URBAN AGE

ELECTRIC CITY

CONFERENCE

CONTENTS

FOREWORD 1
Ricky Burdett and Wolfgang Nowak

THE ELECTRIC CITY 2
Ricky Burdett and Philipp Rode

ELECTRICITY: A THING AND AN IDEA 4
Deyan Sudjic

GLOBAL PROBLEMS: CITY SOLUTIONS 5
Philipp Rode, Nick Stern and Dimitri Zenghelis

THE BENEFITS OF DENSITY 6
Edward Glaeser

AFTER THE CAR 9
John Urry

U.S. METROS AND THE GREEN ECONOMY 10
Bruce Katz

LONDON'S TECH-CITY 11
Max Nathan

URBANISING TECHNOLOGY 12
Saskia Sassen

THE SOCIAL NEXUS 15
Carlo Ratti and Anthony Townsend

THE STUPEFYING SMART CITY 16
Richard Sennett

SKEWING THE CITY 18
Nerea Calvillo, Orit Halpern, Jesse LeCavalier and Wolfgang Pietsch - The Milgram Group

DIGITAL COLLABORATION 19
Dan Hill

ENERGETIC SOCIETY 22
Maarten Hajer and Hiddo Huitzing

THE POLITICS OF CLIMATE CHANGE 23
Anthony Giddens

DATA

GEOGRAPHY OF ENERGY CONSUMPTION 26

ENERGY, ELECTRICITY AND EMISSIONS 28

CITIES AND THE GREEN TRANSITION 30

URBAN AGE CITIES 32

PATTERNS OF CHANGE 34

COMPARING CITIES 36

RESIDENTIAL/EMPLOYMENT DENSITY 38

MAPPING ACCESSIBILITY PATTERNS OF TRAVEL 40

CHANGING LONDON 42

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URBAN AGE

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FOREWORD

In 1879 Thomas Edison invented the light bulb and built the first power station in Pearl Street in Manhattan in 1882, while the German inventor Werner von Siemens installed the first electric elevator in Mannheim in 1880. Since then, electricity has powered – directly or indirectly – the shape and dynamics of urban life. In cities of the developed world, we take for granted that electricity feeds the complex systems which sustain and sometimes spectacularly fail us. In emerging cities of the developing world, a light bulb is still embraced as a symbol of civilisation by some, while others celebrate their urbanity in a visual cacophony of neon. The Electric City is, in many ways, the crucible of patterns of production, consumption and pollution of the 21st century 'urban age' as cities struggle with their impact on the social and environmental well-being of the planet.

After having tackled the urban economy, health and well-being, violence, security, social inclusion and design at conferences held in – amongst others – Hong Kong, Chicago, New York, São Paulo and Johannesburg, the Urban Age returns to London for its eleventh conference since 2005. We turn our attention to the challenges and responsibilities faced by cities in the digital age as Climate Change and economic pressures continue to define our everyday urban realities. Since its inception, the Urban Age has studied the spatial and social dynamics of over 30 cities in the developed and developing world, collaborated with over 40 academic institutions and municipal authorities and been attended by over 5,000 speakers and participants from urban design, policymaking, research and practice.

In London we welcome over 60 speakers from 30 cities in 15 countries across four continents who take part in the two-day Urban Age Electric City conference in the aptly named Shoreditch Electric Light Station in central London – a building that in its own history reflects the connections between power and the city. It opened as an electricity generating station in 1896 to burn rubbish, giving steam for generating electricity with the waste used to heat public baths next door.
The motto above the door is 'E Pulvere Lux Et Vis, or 'Out Of The Dust, Light And Power', reflecting a trajectory of sustainable resilience that parallels the themes and issues debated by the protagonists of the Urban Age.

Ricky Burdett, *Director, LSE Cities, London School of Economics*
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THE ELECTRIC CITY

Ricky Burdett and Philipp Rode

This Urban Age newspaper revisits the notion of the 'Electric City', offering a critical reflection on contemporary innovations in urban infrastructures and technologies as we become more aware of environmental challenges and the threats of Climate Change. For over a decade, our research at LSE Cities has focused on the relationship between the physical and social dimensions of cities. Now, we have turned our attention to the digital and ecological age, to better understand how its technologies and infrastructures – powered by electricity – are transforming our urban futures, at a social and environmental level.

Electricity shaped the architecture of cities at the turn of the last century. Arc lighting, elevators and trams revolutionised the urban landscape and habits of many western cities as they expanded rapidly to absorb urban migrants. Electricity completely transformed cities and urban lifestyles, especially in public transport. The widespread introduction of petrol-based vehicles in the post-World War II era cities led to a reconfiguration of the urban landscape. Yet today, electric power continues to fuel the massive expansion in public utilities, transport, domestic appliances and modern commodities that characterise the 'urban age' where cities consume over 60 per cent of world's energy and contribute to nearly 80 per cent of global CO_2 emissions.

Skyscrapers and suburbs, commuting and sprawl, ghettos and CBDs have all followed on from these past waves of technological innovation. Cities have grown taller and fatter in the space of a few generations. Property values have gone up and slums have been created. Commuting times have escalated in some cities while others have rediscovered the efficiencies of the compact city, building on the synergies of increased proximity and more efficient public transport.

Today, electricity is re-emerging as a common denominator of a new technological revolution as unprecedented advances in information and communication systems are matched by radical innovation in green energy technologies and infrastructures. Much of this pervasive innovation nexus of power and information is, and will continue to be, centred in cities. Smart grid technology and the internet of things, battery-powered vehicles and shared urban mobility, GPS enabled apps for smart phones and integrated mobility services, online retail and virtual consumption, digital collaboration and e-governance are already part of our everyday urban experiences.

The more electricity generation is based on renewables – such as solar, wind and bio-fuels – the more electrification can deliver the greening of energy systems and cities. Electric mobility, electrically-powered gadgets and systems, and even electric heating and cooling can help make cities more environmentally balanced, offering more than just cleaner energy. Today innovation can be found both in the public sector and in private companies. Cities like Berlin, Paris and San Francisco have been proactive in leading on this transition by combining e-mobility with car-sharing. BMW, Peugeot and Toyota are re-inventing engineering paradigms for cars, concentrating on compact, light, and energy efficient electric vehicles as part of multi-modal provision of mobility in cities. Utility companies are beginning to use electric vehicles to store renewable energy that needs to be taken off the grid during peak loads.

But, as the visionary British architect Cedric Price noted over 40 years ago 'Technology is the answer. But what is the question?' The Urban Age Electric City conference has been designed to re-formulate these questions and initiate a new line of research that addresses the wider social, political and cultural impacts of the new technologies.

Some of the results of this research are presented in the Data Section on pages 25-43 of this newspaper. It includes an overview of the global geography of energy consumption and explores where and how electricity is generated and where CO_2 emissions are most prominent in different regions of the world. The section goes on to investigate the physical structure, governance arrangements and environmental performance of twelve case studies, adding to the accumulated knowledge of Urban Age cities fresh evidence form six 'green pioneers' like Copenhagen, Portland and Bogota.

These cities, alongside Singapore, Hong Kong, Stockholm, New York and Berlin have made a step-change in sustainable and policies practice, often led by visionary mayors and an enlightened electorate. We also take a closer look at how London and its directly elected mayors have performed, after a decade of effective metropolitan governance, noting that residential waste and car ownership have dropped substantially, while fossil-fuel dependency, air pollution and per capita levels of consumption remain unacceptably high.

In parallel to this quantitative overview, we engage with some of the more profound sociological, cultural and political questions of the electric urban age though essays and provocations included in this newspaper and the conference itself. Architectural and urban critic Deyan Sudjic defines electricity as both an idea and a thing. It has theoretical and practical implications. It is the combination of the two which has resulted in a particularly strong impact on cities. As such, electricity is an invisible technology but its physical manifestations as basic innovations are easy to detect. History, can help us since, in some ways, we have been there before. The impact of basic innovations on cities is omnipresent, a theme elaborated by Climate Change economist Nick Stern and his colleagues, who argue that cities have both increased their appetite for consumption but also been at the vanguard of sustainable solutions which 'decouple higher living standards and increasing resource consumption.'

Author of *Triumph of the City* Ed Glaeser picks up the baton on relating form to environmental performance, highlighting the economic and environmental benefits of higher densities of city living and working as a prerequisite of urban sustainability. He critiques the US model of profligate car-dependency and urban sprawl, urging emerging countries like India and China to take note that much can be achieved by tight and visionary urban leadership and the adoption of the compact city model. Bruce Katz turns the spotlight onto the green economy and jobs, highlighting research from the Brookings Institution that identifies the potential of the green economy for the renaissance of US metros, a theme that is echoed by Max Nathan analysis of London's growing digital economy sector and the dynamism of the Tech-city initiative.

Sociologist John Urry reminds us of the difficulty to predict potential development pathways particularly when technology is disruptive with respect to existing practices. Instead, he offers four scenarios of what a potential future might be 'after the car', informed by our acceptance of electric hypermobility. Saskia Sassen analyses the effects of such rapid transitions and the effect that technologies have on urban space. She both endorses the effects but recognises the limits of intelligent systems in cities, arguing that the next phase of technological development is charged with negative social potentials where we could slide 'into a managed space where sensored becomes censored.' Carlo Ratti extends this argument by highlighting the potential of new systems of information and communication on the virtual infrastructure of cities and on their impacts on networks of associations and interactions.

In their essays, Richard Sennett and the Milgram Group reflect on the 'stupefying' effect of smart cities, analysing how the new urban environments of Songdo and Masdar currently being shaped by a new generation of urban infrastructures remain alien and lack the visual and creative energies of conventional urban form. By identifying historical precedent, Sennett warns that new tools can have deadening rather than liberating effects and that our first instinct is to blame the machine itself instead of asking ourselves how new urban technologies can be used more intelligently, raising questions about urban design and people engagement. Dan Hill and Maarten Hajer delve deeper into the social dimensions of smart cities in an ecological age, arguing for greater awareness and experimentation in the use of new urban technologies and making more of their political potential. In his closing overview, *The Politics of Climate Change*, Tony Giddens reflects on how technological innovation has to be a core part of any successful climate change strategy, but that the state and government must have a significant role in making such innovation possible, suggesting that now is time to call for a 'return to planning'.

This brief synopsis of the arguments laid out in this newspaper suggests that we are not taking the Electric City at face value. We use this term as a catch-phrase to capture the social, economic, cultural and political complexities of what comes under the general banner of 'smart cities'. We recognise that these dimensions need to be better understood before new technologies are accepted by citizens who are highly sceptical of technological fixes and worried about affordability and data protection. At the same time, urban policymakers and city leaders seem hesitant to embrace change and impose untested technologies. They are also concerned about the risks of investing in what might turn out to be the 'wrong' technology at extremely high costs. It is out hope that this conference will stimulate debate and bring clarity, offering new insights into the social and environmental sustainability of cities. ■

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Electricity has allowed buildings to be turned inside-out (Lloyd's of London)

ELECTRICITY: A THING AND AN IDEA

Deyan Sudjic

Cities are shaped as much by ideas as they are by things; in either case more often than not they are the result of unintended consequences. The car, which is clearly a thing rather than an idea, was meant to offer personal mobility, rather than lead to the emergence of out-of-town shopping, toxic air pollution and traffic jams. The standard shipping container, also a thing, was meant to speed up loading, cut down handling costs and pilfering. It did all that, but, rather more visibly, it also wiped out every up stream dock, wharf and warehouse in the world, and eventually resulted in Canary Wharf becoming London's second financial centre. The three-electrode vacuum tube, or thermionic valve as it is known in the United States, was developed as a switch and an amplifier. It has done more than either the car or the shipping container to change the urban world. It has put electricity to work.

As for ideas: there are the obvious ones, from the obvious sources. The urban theorists who believed in zoning, the modernists, who wanted a tabula rasa, and the followers of the picturesque, such as Camillo Sitte, who understood the city as a work of art. But there are also the kind of ideas that are less immediately obvious in their relevance to the nature of a city, but which may have the biggest impact in the long term. These might include the legal codes that result in certain kinds of leases, the political ideas about participation or centralisation that impact on how decisions about what to build, and what not to build are taken. And the fuel subsidies that may encourage one form of transport over another, and thus favour some forms of urbanism over others. All of these are ideas that are perhaps just as responsible for the way in which our cities work as the things that we use to make them, and to move around in them. But perhaps because things are more visible than ideas, and because we have grown increasingly suspicious of big ideas about cities, we have concentrated perhaps too much on the way we use things rather than on thinking about their effects and their potentials.

Electricity is both an idea, and a thing. As a result it has had an unusually pervasive grip on our attitudes towards urbanism. It has not always been the same idea. For Benjamin Franklin, electricity was about understanding the nature of natural phenomena. Earlier scientists found that they could use electricity to give the appearance of resurrection to dead frogs. For over a century, electricity seemed closer to sorcery or magic than to production. It was only at the end of the nineteenth century that it began to offer solid industrial applications, and to start to shape cities. Electricity morphed from the valve to the transistor, and then the semi-conductor, triggering the digital revolution that quickly put paid to the analogue world. The digital revolution could be understood as the culmination of the electric age. From wireless connection to GPS navigation, it certainly seems to be offering what looks very much like magic.

As an idea, electricity is what the Soviet Union promised to adopt as the road to the future. Elsewhere, out of the grip of the totalitarians, electricity was the inspiration that showed a way forward out of the age of steam and heavy machinery. The dams built by the Tennessee Valley Authority offered electrification as the new-deal escape from poverty. The steam-age city was soot streaked, and smog bound. It depended for its mobility, its factories, and for its comfort on the begrimed stokers confined below ground and below deck whose back-breaking toil fed the boilers. Electricity seemed as far removed from this sweat-soaked reliance on muscle power as the digital economy now is from the analogue. Some electric power might still depend on coal-fired power stations, but they are out of sight, and out of mind. At the point of delivery electricity seemed as if it were clean, manageable, and efficient.

In the early twentieth century, electricity as celebrated by the Futurists was equated with effortless power, with city streets blazing with light, and with an irreversible break with the past. Electricity made the city more connected, metaphorically as well as literally. The endless city can be understood as a force field, its energy crackling over huge areas of apparently unconnected fragments of urban tissue, and connecting them. It is notable in this context to remember that the London Underground map of 1931 owes its graphic language to an electric circuit diagram: not so much a metaphor as a tactical way of making sense of the navigation of a complex system.

Electricity was always a thing too. A thing that has had a massive impact on the form and density of cities. Otis lifts, streetlights, tramlines, air conditioning, neon and escalators changed the face of the first industrial metropolises. Berlin, London, New York City and Chicago as they are today would not be possible without electricity. And not only in the physical sense, but in their political organisation too. For better or worse, electricity made possible the technology that sidestepped literacy, and allowed politicians to speak directly to the masses eighty years ago. There is nothing new about the impact of technology on civic strife, whatever the claims made for Blackberry-fuelled mayhem in the streets of London's Hackney and Haringey last year, or of Twitter in the Arab spring. If Hitler's rise to power was aided by his skill as a radio broadcaster, it was also the transistor radios in the backpacks of the French conscripts in Algeria that allowed them to hear Charles De Gaulle's order to them to disobey their mutinous officers and so put down their attempt at a coup.

In the last two to three decades we have been overwhelmed by the impact of all the things that electricity makes possible, without perhaps the perspective to go on seeing electricity as an idea. It is in part because we have lost the ability to be impressed or charmed by speculations about the nature of the future. The fading appeal of the Expo movement demonstrates the sense of ennui that we have acquired in speculations about the future and the place of technology in it. The Expo was once the most elaborate prototype for urban innovation. Joseph Paxton's prefabricated Crystal Palace, covering an awesome 800,000 square feet (74,322 m^2) haunted the imagination of the nineteenth and twentieth centuries. Subsequently the Expo became a much less inspiring arena in which Robert Moses met Walt Disney, and where urban theory collided with popular culture. From the first Paris Exposition to the Brussels Expo of 1959, from the City Beautiful of Chicago to the starry-eyed futurism of New York in 1939, from the welfare state optimism of the Festival of Britain in 1951 to the grim corporate vision of New York in 1964, each of the fairs sloganised a particular view of urbanism that grew progressively more banal.

The live TV broadcast was introduced to America at the World's Fair. Norman Bel Geddes designed Futurama, the enormous General Motors display that proudly declared itself the city of tomorrow with its 500,000 scale-model buildings and its one million trees and 50,000 cars, 10,000 of which actually moved. They were exhibits that opened the way for Robert Moses to start driving expressways through the Bronx, and demolishing swathes of Manhattan. In 1964 New York staged a second Expo, once more under the direction of Robert Moses. Walt Disney offered his services to several of the big commercial exhibitors, and afterwards he returned the compliment. He hired William Potter, one of Moses's aides at the 1964 fair, to offer guidance on his own plans to build a city. Together they worked on Epcot, the Experimental Prototype Community of Tomorrow, which, to judge by Disney's ambitions, was mooted as a direct answer to Jane Jacobs' anxieties about the future of the city. 'There will be no slum areas, because we will not let them develop. There will be no landowners, and therefore no voting control. People will rent houses, instead of buying them, and at a modest rental, there will be no retirees, everyone must be employed.' We recoiled, or, worse, we sniggered at what dreaming about the future had been reduced to if Epcot was what it had become. If the Expo has declined into senility, it is all the more important to find ways to understand the impact of the electric city, not just as a deluge of things, but in its significance for our notion of what the city can be. We are far too dependent now on electricity to be able to do without it.

In less developed urban societies, the installation of electric street lighting, and the sense of security it brings at night to previously threatening streets, is still an early signal of infrastructure investment, and the maturity that comes with it. Despite the breezy way with which we continue to take the efficacy of Moore's Law for granted, and assume that computing power will continue to double every year or two, for a halving of the cost, the developed world cannot take it for granted that the lights will always stay on. Britain's reluctance to face the challenge of building a new generation of power plants, and German anathema to nuclear power are just two examples of the vulnerability of modern economies to electricity shortages. India's massive power cuts in the last year are another reminder that the future for the BRIC nations is also problematic.

To explore the idea of the electric city offers a powerful way of understanding urbanism as it is being reshaped. Using the word at all involves looking back at ideas about the future, which belong to a historical moment less jaded than our own. It is to take a perspective that has not been desensitised by decades of technological innovation, so rapid, and so relentless that we have lost the ability to wonder, or even be surprised about what it has to offer.

Electricity made the key elements of the modern city possible in successive technological generations. Early on it was the metro system. More recently it was the Internet. The impact of what electricity brought into being has changed fundamentally the geography of the city, and the way we live in it, and the way in which we interact with each other. Now we need to see what it can offer for the near future. It can encourage both anti-urban developments, and their antithesis. We need to find ways in which to emphasise the latter at the expense of the former. Electricity has made new spaces, both physical and virtual, possible. It has powered technologies that have shaped the grain of life in the city. The electric city could be taken to mean a city policed by number-plate recognition systems, kept moving by car-share schemes, and crowd monitoring on the underground network, and Oyster cards that track every journey taken on every bus and metro line in a city.

The electric city that they delineate is both infinitely more transparent and more opaque than urbanism in its more traditional form. An electric city is a city of rippling neon and LEDs at night. An electric city is one that that is continually surveyed by surveillance cameras, a city navigated by GPS systems that make London taxi drivers' painstakingly acquired knowledge as nostalgically useless as the vinyl record some of us cannot bear to discard. The city's anonymity and privacy are under threat as never before from Google's cameras, Apple's location-based services and pervasive security. The iPhone leaves an indelible trail, and so do the Oyster card and the cash machine. This is turning the city into a compound in which every action is known, every form of behaviour can be predicted, every dissident suppressed.

The way in which we navigate and socialise has been transformed. So has the way in which crime, politics and consumption work. The discouraging thing about almost every new technology is how what begins as radical and empowering so quickly turns into part of the apparatus, if not of repression then of consumerism. In urbanistic terms, if the impact of electricity powered digital development is to undermine the physical city, the Internet, which, like all authentic cities has both its light, and its dark side, must step up to the plate, and stand in as the new public realm. Crime and vice hover at the edges of virtual space that also encompasses the great free library that is Wikipedia, the explosion of online archives, and the market stalls that are open source designs. It has become a polyglot mix of the inspirational and the banal. Meanwhile, Twitter is the twenty-first-century equivalent of the lavatory wall, a place for the scurrilous and the anonymous to leave their mark, combined, if we are being generous, with an electronic version of the posters on Beijing's democracy wall.

Electricity has transformed our distribution systems, and working practices. If we have no need to work in an office, we are never really out of it now. We have no need for record shops, no need for bookshops soon, and no need for post offices. But there is plenty of call for big out-of-town sheds for distribution. All the things that people have been speculating about for a couple of decades have happened. John Lewis set about making a real investment in e-commerce only two years ago. In that time it has grown to represent £1 in every £5 it takes at its tills. Why would it think about the investment in bricks and mortar that a department store with the same turnover as its online sales would need? Christopher Bailey's fashion shows for Burberry are now instantly streamed across the globe: no need then for a front-row seat in the tent when you can watch on your smart phone in a bar, or on a beach.

Does the impact of immateriality of the electric city in the end undermine the essence of urbanism, or reinforce it? The electric city offers the possibility of feedback loops, and of making political and technical decisions in real time. It is both an echo chamber for the global village idiot, and a genuinely liberating and empowering phenomenon. But for it to remain a positive force, we cannot turn into passive consumers. ■

Deyan Sudjic is Director of the Design Museum in London.

GLOBAL PROBLEMS: CITY SOLUTIONS

Philipp Rode, Nick Stern and Dimitri Zenghelis

Cities have clearly played a major role in the creation of the problem of anthropogenic climate change and they will form a central part of any response. No effective global collaborative agreement to tackle climate change can be delivered without the full involvement of cities. Yet the evidence suggests that measures that make cities work better in terms of emissions and sustainability, are also measures that make them work better as prosperous and attractive places to live and work.

Cities are well placed to lead the process of low-carbon innovation. They combine a mix of specialisation and diversity derived from a concentration of people and economic activity that generates a fertile environment for innovation in ideas, technologies and processes. They produce and distribute the resources that provide better livelihoods for urban and rural residents alike. Their size and economic complexity mean that city-specific problems such as congestion, waste, education and crime require considered, city-specific public intervention. At the same time high population density and compactness can allow for economics of scale and collaboration.

Greenhouse gas emissions are directly related to income. Per capita incomes are generally higher in cities than in surrounding rural areas, generating higher average per capita demand related to major emissions sources. But not all cities are the same. There is an enormous variation in emissions among cities with similar per capita incomes as a result of local climatic conditions, their energy mixes and industry shares, as well as the extent to which they simply export their emissions. It is the last point that tends to make most developed world urban areas look far better than they actually are, as it ignores emissions linked to their material consumption and the embodied energy generation that occurs elsewhere.

But emissions have also been associated with differences in settlement patterns, leading to an underlying tendency to lower average per capita emissions in denser, compacter cities. Consequently, even when appropriately acknowledging that cities are not self-sufficient entities and ought to share responsibility for carbon-intensive activities beyond their boundaries, some world metropolises seem to be relatively energy and carbon efficient, whether measured by unit output or per capita. Paris, São Paulo, London, Dhaka, Hong Kong and Tokyo have among the world's lowest levels of energy intensity – about one-quarter of that of the five highest scoring cities and less than half of the fifty-city average[1].

Cities with limited urban sprawl and integrated urban transit systems have in many cases become affluent with low emissions per head. Their relative resource efficiency is mainly a result of greater transport energy efficiency due to reduced distances and greater shares of green transport modes, greater heat and cooling energy efficiency in buildings, due to lower surface-to-volume ratios of compacter building methods, and lower embedded energy demand for urban infrastructure due to greater utilisation. But compact, well-managed cities with intelligent infrastructure can also be more attractive to footloose workers than suburban or rural communities. Inner-city Paris, Rome, Barcelona and London, together with New York, Singapore and Tokyo provide examples of creative, growing city centres with access to a variety of amenities, including green space. Dense cities tend to have lower per-capita emissions, provided they are also served by good public transport systems[2].

With shorter transport networks and less diffuse utility infrastructures, denser cities generate significant savings in operating costs, running to thousands of US$ per year for the average household[3]. But suburban living remains popular, so dense cities need to be carefully planned to attract wealth creating individuals who can choose other options. Without coordinated planning, cities will be at risk of 'locking in' to long-lived, high-carbon capital infrastructure that will be costly to reverse. Not surprisingly, cities that today are regarded as green leaders have a track record in long-term and integrated planning, particularly related to land use and public transport infrastructure.

Implementing greenhouse gas reduction strategies can pay economic dividends beyond reduced risks of the great potential damage associated with climate change. It can drive efficiency and allow cities to reduce waste and cut costs. Cities offer a unique environment to innovate, develop and scale up new ideas and processes. These promote the growth of clusters of expertise in knowledge-intensive green production sectors. Cities have become laboratories for action on climate change where learning and experience induces further innovation and falling cost in new technologies. Integrated recycling networks, electric mobility based on renewable energy production, methane capture and combined heat and power have relied on ready access to new technologies and skilled engineers and installation experts, which are all easier to access in a compact urban environment. Scale economy benefits of urbanisation mean that cities can capitalise on developing 'green' investments, such as integrated public transit, sewers and water systems, congestion pricing, smart grids, smart buildings and decentralised energy networks[4] According to some reports, urban regions already produce ten times more renewable technologies patents than rural regions[5].

