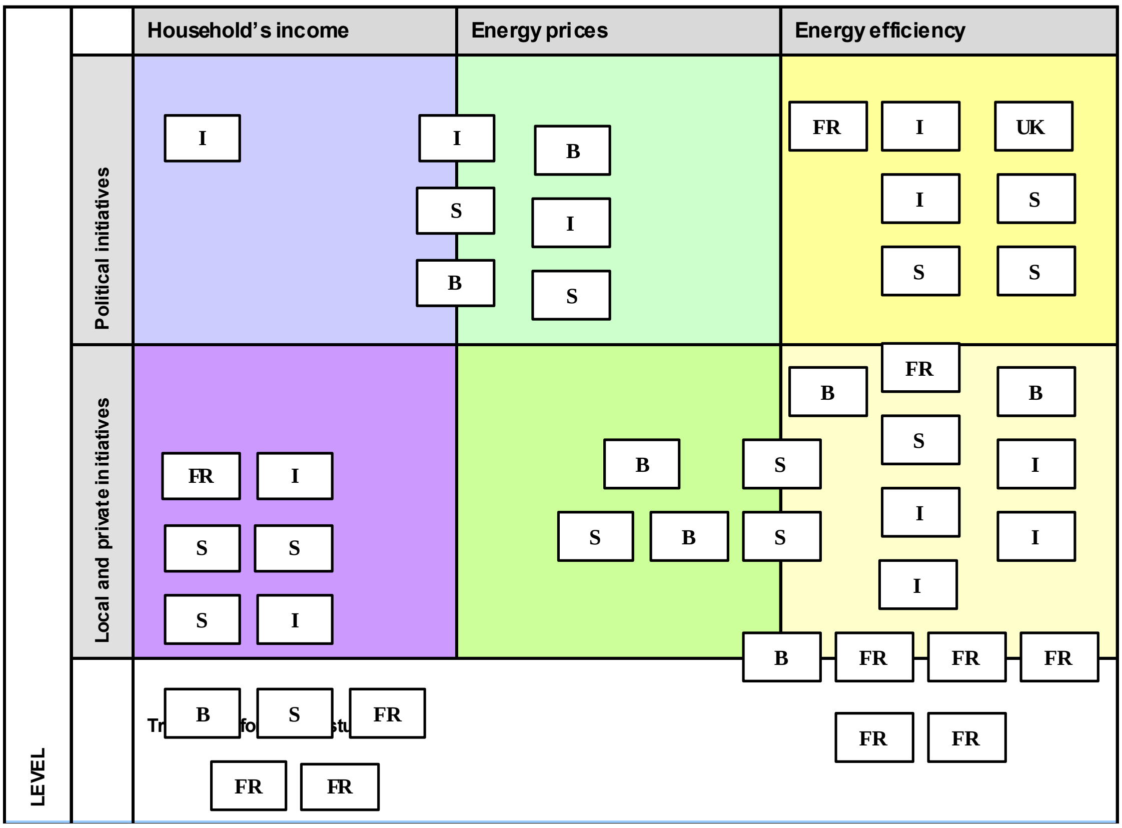


Table 12
Stakeholders for energy poverty measures

	Government	NGOs	Energy Utilities
Financial resources	High	Low	Medium
Contact with households	Low	Medium-High	Medium-High
Technical expertise	Low	Medium-High	Medium

partial or total recognition of the right of its inhabitants to city services.

Furthermore, the reduction of barriers to modern fuels may have positive effects for poverty reduction and climate-change mitigation. As households change to more energy-efficient fuels there is a reduction of indoor pollution, local pollution and global warming.

3.5.2 North: Buildings Energy Efficiency

Implementing energy-poverty action needs the coordination of different levels of governance. Power notes of the US. "In the unlikely event that a national target date for ending fuel poverty was agreed, the manner in which the energy distribution system is structure means that the national government would lack of the legal tools to ensure a unified policy was implemented."[110] Furthermore, as legal and administrative environments vary from one country to another, the implementation of fuel-poverty actions has to take governance architecture into account. The responsibilities of owners and tenants, the bodies responsible for defining and/or applying housing standards, and the organisations charged with financing energy-efficient improvements will also differ.

The EPEE identifies some of the existing policies for tackling the fuel poverty in the European Union: According to McCammish, in the United Kingdom 60% of households moved out of fuel poverty category due to increased income, 17% because of energy efficiency improvements and 22% due to lower fuel prices.[111] Figure 23 shows that most of the fuel-poverty initiatives involve energy efficiency measures.

Experts suggest that the most effective response to fuel poverty is to improve the housing stock.[112] In this way, actions to tackle fuel poverty and climate change can work together. Other policies, such as increasing subsidies on energy prices or making transfers to energy poor households, can lead to higher energy consumption and bigger GHG emissions, and policies directed to reduce emissions by pricing carbon may increase energy poverty.

Experiences of policy implementation in the UK suggest that the local level is best for the introduction of policies. The European Bank for Reconstruction and Development (EBRD, 2005) states that measures to attack energy poverty need to combine forces from a number of stakeholders (government, energy utilities and NGOs). Table 12 shows the relative advantages and disadvantages for each of these agencies. Typically, effective measures to mitigate energy poverty require a combination of significant financial resources with a good understanding of the end consumer, for example as indicated by high-quality data on energy consumption, income levels and the condition of housing stock, together with the technical expertise to carry out energy poverty mitigation measures. These attributes are not

[110] Power, 2006.

[111] McCammish, 2006.
[112] Boardman.

necessarily all held by one party, which is why a partnership approach often works best.[113]

According to Boardman's results for the UK. "The only long-term solution to fuel poverty is to improve energy efficiency of people's homes. Targeting the least efficient homes (F and G bands of the EPC) would help 50% of the fuel poor."

3.5.3 Conclusions

As we have seen before, energy poverty concerns cities in both developed and developing countries. In both cases, energy poverty is highly correlated with poverty. While energy poverty has gained some attention from public authorities there remains an urgent need to find a stable definition of it. This must include the concept of mobility poverty, which is essential when considering policies to reduce energy poverty in urban areas.

Public policies intended to reduce emissions need to take into account the causes and origins of energy poverty, since they may lead to a worsening of the situation. In addition, energy-poverty policies that lead to lower energy prices (subsidies) or an increment of household income (i.e., transfers) may actually increase the total consumption of energy and climate-change emissions. However, energy-poverty policies implemented in the North have proved that energy-poverty reduction targets and emissions reduction targets are compatible. The introduction of energy efficiency in old buildings and social-housing compounds has proved to be the best policy so far.

[113] EBRD, 2005

In the South, energy poverty is generally related to informal settlements and is associated with two different barriers: i) gaining access to modern energy sources; and ii) being able to afford them. For a large part of the energy-poor population in the South, the biggest barrier is gaining access to modern energy sources, given institutional obstacles. Unfortunately, many governments and local authorities are still unwilling to provide basic services to informal settlements, given that it is seen as a partial formalisation of the settlement. However, policy lessons from the South have proved that the provision of legal and safe electricity in these circumstances is beneficial and possible. Moreover, electricity suppliers benefit from the loss reduction. The key to introducing legal electricity has been shown to be the adaptation of traditional ways of providing energy services though technical solutions, payment, and organisational innovations.

3.6 Policy Packages II: Urban Transportation

Because of the systemic relationships between transport, land use, and climate change, the factors that determine the GHG of urban transportation are both complex to analyse, and difficult to influence through public policy. To design public policies that accomplish reductions in GHG emissions in the urban transportation sector is challenging, in part, because, in most countries, climate change is still often a minor factor in decision-making and a less significant goal. Policymakers, especially those in developing countries, face the challenge of ensuring the sustainable development of their transportation sector in order to meet the demands of an increasing population, economic growth, and global competition without compromising human health and environmental quality. The environmental issues taken into account are generally limited to local environmental challenges, especially local air quality. Achieving reductions in GHG emissions may be seen as an accompanying benefit, but is rarely a main objective for urban transport policies.

3.6.1 Integrating Urban Transportation Climate Policies

Around the world, a wide array of policies and strategies has been employed in different circumstances to restrain vehicle usage, manage traffic congestion, and reduce energy use, GHG emissions, and air pollution. There tends to be considerable overlap among these policies and strategies, often with synergistic effects. Almost everywhere in the world has seen increasing travel, bigger vehicles, decreasing land-use densities, and sprawling cities. But some cities are far less dependent on motor vehicles and far denser than others, even with the same incomes. The potential exists to greatly reduce transport energy use and GHG emissions by shaping the design of cities, restraining motorization, and altering the attributes of vehicles and fuels. Indeed, slowing the growth in vehicle use through land-use planning and by using policies that restrain increases in vehicle use would be an important accomplishment. Planning and policy to restrain vehicles and intensify land use lead not only to reduced GHG emissions, but also lower pollution, traffic congestion, oil use, and infrastructure expenditures, and are generally consistent with social equity goals as well.[114]

Matrix approach

Policy instruments can be used to overcome problems and achieve objectives. They include conventional transport methods such as new infrastructure, traffic management, and pricing policies, but they also increasingly involve attempts to change behaviour, and use of information technology. Equally importantly, land-use changes can contribute significantly to the reduction of transport problems. Policy instruments can be implemented throughout a city (e.g., a fares policy), or in a particular area (e.g., a light rail line), or at a particular time of day (e.g., a parking restriction). In many cases they can be implemented at different levels of intensity (e.g., for fares or for service levels). Rarely will a single policy instrument tackle all of a city's problems, or meet all of its objectives. It is important, therefore, to develop strategies that combine policy instruments.[115]

However, no single set of policy instruments will meet the needs of all cities. So much depends on each city's priorities and objectives, the scale of the problems to be overcome, the policy instruments which are already in place, the combination of new policy instruments, the context within which they might be implemented, and the barriers to be overcome in doing so. However, it is possible to give general guidance on the types of policy

[114] IPCC, 2007.
[115] May *et al.*, 2003.

Table 13

An integration matrix

Source: May et al., 2003

These instruments	Contribute to these instruments in the ways shown					
	Land use	Infrastructure	Management	Information	Attitudes	Pricing
Land use		● purple				● purple
Infrastructure	● purple ● lime		● orange			● orange
Management	● purple ● lime	● purple ● orange ● green			● purple	
Information	● purple	● purple ● orange	● purple ● orange ● green		● purple	● purple ● orange ● green
Attitudes	● purple ● orange	● purple ● orange	● purple ● orange	● purple		● purple ● orange ● green
Pricing	● purple ● lime	● purple ● blue ● green	● purple ● blue ● green	● teal	● purple	● purple ● orange

Key: ● (purple) Benefits reinforced; ● (orange) Political barriers reduced; ● (teal) Financial barriers reduced; ● (lime) Compensation for losers

Table 14

Policy instruments and objectives

Source: Adapted from May et al., 2003

Objectives / Key strategy elements	Policy Instruments							
	Land Use	Infrastructure Provision	Infrastructure Management	Information Provision	Attitudes	TDM	Taxation and Pricing	Clean Fuel and Vehicle Technology
Reduce need for travel	● □ □ ●		●	● □ ●	● □			
Reduce car use	● ●	● ●	● ●	● ●	● ● ● ●	● ●	● ● ●	
Improve access to basic services	● ● ● ●				● ● ● ●	● ●		
Improve public transport	● □	□ ● ● ●	□ ● ● ●	● □ ●			● □ ●	
Improve road network performance	●	□ ● ●	□ ● □ ● ●	● □ ●		● □ ●		●
Shift to lower-emission modes		● ● ● ●			● ● ● ●		● ●	
Internalize external costs of transport						● ●	● ● ● ● ●	
Improve use of clean fuel technology							● □ □ ●	● □ ● ● ●
Preserve natural land use	● ● ● ● ●		● ● ●					

Key: □ Minor contribution; ● Major contribution

instruments that are likely to have the greatest impact on specific policy objectives.[116]

A land use and transportation strategy consists of a combination of instruments. More importantly, it involves the selection of an integrated package of instruments that reinforce one another in meeting objectives and overcoming barriers. Table 13 shows, in matrix form, policy instruments that are particularly likely to complement one another: i) to reinforce benefits across the instruments; ii) to reduce financial barriers; iii) to reduce political barriers; and iv) to compensate losers.

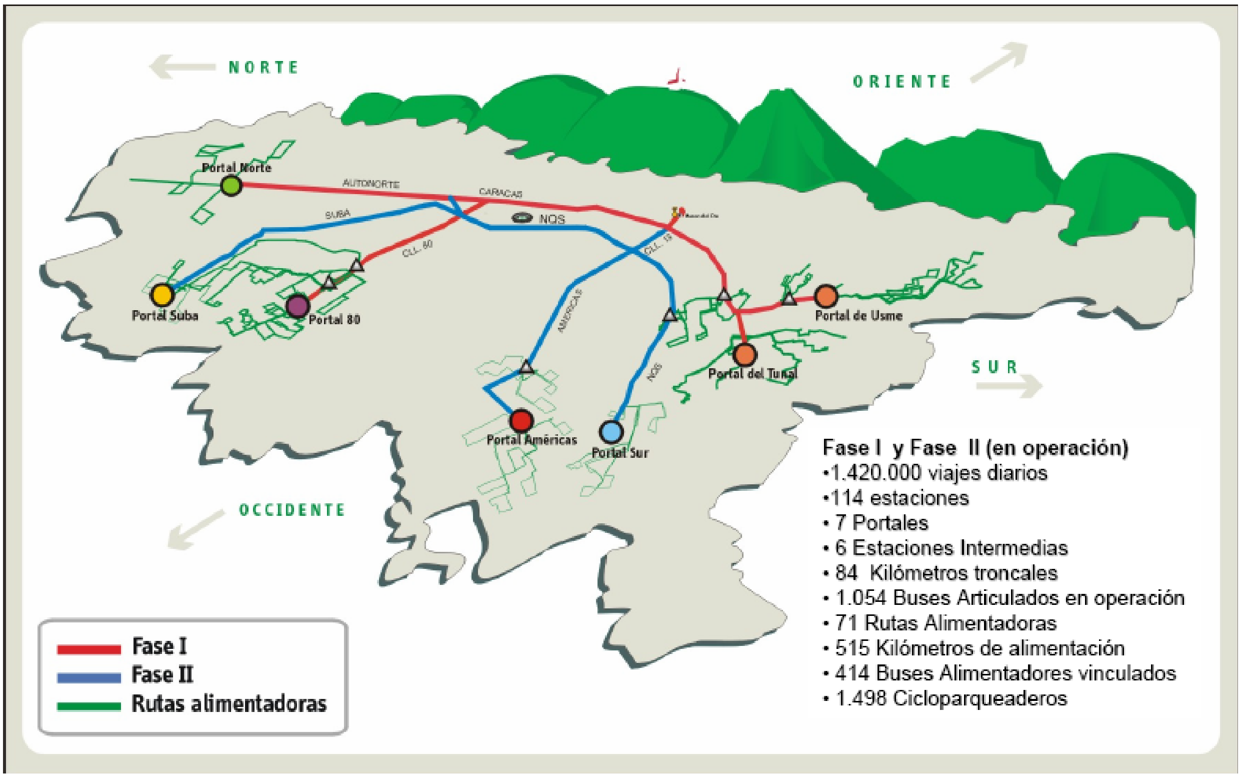
Each type of policy instrument contributes to one or more of the key strategy elements (objectives), as shown in Table 14. Land-use measures contribute most to reducing the overall need to travel, but pricing measures are the most effective way of reducing the level of car use. Management instruments offer the most cost-effective way of improving public transportation and road network performance, but infrastructure, information provision and pricing policies all have an important role to play, as well. This table reinforces the message that there is no single solution to transportation problems; an effective strategy will typically involve measures from many of these types of policy instrument.

Building blocks, levers and institutional frameworks

Transportation has many stakeholders, including private and commercial transport users, manufacturers of vehicles, suppliers of fuels, builders of roads, planners, and transport- service providers. Measures to reduce transport GHG emissions often challenge the interests of one or another of these stakeholders. Mitigation strategies in this sector run the risk of failure unless they take account of stakeholder concerns, as well as offering better means of meeting the needs that transportation addresses. The choice of strategy will depend on the economic and technical

[116] May *et al.*, 2003.

Figure 24
Bogotá



capabilities of the country or region under consideration.[117]

A "building block" can be defined as something that has the potential to generate change if it can be utilized effectively. However, building blocks cannot act by themselves: to move, they require the use of "levers". These are either policy instruments such as pricing, voluntary agreements, regulations, subsidies, taxes and incentives, or they are changes in a society's underlying attitudes and values. The third element, "institutional frameworks", consists of the economic, social, and political institutions that characterize a particular society. Institutions establish the context in which a country or city determines which sustainable mobility goals to pursue and the priority to be given to each; which levers are acceptable to use to achieve any particular goal; how intensively these levers can be used; and the constraints that may be imposed on their use. In short, they are the ultimate determinants of whether and how sustainable mobility is achieved.

3.6.2 Case Study: Bogotá's Bus Rapid Transit TransMilenio

Bus Rapid Transit (BRT) technology has been adopted in large cities and mega-cities throughout the world, including Cape Town and Mexico City. The BRT TransMilenio project in Colombia provides a text-book example of how energy efficient transportation can be implemented through policy packages combining a number of different measures. Since its opening in 2001, the BRT TransMilenio in Bogotá, has been considered as one of the best examples of good transport policy in the world.[118] TransMilenio is credited with having improved the mobility, and reduced the negative externalities, of transportation in Bogotá. TransMilenio is today regarded as a model of efficient transport investment, to be emulated by cities in both the developing and developed world. Following Bogotá's example, China has already constructed seven BRTs and plans to build fifteen, India has three BRTs and sixteen projects, Japan

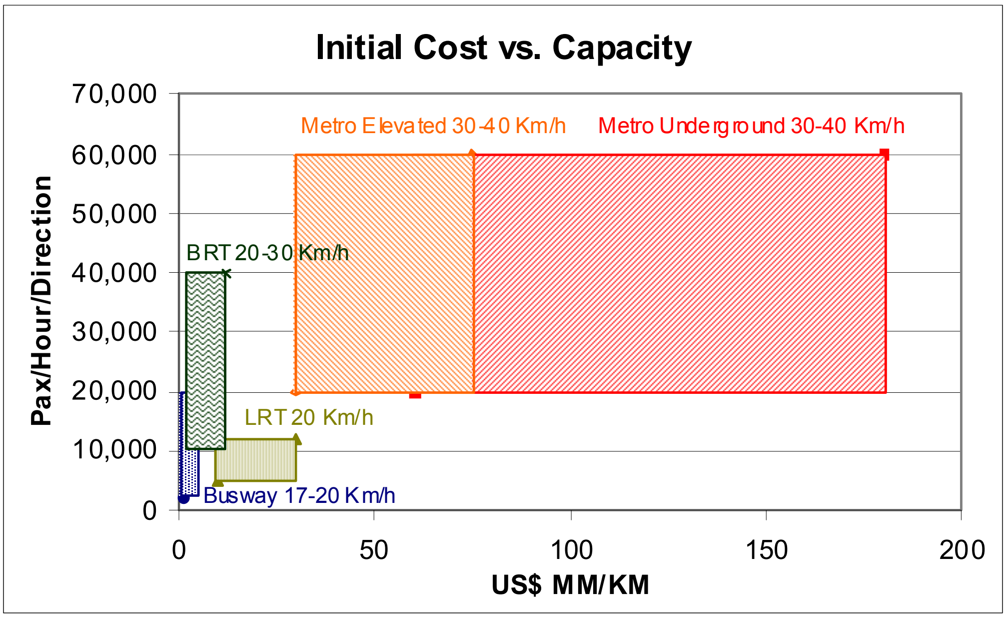
[117] IPCC, 2007.

[118] See for example the World Bank website on "urban transport", the C40 website on "best practices in transport sector", or the GTZ website on "climate protection and transport".

Figure 25

Initial cost vs. capacity

Source: Hidalgo (2004) from Fox, 2000 for Busway, LRT and Metro ; and (Wright, 2002) for BRT



has eight, Latin America has fifteen, Africa two, North America eleven and Europe thirteen.[119]

1998: TransMilenio on the agenda

Bogotá is located in the centre of Colombia, at 2640 meters above sea level, on the *Altiplano* of the eastern Andes cordillera. As the capital and largest city of Colombia, Bogotá has an estimated population of 7,030,000 inhabitants, which represents 15.2% of the total population.[120] In 2006, the annual demographic growth was 3%.[121] The city covers 1,737 km^2 and is one of the densest urban areas in Latin America: 3,717 inhabitants per km^2. The major part of this urban

area is flat, with the Andes cordillera limiting its development to the east. With the poorest population concentrated in the southern part of the city and the wealthiest population in the north,

Bogotá is strongly segregated. The city's expansion is oriented respectively toward the south for the poor and the north for the rich, creating a linear city. There are also urban developments to the west, but they are growing at a less dynamic pace. Bogotá's GDP per capita is increasing (+6.9% in 2006), reaching $3,535.[122] Bogotá produces 25% of the Colombian GDP, and it had concentrated 20% of the national employment, 23% of the industrial added-value, and 32% of the service activity.[123]

At the end of the 20th century, before the implementation of TransMilenio, mobility in Bogotá was characterized by high levels of congestion, pollution and traffic fatalities, and a disorganized, uncomfortable public transit service. In 1998, 70% of trips were made by public transit on about 21,000 buses, 20% of motorized trips by private cars, and 5% by taxis. The average trip by bus was one hour ten minutes with an average peak-hour speed of 5-8 km/h. The majority of buses were more than 14 years old, and the occupancy rate was less than 50%.[124] A total of 48% of transit vehicles were medium-size buses (40-80 passengers); 37% were small buses (20-40 passengers); and 15% minibuses.[125] In general, these buses did not have comfortable seats, ventilation, or security. There were no defined bus stops, and, therefore, buses picked up and dropped off passenger at any location along the road. Because of the low quality of the system, car

[119] See www.cleanairnet.org.
[120] Rodriguez, 2006.
[121] PNUD, 2008.

[122] in Constant Dollars of 1994: Camara de Comercio de Bogotá, 2006.
[123] Camara de Comercio de Bogota, 2006.
[124] Information on buses: Chapparo, 2002.
[125] Leal, Bertini, 2003.

Figure 26

TransMilenio Infrastructures, viewed from a passerel linking the sidewalk with the BRT station

Source: author.

owners were discouraged from switching to public transportation.

Others problems included high pollution levels, mainly due to urban transportation. (Local air pollution is a serious issue due to the higher altitude, which means 27% less available oxygen than at sea level.)[126] In addition, a high number of road accidents (52,764) and traffic fatalities (1,174) were recorded in 1998.[127]

After more than 50 years of debate about the best transport alternatives for Bogotá, (the argument was between a subway and a bus-based solution), TransMilenio was put on the policy agenda in 1998.[128] Construction started in December 1999, and the first three BRT corridors were opened at the beginning of 2002.[129] The entire BRT network was to be constructed in six successive phases, to be completed in 2030. The total anticipated investment was $2.300 million, for the construction of 22 corridors covering 388 km.[130]

In the first phase of construction, 42.4 km and 61 stations were constructed, at a total investment of $217 million.[131] The average cost per kilometre was thus 5.5 million, which is extremely low in comparison with other Rapid Mass Transit alternatives.[132] And this relatively low cost was in fact one of the main reasons for choosing the Bus Rapid Transit, instead of a subway.[133] The second phase of construction was achieved in 2006 with three new corridors.[134] Today, TransMilenio comprises 84 km of corridors, 477 km of feeder routes, 114 stations, 857 articulated buses and 430 feeder buses.

Box 9: Bus Rapid Transit technology and its popularity

Bus Rapid Transit (BRT) technology is defined as an urban mass transport system, using (bi- or simple) articulated buses of high capacity (160 passengers in Bogotá), circulating in exclusive right-of-way corridors. This closed system allows buses to circulate without the obstacles of traffic and traffic lights, and with high frequency. The corridors are integrated with a system of feeder buses, each with an average capacity of 80 passengers, operating

[126] Leal, Bertini, 2003.
[127] TransMilenio SA, 2001.
[128] Hidalgo, Vargas, 1999; Montezuma, 2000; Ardila, 2004
[129] The three first TransMilenio corridors are: Caracas Avenue, North Highway, and 80th Street.
[130] Ardila, 2004.
[131] Hidalgo, 2003.

[132] For a comprehensive comparison of costs and benefices of different Rapid Mass Transit systems see for example (Wright, Fjellstrom, 2003), (Hidalgo, 2004), (GTZ, 2005).
[133] Ardila, 2004.
[134] The second phase corridors are Suba Avenue, NQS Avenue, Las Americas Avenue, and 13th Street.

Figure 27

TransMilenio Station inside (left) and outside (right)

Source: Hidalgo, 2003

without dedicated lanes and covering the peripheries of the system. Ticketing is located at the entry to each station. An integrated tariff system allows passengers to use one ticket to access all the different corridors and feeder routes. At each station, automatic doors are coordinated with those of the buses. A satellite system of control (GPS) follows the whole operation in real-time, and monitors the balance between demand and supply. Using screens in each station it passes on information to passengers about bus arrival times and delays.

Four main reasons explain the international recognition that the Bus Rapid Transit technology enjoys:

- A BRT is relatively economical to construct. Without costs of excavation and expensive rail cars, a BRT can be 100 times less expensive than a subway system. A BRT station in Quito, Ecuador, has cost only \$35,000 while a rail station in Porto Alegre that serves similar number of persons has cost \$150 million.[135]

- Relatively low operational costs allow BRTs to operate without subsidies. Porto Alegre has both a subway and a BRT operating in similar contexts, with similar fare structures. The rail system requires a 69% operating subsidy for each passenger trip, while the BRT operates with no subsidies and returns profit.[136]

- The simpler physical infrastructure of a BRT can be built in less than 18 months. This shorter time holds political appeal: it allows a mayor to decide, plan, construct, and launch the operation—and reap the rewards during his mandate.

- A BRT has a passenger capacity close to that of a rail system. The BRT of Bogotá achieves a peak capacity of 45,000 passengers per hour per direction, while, for example, the rail commuting system (RER), serving the peripheries of Paris, handles 55,000 pass/hr/dir, and the subway of Sao Paulo 60,000 pass/hr/dir.

Effects of TransMilenio on local mobility and transportation's externalities

TransMilenio is credited with having significantly improved the mobility, and reduced the negative externalities, of transportation in Bogotá. The first phase was planned and constructed in less than 26 months—this shorter time held political appeal, and it was one of the key reasons, along with the low average infrastructure cost per kilometre, for choosing the BRT option.[137] This allowed the mayor to decide, plan, construct, and launch the operation, and to reap the rewards during his mandate.

The \$0.36 tariff per trip is affordable for the entire population and covers all operation costs.[138] In 2002, TransMilenio transported 780,000 passengers per day. In 2008, during peak hour, TransMilenio handled 122,000 passengers, which

[135] Wright, Fjellstrom, 2003.
[136] Thomson, 2001.
[137] Ardila, 2004.
[138] Hidalgo, 2002.

Figure 28:

Plan of TransMilenio lines, 2006

Source: TransMilenio S. A

represents 20% of the total public transport trips.[139] According to the CDM Monitoring Report, 4.3% (in 2006) and 2.6% (in 2007) of riders of Bogotá's BRT are people who used to drive a car; 5,5% (in 2006) and 5.4% (in 2007) of total passengers switched from taxis; and 1.1% (in 2006) and 1.4% (in 2007) of total passengers would have used non-motorized modes or not made the trip.[140] The share of TransMilenio has expanded constantly and is now a bit less of than 13% of total trips. The implementation of TransMilenio has reduced the average trip time by 32%, the PM10 pollution by 40%, and traffic fatalities by 94%.[141]

More than a technical success, an institutional revolution

However, it is important to emphasize that the success of TransMilenio is primarily institutional: the TransMilenio constitutes for Bogotá a radical change in organizational models for the provision of public transport service. The launch of the TransMilenio project required the removal of excessive competition among private bus companies, and the gradual replacement of a concession- transportation system based on licenses. While creating a new regulatory framework and adopting a new technology, it integrated traditional players, such as existing small bus companies. Two of the most critical tasks needed to complete the project were i)to convince traditional bus operators to invest in the new system, and ii) to find a means of financing undercapitalized companies.