Climate policy also yields mutual benefits at the local level, while investment in attractive and successful cities will yield climate benefits. Lower particulate pollution reduces health care costs, increases city attractiveness, and promotes competitiveness, while reduced waste makes for a more attractive environment (for example through reduced use of landfill) and enhanced energy security by limiting reliance on imported energy and raw materials[6]. This means policies must be well planned: for example, efficiently reducing congestion and emissions requires complementary measures on public transport, cycling, electric and shared vehicle infrastructure, urban planning, zoning and carbon pricing. During economic downturns, such programmes can boost job creation and stimulate activity, especially in 'shovel-ready' sectors such as building efficiency retrofits, broadband infrastructure and retooling manufacturing. Policies to increase vegetation and green spaces not only reduce the heat island effect, but also improve resilience to flooding.

Implementing Bogotá's TransMilenio bus system was primarily motivated by an urgent need for cost-effective, high-capacity urban transport, congestion reduction and improving the quality of life locally rather than aiming to reduce global carbon emissions. However, this scheme has not only reduced emissions, it has shortened travel time and lowered congestion at peak times by 40 per cent[7]. Overall, health benefits in cities as a result of green transport strategies are particularly high as they combine emission reduction, increased physical activity levels and road safety. Health and safety benefits have been estimated as 5 to 20 times greater than the cost for integrated non-motorised and public transport measures in diverse cities such as Bogotá, Morogoro and Delhi[8] and these are in addition to the substantial benefits in terms of saving time and resources.

Transport contributes around 22 per cent of the world's energy related greenhouse gas emissions. Of about ten billion trips that are made every day in urban areas around the world, a significant and increasing share is with carbon and energy intensive private motorised modes. Until now, many aspects of commuting and transport design have been wasteful and inefficient. Even within the European Union, a highly urbanised region with ambitious carbon reduction policies in place, transport-related CO_2 emissions increased by 36 per cent between 1990 and 2006, while other key sectors have achieved at least modest reductions[9]. In the UK, the cost of public transport relative to private transport has risen sharply over the past twenty years, compounding the waste from congestion. Congestion of roads in the UK causes estimated annual losses of around GB£7 to 8 billion, around 0.5 per cent of the GDP (US$11 to 12.6 billion; €8.1 to 9.3 billion)[10]. Costs are even higher in developing countries with rapidly growing cities unable to catch up with population growth and motorisation. The costs of congestion in Buenos Aires are estimated at 3.4 per cent of local GDP, in Mexico City 2.6 and in Dakar 3.4 per cent[11].

Time losses, wasted energy, higher accident risks and the negative impact on the quality of life make a powerful case for strategies to reduce congestion. London's congestion charge reduced congestion by an estimated 30 per cent between February 2003 and February 2004, in comparison to the same period in previous years[12] and CO_2 emissions from traffic inside the charging zone were cut by 19.5 per cent[13]. Mexico City and Bogotá have introduced number plate restrictions with measurable impacts on congestion and air quality[14]. Efficient, affordable and reliable public transport alternatives further reduce the appeal of the private car. In recent years, more established cities of the global North, like Copenhagen, Amsterdam, London and New York, have consistently invested in pro-cycling and walking strategies.

Electricity and heat production contribute 37 per cent of global energy related carbon emissions[15]. Some cities have invested heavily in clean electricity and heat production such as photovoltaic (PV) systems located on building roofs and facades, or in dedicated open areas. In Freiburg, PV systems cover 13,000 square metres (139,931 square feet) of the city's building surfaces – including the main railway station – while San Francisco operates the largest city-owned solar power system in the United States[16]. Further opportunities are offered by wind energy, with turbines typically located outside city boundaries. The 'London Array' offshore wind-turbine system is projected to produce 1,000 MW, enough to power 750,000 homes[17]. These investments typically carry a higher up-front cost than conventional

energy generation, but with the potential for significant energy cost savings in the longer term, greater energy security, and the ability to drive innovation in dynamic export technology sectors.

Copenhagen's district heating system, which captures waste heat from electricity production, normally released into the sea as hot water, has helped reduce emissions and shaves €1,400 (US$1,907) off household bills per annum. It is estimated that people in metropolitan Portland, Oregon, save US$2 (€1.47) billion annually through coordinated changes in land use and transport policies over the last three decades. These include modest increases in building density, light rail transit schemes and policies to encourage walking and cycling. In many European cities, recycling levels are in the region of 50 per cent of domestic waste, while Copenhagen sends only 3 per cent of its waste to landfills[18]. Buildings contribute 25 per cent of the world's energy-related greenhouse gas emissions[19]. The imposition of tough building standards and mandatory energy certificates, as well as the provision of tax incentives and loans, has also had a measurable impact on energy demand in a number of European and American cities[20].

Integrated technologies will help make dense complex cities work efficiently and consume more collaboratively. Cities provide a critical mass of potential users for a wide range of IT-based services, which build upon complex physical infrastructure systems (such as roads, rail, cabling and distribution systems buildings). A broadband digital infrastructure can connect people to people, people to city systems and city systems to city systems, allowing cities and their residents to respond to changing circumstances in near real-time. Improved monitoring and measurement of resource flow patterns will allow more informed infrastructural investment decisions[21]. In addition, smart transport systems are being used to tackle congestion, facilitate road-user charges or supply real-time information on traffic problems – examples include Stockholm's congestion tax and Singapore's electronic road pricing. Amsterdam currently trials smart work centres that allow workers to use local office facilities rather than having to commute to their main office[22].

From a policy perspective, therefore, this is not only about the construction of the infrastructure for roads, buses and railways; it is also about their pricing and management, regulations applying to the location of homes, the use of cars and the design of cities. It concerns the structure of workplaces and practices affecting conventions for physical attendance. Many, or most of these, involve networks in some shape or form in which the decisions of an individual on where to live, how to move, how to interact and how to commute have powerful effects on others.

Given the growing evidence of a virtuous circle associated with green cities and prosperity, the question arises why not more cities commit to green growth. Firstly, the payback from investment in energy efficiency is not immediate and usually requires an additional up-front investment. Liquidity constraints and limited access to capital may therefore preclude profitable investments. Secondly, the gains from energy efficiency and renewable investment may not have been recognised yet. As fossil fuel and other scarce resources continue to rise in price, and as the policy environment clamps down on waste, this should change. However, even where clear gains have existed in the past, there have been a number of barriers such as split incentives, managerial shortcomings, weak monitoring and a lack of capacity and expertise preventing optimal investment in resource efficiency.

The global low-carbon energy market is expected to triple to US$ 2.2 trillion per annum by 2020[23] while global investment in renewable energy jumped 32 per cent in 2010, to $211 billion[24]. A broad range of successful cities will increasingly specialise in higher-end business services, which can include activities such as environmental consulting and intermediating carbon. Clearly, opportunities will vary from city to city in accordance with income levels, policy frameworks, industry compositions and available options for low-carbon transition. Further empirical investigation is required, and this demands the development of a consistent urban database and improved assessments of best practice. Yet this does not mean that cities should wait for perfect information before taking into account the latest understanding of climate change when making long-term planning decisions. How cities develop is part of the climate problem, but it can also be part of the response.

Successful cities will effectively engage citizens in decision making, while enabling local actors in government, business and the community to build a harmonious and creative environment to live and work. Effecting policy action is often easier at the city level where policymakers are closer, physically and culturally, to their citizens than national governments. All cities have opportunities to guide urban planning and prevent the expansion and lock in of high-carbon infrastructure. Fast growing cities are today planning and committing to long-lived urban structures, which afford either unique opportunities or unforeseeable risks, while old established cities will need to think about how to replace and retrofit existing capital and infrastructure.

Cities are complex heterogeneous entities that share some common properties. There is no 'one size fits all' solution, but all cities have scope to improve efficiency, make greater use of renewable resources and improve the environment for innovation, with significant economic as well as environmental returns. The investments and strategic decisions made over the next few years will determine where the winners and losers will be in rising to the challenge of a sustainable future. ■

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THE BENEFITS OF DENSITY

Edward Glaeser

In the 1970s, Jane Jacobs argued that we could minimise our damage to the environment by clustering together in high-rises and walking to work, and this point has been eloquently argued by David Owen in his book *Green Metropolis* (2009). We maximise our damage when we insist on living surrounded by greensward. Lower densities inevitably mean more travel, and that requires energy. While larger living spaces certainly do have their advantages, large suburban homes also consume much more energy. Anyone who believes that global warming is a real danger should see dense urban living as part of the solution. Over the next fifty years, China and India will cease to be poor rural nations, and that's a good thing. They – like the United States and Europe before them – will move from rural to urban living. If billions of Chinese and Indians insist on leafy suburbs and the large homes and cars those suburbs entail, then the world's carbon emissions will soar. The critical question is whether, as Asia develops, it will become a continent of suburban drivers or urban public-transit users.

Matthew Kahn and I have put together a carbon inventory of new housing throughout the United States. We wanted to determine the amount of carbon emissions that come from building a typical new home in different parts of the country, so we based our estimates primarily on homes built over the last two decades. About 20 per cent of the US's carbon dioxide emissions are related to residential energy use, and almost another 20 per cent are associated with our motor vehicles. An average family in the United States buys about 1,000 gallons (3,785 litres) of petrol a year, which is associated with about ten tons of carbon dioxide. It may be easier to imagine American families buying more fuel-efficient cars than giving up on car-based living altogether, but historically the bulk of variation in petrol usage among various people over various periods of time comes from total distances travelled, not from fuel efficiency. Cars now average about 22 miles per gallon (9.35 km per litre), and the big difference is whether you drive 300 miles per year or 30,000, which depends on whether you live in a city or a suburb. Kahn and I found that area density and distance to the city centre are both strongly associated with petrol usage. The average household living in a census tract with more than 10,000 people per square mile (3,861 per km^2) uses 687 gallons (2,600 litres) of petrol per year, while the average household living in an area with fewer than 1,000 per square mile (386 per km^2) (about one household per acre / 4,000 m^2) uses 1,164 gallons (4,406 litres) of petrol per year.

The density of one's home neighbourhood matters because most car trips aren't commutes downtown. People drive millions of miles to buy groceries, to go out to eat, and to pick their children up from school. The density of shops and schools in an area determines the average distance of those trips. In a city, you often walk to a restaurant. In a low-density area, eating out might entail a 25-minute drive each way. Holding family income and size constant, petrol consumption per family

Old modes of transport are re-connecting new inner cities (Tramlink, Croydon)

Shared systems of mobility are changing urban dynamics (Cycle hire docking station, London)

per year declines by 106 gallons (401 litres) as the number of residents per square mile doubles. These facts remind us that mass transit isn't the only way to lower petrol consumption. If people lived in denser areas, they'd travel far smaller distances and use much less petrol, even if they still drove to work. Public transportation emits carbon too, but most forms of public transit are a lot more energy efficient than driving vast distances in our own personal petrol burners. For example, the New York City Transit system uses 42 million gallons (159 million litres) of diesel fuel and 14.8 billion MW of electricity each year to deliver 2.6 billion trips to its riders. That works out to an average of 0.9 pounds of carbon dioxide per trip – a tenth of the 9 pounds of carbon dioxide emitted in an average car trip.

Kahn and I predicted the amount of petrol that an average family with about US$60,000 (€46,866) of income would consume in every census tract and every metropolitan area in the country. While every other area in our sample was associated with more than 1,000 gallons (3,785 litres) of petrol per year, the average household in the New York metropolitan area was connected with fewer than 850 gallons (3,217 litres) of petrol per year. While people in the United States as a whole are more than fifteen times as likely to drive themselves to work than use public transportation, New York City residents are more than twice as likely to take mass transit than drive to work. Throughout the country, big cities mean less driving. On average, when population doubles, per-household carbon dioxide emissions due to driving decline by almost a ton per year. In almost every metropolitan area, city dwellers consume a lot less petrol than suburbanites. Predictably, some of the biggest city-suburb gaps are in older areas, like New York, where the average urban family consumes more than 300 gallons (1,136 litres) of petrol less per year than its suburban counterpart. Cities are also greener than suburbs because urbanites use less electricity. Bigger, denser cities, where people own smaller homes, use less electricity. The average single family detached home consumes 88 per cent more electricity than the average apartment in a building of five or more units. The average suburban household consumes 27 per cent more electricity than the average urban household. When we standardise for income and family size, we find that central-city residents use less electricity in 44 out of the 48 metropolitan areas that we analysed. To form a total estimate of household carbon emissions, we just add together the emissions from driving, electricity, and heating, and add public transit.

So how should we interpret all these data? Simply put, if we wanted to reduce emissions by changing our land-development policies, more US residents should live in denser, more urban environments.

Higher-density construction in the United States and Europe will reduce carbon emissions, but the most important battles over urban development in the coming years will be waged in India and China. About half of US homes in 2000 were built between 1970 and 2000, so let's assume that about half of America's housing stock 30 years from now will also be new. If every pro-density effort is wildly successful in the US, emissions from driving and powering these new houses might fall by 50 per cent. That would be a great achievement, reducing America's household carbon emissions by 25 per cent and the US's total emissions by 10 per cent. Yet from this momentous shift, world carbon emissions would fall by only 2 per cent. That calculation is not meant to excuse inaction, but rather to make the point that the United States is something of a sideshow in the long-run battle against climate change. The US has trillions of US$ of infrastructure built around the car, and any developed country changes slowly. India and China are changing fast, and they have a lot more people than the US does. If carbon emissions in India and China rose to American per capita levels, the world's carbon consumption would increase by 139 per cent, even if their population stayed the same. The biggest environmental benefits from supporting higher-density development in the United States may well be in helping to persuade the Chinese and Indians to build up rather than out. Today, the United States is the world's second biggest carbon emitter; on average, Americans emit about 20 metric tons of carbon dioxide per person per year. The Chinese are producing almost 5 tons of carbon dioxide per person per year and the Indians 1 ton. If the Chinese per capita carbon emissions rose to American levels, this would lead to an extra 20 billion tons of carbon emitted every year, increasing world carbon emissions by 69 per cent.

So it's essential that we encourage these countries to keep their carbon emissions at the more modest European levels, rather than emulating current American energy use and development patterns. Today, China's carbon emissions are largely industrial. Like the black smoke that once surrounded Pittsburgh or Manchester, they are the by-product of a great industrial power on the rise. So far, China's households are remarkably parsimonious energy users. Matthew Kahn, Rui Wang, Siqi Zheng and I did a city-by-city analysis of China's household carbon emissions, similar to the one that we did for the United States. While the typical household in the Washington DC area generates 43 tons of carbon dioxide per year, the typical Beijing household emits only 3.997 tons – and Beijing is one of the brownest places in China. In more than 60 per cent of the Chinese cities we examined, carbon dioxide emissions per household ran at 2 tons a year or less. Household emissions in Daqing, China's oil capital and brownest city, are one fifth of emissions in San Diego, America's greenest city. Chinese household emissions are driven by home heating and electricity. As countries develop, warmth comes first, long before air conditioning. While half of US household emissions reflect personal transportation, only a tenth of Chinese emissions currently come from cars. The relative paucity of driving and air conditioning in China keeps current emission levels low, but we can hardly expect an increasingly prosperous Chinese population to forego the luxuries that Americans take for granted. If anything, the case for air conditioning in India seems even stronger.

A generation ago, both China and India were solidly rural. They did little environmental damage because, like all poor places, they used little energy. Over a fifty-year period, however, they're achieving the same industrial and urban transformation that took centuries in the West. The result is an inevitable explosion in energy consumption, which is today helping to drive up oil prices and that could produce extraordinary increases in carbon emissions in the future. There is, however, a middle way that combines prosperity and growth with fewer environmental risks. That path involves high-density urban living, not the cars of American exurbs. Growth patterns in India and China offer both hopeful and disturbing signs. On the plus side, the great cities of both nations are enormously dense. Mumbai has more than 50,000 people per square mile (19,305 per km^2), about double the density of New York City. Kolkata and Bangalore are above 20,000 per square mile (7,722 per km^2). Shenzhen, the rapidly growing metropolis in mainland China, across the water from Hong Kong, has more than 15,000 people per square mile (5,792 per km^2). These densities fit well with buses and trains and lifts, but make car usage practically impossible. The world will be safer if China's future involves hyper-dense places made more comfortable with better public transportation and high-rise residences. But there are also warning signs. Car usage in both India and China is soaring. Chinese car ownership hit 60 million vehicles in 2009, with an annual rate of increase of over 30 per cent. A few more 30 per cent years, and China could have 500 million cars by 2020. Meanwhile, India's Tata Group made headlines by producing a US$2,500 (€1,953) car, and Tata's cars could put a billion Indians behind a wheel, if they can handle the traffic jams. A billion Indian drivers will emit a lot of carbon.

There is a powerful whiff of hypocrisy associated with energy-mad Americans – and I'm part of this group – trying to convince Asians to conserve more. One distinguished economist likened it to a 'nation of SUV drivers trying to tell a nation of bicyclists not to drive mopeds'. My awkward suburban life is certainly no model of green living. The only way the West can earn any moral authority on global warming is to first get its own house in order. As long as the US leads the developed world in per capita carbon emissions, we'll never be able to convince China and India and the rest of the developing world to do anything other than emulate our own energy-intensive lifestyles. The West also needs to embrace a smarter form of environmentalism. In the first phase of environmentalism, when the objective was just to make people care about nature, the exact policy prescription was less important than raising public consciousness. Today the stakes are higher. We need instead to focus on those proposals that will have a meaningful impact on climate change. Smart environmentalism needs to embrace incentives. Ken Livingstone's congestion charge showed the power of using prices to get people out of their cars. This can be done in other cities. Fuel efficiency is unlikely to be the only answer, because Jevons's paradox reminds us that as engines and appliances get more efficient, they will also be used more. If the future is going to be greener, then it must be more urban. Dense cities offer a means of living that involves less driving and smaller homes to heat and cool. For the sake of humanity and our planet, cities are – and must be – the wave of the future. ■

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AFTER THE CAR

John Urry

In the first decades of this century there are many indicators of car decline in the West. There has been the spectacular collapse of some American iconic car firms that defined the mobile twentieth century. The city experiencing the most rapid population and economic decline in the States is Detroit, the world's 'car city'. The global supplies of oil are running low, with one new barrel discovered for every four used. The US has recorded the first drops in car mileage for a generation or so; new cohorts of young Americans or Europeans desire the latest smartphone rather than a car. Millard-Ball and Schipper conclude from their extensive review that travel activity has reached a plateau in various western countries. Some societies have reached, or are even passing 'peak travel'.

And the worldwide growth of population of some billions makes it impossible for the oil-based car system to be available around the world, and especially across Asia, on even a European scale. Since around 2005 there has been a major shift in global politics towards searching for low-carbon energy and forms of transport with much experimentation seeking to move away from a high-carbon world. There are a number of very different alternative scenarios for the middle of this century, when the steel-and-petroleum car system that we have come to know and love may be no more.

First, the effects of the politics of climate change, the peaking of oil supplies and periodic economic crises could generate local sustainability. Travel would be substantially reduced and far more local. There might be some cars around but their monopolisation of roads would have long passed. The global population would be smaller through worsening healthcare and reduced food supplies and urban centres would have fragmented. There would be a global shift towards lifestyles and forms of movement that are more local, smaller in scale and that use less energy. Friends would be chosen from neighbouring streets, families would not move away when new households are formed, work would be found nearby, education would be sought in local schools and colleges, the seasons would determine which foodstuffs were consumed, and most goods and services would be simpler and produced nearby. Global GDP would be smaller but wellbeing might be higher for those who are part of this 'small is beautiful' localisation of the future.

A second alternative, a bleaker version of the first, can be termed 'regional warlordism'. In this 'barbaric' future there

would be oil, gas and water shortages and intermittent resource wars within the context of extreme weather events and energy shortages. There would be the breakdown of many mobility, energy and communication connections that now straddle the world. There would be a plummeting standard of living, a re-localising of movement, an increasing emphasis upon local 'warlords' controlling recycled forms of mobility and weaponry, and relatively weak governments. Infrastructures would collapse and there would be increasing separation between different regions. Cars and trucks, and buses and trains, would rust away in the deserts or be washed away in floods. Often regions would be at war with their neighbours, especially for control of water, oil and gas, as prefigured in *Mad Max* 2's portrayal of the future.

A third alternative is 'hypermobility'. The current patterns of mobile lives based on new communications and transportation would develop on an extreme scale. The resource shortages and effects of climate change would turn out to be less significant, at least for the rich North of the globe, partly because a magic bullet would overcome the limits of fossil fuels and provide a new mobility future. People's movement would become more extensive and frequent with novel fuels and vehicles. Personalised air travel, São Paulo writ large, would be common as unfashionable cars would remain stuck on the ground. A Corbusier-inspired future would beckon all to the skies, including regular flights into space with Virgin Galactic! The final frontier would indeed be overcome with a verticalisation of cities.

Finally, there is a post-car electric future. The digital and the transportational would be integrated. Here software intelligently would work out the best means of doing tasks, whether this would involve meeting up or getting to some place or event or simply staying put. Some effects of meeting up would be effectively simulated through virtual communications that are as good as meeting face to face. 'Digital lives' would develop into life instead, so much so that there would be less need for travel, especially over long distances. Much business, social and family life would not be face to face. Manufacturing on demand could be enabled by 3D printing and the replacement of the long supply chains of container-based manufacturing systems.

Personal travel would involve small, ultra-light, smart, probably battery-based vehicles that would be hired, a bit like bikes can now be hired in London, Paris or Barcelona. Streets would be full of often speed-controlled micro cars, demand-responsive minibuses, bikes, electric bikes, hybrid vehicles, driverless rapid transit systems and pedestrians. Ideally these would be seamlessly integrated with larger-scale public transport. Smartphones, or their successors, would control access and payment for multiple and interconnected forms of mobility. Neighbourhoods would be reengineered to constrain sprawl. Carbon allowances would be allocated, monitored and individually measured through new apps. There would be less freedom to walk, drive or move without traces being left and some payment extracted. Such a digital system would be like an Orwellian airport city and would need to be subject to energetic democratic control.

So there are four futures, and all have their costs, dangers and injustices. None is simply preferable, none is the most likely to develop, and all may be contested. And the best is not necessarily the one which will develop. How might the last of these be realised?

Certainly the combination of high oil prices, extreme weather events, and stagnating economic growth indicate some green shoots of a powering down of fast oil-based travel within parts of the rich North. The beginning of this century is like the beginning of the last one, when the car system was being assembled out of many inventions, discoveries, tinkerings, and new marketing. Something similar is taking place today, and a whole new socio-technical system may emerge out of very disparate elements, of technologies, materials, policies, payment systems and social practices that are like islands of an archipelago that may turn out to be components of a new system.

Central here would be some shift from an ownership to an access economy, as Jeremy Rifkin has long advocated. It is also something much trialled with car clubs and new car-hire schemes. Car manufacturers are experimenting with pay-as-you-go schemes for electric vehicles (EVs). Daimler, Peugeot and others expect these to attract younger customers familiar with access payments for Internet services. Better Place will charge by the mile; indeed if the EV is highly subsidised or even free (and then effectively recycled) payments would just be by distance. Central would be so-called 'near-field communications' to enable the supply of interchangeable mobility services to be accessed, paid for, but not predominantly owned.

By the middle of this century a post-car system could emerge unexpectedly, off-centre, not from a current home of the car. Examples here could be electric bike innovation in China, a Better Place EV battery replacement system in Israel, public transport integrated systems in Brazil, the Bay Area becoming the EV capital of the US, Chinese officials making China the world's largest producer of EVs and setting up recharging throughout Wuhan, and so on.

But there are formidable technological, economic, organisational and social problems in engineering this system to push the steel-and-petroleum car system aside. It is necessary that EVs, whether with four, three or two wheels, come to be a socio-technical system that over time makes the steel-and-petroleum system obsolete, instead of merely providing extra vehicles for eco-prestige seekers. Also significant here would be the prevention of the rebound effect, of fun and fashionable EVs being so well used that extra mileage occurs. And this says nothing about how the electricity is itself generated, although EVs are up to four times as efficient as petrol-driven vehicles, although the use of coal as the most common fuel for generating electricity is a major concern here.

During the twentieth century it seemed that oil-based mobile lives would spread to all continents and most peoples, albeit with huge inequalities. That century operated as though there was a free lunch to be enjoyed at the expense of the next century, with half the world's oil being burnt and in a way that resulted in changing global climates. Now we are in that century we find that futures are not at all rosy, that the car and its high-carbon friends have left little standing in their wake.

By the end of this century the steel-and-petroleum car system that we have come to know and love will be no more. If there will be cars, they will be mainly housed in museums, if museums still exist. Cars, one-to two-ton monsters powered by refined oil, built of steel, privately owned, seating at least four people, and with their own territory called roads and car parks, will be seen as dinosaurs, remnants of the twentieth century. People may gawp at them a little, like 1950s American cars are now gawped at by tourists on the streets of Havana. Cars will be so last century! The car system will not be around by the end of this century, but none of the alternatives are without major costs and risks. Much indeed is up for grabs. ■

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U.S. METROS AND THE GREEN ECONOMY

Bruce Katz

In the United States, the broader discourse about the benefits and viability of a clean economy, like most other critical national issues, has become mired in partisan and ideological divisions. The 2012 US Presidential campaign provided only the latest example of the deep chasm that separates our political parties. On the one hand, Republican Presidential nominee Mitt Romney, who supported a state green energy fund as Governor of Massachusetts, criticised the Obama Administration for an 'unhealthy obsession with green jobs', while President Obama defended his administration's investments in renewable energy projects over the past four years and argued that Governor Romney policies show a 'disdain for green energy'.

This partisan debate at the national level occurs at a time in which US federal government support for the clean energy and energy-efficiency sectors are likely to decline, even though President Obama has just been re-elected for another term. In the past several years, through subsidies, loan guarantees, and tax expenditures, the US government became a major supporter of the nascent clean economy, committing more than US$150 billion to clean energy projects between 2009 and 2014. Over the next few years, however, it is likely that federal support will be radically reduced as numerous programmes and policies are set to expire, from production tax credits for wind energy to investment tax credits for solar energy. In total, 63 of the 92 federal clean energy finance policies that were in place in 2009 will have expired by 2014. Given the difficult budget challenges the US government faces as it attempts to control the skyrocketing federal deficit, it is likely that many of these programmes will be scaled back if not eliminated altogether.

The irony, of course, is that in the midst of uncertainty and division at the federal level there is a large, diverse, and growing clean economy emerging in the US, concentrated primarily in America's largest cities and metropolitan areas. Over the past two years, Brookings research has identified nearly 2.7 million clean jobs, making the clean economy nearly 60 per cent of the size of the America's IT sector (4.8 million jobs), and larger than its fossil fuel industry (2.4 million jobs). These jobs span five major categories – renewable energy; energy and resource efficiency; greenhouse gas reduction, environmental management, and recycling; agricultural and natural resources conservation; education and compliance – and naturally break down into 39 fine-grained segments. Renewable energy, for instance, has 9 segments, including solar and geothermal power and renewable energy services, while energy and resource efficiency has 13 separate segments, from electric vehicle technology to water efficient products.

Beyond these large groups, Brookings also identified a group of young, innovative 'cleantech' industries that cross multiple categories and show enormous growth potential. This portfolio of segments, including wind power, battery technologies, biofuels, and smart-grid technology, grew about 8 per cent a year between 2003 and 2010, twice as fast as the rest of the US economy.

The clean economy is not just broad and diverse; it is disproportionately productive and export-oriented. In 2009, US clean economy establishments exported almost US$54 billion, including about US$49.5 billion in goods and an additional US$4.5 billion in services, making the clean economy twice as export-intensive as the national economy. Over US$20,000 worth of exports is sold for every job in the clean economy each year compared to just US $10,400 worth of exports for the average US job. The export orientation of the clean economy today provides a platform for more exports tomorrow. With rising nations rapidly urbanising, the demand for sustainable growth in all its dimensions will only grow, and the US has the potential to serve that demand.

The American clean economy also supports a production-driven innovation economy. In fact, 10 per cent of clean economy jobs are in science and engineering fields, compared to 5 per cent in the US overall, and 26 per cent of all clean economy jobs are involved in manufacturing, compared to just 9 per cent of jobs in the US economy as a whole. Manufacturing accounts for a majority of the jobs in over half of the clean economy segments, with many sectors having a super-majority of production-oriented jobs. Solar and wind energy, for example, have more than two thirds of their jobs in manufacturing. And some segments, including appliances, water-efficient products, and electric vehicle technologies have over 90 per cent of their jobs in manufacturing. Clean manufacturing is a growing sector, part of an overall resurgence of manufacturing in the US over the last few years.

Finally, the clean economy is opportunity rich, providing prospects for a wide range of American workers, and good wages up and down the skills ladder. Forty-five per cent of all clean jobs are held by workers with a high-school diploma or less, compared to only 37 per cent of US jobs. Once a worker enters the field, they are more likely to receive career-building training, as 41 per cent of clean jobs offer medium to long-term training, compared to 23 per cent of US jobs on average. The pay-off is higher wages, as the median wage in the clean economy is almost US $44,000 for the average occupation, higher than the national equivalent of slightly over US$38,000.

America's 100 largest metropolitan areas, which take up only 12 per cent of its land mass but harbour two-thirds of the population and generate 75 per cent of the country's GDP, are driving growth in the clean economy. In 2010, the top 100 metropolitan areas in the US constituted almost 64 per cent of clean economy jobs overall, and an outsized share – 74 per cent – of jobs in cleantech industries, including extraordinarily high shares of jobs in solar photovoltaic, battery technologies, smart grid, and wind energy. Innovative clean jobs are predominantly located in the top 100 metropolitan areas because these places concentrate the assets that drive innovation, from initial research to commercialisation and, ultimately, to deployment.

Metro economies, of course, do not exist in the aggregate. Each metropolitan area has a distinctive starting point and distinctive assets, attributes, and advantages. Brookings research has profiled the clean economy potential of each of the top 100 metropolitan areas. Four of these – New York, Los Angeles, Chicago, and Washington – are supersized job centres, with more than 70,000 jobs each in the clean economy in 2010. The New York metropolitan area alone has more than 152,000 clean economy jobs, while other major metropolitan areas, such as Philadelphia, San Francisco, Atlanta, Boston, Houston, and Dallas, are also large clean job centres, with more than 38,000 jobs each in 2010.

Yet this is not just about the largest metropolitan areas. A number of small and medium-sized metropolitan areas, including Knoxville, Tennessee, Harrisburg, Pennsylvania, and Toledo, Ohio, have more than 3.3 per cent of their jobs situated in the clean economy, while Albany, New York, leads the way with clean jobs accounting for an impressive 6.3 per cent of its total employment.

The power of cities and metropolitan areas is the power of agglomeration, networks, and clusters. Our research found that clusters – the proximity of firms to businesses in related industries – boost metropolitan areas' growth performance in the clean economy, and also that metropolitan areas facilitate clustering. There are numerous examples of clean clusters throughout the US, including professional environmental services in Houston, solar photovoltaic in Los Angeles, fuel cells in Boston, wind in Chicago, water industries in Milwaukee, and energy efficiency in Philadelphia.

As US continues to struggle with the challenge of high levels of joblessness – 11.1 million jobs are needed by the most recent estimates – and an overall sluggish economic recovery, how does one unlock this engine of growth in its cities and metropolitan areas?

A strong policy platform is critical for the clean economy to realise its full potential. In an ideal world, an economy shaping of this magnitude should start at the national scale, with the federal government implementing policies to scale up markets to catalyse demand for clean economy goods and services, and finance to produce and deploy more of what the US invents, drive innovation by investing in advanced R&D at scale and over a sustained period of time, and align its policies with cities and metropolitan areas to realise the synergies of clustering and place.

But, as mentioned before, political polarisation and fiscal retrenchment at the federal level will likely prevent this from happening. Fortunately, the US has a default proposition when the national government falters – US states act as 'laboratories of democracy', and cities and metropolitan areas act as the laboratories of innovation.

America's states, cities, and metropolitan areas are awash with leadership. This 'Pragmatic Caucus' of political, business, civic, university, and environmental leaders prize place over party, collaboration over conflict, and evidence over ideology. And this Caucus is building the clean economy the hard way – from the ground up, despite political odds and fiscal obstacles.

There is no shortage of policy innovation and political commitment to highlight in America's states and metropolitan areas.

To scale up markets, California has set an aggressive renewable portfolio standard (RPS) that mandates 33 per cent come from renewable sources by 2020. With this strong foundation, San Jose and other cities and counties in California are doing their part to facilitate consumer adoption by streamlining or even eliminating building permitting for solar panels.

To drive innovation, Wisconsin has created the School of Freshwater Sciences at the University of Wisconsin-Milwaukee to leverage that metro's rising position in the "blue economy." The Milwaukee Water Council is building on this, spearheading a network of scientists and companies to realize Milwaukee's ambition to be a global hub for freshwater research, firm creation and business expansion.

To catalyse finance, Connecticut recently created the Connecticut Clean Energy Finance and Investment Authority. This Green Bank, capitalised with some US $50 million annually, could accelerate the generation, transmission and adoption of alternative energy in the state. At the municipal level, Connecticut's neighbour New York City has capitalized an Energy Efficiency Corporation to spur the financing of energy efficiency in the building sector.

And, finally, smart metros are now moving to build out their distinctive industry clusters. In Greater Seattle, for example, the Puget Sound Regional Council has developed a business plan to cement that metro's natural position as a global hub of energy efficient building technologies. The smart public-private initiative to date is the establishment of a facility to test, integrate and verify promising energy efficient products and services before launching them to market. Significantly, this metro vision is being supported by the State of Washington, which has committed to match any federal investment in the testing network.

These examples from states and metropolitan areas demonstrate that the US – and the world – is in the early stages of a clean economy revolution. This revolution will be determined, shaped, and delivered by cities and metropolitan areas, both in mature economies and rising nations alike. As in any industrial revolution, benefits will accrue disproportionately to those firms and communities that are the first movers, the first inventors, the first adaptors, and the first producers. To update an old maxim, "to the innovative belong the economic spoils: jobs, investment, and a higher quality of life."

Will the US step up to the challenge? Over the next four years, President Obama will let us know. ■

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LONDON'S TECH-CITY

Max Nathan

Since the late 1990s, a vibrant high-tech scene has been developing in Inner East London. The neighbourhoods around Clerkenwell and Shoreditch form the core of this cluster, with the Old Street roundabout – also called 'Silicon Roundabout' – at its heart. Since 2010, the Coalition Government has led a high-profile drive to accelerate its economic development: the 'Tech City'initiative. Launching the strategy in November 2010, and drawing heavily on the imagery of Silicon Valley, David Cameron set out an agenda to develop Inner East London into 'one of the world's great technology centres'[1]. By March 2012, George Osborne was hailing Tech City as central to Government's industrial strategy[2].

Ministers are right to get excited. Inner East London plays an important role in the capital's digital ecosystem. In recent research that I led for the Centre for London (CFL)[3] we found that on a broad count, the cluster contained over 3,200 digital economy firms in 2010 – double the count of 1997. That business base is particularly strong on digital content industries, and now includes global players like MindCandy, Unruly, Songkick and Last.fm. The area also contains over 48,500 digital economy jobs, increasing its share of London's tech employment by a third since 1997 – and in 2010 it continued to gain jobs while digital economy employment in the rest of the city fell.

With the area approaching critical mass, policy and industry voices are starting to think about the next phase of Inner East London's digital evolution – a corporate invasion? 3D printing, and a revival of manufacturing? This article explores a third scenario – the development of a smarter, greener core. The area has been quietly hatching a number of 'cleanweb' firms, and has the beginnings of a green ecosystem, with networks, meetups and accelerators in place. Over the past year, angels and venture capital (VC) players have been picking up interest. But as with London's wider digital economy, there are real challenges ahead.

Smart city, clean tech, cleanweb

Terminology matters here. Precise definitions of the 'smart city' are elusive, as LSE's Ayesha Khanna points out. For some it's a city that uses advanced technologies to manage energy, lighting and transport infrastructures more efficiently. For others it's a city that places the minimum demands on the environment. In practice, it's probably both. Certainly, the smart city agenda is driven by the diffusion of new digital technologies and systems (broadband and mobile broadband, cloud computing, big data and the social web). It's also driven by urbanisation and by the challenges of updating and retrofitting urban infrastructures, and by policymakers' increasing awareness of limits on current economic development paths. As the world develops more cities, especially in the Global South, we need to find more efficient and more sustainable ways to help them run.

We also need a sense of the smart city product space. Paul Miller, of Bethnal Green Ventures, talks about 'cleantech and cleanweb'. Cleantech is the physical green economy – involving electric and driverless cars, smart grids, smart meters, PV cells. Cleanweb is online technology for information and organisation – crowd-sensing apps and maps, environmental information, online marketplaces. These aren't always wholly distinct: US firm SolarCity, for instance, offers design, installation, finance and online monitoring of domestic solar energy systems.

On the ground, two very different versions of the smart city are appearing. Carlo Ratti and Anthony Townsend dub these 'top down' and 'bottom up'[4]. Top down smart cities are masterplanned demonstration projects – think Masdar in Abu Dhabi, or Cisco's 'city in a box' in Songdo, South Korea. Bottom up smart cities are messier, more complex, building and retrofitting new services on top of existing social media networks and technological infrastructures. For a city like London, it's this social, citizen-powered approach that's most likely to take off. London faces multiple challenges: a growing population, overloaded transport systems and an energy-inefficient housing stock. But it is also developing smarter systems – such as the congestion charge, the Oystercard and 'Boris Bikes' – which offer glimpses of how a smarter capital might work in the future.

Cleanweb products and services, which focus on making existing infrastructures work better, are particularly attractive for London policymakers. And London's digital businesses, with their strengths in web design, apps and digital content, are well placed to develop new tools and ideas.

Going green in East London

Over the past five years, a green layer has gradually developed in the East London digital scene. These firms are mostly very small and very young, and are operating in both cleanweb and social smart city product space. Some offer online apps and tools – such as Carbon Culture[5] (a community platform to engage people in saving energy), Gnergy[6] (web apps to assess and improve energy performance) or Pad Partners[7] (using social networks to source home energy efficiency advice). Others have developed green transport marketplaces, like Carbon Voyage[8] (online car sharing and journey matching) and Loco2 (pan-European train booking). A third group are more focused on hardware and systems, such as Cosm[9] (a platform to connect smart devices like energy monitors), Fairphone[10] (an ethical mobile) and Mastadon C[11] (greener cloud computing, which sends work to the most energy-efficient location).

Amee[12] is, arguably, the daddy of East London's cleanweb scene. Founded five years ago, the firm now has 13 staff and offices in London and San Francisco.

Amee offers a combination of aggregated environmental information, carbon/energy audits and data/tech management consultancy services. Amee was the first of the scene's cleanweb firms to get major VC investment, now helping to seed the next generation: founder and chairman Gavin Starks is now Chief Executive of the Open Data Institute, and Amee alumni are involved in the London Cleanweb network – 'because we don't want to bluescreen the planet' – which organises meetups, talks and hack days[13].

Such social infrastructure is an important part of the local ecosystem for young firms. Bethnal Green Ventures (BGV) is another[14]. An accelerator for social/environmental start-ups, BGV offers a combination of seed funding (GB£15,000 / US$23,877 per firm), a peer group, structured networking and mentoring, as well as shared workspace at Google Campus. BGV is increasingly in demand – working with six firms at a time, they interviewed 50 candidates for its latest cohort, and expect to see more in the next round.

BGV's Paul Miller notes rising angel and VC interest over the past 12 months. The Tech City initiative has shone a bright light on the area; more importantly, variable experiences with cleantech investments have pushed many US investors towards cleanweb, where capital requirements are lower and returns potentially higher.

The future

So what next for East London's nascent green economy scene? London's cleanweb firms feel well positioned. Their great shared asset is the collective knowledge and resources of the wider urban digital economy. Cleanweb activity builds on London firms' skills in programming and digital content – perhaps more than physical engineering. As far as East London goes, cleanweb goes with the grain.

The next few years won't be easy, however. Many of the challenges are common to all digital start-ups: the CFL research identified problems around skills, finance, workspace, connectivity and mentoring that may prevent firms growing to scale. Even so, green digital economy firms may have it harder than others.

One challenge is reaching paying customers, both in the UK and abroad. Gavin Starks notes that 'the main challenge is making environmental issues carry enough financial weight to be relevant to businesses.' Paul Miller suggests a wider British cultural aversion to 'buying things off start-ups' – shared across public and private sectors.

Accessing finance is another issue. CFL found a number of companies bootstrapping, or relying on family and friends. Those who had approached angels or VC for equity had often had disappointing experiences – many providers lack knowledge of digital sectors and are often very risk-averse, problems compounded by VC firms' lack of physical presence in – and thus knowledge of – the area. These issues are amplified for very novel technologies like cleanweb (Amee, notably, got its first VC money from New York and the South Bay). These constraints may ease in the years to come, as more US investors arrive and specialised VC and boutique operations like Passion Capital, Amadeus and Seedcamp step up operations. The UK's Technology Strategy Board is also helping out, with GB£1.25m (US$1.99m) on the table for innovative energy-efficient computing ideas and £1m (US$1.59m) for energy harvesting technologies.

A third challenge will be the continued supply of physical workspace. Shoreditch and Clerkenwell are dense urban areas, with limited space for new building. Tech City has brought welcome attention, but is also contributing to rising property costs. Many policymakers hope that digital firms will migrate to brand new spaces in the Olympic Park, Stratford City and the Royal Docks. The iCity development, on the former Olympic Broadcast and Media Centre, is hoping to attract a mix of major players and start-ups. Siemens' The Crystal exhibition centre is intended to kick-start a Green Enterprise District. No doubt some firms will head further East, but many have little interest in doing so. At present, there are few obvious connections between the grassroots cleanweb scene around Shoreditch, and shiny new buildings further East.

A fourth big issue is the policy environment. As with many frontier technologies, this kind of activity needs government support – through legislation, enabling frameworks and funding tools. National and local government are both actively focused on the digital economy, although the strategy and policy mix can be improved (see the CFL study for more on this). For cleantech and cleanweb firms, the wider policy environment is also key. The lack of certainty on flagship UK initiatives like the Green Deal, for example, makes life harder for nascent providers, as do ongoing rows about support for renewables. And the failure of the Copenhagen climate negotiations has knocked substantial sums off firm valuations.

Finally, we need to consider the bigger picture. Smart city optimists suggest a new electric age for cities is beginning to appear. As Carlota Perez would put it, cleantech and cleanweb technologies have already arrived, and the next two decades will see a 'deployment period', as they become embedded in urban structures[15]. Pessimists, like Robert Gordon or Tyler Cowen, suggest we've already wrung the maximum innovative potential out of the Internet, and those gains have been relatively small[16]. My personal view is that there's still great potential for the diffusion of new technologies into smart city products and services. It's certainly one plausible – and encouraging – possible future for East London's vibrant digital economy. ■

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URBANISING TECHNOLOGY

Saskia Sassen

Periods of rapid transition have heuristic potentials. The velocity of change itself makes novel patterns legible. When the object of study is cities, legibility is even more pronounced insofar as the material reality of buildings, transport systems, and other components of spatial organisation are on the surface, so to speak. Simultaneous rapid transformation in several cities with somewhat comparable conditions also makes the variability of such spatial outcomes visible, even when they result from similar novel dynamics. Our global modernity is one of those periods of rapid change. Major advances in building and other technologies have left a massive imprint on urban space.

What stands out is that these technologies have not been sufficiently 'urbanised'.[1] On the one hand, cities tend to urbanise technologies – it is not quite feasible to simply plop down a new technology in urban space. This becomes clear in the fact that the spatial formats through which density is constituted vary sharply across cities; it means that each city partly reshapes even standard technologies. On the other hand we need to push this urbanising of technology further, and in different directions. For instance, the elusive quality we in the West have come to call urbanity and tend to associate with a high-density centre might take on different shapes in other cultures. The notion of cityness helps us take some distance from that western notion and allow for a far greater variability in what constitutes urban density and its technologies. This opens up a whole field for research and interpretation, and invites us to reposition western notions of urbanity and to explore a far broader range of articulations of building technologies and urban space.

A first step into this exploration of what it means to urbanise technology is to engage the notion of intelligent systems, a rapidly expanding input for cities. In other words, what does it mean to use intelligent systems without de-urbanizing cities?

The limits of intelligent systems

Much of what is put under the 'smart city' umbrella has actually been around for a decade or more. Bit by bit (or byte by byte), we have been retrofitting various city systems and networks with devices that count, measure, record, and connect. The current fashion, however, centres around a costlier, difficult to implement vision. Rather than retrofitting old cities, the buzz today is about building entire smart cities from scratch in a matter of a few years (hence the alternative name 'instant city') at what seems to be an average price of US$30 to US$60 billion (€23.5 to €47 billion). Building such a city is a daunting proposition. But I think the biggest challenge is more conceptual: it is the need to design a system that puts all that technology truly at the service of the inhabitants, and not the other way around: the inhabitants as incidental users.

The best known example of an instant smart city is the now famous Songdo International Business District, an intelligent city near Seoul that is equipped with advanced sensors and monitors from Cisco Systems, among others. The city's multitasking devices are able to open and close, turn on and off, or stop and start everything: from the toaster to the video conference with your boss, or the video camera view of your child at play – and that is just from the perspective of workers. All of this can be done from both your home and your office, though the distinction between the two becomes increasingly fuzzy in a fully 'sensored' city. Songdo is also about recycling and greening: it is built on reclaimed land and deploys all the latest green technologies.

The other famous example would be Masdar City, in Abu Dhabi. Designed to be carbon free, it is both more scientific, yet, in many ways, less 'business intelligent' than Songdo. It is common to emphasise the commercial side of Masdar as a showcase for products from firms around the world. But I think it is incorrect to simply see it as a commercial showcase. I would describe it as a laboratory, or what social scientists refer to as a natural experiment: a piece of real life that functions as a window, allowing us to learn about an abstract, complex condition (for example, a fully intelligent and green large city), that we cannot replicate in a university laboratory.

Masdar has the same upper and lower worlds that all cities have, but in this instance the lower world includes much more than the usual pipes and tunnels. In Masdar it also includes a hidden trove of advanced technologies for handling all of the basic urban systems: all that flows in and out of the city, whether water or refuse, is measured and monitored and thus produces information. In this sense, everything in Masdar is considered significant. Even refuse is not simply refuse – it is a source for building knowledge. Meanwhile, the upper part of Masdar, built on a raised platform to give the technology 'plumbers' access to the pipes, is a showcase for an enormous variety of green technology.

All of this brings me to the second reason why I think of Masdar as a laboratory, albeit a lived-in one: few places in the world will be able to replicate Masdar. It is a multi-billion US$ investment for 40,000 residents. While the retrofit innovations of Amsterdam Innovation Motor (AIM) can be replicated throughout the world, in rich and poor cities alike, it is unlikely that anyone will replicate Masdar.

At the other end of the scale is China, which is also building cities – at least 20 of them are on the drawing board as I write. China will need to house well over 300 million people in the next few years. Its new cities will be planned and intelligent but they will not be little Masdars. They will be giant cities. They will have generous budgets of several hundreds of thousands of US$ to plant and maintain millions of trees, and, with luck, they will have bike lanes and photovoltaics everywhere. That would be a good practical beginning. We need both:

Technology is now part of way-finding in cities (South Bank, London)

a laboratory for the ideal as well as the practical solution.

What comes next is worrisome

The first phase of intelligent cities is exciting. The city becomes a living laboratory for smart urban technologies that can handle all the major systems a city requires: water, transport, security, waste, green buildings, and clean energy. The acts of installing, experimenting, testing, or discovering can all generate innovations, both practical and those that exist mainly in the minds of weekend scientists. This is thrilling. And these are projects that will involve foreign and local inventors, scientists, technologists, firms, artists, and curious tourists from around the world. This phase is likely to create a public conversation, not just between the residents and the city's leadership, but also horizontally, among citizens comparing notes. It could lead to a new type of open-source network: instead of simply having IT workers detect and fix software and recode to solve problems as they see them, there would be a collective upgrading and problem-solving dimension involving citizens, a sort of open-source urbanism.

But the ensuing phase is what worries me; it is charged with negative potentials. From experimentation, discovery, and open-source urbanism, we could slide into a managed space where 'sensored' becomes 'censored'. What stands out is the extent to which these technologies have not been sufficiently 'urbanised'. That is, they have not been made to work within a particular urban context. Consider the sharply varying kinds of architecture and building types that have evolved around the world in response to the need for increased density. Masdar looks nothing like Songdo. And compare Dubai and London; both have dense centres but they are built in very different styles. Technology systems that might work in one city might not be desirable in another. But it also tells us that a city can urbanize that technology and wire its capacities into an older concept of the urban or into a whole new visual order.

The push to urbanise technology

We need to push this urbanising of technology further, and in different directions.

Wherever I go in the world, I find at least some technologists, urbanists, and artists who are beginning to 'urbanise' technology. Cloud9, a Barcelona-based project that mixes science, technology, and architecture is a good example, one that draws and needs all types of people – children, professionals, and tourists alike. When this happens, the city becomes a heuristic space; it talks with the average resident or visitor rather than simply commanding them. The technology becomes visible and explicit and can be understood by any passer-by. I have long thought that all the major infrastructures in a city – from sewage to electricity and broadband – should be encased in transparent walls and floors at certain crossroads, such as bus stops or public squares. If you can actually see it all, you can get engaged. Today, when walls are pregnant with soft- and hardware, why not make this visible? All of our computerised systems should become transparent. The city would become literally a publicly shared domain.

The challenge for intelligent cities is to make the technologies they deploy responsive and intellectually/practically available to the people whose lives they affect. Today, the tendency is to make them invisible, hiding them beneath platforms or behind walls – hence putting them in command rather than in dialogue with users. This secluding of technologies reduces the possibility that intelligent cities can promote open-source urbanism.

Open source urbanism?

Taking the urbanising of technology to the next stage would increase and diversify the articulations between technology and urban space. It would unsettle current internal boundaries in cities and cut across the traditional domains – the economy, the polity, the social, culture. Technology and the environment can come together in many more ways than they do today in most cities.