The TransMilenio constitutes a new public private partnership (PPP) scheme for transportation services in Bogota, from its design and planning—which allowed reforming the previous, inefficient PPP institutional organization—to its operation. Indeed, private partners have been incorporated into the project since its design: international consulting firms worked closely with the team of planners and traditional bus companies, and without them nothing would have been possible. The operation of TransMilenio is thus based on a public-private alliance at all levels. The public company TransMilenio SA is in charge of planning, building infrastructure, coordination, and control of the service. TransMilenio SA receives 3% of revenue collected. The purchase, operation of buses, and paying of contract drivers are the responsibility of private enterprises that receive 66.5% of revenues in the case of operators of corridors, and 20% in the case of feeding lines. A company and a bank are responsible for ticket-selling, and receive 10% of revenues. The remaining 0.5% returns to a management deposit agency.

[139] Wright, 2003: By comparison, the subway of Hong Kong handle 162.000 passengers per hour, and the subway of Sao Paulo East line handle 120.000 passenger per hour; UNDP, 2008.

[140] Grutter, 2007, 2008.

[141] Ardila, 2004.

TransMilenio's infrastructure was financed by the central government (66%) and municipality (34%). The contribution from the latter comes mainly from a surtax on fuel (+46%). Thus the public supports 51% of total investments and receives 3% of profits, while private operators provide 49% of total investments and receive 97% of earnings. This difference is explained by the recovery goal of operating costs for the private sector, ensuring the sustainability of the system, and the significant investments needed to build infrastructure, including the land cost that can represent up to 22% of total investment (average 12.5%). This is largely due to the fact that actors on the real-estate market anticipate the positive effects of TransMilenio's construction

2007, Bogotá shifts from TransMilenio to a subway project

Since the beginning, TransMilenio's public image has diminished: the proportion of the population who felt that BRT service had improved life in Bogotá went from 70% in 2005, to 54% in 2008.[142] Three main reasons contribute to this decrease in TransMilenio's public image:

- During 2007, a confusing reorganization of the bus routes significantly damaged the efficiency of TransMilenio, making it a less desirable choice.[143] As interviews with transport operators confirm, people were losing time trying to understand what routes they had to take in order to reach their destinations, often getting lost within the system. This mess has since been fixed, but the bad impression remains, and this subject was raised repeatedly during interviews about TransMilenio's current bad image.
- •The second reason is linked to the government requirement of financial sustainability: TransMilenio's operation costs have to be covered by receipts from users, they are not subsidized. Because of this, TransMilenio operators adapt bus supply to existing demand, in real time, and TransMilenio buses are too full, even during non-peak hours. This packing of TransMilenio buses, and consequently of TransMilenio stations, significantly reduces users' comfort, and thus the attractiveness of TransMilenio. Even if financial sustainability was originally imposed on TransMilenio operators, several experts interviewed consider that the public is now convinced that it is a choice made by the operators to increase their profits, and, therefore, that private interest is taking precedence over public interest.
- The third reason, often forgotten in public debates, is rooted in the way spatial distribution of residences and activities has evolved since TransMilenio began to operate. Even though Bogotá experienced condensation during the nineties, the construction of highways and of TransMilenio took place in the absence of an adapted land use policy.[144] Furthermore, the economic recovery of Colombia at the beginning of the 21st century has fostered expansion of the

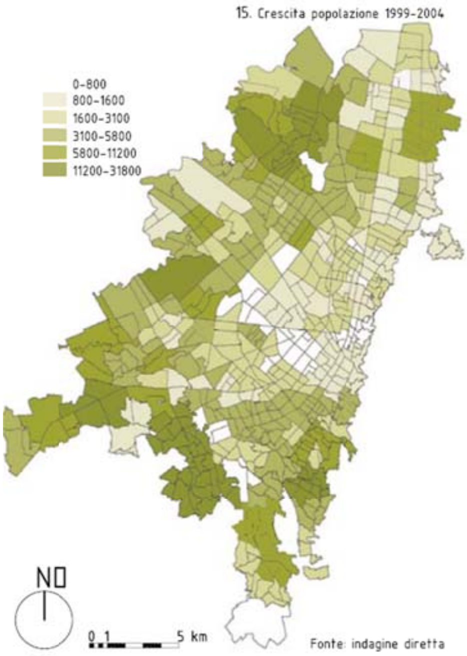
[142] Bogota Como Vamos, 2008.
[143] Grutter, 2008.

[144] Montezuma, 2000; Dureau, 2000; Arango, 2001.

Figure 29:

Spatial distribution of demographic growth between 1999 and 2004

Source: TransMilenio S. A



functional urban area.[145] At the same time, this expansion of the urban area has also been supported by extension of the bus companies' network towards the periphery, notably based on the usage of buses escaping the *Chatarizacion* law, according to which every new TransMilenio bus entering the BRT system must be offset by the purchase and destruction of 2.7 old buses owned by traditional bus companies.[146] In accordance with this urban sprawl, use of private vehicles has increased dramatically, notably for the wealthy population living in the northern part of Bogotá.[147] This growing motorization rate has been encouraged by financial incentives put in place by national banks. The lack of adequate integration between land-use planning, investments in the transport sector, and transport policies, has therefore contributed to increasing congestion and to the public's dissatisfaction. This increasing congestion at the city level is not directly linked to TransMilenio planning or operations. On the contrary, TransMilenio remains one of the fastest transport choices (with motorcycle) when one wants to cross the city. But, as an indirect result of this increasing congestion, TransMilenio is now considered unable to tackle mobility challenges in Bogotá, which needs a "first world solution": a subway.

The result of the drop in TransMilenio's popularity is that the 2007 mayoral election played out as a referendum on the Bus Rapid Transit.[148] Two main candidates faced off: Enrique Peñalosa, from the liberal party, former mayor of Bogotá (1998-2002), and architect of TransMilenio's success, on one side, and Samuel Moreno, from the left party, on the other side. Transport issues were the main focus of the electoral debate. Peñalosa was in favour of continuing an extension of the BRT network. Moreno proposed to stop BRT construction and launch two rail projects: a metro for the city centre, and a regional commuter train serving the peripheries of Bogotá. Samuel Moreno defeated Enrique Peñalosa in October 2007, with 43.7% of the votes against the 28.15% achieved by Peñalosa. He took office on January 1, 2008, and Bogotá is now engaged in a metro project. The

[145] Grobbeiro, Robazza, 2005; Robles, 2006, Lefevre, 2007.
[146] Grobbeiro, Robazza, 2005; Robles, 2006, Lefevre, 2007.
[147] Duarte, 2006.

[148] For example, the August 5^{th} of 2007 headline of the national Colombian newspaper *El Tiempo* was: "Movilidad, Tema Critico" (Mobility, critical theme). In this article, the current mayor L. Garzon assert that the electoral campaign for his succession revolves around the mobility issue ("Luis Eduardo Garzón, afirmó que la campaña electoral para sucederlo giraría en torno a la movilidad").

necessary metro studies were launched in mid-2008, funded by the World Bank and the Inter-American Development Bank. The third phase of the BRT expansion has lost one of the three previously planned corridors, and the three following phases have simply been abandoned.

3.6.3 Conclusions and Lessons from Bogotá

General lessons for other cities, and especially those in developing countries, which plan to invest in a mass transit system, can be drawn from this analysis of the Bogotá case study. Lefèvre shows that the reasons for the shift in Bogotá's urban transportation policies do not pertain mainly to technical, financing, or regulation issues related to TransMilenio, but rather to the coordination of transportation sector policies with other urban policies, and with the evolution of the Bogotá's political context.[149]

On the technical side, the BRT TransMilenio has exceeded expectations, and that explains its international recognition. While underground and elevated rail systems often take over three years, the first phase of TransMilenio was planned and constructed in less than 18 months, allowing Mayor Penalosa to set up the project from start to finish and see its operation during his term in office. The BRT of Bogotá achieves a comparable passenger capacity to that of rail systems. As a result, the share of TransMilenio has expanded constantly, and in 2008 it handled a little less than 13% of total trips. Moreover, thanks to the efficiency measures brought by TransMilenio, the average peak-hour speed of public buses increased from 5-8 km/h to 28 km/h on main corridors, and the average trip time reduced by 32%, from 70 minutes per trip to 48 minutes. TransMilenio SA estimates that the internal return rate of phase I is 61.44%, and the benefits/costs ratio 3.16.[150]

As construction of a subway is estimated to be at least five times more expensive per kilometre than the BRT, funding TransMilenio is obviously not a key reason for the shift in urban transportation policies. As discussed, part of the reason for the degradation of TransMilenio's public image is the regulation of its operation: for example, the decision that TransMilenio's operation costs have to be covered by receipts from users; and the requirement of financial auto-sustainability that leads TransMilenio operators to adapt bus supply to existing demand, in real-time, so that TransMilenio buses are too full, even during non-peak hours. These problems could have been solved by fiscal corrections and appropriate regulation

Lefèvre shows that the attitudes and behaviours of transport companies are highly influential, not only in the way many people see the mobility problem, but also in the development of the political consensus that sees the subway as a solution.[151] Bus companies have a strong influence on both national and local rules and norms; they also help to shape the political position of mayoral candidates or congressmen on urban transportation policies. Bus companies also contribute to the urban sprawl through the

[149] Lefèvre, 2009.

[150] TransMilenio, 2008.
[151] Lefèvre, 2009.

Table 15

General example of a policy package, with the framework previously developed

	Modes of governing			
Policy Sectors	**A. Self-governing**	**B. Governing by Authority – Planning and Regulation**	**C. Governing by Provision – Direct Service Provision**	**D. Governing through enabling**
Building Energy-Use Package	- Investment in efficient public buildings (new and retrofitting)	- New-construction codes - Retro-fit codes - Regulation of energy-efficiency contractors	Network services (district heating & cooling)	Campaigns to train private sector (guidelines for renovation, training programs, etc.)

extension of their network towards the periphery, in particular, the use of buses escaping the *Chatarizacion* law. As Lefèvre shows, this urban sprawl has increased congestion in the entire city.

One lesson of this case study is that investment in a technology, such as a metro or BRT, cannot solve the urban accessibility crisis in the long run. Cities would be better off investing in both mass transit systems that affect the whole transport system, and interrelated land-use policies. The transport infrastructure needs to be integrated:

i. Within a larger institutional reform of the transport sector that brings existing transportation operators into the new transport system: taking advantage of important public investments in local mobility issues, along with major institutional reform of the transport sector, would take into account existing and future competition for and within the transportation market. It would help to

   associate existing transport operators (e.g., buses, taxis, etc.) with the project. The creation of such a win-win situation would generate shared goals for the chosen transport infrastructure development, and help to secure its successful long-term realization.

ii. With land use policies that discourage urban sprawl: integrating investments in transport infrastructure with land-use policies would give municipalities the capacity to influence market-based urban dynamics, and resist urban sprawl.

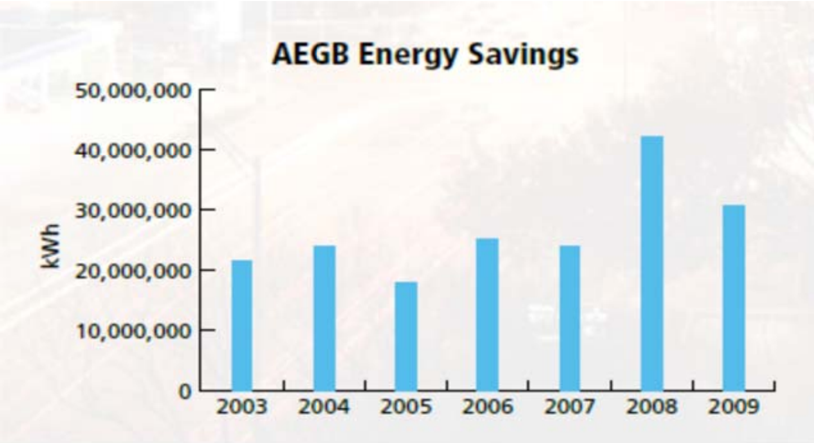
These two critical elements were not sufficiently taken into account in Bogotá, and are key explanations of the drastic shift in urban policies that Bogotá is facing.

Finally, Lefèvre also demonstrates the need to find tools to support long-term investments in mass transit systems from the perspective of climate change. If there is a consensus that certain technologies, such as subways or BRTs, are needed to mitigate climate change, an issue becomes how to secure their future implementation and protect them within their institutional framework. As this research shows, multi/bi-lateral agencies appear more interested in making *some* deal than in making the sustainable one. After having promoted investment in BRT systems around the world, based on Bogotá's success, the World Bank and the Inter-American Bank of Development have agreed to finance studies for the subway project. In doing so, they give credence to those who claim that BRT systems are unable to tackle mobility challenges in the cities of developing countries. Therefore, there is a need to imagine incentives (carbon market, sustainability prize, awards, etc.) that can spotlight mayors' decisions and also those of the multi/bi-lateral agencies and to secure long-term implementation of needed technologies to tackle climate change.

Figure 30

Energy savings in Austin 2009. Results are for the individual achievement of 712 single-family homes, 1,721 multi-family units, 2.3 million square feet of commercial space and improvements to the City of Austin energy code.

Source: Austin Green Energy Building, Annual Report 2009



3.7 Policy Packages III: Efficiency in Old or New Buildings

Buildings consume large amounts of energy in mega-cities Residential buildings represent respectively 15% and 25% of the total energy consumption in Mexico City and Tokyo (see case studies). In cold cities, heating is a major part of this energy consumption and can represent 70% of building energy consumption, as it does in Europe.[152] In cities where climate does not necessitate large heating needs, domestic hot water can still represent 30-40% of buildings' energy consumption.[153]

Many examples show that, whatever the city, efficiency can be improved and non-negligible energy savings can be achieved in old or new buildings. This is possible not only technically, as the potential clearly exists, but equally economically, given that many of these savings are at virtually negative cost.[154] Nevertheless, difficulties come from the decentralization of the consumption source, which makes reductions in this domain complex. Moreover, the reduction of energy consumption in buildings depends on changing behaviours, as well as many different features and devices, as a building is a complex object.

Major barriers exist to an ambitious efficiency strategy. Generally, we can say that there is a lack of information and access to credit for owners; lack of market development to encourage the efficient implementation of actions to reduce energy use; lack of investment in uncertain energy savings; a lack of scale economy; and a split incentive between owners and tenants. Much work has to be done to overcome these difficulties.

Three examples follow which show how some of these barriers can be bypassed by policy packages. The first concerns the city of Austin in the US and the efforts deployed there to assess and rate the building stock and incentive-reduction actions by increasing awareness and educating the workforce on this domain. Austin's municipality aimed to transform the building market and to overcome many of the barriers cited above. Following this, three examples—from Germany, France, and Belgium—illustrate the mechanism of third-party investment, which is able to facilitate crucial investment needs. Finally, we will briefly explain how the city of Rizhao, in China, succeeded in spreading solar-heated water panels among residents.

These three examples demonstrate how policy packages can be implemented to improve buildings' energy efficiency. Not one is based on

[152] WBCSD, 2009a.
[153] See figure 11, Chapter 1, WBCSD 2009a
[154] If the market was perfect, see Sustainable Urban Infrastructure, London Edition —a view to 2025, Siemens, 2008.

large public financing; instead, they consist of coordinated efforts, whether to facilitate an economic transaction (third-party investment), to change building habits or customer choices, or to better adjust industry offers and city needs.

3.7.1 Austin: Building Efficiency Program[155]

In Austin, efficiency policies began in 1991 with the Austin Green Buildings Program (AGBP), which developed specific tools in order to rate the sustainability of buildings in the city (starting with single-family homes, then moving on to commercial and multi-family buildings). Austin Energy, the city's public utility, developed a consulting activity: Green Building's staff help designers, architects, building professionals and owners to build homes that are energy, water and resource efficient, establishing sustainability goals for the construction, reviewing plans and specifications, providing recommendations for improvements, and rating the final product. There is generally no fee for Green Building's services within the Austin Energy service area since Austin Energy is a publicly owned power company, the nation's ninth largest community-owned electric utility, and a city department.

The mission of this programme was to lead the transformation of the building industry and to develop and enforce the energy code. Thus, AGBP provides education programmes for the general public as well as for professionals, for example by organizing a 12-session seminar with expert guests for home-builders of the city. By providing guidelines to professionals, rating tools, supplying education materials and updating energy codes, AEGB achieves large energy savings in new construction (Figure 30) and viable change in the building industry.

Moreover, in 2007, "the City Council passed the Austin Climate Protection Plan resolution that mandates that all new homes built in Austin by 2015 shall be Zero Energy Capable Homes (65% more efficient than homes built to current code) and that all non-residential buildings shall be 75% more energy efficient than current city code by 2015."[156] Since then, a Zero Energy Capable Homes Task Force has been in place, with representatives from the various building trade associations, energy-efficiency advocates, and Green Building.

Finally, as Austin's existing building stock also represents a critical opportunity for energy savings, a city ordinance now requires homeowners to conduct energy-efficiency audits before they can sell their house, and to reveal the results to tenants and potential buyers. In six months, 2,330 single-family homes were audited. Austin Energy found that, on average, insulation and duct systems were

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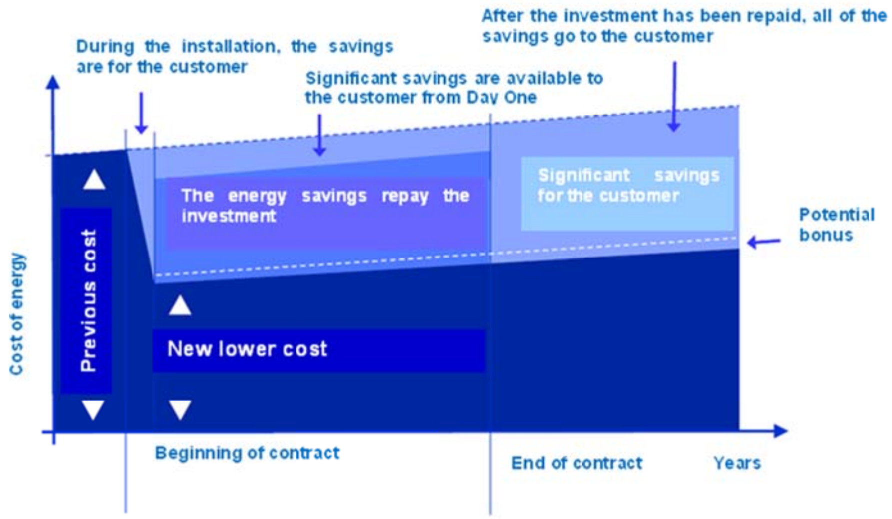
[155] C40, *Best Practices on Buildings*, see http://www.c40cities.org/bestpractices/buildings/austin_standards.jsp; [accessed April 2010]; Benning , 2009, http://online.wsj.com/article/SB124441959646192659.html [accessed April 2010]; Austin Green Energy Building, Annual Report 2009; Austin Energy website.http://www.austinenergy.com/Energy%20Efficiency/Programs/Green%20Building/aegbAnnualReport2009.pdf [accessed February 2010].

[156] C40, *Best Practices on Buildings*, see http://www.c40cities.org/bestpractices/buildings/austin_standards.jsp; [accessed April 2010].

Figure 31

Structure of a third-party investment strategy

Source: L Vanstraelen, 2008. [Information for footnote MISSING]



far below efficiency standards. These programmes have incentivized homeowners to retrofit their houses, since buyers are now more likely to bargain the price down if the energy efficiency is low. To help owners making energy-efficient upgrades, Austin Energy offers rebates and low-interest loans.

The AGBP is a good example of a policy package that addresses the building efficiency issue step-by-step. It first introduced a rating organ, gathering data and experience; followed by the offer of consulting services, and increasing professional awareness of this issue; and, finally, a central part of the climate plan, with ambitious targets. Three different approaches combine in the program: rating and tool developing; support and consulting without global objectives; and support and consulting with global objectives.

An essential point is that Austin Energy Green Building Program is led by staff from Austin Energy, which is a city-owned energy utility and a city department. By reducing electricity consumption, the city has likely avoided building a 700 MW power plant by 2020. As Austin Energy is responsible for the supply, the jurisdictional context seems favourable to that achievement. For cities that are not in this situation, there is a need for a collaborative relationship with a private utility in order to manage the trade-off between supply and demand.

3.7.2 Efficiency in Existing Buildings Through "Third-Party Investment" [157]

The existing building stock in urban areas worldwide is turning over, in general, at a slow rate (less than 1% in France).[158] The majority of energy reductions will be found not in new construction, but rather in renovation of the existing commercial and housing stock. As described in Chapter 2, a range of different technological solutions exists to improve energy efficiency that can lead to long-term savings for owners and occupants. However, market imperfections, such as limited access to credit and information asymmetries, in addition to the different transaction costs encountered, can limit ease and widespread efficiency improvements. These barriers place limits on local authorities as well as on private citizens and companies. Moreover, conducting energy-efficiency renovations in order to reduce GHG emissions between 50- 80% (the order of magnitude that has been targeted in France and in other developed countries) requires the

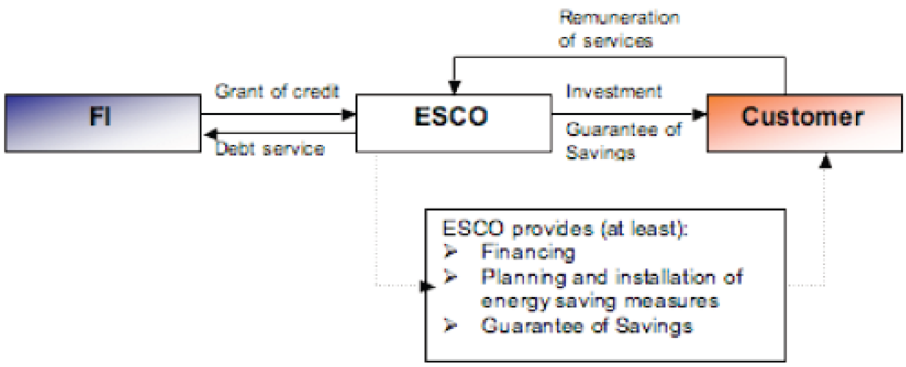
[157] Sources: Report prepared for the Club ViTeCC (22 January 2010), Caisse des dépôts, Strategy, Economy and Sustainable development Department; An Innovative Energy Efficiency Program that Costs Building Owners Zero, Drives Down CO2, and Generates Immediate Savings. 2009, Berlin, C40 Large Cities website [INSERT WEBSITE]; Vanstraelen, L (2008), Le tiers investissement et les bâtiments publics. Fedesco, presentation at the Cargo Conference, Brussels.

[158] See http://www.minefe.gouv.fr/directions_services/daj/guide/gpem/efficacite_energetique_chauffage_climatisation/1-2.pdf

Figure 32

Contractual form of third-party investment for Berlin where the energy agency makes recommendations and helps the ESCO and the client to create the contract: it is an interface.

Source: An innovative energy efficiency program that costs building owners zero, drives down CO2, and generates immediate savings in C40 Large Cities, 2009.



combination of a number of different sources of financing. When combined with existing financial tools and mechanisms to induce energy-efficiency renovations, third-party investment is an important tool, allowing for:

- The mobilization of additional financial resource: energy saving future (free resource for homeowners and the public)
- The removal of the burden of initial funding (investment and debt) from the property owner

Overcoming these two limits are important steps in fostering energy-efficiency actions and promoting policy packages that not only take into consideration new construction (energy-efficiency norms and standards), but also treat the existing building stock at the heart of the problem.

Third-party investment in the residential/tertiary sector

"Third-party investment" is a financial mechanism that allows a property owner to secure upfront

financing for energy-efficiency improving renovations. This mechanism has principally been applied to the reduction of energy use in buildings, within both the public and private sector. Third-party financing requires the implementation of a contractual engagement guaranteeing energy performance in order to isolate the owner from financial risk. An Energy Performance Contract (EPC) is typically used, a generic term used for a contract established between an energy services company (ESCO) and given client (project manager, developer, or private party, etc.). The investor is subsequently repaid over a contractually defined period with a type of "rent". In the case of energy-efficiency renovations, energy savings obtained for the benefit of the owner or renter may be the main or sole source of compensation. This mechanism allows an owner to improve the energy efficiency of a property without advancing substantial sums.

Figure 31 presents the financial flows of a third-party operation on investment over "n" years in the building sector:

- In year 0, the utility charges are substantial, and the third-party investor invests to improve the energy efficiency of the building.
- In years one to "n", the utility charges have decreased, the owner pays an amount set by contract to the third-party investor, and makes a saving on his previous charges. The sum paid to the investor covers initial investment costs and generates a return on the investment. The contract, however, should be based on energy-use reduction rather than a reduction of energy costs, given that changes in energy prices may lead, in the medium term, to a slight increase rather than decrease in charges, despite a large reduction in energy use. The contract may stipulate how energy

Table 16
Examples of third-party investment mechanisms, Germany and Belgium
Source: Caisse des Dépôts, Service Développement Durable

Country	German	Belgium
Actors	Energy Agency of Berlin (Berliner Energieagentur)	Firm Fedesco
Period	Since the middle of the 90s	Since 2005
Target	Public buildings	Public buildings
Financial Mechanism	Third-party investment with energy performance guarantee, sometimes for pool of buildings. The investment is made by private energy contractors.	Third-party investment with energy performance guarantee. Fedesco has a capital of €6.5 million, with a debt capacity of €10 million.
Types of retrofitting	Heating production, heating control system, lighting, ventilation system, sometimes windows.	Heating production, heating control system, lighting, entilation system sometimes windows.
Actors' roles	Technical data collection/baseline, check of potential, creation of building "pools" (decreases management cost and permits to share risk), technical economic objectives, draft of the invitation for tenders, negotiation with tenders, contracting.	Third-party investor with a monopoly on public buildings. Invitation for tender not necessary for Fedesco customers. Building assessment, technical analysis. Global coordination and outsourcing of the different tasks.
Weak points of the model	No insulation works Until now only public buildings	No insulation works. Payback period needed (5-7 years) is too short for this kind of work.
Strong points of the model	Help to draft the invitation tender and the contract Creating "pools" of buildings	Jurisdictional exception that avoids the competition step: Fedesco itself organizes the competition for the retrofitting work.

- savings are divided between actors due to changes in energy prices.
- In years "n" +1, the contract expires, and the owner has much lower charges than year 0.

Economic and efficiency benefits

Third-party investment mechanisms offer a number of benefits, depending on the circumstances under which they are deployed. These mechanisms can mobilize private capital to renovate public buildings, stimulate innovation in financial PPPs, and circumvent the difficulties of obtaining capital budgets, not fungible with operating budgets in government accounts.

In relation to projects focused on improving social housing, third-party investment can find new sources of equity for renovation operations, thus multiplying financial capacity to maintain and expand the number of units. It can allow for more ambitious energy performance goals by raising capital from outside sources; and finally, it can avoid delays due to capital shortages.

For private buildings, third-party investment allows for the renovation of private dwellings without households having to advance funds themselves--and thus, it avoids households accumulating debt. It allows for upgrades even in cases of limited financial capability—and where there may be other difficulties (for example, it allows co-ops to conduct energy efficiency renovations, where decisions are often blocked not only by the lack of financial capability, but also by the different motivations of different owners).

Third-party investment holds the potential for speeding up the energy-efficiency renovation process in existing structures. Equally, in certain circumstances, it allows projects to go further by seeking a more ambitious energy performance than normally permitted due to budgetary constraints. The contribution of third-party

Table 17

Summary of the Energy Saving Partnerships in Berlin

Source: Berliner Energie Agentur, 2006

Number of buildings	Total investment	Average contract period	Guaranteed budgetary Savings	Energy Guaranteed Savings	Reduction on Carbon Dioxide
502	€40 illion	11.8 yea s	€2.3 million	25.75%	57,00 t/y

investment can be crucial to convince homeowners to start a renovation and target improving energy performance

Contract structure

Third-party investment can take a number of different contractual forms. As shown in Figure 32, which illustrates a relatively simple structure, an ESCO is the linchpin of the third-party finance contract, securing the necessary financing, planning and installation of energy-saving measures, and providing a guarantee of savings to the financing party.

Past experiences and current practices

The third-party investment mechanism has been applied to a number of cases in Germany and in Belgium; however, it has been limited to heating systems and public buildings. These cases, summarized in the table below, demonstrate a number of limitations.

However, few contracts have focused on building insulation—the principal pathway for energy savings—as payback on investment in such cases is longer and more complex. According to CSTB, Icade and the Energy Agency of Berlin, the integration of building insulation and alternative systems of energy production is the future of energy performance contracting and the only means of achieving "factor 4" GHG reductions by 2050 in the residential/tertiary sector. Therefore, it is necessary to extend the innovations of energy performance contracting, incorporating the building's "envelope" itself. It is also necessary to extend this mechanism to smaller buildings and private buildings. The experience earned with public buildings must lower the transaction costs, making possible and profitable the retrofitting of smaller building pools, and helping to convince private actors of the efficiency and the reliability of this mechanism.

Box 10: Third-party financing by the energy agency of Berlin

Why do owners need a project manager and why can't they simply establish an energy-saving partnership directly with a contractor?

As noted in the Energy Saving Partnership document: "The project manager has the know-how and the necessary overview of the market to award the contract to the optimal contractor. He works at the interface between building owner and potential Energy Saving Partner in managing the tendering process and is responsible for awarding a contract guaranteeing the highest possible savings. The building owner does not generally have access to this comprehensive knowledge of the market."[159]

The project manager is also a consultant throughout the duration of the contract, which dictates all details of technical measures to be taken, the different investments to be made by the contractor, and the length and level of savings. Moreover, information about responsibility, maintenance and rights of ownership and usage are clearly laid down in

[159] Berliner Energie Agentur, 2006.

the contract. Lastly, since the agency is funded by state and district municipal governments, its services are for free. Here are the results of this initiative (many of the retrofitting projects are still in process) (Table 17).

3.7.3 Rizhao City: "City of Sunshine"[160]

In Rizhao City, ("City of Sunshine" in Chinese), 99% of households in the central districts use solar water heaters, in addition most traffic signals, street and park lights are powered by photovoltaic (PV) solar cells. Even in the suburbs and villages, more than 30% of households use solar water heaters, and over 6,000 households have solar cooking facilities. Yet Rizhao is a small and ordinary Chinese city, and its per capita incomes are even lower than in most other cities in the region.

According to Xuemei Bai this success can be explained by the convergence of three key factors: a government policy that encourages solar energy use and financially supports research and development, local solar panel industries that seized the opportunity and improved their products, and the strong political will of the city's leadership to adopt it."[161]

The provincial government preferred to subsidize research and development of the solar industry rather than end-users. The cost of a solar water heater was brought down to the same level as an electric one: about $190, which represents about 4-5% of the annual income of an average household in Rizhao City, and about 8-10% of a rural household's income. To spread the use of solar panels, the City mandated that all new buildings incorporate this technology. In addition the City oversaw the construction process, in order to ensure proper installations. It also set up seminars and advertisements— until the idea of using solar panels seemed like common sense.

This initiative for solar panels (which started 15 years ago) is part of a larger environmental program, as recognized by the State Environmental Protection Agency. In 2006, Rizhao was designated as the Environmental Protection Model City. Rizhao's environmental performances improved its attractiveness and its competitiveness both culturally and economically.

It is worth noting that Mayor Li Zhaoqian, who worked to implement this programme (although it was started by his predecessor), is former vice president and professor at Shandong University of Technology and served as vice director general of the Economic and Trade Commission of Shandong Province, where he worked with industries for the improvement of solar technology efficiency.

3.7.4 Conclusions

These three examples of Austin, third-party investment in Berlin, and Rizhao, demonstrate

[160] Xuemei Bai, China Solar-powered City http://www.renewableenergyworld.com/rea/news/article/2007/05/chinas-solar-powered-city-48605 (accessed 01/04/ 2010]; C40 large cities, http://www.c40cities.org/bestpractices/renewables/rizhao_solar.jsp [accessed 01/12/ 2009]; and WorldWatch Insitute (2006) State of the World 2007: Our Urban Future, http://www.worldwatch.org/node/4752 [accessed 19/7/2010]

[161] World Watch State of the world 2007: our urban future, Rizhao China, Solar-powered city.

interesting and different ways to increase energy efficiency in buildings. In Austin, the public energy utility is used by the municipality to assess and rate the building stock, to educate and advise the building workforce, and to update the building standards. It is a powerful interface between private building firms and the objectives of the municipality in terms of efficiency, because it has a comprehensive knowledge of the building stock and is closed to the local firms. In Berlin, the energy agency, through a third-party investment mechanism, succeeds in achieving great energy savings by mobilizing private money. As an interface between owners and private energy firms, the agency helps increase trust and certainty between players, for example, in the processes of tender and contract. In Rizhao, a specific and very ambitious policy package in one domain fosters solar water heaters, which brings impressive results. This city-wide programme uses a mix of education initiatives, building norms and cooperation with industry. It has organized the market to stimulate both demand and supply, and it shows that these kinds of packages can work.

Box 11: The importance of institutional contexts: learning from Cape Town

The City of Cape Town has made increasing the energy efficiency of buildings a core component of its action plan to reduce GHG emissions and treat energy-security concerns. However, the institutional context within which the municipal government operates has led to a number of difficulties in accessing third-party finance through energy service companies (ESCos). Across South Africa, the Municipal Financial Management Act has made important strides in reducing corruption in local government. However, this has also led to a number of difficulties in establishing contracts with private companies for periods longer than three years—a necessary step in establishing an energy-savings contract with an ESCo.

Other budgeting policies do not allow departments to ring-fence savings and use them for paying third parties. While these budgetary problems have been proved to work against corruption, they have also thrown up barriers for procurement and making choices based solely on economic prerogatives. This institutional structure has also posed a number of problems for municipal governments who want to participate in programmatic Clean Development Mechanism projects within the framework of the Kyoto Protocol. Currently, a network of municipal governments in South Africa is attempting to change national policies.

3.8 Conclusions

This chapter started and finished with the premise that there is no “ideal” city shape, but there are density thresholds. Discussing the shape, density, and mix of the ideal city is largely a false debate. Rather, the challenge is dynamic: instead of aiming for perfecting cities, policies should focus on shaping the rapid growth of cities in emerging countries and reshaping those in developed countries. Nevertheless, for a number of the technological solutions discussed in Chapter 2 to be feasible, there are a number of basic considerations. For example, there appears to be a robust density threshold (50-150 inhabitants/ha), below which mass transportation systems are not economically feasible. Market forces and urban planning must both be taken into consideration when rethinking approaches to urban energy policy and the role of the private sector. Market forces have great influence on land and building markets, and on labour and urban services markets. Urban planning at the appropriate level remains an absolute necessity.

This chapter has attempted to demonstrate that there is a real case for action at the city level. Nevertheless, providing energy to all, combating energy poverty, curbing GHG emissions, and local energy-related pollutions do not all depend on municipal and local policies. For example, the London Climate Action Plan estimates that the required 60% reduction target will be met by a combination of: the Greater London Authority Level (15% of requirement); the London boroughs (5-10%); London companies and public sector organizations (35-40%); Londoners (5-10%); and national government (30%). While national and regional action is equally necessary, local authorities are often best placed to overcome institutional and organizational barriers to the adoption of sustainable technologies and behaviour. Therefore, in a number of cases, it might be efficient to give more power to local authorities.

When thinking about urban-scale action, it is important to conceive of policies as packages of measures. It is not enough for technically and economically mature solutions to be available “off-the-shelf”. Policy actions plans are always a complex package of public investment and technical, institutional (to coordinate different types of actors), regulatory, and financial measures. Regulations must always be combined with incentives, information and other actions aimed at improving market efficiency. The three examples presented above on energy poverty, energy efficiency in transport, and energy efficiency in buildings have attempted to demonstrate how these packages might be created, combining regulation, and policies to create demand, as well as policies to enable a wide range of actors to access basic energy needs and achieve energy-efficiency measures.

Chapter 4: What Are Cities Really Doing? A Summary of the Case Studies

4.1 Introduction

This chapter gives a summary of the case studies. For each one, some actions of general interest are highlighted. Detailed reports are available online (see Annex 1).

4.2 Cape Town

4.2.1 The City in a Few Numbers

Population	Between 3.7 million, about 65% of the province's population (2009)
Density	12.28 people/hectare, 1425/km^2 (2007)
Administrative structure	Cape Town is subject to regulations and laws established by the West Cape provincial government and the national government. The city has limited authority over rail and port transport sectors. It has authority over electricity distribution in its distribution area (Eskom distributes to 25% of the city). It has very little generation capacity and little control over generation (This is the responsibility of the national parastatal utility.)
Economy	Produces 11.1% of national GDP; heavily reliant on the tertiary sector, (finance and business services, trade, catering, accommodation, etc.); 58% to the gross geographic (Western Cape) product with the secondary sector, (manufacturing, electricity, water, construction etc.) contributing ±40% to the GGP.
Energy Poverty	97% of population has electricity access. Low-income households can spend up to 25% of budget to meet energy needs.

4.2.2 Energy Consumption and Carbon Emissions

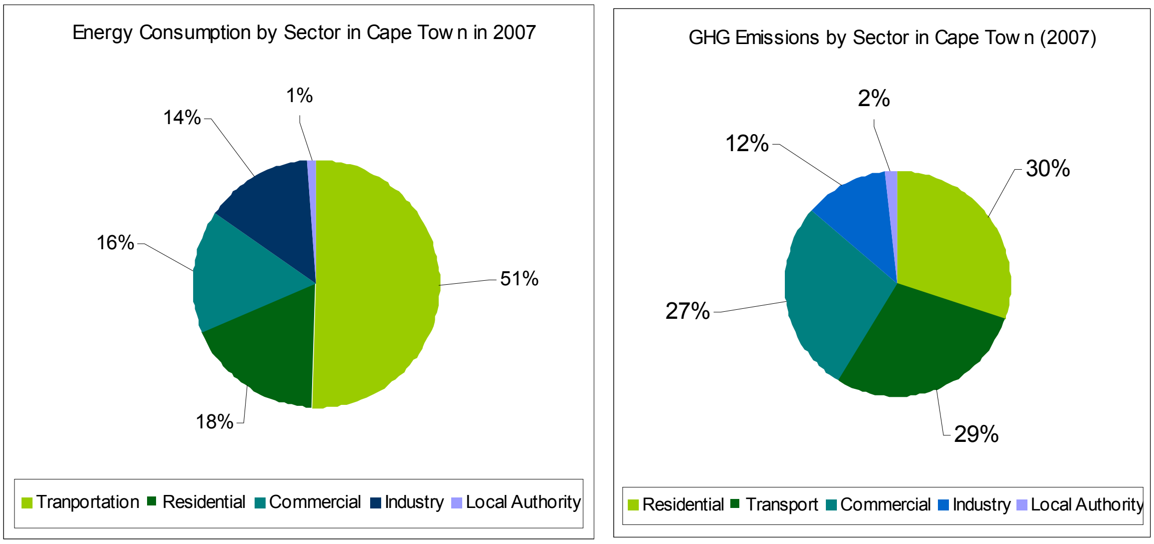
Between 1996 and 2001, Cape Town's population grew fairly rapidly, with an increase in population of 330,000 people, at an annual average growth rate of 2.6%. Population growth projections are 4% per year. Formal settlement growth is increasing by 1.7% a year, but informal dwelling growth by 13% per year. The majority of energy consumption in Cape Town occurs in the transportation sector, accounting for 50%, followed by the industry, residential and commercial sectors (Figure 33). However, due to South Africa's heavy dependency on electricity and the carbon-intensive nature of this energy source (88% of electricity is from coal power stations), of total generation, transportation is only responsible for 29% of carbon emissions, with residential and commercial making up 30% and 27% respectively. Carbon emissions for the city stand at five tons per capita.

The availability and relative affordability of coal has meant that, historically, electricity generation has depended heavily on coal; 88% of electricity is generated through burning low-grade coal, 6% through nuclear power, and 2.3% by hydroelectric stations. (Pumped storage stations assist with load management.) A single public company, Eskom, has a structural monopoly on electricity generation and is responsible for supplying 95% of electricity to South Africa (and 45% of electricity in Africa).

Figure 33

Energy consumption and GHG emissions by sector

Source: City of Cape Town LTMS Study 2010



This power is generated 1,600 km away from Cape Town (all coal resources are in the north of the country). In addition to the extremely narrow reserve margins on which the country's electricity supply is currently running, Cape Town's position so far from the source of generation makes the city extremely vulnerable to load shedding and blackouts: between 2006 and 2008 Cape Town experienced extensive load shedding. Energy security is therefore one of Cape Town's primary concerns owing to the social and economic impacts of black-outs and load shedding.

4.2.3 Plans and Objectives

The city formally adopted the Integrated Metropolitan Environmental Policy (IMEP) in 2001 as an overarching environmental policy that places sustainable development, an integrated environmental plan, the well-being of people, and the natural resources on which they depend at the very top of the agenda. The city's Energy and Climate Change Strategy of 2006 has now been given real teeth with the acceptance by the Council of an Energy and Climate Action Plan (2010). The city's *State of Energy Reports* (2003 and 2007) and its current Long-Term Mitigation Scenarios Study provide essential data to inform strategy and implementation.

After the load-shedding and black-outs of 2008, the city established a political committee (the Energy Committee) to drive its new Strategic Focus Area "Energy for a Sustainable City". This is reinforced at the official level by an Executive Management Team on Energy and Climate Change and cross-cutting work streams; all this has helped to initiate the development of the Energy and Climate Action Plan ("the Action Plan"). The Action Plan compiles both existing and proposed City energy and climate change projects across all directorates and departments. The objectives of the Plan include:

- Objective 1: City-wide 10% reduction in electricity consumption on unconstrained growth by 2012 (3.3% / annually 2010-2012); all growth in demand to be met by a cleaner/renewable supply
- Objective 2: 10% renewable and cleaner energy supply by 2020; all growth in electricity demand to be met by cleaner/renewable supply
- Objective 3: Council operations: 10% reduction in energy consumption on unconstrained growth by 2012 (3.3% / annually 2010-2012); all growth in demand to be met by a cleaner/renewable supply
- Objective 4: Compact resource efficient city development
- Objective 5: Sustainable transport system
- Objective 6: Adapting to and building resilience to climate-change effects
- Objective 7: More resilient low income/vulnerable communities

Table 18

National, provincial, and local policy objectives (this is for information—target data are not directly comparable

	City of Cape Town	Western Cape Province	National
Overall	10% Reduction in electricity consumption by 2012	15% Overall energy efficiency against business as usual scenario 2014	12% Final energy demand reduction by 2015
CO_2 Emissions	CO_2 emissions reduced by 10% by 2012	15% Carbon emissions reduction (off 2000 levels) 2020	CO_2 emissions to peak btw 2020-2025; CO_2 emissions reduced to 34% below expected levels by 2020; 42% by 2025 (National CC Response Strategy)
Renewable Energy Supply	10% Renewable energy supply by 2020	10% renewable energy purchased by Provincial Government 2010	10 000 GWh (0.8 Mtoe) of renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar & small-scale hydro.

- Objective 8: Development of carbon sales potential of all projects
- Objective 9: Local economic development in the energy sector
- Objective 10: Awareness: energy and climate-change communications and education programmes (driven by Objectives 1-9)

Cape Town is preparing extensive emissions and energy-use scenarios to aid in the policy and decision-making processes under its Long-Term Mitigation Scenarios Study.

4.2.4 Main Actions

To achieve its objectives, Cape Town has moved forward with a range of actions to reduce energy use, having little leverage in terms of national electricity production. Projects include support for the mass roll-out of solar water heaters to existing households, low-income housing improvements, and an extensive bus rapid transit (BRT) system to address the severe shortage of public transport. These projects are combined with an extensive communications campaign and education programme. A key objective for the city is to lead by example in reducing energy use in its own operations and, where possible, generating power (for example, from waste and waste water). Furthermore, the city is making climate-related issues part of key performance targets in citywide evaluation processes.

4.2.5 Conclusions

Ensuring energy security as well as building a much lower-carbon future for Cape Town is a complex and difficult task. The city's institutional changes to drive the energy and climate strategy, and the Energy and Climate Action Plan are critical steps in accomplishing this. Ensuring that the Plan is properly integrated into the City's performance management systems will be critical. Obtaining additional staff, devising appropriate financing mechanisms and accessing sufficient funding will lay a more solid foundation for achieving the Plan's objectives. Barriers imposed by national legislation have yet to be dealt with, such as the Municipal Finance Management Act, which has been effective at fighting local corruption, but makes it difficult for local governments to enter into long-term contracts and energy performance contracts, or establish feed-in tariffs for wind power.

4.3 Delhi

4.3.1 The City in a Few Numbers

Population	Delhi was a small town in the beginning of the 20th century with a population of 0.4 million. Its population started increasing after it became the capital of British India in 1911. Delhi's population in 2007-08 was 16.9 million. Delhi is highly urbanized, with 93.18% of its population living in urban areas as against the national average of 27.81%.
Density	9,340 people/km^2 in an area of 1,483 km^2
Administrative structure	Delhi as the national capital has a distinct and unique character. It is a growing and expanding magnet for people from across the country and also a hub for the region surrounding it. Planning for a metropolis like Delhi, therefore, cannot be limited within its boundaries. The NCR (National Capital region) is a planning concept and entity and is not a single administrative or political unit. The area under the NCR comes under different federal states that have their own administrative boundaries, but they have a common National Capital Region Planning Board, which helps coordinate their development plans. However, within the region, there are agencies under the central government, state governments, and local and village-level bodies.
Economy	Gross State Domestic Product (GSDP) of Delhi was on the order of Rs.1,252.82 billion (US$ 27.84 billion) during 2006-07. Rs.1,439.11 billion (US$ 31.98 billion) for 2007–08. The per capita income of Delhi was Rs.78,690 (US$ 1,749) in 2007-08, which was more than double the national average.
Energy Poverty	Construction activities in general, and especially in view of commonwealth games, have seen a large influx of construction labour. Without proper settlements, they land in slum clusters (called J&J Colonies, Jhughi Jhopadi Colonies, i.e., hutments colonies). Predicting growth patterns is difficult; therefore, planning for energy supply to meet 100% energy needs will always remain a 'pipe dream'. Energy depends most on biomass or dung cakes. Few have metered electricity connections and many use unauthorized electricity. Electricity is subsidized for small consumers. Kerosene is also subsidized for the poor.

4.3.2 Energy Consumption and GHG Emissions

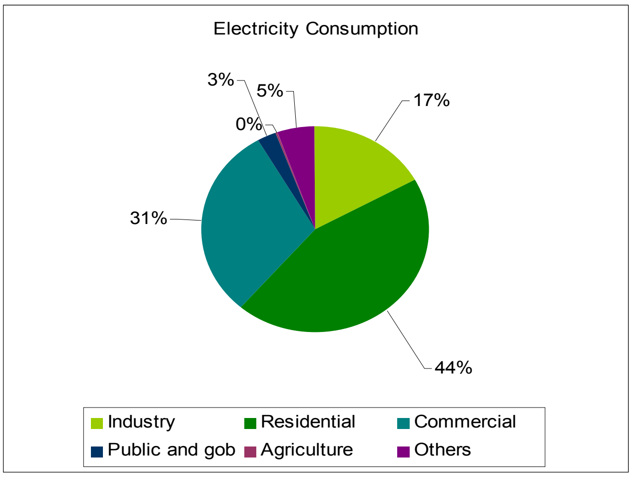
In Delhi, 98.74% of total households depended on electricity for lighting, and 85.14% households were using LPG as the primary source of cooking, and 1.82% were using firewood. Delhi's peak energy demand in 2008-09 was 4,034 MW and the energy consumption was 21,738 million kWh. Delhi has the highest per capita power consumption of electricity among the States and Union Territories of India. The per capita consumption of electricity in Delhi has increased from 1,259 units per year in 2000-01 to 1,615 units in 2007-08 (the national average was 717 units that year). The electricity tariff in Delhi is the lowest of all metros at Rs. 1.20 (2.67 US cents) for monthly consumption, less than 200 units in peak months and less than 150 units in non-peak months. A low tariff encourages lower energy consumption and protects weaker sections of society. Load-shedding has been brought down to 0.6% (2007-08) from an abnormally high 4.9% in 2000-2001. Peak demand deficit in Delhi is low, around 1.5% against the national average of 12.3%.

From 1st July, 2002, under the Delhi Electricity Reforms Act, Delhi Vidyut Board 55 was unbundled into six companies composed of a generation company, a transmission company, three distribution companies, and one holding company. The position of Aggregate Technical and Commercial Losses (AT-&-C losses) has also improved from 52% in the period before reform to around 25% in 2007-2008.

Figure 34

Pattern of electricity consumption in 2007-2008

Source: General Review 2009, Central Electricity Authority



Road transport is the major travel mode in Delhi, though some shifting has come with the expansion of metro rail service in Delhi and the National Capital Region (NCR). Consumption of petroleum products in Delhi and the NCR for the years 2007-08 and 2008-09 show, that consumption of petrol has increased by 2-4% over this period. However, consumption of diesel has come down by a massive 12.4% in Delhi, though in NCR as a whole it has remained unchanged. Increased penetration of LPG is reflected in the 6% growth figure of LPG, as well as a reduction in the consumption of kerosene by over 10% (Figure 35).

Public transport has been shifted to compressed natural gas (CNG) fuel. The number of vehicles has grown exponentially from 3.033 million in 1997-98 to 5.627 million in 2007-08 at an annual compound growth rate of 6.42%. Decennial growth rate is substantially higher in the case of private vehicles (92.53%), as compared to commercial vehicles (13.41%). Car density in Delhi, at 85%, is more than ten times the national average. Until 2003, buses constituted about 1% of the total number of vehicles, but catered to 60% of the total traffic load, while personalized vehicles accounted for 93.73% of the total vehicles but catered to only 30% of the total traffic load.

4.3.3 Plans and Objectives

Energy efficiency is an important element of GHG emissions reduction. Energy-efficiency policies are administered through the Bureau of Energy Efficiency at the central level, and through the state level wing of the Bureau of Energy Efficiency for the city of Delhi. The government of India has announced its “Energy Efficiency Mission” and “Solar Mission” as major government directives for climate-change mitigation and adaptation measures. These missions have been appropriately funded and provided fiscal support in the budget for the next year, 2010-11. Policy measures include improvements to strengthen public transportation, provide better and signal free roads, and an integrated multimodal transport system; as well as to shift polluting industries out of town. Delhi has announced its own climate-change action plan.

4.3.4 Main Actions

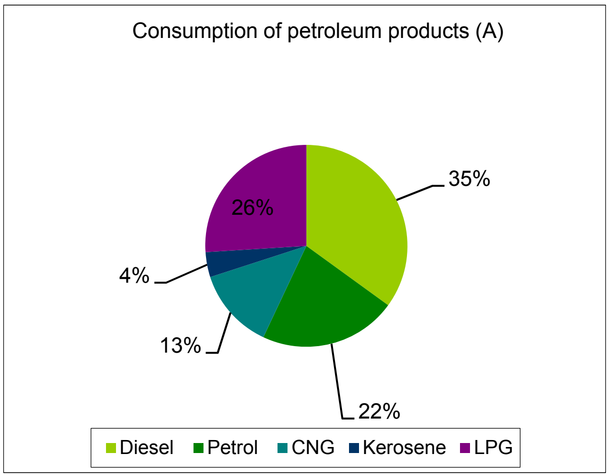
Delhi has recently published a *Climate Change Agenda for Delhi 2009-2012*. Delhi is one of the first cities to have its own climate-change agenda and action plan. The document stresses the need to put in place *“small efforts which are encapsulated in a framework which makes it possible for each Delhite to become a part of the process of change which is globally acceptable for the future generations”*.

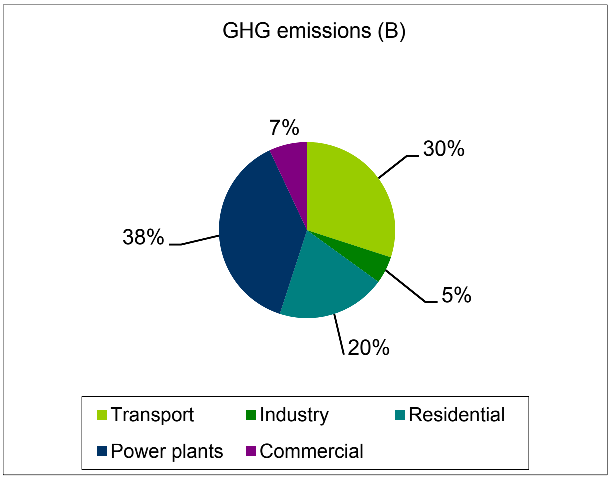
The Climate Change Agenda for Delhi 2009-12, adopted by the government of the NCT of Delhi, puts forth several action items that the government intends to undertake in the coming years in areas such as air, water, noise, municipal waste management, and greening, with clear-cut targets

Figure 35

Consumption of petroleum products (2008-2009) and Sources of GHG emissions (2007-2008)

Source: Inputs from Petroleum Planning & Analysis Cells (PPAC), Ministry of Petroleum and Natural Gas (Government of India) (A); Executive Summary of Inventorization of Green House Gases – Sources and Sinks in Delhi Sponsored by Department of Environment, Government of Delhi (B)





for 2009 and 2012. Responsible departments have been clearly identified. In fact 65 agenda points for action on various sectors have been identified.

Over and above the adoption of the mandatory Energy Conservation Building Code (necessary for environmental clearance) in government buildings and all new construction projects, the Delhi cabinet has decided to upgrade the energy efficiency of existing government buildings through retrofits, to be carried out by energy service companies in a performance contract. The objective is to ensure that government buildings can achieve a rating of at least one star from the Bureau of Energy Efficiency (BEE) under their building-labelling program.

As the national capital, Delhi has a distinct and unique character. It is a growing and expanding magnet for people from across the country, as well as a hub for the region surrounding it. Planning for a metropolis like Delhi cannot be limited within its boundaries, and, in response, the Regional Plan 2021 has been drawn up. The effort in planning settlements is focused to ensure that optimum socio-economic development becomes possible with minimum movement. There are efforts to develop counter "magnet" cities in the surrounding and nearby states. A phenomenal increase in the growth of vehicles and traffic has been seen in Delhi in recent years: a strong network of road and rail routes has been planned to give intracity and intercity connectivity. The development of the City Metro Rail is expected to bring about a major shift in public preference of transportation: with phase-II of the Metro becoming operational, more than one million passenger trips are already being covered by the Metro.

Because the projected load demand is expected to reach 11,000 MW by 2021, the existing generation capacity is not sufficient, and the gap between core generation and load demand will further increase. Also, coal-based generation is not permitted in Delhi, due to environmental and ash-disposal constraints, only gas-based power plants are envisaged in Delhi. All thermal power plants located in the NCT of Delhi will be gradually converted to gas. To improve the overall power situation in the National Capital Region and for the harmonized and balanced development of the region by 2021, proposed strategies and policies include, setting up new power plants; introducing modern techniques of load management; improving transmission and distribution; and promoting both renewable sources of energy and promoting public private partnerships (PPP). On the energy-efficiency front, initiatives that have been launched in Delhi are: *Bachat Lamp Yojana* (*BLY*, "Save through energy efficient lamps"); a labelling programme; a star rating for buildings; the Commonwealth Games, New Delhi 2010; Green Buildings; and energy audits of buildings.

4.3.5 General Comments and Conclusions

Delhi is a unique case study: a mega-city that is growing exponentially, accommodating low-skilled and highly skilled manpower. Delhi is not only a seat of power, but also a major commodities wholesale market. Being surrounded with satellite industrial townships, the city remains attractive for two-way daily movement of people that creates challenging traffic loads on highways and arterial roads. Delhi has to face formidable challenges in trying to contain rising energy demands, but the options, technology and funding available to the city give hope for the sustainable development of the city.