'Urbanised' technology can make the city a heuristic space. It could tell the average resident or passer-by something about the most advanced types of applied technologies used in cities and about the variability of spatial forms through which these uses of technology work and become legible to the passer-by. This variability of spatial formats can become a powerful representation of the many ways in which technologies can be urbanised. It can show how multiple applied technologies within a city also make the diverse interactions that can take place in urban space visible, thus having the double effect of being both operational and inform the passer-by on what it means to urbanise technology. This brings to the fore the differing degrees of openness of cities. I prefer to think of this as the incompleteness of cities, which means that they can constantly be remade, for better or for worse. It is this incompleteness that has allowed some of the world's great old cities to outlast kingdoms, empires, nation-states and powerful enterprises.

Let me take the imagery of incompleteness further. Powerful actors can remake cities in their image. But cities talk back.[2] Sometimes it may take decades, and sometimes it is immediate. We can think of the multiple ways in which the city talks back as a type of open-source urbanism: the city as partly made through a myriad of interventions and little changes from the ground up. Each of these multiple small interventions may not look like much, but together they give added meaning to the notion of the incompleteness of cities, the city as somewhat of a mutant.

In sharp contrast, I think there is a futile search to eliminate incompleteness in the model of 'intelligent cities' as propounded by and through the purveyors of increasingly massive intelligent systems. The planners of intelligent cities make these technologies invisible, and hence put them in command rather than in dialogue with users. One effect is that intelligent cities become closed systems, and that is a pity. It will cut their lives short. They will become obsolete sooner. And, as these complex technical systems become obsolete, they may drag down with them the buildings within which they are housed. This becomes particularly acute given the accelerated rate of technological obsolescence.

Beyond the imagery of open-source urbanisms, can we strengthen the positive scenario of the city's incompleteness by actually deploying open-source technologies in a variety of urban contexts? Can we urbanise open-source technology itself, and might the complexity of urban settings help us do so?

As a technological practice of innovation, open source has not quite been about cities, but about the technology. Yet it resonates with what cities have and are at ground level, where its users are. The park is made not only with the hardware of trees and ponds, but also with the software of people's practices. A good example here is the turnaround of New York's Riverside Park from being a no-go zone in the 1970s to being a park for all those who wanted to use it, in part because dog owners started to walk their dogs in large numbers. Having a dog was itself an effect of feeling insecure in a city of high murder rates and much mugging. But the city allowed people to talk back: get a dog, walk your dog, usually a routine of mornings and evenings which produced a group effect, and you recover the territory of the park. This shows us how the mix of urban space and people's daily practices generated a public good –no matter how selfish the dog walkers might have been. I see here an urban capability at work.3 The proliferation of farmers' markets was also not a top-down decision. It resulted from a mix of conditions, primarily the desire of city residents to have access to fresh produce. A thousand individual decisions created a possibility for viable farmers markets.

Could urbanising open source technology and its cognates generate such capabilities? Sorts of events whereby many individuals react to conditions in similar ways to produce perceptible civic outcomes: buying dogs/recovering the park, or wanting fresh produce/creating farmers' markets? And how can this open sourcing be used to better predict and avoid negative outcomes? How can we urbanise actual technology?

In many ways, cities tend to urbanise technologies semi-autonomously, since it is still not quite feasible to simply plop down a new technology in urban space. It requires modifications, mediations. Major advances in building and other technologies have left a massive imprint on urban space. This is perhaps most visible in the sharp increases in density and networked systems that the new technologies have made possible. But a closer look suggests that these modifications have to do with overcoming rigidities and risks, especially risks catalogued by insurance companies. This mode is then only vaguely one of urbanising the technology.

Since open source is different from those technologies and technological applications, I am interested in understanding how it can take us to the next step. I see in open source a DNA that resonates strongly with how people make the city theirs, or urbanise what might be an individual initiative. And yet, as a technology it has mostly not engaged the city. I think that it will require *making*. We need to push this urbanising of open source technology to strengthen horizontal practices and initiatives. Leading urban civic institutions matter in this effort, but they tend to verticalise the work of making the urban. I think of this project as a sort of 'Urban Wikileaks'. By this I mean, for instance, vertical institutions that begin to leak some of their power and bureaucratic control to a more generic operational space that enables citizens to work with at least some of what is useful in those leaks. This is akin to horizontalising what is now vertical, imposed by top-down authority and expertise. Developing an Urban Wikileaks would take cities in a very different direction from the intelligent city model – and for the better.

There is much work to be done. Recovering the incompleteness of cities means recovering a space where the work of open-sourcing *the urban* can thrive. ■

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Endnotes

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2 This is further developed in "Does the City Have Speech?", Public Culture, forthcoming.
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THE SOCIAL NEXUS

Carlo Ratti and Anthony Townsend

On 25 January 2011 the streets of Cairo erupted in protest against the then President Hosni Mubarak's repressive Egyptian regime. Over the next 72 hours the government shut down the country's Internet service and mobile phone system in an attempt to squelch the rebellion. To no avail: a rich ecosystem of Facebook conversations, Twitter outbursts and chat room plans had already unified millions of Cairo's people, who continued the relentless uprising. The government backed down and restored communications to keep the country's economy on life support, but the masses kept up the pressure until Mubarak resigned two weeks later.

Just weeks before, during Tunisia's 'Dignity Revolution', dissident blogger and protest organiser Slim Amamou used the mobile social app Foursquare to alert his friends of his 6 January arrest. By 'checking in' at Foursquare's virtual depiction of the prison in Tunis where he was being held, Amamou revealed his location to a global web of supporters and immediately grabbed the international spotlight. The news stories sparked further uprisings, and long-time president Zine El Abidine Ben Ali was soon ousted.

Across the archipelago of places where the 'Arab Spring' revolts played out, citizens used new Internet applications and ubiquitous mobile phones to wage a battle over the soul of their cities, shifting resources back and forth, from cyberspace to 'cityspace'. Contrast those transformations with a handful of large urban development projects that have been vying to be crowned the model 'smart city' of the future. Furthest along are the comprehensively pre-planned, walled community of 50,000, Masdar, outside Abu Dhabi, Songdo City in South Korea, and PlanIT Valley in Portugal, where experiments to determine how future cities will be built are carried out by governments, real estate developers, ICT companies, and designers.

But as models, these top-down projects pale in comparison to the emergent form of intelligence that is bubbling up from millions of newly cyber-connected residents. Truly smart – and real – cities are not like an army regiment marching in lockstep to the commander's orders; they are more like a shifting flock of birds or shoal of fish, in which individuals respond to subtle social and bhavioural cues from their neighbours about which way to move forward. Although the mobs in Cairo and Tunis appeared unruly, their actions resulted from digital coordination of human activity on an unprecedented scale. Hundreds of thousands of people appeared in Tahrir Square in Cairo because text messages and tweets summoned them – reflecting an immensely powerful, democratic and organic alternative vision of the smart city.

Rather than focusing on the installation and control of network hardware, city governments, technology companies and their urban planning advisers can exploit a more ground-up approach to creating even smarter cities, in which people become the agents of change. With proper technical support structures, the populace can tackle problems such as energy use, traffic congestion, health care and education more effectively than centralised dictates can. And residents of wired cities can use their distributed intelligence to fashion new community activities, as well as a new kind of citizen activism.

Going beyond urban efficiency

Why are countries racing so haphazardly to implement smart cities? Why is IBM forecasting US$10 billion of revenue in its Smarter Planet initiative by 2015? What is happening at an urban scale today is similar to what happened two decades ago in Formula One. Up to that point, success on the circuit was primarily credited to a car's mechanics and the driver's capabilities. But then telemetry technology blossomed. The car was transformed into a computer that was monitored in real time by thousands of sensors, becoming 'intelligent' and better able to respond to the specific conditions of the race.

In a similar way, over the past decade digital technologies have begun to blanket our cities, forming the backbone of a large, intelligent infrastructure. Broadband fibre optic and wireless telecommunications grids are supporting mobile phones, smartphones and tablets that are increasingly affordable. At the same time, open databases – especially from the government – that people can read and add to are revealing all kinds of information, and public kiosks and displays are helping both literate and illiterate people to access them. Add to this foundation a relentlessly growing network of sensors and digital-control technologies, all tied together by cheap, powerful computers, and our cities are quickly becoming like 'computers in the open air'.

The vast amount of data that is emerging is the starting point for making efficient infrastructure programmable so that people can optimise a city's daily processes. Extracting information about real-time road conditions, for example, can reduce traffic and improve air quality. In Stockholm's road-pricing scheme, cameras automatically identify licence plates of vehicles entering the city centre and charge drivers' accounts up to SEK60 (US$9, €7) a day, depending on where the cars go. The system has shortened the waiting time for vehicles traversing the central district by up to 50 per cent and has reduced pollutant emissions by up to 15 per cent. Similar technologies can help bring down water use (one example is being used by the Sonoma County Water Agency in California) and provide better services to citizens.

Building from the bottom up

If we focus on sociability as the starting point for design and tapping into citizens as the source of innovation, how do we go about crafting a smarter city?

An ideal beginning is to leverage the growing array of smart personal devices we all wield and recruit people as the sensors of a city, rather than relying only on formal systems embedded into infrastructure. The traffic function on Google Maps is a good example. Instead of building a costly network of dedicated vehicle sensors along roads, Google constantly polls a large network of anonymous volunteers whose mobile devices report their up-to-the-minute status, which reveals where traffic is flowing, has slowed or stopped. The information is delivered to drivers via mobile mapping applications in various ways: as coloured overlays indicating traffic speeds, as estimated driving times that account for delays, or as a factor in determining alternative routes. These handy data allow users to see the circulatory network of the city in real time and understand the constantly changing cost in time of getting from point A to point B. Although Google is certainly not a grassroots platform, this example shows how peer-to-peer sharing of sensory data can have a huge impact in helping to manage urban infrastructure. This scenario also shows how smart cities can be both sociable and more efficient without imposing order from above; you choose the best route based on your peers' observations instead of being directed by traffic engineers.

Google's traffic app leverages a large base of existing consumer devices. But bottom-up approaches to sensing can also provide rapid, cheap deployment of new kinds of sensors that measure and record data about people's activities, movements, surroundings and health. As recently as 2009, Paris had fewer than a dozen ozone monitoring stations. To greatly expand this official data stream, the Green Watch project, overseen by Internet think tank Fing, distributed 200 smart devices to Parisians. The devices sensed ozone and noise levels as their wearers went about their daily lives, and the ongoing measurements were shared publicly through the Citypulse mapping engine. In the first trial, more than 130,000 measurements were taken in a single city district. The experiment showed how a grassroots sensory network could be deployed almost in an instant – at dramatically lower costs than expanding the city's archaic fixed stations. The project also showed that citizens could become deeply engaged in environmental monitoring and regulation. Ultimately, sensors for grassroots networks will be built into everyday objects: phones, vehicles and clothing.

Bottom-up approaches are also leveraging the sociability of cities to change patterns of activity. As the booming popularity of local shopping networks such as Groupon and LivingSocial shows, connecting local businesses and city dwellers through mobile social networks is a powerful catalyst for action. These new ways of scripting the city can create more lasting kinds of social touch points, too. The Foursquare mobile social network that Amamou used in Tunis can also turn going out into a kind of mobile game. It crowns the most frequent visitor to every cafe, bar and restaurant as the 'mayor' – a reference to the 'self-appointed public characters' described in 1961 by urbanist Jane Jacobs in *The Death and Life of Great American Cities*. Like the corner gossips that Jacobs argued were so critical to neighbourhood cohesion and safe streets, Foursquare's mayors remind us that even the most intelligent of digital cities are vital because they are filled with interesting and accessible people. ■

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THE STUPEFYING SMART CITY

Richard Sennett

Throughout the history of technology, new tools have come into being before people know how to use them well. This is the problem we face with today's new 'smart city' tools – the CCTV cameras, motion sensors, and computers capable of processing immense amounts of data. The problem is in a way understandable. It takes a long time and much experiment, entailing failure as well as success, to plumb a tool's possibilities. This was the case, for instance, of the hardened-edge scalpel, which appeared in the sixteenth century: surgeons required nearly a century to figure out best practices and innovative operations with a super sharp knife.

But tools for the smart city come with a sting in the tail. Their application can inhibit experiment by ordinary urbanites in their everyday lives. A large city can be thought of as a complex organism whose innards do not work perfectly in sync, whose parts do not add up to a unified whole. Yet there is something valuable just about these dissonances. They can create opportunities economically, when someone seizes on a market irregularity, while lack of coherent control enables personal liberty, and disorder might make subjective experience rich and multi-layered – at least novelists from Defoe to Proust hoped so. To take advantage of these possibilities, the big city needs to be *learnt*. The risk is that new technologies might repress the inductive and deductive processes people use to make sense, for themselves, of the complex conditions in which they live. The smart city would then become a stupefying smart city.

When a new tool proves deadening rather than liberating in use, our first instinct may be to blame the machine itself. That is what Lyon's silk weavers in the eighteenth century did; they attacked mechanised looms as 'perfidious works of the devil'. Instead of blaming the machine, we want to ask how the new urban technologies can be used more intelligently – which is more a question about urban planning and vision than about machinery. What kinds of urban design empower people in the street to experiment with their behaviour, and to draw their own conclusions from those experiments?

In the 1930s, urbanists like the American Lewis Mumford and architects like the Swiss Sigfried Giedion worried about machines and materials in relation to urban design. Mumford challenged the urban planners' uncritical embrace of the automobile; Giedion attacked the architects' conservative use of new building materials. Digital technology has shifted the technological focus to information processing. This can occur in handhelds linked to 'clouds' or in command and control centres. The issue is: who controls such information and how is this information organised? Which in turn raises new issues of urban design. The questions the technology poses are much more profound than which software to buy.

In this light, I want to make first a comparison between designs that create a stupefying smart city and designs that envision a stimulating smart city. By drawing this contrast, a formal issue then appears: that of the difference between a closed and an open system. And a social possibility emerges as well: the use of stimulating, open system technology to render the city more informal. My own comments here draw on a decade of research done by Urban Age on the visual and social conditions that can enable urbanites to take ownership over their lives.

Two Stupefying Smart Cities

Imagine that you are a masterplanner facing a blank computer screen and that you can design a city from scratch, free to incorporate every bit of high tech into your design. You might come up with Masdar, in the United Arab Emirates, or Songdo, in South Korea. These are two versions of the stupefying smart city, Masdar the more famous, or infamous, Songdo the more fascinating in a perverse way.

Masdar is a half-built city rising out of the desert, planning of which has been overseen by the master architect Norman Foster. The plan comprehensively lays out the activities of the city, in which technology monitors and regulates the function from a central command centre. This is to conceive of the city in 'Fordist' terms – that is, each activity has an appropriate place and time. Urbanites become consumers of choices laid out for them by prior calculations of where to shop or to get a doctor the most efficiently.

Such practical knowledge is always necessary; the question is how urbanites get it. Foster's idea is that there is a one-way flow from the central command centre (CCC) to the handheld. The handheld (that is, the urbanite) can report information, but the CCC makes the interpretation of what it means and how the handheld should act upon it. Masdar is an extreme in this, and also in conceiving that no knowledge of the city has to be fought for. So there's no cognitive stimulation through trial and error, no personal encounter with resistance. User-friendly in Foster's plan – expensive fantasy that it is – means choosing menu options rather than creating the menu.

There is a further issue here: creating a new menu entails, as it were, being in the wrong place at the wrong time. In nineteenth-century European cities, for instance, new markets for semi-legal goods developed at the supposedly dead zones near the city's walls; so in twentieth-century American cities like Boston, new 'brain industries' developed at the edges, in places whose zoning never imagined their growth. Foster's idea of the city on the contrary assumes a clairvoyant sense of what should grow where. Put crudely, the city is over-zoned: the algorithms of the CPU do not envision their own violation.

Songdo represents the stupefying smart city in its architectural aspect. It is no accident that Songdo is so badly designed. The massive units of housing are not conceived as structures with any individuality in themselves, nor are the ensemble of these faceless buildings meant to create a sense of place. The structures are programmed simply as functions. Uniform architecture need not inevitably produce a dead environment, if there is some flexibility at the ground plane. In New York, for instance, the ground plane of essentially monotonous residential towers is subdivided into small irregular units, which yield, along the Third Avenue in the 1920s or again the 1960s to the 1990s, a sense of neighbourhood. But in Songdo, lacking that elemental principle of diversity within the block, there is nothing to be learnt from walking the streets. And user intelligence of urban space arises basically from ground-plane experience.

When working in Mumbai, Urban Age research found Songdo-like efforts at urban design to be counterproductive. In Dharavi, a city in itself of nearly a million people, many efforts have been made to erase the anarchy that seems to reign on the streets, to push the built environment upward, off the street, in order to make it more orderly. These efforts have largely failed, rejected by people who instead use their own street smarts for survival.

A Smart Smart City

A more intelligent attempt to create a smart city comes from work currently under way in Rio de Janeiro. Rio existed long before the computer, and its history includes the appearance of massive poverty and of violent crime, but equally of complex and living tissues of local life. Its collective physiology is not that of a well-balanced organism, made worse by its topography, a city subject to devastating flash floods. Yet its inhabitants, struggling against the odds, have made a life for themselves which most of them prize.

The role of new information technologies in such a city could not be more different than that in cities designed from scratch like Masdar and Songdo. Led by IBM, with assistance from Cisco and other subcontractors, the technologies have been applied to forecasting physical disasters, to coordinating responses to traffic crises, and to organising police work on crime. The new command centre for these activities, IBM's local director tells us, looks forward to getting the city in reasonable condition to host the next Olympic Games. To make this centre work has required more political effort than sheer technological innovation, since Rio's government bureaucracy has been a landscape of isolated silos; the implementation of new technology has required an engaged mayor.

The advent of computerised information sharing has not been entirely benign, in the eyes of some citizens, since the police can now be more coercive more effectively – and technological modernisation, like other forms of modernisation, can be used as a cover for disempowering or physically dispossessing the poor. Still, the principle of machine use here is coordination rather than prescription, as were the cases in Masdar and Songdo. The technology is meant to be responsive to conditions not of its own making.

It could be objected that this comparison is unfair. Would not people in the favelas prefer, if they had a choice, a pre-organised, already-planned place in which to live? The research Urban Age has carried out over the last years suggests that once urbanites rise above the poverty level, they in fact don't. The prospect of the orderly city has not be a lure for voluntary migration, neither in the past to European cities, nor today to the sprawling cities of South America and Asia. If they have a choice, people want a more open, indeterminate city in which to make their way: that is how they can come to take ownership over their own lives.

Open and Closed Systems

There is a formal issue involved here: the contrast between the determinative and the coordinative use of technology shows at a deeper level the difference between a closed and an open system. Put simply, a car engine is a closed system while a discussion is, or should be, an open system. More detailed, in a closed system unforeseen activity is either integrated into the existing rules – the algorithms – of the system, or expelled as irrelevant 'noise'. Both feedback loops and exclusion help the closed system maintain equilibrium. Whereas in an open system, balance is not so much the aim: the system is programmed to evolve, being open to the unforeseen, changing its very structure as it absorbs new data. 'Noise' is valued. Another way to think about the difference is that open and closed equate linear and non-linear. In a closed system, when change occurs it is meant to happen in a one-after-another problem-solving fashion, whereas the process of change in an open system does not try to resolve all conflicts; its greater emphasis on chance means that the system inhabits non-linear time.

Cities are open, non-linear systems. They grow in unpredictable ways, which would be missed by closed-system thinking. For instance, increasing population density in cities follows an erratic, non-linear path – even more so in today's Asian and Latin American megacities than in the European cities of the nineteenth century. It would be bad science if we tried to model this growth using closed-system concepts of equilibrium and integration. Again, at a certain point large size and high density make for new urban forms; Rio is something more of a public realm than the addition of all its individual streets. The danger of much closed-system urbanism is to treat the city instead as nodes and locales that can be added up, a linear progression up from the small to the large or down from the large to the small. Exactly this kind of urbanism appears in the planning of Masdar and Songdo.

Informality

In sum, a better use of new technologies would focus more on coordination than on command, and it would suppose an evolutionary, open system rather than a steady-state, closed system. Further, smart-smart urbanism should follow specific planning principles, privileging the complexity of ground-plane design, recognising the cognitive value of pedestrian experience. The result would be that technology might aid informal social relations rather than repress informality in the name of coherent control. The use of Facebook in the Arab Spring of 2011 is an obvious and extreme example of doing so, but in more peaceful urban conditions why should we want to marry the technological and the informal?

Informal social processes are the genius of the city – the source of innovation economically and the foundation of an arousing social life. Technology must be part of the process of giving the city that informal energy – and can do so, if we think of our new technological tools as enabling the open systems of the city. ■

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The virtual and the physical create new spaces of association (Royal Festival Hall, London)

SKEWING THE CITY

Nerea Calvillo, Orit Halpern, Jesse LeCavalier and Wolfgang Pietsch – The Milgram Group

Where parks, boulevards and towering skyscrapers now await an increasing influx of inhabitants, not so long ago there used to be only water, just plain, grey ocean. On 610 hectares (2.35 square miles) of reclaimed land in the greater Seoul area, at a projected cost of US$35 (€27) billion, Songdo City is being built from scratch. Conceived in the wake of the Asian economic crisis, the city is located in a free economic zone and intended to become an important business hub in Northeast Asia. A 7.5 mile (12 km) long suspension bridge connects Songdo with Incheon International Airport, placing it within an hour or two from many major metropolitan areas in the region: the ideal place to set out from for an afternoon business meeting in Tokyo or a weekend shopping spree in Shanghai. Songdo has been hailed as a 'city of the future'[1], and as an 'experimental prototype community of tomorrow'[2]. As a complete greenfield development, it stands the unique chance of becoming one of the first genuinely smart and ubiquitous cities, and thus a role model for similar projects all over the world, designed to house the hundreds of millions who are projected to move into cities in the near future.

The vision for Songdo is largely technological, driven by an engineering perspective. In recent years, a number of companies have recognised the apparently huge potential for modern information technologies to transform the cityscape. IBM has launched its Smarter Planet initiative, for example, while Siemens has established a fourth company sector focusing on infrastructure and cities. Cisco, an American company specialising in networking equipment, is heavily investing in urban innovations with its Smart+Connected Communities programme. Cisco in particular is heavily involved in Songdo and considers it a 'model for smart cities around the globe'[3].

Cisco's brochures summarise the central idea behind building smart cities with a remarkable statement: 'the foundation for the city of the future will be the network and the information it carries'[4]. Supposedly, one starts with the network and everything else will follow. Of course, this network has a technological component that links up with different infrastructure systems, like transport, health care, education, or energy. But in the end it will serve the needs of the people, support the social networks in the city and beyond. This essay is an attempt to elaborate on the issues that are involved in a vision of the city as network[5].

Connecting people through things

Looming in the background is the familiar vision of the Internet of Things, which predicts an extension of the Internet into ever more realms of the physical world. An increasing number of objects will be recognisable through ID tags, will be equipped with sensors to collect information, and will, through radio transmitters, be integrated into the larger network. Supposedly, this will create smart and sensing environments that can adjust to human needs in sophisticated ways. There will be a steady flow of information that links the physical with the social world and the data cloud. To a considerable extent, the Internet of Things has already become reality. Many mobile phones or CCTV cameras are integrated in this network now, and other objects, like cars or televisions, are likely to follow soon. In Songdo, IT specialists experiment with tele-presence systems that are supposed to deliver education, healthcare, and government services directly into the homes. Lampposts equipped with public Wi-Fi, CCTV and information services are set up all over the city.

As the Internet expands, the principles that now govern the digital world will increasingly determine the physical world and the conditions of urban living. The infrastructural networks will become increasingly autonomous and less dependent on human intervention. And yet, their ultimate purpose remains to connect people and their needs. As the techno-social networks around us grow tighter, the social and the technological spheres will become increasingly interdependent. The data stored in the networks will make our steps through the cityscape increasingly predictable and, eventually, also controllable.

The skewed city

From a social perspective, objective physical space has always been an illusion, if a persistent one[6]. Networks are a much more adequate representation of the social world; of friendships, romantic relationships, family bonds, or professional interactions. Humans pertain to a large number of highly complex and interconnected networks. Each of these comes equipped with its own metric system, determining the distances between the various actors in society. These metrics often differ enormously from each other between networks and also from physical space. Indeed, most social networks are only remotely constrained by their physical substrate: one may live at a distance of a thousand miles from a good friend, but in terms of a friendship network be direct neighbours.

A major force driving infrastructural evolution has consisted in the need to overcome the various restrictions imposed by physical space in order to enable more flexible social networks. With regards to communication, the advent of the Internet is certainly one of the biggest leaps towards making physical distances irrelevant.

As modern information infrastructure allows citizens to become enmeshed in a growing number of ever more complex and interconnected networks, traditional places and boundaries of the social sphere rearrange themselves, or completely disappear. With respect to physical space, the network structures of the city become increasingly skewed. Once familiar locations, like the library, the travel agency, the flea market or the department store, lose their spatial reference points and dissolve into a diffuse data cloud. Long established boundaries, which were once all referenced by physical space, between home and work, the public and the private, the commercial and the non-branded, or the urban and the rural, become increasingly blurry.