4.4 London and Paris

4.4 London and Paris

4.4.1 Greater London Area and Paris Agglomeration

Population (UN 2005)	**London agglomeration: 8.5 million** (Greater London Area: 7.5 million: data in this document are for this area)	**Paris agglomeration: 9,5 million** (Paris city: 2.2 million, Île de France region (IdF): 11 million; data in this document are for this area)
Density	4,700 people/km^2	3,500 people/km^2
Administrative structure	The GLA is responsible for the strategic administration of the 1,579 km² (610 sq. miles) of Greater London. It shares local government powers with the councils of 32 London boroughs and the City of London.	No administrative structure corresponds to the Paris agglomeration. The municipal area of Paris is only 105 km^2. The IdF has strategic power but weak capacity, with an area of 12,000 km^2.
Economy	The GLA accounts for around 16% of UK's GDP.	The IdF accounts for around 25% of France's GDP
Energy Poverty	Relevant	Relevant

4.4.2 Energy Consumption and GHG Emissions

In terms of energy, the building sector (housing and commercial) represents the biggest share of energy consumption in these two cities, reflecting the predominance of the business sector in their economy. Transportation represents quite a small share; it shows the relatively good performance of public transportation in these two mega-cities.

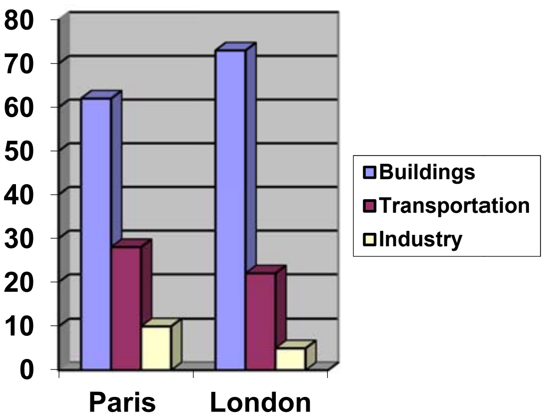
Considering emissions, the shares between the two cities are somewhat different, mostly because of the low-carbon energy mix of France (some 90% of the electricity is carbon-free, and is used mainly in buildings) and because natural gas (only for stationary uses), has a lower CO_2 emissions factor than oil products. As a result, transportation emissions represent almost 40% of total emissions in the Île de France region.

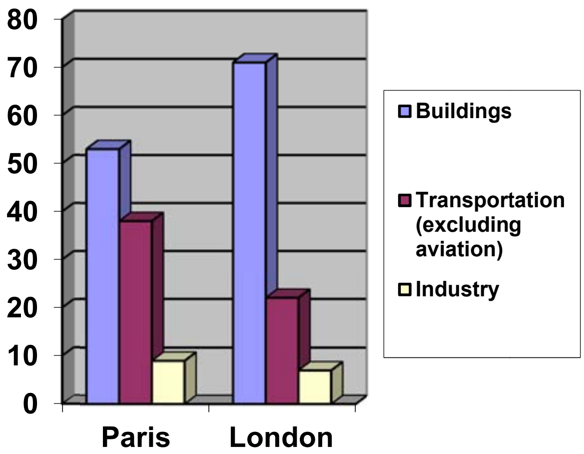
The importance of transportation emissions in Île de France is also explained by the differences between network designs. The centre of the Paris agglomeration is well served by a very tight subway network, whereas the periphery is much less well served. In London, rail systems are more available across the whole territory, including the periphery.

Even if the subway network in the centre is not very tight, mobility is preserved in inner London thanks to an important bus network, larger than in Paris. As a result, public transportation's modal share is bigger in London (London public transport, 36% and cars, 40%; for the IdF, public transport, 20% and cars, 44%). To decrease these emissions, the Paris agglomeration should implement an ambitious plan for sustainable mobility, but current global projects (Arc Express, Grand Paris metro) are unlikely to be successful.

Figure 36

Energy consumption by sector (2005), final energy excluding aviation, (left) and GHG emissions by sector, (2005, 2006), % of total (right)





In London, the building sector represents 70% of emissions and is therefore the priority for mitigation efforts. Thermal renovation and a local lower carbon energy mix at the local level are then required. We can see in Figure 37, that if per capita energy is equivalent, the low carbon electricity of France (90 gCO_2/kWh against 500 g CO_2/kWh in UK) makes the difference for emissions.

4.4.3 Plan and Objectives

Both London and the Paris agglomeration have an urban development strategy. For the agglomeration of Paris, it is the role of the *Schéma Directeur de la Région Île de France* or SDRIF. This was published in September 2008, but is still awaiting approval by the central government, who, at least for the time being, holds different views on the future of the agglomeration. Without this approval, the SDRIF is not legally binding. This is just one example of the Paris authorities' coordination problems in the IdF.

The main targets in these plans are:

- To make the city more compact and integrate the future scale and phasing of development with the capacity of the public transport system and accessibility of different locations
- To improve and expand public transport.

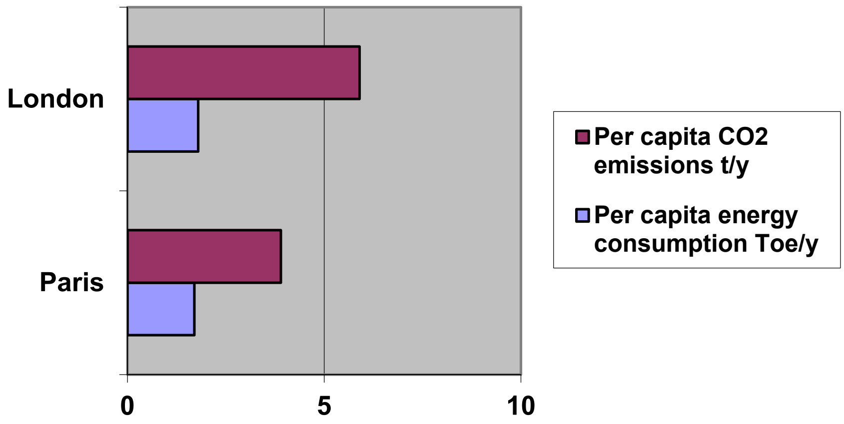
In the IdF, the most ambitious public transport project is a new fully automated railway around Paris, called "*Arc Express*" by the *Région*. At the same time, the French central government is promoting an even more ambitious project, which has been heavily criticized by most specialists. Nevertheless, neither project is precisely defined (e.g., details about when and where they will take place, and at what cost). This is in sharp contrast to the Crossrail project of London, an east-west, high-capacity, high-frequency railway line, 70 miles long, and costing an estimated £16 billion.

The difficulty of producing a shared and feasible project for the Paris agglomeration, due to coordination problems and conflicts between different authority levels, is an important issue because this mega-city needs a strategic plan at a relevant scale. It is likely that neither of these two projects will be fully implemented because of their weakness, the lack of consensus about them, and the need for funds to support them. In Paris, mobility sustainability will mainly depend on the ability of many authorities to work together, especially concerning land use and strategic development plans.

Concerning climate change, the London plan, released in 2007, aims to stabilize London emissions at 60% below 1990 levels by 2025. The expected contributions to savings are 50% for local authorities, and 50% for the national authority. Hence the objective is rather a 30% emissions reduction. Expected savings by sectors are: 22% for ground-based transportation, 39% for domestic, and 39% for commercial and public sectors.

Figure 37

Per capita comparison (excluding aviation) 2005, 2006



In the Paris agglomeration, there is a climate action plan for the city of Paris only. There is no similar document for the agglomeration and the region climate plan is in preparation. The targets of the Paris action plan are more than the European Climate and Energy package: to stabilize emissions at 25% below the 2004 level by 2020, to achieve a 25% reduction in energy consumption, and to provide an energy mix with 25% renewable energy.

4.4.4 Main Actions

For London, one of the most important measures is probably the development of CHP, and of the use of biomass to generate heat and power, notably in the Thames Gateway urban regeneration project area. The replacement of London's buses with hybrid buses has already started; by 2012 all new buses should be hybrid.

In Paris, the company providing district heating (*Compagnie Parisienne de Chauffage Urbain*, CPCU) is partially owned (33.5%) by the City of Paris. This company will increase the share of renewable energies (more biomass and geothermal energy) in its mix to reach 60% by 2012. More generally, the City of Paris acts through the companies of which it is a shareholder, or with which it has contractual links, so as to reduce energy consumption (e.g., public lighting, social housing, etc.). It also sets up and implements ambitious targets in terms of energy consumption per square metre for the new buildings it directly owns, and for the retrofits of its existing buildings. After the success of *Velib'* (a self-service bicycle scheme), this service is being extended to neighbouring municipalities. A large-scale, self-service electric car scheme on a large scale (*Autolib'*) is foreseen in the near future (2011).

With regard to private buildings, London has set up a concierge service that could coordinate the different actors of renovation, and identify barriers to installing these measures. Paris performed infrared thermography on 500 buildings representative of Paris's buildings, revealing typical heat losses in particular locations. An awareness-raising exhibition of the thermography pictures has been set up, along with advice on what kind of improvements are most necessary. Other ambitious policies will be required in this domain to achieve important reductions.

4.4.5 Conclusion

The comparison between London and Paris reveals that even if the cultural, demographic, and economic aspects of these cities are very close, the climate change challenges they present are quite different. Thanks to its national electricity generation mix, Paris already has low carbon electricity, whereas London has to push local initiatives to reduce the carbon content of its energy and reduce its emissions. Density profiles of the two cities also differ: London is quite homogenous, while the IdF has a very dense city centre surrounded by a quite low-density periphery. The transport system shows similar differences, explaining high emissions in transportation in the IdF. The lack of strong authority for the agglomeration of Paris may explain this situation; in all cases it makes it difficult to generate actions for mitigation in the crucial transportation-land use domain. One common challenge is retrofitting buildings, which will require strong public participation and investment, which is not the case yet in either of these two mega-cities.

4.5 Mexico City

4.5.1 The City in a Few Numbers

Population	In 2010, 9.2 million inhabitants in the Federal District and 11.4 million in the 59 surrounding municipalities, (one belongs to the State of Hidalgo and the rest to the State of Mexico).
Density	200 people/hectare (1970) to 100-150 people/hectare (2000) in Mexico City central area, 240 people/hectare (2005) in the Metropolitan Area of Mexico Valley (*Zona Metropolitana del Valle de Mexico*, ZMVM).
Administrative structure	The ZMVM is composed of 16 delegations of the Federal District and 59 municipalities belonging to the State of Mexico.
Economy	The ZMVM accounts for around 26% of Mexico's GDP, but the trend is decreasing.
Energy Poverty	Electricity is subsidized for the lowest levels of consumption. Official sources estimate that 98% of the population has connections to electricity, but evidence suggests that there are around one million illegal connections.

4.5.2 Energy Consumption and GHG Emissions

Total energy consumption in the *Zona Metropolitana del Valle de Mexico* (ZMVM) has been estimated at 565 PJ (2008). The transportation sector has the highest energy demands, followed by the industrial sector, and then the domestic sector. The expansion of Mexico City beyond its borders, and the decrease in density in central areas has generated an increase in distances and commuting times. Vehicle ownership increased by 13% per year from 1997-2007.

According to estimates, around 23% of the increase in GHG emissions can be explained by the growth in energy consumption. The emissions per capita in 2006 were estimated at 2.2 ton-eqCO_2, which is relatively small when compared to the national value (4 ton-eqCO_2). A comparison of GHG emissions between sectors shows the increased relevance of the transportation sector, which is responsible for 43% of the emissions. In terms of energy mix, most of the energy consumed in the ZMVM comes directly from fossil fuels as compared to electricity. Most electricity generation is also from fossil fuels. Furthermore, given that Mexico is a fossil fuel-rich country, this trend is not likely to be changed in the near future.

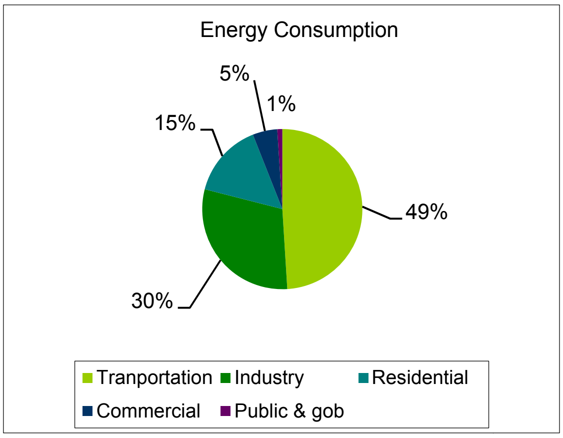
4.5.3 Plans and Objectives

The Climate Action Plan (*Plan de Accion Climatica*) of the Federal District was developed to achieve an emissions reduction objective of 4.4MtCO_2eq by year for the period 2008-2012, the equivalent of reducing 12 with 2008 as a reference year. The Climate Action Plan describes a series of 26 actions divided into four sub-themes: water, energy, transport and solid waste (Figure 39).

Figure 38

Energy consumption and GHG emissions by sector

Source: Estrategia Local de Accion Climatica Ciudad de Mexico (2008)



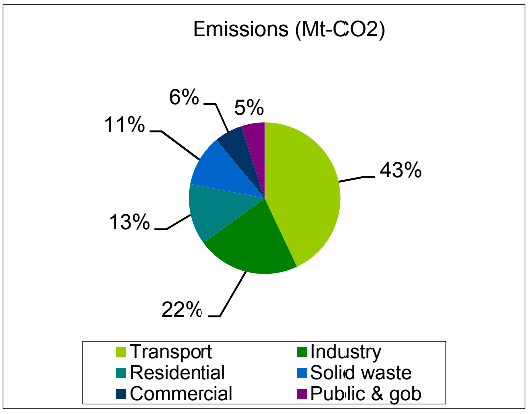


Figure 39:

GHG emission reduction actions

Source: Mexico City Climate Action Program

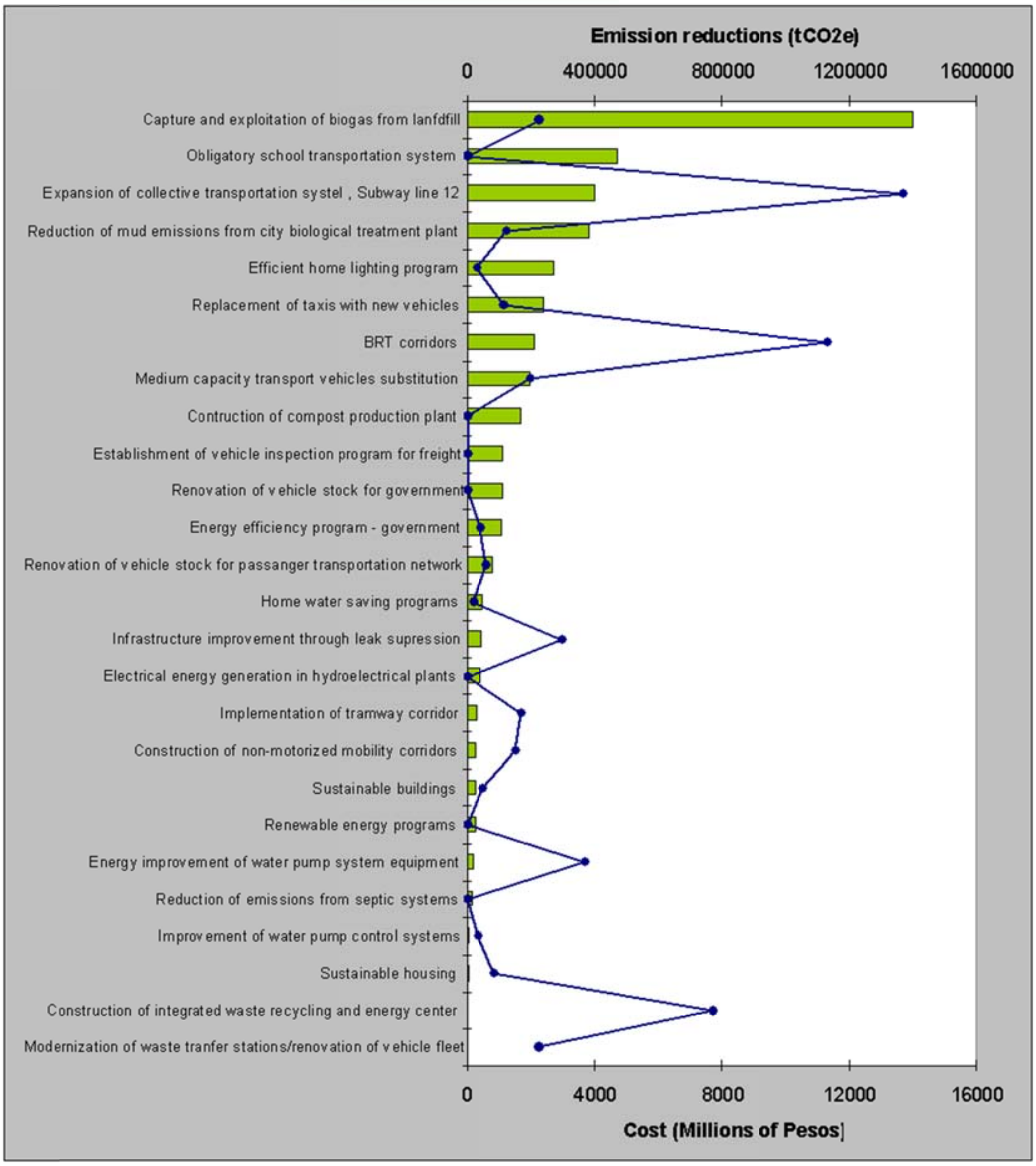
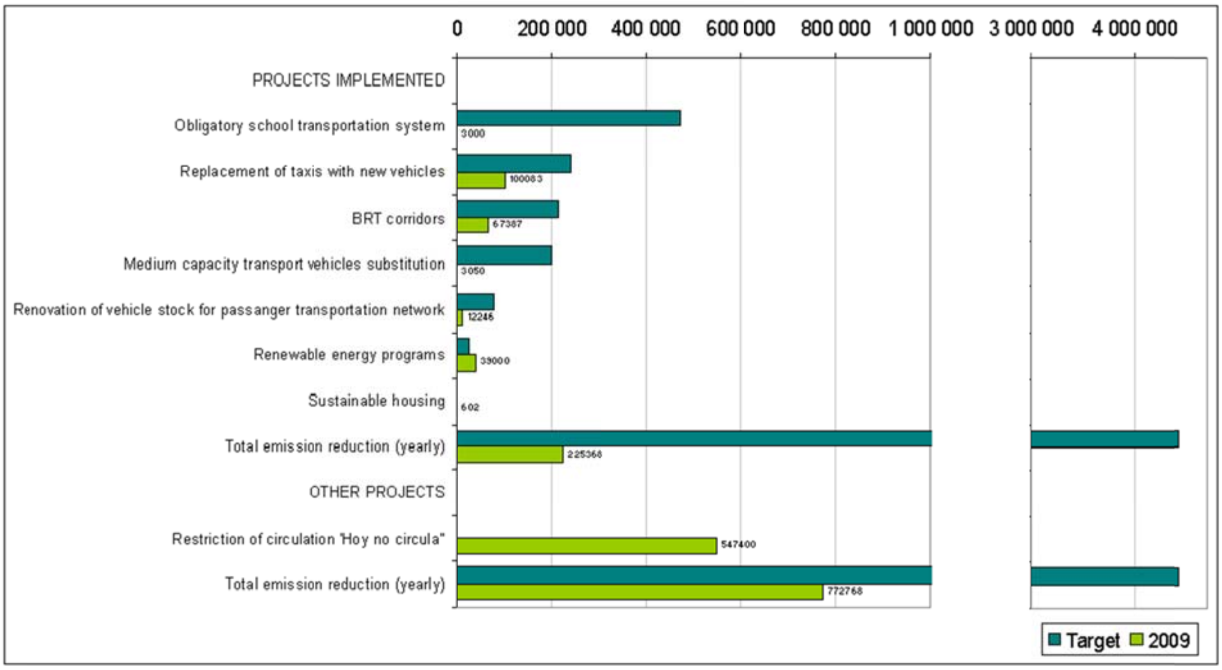


Figure 40:
Program and emissions completion
Source: Workshop "Planeacion Ambiental" and data on Mexico City Climate Action Program



The biogas-capturing programme is one of the most cost-effective. Given the technical solutions and financial mechanisms available (Clean Development Mechanism, CDM), it could be expanded to other cities and/or developing countries. However, as shown in Figure 40, it has not yet been implemented, delayed by various problems of coordination between different entities. For instance, the Federal Government and the Federal District have not yet agreed who will benefit from the carbon bonus generated by the project.

4.5.4 Main Actions

Four of the twenty-six programs have been, or are, being implemented and eight others are being researched. The following figure shows what has been done so far in terms of yearly emissions reduction. Only 5% of the annual emissions reduction target was accomplished in the first year of implementation, which represents around 2% of total GHG emissions of Mexico City.

4.5.5. Conclusions

Even though Mexico City has taken the climate change-challenge seriously, achievements so far suggest that the original targets were too ambitious. To achieve substantial emissions reduction, some radical changes need to be introduced. The best cost-efficient actions, including the development of cleaner energies, increased energy efficiency, and education about these aspects could be achieved relatively easy and in a short period of time. However, other actions do require bigger investments, such as those involving the transportation sector, which require more time in order to be fully implemented. Policies that favour public transportation need to be put into practice, but these generally need big investments and will probably take more than four years to be implemented. In addition, the sprawl and expansion of Mexico City have generated serious coordination problems between authorities from the State of Mexico and the Federal government. One of the main challenges will be to ensure cooperation between the two authorities of this split mega-city and guarantee consistency between energy and climate-change policies.

4.6 San Francisco Bay Area

4.6.1 The Bay Area in a Few Numbers

Population	7.2 million people with an additional 1.6 million residents expected over next 25 years (65,000 residents per year). Aging population—by 2035, 25% will be 65 or older.
Density	840 people/square mile
Administrative structure	The Bay Area consists of nine counties, 101 cities. Two regional-scale planning institutions (no independent authority)
Economy	It is the second-largest economic centre in California, dominated by high-technology electronics, biotechnology and financial services (46% of employment).

Located in Northern California, the San Francisco Bay Area is a 7,000 square mile metropolitan region surrounding the San Francisco Bay. The Bay Area's 9 counties and 101 cities are home to 7.2 million people, making it the fifth most populous metropolitan region in the US. Approximately 16%, or 700,000 acres, of the Bay Area's 4.4 million acres of land are developed for urban use. Of those urban acres, 61% are residential and 42% are non-residential employment and retail centres, government buildings, schools, and major infrastructure. San Francisco is the Bay Area's most urbanized county, with 82% of its land developed. Napa is the most rural county, having less than 4% of its land area developed. The remaining counties have developed land areas ranging from 7-28%.

4.6.2 Energy Consumption and GHG Emissions

The Bay Area emits GHGs, principally CO_2, at three times the world average. Transportation accounts for 50% of the region's GHGs. Of this 50%, 84% is from on-road vehicles (essentially cars) (Figure 41 and 42).

4.6.3 Plans and Objectives

i. Regarding the urban energy system, actions taken at the local level have to be understood as the convergence of three poorly-coordinated forces: The first one is a top-down force, coming from the legislature of the State of California. In recent years, the State of California has taken a central role in defining a roadmap for a future sustainable urban energy system. This leadership has been translated into a number of bills, including the Global Warming Solutions Act of 2006 (Assembly Bill 32, AB32), which serves as an over-arching framework. Signed by Governor Arnold Schwarzenegger, AB32 sets a goal of reducing emissions to 1990 levels by 2020, and 80% below 1990 levels by 2050.Further, the recently signed Senate Bill (SB) 375 charts a process for establishing regional targets for transportation-related emissions.

ii. The second is a grass-roots force, coming from local authorities themselves and/or through city networks such as ICLEI—Local Governments for Sustainability, the

Figure 41:
GHG Emissions in the San Francisco Bay Area, 2007
Source: BAAQMD 2007

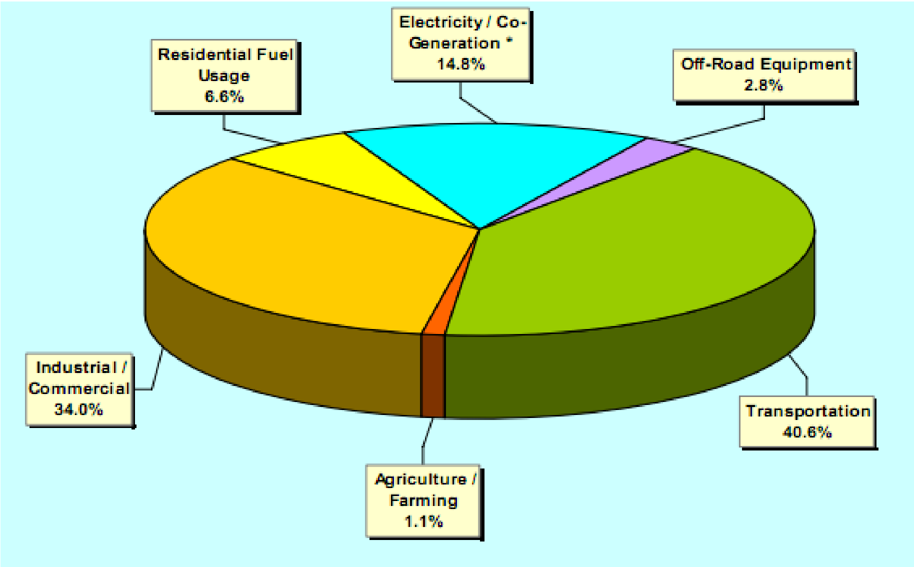
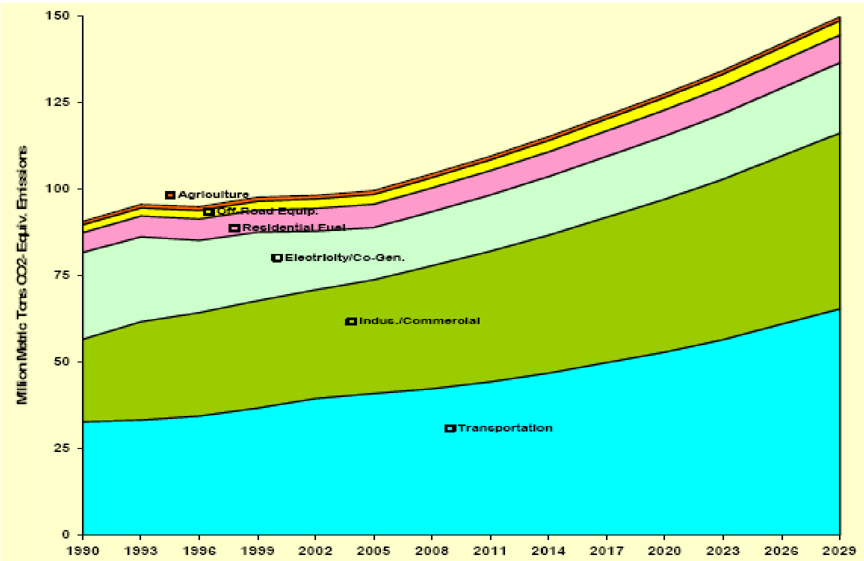


Figure 42:
Projected evolution of GHG emissions, by sector



iii. League of California Cities or the California State Association of Counties. This approach is notably translated into the Local Climate Action Plan. While there are many doubts about the effectiveness of local climate plans for reducing emissions, given the limited concrete information on what local governments are doing across the San Francisco Bay Area, it is difficult to judge definitively.

iv. The third force comes from the regional agencies—mainly the Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG)—that are not directly accountable to voters, but represent a region-wide perspective. Given the governance structure, these regional agencies rely on incentive-based approaches.