The network as carrier of social evolution

To further emphasise why networks are so important for understanding the social dimension of city life, it is useful to refer to a somewhat obscure social theory developed by the French sociologist Gabriel Tarde in the last decades of the nineteenth century. Tarde insisted that everything social results from repeated imitation, which is only occasionally interrupted by more or less ingenious invention. The theory holds the germ of a powerful idea, recently popularised through Oxford biologist Richard Dawkin's concept of the *meme*[7]. In an analogy to the gene, a *meme* is the basic entity that drives cultural and social development according to evolutionary principles. Supposedly, evolution is not restricted to the genome but results whenever the following conditions are fulfilled: there must be a) a copying mechanism, b) the possibility for mutations in a copy, and c) a selection mechanism that singles out those copies that are particularly well adapted to the environment.

If Tarde were right and much of the dynamics of the social sphere is guided by imitation, then the development of traditions and customs should indeed follow evolutionary principles, but also the development of more specific everyday, professional, or even technological skills. There is little reason to doubt the significance of imitation to our social lives. From the first days in this world, throughout the various phases of education and training, we are constantly copying skills and behaviours from others: from role models in the family, among friends, at school, or at work. And only every once in a while we step back and try to reflect on what we are actually doing, often in an attempt to introduce small mutations in order to optimise.

Why is this perspective on social evolution relevant for the view of the city as network? Because social networks have in essence become the topologies that determine the dynamics of imitation. Copies of certain ideas and behaviour are now mainly exchanged via the links of social networks. Network structures thus determine who can serve as role model, and from whom we can imitate. It is therefore crucial to grasp the basic principles of the networks in which we are entangled.

A science of networks

Until the 1990s, graph or network theory was largely a mathematical specialism with very few everyday or real-world applications. This changed completely with the advent of the computer and its power to analyse large datasets, and also with the emergence of the Internet and the World Wide Web as examples of large network structures. Today, the study of real-world networks has become a major industry in various scientific fields, including biology, engineering, and the social sciences[8].

The emerging science of networks has helped unearth some general principles that are realised in many social and technological networks. Most networks arise from feedback mechanisms, for example, where the simple fact that a certain node already has a large number of links increases the probability that it will acquire new ones, in the same way as a person who already has many friends is likely to make new friends more easily: not because he is such a great guy, but just because it is nice to have popular friends. As a result of such feedback mechanisms many networks have a similar structure: with very few extensively linked nodes, and a large majority of nodes with only a small number of links.

If we follow that principle, obnoxious YouTube videos apparently become viral not so much due to their content, but somewhat paradoxically due to their very popularity. Also, the rise of websites like Amazon, Facebook, eBay or Google is due in part to feedback mechanisms, and a subsequent winner-takes-it-all phenomenon. These are obvious examples, in which changes in network structure have a decisive impact on economic and social conditions[9]. As the Internet expands into the physical world, one can only speculate on how the basic principles of large-scale networks will further transform our social and cultural lives.

Linking things and data

A number of interesting questions arise in connection with the integration of objects into the Internet. Will future smart and sensing infrastructures have a memory of past interactions, like websites like Amazon, Google or Facebook now have? Will these infrastructures at one point become personalised[10], as those websites are, presenting a best guess of what a user wants on the basis of their history? Such, and similar possibilities are already being explored at innovative research centres like the Media Lab[11] at MIT. It is quite plausible that smart infrastructures will one day, in the not too distant future, be so flexible as to predict and respond to specific user needs. Simple examples may be adaptive lighting in public places, or adaptive driving behaviour of cars.

This sketch of some general features of the networked city and society leaves us in a better position to assess if places like Songdo indeed constitute a step towards the city of the future. Songdo seems determined by an engineering vision, by the technologically possible. However, at least up to its current state of development, it largely fails to address the social ramifications that are directly implied by the technological innovations used. Future city designs will have to more profoundly consider certain topics, like the shift in spatial relations implied by changing network structures, or the increasing dissolution of familiar social spaces and boundaries. They will also have to take into account that cityscapes will become increasingly dominated by the flexible, personalised, and responsive infrastructures that are a direct consequence of the Internet of Things. All these developments lead to a further merging of the social and the technical spheres, eventually realising a cyborg vision of the city as a complex socio-technical network. ■

Endnotes

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DIGITAL COLLABORATION

Dan Hill

The promise of smart sustainable cities is predicated on the harmonious interplay of three forces: the dynamics of social media, allied to the analytics of Big Data, generated by a 'self-aware' urban infrastructure. Can these three forces be held in a productive tension? Can we harness emergent urbanism to the centralising tendencies of smart urban infrastructure? Are the biases inherent within social media consistent with the need for a broader civic empathy to address urban sustainability? Are we working with the primary drivers of urban life, or with the secondary drivers of infrastructural efficiency? As Cedric Price said in the mid-1960s: 'Technology is the answer. But what is the question?' This essay focuses on the issue that in smart cities, as much as with any other technology-led visions, we spend too little time thinking about questions.

The vision of the smart city tends to focus on feedback loops generated by infrastructure, buildings, and vehicles, often by people looking for clients among national and municipal governments. But the city is something else: it consists of its people. We do not make cities to make buildings and infrastructure, we make cities in order to come together, to create wealth and culture. As social animals, we chose the city so that we could be with other people. Buildings, vehicles and infrastructure are mere enablers, not drivers.

To see the city as a complex system to be optimised, made efficient, made smart, is to read the city along only one axis. But luckily, we are seeing more 'smart citizens' than 'smart cities'; citizens use social media and related technologies to organise and act, through a flurry of crowd-sourced, crowd-funding platforms and collaborative city making. This crowd-led smart city needs no marketing and little urban infrastructure. It relies on loosely joined up open networks overlaid onto the city. Active citizens are knitting together their own smart city, albeit not the one envisaged by the systems' integrators and technology corporations. Might this process alone deliver resilient urban environments?

The answer may be in the weak signals that indicate citizens are increasingly engaged in making decisions about their cities. Again, at its most viscerally obvious, we can see this in Tahrir Square, Zuccotti Park, Athens, Madrid, or recent underreported protests in urban China. Yet for all their impact, Occupy, the Arab Spring and last year's UK riots have not projected any kind of alternative structure for a new, resilient decision-making culture. Their effects tend to be unpredictable and uneven.

Beyond these flashpoints, however, we can see numerous examples of a more systemic change: urban activism becoming urban activity. They enable the exploits of urban activists – today's equivalents of the heroics that produced New York's High Line, London's Coin Street, or Renew Newcastle in Australia, for instance – to be shared, copied, translated and scaled. What these emerging tools deliver is a blueprint for more rapid, even, and sustained change. Due to the inherent dynamics and platform characteristics of social media, such tools suggest a new interface with the city that could, potentially, alter the way in which most citizens interact with it.

Over the last year many cities have witnessed an explosion in crowd-sourcing and crowd-funding platforms. In the wake of the increasingly high-profile crowd-funding platform Kickstarter, and popping up at the rate of one every couple of weeks, new platforms include Neighborland, In Our Backyard, SpaceHive, Brickstarter, Neighbor.ly, Change By Us, Give A Minute, Smallknot, Joukkoenkeli, Lucky Ant, I Make Rotterdam, as well as several more general crowd-funding services, occasionally bent into shape to serve as urban incubators – such as Indiegogo, PeopleFundIt, PleaseFundUs, Crowdfunder, and Kickstarter itself.

Behind all these initiatives sits the basic notion that someone thinks of and pitches a local project, and people in the community 'back' that idea, typically donating small amounts of funding. The network effects of social media and the architecture of contemporary websites enable the projects to be tracked, discussed, updated, voted upon and funded. Several crowd-funding projects indicate that they might be able to generate significant resources, certainly enough to build catalytic funding at the start of projects, alongside mechanisms for otherwise backing, discussing or sharing best practice or tacit knowledge about how to get things done.

This last aspect may be key. Traditionally, 'bottom-up' urban activism is the province of an individual who wants to give up every weekend for years, battling bureaucracy and inertia. They have to learn from scratch in each instance, as there are no breadcrumb trails to follow. With new platforms deployed, activism might become something akin to plain old *activity*, in which citizens are more deeply woven into the fabric of their city's decision making, by leaving traces for others to follow. This is the kind of thing the Web has done since day one.

Entirely new governance models are implied as a result, with far more frequent, open and active engagement than a vote in the municipal elections every four years. City halls rarely have a meaningful 'suggestions box' on the front door, and these new platforms could be just that. By shifting where and how ideas come from, they might reverse a NIMBY (Not In My Backyard) tendency such that it becomes YIMBY (Yes In My Backyard!) through genuine collaboration and participation in city making, in stark contrast to the dreaded 'consultation'.

Equally, such systems might be read as 'desire paths' for a more ongoing, everyday form of deliberative democracy in urban governance. The promise is that, through the familiar transformative effects of 'The Network', the practice of urban development itself might change radically. This is in direct contrast to the public perception of the current system, where lumbering and opaque urban planning functions as a countervailing force against developers and politicians who are inevitably 'on the make'.

The premise behind this argument is that citizens want to engage in their city; that it is citizens, not planning departments or property developers, who are best placed to notice, suggest, aggregate and drive a certain kind of urban intervention. This 'Kickstarter urbanism' is typically oriented towards the small things in cities – let's turn this parking lot into a community garden, let's renovate a co-working space, let's start a bike-sharing scheme – rather than taking on urban governance models, or attempting to fund large-scale infrastructure.

This in itself is not a criticism: what city would not benefit from people caring about the small things? But is there maybe the lingering sense that this might be a little 'bread and circuses'? A stream of micro-distractions to occupy the community, focusing citizens on trying to crowd-fund a park bench while the big boys in government get on with the big stuff – education, transport systems, energy policy, grand civic buildings, housing, and so on?

Social media can help catalyse an Arab Spring, but when used for a more local issue elsewhere – like Neighborland,enabling a proposal to extend commuter rail in Denver – it only attracts 50 'neighbours' who agreed with the proposal. Their well-meaning comments are unlikely to change the situation much – that billions of dollars would need to be found, somehow, from within a culture not particularly predisposed to funding sustainable public transit. Neighborland is a wonderful example of a new platform, but it is, in itself, not enough to create a new decision-making culture for making more sustainable decisions.

Although omnipresent, social media still betray the cultural conditions they were created in. NYU/Harvard Law School researcher Alice Marwick's analysis of social media centres on the assertion that they breed what she calls 'status seeking behaviour' ('self-branding') within a 'competitive attention economy', transposing a Silicon Valley-derived model of neo-liberal principles onto social organisation. Douglas Rushkoff described a related set of biases in his book, *Program or Be Programmed*, in which he identifies decentralising or individualising tendencies. For Malcolm Gladwell, the critique rests on a variant of 'bread and circuses', that social media do not generate ties strong enough to engender the genuine action required to change a regime – or perhaps a city. Either way, side-stepping the question of ideology, if we accept that sustainability ultimately requires an intrinsic selflessness – right now, it is about subsequent generations, distant lands, global conditions, and often it is *not* in my backyard – then this should be, at the very least, a red warning light on the dashboard.

All of this can be contested, of course. Clay Shirky's response to the Gladwell's critique, for instance, must be taken on board. He says that while digital networks 'do not (necessarily) allow otherwise uncommitted groups to take effective political action… they do, however, allow committed groups to play by new rules.'

The Network's ability to connect can, of course, enable civic empathy as much as it destroys it – depending on how we work with its tools and materials. There is genuine potential in the new tools, if we see them as sketches and not as solutions. One might take these settling design patterns and scale them up to a new form of urban governance, based on more frequent, more engaged, shared decision making, and not simply in bread and circuses mode. And one could shape those governance cultures in such a way that they counterbalance the potentially destructive individualistic biases within social media, enabling citizens to act with meaningful responsibility for their city. Government is there to take disruptive innovations and productively absorb them into a resilient system, such that it smothers social inequalities and generates broader access. That goal need not be solely achieved through our current systems of increasingly disengaged citizenship.

There is only one way to find out what balancing act might thrive under these new conditions, and that is to try it. 'Trying it' means considered, iterative prototyping of user-centred platforms; local experiments that can nonetheless scale up, and that are produced by designers, coders and city managers who understand both the Web and the city. There is no fundamental reason why municipalities could not work in this way, in terms of their strategic positioning, function and history. What if government was directly and boldly prototyping new versions of itself, using these new technologies: starting small, pivoting and scaling up, as all robust, resilient and popular contemporary systems do? It might be that a sense of public good, of civic responsibility, could be found within such a re-calibrated approach to municipal government.

We are in a radically different urban condition than the post-Enlightenment era in which we invented the modern municipality. Not just in terms of built fabric, whose significance is overplayed due to its sheer obviousness, but in terms of our highly interconnected patterns of living. The nature of our challenges are entirely different, with climate change the clearest example. The very idea of the city as a public good fundamentally rests on our ability to transform our municipalities for the twenty-first century. And the very idea of the sustainable city relies on understanding that the city is a public good.

For if sustainability requires us to think long term, we must surely create

The digital economy is attracted to resilient urban areas (Old Street 'Silicon Roundabout', London)

decision-making cultures that not only take the tendencies of these swirling vortices of individualism and short-termism into account, but actively counter them. Like judo, we might need to use the powerful dynamics of social media against themselves. Otherwise these opposing forces may cause shared cultures to tear themselves apart.

What possible models for cooperative urban governance might emerge? Do we need a city in which citizens understand that they are part of a wider, more holistic system, and act accordingly? To be actively engaged with, as opposed to being passively observed and 'fed back to', as is the case with most myopic smart city visions? How might we enable patterns of sustainable living that nonetheless recognise that cities thrive on the very unpredictability and inefficiency of citizens; that the city's ecosystems will refuse to settle in 'natural equilibrium'? How might we guide and shape a resilient city through shared governance cultures based on its incompleteness, openness and a sense of possibility, recognising that the city is a process, not a mere accretion of infrastructure?

Are we sure that these ideas – drivers and enablers, unpredictability and inefficiency, prototyping and pivoting, personal and civic responsibility, active citizens and active municipalities, the city as public good, recalibrated governance – are part of the emerging smart city vision? For these are all part of what makes a city work, what makes a resilient city and what makes a good city rather than just a smart city. ■

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ENERGETIC SOCIETY

Maarten Hajer and Hiddo Huitzing

The Dutch urban developer Dirk Frieling noted that 'rather than a densely populated country, The Netherlands is more like a sparsely populated city'. His words are still reason for pause for thought. Cities do not end at their municipal limits, and, in fact, they often spread out over regions. This is significant, especially because people who interact with each other, face to face in business districts, universities or city centres, often commute on regional scales. CEOs seldom live on their companies' doorsteps. These kinds of cities are constructed from a kaleidoscope of places and experiences. A city's diversity, the activities that take place within it, and the mutual relationships between its inhabitants often determine that city's strengths or weaknesses. A city is not only morphology: it is also about connections and spatial structures. Strong cities have energy, which cannot be attributed to the actions of local government. Yet, government has an important role to play in engendering such energy. The task is to determine what kind of governance philosophy would fit such a city, to generate a new form of energetic urban society.

The resolution of big issues is conventionally thought to require large government decisions. In this case, however, thinking big may not be the answer to today's problems. We have left the era of Le Corbusier behind. For the twenty-first century, the strength of the city must be sought in new relationships between government, citizens and the business community. All too often, government agencies alienate themselves from citizens, taking the moral high ground and intervening in a top-down manner.

In the 'energetic society', city governments can make more and better use of the energy embedded within a society, shaping its policies through positive and negative incentives, and setting medium- and long-term public goals. Sustainability is one such goal. Between now and 2030, the world must find a way of decoupling human welfare from the use of the earth's resources and its environmental effects. The relationship between the residential environments and global issues is abundantly clear to anyone tracing the origins of our food, transportation or home furnishings. The urban hinterland covers the globe and includes a huge variety of services, goods, materials, as well as flows of money, people and information. Every day container ships from around the world enter the port of Rotterdam to deliver flat screens, smartphones and the latest fashion items to cities and surrounding areas. The production and distribution of food, for example, involves a meticulously planned global logistics chain. Our daily lives are local in perception, but global if we take the logistics of production, use of resources and resulting emissions into account. Both citizens and public administrators seem to realise that liveable, clean cities are likely to be the champions of the future; not only because of the size of their share in the use of physical resources, but also because cultural change must begin within cities, in order to continue along the road we are on.

The fossil fuel era will not end because of a lack of coal, just as the Stone Age did not end because people ran out of stones. Literature on 'the history of the environment' shows that major breakthroughs were often attributed to a reorientation of values, with city dwellers always playing an important role. Such shifts in values can be seen today in societies where citizens want to generate their own power, and where companies that base their business cases on green operational models are the leaders and frontrunners in their field. However, government policy is lagging behind. When urban civil society adopts these new values, a new perspective on the future of cities will emerge.

Just as 'high carbon' could soon become synonymous with 'high risk', conversely a low-carbon profile could boost a city's image. The idea of a liveable, innovative city with a good air quality that makes efficient use of increasingly expensive resources is a visible leitmotiv for many urban administrators. But even so, the question is how to harness the energetic city to achieve a sustainable world. The answer will not come from large-scale governance delivering a masterplan, but will require individual administrators channelling societal energy in the right direction.

A society of well-educated and articulate citizens places large demands on public administration. Attempts to 'capture and store' CO_2 emissions underground in empty gas fields, has proven difficult and controversial in the Dutch town of Barendrecht, and the main reason is that its citizens were treated as if they were objects. The debate was framed in technological terms, with little consideration for their desires and fears. This emphasis on technology is also apparent in the thinking around sustainable cities. Solutions that regard the inhabitants of cities as objects are likely to be met with resistance, irrespective of whether those solutions come from a top-down government, or from a top-down technocratic perspective. Moreover, around 70 per cent of European cities that will be in existence in 2050 are already here. Over the coming decades they will merely be expanded or retrofitted to varying degrees. The main challenge facing these cities will be to improve and restructure existing urbanisation. With respect to the future, it will, therefore, be today's cities that lead us into the next phase.

The examples show that the transition towards a sustainable society cannot be achieved by government decree or technology alone, and certainly not without the participation of urban citizens. Increasingly, citizens, businesses and local governments are taking the initiative, obtaining their information from online networks. A scenario in which public administration focuses on *governance*, instead of being a *government* agent, must be created through collaboration between citizens and government. Only then can both parties approach each other in a positive way, resolving disagreements and facing challenges such as urban agriculture, local energy generation, and the setting of climate-neutral goals. In the business community this can be observed in the strategic reorientation of companies like DSM, Unilever, Tesco and the Van Gansewinkel Groep. The key feature of these initiatives is the evident shift in values, not the change in CO_2 emission levels. These changes put the government into a somewhat awkward position; society, in these cases, is more involved in the complex difficult transition than the government itself. Although this concerns only a small part of society, it could also present an opportunity for policy to play a role.

A recent report by the Dutch government on 'The Energetic Society' states that government currently does not utilise all of the creativity and learning capacities present within society. Concepts such as 'Empowered Deliberative Democracy' (EDD) and 'information society' give a new perspective on the political and institutional dimension of the energetic society. EDD was developed as a concept in 2001 to describe the innovative ways in which governments can utilise the energy and impact of ordinary citizens to achieve institutional reform. Combining everyday practice with communication, responsibility and deliberation, it extends beyond abstract issues (such as conflicting values, justification) and focuses on concrete issues (such as repairing potholes, improving schools and managing nature reserves). One of the basic principles of EDD is to focus on specific, tangible problems, the engagement of ordinary citizens and public administrators at a local level, and to jointly search for solutions to those problems. The technical possibilities offered by Web 2.0 to create two-way communication, as well as the increase of information available, provide the right circumstances for hands-on involvement of articulate citizens and companies in formulating sustainability and local environmental policies.

Urban citizens within the energetic society also create new structures themselves – by calling on the government to take responsibility, by focusing attention on tangible problems, and by searching for solutions through deliberation. In such cases, existing rules can hinder the development of new, previously unimagined and unconventional forms of collaboration, particularly in the field of energy. Surplus heat can, for example, be used to heat houses, flat school roofs can provide space for solar panels that generate power for their neighbourhood, and PV installations are cheaper when they are bought and installed in bulk. However, citizens are discouraged from collaborating in these unconventional ways by rules and costs, such as higher taxation on small-scale consumption, which become barriers to using innovative social sources of energy.

The twenty-first century may very well see a return to spruced up versions of former social forms of collaboration, such as cooperatives and societies – citizens' associations, focused on incorporating sustainability into their own local environments. People who want to generate their own power, or grow their own food, are becoming united and can now make use of the knowledge and experience available on the Internet. In San Francisco, if you consider installing PV panels to your home, you can analyse costs and benefits through a website using aerial photos to estimate the size of your roof surface, after which a database will provide information on local regulations and the procedures to be followed. Should you wish to do so, you could unite with your neighbours online, and jointly purchase such solar systems (see http://1bog.org; http://zonability.com). The same applies to urban agriculture, where citizens worldwide share their knowledge and experience of innovative techniques to grow vegetables indoors, using hydro-culture techniques (see www.rndiy.org; www.windowfarms.org) and exchange practical knowledge on how to start a temporary farm on a patch of wasteland (see http://enablingcity.com/). In these cases the government would just have to stand back and watch, doing what they find most difficult: do as little as possible. Citizens must be given the opportunity to get organised, and, together with public administrators, search for solutions. Only then would the energetic information society function properly.

The core challenge for the energetic city is sustainability. Citizens and administrators are already involved in this, each in their own way. Companies consider sustainability in terms of financial returns and investment security. Multinationals consider the greening of cities, including new infrastructure, as one of the major investment opportunities of the future. Governments would do well to recognise both the value and risks of this energy, and to distinguish the physical from the cultural dimension. A clean economy is feasible, but it implies far-reaching adjustments.

The use of resources and emission levels of greenhouse gases, such as CO_2, should be around five times lower than they are today. This requires government to take on a large role, starting with the commitment to seriously address the issue, by using effective, traditional tools such as pricing and regulation, and especially by identifying new revenue models. But cultural shifts need to take place as well. Initiatives taken by citizens, businesses and local administrators on their own may be insufficient to find solutions to the big problems of climate change, but they are indispensable components in reassessing the economy and the thinking on welfare and well-being. Without these cultural changes, reducing the burden on the environment and natural resources by a factor of five will be impossible.

Jointly, these initiatives within society can help create a widely shared vision of a new, stronger one. A smart, social and sustainable city creates an attractive image. Cities and the Internet, at both the local and global level, together are the breeding ground for ideas and shared visions of a sustainable society. However, to achieve the required 80 to 95 per cent reductions, we need both a local government that encourages and loosens the reins and a national government that helps to scale up promising initiatives and enables their widespread implementation. ■

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THE POLITICS OF CLIMATE CHANGE

Anthony Giddens

How do we plan for a future that is inherently uncertain and in order to limit risks which, since we have no prior experience of them, cannot be assessed with complete precision? How can the mistakes made by the previous generation of planners be avoided? Planning in the old days was based on forecasting, but the limitations of this method are by now well known. It works best for short-term scenarios and also in cases where present-day trends are to some degree set in stone. In the case of energy forecasting in Britain, for instance, we know that the existing generation of power stations will need replacing within a certain timescale.

We often want to predict the future in order to change it and where our attempts to change it become part of that future. This situation holds in the case of climate change. One way of dealing with it is by *backcasting*: asking what changes have to be made in the present in order to arrive at alternative future states. A successful outcome is imagined in the future, and different scenarios are calculated as to how it might be reached. We are talking therefore of alternative and plural futures, where adjustments, even radical revisions, are made as time unfolds and then built into other scenarios. This approach is essentially the one used by the Intergovernmental Panel on Climate Change (IPCC). The distinct advantage over traditional forecasting is that it allows much greater space for unforeseen contingencies that might dramatically alter predictions made at any specific date.

The point of backcasting is not to reveal what the future will be, but to weigh up future options and policy goals. Backcasting is especially relevant for environmental and energy planning issues, since they fit the circumstances to which the approach is most relevant. These are that the context is complex, a major reorientation of current trends is demanded and a timescale of several decades or more is involved. There are many examples across the world. A project was instituted in the Netherlands in the late 1990s, for example, to look for alternatives to meat production and consumption. Its key assumption was that by 2040 new protein foods should replace 40 per cent of current meat consumption. The foods would have to be at least as tasty as the most popular forms of meat, while having superior health value, among other qualities. The project considered how tastes might change to promote acceptance of such foods. It concluded that new protein foods could be produced 10-30 times more efficiently than meat, as measured in terms of reducing emissions, while at the same time producing a health bonus[1].

Backcasting sounds technocratic. In fact, it almost always involves a visionary element, since, by definition, it projects a future that is different from that seen from the present. Of course, forecasting will not disappear and will continue to be part of government planning. It is obvious that backcasting and forecasting are often complementary. Take, as an example, planning for the future of the water industry in Australia, a country suffering from droughts that are probably influenced by global warming and where water is becoming an ever scarcer resource[2]. Cynthia Mitchell and Stuart White argue that forecasting can identify policies that will produce results in the short term – it can help pluck the low-lying fruit. Backcasting is needed to think more radically about future possibilities. Forecasts about security of water supply in urban areas in Australia indicate major problems in guaranteeing adequate supply within a few years. Several policies that could quickly make a difference within the existing water system were identified, such as installing water-efficient shower heads and tap regulators, dual flush toilets, waterless urinals, taps operated by sensors and local water collection and recycling. In Queensland, where there have been prolonged periods of drought, reductions in customer demand of up to 30 per cent have been attained using such measures.

Backcasting, however, has helped suggest more far-reaching innovations. At the moment it is commonly assumed that water, sewage and storm-water systems should be considered and planned for separately. Thinking 'backwards' from a hypothetical situation of a total water cycle has produced quite a different perspective…

In thinking about planning, especially over the longer term, we find ourselves back with risk and uncertainty. Planning sounds like a straightforward process, but this is far from the case: it is highly complex and contingent. One of the main reasons for this is the fact that predictions, forecasts and plans that are made become themselves part of the universe of events that they are about. In an important sense they have to, since the point is to shape the future. Yet, at the same time, an inherent element of unpredictability is introduced and has to be coped with. Trying to alter public attitudes towards risk is a key part of planning policy…

A return to planning

… For most of the time and for the majority of citizens, climate change is an issue at the back of the mind, even if it is a source of worry. It will stay that way unless its consequences become visible and immediate. In the meantime, no strategy is likely to work if it concentrates solely upon provoking fear and anxiety, or if it is based on instructing people to cut down on this or that, and also on expecting them to monitor that process on a continuous basis.

A different approach is needed from the one currently prevalent at the moment. It must place an emphasis on positives as much as on negatives, and on opportunities rather than on self-induced deprivations. I would set out its main principles as follows.

Incentives must take precedence over all other interventions, including those which are tax-based. 'No punishment for punishment's sake': in other words, punitive measures should either supply revenue that is spent directly for environmental purposes, or be linked in a visible way with behaviour change – and preferably both. The drivers of petrol-guzzling vehicles, for example, should face heavy tax duties for the privilege, as heavy as is politically feasible, under 'the polluter pays' principle. Clear and self-evident options for behaviour management are available: switch to smaller cars or drive less.

The positives must dominate. This isn't as difficult as it might sound. Take the issue of making homes more energy efficient. There are several countries in the world that have managed to make major progress in this respect. How have they done so? Not by trying to scare people, but by emphasising the advantages of having homes that are snug, protected against the elements and which also save money. An example comes from Sweden, which was achieved by placing a strong emphasis on what was called 'community, style and comfort'.

Low-carbon practices or inventions that initially have only limited appeal can be fundamentally important if they set trends, or if they are seen as in some way iconic[3]. Most initiatives, whether social, economic or technological, are, in the early stages, open only to a small elite. In California, for example, there are long waiting lists for the hydrogen powered Lifecar, although the first models will be extremely expensive. However, investment in such a car will provide the opportunity to see whether the vehicle might have a wider market, and also gives it an avant-garde cachet. This is what happened with the Toyota Prius hybrid car, nearly a million of which have been sold worldwide. It was a vanguard model in the sense that it stimulated other manufacturers to start producing low-emission vehicles, whether hybrid or not.

Most initiatives that have successfully reduced emissions so far have been driven by the motivation to increase energy efficiency, rather than the desire to limit climate change. This observation applies to whole countries as well as to regions, cities and the actions of individuals. People are able to grasp and respond to this perspective more easily than they have done to climate change, with all its surrounding debates and complexities; it is not difficult to present energy efficiency in a positive light. What is at stake, as mentioned earlier, is energy efficiency in the economy as a whole, since efficiency gains in one context are of little or no value if savings made are spent on energy-consuming activities elsewhere. The fundamental problem at the moment is to make clean energy sources competitive with fossil fuel energy sources, whether through public provision of subsidies or through technological advance. Utility companies in the US have been offering electricity generated from wind or solar sources to consumers since the late 1990s. Initially, take-up was very small, since the prices were not competitive. In early 2006 Xcel Energy in Colorado and Austin Energy in Texas offered tariffs below those of the regular energy sources. Austin Energy encouraged its customers to sign up for ten-year energy contracts, and was able to prosper even when the price of electricity dropped.

The role of technology in promoting low-carbon lifestyles is bound to be considerable. Technological innovation rarely determines what people do, since we often react to it in ways in which its initiators did not suspect. Thus, when the telephone was invented in 1876 as a signalling device; no one imagined that it would become so intrinsic to our lives as a medium of talk and conversation[4]. Yet, at the same time, our lives can change dramatically through such interaction with technology. It is said that we are creatures of habit, and it is often true, especially if habits become addictive. Yet this is far from always the case – we can change our behaviour quite rapidly and dramatically, as has happened, and on a global level, with the arrival of the Internet.

Government should be actively encouraging the creative economy and the creative society, even when these don't seem to have an immediate bearing upon climate change, since creativity has to be the order of the day. Richard Florida, who has written extensively on the subject, argues persuasively that the creative sectors of the economy – where innovation, lateral thinking and enterprise can flourish – are

increasingly becoming the driving force of the economy as a whole. Florida rejects the idea that creativity – the capacity to innovate, to question conventional wisdom – is limited to the few. Creativity is a 'limitless resource.... It's a trait that can't be handed down, and it can't be owned in the traditional sense.'[5] R&D investment is important, but in pioneering responses to climate change, we need to be bringing science, the universities and social entrepreneurs closer together.

Step changes or 'tipping points' aren't confined to the field of climate change science. They apply to social and economic life too – that was the context, in fact, in which the author who popularised the term, Malcolm Gladwell, originally discussed it[6]. We should be looking to create tipping points when it comes to the transition to low-carbon lifestyles. From small beginnings, much larger changes can occur when a certain threshold is reached.

Governments have an important role in 'editing choice', and, in pursuing that aim, they shouldn't be afraid to take on big business when it is necessary to do so. Corporations influence our choices in many direct and indirect ways – the state shouldn't be reluctant to take a leaf out of their book. For instance, supermarkets usually place sweets and chocolates close to the exit, where customers line up to pay for their purchases. The reason is that at that point they are open to impulse buying, having relaxed after making their main purchases. Given the advance of obesity, I see no reason why such a practice shouldn't be either prohibited or actively discouraged (although thus far it has not). How far we should go with choices that affect carbon consumption is a moot point. Some examples of choice editing appear to be completely unobjectionable. We could, for example, we could propose that heating and air conditioning should be organised in such a way that everyone knows immediately how much they are spending at any given time. The effect would be even more powerful if we knew how our expenditure rated compared to that of our neighbours. A study showed that heavy users made bigger cuts in consumption if a smiling face was inscribed on bills below the average, with a frowning face on the bills of those having higher than average expenditure. Other examples are more complicated. I see no civil liberties issue in cases where our behaviour is being significantly influenced, or manipulated, already by companies, and where the object of government policy is to counter that influence[7].

Technologies and Climate Change

Ambitious attempts have been made to anticipate how the spread of renewable technologies will transform modern economies. Some speak of the coming of a new industrial revolution, which will be initiated by such technologies. The American political thinker Jeremy Rifkin argues that the great changes in world history have taken place when new sources of energy have emerged in tandem with developments in communications. The convergence of coal-based power and the printing press gave rise to the first industrial revolution. Previous forms of communication would not have been able to handle the social and economic complexities introduced by the new forms of technology. The 'second industrial revolution' started in the late nineteenth century. It was marked by the invention of electric communication, beginning with the telegraph and branching out into the telephone, radio and television. These developments converged with the emergence of oil as a major form of power generation and as the dominant source of energy for transport.

We now stand on the verge of a 'third industrial revolution', Rifkin says, which will have as its backdrop the development of networked communication, represented by personal computers and the Internet. The potential of these technologies lies in their convergence with renewable energy. We can envisage a global energy economy where millions of people produce renewable energy and share it with others through national and international power grids – as happens today with information. Just as personal computers have vastly more power than the early machines, which took up several rooms, so intelligent energy networks will become more powerful and ubiquitous than anything we know at the moment.

Rifkin has his favourite renewable energy source to help point the way ahead: hydrogen[8]. Hydrogen, he says, is the 'forever fuel', since it is the most ubiquitous element in the universe – and it produces no greenhouse gas emissions. Fuel cells using hydrogen are already being introduced into the market for home and industrial use. The top-down energy regime that exists today with the emphasis on oil and gas will be replaced by decentralised energy production and use. It will be 'the first truly democratic energy regime in history'[9].

Such ideas aren't particularly compelling. In the first place, they reflect a view in which history is driven in large part by technology, a partial notion at best. The dating and nature of the supposed second industrial revolution are vague – as can be seen by the fact that other authors who propose similar ideas come up with quite different versions of when it happened and what its content was. Some, for example, date it 40 or 50 years later than Rifkin does. No one knows as yet what role a specific energy source such as hydrogen might play. Moreover, technologies never operate on their own – they are always embedded in wider political, economic and social frameworks, which are likely to govern both how they develop and what their consequences are.

In addition, the 'next industrial revolution' hasn't as yet actually happened. The original industrial revolution did not occur in a conscious way. The next one, however, has to be created as a deliberate project to protect us against future dangers – a very different situation. We don't know how things will turn out. It could be, as Rifkin hopes, that energy and politics will march in line – decentralised network systems, rooted in communities, will replace current forms of political and economic power. It is the vision that many in the green movement would like to see realised. I'm not sure such an outcome is either likely or desirable. Certainly, it is very possible that most households will help create energy, rather than just consume it – as is already the case, for example, with feed-in tariffs. However, we will also need coordinated energy management on a national as well as an international level.

Technological innovation has to be a core part of any successful climate change strategy and the same is true of energy policy. The state and government must have a significant role in making such innovation possible, since a regulatory framework, including incentives and other tax mechanisms, will be involved. What role should this be exactly? The issue overlaps with that of planning. For a while, it became conventional wisdom that markets cannot be second-guessed. Nor can we predict with any precision where innovation will happen. Today the pendulum is swinging back again. Various technologies or non-fossil-fuel energy sources are touted as the answer to our need to reduce emissions; large amounts of investment are flowing into them. People are again placing bets on the future. ■

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Edited extracts from A Giddens, *The Politics of Climate Change*, Polity Press, 2009, reproduced with permission of the author.

Endnotes

1 Jaco Quist and Philip Vergragt, 'Backcasting for Industrial Transformations', in Klaus Jacob et al. (eds), Governance for Industrial Transformation (Berlin: Environmental Policy Research Centre, 2003), pp. 423-5. Many other examples are discussed in this text.
2 Cynthia Mitchell and Stuart White, 'Forecasting and Backcasting for Sustainable Urban Water Futures', Water 30 (2003).
3 Ron Pernick and Clint Wilder, The Clean Tech Revolution (New York: Collins, 2007), pp. 263-73.
4 See Ithiel de Sola Pool, The Social Uses of the Telephone (Cambridge, MA: MIT Press, 1977).
5 Richard Florida, The Rise of the Creative Class (New York: Basic Books, 2004), pp. 34-5.
6 Malcolm Gladwell, The Tipping Point (London: Little, Brown, 2000).
7 For a discussion of some of these practices, see Richard Thaler and Cass Sunstein (yes, the self-same destroyer of the precautionary principle), Nudge (New Haven: Yale University Press, 2008).
8 Jeremy Rifkin, The Hydrogen Economy (New York: Tarcher, 2002).
9 Ibid., p. 9.

DATA

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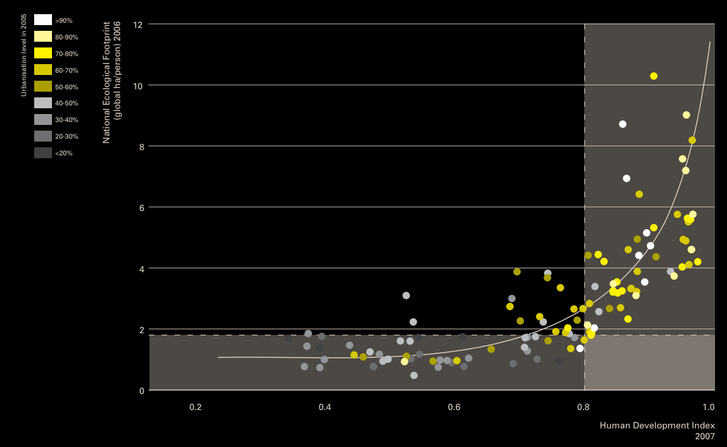
LSE Cities investigates the links between social and physical dimensions of cities. Over the last year, our research has focused on the environment and climate change in a series of projects that investigate how cities are becoming more innovative in promoting the green agenda. Some of this research is summarised in the following pages of the Urban Age Electric City newspaper, providing a global overview of energy consumption and pollution patterns and detailed comparisons of density, transport and governance between established Urban Age cities – London, New York, Berlin, Istanbul, Mumbai and São Paulo – and a selection of 'green pioneer' cities – Hong Kong, Stockholm, Copenhagen, Portland, Singapore and Bogotá.

Human Development, Ecological Footprint and Urbanisation Level



This graph captures the key relationships that drive much of LSE Cities' research on cities, by mapping social and environmental dimensions of cities against each other. In countries across the world urbanisation has been accompanied by an increase in well-being – but also by unsustainable environmental impacts. Only a few highly urbanised countries have low environmental impact, but almost all countries with high levels of human development are urbanised. Achieving sustainability – a human footprint that fits within the earth's bio-capacity while allowing for social wellbeing – has proved elusive. Nevertheless, considerable variation in the environmental footprint of urbanised societies provides evidence that certain forms of urban living are more sustainable than others. The challenge for future cities lies in learning from the world's green leaders to ensure cities provide for human flourishing by using innovation, design and technologies to live within the earth's ecological limits.

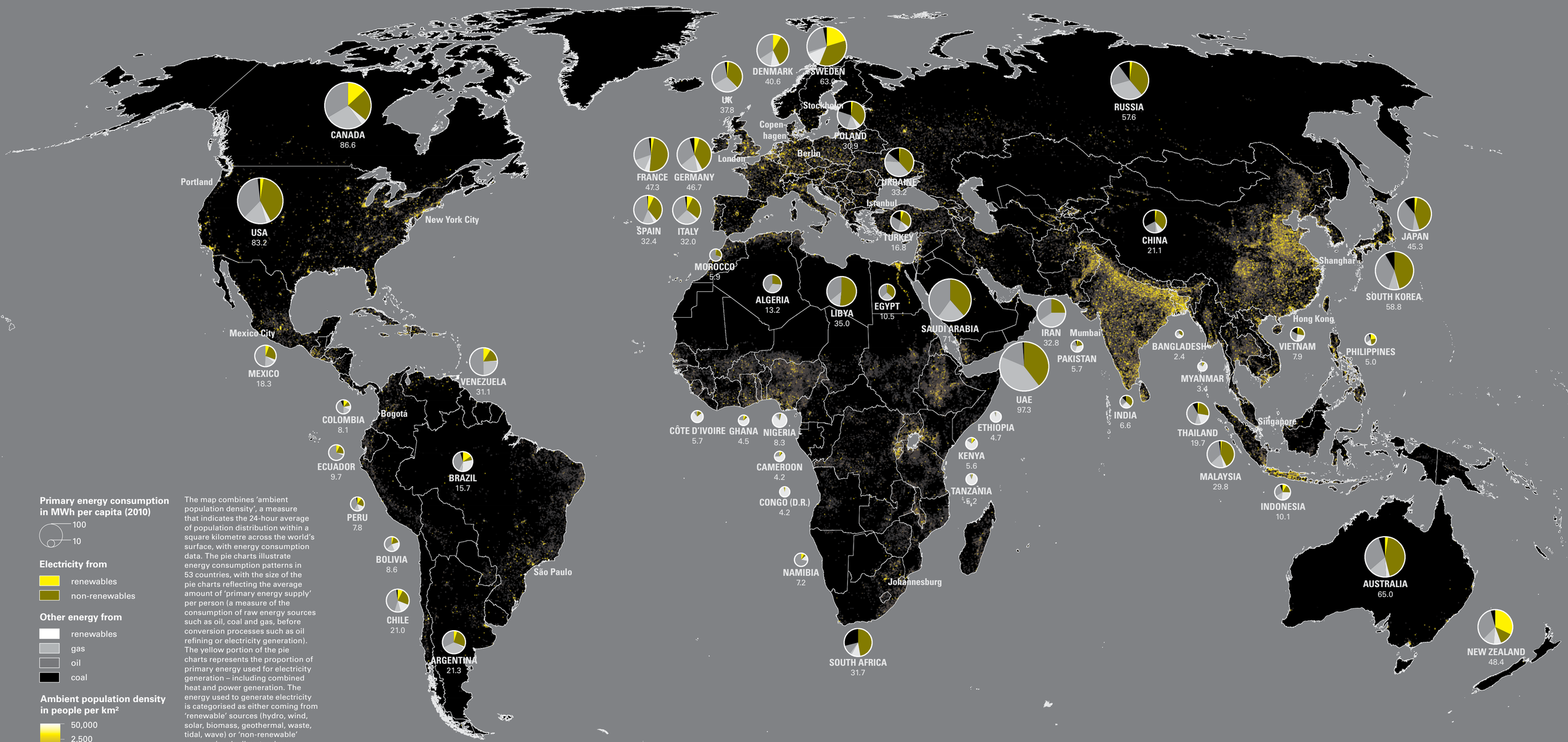
For full references to data sources, please see: http://ec2012.lsecities.net/references/

GEOGRAPHY OF ENERGY CONSUMPTION

Where people live and how much they consume are inextricably linked. Yet, their patterns of distribution do not match up. People living in the highly concentrated urbanised regions of eastern China and the Ganges Valley in India have modest consumption patterns compared to the oil and petrol-guzzling habits of those in the more sparsely populated regions of North America and the Middle East. There are equally varied patterns between the established urban areas of Europe and the US and the more widely scattered, but dense cities of Latin America and Africa. Reflecting global disparities in wealth, lifestyles and consumption, these data show that a person living in the United Arab Emirates is likely to use 40 times more energy than a Bangladeshi, while a UK citizen consumes less than half of his US counterpart, but twice as much as a Mexican, and slightly less than a Dane.

Electricity is a major component of the world's energy mix. Yet, despite living in the 'electric age', electrification differs substantially between countries, swinging from less than 5 per cent of total energy in Nigeria and Nepal, to more than 50 per cent in Sweden and France. But a high share of electricity does not necessarily deliver environmental benefits. Generation is still dominated by carbon emitting fossil fuels, and electricity is not always the most efficient energy choice for uses such as heating and cooling in buildings.

Aside from electricity, most of the world's energy consumption involves directly burning fossil fuels, such as oil for transport, coal for making steel and cement industries and gas for heating. Despite recent improvements in some countries in procuring energy from renewables, they make up only 13 per cent of the world's total consumption – mostly hydro-electricity in high-income countries and biomass for cooking and heating in low-income countries.



Primary energy consumption in MWh per capita (2010)

100
10

Electricity from

renewables
non-renewables

Other energy from

renewables
gas
oil
coal

Ambient population density in people per km²

50,000
2,500
0

Sources: LandScan (2012)™ High Resolution Global Population Data Set International Energy Agency (2010). World Energy Balances Database (2012 Edition)

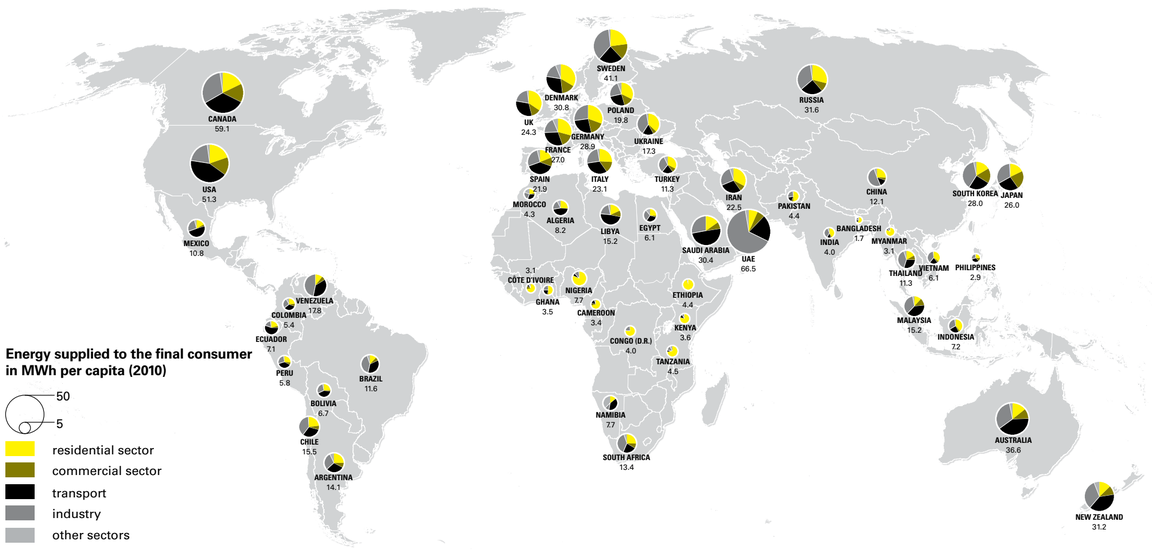
The map combines 'ambient population density', a measure that indicates the 24-hour average of population distribution within a square kilometre across the world's surface, with energy consumption data. The pie charts illustrate energy consumption patterns in 53 countries, with the size of the pie charts reflecting the average amount of 'primary energy supply' per person (a measure of the consumption of raw energy sources such as oil, coal and gas, before conversion processes such as oil refining or electricity generation). The yellow portion of the pie charts represents the proportion of primary energy used for electricity generation – including combined heat and power generation. The energy used to generate electricity is categorised as either coming from 'renewable' sources (hydro, wind, solar, biomass, geothermal, waste, tidal, wave) or 'non-renewable' sources (coal, oil, natural gas, nuclear). The grey and black portions represent energy used for purposes other than electricity generation, including transport, heating and industry.

ENERGY, ELECTRICITY AND EMISSIONS

Energy consumption by sector shows variations in levels of average consumption per person and differences in the mix of activities for which energy is used. Energy is used at higher proportions in Sub-Saharan Africa for domestic use, especially for cooking and lighting, and by the transport sector in North Africa and in the Middle East, reflecting high levels of motorisation combined with inexpensive local oil supply. Energy for the commercial sector – offices, shops and public services – accounts for less than 10% of total consumption, although the proportion is higher in advanced economies. Industrial energy use dominates Asian manufacturing hubs in China, South Korea and Thailand.
Electricity share at home reveals wide variations in household use and the degree of electrification. In Saudi Arabia, Australia, New Zealand and Japan, most household energy is electric but in other high-income countries other sources, such as gas for heating, make up a greater proportion of total consumption. Average consumption per person is highest in wealthy parts of Europe and North America, but is also high in Sub-Saharan Africa where dependence on biomass sources (such as wood for cooking) explains the reasonably high levels of domestic energy use in the absence of electricity infrastructure.

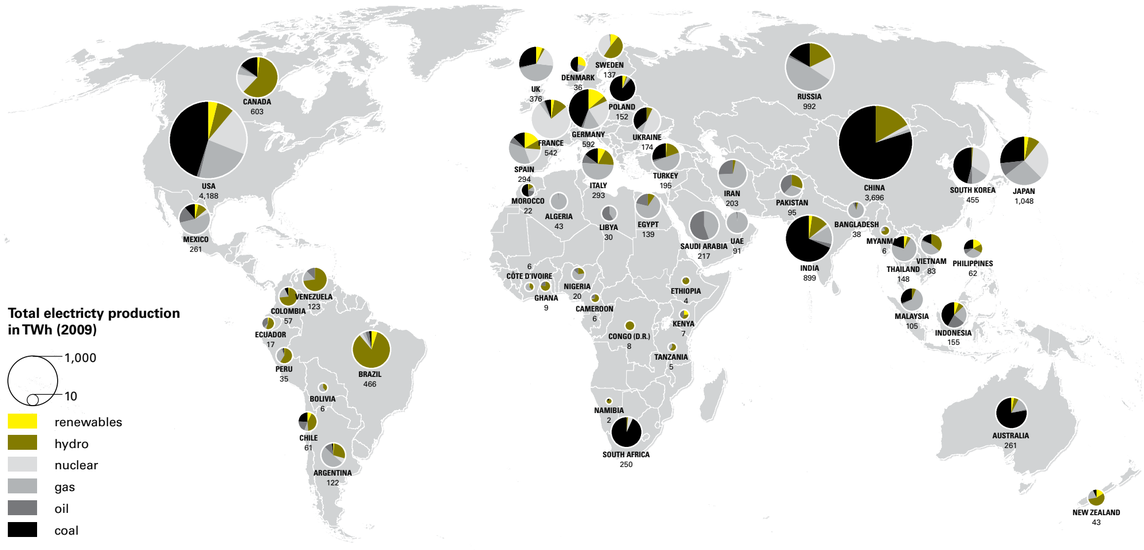
Electricity generation by source shows variations in the total amount of electricity generation (rather than per capita values as in the other maps). Coal is a major source of power in the US, China, India and Germany – some of the world's biggest economies. The oil-rich Middle East and North Africa burn oil and gas, while in South America cleaner hydro-sources dominate. Despite recent policy shifts, renewable sources other than hydro-electric power – energy generated from wind, solar and geo-thermal sources – contribute to only 3 per cent of the world's electricity generation – with the highest proportion in Denmark, where they fuel around a quarter of electricity generation.
Carbon emissions by sector confirms that fossil-fuel based electricity is an important contributor to global climate change. Emissions from electricity generation vary depending on fuel source, with coal-dependent countries such as Australia, China and South Africa showing high proportions. In contrast, Denmark has lower emissions fom electricity due to its high level of renewable generation. Varying levels of emissions from transport echo motorisation rates. Global carbon emissions are concentrated in a few nations with China and the US alone producing 39% of global emissions.