4.6.4 Main Actions

Decentralized and Fragmented Context

- State:
  - Establishes procedural structure requiring certain subjects to be taken into consideration
- Local governments:
  - Building codes, waste management, zoning ordinance, and general plans
  - Building permits and development approvals

State

- California Climate Action Registry (2001)
  - Track and report GHG emissions
- Global Warming Solutions Act 2006 (AB 32)
  - Reducing emissions to 1990 levels by 2020
  - 80% below 1990 levels by 2050
- Urban smart growth policy (SB 375)

Local authorities

- Little concrete information available; however,
  - Increased participation in networks and best-practices sharing organizations
  - GHG inventories
- Climate Action Plans

SFBA Regional Agencies

- Metropolitan Transport Commission (MTC)
  - Regional Transportation Plan
  - Control of transport revenue spending
- Association of Bay Area Governments (ABAG)
  - Information on regional problems
  - Create demographic projections
  - Land-use planning functions
  - FOCUS: incentive-based approach carried out by MTC and ABAG: development and conservation strategy that promotes a more compact land-use pattern

The San Francisco Bay Area's sustainability challenges represent similar situations in cities across the developed world. Transportation, and its relation with land-use, is certainly the key issue for questions of energy, affordability and climate-change adaptation and mitigation. This is a regional challenge, and therefore, policies intended to tackle it have to be analysed from a regional perspective.

In California, and in the Bay Area in particular, there is a real political will to tackle energy-related challenges, and to significantly alter Californian's urban dynamics and urban energy systems. However, actions taking place at the local level are still poorly coordinated. This is because of the multilevel and multi-actor governance structure on the one hand, and on the other hand, the current procedural and decentralized governance structure, which results in a weak regional authority. There are notably many counter-productive policies that will need to be harmonized with the objectives of urban sustainability.

4.6.5 Conclusions

Actions to put urban energy systems on a sustainable path also face many vested interests and financial barriers. The current economic crisis is a particularly difficult context in which to try to change the usual processes. Indeed, without additional money, the only way to enforce a sustainable transition is to reallocate budgets among priorities.

In these circumstances, there are some interesting developments: for example, the evolution of the stakeholders' relationship. For instance, giving a role to the California Air Resources Board (CARB) in the local land-use planning process is an important step towards a sustainable urban planning framework. As a state institution in charge of air quality issues, CARB brings a new perspective on finding a balance between local costs and regional interests. Another example is the use of a broad set of complementary tools: incentives and obligations are being used in a "stick and carrot" approach. Market instruments such as carbon price are combined and/or completed with regulations when and where it is necessary.

Finally, California's energy and climate policies can be understood in an "urban trajectory" perspective, which takes into account how the short-term efficiency of a specific policy can serve or work against long-term goals. Indeed, the legislature recognized that technical solutions would not be sufficient to achieve the state's goals for 2050: even with much greater fuel efficiency and low-carbon fuels, California will not achieve its climate goals unless it can reduce the rate of growth in vehicle miles travelled. Therefore, the issue was not "if" land-use and transportation policy were going to be connected to reduce GHG emissions but "how" and "when".

4.7 Shanghai

4.7.1 The City in a Few Numbers

Population	18.5 million people in 2009
Density	2,600 people/km^2 (up to 40,000 in the core of the city)
Administrative structure	Shanghai Municipal Government (SHMG) has a government leader (Han Zheng) that oversees local government organisations.
Economy	Shanghai accounts for 4.5% of national GDP; 60% of the overall workforce is allocated to the tertiary sector.
Energy Poverty	Shanghai residential energy consumption is growing quickly with the increase of Chinese living standards. Household electricity consumption was 1,618 kWh/year/household in 2000 and rose to 2,480 kWh/year/household in 2004.

4.7.2 Energy Consumption and GHG Emissions

The energy supply mix is also composed of coal, but in a much lower proportion than at the national level. Oil represents an important part of the mix, and has gradually increased over the years to equal the percentage of coal as supply primary energy. This is linked with Shanghai's rapid rise in vehicle ownership. The contribution of natural gas is minor, but increasing, as is electricity coming from other sources, reflecting the increase of cleaner sources.

Being both a major industrial basin of China and the most developed city of the country, with fairly higher living standards than the average, Shanghai emits much higher GHGs per capita than the rest of the country. It was three times higher in 2004 than the national value, and higher than most European countries. However, its GHG to GDP ratio is much better than the rest of the country, and has been constantly improving.

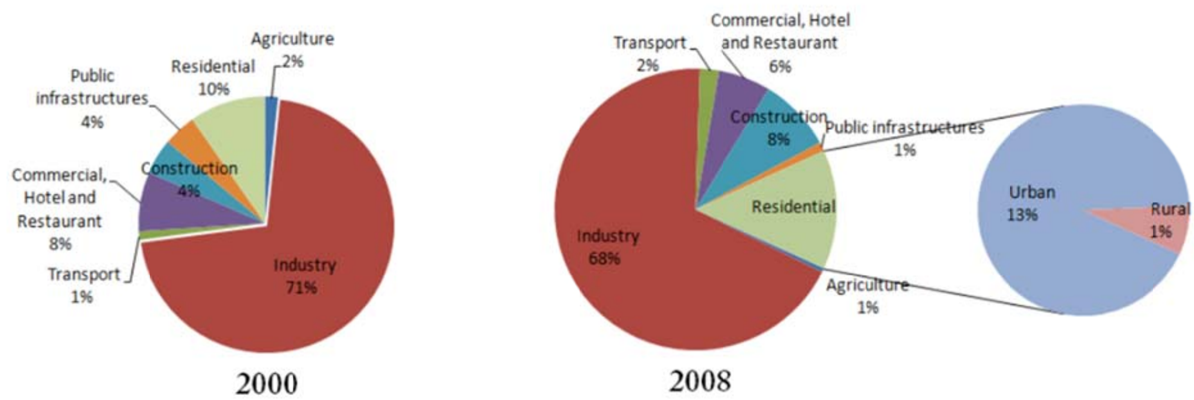
4.7.3 Plans and Objectives

Shanghai's strategy to reduce its energy challenges are divided in different categories:

- Develop renewable energies
- Increase gas supply
- Improve energy efficiency, especially in industry, transportation, construction, and new source of energy

Shanghai needs to reduce the proportion of coal in its energy mix as the carbon-emission factor of this primary energy source is the highest. Even if the percentage of coal in the supply mix is decreases, the number of tons increases quickly: from 26 Mt in 1990, it has more than doubled in fifteen years to reach 58 Mt. Control of the growth in use of coal is a challenge for the city, but it can be achieved by improving energy efficiency. Coal consumption is primarily an indirect reflection of electricity use; electricity mix hardly falls under the purview of Shanghai. As for industry, Shanghai has made the political choice to retain an industrial base.

Figure 43
Evolution of Shanghai electricity consumption by sector
Source: China Energy Yearbook 2008



According to the eleventh five-year national plan (2006-2010), energy consumption per unit of GDP in Shanghai will be reduced by 20% by 2010. Subsequently, Shanghai distributed this indicator among the industries and departments in the Suggestion for Further Strengthening the Energy Conservation Work in Shanghai (2006). In addition, Shanghai issued *Shanghai Eleventh Five-Year Plan for Energy Conservation*, with amended parts similar to the national ones, and *Implementation Plan for Energy Conservation and Emission Reduction in Shanghai* (2007) to further determine the targets for its municipality.

New regulations effective from July 1, 2009, regarding rational utilization and energy conservation were ratified, for energy conservation of industry, architecture, communications and transportation, public institutions and for major energy users.

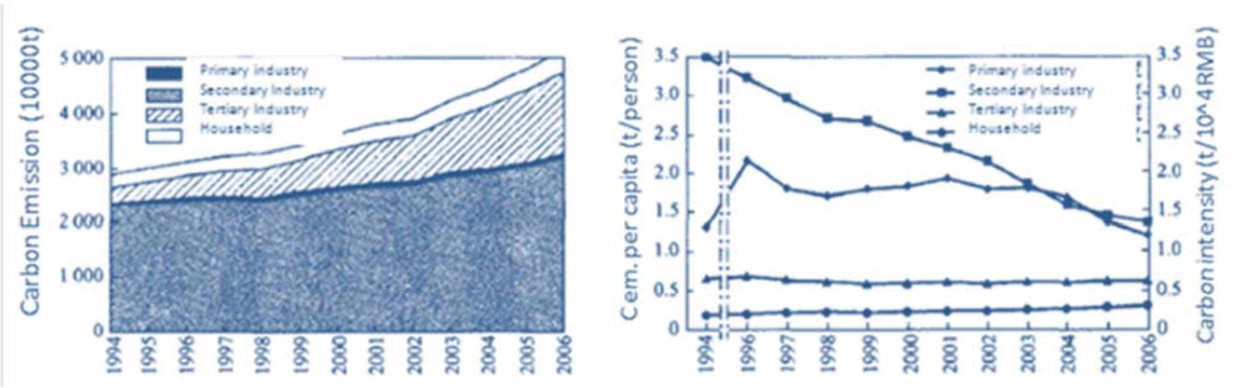
4.7.4 Main Actions

Buildings: In 2007, Shanghai municipality established that newly erected buildings should follow a binding energy-saving 50% standard (soon to be extended to a 65% standard) and reaching the standard is the precondition for getting a construction permit.[162] With these measures, Shanghai expects to reach its energy-saving goal of 15%. Shanghai also wants to transform all public and government buildings into energy-saving buildings, to set a good example to the construction industry. However, a study by the Chinese Ministry of Construction has shown that only 53% of the newly constructed buildings meet the 2007 standards of energy efficiency. Although respecting energy-saving standards would only increase building costs by 5-10%, many real estate developers are unwilling to bear the costs, favouring short-term profits over long-term considerations.

Industries: The 2009 update of the Shanghai Energy Conservation pushed energy-conservation technology in major energy-consuming industries to raise their energy efficiencies, such as electric power, iron and steel production, petroleum processing, chemical engineering, and building material and equipment manufacturing. It emphasized the efficiency of electric motors, blowers, boilers, furnaces, pumps and other equipment, and promoted the adoption of technologies such as the combined generation of heat and electricity (different from the elimination of coal, see above); utilization of afterheat and residual pressure; optimization of energy systems; and advanced detection and control of energy consumption. It also pushed the Shanghai power-grid enterprises to sign grid-joining agreements and electricity-purchase agreements with renewable energy power enterprises, and to provide these enterprises with on-grid services such as switching-on, measurement and settlement. Finally, Shanghai Municipal Government has prohibited construction of coal- or oil-fired generator sets, or coal-fired thermal power sets that fail to conform to the national standard.

[162] The Implementation Plan for Energy Conservation and Emission Reduction in Shanghai, 2007

Figure 44
Carbon emissions and carbon intensity of different sectors in Shanghai
Source: Minet al., 2009



Transportation: Under the guidance of the central government, urban public transport in China has demonstrated innovation led by regional and urban governments. Unlike other public enterprises, public transportation has its own features, therefore can create special policies in different cities. The three-year action plan on developing public transportation from 2007 to 2009 aimed to ensure that public transportation passenger volume would represent 65% of the whole vehicles, and 33% of all transportation modes. Despite efforts already made in underground and surface transportation, in order to reach this goal, several further steps had to be taken: the construction of public transport infrastructure had to be speeded up; the public transport management and service level strongly enhanced (by strengthening the supervision of the public transportation company); and supporting public transport development policies, with long-term mechanisms or purchase by government, set up.

Renewable energies: The Shanghai Green Electricity Scheme offers electricity consumers the opportunity to “green” their electricity consumption by buying some amount of green electricity for which a premium is paid. To improve energy efficiency in Shanghai, the government not only adopted macro-control policies to address energy issues, but also promoted the awareness of energy conservation by the public The Shanghai experience shows that it is important to keep the local residents aware of the problem of energy conservation and environment pressures.

Shanghai Municipality would like to reach a wind power installed capacity of 200-300 MW in 2010. Space is limited in the Shanghai municipality and only allows three wind parks (Fengxian, Nanhui and Chongming) to produce a total of 24.4 MW. Nevertheless, offshore wind farms have higher potential for Shanghai: 100 MW of offshore wind capacity are planned by 2009/2010 in Donghai. For solar energy, the Shanghai municipality’s target is to reach a production of 10 MW by 2010. Shanghai’s power companies are also now financing nuclear power plant projects in nearby provinces. One illustration is the Qinshan nuclear power plant in Zhejiang province, which uses two 650 MW reactors and is planning two more 700 MW reactors.

4.7.5 Best Practices

- Shanghai launched its own market place, of environmentally related financial products, in 2008. As no compulsory regulation is yet creating compliant-buyer demand in China, the exchange aims to become a forum for stakeholders in GHG reduction projects, mainly through disintermediation and improved access to international markets. It also initiates domestic trading schemes related to Pollution Discharge Rights, starting with sulphur dioxide and chemical oxygen demand but aimed at expanding soon to CO_2. It will start with a voluntary trading scheme in a pilot phase, targeting the building sector.

- Shanghai Municipal Government has implemented measures to make the public aware of the problems of energy efficiency and energy conservation. Shanghai Energy Conservation Supervision Centre (SECSC), which is the first non-profit energy conservation administrative organization in China, affiliated with the Shanghai Economic Commission, has taken an active part in the dissemination of energy conservation information, good case studies, technological consultation and energy conservation popularization and training. Shanghai has been a pioneer in this public education process.
- Public transportation has been a key area, with an active extension of underground lines, and ambitious plans to be a major actor in the national plan to launch China as the first market for green/electric cars. Shanghai has the advantage of hosting a joint venture between General Motors and SAIC, the largest car and utility vehicle maker in the country.

4.7.6 Conclusions

At the national level, it is increasingly clear that a carbon tax will occur in China during the twelfth Five-Year Plan (2011-2015). However, the details of a carbon cap-and trade-system (CTS) and/or taxes in China are still debated. What seems clear now is that a large set of measures will likely be deployed over the coming five years, which might be different in various sectors. A carbon tax for buildings is likely, but also pilots for a CTS (including Shanghai). Deployment of a national CTS in various sectors will most likely take place, probably for the steel and cement sectors, while trying to keep CDM cash influx in sectors already covered (wind, solar, hydro). It is clear that Shanghai will be best placed to benefit from these measures in taking a lead toward a modernized urban (and industrial) economy— and several lobbies are pushing for this.

4.8 Tokyo

4.8.1 The City in a Few Numbers

Population	12.8 million (City of Tokyo), 35.7 million (Greater Tokyo Area).
Density	Highly compact city: 8,613 people/km^2 (1990) to 9,010 people/km^2 (2005).
Administrative structure	Tokyo comprises 23 special wards, the Tama area and the Islands. The Greater Tokyo Area comprises Tokyo along with most of the prefectures of Chiba, Kanagawa and Saitama.
Economy	Tokyo's economy accounts for around 18.7% of Japan's GDP; 77.4% of its active population is employed in the tertiary sector
Energy Poverty	No evidence found from available data

4.8.2 Energy Consumption and GHG Emissions

In terms of GHG emissions, the performance of Tokyo, when compared to other OCED cities is outstanding. Tokyo's compactness, and its predominant use of public transportation, makes it not only an energy-efficient city, but also a relatively low carbon emissions city. The former explains why emissions related to the transport sector are not as large as in other mega-cities (Figure 45).

A comparison of GHG emissions and energy consumption between sectors shows the increased relevance of the business sector, and decreased influence of the industrial sector. Overall emissions were reduced slightly between 2000 and 2006. In terms of energy mix, the proportion of energy needs of the Tokyo Metropolis supplied by electricity has grown considerably, from 33% in 1995, to 40% in 2005, while the proportion of fuel oil has been reduced, from 41% in 1995 to 30%. As the share of electricity grows, policies focused on greening the energy mix become more relevant. The primary energy-sources mix for electricity generation has suffered serious changes since the late 1960s. The share of nuclear power has increased and the share of oil and coal has been reduced and replaced by gas. In addition, projections for the year 2017 show a further decarbonisation of energy sources, and growth of the nuclear energy use.

4.8.3 Plans and Objectives

Tokyo is targeting a reduction of 25% of the CO_2 emissions by 2020 from the 2000 level, which means a reduction of about 20% when compared to the 1990 level. To achieve this target the *Tokyo Climate Change Strategy (TCCS)* will turn Tokyo into a low carbon society based on two principles: i) reducing energy consumption by implementing energy conservation measures and using passive energy; and ii) striving to use renewable energies and unutilized energies in a positive manner. Five initiatives were created to put the *TCCS* into action (Box 12).

Box 12: Tokyo climate-change strategy initiatives[163]

Initiative I: promote private enterprises' efforts to achieve CO_2 reductions

- Cap-and-trade system: big business
- Environmental Collateralize Bond Obligation (CBO): small businesses
- Environmental investment and loan options
- Green purchasing program

Initiative II: reduction in households— light and fuel expenses

- Incandescent lamps elimination campaign
- Passive energy (light, heat, and wind)
- Energy-saving performance of houses
- Renewable energy and energy-saving equipment

Initiative III: reductions in the urban development

- World's highest energy-conservation specifications for buildings: Tokyo Metropolitan government facilities
- New buildings to have energy-conservation performance
- Energy-conservation performance certificate program
- Effective utilisation of energy and use of renewables in local areas

Initiative IV: vehicle traffic

- Fuel-efficient vehicles and widespread diffusion of hybrid cars
- Green vehicle fuel conducive
- Voluntary activities: eco-drive campaign
- Traffic volume measures

Initiative V: Tokyo Metropolitan government's own mechanism to support activities in respective sectors

- Emission trading system
- Programme to encourage and support small business and household energy-saving efforts
- Study on tax reduction and taxation

[163] Tokyo Metropolitan Government 2007

4.8.4 Main Actions

Probably the most innovative action for combating climate change taking place in Tokyo is the cap-and-trade system (CTS). This CTS is applicable only to commercial and industrial buildings in which total energy use is 1,500 kL or larger on a crude-cap-oil equivalent basis. The Tokyo CTS will cover around 1,440 installations and is planned to reduce emissions by around 17% from the base year's level (2010). It is the first urban CTS.

The installation of heat pumps has been proposed by the City Planning Institute as one of the main technical solutions at hand to achieve emissions reduction. According to the Institute, with the introduction of heat pumps, businesses could achieve an overall reduction of around 33%. On the supply side, TEPCO, the main electricity supplier of the Tokyo Metropolis is expected to expand both the share of nuclear power and renewable energies for electricity generation. A set of projects of wind, photovoltaic, and geothermal power generation have been planned or are in the process of being developed.

4.8.5 Conclusions

While initial climate-change policies in the city of Tokyo were initially based on voluntary approaches, it became evident that more restrictive policies were needed in order to achieve reduction targets. With the introduction of the business CTS, the Tokyo Metropolitan Government is resolved to lead national efforts to combat global warning.

Even though technical solutions to achieve reduction targets are at hand it is difficult to predict the real effects of policies in advance. Looking further into the future, one of the main challenges for the Tokyo agglomeration will be the adaptation of its city structure to an aging society with declining birth-rate.

4.9 Toronto

4.9.1 The City in a Few Numbers

Population	2.7 million (City of Toronto), 6.3 million (Greater Toronto Area), 9 million (Greater Golden Horseshoe). *(*Given that the Greater Golden Horseshoe region makes up 70% of the province of Ontario's population, much of the statistical data is reported at the scale of the entire province.)
Density	Highly compact city: 4,000 people/km^2 (City), 866 people/km^2 (Greater Toronto Area)
Administrative structure	No single administrative structure functions at the scale of the Greater Toronto Area, although the Provincial Government plays an important role in terms of energy policy. The Metrolinx agency has been created to coordinate public transport policy across the entire Greater Golden Horseshoe region.
Economy	79% of Ontario's active population is employed in the service sector, with manufacturing employment decreasing from 21% to 13% between 1988 and 2009.
Energy Poverty	Natural gas and electricity costs represent between 6-10% of household budget for close to 25% of

4.9.2 Energy Consumption and GHG Emissions

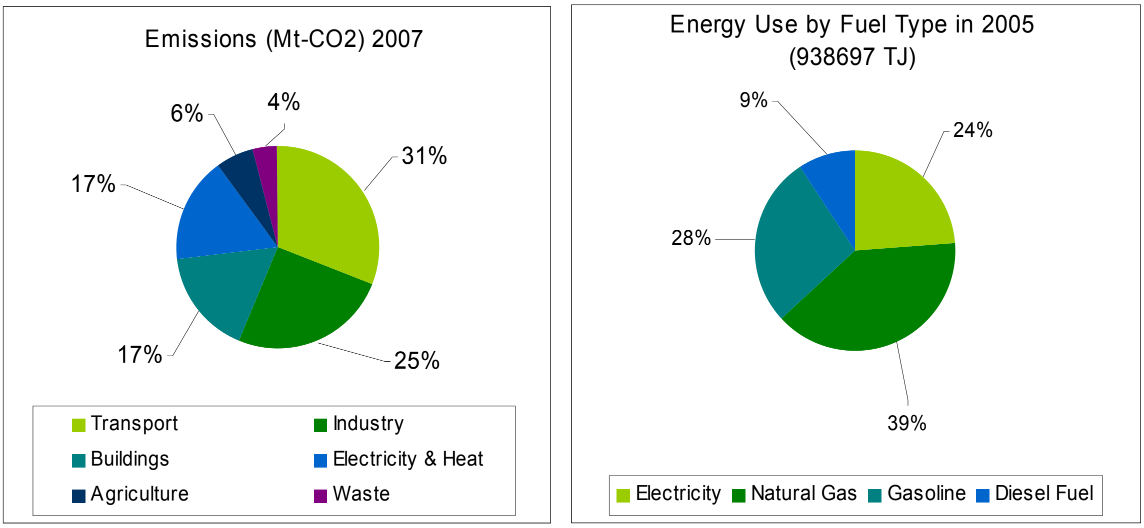
Over 70% of the population of the Province of Ontario is situated in the Greater Golden Horseshoe area, making it a significant site of energy use and GHG emissions for the entire province. The City of Toronto itself is relatively dense for a North American city at 4,000 people per km^{2,} with significant development of high-rise residential towers and high use of public transportation (only one third of trips occur using personal motor vehicles in the city centre; 56% city-wide). However, density reduces rapidly in the greater urban area to 866 people per km^2. The majority of the rapid population growth (9.3%) in the region, between the 2001 and 2006 census, has occurred in the greater urban area, where private motor vehicle use is on the rise and public transportation represents only 7% of trips. The transport sector continues to present a significant challenge in terms of energy use and GHG emissions.

While GHG emissions are at 9.8 tons CO_2eq per capita in the City of Toronto, this figure rises to 11.6 tons in the greater urban area. As seen in Figure 46 transportation accounts for over 30% of all GHG emissions with gasoline and diesel making up close to 40% of the energy mix in the Greater Toronto Area, as well as 38% of all GHG emissions. A partial decoupling of GHG emissions and economic growth has occurred as, while GDP increased by 2.6% annually between 1991 and 2007, GHG emissions increased only by an average of 0.5%. A portion of this can be explained

Figure 46

Energy consumption and GHG emissions by sector and fuel type in Ontario

Source: Ontario Ministry of Environment, Climate Change Action Plan, Annual Report 2008-2009



by a concerted effort at the level of the Province to phase out all coal-powered electricity generation. The share of Ontario power generated from coal-fired sources has been reduced from 19% in 2005 to 7% in 2009. Coal-fired power generation will be fully eliminated by the end of 2014 (Figure 48).

4.9.3 Plans and Objectives

Ontario has established GHG emissions reduction targets substantially more ambitious than the national targets set by the federal government: from 1990 levels, a 6% GHG emissions reduction by 2014 and 15% by 2020. The City of Toronto has set an even more ambitious GHG emissions reduction target: 30% from 1990 levels by 2020. Since Ontario emissions rose 13% between 1990 and 2005, these targets are equivalent to 20% and 33% reductions, respectively, from 2005 levels. Ontario has also set a 2050 target of 80% below the 1990 GHG emissions level. The 2020 target represents a 41% reduction in per capita CO_2 emissions from 2005 levels. It would bring Ontario's per capita CO_2 emissions to roughly the level that currently exists in the City of Toronto. This target also represents a 60% reduction in provincial emissions intensity (CO_2 emissions per unit of real GDP) over the next ten years.

4.9.4 Main Actions

The largest portion of GHG emissions reductions are estimated to come from the planned phase-out of coal-fired plants, the expansion of renewable energy sources, electricity conservation, and a refurbishing and expansion of nuclear facilities to make up close to 50% of electricity production. Paired with the potential electrification of the commuter rail transport system under the Metrolinx area-wide transport authority, the Province is working to decarbonise the electricity supply, while simultaneously reducing dependence on liquid fossil fuels for transportation.

These actions have been combined with the development of an integrated Growth Plan for the entire Greater Golden Horseshoe area by the provincial government. The Plan envisages increasing the existing built-up area, with a focus on urban growth centres, intensification corridors, major transit station areas ("mobility hubs"), and redevelopment of brown-field sites and grey-fields. Concentrating growth in these areas focuses transportation and infrastructure development. The larger planning document is being paired with local initiatives by both private and public actors, in order to reduce energy consumption and the GHG intensity of activities. The City of Toronto, for example, is home to the ENWAVE Energy Deep Lake Water Cooling, one of the largest district

Figure 47

Where emission reductions will be achieved by 2020 in Ontario

Source: Ontario 2009 Climate Change Action Plan Annual Report, May 2010

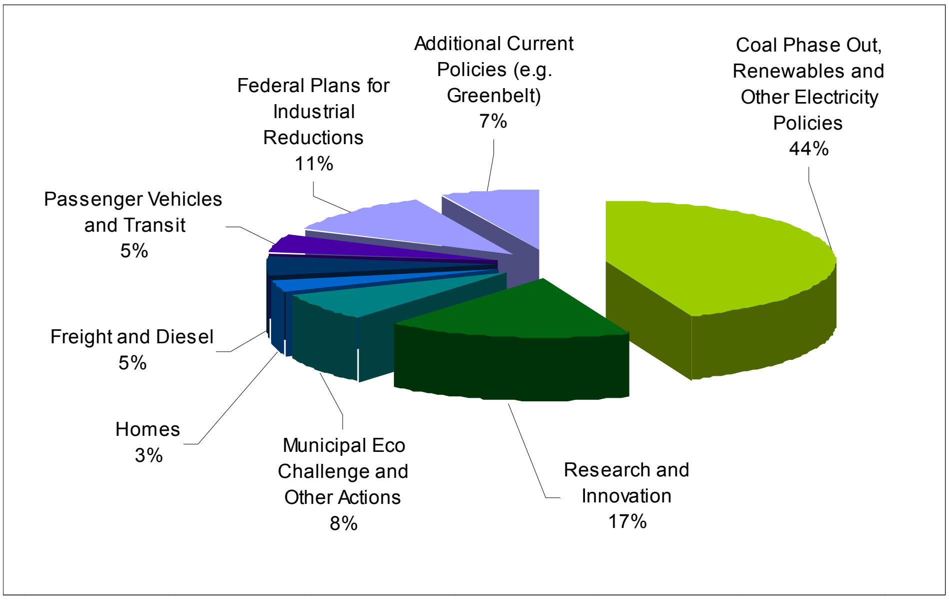
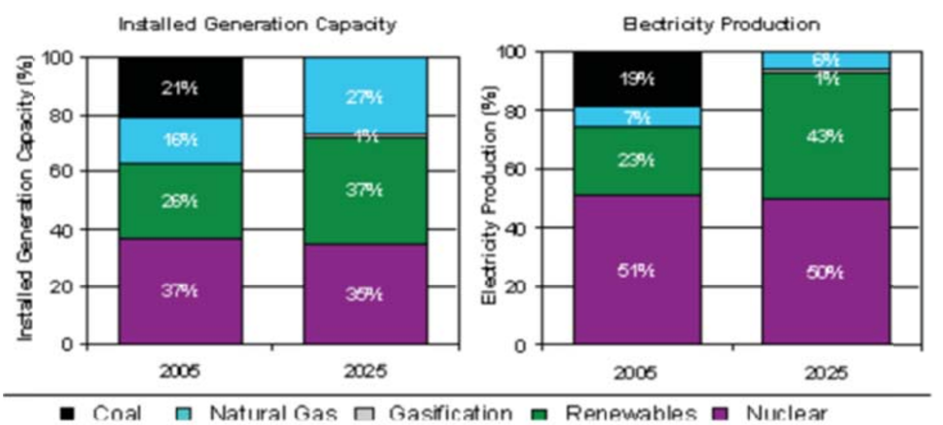


Figure 48

Direction for Ontario's electricity system development

Source: Ontario Power Authority, Integrated Power Supply Plan, 2007



energy companies in North America. It provides 2.5 billion pounds of steam each year, as well as a deep water cooling system, using cold water from Lake Ontario, which provides air conditioning to large buildings in downtown Toronto. The system has enough capacity to cool approximately 100 large office towers.

4.9.5 Conclusions

National, provincial, and local governments have set targets to reduce emissions. A wide range of initiatives to reduce emissions have been identified and are being implemented. To meet these aggressive targets established for 2020, governments, communities, corporations, and non-governmental agencies throughout the Toronto region will need to cooperate. The creation of Metrolinx and regional planning documents are important steps in this direction. However, more work is necessary to coordinate actions and ensure necessary financing. Further measures will be required to meet the ambitious 2020 targets. Governments acknowledge that meeting the 2050 target of an 80% reduction in GHG emissions will require fundamental changes in the way that residents live and move about the region.

Chapter 5: Local Action, Multilevel Governance

5.1 Multilevel Governance of Urban Energy Policy

The management of energy use in urban areas can be seen as a policy challenge functioning both vertically between different levels of government (local, regional, national, and international), and horizontally, across individual levels of authority. Local authorities are often key actors in a number of policy areas directly or indirectly tied to energy use, and other sources of GHG emissions. The multilevel governance framework is used to analyse processes operating vertically across multiples scales of government (e.g., local to national) and horizontally across governmental departments as well as non-governmental actors.[164] If it is determined that implementation at the local level is the most appropriate for energy policy, it is important to evaluate the authorities' capacity to work at this level.

An analysis of a given local authority's capacity to act can be based around three elements: jurisdictional capacity, coordination capacity, and financial capacity.[165] Limitations in terms of any of these three elements can reduce both the range of policy options available for addressing energy and climate issues, and the success of these measures (due to demands for coordination not only within a given level of government, but also between levels). Further, there is an apparent need for tools to facilitate coordination, such as GHG inventories and climate action plans in the case of climate change.[166]

5.2 Jurisdictional Capacity to Act

An analysis of the jurisdictional capacity of local authorities to treat climate change must consider their ability to treat specific policy sectors. Generally, the competencies of local authorities are embedded in larger, national policy and institutional frameworks, which may limit their access to a range of important competencies for managing energy access and use. This section will apply the multilevel governance theory to questions of jurisdictional capacity, using an example from New York City to illustrate both the potential obstacles and means of resolving them.

5.2.1 Legal Hierarchy of Power

Vertically, local governmental authority to act in energy policy areas is hierarchically "nested" in legal and institutional frameworks at higher levels.[167] For example, while regional and local policies determine the specific details of land use, human settlement patterns and transportation planning, space for action is usually limited by national development paths (dominant industries, principal energy sources, etc.), technical standards and funding priorities).[168] While national and regional governments may be engaged on energy

[164] Bulkeley and Betsill 2005; Hooghe and Marks 2003; UNFCCC, 2006.
[165] Adger, *et al*., 2009; Bulkeley, *et al*., 2009; and Sippel and Jenssen, 2010 for thorough reviews of this literature.
[166] For an extensive review of the literature on the capacity of local authorties to take action on questions of climate change, see Sippel and Jenssen (2010).
[167] Dietz *et al.* 2003; Hooghe and Marks 2003.
[168] Sathaye, *et al.* 2007.

and climate issues, they may not be in a position to coordinate policies with local interest and needs, affecting both their long-term acceptability and their effectiveness. This can have both direct and indirect implications for the ability of local authorities to influence energy policy. In terms of direct ramifications, the necessary competencies may not be devolved, so local authorities are unable to have direct control of the planning, construction and operation of energy-related infrastructures. Indirectly, local authorities may depend on national authorities in terms of the strictness of energy efficiency and other regulations and standards that can be used to influence energy use. Moreover, decisions made concerning funding and investment priorities can influence the range of measures that local authorities can put into place.

Box 13: Standardized functions of a municipality's capacity to act on climate-related issues

Hammer suggests that to evaluate a municipality's capacity to act in the energy/climate arena, it helps to view the situation through the prism of standardized functions common to all cities.[169] These can include:

- Direct service delivery responsibilities: Municipal gas and electric utilities are a relatively common form of direct service delivery in the energy arena, although the frequency of this ownership model varies dramatically from country to country.
- Regulatory responsibilities: Local authorities are frequently in charge of certain regulatory functions, such as land use control and building codes that can influence local energy-use levels in many ways. Cities may also exploit regulatory processes to promote certain types of energy technology use or consumption behaviour, easing rules or expediting the speed with which plans are reviewed by agency staff as an incentive for behavioural change.
- Procurement responsibilities: Local governments can require their energy providers to supply electricity from certain fuel sources, just as it can buy certain types of fuels for its vehicle fleet, or aggregate the energy demand of local consumers to help command more competitive prices.
- Advocacy/education responsibilities: Mayors have a highly visible public platform from which they can speak out on sustainability issues. Mayors are also expected to play an advocacy role on behalf of their constituents.
- Facilitation responsibilities: A closely related role involves a local authority's use of its convening powers to achieve certain goals.

5.2.2 Limited Control over Utilities

In addition to vertical jurisdictional issues, it is increasingly the case that local authorities have limited capacity directly to influence the operations of the various utilities providing what are often energy- and emissions-intensive services within their jurisdiction. Historically, local authorities have

[169] Hammer, 2008.

played an important role in the provision of services. However, the processes of market liberalization, among others, have reduced their involvement.[170] While increased market participation in these sectors may have other economic and social benefits, it has decreased the ability of local authorities to use their leverage over the utilities involved in energy supply, public transport, housing, and water, waste water, and waste management to reduce emissions.

Numerous studies have noted that the privatization of utilities has limited the capacity of local authorities to act.[171] In the United States, Betsill has observed that this limited control reduces the ability of local authorities to implement policies that foster energy conservation or fuel switching.[172] Promoting energy conservation and efficiency measures are increasingly important in reducing GHG emissions. However, these policies may not be in harmony with a profit-driven business model of utility provision.

Alber and Kern have noted that the demand-management programs that were in place while utilities were public have been almost completely phased out during the privatization process.[173] They have reported that local authorities that still have direct control of their utilities have been more successful.[174] A similar phenomenon has been noted in the transportation sector: since the deregulation of the public transportation system in Mexico City, there has been a marked increase in the use of private cars, principally related to a "vacuum" in the provision of high-capacity modes and a shift to private minibuses.[175]

Nevertheless, it should certainly not be concluded that the involvement of private utilities in public service provision is antithetical to energy conservation, improving accessibility and reducing GHG emissions. Experience from Europe, and other countries with efficient regulation authorities, demonstrates that this may be less an issue of public ownership, and more an issue of contractual design, and a question of providing the proper incentives, along with the ability of local authorities to enforce the necessary regulations. For the regulation to be efficient, the inescapable asymmetries of information between business firms (be they privately or publicly owned) and regulatory authorities have to be reduced to the minimum. This implies that cities can afford to recruit or hire the services of high-level independent experts. This is indeed more affordable for a mega-city than for a smaller city. Finally, the potential consequences of the remaining asymmetries of information have to be balanced with the potential productivity gains resulting from a competition between private firms to win the service contracts.

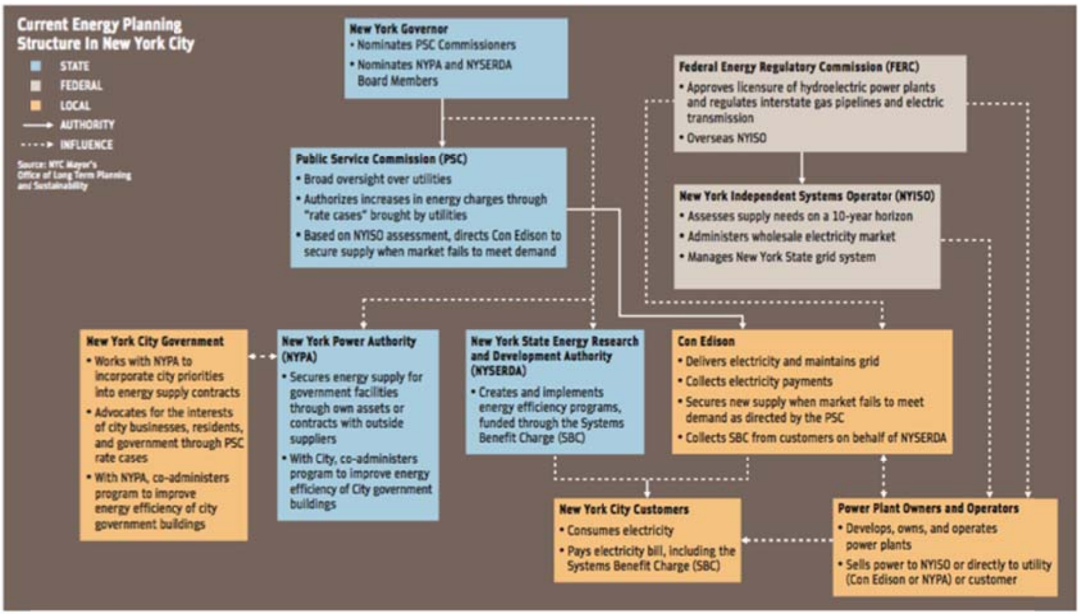
5.2.3 Political Incentives

Additionally, given that questions of energy use, efficiency, and climate change exist among a number of different social, economic, and environmental issues local authorities must struggle with the question of mandate. The political

[170] Bulkely and Kern 2006.
[171] See Sippel and Jenssen 2010 for an extensive review.
[172] Betsill 2001.
[173] Alber and Kern, 2008.
[174] Kern *et al.*, 2005; Weimer-Jehle *et al.*, 2001.

[175] Lankao, 2007.

Figure 49:
Map of Energy Planning Structure in New York City (2007)



"jurisdiction" to engage the subject is increasingly important: numerous studies have identified the lack of a formal political mandate from national or regional authorities as a significant limitation.[176] While many authorities, particularly in the United States and Canada, have taken up the banner of climate action due to a lack of movement at the national level, actions may remain fragmented and voluntary. This stems not only from the prioritization and demands of national mandates on other subjects (e.g., social inclusion, education, etc.), but also from fear of loss of competitiveness compared to similar urban areas.[177]

Box 14: Nesting of jurisdictional capacity on energy climate policy—the case of New York City and London

Hammer notes that cities such as New York City (NYC) and London play "subordinate roles" on most energy planning matters, due to limitations by "… state or national laws or rules specifically designed to rein in the energy policymaking powers of local authorities".[178] It appears that the capacity of local authorities, in this case the Office of the Mayor, to influence policy is limited by the large web of state-institution involvement, as seen in Figure 49.

Hammer's analysis equally indicates a few areas within which the local authorities' capacity to act in New York City and London is limited. In London, the limits come in the form of the mayor's weak budgetary power and laws, which give the mayor planning-permit authority over just 250-300 planning applications each year. Similarly in New York City, laws passed over 100 years ago have stripped the city of regulatory authority over utilities. Nevertheless, the two cities have also attempted to take action through the promotion of voluntary actions, either with other local authorities or directly with citizens. Equally, both cities do clearly have some capacity in areas where the municipality has regulatory control, such as municipal purchasing authority in New York City and regulatory controls over new development.[179]

Hammer also indicates how institutional arrangements within the city government influence the capacity of the mayor to take action on the deployment of renewable energy technologies. In the case of London, a new

[176] E.g. Bulkeley and Kern, 2006; Betsill, 2001; Alber and Kern, 2008; Schröder and Bulkeley, 2009.
[177] Kamal-Chaoui, 2009.
[178] Hammer, 2007 and 2009.

[179] Hammer, 2007.

Climate Change Agency was created, shifting the institutional arrangements to overcome identified funding barriers as well as regroup capacities horizontally. Similarly, the city of New York created an Energy Policy Task Force in 2003, to shift the interactions between different institutional players at the local-scale.

Box 15: Local capacity to act, the example of London

Assessing the capacity to act can be challenging, but some cities are forging ahead. For instance, the Greater London Authority (GLA) has the responsibility for different initiatives proposed in its Climate Change Action Plan, which it hopes will reduce city-wide GHG emissions by 60% by 2025. The Plan specifically notes that local policy powers are capable of delivering no more than 15% of the total target (GLA Climate Change Action Plan), and goes on: “Responsibility for tackling climate change must be shared between the Mayor, the London boroughs (5-10% of requirement), London’s companies and public sector organizations (35-40%), Londoners (5-10%) and national government (30 per cent)”.

5.2.4 Specificity of Mega-cities

In mega-cities, a number of tensions make addressing energy policy more complex than in other contexts. Because of the concentrations of both population and economic activity, a tension may be present vertically, between the metropolitan government and national authorities. As such, direct control is often not devolved to metropolitan authorities because of concerns about establishing a pseudo-“state-within-a-state”. National oversight of policies, designed to function as controls on excessive local authority, can actually limit the capacity of local authorities to act on a number of energy policy issues.

5.2.5 Conclusion

Providing energy to all, combating energy poverty, and curbing GHG emissions and local energy-related pollutions do not only depend on municipal and local policies: multilevel coherence with a clear distribution of tasks is required. Before defining local policies, an assessment of the jurisdictional capacity to act of local authorities is needed, followed by a shift of capacity to act towards the most appropriate policy level, if necessary. At the very least, a clarification of the responsibility among actors for each topic is needed.

It is difficult to speak generically about a municipality’s capacity to act, because the key attributes of a local authority—its institutional structures, responsibilities, and powers of taxation—are all derived from state or national government allocations of authority, and these vary. A review of local capacity to act can therefore be seen as a fundamental precursor to each city’s ultimate policy recommendations: policies must be designed around a jurisdictional reality.

5.3 Capacity for Coordination

The previous section treated the devolution of competencies and jurisdictions to local authorities in order to take action on energy and climate issues. However, even if the requisite competencies have been devolved and the local authority has the power to act, the structure of the decision-making and implementation processes may still prevent action. This may be because of difficulties in:

- Coordinating internally
- Coordinating horizontally between adjacent local authorities
- Designing and managing public private partnerships (PPPs)

5.3.1 Internal Coordination

Internal coordination is needed to implement the often transversal and interconnected policy packages identified in Section 1 of this chapter. Coordination is necessary across traditionally "siloed" policy sectors that may or may not have developed institutional and work cultures that frame energy and climate questions in very different ways. City governments are usually organized into a limited number of specialized departments with specific mandates, evaluation criteria and operating cultures. Divisions between departments can be difficult to bridge: they may often have separate budgets and timelines, as well as being used to focusing on often narrowly defined tasks, with limited, to no, cooperation and interaction between departments.[180]

Within this context, there is often no clear institutional home for climate-change and energy-related issues that are, on the one hand, tied to environmental concerns, and on the other, intrinsically linked with economic development. As noted by a number of authors, the relegation of climate to the environmental department may further increase coordination problems, as these units may be marginalized, understaffed, and lack the political weight and competencies to coordinate between the various departments that need to be involved.[181]

Box 16: New York City Mayor's Office of Long-Term Planning and Sustainability[182]

Finding an institutional home for climate change and energy policy is important to the success of mitigation and energy-efficiency efforts. The Mayor of New York City, Michael Bloomberg, created the Office of Long-Term Planning and Sustainability (OLTPS) in 2006 to develop and implement the City's long-term sustainability plan. With ten principal objectives laid out in the PlaNYC, including a 30% reduction of GHG emissions by 2030, the OLTPS, as part of the Mayor's Office of Operations, is institutionally located in a powerful position to coordinate cross-cutting policy changes and enforce the implementation of sustainable initiatives. The OLTPS coordinates between implementing departments and agencies, tracks and evaluates progress towards programme milestones and goals, and assists in the production of a sustainability indicator

[180] Suzuki *et al.,* 2009; Betsill, 2001.

[181] Alber and Kern, 2006; Bulkeley *et al.,* 2009.
[182] ICLEI and City of New York 2010.

"dashboard", which is used to track performance.

In the case of New York City, the creation of this office and the delegation of the appropriate authority and competencies have raised the level of attention to the issues of energy and climate change among policymakers and administrators. This has led to the development and implementation of aggressive, but achievable, initiatives. In 2008, the office and its planning practices were institutionalized as permanent offices, with a dedicated director responsible for periodically revising and implementing the City's sustainability plan.

In addition to finding the necessary institutional arrangements and mechanisms, there is also a need for sufficient dedicated human resources. A number of researchers have noted that having to few staff, a situation often tied to financial resources, makes it difficult to achieve the necessary level of planning and coordination to achieve reductions in energy use and GHG emissions.[183] Examples from Mexico City, Germany, and South Africa show that a limited number of staff (especially if none is exclusively dedicated to the particular issue), will struggle with the implementation of a large number of mitigation projects.[184] Additionally, staff must also have the necessary expertise to cross the traditional sectoral divides.

5.3.2 Horizontal Coordination between Municipalities

Ensuring horizontal coordination between border municipalities and other sub-national authorities in addressing energy challenges also poses an equal number of difficulties. In many instances (from our case studies which include, Mexico City, Toronto, San Francisco Bay Area, and Paris), no single administrative structure or agency has jurisdiction over the entire urban area and/or other appropriate perimeter. As such, the different municipalities are required to work together in terms of service provision for those sectors that often achieve their economies of scale at the size of an entire basin (e.g., water) or urban area (e.g., waste treatment, transport, etc.). In many instances, special purpose districts or agencies are set up (e.g., Metrolinx in Toronto, and Metropolitan Transport Commission in the San Francisco Bay Area). However, these agencies often do not have the statutory authority to regulate and direct policy, and are forced to depend on the voluntary cooperation of municipal governments.

An analysis of the question of why metropolitan-scale governments, with the appropriate jurisdictional capacity to treat policy issues effectively, have yet to emerge in a number of countries, is beyond the scope of this report. Nevertheless, it is useful to note a few observations:

- First, national governments may view the establishment of integrated governmental authorities at the scale of the entire urban region, particularly in capital cities, as a

[183] Jones *et al,*. 2000; Betsill, 2001.
[184] ESMAP, 2008; Kern *et al.,* 2005; Holgate cited in Bulkeley *et al,*. 2009.

potential challenge to their authority. Given that mega-cities typically account for a higher-than-average portion of GDP per capita and are often social and cultural hubs for the entire country, national governments may choose both to play a large role in these areas and to retard the development of strong urban-region governments. This has been suggested as the reason, for example, that Mexico City remains divided between the municipal government and the jurisdiction of the federal district, effectively cutting the contiguous urban area in half.

- Secondly, an equally strong bottom-up opposition to the formation of metropolitan governments on the scale of the entire urban area often comes from individual cities and towns themselves. Whether small towns are afraid of being economically and politically dominated by the larger central-municipal area or adjacent municipalities are unwilling to cede their jurisdiction and merge to form a larger authority, the opposition of local governments has been noted worldwide. Furthermore, in many countries local governments are often seen as the hallmark of democracy and as having the closest connection with individual citizens. Toronto, San Francisco, and Paris all present cases where the lack of a single metropolitan authority, often due to the opposition of individual local governments, limits efforts to coordinate energy policy at the most appropriate scale.

The issue of horizontal coordination is illustrated with an example from a medium-size city, Grenoble in France, which is by many aspects a pioneer in the field of energy and climate policies. The lessons from this case appear to be valid for much larger cities. The urban agglomeration of Grenoble has developed a tool to combine urban development and transportation network deployment: the *Contrat d'Axe* ("The Axis Contract").

An example: The *Contrat d'Axe* of the urban agglomeration of Grenoble.[185]

Contrat d'Axe is an initiative of the French urban region of Grenoble (400 000 inhabitants, 27 cities) to control the interaction between land use and transportation networks. The public urban planning agency and the regional transportation authority worked together to convince all the cities that will be crossed by a new tramway line (from Grenoble to the periphery) to collaborate with them. The objective was to stimulate construction along the transport line to avoid urban sprawl at the end of the line, and to improve the functioning and profitability of the line by providing customers all along the route. The project began with a dialogue process between local actors, which led to a charter, outlining the principles of the initiative. This charter was integrated in the transport plan of the agglomeration. The *Contrat d'Axe* has several principles:

- Encourage land mutation
- Support densification principles and a local urban plan to match

[185] Main source: seminar organized by the planning agency of urban area of Grenoble, the CERTU and the SMTC, December 10th, 2009.

- Contribute to densification
- Encourage local shopping mall and local services
- Encourage social mix
- Build cycle lanes and pedestrian facilities
- Organize local transport networks to feed the new line
- Incentivise not using a car

Contrat d'Axe is a voluntary contract that is not legally binding. The idea behind it is voluntary planning, negotiated between stakeholders. The tramway project is scheduled to take ten years, from research to construction. Actors commit to work together, to change their own urban plan and to respect the contract's principles. The contract will be signed in 2010, and it will describe the tramway line, its stops, urban spatial layout, urban projects and densification initiatives, cycle lanes, and associated bus network. Maps will be provided with corresponding documents to describe the financing plan, the schedule, and the partnerships for each project. All these documents will offer a global and integrated view of the whole urban and transportation project.

The public land bank analysed the densification possibilities of the territories. Because the planning agency and the transport authority are not operators in the land market, it is essential to integrate this agency in order to implement the project principles.

Building coherence

The target of this contract is to build coherence between urban planning and transport policies in spite of the institutional competence split. Moreover, the planning activity has its own limits: it authorizes or forbids, but does not lead directly to, implementation, and spatial jurisdiction limits decrease its power. The junction between the different planning documents (an urban strategic plan for the region, an urban plan for each city, and a transport plan for the agglomeration) is often difficult and insufficient: compatibility is weak. The *Contrat d'Axe* aims to overcome these limits through its reciprocal commitment to work together. It is the missing link between planning and project implementation. The main challenge that follows is to make the different actors work together.

This initiative is in process so results are not known yet. There are obvious difficulties: for example, it is not easy to balance the development of cities along the new tramway. Cities have to have a reason to increase housing production. The involvement of the public land bank is crucial. Similarly, although urban plans give a maximum density rate, they cannot make this density occur: so, for example, in another French region (Lille agglomeration), promoters usually comprise 80% of this density rate, social housing developers 66%, and private people 50%. Nevertheless, the idea of a contract at the beginning of such a process is of interest, and can probably be a useful model for many cities.

What can be learned for mega-cities?

Many studies highlight the central role of coordination and integrated policies for urban areas development; for example, the interaction between land use and transportation networks deeply impacts the structure of the city and the profitability and efficiency of public transport.[186] However the "capacity to plan effectively" is difficult to achieve because of departmental boundaries, jurisdictional structures, lack of will, or lack of workforce.[187] Urban development tends to devolve to the market, while municipalities cannot exert sufficient control. Moreover, the planning authority, when it exists, is often not equal to solving the issues.

A great variety of contexts exists for mega-cities, so it is highly likely that there will be a mismatch internally (between departments and agencies) or externally (between cities, or between cities and agglomeration or regional levels), along with coordination difficulties. Mega-cities are likely to be regulated by different planning documents (probably in many different ways), with complex priority and compatibility principles, which do not permit the effective implementation of key ideas.

Considering the variety of contexts and the different difficulties that make coordination and planning complex, there is no single or easy solution. Nevertheless, ideas like the *Contrat d'Axe* can bring together the institutions which hold the competencies to coordinate around a project.

[186]Eco2cities, World Bank 2009; Dalkman and Brannigan, 2007; 'In Bangalore, the lack of coordination and integrated planning is severely impacting the use of land.'WBCSD, 2009b.
[187] WBCSD, 2009b.

Instead of aiming for the impossible (a large integrated department which would perfectly tackle these issues, or departments working together consistently and in harmony) an idea like the *Contrat d'Axe* allows cities to aim for the possible. Such a *contrat* could be used in situations where a key project has been identified, like a new line of public transport or a large urban operation, which deserves the coordination of different departments and authorities and needs to overcome (some) jurisdictional problems. It would require not only information exchange but also a co-construction process. A *contrat* is not a tool able to eliminate jurisdictional or structural blockages, but it can help to overcome them, by bringing people together and instituting a procedure. The contract structure can also be adapted to integrate private actors, who play an important role in urban development.

Specificity of mega-cities

Horizontally, the typically fragmented internal structure of mega-cities can also reduce their capacity to coordinate, both between internal administrative units and across sectors. Typically, mega-cities have grown up too quickly to allow the reciprocal modification of administrative boundaries, jurisdictions, etc. As these urban areas have grown, they have absorbed surrounding towns, villages, and mid-sized cities. While the urbanized area is often contiguous, the administrative jurisdictions may be anything but, creating a patchwork of jurisdictions, competencies, and a maze of approval and implementation pathways. This can be further complicated when competencies are spread between local governments and larger urbanized regions.

5.3.3 Public Private Partnerships

From urban government to urban governance

Hammer reports that the concept of governance refers to "a new process of governing" that involves the "blending and coordinating" of public and private interests.[188] Therefore, the concept of governance characterizes the "end of a public-authority-centred and formal process of decision making". Several reasons explain this shift away from urban government towards urban governance:

- First, due to globalization and the consequent competition between cities to attract and retain businesses, national authorities have lost some of their local economic control.
- Second, the move away from urban government is linked to the end of the "Fordist" period (after the US car manufacturer Henry Ford), during which local authorities were responsible for the provision of basic infrastructure, education, health, and housing services. In the post-Fordist era, the rise of the service sector and knowledge economies has modified expectations on local government. Now governments develop collaborative partnerships to serve public interests.
- Finally, the emergence of "semi-autonomous public agencies", which focus on single issues and benefit from independent budgets, has made policy coordination more complicated.

The rationale for PPP

Contracting is the fastest developing mode of organization, by which a public authority, such as a municipality, entrusts a private operator with an investment (possibly its management for a period of time), and its relinquishment at the end of the contracted period. This form of delegation, which is the most common type, is also known as "BOT", which stands for "build, operate, transfer". It applies to an increasing amount of infrastructure, but also develops by concessionary or public-service delegation-type contracts.

The logic behind contracting is primarily the economic efficiency associated with the introduction of competition. It applies today not only to a growing area of urban infrastructure, diverse networks, and motorways, but also to cultural or sports facilities, hospitals, and prisons, etc. The main argument in favour of it concerns expertise: public authorities do not always have the necessary proficiency to provide more and more complex services.

How well this solution may work will depend largely on the capacity of public bodies to negotiate with operators, and the ability to define and manage the terms of the tender, with the conditions that may be attached, particularly as regards sustainable development. This explains why larger cities tend to use it, since they have competent technical and financial services, and communities of a higher level. It has undoubtedly improved the production

[188] Hammer, 2008; Rhodes, 1996; Pierre, 1999.

and distribution of a number of services, even if it does not always reduce costs.

However, when a company takes charge of the provision of a service it deprives the public authority of information on the real costs of the product service. This asymmetry of information may lead to the capture of an “information rent” by the trustee. While there is no general answer to this problem, solutions can be found on a case-by-case basis where the optimal organization of public services can reduce this asymmetry of information on costs and techniques. Finally, we can highlight the vital importance of the negotiation process for this type of contract, especially for long-term contracts, which may involve the issue of sustainability.

In conclusion, the role of public-private partnerships (PPPs) is now crucial, particularly in large cities and mega-cities. But the main outcome of a PPP is the capacity to develop technologies and management efficiency in otherwise old, stagnant, and inefficient public services or dispersed private businesses. They also allow the leveraging of private-sector capital. However, PPPs alone cannot solve the financing problems of extending basic services and curbing GHG emissions. Public money is still needed, especially on issues that may be perceived as high-risk to the private sector. In addition, PPPs require the setting-up of independent regulatory authorities and substantial investment in social and human capital, in order to overcome asymmetries of information between public and private actors, and to create a clear and stable regulatory environment.