ENERGY CONSUMPTION BY SECTOR



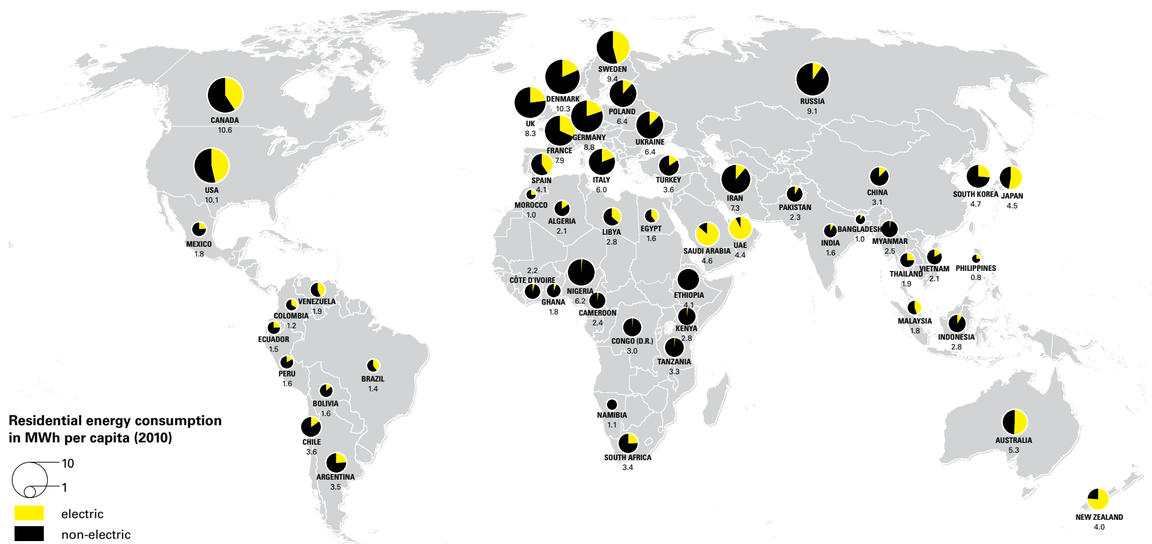
Source: International Energy Agency (2010). World Energy Balances Database (2012 Edition)

ELECTRICITY GENERATION BY SOURCE



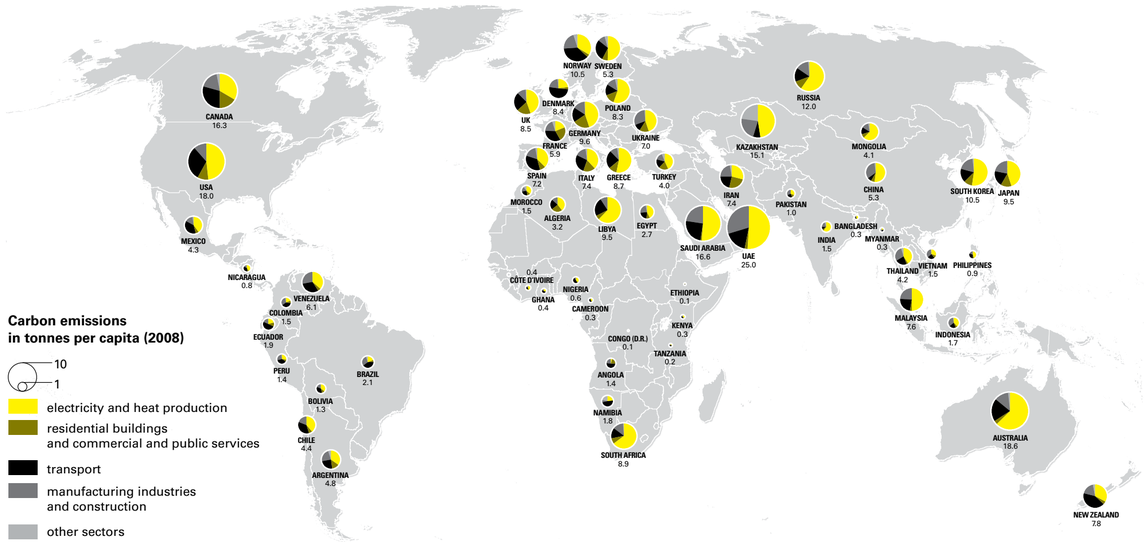
Source: IEA Online Statistics © OECD/IEA 2012

ELECTRICITY SHARE AT HOME



Source: International Energy Agency (2010). World Energy Balances Database (2012 Edition)

CARBON EMISSIONS BY SECTOR



Source: World Bank (2008). World Development Indicators – CO_2 Emissions

CITIES AND THE GREEN TRANSITION

Between January and September 2012 LSE Cities surveyed close to 100 city governments from around the world to better understand the leading role cities are playing in adopting environmental policies and transitioning to a green economy. The survey was completed in partnership with ICLEI (Local Governments for Sustainability) and the Global Green Growth Institute, with results published for the Rio+20 Summit in June and the Global Green Growth Forum in Copenhagen in October 2012.

The survey included a diverse range of cities representing variations in population size, regional location and income level. The findings reveal insights on cities' motivations for adopting green policies, their progress in integrating complementary economic and environmental objectives and their experiences in coordinating governance for green policy. While a range of environmental challenges and green aspirations were found to be widely shared across the world, the results also find important distinctions in green policy experiences, particularly associated with the substantial differences in wealth across the surveyed cities.

The results featured on this page summarise key findings from the survey, with a more comprehensive set of results available at: http://lsecities.net/publications/reports/going-green/.

ENVIRONMENTAL CHALLENGES

The survey responses confirm that environmental problems are some of the most pressing challenges facing cities today. Many of the most widely experienced problems are associated with transport and urban planning and include air pollution, road congestion and urban sprawl – all significant challenges for more than 60 per cent of the surveyed cities. Storms and flooding, solid waste management, water pollution and lack of green space are also problems for the majority of them.

Cities in middle- and low-income countries face additional environmental challenges compared to those experienced in high-income countries. Commonly reported problems are often associated with inadequate infrastructures and include clean water supply, sewage treatment and dumped household waste.

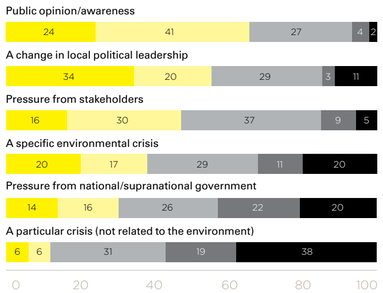
GREEN TRANSITION: PROGRESS TO DATE

In a context where many urban environmental problems continue to be unresolved, virtually all city governments regard green objectives as important components of their political agendas. This priority for green issues is a relatively recent shift, with 65 per cent of cities reporting that green objectives have only become politically important since the 1992 Rio Earth Summit.

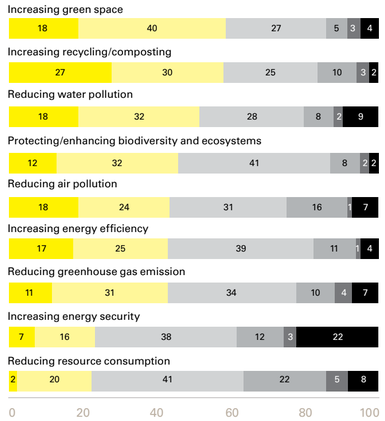
Although urban environmental problems are significant, local environmental crises or tipping points have not been the primary drivers of the green transition. Rather, public awareness and changing political leadership have been more important triggers prompting the adoption of green objectives. In middle- and low-income countries, pressure from national governments and international agencies has also been important in prompting green policy development.

Green objectives are widely shared, but progress in developing policies varies across sectors. More than half of cities report their policies as well-developed in the waste (65 per cent), land-use (60 per cent) and water sectors (60 per cent), while only one in five cities report having well-developed policies for the food sector. For the waste and water sectors, comprehensive policies have translated into successful outcomes on the ground, with most cities increasing waste recycling and reducing water pollution – particularly those in high-income countries. Reducing resource use and establishing energy security have proved more challenging, with less than a quarter of cities reporting success in achieving these objectives.

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



To what extent have the following green policy objectives achieved successful outcomes in your city?



BUILDING THE GREEN ECONOMY

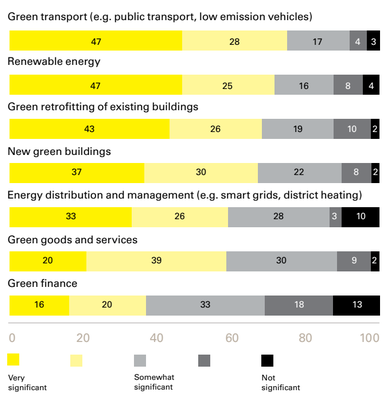
In tackling environmental problems, cities are realising the opportunity for considerable economic co-benefits. An overwhelming majority of city governments (93 per cent) expect their green policies to have a positive economic impact. Most cities view economic growth and improved environmental outcomes as complementary, with 65 per cent describing economic growth as a primary goal of their green policies, and a further 31 per cent regarding growth as a secondary goal.

Alongside economic growth, cities expect a broad range of economic benefits arising from their green policy agendas, including attracting investment (78 per cent of cities), increasing innovation (76 per cent), creating jobs (72 per cent), and increasing economic resilience (69 per cent).

Cities identify urban transport, buildings and energy as the key sectors for green economic growth. Both new green buildings and retrofits of existing buildings are seen as making important contributions to green growth, while renewable energy generation and energy distribution networks, such as smart grids, are identified as particularly promising areas within the energy sector.

While city authorities are confident that green policies can lead to economic gains as well as environmental benefits, economic impact assessments of these policies are rare. This presents a major gap. City governments could strengthen their case for more effective and efficient green economic policies by building a rigorous evidence base for the economic impacts delivered.

How significant are the following sectors of the green economy for your city's economic growth?



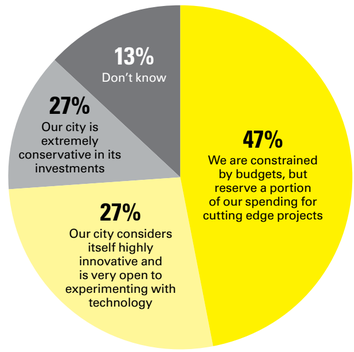
TECHNOLOGY AND INNOVATION

Cities see technology as playing a key role in the transformation to a green economy. New technologies are identified as being particularly important for green transport, energy generation and green buildings – with more than three quarters of surveyed cities agreeing that new technology is important in these sectors. A number of specific technologies are seen as most relevant for green economy strategies including transport technologies, such as intelligent traffic management and low-emission vehicles, and energy-saving technologies, such as efficient home appliances and building control systems.

The surveyed city governments generally believe that they should play a leading role in driving green innovation – with 81 per cent agreeing that they should lead by example and introduce innovations within their own operations. Furthermore, 74 per cent of city governments report that they are willing to invest in experimental cutting-edge projects to stimulate change – while only 15 per cent report taking a conservative approach to technological innovation and investment. Municipal governments see themselves as playing an important role in facilitating innovation, with only 6 per cent of respondents agreeing that responsibility for driving green innovation should be left solely to the private sector. The responses indicate that many cities are willing to be first movers and accept some degree of risk in fostering green innovation.

Which of the following technologies is your city intending to use as part of its green strategy?

Which of the following statements best describes the way your city approaches green technology innovations and investments?



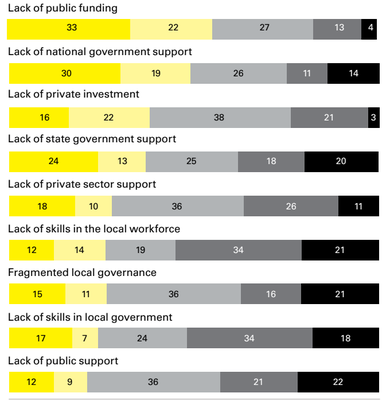
CHALLENGES TO GOING GREEN

City governments have bold green aspirations, yet the successful implementation of environmental and green economy policies is not without challenges. Insufficient public funding and lack of support from national-level governments emerge as the most important barriers thwarting achievement of green objectives – and were reported as significant by more than half of the cities involved.

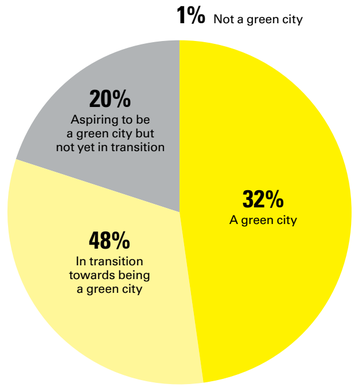
Coordinating government objectives across scales – particularly between city and national governments – is seen as particularly important for accelerating green initiatives. For 60 per cent of cities, national policy frameworks currently fall short of supporting cities' green agendas – a problem particularly noted by North American and European cities. Policies in the transport and energy sectors are most frequently noted as undermining cities' green goals.

While lack of policy expertise or public support for green policies do not emerge as a particular challenges across the overall sample of surveyed cities, these problems do often exist for cities in middle- and low-income cities. Cities in these contexts report more challenges to going green and commonly identified lack of public support, lack of private-sector support, and lack of government and workforce expertise and skills as important barriers preventing progress towards their green agendas.

How significant are the following barriers to achieving your city's objectives?



How would you define your city in relation to the green agenda?



CAN CITIES DRIVE THE GREEN TRANSITION?

The survey highlights a number of common experiences for cities around the world as they develop environmental policies and build green economies. For instance, problems associated with unsustainable transport systems, including air pollution and urban sprawl, are widely reported. Cities from diverse contexts also report common challenges working against their green objectives – with coordination and alignment of policy between local- and national-level governments emerging as a particular problem.

Important differences in city governments' experiences also exist, with cities in middle- and low-income problems facing a broader range of local environmental problems, often associated with poor basic infrastructure, such as clean water supply and solid waste management. In working to resolve these challenges, poorer cities also unsurprisingly report more barriers to developing green policy with lack of public- and private-sector support and inadequate skills and expertise all being barriers that exist to a far lesser degree in high-income cities.

The survey reveals a promising opportunity for transitioning to a greener economy, with cities around the world embracing green aspirations. Most cities report good local capabilities and a willingness to take risks and innovate to achieve green objectives. Green policies are widely developed and success has been achieved in areas such as cleaning up waterways and increasing waste recycling. Cities have the opportunity to build on this momentum and take a leading position in driving the green transition.

URBAN AGE CITIES

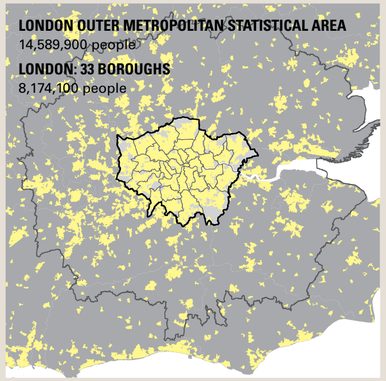
Since 2005, Urban Age has investigated cities experiencing significant growth and change across the globe. As approximately 75 per cent of the world's energy use and 80 per cent of the world's carbon emissions result from urban activities, cities have an essential role in achieving environmental and economic sustainability. These goals need to be achieved in tandem with improving quality of life for the world's 3.5 billion urban residents. This analysis explores the overall form, population and administrative boundaries of six established Urban Age cities and introduces a further six 'green pioneer' cities, noted for their innovation in environmental policy and practice.

Strong civic leadership is a critical component in managing urban change and directing cities towards a more sustainable future. Governing cities is more challenging where the powers of city administrations are limited, and where dynamic urban regions extend beyond administrative boundaries. This is especially true in rapidly growing cities. In São Paulo, for instance, less than two thirds of the city's built-up core falls within its administrative boundary, and consequently this increases the importance of the State of São Paulo, its regional governance body. Metropolitan governance is strong in Berlin and Istanbul, enabling better coordination of growth, in contrast to New York and Mumbai, where functional regions extend far beyond administrative areas. The devolution of power to the Greater London Authority in 2000 has ensured alignment between population distribution and political authority, enabling more integrated and strategic planning in the UK capital.

As national governments struggle to agree to environmental targets and objectives, greater innovation in sustainable urbanism is becoming more established in cities around the globe, regardless of size or geographical location. Here LSE Cities focuses on six cities that have provided leadership as 'green pioneers'. Environmental initiatives can result from long-standing policy traditions, as well as through new city programmes that cut across different sectors. In this respect, the Scandinavian capitals of Copenhagen and Stockholm stand out as having made a big impact in the fields of decentralised energy, building efficiency and promoting walking and cycling.

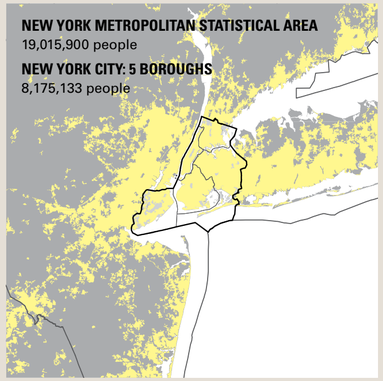
Other cities have made progress in more specific sectors. Portland is an interesting example from the US, where cohesive regional governance has implemented effective mechanisms to control sprawl, increase public transport use, and encourage walking and cycling. Implementing the policies of strong city mayors, Bogotá is an early developer of green transport and cycleway systems, which have transformed travel patterns and road safety in the South American city, confirming that innovation from the developing world can have major impacts in areas of rapid urban change.

Hyper-dense and affluent cities, like Hong Kong and Singapore, offer a very different context for urban sustainability. Both cities have taken advantage of their limited land resources and centralised planning structures, promoting compact and well-connected urban form to render their cities more efficient and competitive. The highly controlled city-state Singapore has pioneered congestion charging, and radically improved efficiency in water use and in waste production. Hong Kong continues to invest in strong economic and social connectivity across the region, creating and sustaining one of the world's most efficient public transport and pedestrian networks.



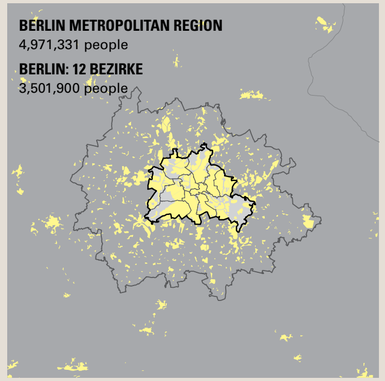
LONDON

London's population has grown by 900,000 in the last decade and reached 8.2 million in 2011. This is close to the city's historic peak of 8.6 million, recorded in 1939, and 400,000 more than anticipated by the Office of National Statistics. The establishment of an elected mayor has seen improved land use and transport coordination – reinforcement of the Green Belt and introduction of Congestion Charging – and a range of environmental initiatives aimed at reducing carbon emissions and improving air quality.



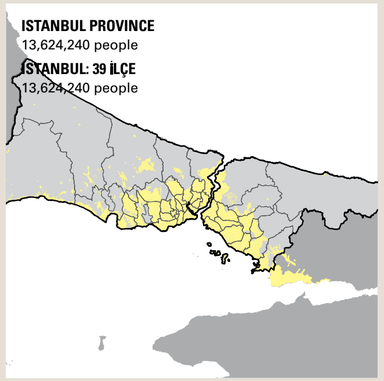
NEW YORK

New York City's population reached a record high of 8.2 million in 2010. The city is the core of an extensive metropolitan region of over 19 million people. Recent planning policy has focused on improving the quality of green spaces and upgrading building energy efficiency, but transport improvements have been frustrated by control of the Mass Transit Authority by the State of New York. On the economic front, digital sectors have been a key component of recent growth, including new media start ups concentrated in the high-profile 'Silicon Alley' cluster.



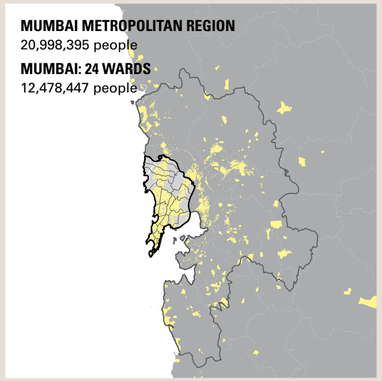
BERLIN

Berlin has undergone modest growth in the last decade and now has over 3.5 million residents. Despite its fragmentation, the city has an effective municipal and regional planning system, which has made the most of its dense inner city core and highly integrated multi-modal public transport network. Although the city has underperformed economically compared to Germany as a whole, it has fostered a significant cluster of digital economy and creative industry firms, and remains highly attractive to young families and artists due to affordable house prices and good quality of life.



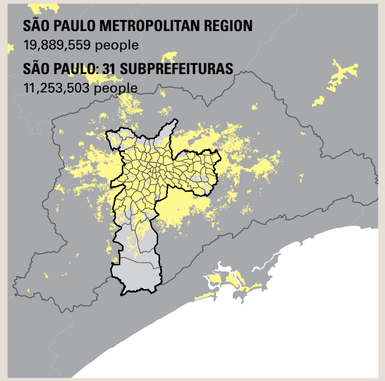
ISTANBUL

Istanbul's population has expanded rapidly in the last decade, from 10 million in 2000 to 13.6 million in 2011. Strongly committed to achieving global city status, the ancient 'hinge city' has a large, unified provincial and city government, which ensures greater regional coordination in transport and economic planning. The city is accommodating large numbers of new government-funded housing (TOKI) and has a complex public transport network of rail, metro, ferries and trams. The city introduced a Bus Rapid Transit system and is completing the first rail link across the Bosporus through the Marmaray tunnel.



MUMBAI

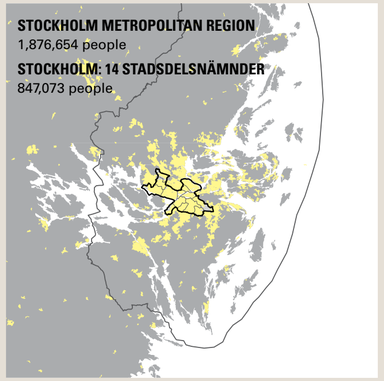
Mumbai's population has more than doubled in the last 40 years to reach 12.5 million within the city boundary, and over 20 million in the wider metropolitan region. This extreme growth has placed pressure on the city's infrastructure, with large sections of the population living and working in the informal sector. Significant investment is taking place in the regional rail network and a new metro, and in a controversial road building programme. The regional development authority coordinates planning between the seven municipal corporations in the wider metropolitan area, but many key policy decisions are taken by the more extensive and remote State of Maharashtra.



SÃO PAULO

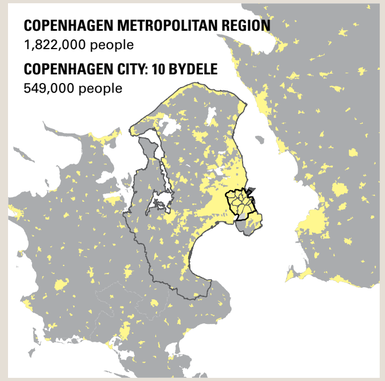
Brazil's economic engine extends horizontally across a vast area that cuts across the city and state boundaries of São Paulo, with areas of poor infrastructure and informal housing pushed out to the periphery. Security and health care are prime concerns of Paulistanos, in a city with high crime and inequality rates. São Paulo's notorious traffic congestion can require four hours of daily commuting times for its residents, even though there have been recent attempts at both state and city level to improve public transport and make the most of Brazil's leadership in sustainable energy initiatives in biofuels and hydro-power.

40 km 80 km



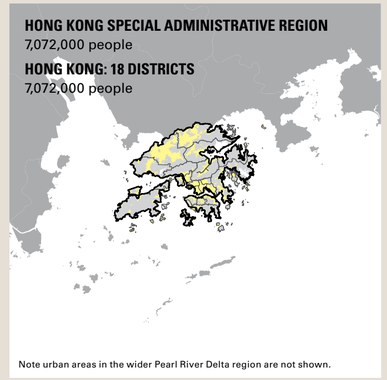
STOCKHOLM

Stockholm's population expanded to nearly 850,000 inhabitants (1.9 million at metro level) by 2010, and its administration has prioritised environmental sustainability for decades. The development of the city's district heating network started over 50 years ago, and now accounts for nearly 80 per cent of the city's demand, with its strict building regulations, which exceed Swedish national standards, set by the city government. Stockholm has a comprehensive public transport system and high quality pedestrian environment, and has been effective at promoting high-density development on redundant industrial land.



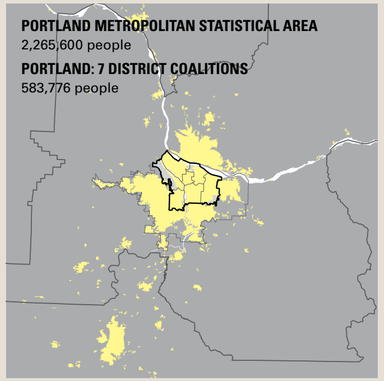
COPENHAGEN

Recognised as a world leader in green policies, Copenhagen's population has grown 18 per cent since 1990 to reach 550,000 (1.8 million at metro level). In addition to district heating and regional land use planning initiatives, Copenhagen is best known for its investment in a wide and well-used cycling infrastructure with 370 km (224 miles) of bike lanes across the municipality. The city has invested in public transport by expanding the new metro system and improving links in the cross-border Øresund region, and is promoting a new generation of green buildings and housing typologies.