5.3.4 Conclusions

The improvement of jurisdictional and cooperation capacities is an important step towards enabling local action on energy-policy issues. In many cases, higher government levels should perhaps allow cities an increased jurisdictional capacity in this respect. All levels of government must strongly improve their capacity for coordination, looking at the internal coordination among municipal services, the coordination between adjacent municipalities, and the fostering of PPPs.

5.4 Financial Capacity[189]

A third, and key, determinant of a local authority’s capacity to take action on energy and climate issues is the availability of financing. Energy-efficiency improvements and GHG emissions reduction efforts often involve substantial investments, with high up-front costs and long pay-back periods. Finding an additional 5-10% of total project costs can be a challenging task, particularly when large-scale infrastructure investments are necessary.[190]

Sippel and Jenssen’s review of the literature finds that financial constraints rank high among the barriers cited by local authorities. Two principal limitations have been identified. First, local governments often have a low and unstable

[189] This section owes much to Lefevre, B. and Renard, V., Financing urban sustainability policies, background paper for OECD

[190] Number cited by M. Guillard (Nantes Metropole) as an estimate percentage of total project cost necessary to render a project less-GHG intensive.

revenue base.[191] This introduces both difficulties in financing new measures, and the need for planning the long-term investments often necessary to achieve emissions reduction objectives. Further, an inability to demonstrate long-term financial stability may limit local authorities' ability to access private capital markets. Second, transfers from national and regional sources are typically viewed as insufficient.[192] These budgetary constraints may be even more pronounced in developing countries.[193]

5.4.1 The Resources of Local Communities

Without resorting to printing money, which could occur in city-states such as Singapore and Oman, three main sources of funding are open to local authorities: i) transfer through another level of public bodies (often the state); ii) local taxation; and, finally, iii) the pricing of services provided by the municipality ("user charge").

Borrowing (most commonly from the domestic market, but also, increasingly, from international capital markets), is not strictly speaking a source of funding, since loans are to be repaid through the above sources. However, it is a means to speed up economic growth, and anticipate future municipal revenues. With the emerging carbon markets, a new potential funding source appears.

The respective shares of these components vary widely from one country to another, and the revenue structure may play an important role in terms of sustainable development. Each of these funding sources raises different questions concerning the problem at hand.

Eco grants

The incorporation of ecological indicators into general grants has been considered in several countries. Since 1996, the German Advisory Council on the Environment has called for the integration of ecological indicators into intergovernmental fiscal transfers. This has resulted in a number of detailed studies, such as, for example, financing on the basis of improvements to local nature and wildlife, or on the basis of "nature points" that evaluate activities to improve nature protection.[194] The incorporation of an indicator for "biodiversity per standardized area" has been suggested for the general grant system in Switzerland, which would lead to cantons with greater biodiversity receiving a relative increase in fiscal transfers.[195] In India, the 13th Finance Commission stated that 7.5% of fiscal transfers to states and territories would be based on forest cover. In this proposed formula, the states and territories with less forest-cover area would receive fewer lump sum transfers, while the others would gain according to their forest-cover area.[196]

Local taxes

Taxes are raised mainly from three sources: income, property, and expenditure. The flexibility of these funding sources is limited, both for political

[191] Carmin et al. 2009; Mukheibir, Ziervogel 2007; Romero Lankao 2007.
[192] Sippel and Jenssen 2010.
[193] Bai 2007.

[194] Perner and Thöne, 2005.
[195] Köllner *et al.*, 2002.
[196] Kumar and Managi, 2008.

and economic reasons. In the absence of a strong evolution of the tax base, the increase in rates will be limited, both for local political reasons and often because of the application of ceilings or legal limitations, which are set at the central level, to avoid potential local drifting.

Taxes on land and buildings are the most common form of direct revenue for local municipal governments. In several countries, they are a major source of revenue for financing various types of expenditure, for both operational and infrastructural projects, sometimes including sustainable development.

This form of taxation is not very popular and raises serious problems in developing and emerging countries. Moreover, the sustainability of this type of resource is a concern: land and property markets worldwide are increasingly cyclical, which is to some extent threatening the regularity of the long-term evolution of this form of taxation, which is based on market value. These problems have been highlighted during the period between 2007 and the present, with serious financial problems, including bankruptcy, affecting local authorities in many countries as land and property values have collapsed. A possible alternative to property tax is local income tax, usually perceived as a supplement to national income tax, which is not associated with problems of assessment, but at the same time has a limited degree of flexibility.

There are several other types of local taxation, mainly sales tax, but also including licenses, permits, and charges for certain services. Giving a level of coherence to the assortment of existing local taxes is a difficult task, but it is necessary in order to reach clear policy goals, including long-term sustainability objectives.

User charges

Beyond local taxation, user charges levied directly on the recipients of public services represent a frequently used and important resource for local governments. The most common services to be financed (at least partly) through user charges are: water distribution, sanitation, parking, toll roads, recreational facilities, and refuse collection.

Such user charges should be designed to recover costs, so as to minimize the taxation burden and maximize revenue, with the possibility of realizing some benefits. These charges are not simple to implement and the fees seldom reflect economic efficiency. Revenues are therefore usually fairly limited. Nevertheless, the modulation of user charges enables a number of incentives for sustainable development (e.g., water, energy, etc.) to be introduced.

Tariffs and subsidies

The dilemma on tariffs is still pending. The main idea of the end of the 20th century—that the customer must pay the full cost of urban services—has proved difficult to implement in the early part of the 21st century. It is now clear that services for the poor will have to be subsidized for a long period of time, if access rates are to increase. Cross-subsidizing from the rich to the poor, and from some services where the willingness to pay is higher (e.g., mobile phones) to others where it is lower (e.g., sanitation networks) is, at most, only part of the solution. If the level of cross-subsidy necessary to give access, at minimum service, to all the poor is politically unfeasible or economically counter-productive, then subsidies from the general municipal or state budgets will have to be instituted.

There are many different ways of setting or removing subsidies for basic services—and many different rationales behind these approaches. In public mass transit systems, infrastructures must be subsidized as long as road services for private cars are subsidized. Network industries may need to subsidize the connection cost for the poor, but not necessarily a minimum level of consumption. Subsidizing fuel may harm the local as well as global environment, but removing these subsidies harms the poor through an increase of their transportation or cooking costs.

Taxation of capital gains on land and real estate

As explained in Box 17, land values are to a large extent the result of public decisions and actions; thus it would seem legitimate and equitable for public authorities to be able to recoup at least a share of such increases in value. Many countries use a different approach where capital gains on land and property are taxed: for example, it may be carried out at the local level, as in Germany, or nationally, as in France.

At first glance, taxing capital gains on land can appear to be an equitable solution, providing a way for local authorities to recoup increases in value that do not result from a landowner's activity. However, in most countries, the practical application of such a tax is usually complex, involving a lot of rebates and exceptions, difficulties in evaluation, and excessive amounts of litigation. Moreover, in terms of sustainable development, it can constitute an incentive to hold on to a piece of land, instead of selling it for a more efficient use that would be in accordance with plans and regulations. This can be especially important when the rate of capital gains tax, as applied for instance in France, is progressively declining over time, thus strengthening the incentive to wait before selling.

Box 17: Should urban land be private or public?

Land prices do not only reflect an intrinsic value, in the way that agricultural land does for instance, but also capitalize externalities, particularly the impact of infrastructure, which is usually provided by a public authority. The private appropriation of capital gains resulting from public activities financed by the taxpayer is an issue that has existed for at least 150 years. Despite a huge amount of literature that has been generated during this time, the conclusions reached in terms of public policy are still controversial.

An apparently simple solution would be the public appropriation of land for urban development, which is then managed by a public agency that is able to introduce fundamental elements of equity and sustainability into its land policies. In some countries, mainly in northern Europe, this solution is already in use, for instance in Sweden or the Netherlands, and has produced interesting results in terms of equity (i.e., betterment recoupment), as well as in terms of sustainability, city compactness, and coherence between transportation systems and land development.

It must be emphasized that this is not the direct result of public possession of land, but of a sound and firm planning mechanism, the implementation of which is made more efficient through public ownership. It should be noted that the development itself in these public ownership schemes is submitted to competitive mechanisms (for example, development rights are granted through a tendering process), but land, especially in major cities, remains public property under the leasehold system.

Public ownership of land thus appears as an efficient and equitable system, if there is a sound planning system. However, if no such system exists, public land ownership can lead to quite different results, switching from private speculation to public speculation. There are several examples of public land agencies, in developed and developing countries, which have progressively implemented their own land development policy instead of applying policies designed by the appropriate public authority. In these instances, such policies, probably aimed at short-term benefits did not enhance sustainable urban development. This partially explains the recent trend towards the privatization of land and property.

Land values and infrastructure funding

Funding infrastructure seems straightforward: any new development should pay its own real cost in infrastructure. For several reasons, the simplicity of this solution can be misleading: the cost is difficult to assess, internalization of external effects is often not possible, and the real cost cannot be calculated for an isolated house. Most importantly, there are always three possible payers of this cost: the taxpayer (local or national), the developer, i.e., the purchaser of the dwelling, and the initial landowner who benefits from increases in land value that result from the building of infrastructure. Given the extreme complexity and diversity of the systems that apply in OECD countries and others, we shall limit our comments to some basic principles. The methods in use obviously have some influence on urban trends and sustainable development, but the precise relationship between both is usually difficult to assess.

The first possibility, used for instance in Germany and Switzerland, relies on betterment recoupment by charging the initial landowner a part of the costs of infrastructure. There is an evident connexion between betterment recoupment and infrastructure funding, inasmuch as an element of the "betterment" value of a piece of land occurs to some degree as a result of both the building of infrastructure in the vicinity (such as road networks, water, sewage, electricity etc.), and the expectation of such developments.

It thus appears logical and equitable to finance such an infrastructure, at least partly, through betterment recoupment among landowners. Many countries, following different methodologies, use such an instrument, for example: "special assessment" in the US, "valorisation" in some South American countries and "contribution de plus values" in Switzerland. The design of such a device can raise a serious empirical and theoretical difficulty, since the relationship between the building of infrastructure and the rise in land value cannot be measured in a rigorous way: the price of a piece of property, especially land, is the result of the interaction of a broad set of events, e.g., changing urban trends, infrastructure, zoning, etc. Therefore this fiscal device can, and often is, challenged due to the inherent approximations in its calculation.

5.4.2 Access to International Capital Markets

Municipalities, especially the larger ones, have increasing access to international capital markets, although this aspect of their funding is still a modest proportion of the total. It occurs mostly by intermediation of a specialized body, and in all cases, the issuing community (or financing body) must have been subject to a credit rating carried out by a rating agency, such as Moody's or Standard and Poor's. The issue of credit rating is not simple: it is only an opinion on the financial soundness of the borrower, in relation to a specific loan, and is essentially based on the default risk of the borrower. Such an evaluation thus requires detailed knowledge of funding mechanisms for local communities. The question should be asked whether indicators of sustainable development could be selected by the financier in its decision to fund the project or not. The "environmental rating" is still in its infancy but is expected to become important.

Initially it is not easy for a local authority to obtain the confidence of an investor. On this point, transparency of management and accounts, as mentioned above, must play a key role, particularly when a community wishes to address the international capital market. Broadly speaking, when addressing markets, it is easier for local authorities to finance projects than to increase the overall investment budget of the municipality. Indeed, projects are generally more transparent and reflect more easily the expected. That said, a striking difference in this respect separates Europe and the US: in Europe, investments are made largely by specialized financial institutions, such as Dexia in France and Belgium; while in the US, a large part is provided by the bond market. This can be explained by both the absence of a financial institution specialized in financing local authorities, and also the reluctance of banks to finance them.

In the case of the US, two main types of obligations can be issued: i) obligations of a general nature (general obligation bonds), which are guaranteed by the ability of states and local governments to raise taxes; or ii) bonds for financing projects ("revenue obligation bonds"). Revenue obligation bonds are based on the ability to be repaid by a revenue source coming directly from the provided service, for example water distribution companies or public transport in which financing is provided partly by fees.

More sophisticated financial tools, in particular "structured" products that combine traditional products with derivatives such as swaps, "futures", or "options", have developed in recent years. The financial crisis that has developed since the end of 2007, which is largely due to the proliferation of such tools, has clearly resulted in a marked halt to this type of development, which is unsustainable, opaque, and high risk.

Overall, the use of the bond market is very important in the United States. It is estimated to finance between 70% and 80% of local authorities' investments.

5.4.3 Carbon Finance

Carbon markets (see Box 15) have been positioned as an economically efficient institution for delivering global carbon-emissions reductions, as well as spin-off benefits for the local area. However, because of the way in which global and regional carbon markets are structured and also due to characteristics of urban planning, these markets are rarely used to encourage urban trends in energy and carbon efficiency. Thus far, cities have only been able to make use of these markets in a very restricted way, while their application to the urban transportation and buildings sectors, two of the main urban sources of CO_2, has been even more limited:

- City participation in carbon markets is limited to flexibility mechanisms (offset project, voluntary, or Clean Development Mechanism/Joint Implementation CDM/JI).
- There has been little use of these markets to promote a more energy- and carbon-efficient urban transportation pattern: to date, of the 1,224 CDM projects registered by the UNFCCC Executive Board, only two have been transportation projects, representing less than 0.13% of the total CDM projects (the Bogotá bus rapid transit (BRT), TransMilenio, and the Delhi subway regenerative breaking system).
- The buildings sector exemplifies the CDM's inadequacy for the promotion of energy efficiency and the reduction of energy-related carbon emissions in cities. Although buildings (in particular with regard to energy efficiency) offer great potential in the global carbon market, the current CDM framework does not sufficiently exploit this potential, with only a trivial number of CDM projects (0.57%) and generated CERs by 2012 (0.16%) that deal with energy efficiency in the buildings (residential and service) sector.[197]
- Carbon markets favour projects with easily achievable aims that do not have the greatest potential for reducing GHG emissions.

In conclusion, intense efforts have largely focused on industry and energy sectors in recent climate-change negotiations. However, so far, although cities comprise the majority share of global emissions, they have not yet been considered as a legitimate entity to implement different GHG mitigation policies and measures, with technical and financial assistance. Moreover, sustainable transportation and buildings are expected to be integrated into local urban planning schemes. Actions to reduce GHG emissions in urban transportation and building sectors should be included in the on-going international climate negotiations, keeping in mind that a significantly broad part of new programs must be included in

[197] Fenhann,F. CDM pipeline UNEP Risø, as of the 01-Mar-09

the scheme; otherwise transaction costs will be too high.

Within the existing CDM design, municipalities would be advised to: i) focus on easily attainable objectives and carbon projects with beneficial by-products for the local area; ii) build partnerships with carbon commodities producers, such as bi-/multi-lateral agencies, consultants and operators, etc.; iii) "sell" capacities to act and technical information; and iv) exercise more caution in the use of the CDM financial stream and how carbon successes are advertised. National stakeholders are key drivers for the initiation of complex CDM projects. Both municipalities and national authorities are right to focus their efforts on data generation, baseline establishment, and sectoral assessment of the marginal costs of GHG emissions reductions.

Box 18: Carbon markets

To understand carbon markets it is important to recognize the differences between two fundamentally distinct types of carbon commodities—allowances and offsets—and the systems that create them. Allowance carbon commodities are created by cap-and-trade systems, while offsets are created by baseline-and-credit systems, also called project-based systems. Both are expressed in terms of "tons of CO_2 equivalent emitted or avoided per unit of time" (generally per year). A baseline-and-credit system does not require a finite supply of allowances, nor does it involve projects that are implemented under the umbrella of a cap-and-trade system. Rather, additional credits are generated with each new project implemented. Buyers who want to comply with a regulatory emissions target, to "offset" an emitting activity or to become a "carbon neutral" organization with zero "net" emissions can use these credits. Therefore, carbon offset markets exist under compliance schemes (€20 billion traded in 2006) and also as voluntary programs (€62.6 million in 2006).[198]

When they are certified and issued by the UNFCCC, carbon offset credits are known as Certified Emission Reduction (CER), within the framework of the Clean Development Mechanism (CDM), and Emission Reduction Unit (ERU), within the framework of Joint Implementation (JI). Both CDM and JI are part of the Kyoto protocol. CDM allows developed countries to purchase carbon credits from emissions reduction projects in developing countries, and JI from emissions projects in other developed countries. When they are verified and issued by another carbon market standard, carbon offset credits are called Verified Emission Reduction (VER). There are currently 12 carbon offset standards operating on voluntary carbon markets.[199]

[198] Capoor and Ambrosi, 2007; Hamilton, 2007

[199] The twelve voluntary carbon offset standards are: Chicago Climate Exchange (CCX); Gold Standard (GS); Voluntary Carbon Standard (VCS-2007); VER+; Voluntary Offset Standard (VOS); ISO 14064-2 ; GHG Protocol; The Climate, Community & Biodiversity Standards (CCBS); Plan Vivo System; CDM A/R; VCS-AFOLU; RGGI. For a detailed comparison of these voluntary standards see SEI, 2008, Making Sense of the voluntary carbon market. A comparison of carbon offsets standard, WWF.

Table 19
Registered CDM Projects in Mexico

Registered projects	Number
Energy Efficiency	2
Waste water management	2
N201	1
HFC-23 incineration (cooling? Gases)	1
Hydroelectric	3
Wind power	8
Methane recuperation from landfills	13
Waste management in farms	91
Total	121

All projects presented to the board of a carbon market standard have to use a methodology approved by the competent authority. In UNFCCC language, the term "methodology" denotes all the procedures that a project must adhere to in order to submit its candidature to the UNFCCC CDM Executive Board for certification of GHG emissions reductions. There is a system that describes the context in which this methodology can be applied, the project boundaries, how the baseline has to be established, the whole monitoring process and schedules. If the project does not follow the approved methodology, changes can be made (amendments), or a new methodology can be submitted. In the CDM framework, the proposed methodology is reviewed by the Methodology Panel of the UNFCCC and approved or rejected by the Executive Board of the UNFCCC.

Box 19: Learning from Mexico City: obstacles to carbon finance[200]

One of the most promising programs that can be easily implemented in many developing countries is landfill biogas recuperation. This type of programme does not require significant investments or the developments of new technologies. However its application at the city level is not always easy. For example, in the Climate Action Plan of the City of Mexico, biogas recuperation from landfill is a "best cost-efficient action". However, in practice, it has been difficult to put into action. First, as landfills are normally located outside city boundaries, this poses a problem in terms of responsibility for emissions, and thus, for the financial flows stemming from reduction projects. In particular the question of who is getting the carbon bonus is not settled: should it be the city that has generated the waste or the city/state within which the landfill is located? In the case of the City of Mexico, it has not been possible, to date, to reach an agreement between the Federal District (City of Mexico) and the Federal Government. Second, differences between the legislation at state, national and local levels have delayed the program's implementation.

5.4.4 International Climate Instruments in Post-Kyoto Negotiations

We can currently distinguish three significant and promising interrelated processes regarding the large and complex area of cities and climate change:

- A growing awareness of the crucial role that urban territories must and can play in reducing GHG emissions
- The emergence and consolidation of various urban territory networks providing benchmarking, exchange of best practices, and decentralized cooperation
- The growing power of a (still heterogeneous) lobby dedicated to supporting the voices of urban territories vis-à-vis national states. The objective was summarized during the most

[200] Interview with Gerardo Bazan, WEC-Mexico, July 2010

recent C40 meeting in Seoul by the formula "Engage, Empower and Resources", which calls for clear and quantified commitments with a timetable for delivery; additional power and competencies for cities to increase their capacity to act; and substantial financial resources

The current post-Kyoto negotiation is crystallizing these three processes and there are now multiple city and/or urban region networks that are lobbying for an acknowledgement of the role of local governments in achieving stringent CO_2 emissions reduction, within a post-2012 climate-change agreement. Regarding climate-change negotiation, these networks essentially advocate three objectives:

- To be recognized: international acknowledgement of the critical role of local governments in achieving stringent CO_2 emissions reduction
- To have a seat at the decision-making table: their participation (or consultation) in climate-related policy design
- To be supported in their actions: the deployment of a set of policies and instruments to support their efforts (e.g., capacity building, carbon finance, technology transfer, etc.).

Regarding cities, in the post-2012 perspective, there is a unanimous call for change in the design of carbon markets. Many important opportunities for buildings and transportation emissions reductions do not easily fit into individual CDM approaches. Various propositions are under discussion:

- Sectoral, policy-based approaches crediting new green policies or standards enforcement: a sectoral approach would not reduce methodological difficulties. Its advantages are rather that it enables activities to be scaled up to a level equal to the challenges faced in redirecting transportation into a more sustainable direction.
- A city commitment could reduce GHG emissions along with "No Lose Target" approaches.
- A register could provide a list of National Appropriate Mitigation Actions (NAMAs) for cities and/or the building or urban transportation sectors.
- GEF and ODA could be integrated into CDM funding, notably to finance transaction costs, to fund capacity-building activities, and generate data.

The three first points are discussed below.

In brief, the idea is that a broader and flexible approach (based on a bottom-up mechanism definition) would:

- encourage cities to take the lead on GHG emissions reduction strategies (financial and electoral motivations);
- provide incentives to act not only for the short term (easily achievable targets), but also for the long term, and thus change the urban development trajectory; and

- simultaneously, leave unchanged the ability of cities to create and implement solutions that are relevant and acceptable to local specificities (for example, land-use policies that increase density in the CBD, or transport policies that modify relative prices of different transport modes.)

5.4.4 Conclusions

Where funding sources for local climate governance do exist, they should be transparent and easy to access. But Fleming and Weber find that this is not the case in the United Kingdom: *"There are a wide variety of different bodies and funding sources […]. The combination of different bodies, funding streams and changes in names presents a very complicated and confusing framework from within which local and regional energy management activities take place"*.[201]

Ambitious policies are costly: in most cases, they imply large substitution of technical capital for fossil fuels and /or unskilled labour. Furthermore, they require a complementary, as big if not bigger, investment in human and social capital, if the best tailored technical solutions are not to fail. As indicated above, the ability to invest is therefore a strong constraint. Studies have that there is a great potential for emissions reduction at negative cost. However, such a claim tends to neglect the transactions costs and the investments in social and human capital needed to achieve the required institutional changes.

From this point of view, it would be fair to differentiate the burden between poor, emerging, and rich cities, and ask less of poorer cities. For example, it is possible that urban governments in developing countries could be asked to choose Bus Rapid Transit (BRT) over metro systems, since the former emit more, but are much less capital intensive. There are a number of possible ways to increase the funds available to a municipality, particularly in the South, e.g., by increasing the land and property taxes in a progressive way, or taxing the capital gains on land and building streaming from public investments and regulation changes. However, both imply the setting up of a minimal land registry and monitoring of the property market. Carbon finance sells emissions rights to parties in the North, benefitting future North–South transfers aimed at lowering the cost of curbing emissions and at "sharing responsibilities".

While the idea of charging users the full cost of urban services continues to receive attention, the dilemma about how and whether to implement tariffs and subsidies is still pending. The main idea of the 1990s—that the customer must pay the full cost of the urban services—has proved difficult to implement. It is now clear that services for the poor will have to be subsidized for a long period of time (if not by the OPEXs, at least by part of the CAPEXs), if cities seek to increase the access rates. In theory, these subsidies should take the form of budgetary transfers to the poorest, the market price being set at full cost in order to deliver the right economic signal. These kinds of transfers are difficult to implement, and subsidizing the energy prices themselves, for the rich as well as for

[201] Fleming and Webber, 2004, p. 765.

the poor, remains a widespread policy in developing countries.

5.5 Tools

A number of tools exist that can assist local authorities in tackling the transversal policy challenges posed by energy use and GHG emissions. This section will explore: i) the fundamental importance of GHG emissions inventories in the policy-making, implementation and evaluation processes; and ii) the conception, elaboration and implementation of local-level climate action plans, looking at how these documents serve to tie together the full range of policies and approaches that are needed.

5.5.1 GHG Inventories

To help cities harness their full potential for reducing carbon emissions, there is an urgent need to establish harmonized methodologies for creating carbon emissions inventories, alongside standardized "measurable, reportable and verifiable" (MRV) procedures, at least in terms of a core set of parameters. This is a condition for both designing and implementing actions that can involve businesses in accessing international climate instruments.

GHG inventories are important tools in the development, implementation, and evaluation of policies designed to reduce GHG emissions at all levels of government and within the private sector. Historically, inventory tools have been developed primarily for use by both national governments (within or around the commitment made through the UNFCCC climate negations and the Kyoto Protocol), and corporate actors. A relatively recent process of "territorialisation" of climate-change policy, which brings an increasing emphasis to the role of cities in GHG mitigation, has made the question of local-level inventories increasingly relevant. To date, no single methodology has been adopted by a large enough number of cities to give it dominance. In most cases, local authorities have taken an *ad hoc* approach to the establishment of what to include in terms of gases, scopes and geographical/jurisdictional boundaries, their choices often simply depending on the availability of data.

Uses of local-level GHG inventories

Among a wide range of possible uses of GHG inventories, two principal categories can be identified: i) internal uses by the local authority; and ii) external uses, either by the entity itself or other actors or institutions. External uses can be further sub-divided into voluntary and compulsory uses. These are all discussed below. In practice, emissions data are often used for a number of purposes and do not have a single use.

Internal use

GHG emissions inventories, when appropriately calibrated can be powerful tools for local authorities. They can be used for two basic purposes:

- *Setting a baseline and planning mitigation policies*

Inventories established for the purpose of establishing an emissions baseline for a project, a city government, or a territory are used principally for identifying opportunities for emissions reductions. These inventories function as a snapshot of current emissions, disaggregated by a given set of criteria (usually corresponding to the IPCC sectors). This information can be used at the city level to identify cost-effective actions, as the marginal cost of abatement can be compared across different policies and sectors. As such, it is important that these inventories are comprehensive in order to fully understand the complete emissions profile and thus the full range of measures available.

- *Indicators of policy progress*

  Inventories developed for policy evaluation focus primarily on tracking the progress of policies that have been put into place. While it is often difficult to establish direct links between many mitigation policies and total emissions reductions, a tracking inventory can be used more generally in evaluating the effectiveness of emissions reduction investments and actions.202 A tracking-based inventory would collect emissions data from the specific emissions sources and sectors upon which the local authority has chosen to focus, attempting to evaluate progress towards mitigation goals and, if possible, relate this to specific policy measures.

[202] It is difficult to track the direct effects of many policy instruments to reduce GHG emission as they will often be one factor among many influencing both the GHG intensity of certain activities as well as the frequency with which the activity is performed. While it is possible accurately to quantify the GHG reductions from, for example, the retrofitting of public buildings using physical data, it is more difficult to calculate the impact of improved financing options for renewable technology deployment over an entire territory.

External use

Local-scale emissions inventories can be used externally for voluntary comparative or compulsory reporting purposes, regionally, nationally, or even internationally. While serving different purposes, these types of inventories share a number of methodological requirements: both require a high level of homogeneity in how they are conducted (inclusion of scopes and sectors, quantification) and in the data reporting framework.

Voluntary uses

The comparison of GHG inventories across local areas is an important means of information sharing, creating opportunities for collaboration and sharing. Comparisons allow cities to compare results and cost-effectiveness of emissions reductions at the sector level. Local authorities can also use these comparisons to rank themselves with other urban areas with similar characteristics, for example wealth, population, or average climate, etc., and to understand how and why major changes in emissions occur over time.[203]

Compulsory uses

Compulsory uses of GHG inventories are those where, either through voluntary “opting-in” or mandatory participation, local authorities must follow specific prescriptive guidelines. Two broad

[203] Corfee-Morlot *et al.*, 2009

categories of compulsory uses exist: national-government programs, and access to carbon-finance. In the first case, whether in the interest of territorializing national GHG-reduction commitments or in as a basis for assistance subsidies, local-scale inventories are a key tool for relevant national agencies to track and assist sub-national mitigation progress. When implemented widely, they can be used to understand how different national-level policies influence local GHG emissions, and to target promising mitigation actions for financing and to track progress. In the second case, inventories, and, more generally, accurate data on baseline emissions and mitigation potential, are key elements for access to project financing through carbon finance via both formal mechanisms, such as domestic offset projects through the Kyoto JI mechanism, or through structured voluntary markets.

One indicator among many

While GHG inventories are an important tool in the planning, tracking, and evaluation of both mitigation and other policies implemented by local authorities, it is only a single indicator among many that are weighed during the policymaking process. Moreover, due to the difficulty of placing a financial value on emissions reductions, there is still much work to be done on how to integrate GHG inventories into local-level policymaking processes that may often be driven by traditional cost-benefit analyses.

5.5.2 Climate Action Plans

The increasingly widespread development and adoption of climate action plans by local authorities indicates that they are becoming an increasingly accepted method of coordinating energy and climate policies. Nevertheless there is little harmonization in terms of what these plans cover, how different actions are detailed and presented, what kind of statistical information is available, etc.

Typically, climate action plans attempt to bring together the disparate policy measures and packages that function alongside one another to reduce GHG emissions and coordinate them into a long-term planning framework. Climate action plans must both put forward short-term incremental changes and address long-term systemic issues that can foster a transition to alternative, low-emission development pathways. These plans must be coordinated and integrated with other planning tools and mechanisms (e.g., urban and regional master plans, transport planning, social housing, and electricity generation and distribution networks, etc.).

In general terms, two large groupings of climate action plans can be identified. In the first group, climate change is treated as a distinct policy question, often separate from other economic and social objectives. These plans can address either the emissions stemming directly from city operations and/or those from the larger urban area. A second group of plans factors climate change and energy use into a larger, integrated framework for urban development (Box 20). While the state of research does not allow for a clear indication as to whether one approach is more successful than the other in achieving energy efficiency and emissions reductions, it seems logical that the second approach may be more successful in ensuring that energy and climate concerns are taken into consideration in the majority of decision-making processes surrounding economic and social development.

Box 20: PlaNYC a greener, greater New York[204]

The City of New York released its long-term sustainability plan in 2007. Produced and subsequently implemented by the Office of Long-Term Planning and Sustainability, the plan establishes ten aggressive, yet achievable, objectives to place the city on an economically, socially and environmentally sustainable trajectory for 2030. These objectives range from the creation of affordable housing, to ensuring reliable and clean energy, to the reduction of GHG emissions by 30%. Through the consultation of a panel of locally and internationally renowned experts, as well as an extensive public consultation process, the plan has identified 127 separate initiatives to achieve the ten sustainability objectives. These initiatives cut across traditional sector-based departmental and agency "silos", representing not only a development plan, but also a systemic sustainable strategy for growth.

A number of elements have made this plan a model for others. First, it is the result of in-depth research and analysis performed by a dedicated city agency staff involving extensive coordination and collaboration between agencies. Second, the development and implementation process had a powerful institutional "home" in the Mayor's Office of Long-Term Planning and Sustainability. Third, the external Sustainability Advisory Board provided advice and guidance. Fourth, the development process included a comprehensive public outreach process to assure broad public support. Finally, the plan not only set objectives, but also included a detailed implementation plan with a timeline and milestones; it also identified the financial resources for each initiative, so that action could be taken immediately.

As described above, GHG emissions inventories are an important step in understanding the emissions profiles of an urban area. However, while they may be able to target the sectors within which action should be concentrated, they may not be sufficient to identify the drivers behind the emissions. A number of tools are available to help break down the sources of emissions and identify the specific actions that can be taken to reduce their emissions; Box 21 describes a specific example for the transportation sector.

Box 21: Tools to break-down drivers of carbon emissions

Regarding urban transportation CO_2 emissions, the ASIF framework was developed to identify the drivers of CO_2 emissions due to transportation, and so identify the types of

[204] ICLEI and City of New York, 2010; City of New York, 2007.

project that will reduce these emissions.[205] ASIF describes the four basic components that drive transportation energy consumption and emissions.

- Emissions = [A. Activity (passenger km = trips x km)] X [S. modal structure (% passenger-km)] X [I. fuel Intensity (quantity per Km)] X [F. Fuel mix (emission per quantity)]

It highlights that there are multiple factors influencing each of the ASIF components, with many affecting more than one component.

- A = f [population, demographics (age, gender, etc), income (trip rates and distance tends to rise with income), economy and its composition, urban form and size (spatial distribution of actors), etc.]
- S = f [income (influence value of time and thus demand for speed, comfort and privacy, vehicle ownership, etc.), motorization rate, infrastructure provision (affect the willingness to choose NMT options, availability of certain fixed-transit options, modal attractiveness through effects on reliability), service provision (quality), relative costs (out of-pocket and perceived costs), urban form and size (spatial distribution of actors), etc.]
- I = f [engine type, vehicle load, vehicle age, (government standards), Driving conditions (congestion levels), vehicle occupancy, urban design (street network type), etc.]
- F = f [fuel type (Life Cycle Analysis [1]), engine type, vehicle technology, vehicle age, temperature, altitude, etc.

It allows the identification of the categories of project to tackle each component, but also how policy can have contradictory effects on other components.

- Activity: Land-use planning, tax system, or other financial incentives interfering with location choices, etc.
- Mode Share: Investment in zero/low-carbon transportation modes, inter-modality, etc.
- Fuel Intensity: low-carbon vehicles, ‘feebate’ (fee and rebate), etc.
- Fuel mix: low-carbon fuels

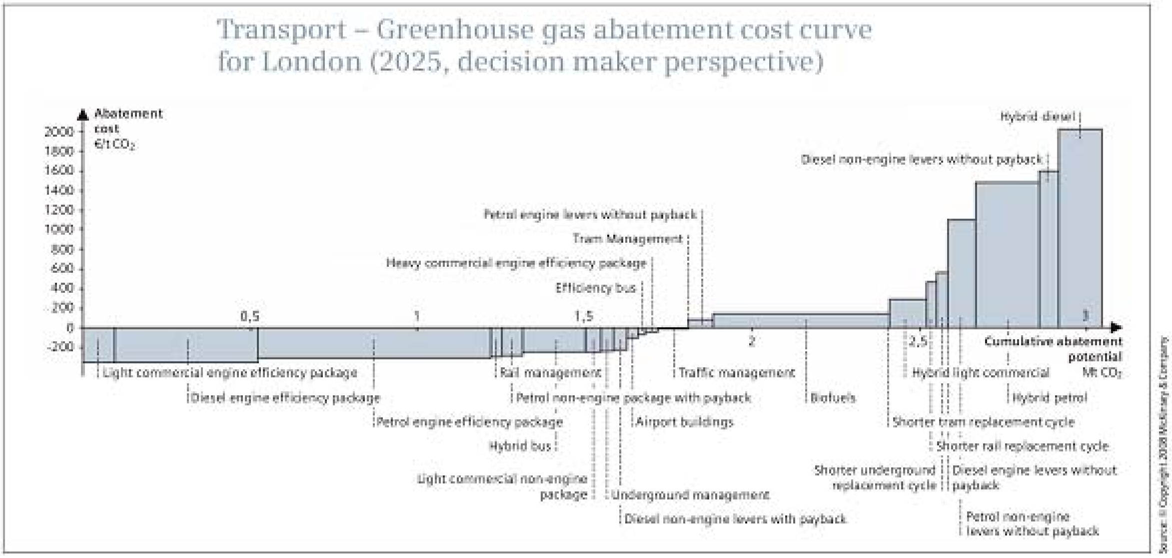
Finally, it highlights the responsibilities and the key role of each stakeholder.

- Activity: local/regional authorities
- Mode share: local/regional authorities, national/European supports
- Fuel intensity: National/European levels, negotiation with car manufacturers,
- Fuel mix: National/European levels, tax policies, agricultural policies, etc.

Other important steps include determining how to prioritize actions, to identify synergies, and to understand the costs of action. Marginal abatement

[205] IEA; Schipper *et al.*, 2001

Figure 50:
Marginal Abatement Cost Curves (MACC) for London transportation sector



cost curves (MACCs), as described in Box 22 can be an important tool for this. Since cities are systems with complex interrelationships and feedback between their multiple elements, a project-based approach is not sufficient to tackle their potential for reducing urban CO_2 emissions. We are facing the challenge of altering trajectories of urban development, so as to move towards sustainable trajectories.

Two conclusions can be drawn from this observation:

- Local climate action plans have to combine consistently incremental changes, such as very low emissions vehicles and buildings, together with systemic innovations in urban design, spatial organization, networks, and transportation systems.
- Therefore, a coherent and systemic approach, addressing both incremental and systemic changes, is needed to tackle the issues of transition in the urban trajectory.

Today, the challenge for the design of cost-effective local climate action plans is to develop the capability of combining the systemic and the incremental approaches within the plans themselves, and even more so when creating MACCs.

Box 22: Marginal abatement cost curves (MACCs)

Marginal abatement cost curves (MACCs) offer an additional planning tool for local authorities targeting their potential to reduce GHG emissions. Until now, the issue of cost-effectiveness has been successfully applied to international negotiations (European Emissions Trading Scheme, EU-ETS) and to national policies. Energy-economy or sectoral energy models have made it possible to simulate different policies and especially to build sets of marginal abatement cost curves. These mechanisms are highly efficient tools for analysing different aspects of climate policies, and helpful for those seeking to reduce global costs through a certain levelling of the marginal costs of sectoral initiatives.

As for the analysis of international negotiations, the development of MACCs for urban situations is certainly one of the simplest and most powerful solutions. They 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.

While a list of actions can be established and prioritized, emphasis should be placed on the engagement of the full range of actors and stakeholders in the consultation and elaboration process. As the reduction of GHG emissions is a transversal policy issue, it requires the cooperation of actors both within government and from the private sector. Their engagement in development and elaboration processes, as well as the use of mechanisms to formalize their involvement in the implementation (e.g., voluntary or binding contractual engagements, yearly forums, etc.), can significantly aid implementation. Buy-in by the full range of actors is essential to success.

An analysis of the brief experience of early adopters of such plans indicates several interrelated issues that require further consideration.[206] First, local authorities have technical difficulties defining quantified targets, measuring the outcomes of their actions and determining their priorities for action accordingly. Second, since most policies serve multiple objectives and functions, they are not ideal for identifying which actions to include in the framework of climate action plan. Thus, estimating the budget required to cover action plan activities represents a major challenge. Third, putting in place and activating a climate action plan requires important human and financial resources, which local authorities usually do not have. Finally, mitigating emissions at the local level inevitably implies urban planning tools that properly address climate and energy issues. Changes, notably in master plans and transport plans, are therefore necessary to incorporate the objectives of climate action plan coherently, and to deliver their goals.

5.6 Conclusion: From Strategic Planning to Local Implementation

The fact that the operational definition of sustainable urban development is not yet universally agreed means that it remains problematic to adjust urban planning, governance and finance to meet such objectives. Therefore, our analysis is limited by the very modest record of relevant literature and concrete practical experience.

However, several general lessons can be drawn from this analysis, which focus on how different challenges stemming from the concept of sustainability impact upon urban governance and finance practices:

- One important concept, not new but strongly reinforced by the challenges of sustainability, is that the funding and financing of urban policies is deeply connected with their design and implementation. Therefore, these too-often separated issues should be analysed and elaborated according to a coherent common framework. Particularly difficult challenges arising from the requirements of sustainability will not be tackled by the marginal adoption of several instruments. A more global and integrated approach, dealing simultaneously with urban planning and finance, is needed.

[206] Yalcin, Lefèvre, 2009.

- Given the trends of urban development around the world, the challenges of urban sustainability require strong public intervention, characterized by a flexible and strategic approach to urban planning and finance, which aims to frame market dynamics so that they move forward on a sustainable urban development pathway.
- The critical questions are when and how to intervene. Public intervention is particularly challenging because of two recent developments: first, the shift from urban government to urban governance and, so, the need to take into account a plurality of public and private stakeholders with different values; and, secondly, the strength of market forces in urban dynamics.

The frequent complexity, plurality and volatility of the objectives of urban policies or financial practices is particularly critical for tax systems, which have a complexity and plurality of objectives that often lead to instability and difficulty with efficiency assessment. We should thus keep in mind, a slightly adapted version of the acronym "KISS", (keep it simple *and stable*). According to this, two important features of a tax system should be its simplicity, making it understandable to taxpayers, and its stability, to enable the evaluation of a tax according to its main objectives.

As sustainable urban policies and measures, such as climate policies, would only be a piece of a broader set of incentives and financial instruments, building a coherent framework remains the big issue. Indeed, staying with the example of climate policies, one crucial challenge to climate-change mitigation is to coordinate climate policies with other fields of public action, at both the local level (e.g., land-use planning, transport planning, energy deployment, etc.) and national and international levels (e.g., energy policies, industrial policies, recovery plans, regional policies, etc.). Without doubt, to be effective, sustainable policies targeting cities must be part of a coherent policy framework, whose components are designed at the local, national and international levels.

Another key idea drawn from our analysis is that it appears crucial to strengthen both the role of local planning and the relationship between strategic planning and short- term planning. City planning has displayed two main developments in recent decades: The first has been an increasing flexibility in short-term planning, with a key role for negotiation. This development has positive aspects, especially in a rapidly changing economic context. It can however lose its main value when the regulations are constantly under negotiation, which is possibly in contradiction with the very purpose of planning. The second is the appearance of a large gap between strategic long-term planning and short-term planning and zoning.

These two trends together raise serious problems in terms of sustainability, where the challenges are both long-term objectives, and at the same time, comprise the paths that must be taken to reach such objectives. Strengthening both the role of local planning and the relationships between strategic and short-term planning may help to achieve the integration of the objectives of sustainable development into city management.

Last but not least, our analysis shows that the existing toolbox is already well supplied with the relevant instruments and practices for effective strategic planning. Therefore, rather than looking for new instruments, efforts would be better dedicated to assessing the relevance of these existing tools, identifying conditions of successful implementation, and promoting their usage.

Chapter 6: Key Points and Important Messages

6.1 Facts and Challenges

- **Urbanization is a strong trend and can be positive.**
  - Rapid urbanization of the world population will be a widespread and strong trend during the coming decades, as i) people generally prefer to be "poor" in a city slum than in a remote rural area, since a city can provide more economic opportunities; and ii) urbanization can also be used to promote better health and education, if well managed.
  - Although living conditions in rural areas can be improved through appropriate public policies, there is no *a priori* reason to prevent migration to cities. The real challenge is to make cities "work for all", particularly for the poorest residents.
- **Mega-cities are paradigmatic of energy-related urban challenges.**
  - Most of the urban population does not live in mega-cities, but in smaller cities. However, in the past decade, there has been a considerable growth in the number and size of mega-cities, mainly in Asia and Africa.
  - Mega-cities are the most visible part of the urbanizing world. They concentrate a large part of the national population (e.g., Latin America) and contribute disproportionably to national and world economies.
  - Mega-cities are often better armed to meet sustainability challenges, but also face specific obstacles due to their size, which may present institutional, and governance problems, de-economies of scale, etc.
  - Many of the technical and institutional solutions implemented in mega-cities can be feasible in smaller cities.
- **Data at city level are still problematic.**
  - Data on population, surfaces, and density, energy consumption and GHG emissions, and energy poverty are of varying quality and are built with different parameters and methodologies. This renders accurate comparisons and benchmarking between cities difficult.
  - There is thus a need for standardised accounting methods of urban energy consumption and GHG emissions. However, defining energy poverty is highly political and is usually left to national governments.
- **All the large and mega-cities in the world share huge sustainability challenges.**
  - Even with no anthropogenic climate change, a number of energy-related sustainability challenges remain:
    - Bringing good quality urban services to all;
    - Tackling energy poverty; and
    - Curbing local pollutions

- Mitigating climate change adds another significant challenge to mega-cities and smaller cities alike. Moreover, while not treated in this report, cities (particularly those in coastal areas, and others already facing water scarcity) must prepare to adapt to the impacts of climatic change.

- **Specific challenges arise from specific circumstances.**
  - The three, energy-related sustainability challenges are much more significant for the rapidly growing cities of the emerging and developing world.
  - As for reducing GHG emissions, different circumstances require diverse measures:
    - i. In the South, control urban growth: limit urban sprawl, so that cities remain dense and mixed; refrain from a widespread use of private vehicles; organize efficient mass transportation networks; set and implement stringent norms in new buildings.
    - ii. In the North, change policies to: reshape the cities; stop urban sprawl and make the suburbs denser; reduce dependence on private motor vehicles; retrofit existing buildings; promote a more systemic approach to energy networks (e.g., energy cascading, etc.)

6.2 Technical Solutions

This report focuses on those energy technologies aimed at improving the sustainability of mega-cities and smaller cities. Many of these technologies are on the demand side.

- **Existing technologies**
  - There are many technological solutions that are already technically mature, i.e., their costs are documented in different contexts.
  - Costs may still decrease through incremental innovation and economies of scale due to widespread adoption, but breakthrough innovations are not expected.
  - The main mature technologies are:
    - Buildings: heat pumps, insulation, high efficiency gas boilers, etc.
    - Transport: BRT, metro, tramway, hybrid cars, etc.
    - Energy: energy from waste recycling, combined heat and power, PV (PV costs still need to decrease)
- **Costs of existing technologies**
  - The costs, potentials, and conditions of deployment of existing technically mature technologies vary widely according to the national and local context. There is thus no single “best solution” that will fit each city: it is

important to be cautious about simply trying to replicate best practices in a different context.

– Adequate technical solutions depend on: building stock, climate, urban shape, cultural behaviours, dynamic effects, and financial capacity.

- **Sustainability of technologies**

  – Sustainability has multiple dimensions, including social, economic and welfare, and environmental. There are frequent trade-offs between dimensions, as well as conflicts within them. Bus occupancy rates offer an example: if the occupancy rate is very high in peak hours, it is good for curbing pollution, but less good for passenger comfort, and for the use of buses by middle-class car owners. During low-demand hours, maintaining bus services improves the mobility of poor people, but leads to a low occupancy rate, thus raising the rate of emissions per passenger-km.

  – Technology alone is not enough to improve all the sustainability dimensions of, for example, a transportation system: urban planning and combined policies are always required.

- **Efficiency of technologies**

  The efficiency of technologies remains heavily dependent on use and behaviour, and therefore on policies (e.g., norms, incentives, information, education) influencing them. For example:

  – Hybrid cars with an occupancy rate of 1.3 (the average for Paris) still lead to congestion and significant emissions.

  – Efficiency in buildings is dependent on household behaviour, for example, for heating and cooling levels. “Rebound effects” also have to be taken into account. For example: better insulation can lead to households seeking higher comfort, thus reducing any initial efficiency gains.

- **Technology adoption: a big challenge**

  – Economic maturity (i.e., profitability for the adopter according to existing regulations and fuel prices) is never enough for a sustainable technology to be widely and rapidly adopted. Difficulties in adoption are rooted in immature and imperfect markets (e.g., workforce education, absence of competition between firms), transaction costs, and coordination problems and lack of planning.

  – Institutional innovations to support the adoption of existing economically mature technologies (e.g., coordination of actors, education, market transformation, investment mechanisms, financing schemes, etc.) are therefore as important as purely technical innovation efforts.

- **Research and development is still needed**

  – We already know what a very low-carbon city could look like: an “electric” and “wired” city, using a very low-carbon electricity (and later possibly hydrogen), relying on biofuels for the remaining liquid fuels. Further characteristics might include:

- Transport: dense and mixed city, electrified mass transportation systems, electric or bio fuelled personal vehicles, lots of cycling and walking
- Buildings: highly insulated and using heat pumps
- Urban energy system: maximum use of local renewables (although solar and wind limited in dense cities) and energy cascading
- IT to monitor energy use and economic activity in the city

– Research and development is needed to lower the cost and enhance the social acceptability of “urban” energy technologies.

– Breakthrough technical innovations are needed in sustainable energy supply, particularly in the “greening” of electricity generation. But this is not a specifically “urban” problem.

- **Technologies still needing industrial development**

  Bearing in mind that the discussion has covered only “urban” technologies:

  – The substitution of gas or fuel boilers with high temperature heat pumps has a significant potential to decrease costs and improve performance, leading to widespread use.

  – Better insulation products, including high-performance, “thin” products that can be easily installed in houses, are needed

  – PV will continue to benefit from cost reductions due to the effects of scale

  – Standardization of technologies is an essential industrial issue.

  – As far as electric vehicles are concerned, CO_2 reductions depend on the local energy mix. A number of questions remain open:

    - Rechargeable hybrid and/or “fully” electric?
    - New business model for plug-in and/or recharge infrastructures?
    - Car batteries and plug-in infrastructure are still expensive but can benefit from cost reductions due to scale effects.
    - Cars batteries could help with intermittent energy sources.

- **Most promising research topics**

  Bearing in mind that this discussion has focused only on “urban” technologies:

  – Electricity storage: if it becomes affordable, would greatly alleviate many problems, including integration of renewables, continuity of supply, and reduction of peak load.

– Socio-economic research to improve urban planning and policies: this could help policymakers better understand how individuals behave, how markets function, and policy efficiency.

6.3 Policies

- **There is no "ideal" city shape, but density thresholds do exist.**
  - There is no ideal shape, density and mix for a city.
  - The challenge is dynamic: shaping the rapid growth of cities in emerging countries and reshaping existing "rich" cities. For example, there are robust density thresholds (50-150 inhabitants/ha), below which mass transportation systems are not economically feasible.
- **Market forces and urban planning are important.**
  - It is important to take account of the strength of market forces on land and building markets, as well as on the city labour market and the urban services markets.
  - Urban planning at the appropriate level remains an absolute necessity.
- **There is a case for action at the city level.**
  - Providing energy to all, combating energy poverty, curbing GHG emissions and local energy-related pollution does not only depend on municipal and local policies.
  - For example, the London Climate Action Plan estimates that the required 60% reduction target will be met by the Greater London Authority; (15% of requirement); the London boroughs (5-10%); London companies and public sector organizations (35-40%); Londoners (5-10%); and national government (30%).
  - Local authorities are often best placed to overcome institutional and organisational barriers to the adoption of sustainable technologies and behaviour. Therefore, in a number of cases, it might be efficient to give more power to local authorities
- **Policies are always packages of measures.**
  - It is not enough for technically and economically mature solutions to be available "off-the-shelf".
  - Policy action plans are always a complex package of public investment, private investment, and technical, institutional (to coordinate different types of actors), regulatory, and financial measures.
  - Regulations must always be combined with incentives, information, and other actions aimed at improving market efficiency. Three examples include:

i. **Combating energy poverty**
Tackling energy poverty while diminishing impacts on the environment is possible:

- In the South: giving access to modern fuels to illegal settlement will allow them to shift from less efficient fuels and improve health. Those efficiency gains are also good for curbing GHG emissions.
- In the North: instituting energy efficient policies in old buildings can both reduce energy poverty and energy consumption

Both of them require innovations and adaptation in policy implementation and technical standards:

- In the South: payment options, types of electric installations, stakeholders involved
- In the North: introduction of third-party finance

ii. **Mass transportation infrastructure**

- Mass transportation infrastructure policies and land-use policies have to be coordinated in order to increase density along mass transportation lines and avoid urban sprawl at the ends of lines.
- They also require the management of vested interests of every size, for example, private buses, taxis and rickshaws.
- They are all the more efficient if they take care of interconnectivity, favour the use of walking and cycling to connect to mass transportation and discourage the use of personal vehicles.

iii. **Buildings efficiency**

- Significant energy savings can be economically (i.e., with current available technologies and fossil fuels prices) achieved in old and new buildings. However, uncertainty in terms of cost savings, split incentives between developers, owners and lenders, and market limitations pose major barriers to ambitious efficiency policies.
- Addressing energy use in buildings requires policy packages that treat the multiple facets of the policy challenge: investment, regulations, network services, private-sector training, and financial arrangements.
- The existing building stock in urban areas worldwide is, in general, turning over at a slow rate (less than 1% in France). The majority of energy reductions will be found in renovating existing commercial and housing stock.
- Market imperfections, such as limited access to credit and information asymmetries, in addition to the different transaction costs encountered, can limit improvements

in widespread efficiency. These barriers place limits on local authorities as well as on private citizens and companies.

   - Third-party investment is a financial mechanism that allows a property owner to secure up-front financing for renovations that improve energy efficiency. It holds substantial promise for accelerating the renovation of the existing building stock.

- **Multilevel governance of energy**
  - Since providing energy to all, combating energy poverty, curbing GHG emissions and local, energy-related pollutions do not only depend on municipal and local policies; coherence across levels of government is required, with a clear distribution of tasks.
  - Before defining local policies, an assessment of the jurisdictional capacity to act of local authorities is needed, followed by a shift of capacity to act towards the most appropriate policy level, if necessary. At the very least, a clarification of the responsibility among actors for each topic is needed.
- **Jurisdiction and cooperation**
  - In many cases, cities should be allowed increased jurisdictional capacity to act on a number of energy-based issues; in particular, they should be given the power to experiment.
  - Everywhere, cities must strongly improve their capacity for coordination, including internal coordination among municipal services; coordination between adjacent municipalities; and public private partnerships.
- **The role of PPPs is crucial in designing and implementing efficient solutions.**
  - The main outcome of a PPP is transferral of technologies and management efficiency to public services or dispersed small private businesses, wherever they are inefficient. PPPs also allow the leveraging of private-sector capital
  - However, even if they can greatly help, they generally cannot by themselves solve the financing problems of extending basic services to the poor, and curbing the GHG emissions; public money is still needed.
  - In any case, PPPs require the setting-up of independent regulatory authorities and substantial investment in social and human capital within the public administration.
- **Ambitious policies can be costly.**
  - In most cases, policies imply large substitutions of technical capital for fossil fuels and/or unskilled labour, plus a complementary (as big if not higher) investment in human and social capital; without these, the best tailored technical solutions will fail.

– The ability to invest is therefore a strong constraint, contrary to the claim that there is in all cases great potential for emissions reduction, with negative cost (see for example Figure 50). Such a claim tends to neglect the transactions costs and the investments in social and human capital needed to achieve the required institutional changes.

– From this point of view, it would be fair to differentiate the burden between poor, emerging, and rich cities, and ask less of poorer cities. For example, it is possible that urban governments in developing countries could be asked to choose Bus Rapid Transit (BRT) over metro systems, since the former are much less capital intensive, although their emissions totals are higher.

- **Ways to increase the funds available to a municipality, particularly in the South:**
  – Increase the land and properties taxes in a progressive way.
  – Tax the capital gains on land and buildings, streaming from public investments and regulation changes (both implies the setting-up of a minimal land registry and monitoring of the property market).
  – Use carbon finance, both in order to sell emissions rights to parties in the North, and, more generally, to benefit from future North-South transfers aimed at lowering the cost of curbing emissions and sharing responsibilities.
  – Charge users the full cost of urban services (albeit in a progressive way, as above)
- **The question about whether to use tariffs or subsidies is still unanswered.**
  – The main idea of the 1990s, that the customer must pay the full cost of urban services has proved difficult to implement in the first decade of the 21st century.
  – It is now clear that services for the poor will have to be subsidized for a long period of time (if not the OPEXs, at least part of the CAPEXs), if access rates are to rise.
  – In theory, these subsidies should take the form of budgetary transfers to the poorest, the market price being set at full cost in order to deliver the right economic signal.
  – But transfers of this kind are difficult to implement, and subsidizing energy prices themselves, for rich as well as for poor, remains a widespread policy in developing countries.
- **There is a basic policy tool-box already available for cities.**
  – The setting-up of a commonly accepted system of measuring GHG is necessary for:
    - Allocating scarce funds efficiently
    - Benchmarking and record tracking

- Using carbon finance if opportunities appear

- “Robust” climate action plans are necessary for:
  - Long-term planning
  - Prioritizing actions according to cost-benefits analysis
  - Burden-sharing
  - Coordination among actors

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Annex 1

The complete case studies can be found under the below listed links:

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