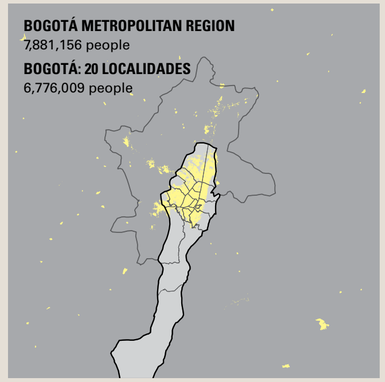
HONG KONG

Constrained by mountains and the sea, Hong Kong's population reached nearly 7.1 million in 2011, building on its connections to mainland China and its international port activities. The city has achieved a high level of integration between land use planning and transport, developing one of the world's most efficient rail networks in one of the world's densest cities. The unitary government structure gives the city extensive powers in planning and fiscal policy, maintaining control over land freehold and development rights.



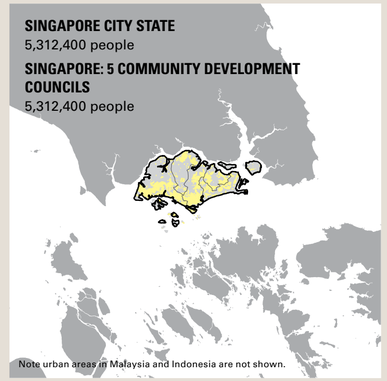
PORTLAND

The city of Portland in the US north-western state of Oregon forms part of a wider urban region integrating several municipalities in a continuous built-up area. Grouped in a regional metropolitan authority that controls land use planning, these authorities have led the field in environmental policy innovation, making the city and its region a radical pioneer within the North American context. The implementations of an Urban Growth Boundary and allied initiatives have boosted public transport demand, with the city developing a light rail network and significant cycling provision. Portland is also an innovator in green buildings and developing digital tools for civic participation.



BOGOTÁ

Bogotá's population increase has mirrored South American trends, expanding nearly seven-fold, from less than 1 million in 1950 to 6.8 million in 2010. The population lives in a dense urban environment, constrained by the city's mountainous hinterland, with a large and growing informal sector. For over a decade, subsequent city mayors have invested in innovative transport policies, creating the successful and affordable TransMilenio Bus Rapid Transit and Ciclovia cycle network. Like many South American countries, over two-thirds of electricity production in Colombia is based on hydropower, which significantly reduces greenhouse gas emissions for the city.



SINGAPORE

As the leading global port city, Singapore's population increased by over a million between 2000 and 2011, and now totals 5.3 million. With a highly integrated and efficient form of city governance, it has implemented significant initiatives across all sectors of land use and transport planning, housing and public space, and more recently has focused on the need to reduce civic waste and improve water use efficiency. In addition, Singapore is investing heavily in the digital economy, with many smart city initiatives and innovation in green ICT tools.

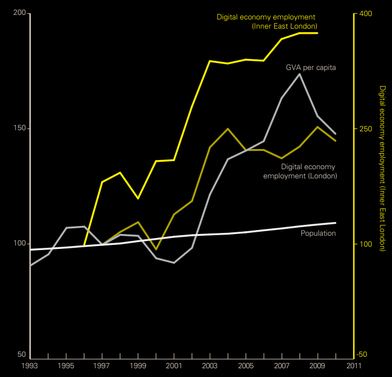
For full references to data sources, please see: http://ec2012.lsecities.net/references/

PATTERNS OF CHANGE

The challenges cities confront in becoming more sustainable places to live and work vary depending on the distinct socio-economic, environmental and spatial constraints of each of them. Yet all cities are broadly united in their efforts to improve the well-being of their residents, ideally by raising their income while improving their quality of life through accessible social services and environmental amenities. While there are no universal approaches, the main objective of sustainable cities is to ensure that continued economic and population growth can occur without a commensurate increase in a city's environmental footprint. This so-called 'decoupling' of economic prosperity from increasing levels of resource consumption impact is increasingly seen as a fundamental component of a sustainable future. The graphs below show the diverse patterns of change taking place in cities over the past 20 years. Comparing economic and population growth to selected environmental indicators provides a sense of the drastic transformations these cities have experienced over a relatively short time span.

Several of the cities profiled below have achieved a remarkable level of positive decoupling. This is particularly visible in leading green cities of the industrialised world (Portland, Copenhagen, Stockholm), demonstrating a rapid decrease in energy use and per capita CO_2 emissions, and the proliferation of more sustainable modes of transport. On the whole, cities in the emerging economies do not seem to be leapfrogging to a post-fossil fuel future, appearing at least in part to be following in the developmental footsteps of the industrialised world. Rising electricity consumption and per capita CO_2 emissions, as well as increased car ownership rates and traffic congestion, together with increase in population and wealth highlight the worrying trends that underlie growth in Mumbai, São Paulo and Istanbul. Yet the data also indicate some positive trends in cities that have decided to buck the 'business-as-usual' trajectory, investing in new policies and initiatives that have changed things for the better, and often at a remarkable pace. The success of Bogotá's TransMilenio bus system and corresponding improvements to road safety are evidence that innovative thinking and the targeted application of new technologies can drastically change the urban experience of millions of people. Such changes in public transport provision are not confined to developing world cities. Increasing numbers of cyclists on the streets of London and New York, and a rise in public transport use in Singapore and Hong Kong demonstrate a growing awareness of the need to move away from private vehicle use, with people embracing more efficient and environmentally sustainable ways of getting around the city.

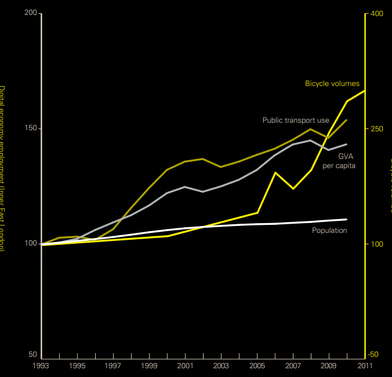
The selected statistics illustrate that all cities, irrespective of their level of development, are experiencing profound and far-reaching changes across a variety of sectors. How a city changes and at what pace this change takes place is often dependent on targeted policies put in place by city, regional or national governments, highlighting the importance of a comprehensive and integrated approach to urban planning.



All variables are indexed: 1997=100

LONDON

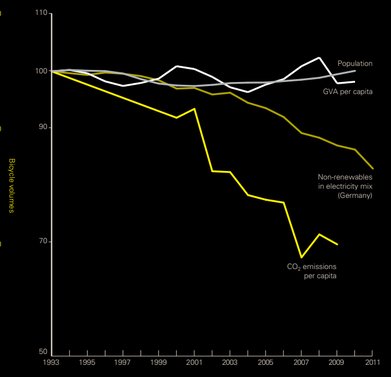
London's metropolitan economy has grown strongly over the past 20 years. Despite the recent global downturn, the economy grew by 47 per cent between 1997 and 2011 (measured by Gross Value Added (GVA) per capita), accompanied by a 10 per cent increase in the metropolitan population. Some sectors of the economy have experienced particularly rapid growth: employment in the digital economy has grown by 44 per cent since the late 1990s. The majority of recent job growth in the sector has been concentrated in Inner East London, where an emerging tech cluster now employs nearly 50,000 people – a 400 per cent increase since 1997.



All variables are indexed: 1993=100

NEW YORK

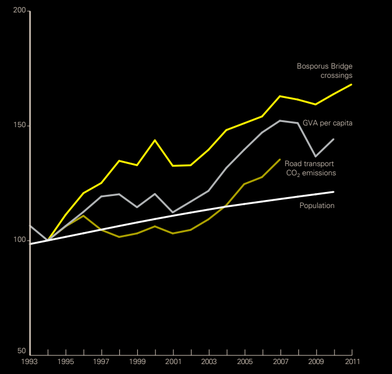
New York City's metropolitan economy has grown by 43 per cent since 1993 and the region's population by more than 10 per cent to 19 million people in 2010. A top global city, New York City's dense concentrations of firms and jobs has long been supported by an extensive public transport system. Recent upgrades to the subway and bus systems have contributed to a 43 per cent increase in public transport use between 1993 and 2010. Cycling still only accounts for 0.7 per cent of all trips, but is growing rapidly, with the number of people entering and leaving Manhattan by bicycle more than tripling since 1993.



All variables are indexed: 1993=100

BERLIN

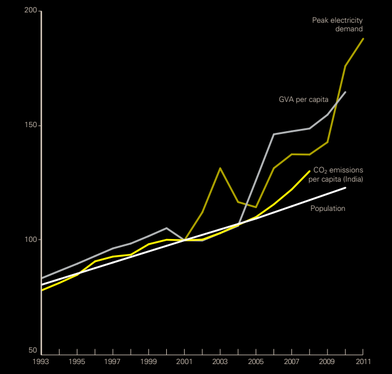
Berlin's regional economy contracted slightly, by 2 per cent, between 1993 and 2010, while the population remained relatively stable at 4.9 million. During the 1990s, rapid de-industrialisation resulted in the loss of more than 150,000 manufacturing jobs, which initially helped reduce greenhouse gas emissions. Today Berlin is re-inventing itself as a clean technology hub, having cut per capita carbon emissions by more than 30 per cent since 1993. This trend is in line with Germany's national-level policy ambition for a sweeping energy transformation. Between 1993 and 2011, the share of renewable energy in Germany's electricity mix increased from 3.9 per cent to 20.3 per cent.



All variables are indexed: 1994=100

ISTANBUL

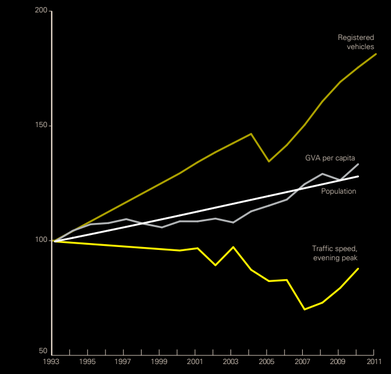
Istanbul's continuous growth over the past two decades has been accompanied by rapid motorisation. The population reached 13.6 million in 2011, while GVA per capita increased by 44 per cent between 1994 and 2010. The city's expanding suburbs and higher car ownership rates have led to a 68 per cent increase in Bosporus Bridge crossings and a 37 per cent rise in carbon emissions from road transport, despite considerable investments in public transport. These developments raise questions about the environmental impact of a planned third Bosporus Bridge and a new motorway North of the city.



All variables are indexed: 2001=100

MUMBAI

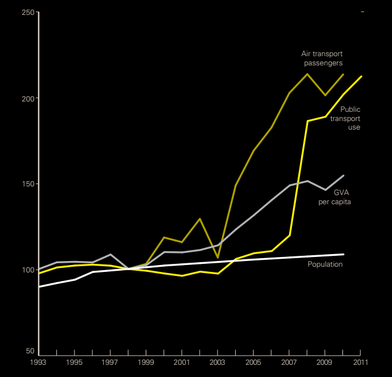
Mumbai's metropolitan economy has grown at a strong pace, with GVA per capita increasing by 65 per cent over the last 10 years, and the population by 23 per cent to reach 20 million. Growth has been accompanied by drastically changing consumption habits: peak electricity demand in the city increased by more than 90 per cent since 2001 straining the system beyond its limits. Carbon emissions for India as a whole have increased by 30 per cent since 2001, but remain at very low levels on a per person basis. Shifting Indian cities' reliance on coal-fired electricity and investing in renewables will become increasingly vital as electricity demand continues to rise.



All variables are indexed: 1993=100

SÃO PAULO

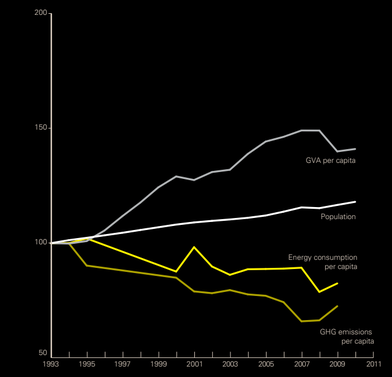
São Paulo's GVA per capita has grown by 33 per cent and the population by 28 per cent between 1993 and 2010. In this city of nearly 20 million people, the number of registered vehicles increased by 82 per cent between 1993 and 2010, and the city currently has a motorisation rate of 368 cars/1,000 people. Unsurprisingly, traffic congestion is a perpetual problem: average evening rush hour traffic speeds decreased by 30 per cent between 1993 and 2007, although recent efforts to restrict private vehicle use and improve Metro and Bus Rapid Transit (BRT) infrastructure have shown promising success.



All variables are indexed: 1998=100

HONG KONG

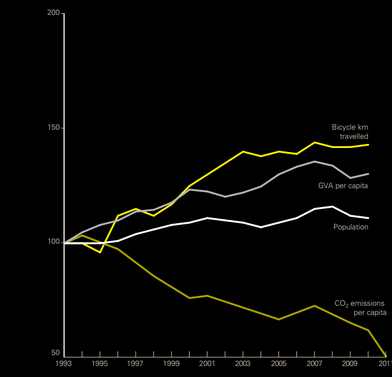
Hong Kong has cemented its position as a global hub for trade and finance since the 1997 handover from the UK to Chinese control. Since 1998, the city's per capita GVA experienced rapid growth, increasing by 51%. The city's strong international connections are reflected by continued air passenger growth, with numbers more than doubling since 1998. Hong Kong is one of the most densely populated cities in the world and a sophisticated public transport system efficiently provides mobility for the city's 7 million residents. Expansion of the Mass Rapid Transit system has contributed to a doubling in passenger numbers since 1998 and only 6 %of trips are made by car.



All variables are indexed: 1993=100

STOCKHOLM

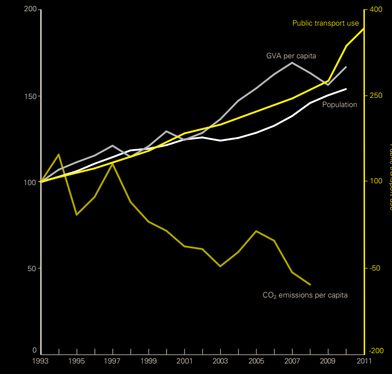
Stockholm's metropolitan economy grew by 41% between 1993 and 2010, while the population increased by 18 % to nearly 1.9 million. Stockholm's is successfully 'de-coupling' growth from negative environmental impacts, and GHG emissions in the city have declined by 31 %since 1993 to 3.7 tCO_2e per capita, while energy consumption per person has fallen by 18 %. Much of this success can be attributed to energy efficiency improvements in buildings prompted by strict green building policies at the national level. Today, 80% of the energy used for Stockholm's district heating comes from renewable fuels, energy from waste, or residual heat from combined heat and power plants.



All variables are indexed: 1993=100

COPENHAGEN

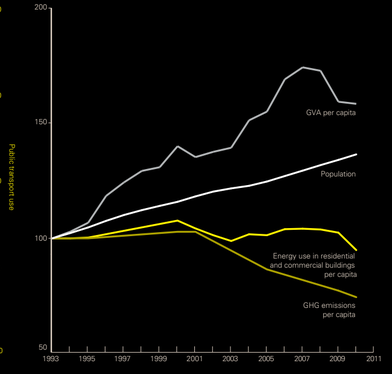
Copenhagen's GVA per capita grew by 30 per cent between 1993 and 2010, while the metropolitan population grew by 11 per cent to 1.8 million. The city has been successful in its pursuit of 'green growth': in the Municipality of Copenhagen carbon emissions halved since 1993 to 3.5 tCO_2 per capita, moving the city closer to its goal of becoming carbon neutral by 2025. Replacing coal with biomass for heating and power generation, and increasing the use of wind energy have contributed substantially to emission reductions. The city's progress has been further accelerated by the increased use of non-motorised transport, with bicycle kilometres travelled growing by 43 per cent since 1993.



All variables are indexed: 1993=100

SINGAPORE

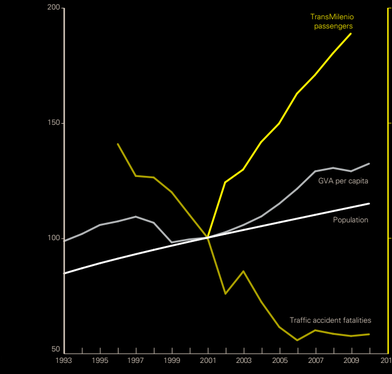
Singapore's GVA per capita grew by 67 per cent and the population by 54 per cent between 1993 and 2010. Public transport use has seen a substantial increase at a rate of 270 per cent in passenger trips on the rapid transit network since the early 1990s, helping to lower carbon emissions. The city-state has managed to dramatically cut emissions by 60 per cent: from 16.4 tCO_2 in 1993 to 6.7 tCO_2 per capita in 2008, by switching from coal to gas and improving energy efficiency of its urban distribution systems. However, Singapore remains almost exclusively reliant on imported fossil fuels for its energy needs.



All variables are indexed: 1993=100

PORTLAND

Portland's metropolitan region has experienced rapid economic growth, amounting to a 59 per cent increase in GVA per capita between 1993 and 2010. The region's population has also grown strongly – by 37 per cent over the same time period to reach almost 2.3 million in 2010. A comprehensive green policy programme has led to notable achievements, with greenhouse gas emissions decreasing by 26 per cent to 10.4 tCO_2e per capita in Multnomah County. Building energy use has fallen by 5 per cent per capita since 1993. Despite this, Portland's energy and resource use is still very high by global standards. .



All variables are indexed: 2001=100

BOGOTÁ

Bogotá's economy grew by 32 per cent between 2001 and 2010, following a severe recession in the late 1990s, while the metropolitan population increased by 14 per cent to nearly 8 million. Together with Curitiba, the city is regarded as pioneering the establishment of Bus Rapid Transit (BRT) systems, a cost-effective form of public transport. Bogotá's TransMilenio system has been gradually expanded since opening in 2001 and now carries 0.5 billion passengers a year. The 40 per cent decrease in road fatalities since the introduction of the TransMilenio can partly be attributed to improved road safety as a result of fixed bus lanes and enclosed stations.

COMPARING CITIES

Behind the statistics of global city growth lie very different patterns of urbanisation, with diverse spatial, social and economic characteristics that dramatically affect the urban experience. In addition to standard measures of population growth and the economy, LSE Cities has assembled socio-economic and environmental data from a range of official sources, allowing for a preliminary assessment of how these twelve cities compare to each other on a set of key performance indicators.

The graphic overview of these results highlights some striking differences, especially when it comes to these cities' speed of growth. While São Paulo has grown nearly 8,000 % since 1900, and London only 16 % (having experienced its major growth spurt in the previous century), it is Mumbai that is changing the fastest of the twelve, adding 54 additional residents every hour. In comparison, Copenhagen and Berlin will only gain 1 person per hour, Hong Kong 8 and London 10. These trends are also reflected in different patterns of age distribution: around a third of the residents of Mumbai, São Paulo, Bogotá and Istanbul are under the age of 20, while in Hong Kong and Berlin the younger generations shrink to 20 % or less. Mumbai also leads on economic growth, having experienced an average annual increase in GVA of 6.7 % between 1993 and 2010. Over the same period, the economies of São Paulo and Bogotá grew at about half that speed – nevertheless impressive when compared to Berlin's nearly stagnant economy. Another factor that differs drastically between cities is the proportion of the country's population residing in the metropolitan region and the corresponding contribution to national economic growth. Mumbai, with the largest metropolitan population of all twelve cities, only makes up 1.3 % of India's total population, and produces a mere 3.8 % of the national GVA. In contrast, 30 % of Denmark's total population reside in Copenhagen, and the capital region accounts for a staggering 38 % of national GVA. However, national level economic patterns tell us very little about the differences in wealth between cities. Looking at total GVA per capita, Stockholm and New York top the list (US$52,267 and US$51,337 respectively), closely followed by Copenhagen (US$48,294) and London (US$47,313). People living in these four cities are many times wealthier, on average, than in other world cities such as Istanbul and Bogotá (less than US$10,000), which in turn are significantly wealthier than the average resident of Mumbai (US$1,550). Despite its low per capita GVA, Mumbai's level of income inequality indicated by the Gini coefficient – a measure of income distribution with a higher number representing greater inequality – is nearly half that of São Paulo, which is the most unequal of the twelve cities, while Copenhagen and Berlin are the most equitable.

London, Hong Kong and Berlin contribute similar levels of CO_2 emissions per person, but the number doubles in Portland, where annual per capita carbon emissions exceed 10 tonnes, mainly owing to emissions related to high car use. Istanbul, with close to 38 %of its workforce in the manufacturing sector, produces just 2.7 tonnes of CO_2 per person, while Mumbai's residents contribute only 0.4 tonnes – less than 10 % of that of residents in most other global cities. Car ownership varies drastically between all twelve cities, highlighting their diverse economic and spatial characteristics and varying transport infrastructure. Paralleling the trend in CO_2 emissions, Portland has the highest car ownership rate: 690 cars per 1,000 inhabitants, five times higher than the rate for New York. São Paulo has more than ten times as many cars per 1,000 people as Mumbai, the second highest figure, although improvements in public transport over the past few years are slowing the trend towards private motorised transport. Mumbai is catching up fast, with an increase of 35 % in vehicles on the city's roads in the past 5 years alone. Yet the majority of Mumbaikars still get around the city on foot or by bicycle, making it the city with the highest non-motorised modal share of the twelve. In contrast, only 11 % of all trips in New York are made by walking and cycling, with most people relying on the city's nearly 600 km long rail network. Looking at rail network systems for other cities provides an indication of their public transport infrastructure. London and Berlin have by far the most extensive network (1,393 km and 984 km respectively), with the average rail network length for all cities just below 500 km. This is in stark contrast to Bogotá, famous for its TransMilenio bus system, but lacking a rail network, although the Bogotá metro is currently under construction with a planned opening date of 2016.

Looking at water and electricity use highlights the divergent consumption patterns of residents in these twelve cities. Mumbai has the smallest consumption footprint, using just 90 litres of water per person per day, compared to 572 in New York, 229 in Stockholm and 185 in Istanbul. Although electricity consumption is rapidly increasing, the average resident of Mumbai or Bogotá still uses less than 1 MWh of electricity per year, compared to 12.1 in Portland and 7.8 in Singapore. Stockholm, Copenhagen and Berlin have managed to lower their electricity use over the past twenty years and all consume less than 2 MWh per capita, largely owing to the widespread use of district heating in these cities. How the electricity is generated also differs widely between cities. While decentralised power generation is becoming increasingly common, the vast majority of energy is still distributed to individual cities via a national grid, which is why energy use and renewable energy performance are shown at the country level. Unsurprisingly, the United States is by far the biggest energy user, with the average person consuming more than ten times as much as someone in India or Colombia. Due to their cold climate, Denmark and Sweden also have higher than average per capita energy consumption levels. Renewable energy sources make up nearly 90 % of the total national electricity generation in Brazil and more than 70 % in Colombia, owing to the predominance of hydro-power in these countries. In contrast, Hong Kong and Singapore still rely almost exclusively on fossil fuels for their electricity generation. With the exception of Sweden (57.7 %) all other countries currently generate less than a quarter of their electricity from renewable sources (see the World Maps at the beginning of this section for a more detailed discussion of global energy patterns).

Measurement years and methodologies used to calculate indicator values may differ between cities and data are not always comparable.
For full references to data sources, please see: http://ec2012.lsecities.net/references/

	Current population in the city (millions)	Current population in metropolitan region (millions)	Projected growth 2010 – 2025 (people per hour)	Percentage of the country's population residing in each metropolitan region	GVA per capita (US$)	Percentage of national GVA produced by each metropolitan region	Average annual growth of GVA 1993 – 2010	Income inequality (measured by the Gini index)	Percentage of the population under 20	Life expectancy (years)	Percentage of daily trips made by walking and cycling	Rail network system length (km)	Car ownership rate (per 1,000 inhabitants)	Daily water consumption (litres per capita)	Annual CO_2 emissions (tonnes per capita)	Annual electricity use (MWh per capita)	Annual energy use (MWh per capita, national)	Renewable energy as percentage of total electricity
LONDON	**8.2** 2011	**14.6** 2011	**10** 2011	**23.9** 2010	**47,313** 2010	**32.8** 2010	**2.9** 2010	**31.7** 1995	**23.8** 2009	**79.2** 2004	**32** 2011	**1,393** GIS-BASED	**331** 2009	**167** 2005	**5.6** 2010	**5.2** 2011	**24.3** 2009	**7.3** 2009
NEW YORK	8.2 2010	19.0 2011	26 2011	6.3 2010	51,337 2010	8.5 2010	2.8 2010	53.5 2011	25.7 2008	77.6 2001	11.2 2008	579 GIS-BASED	209 2008	572 2005	6.5 2010, CO_2E	6.0 2011	51.3 2009	10.6 2009
BERLIN	**3.5** 2011	**5.0** 2010	**1** 2011	**4.3** 2010	**26,909** 2010	**3.5** 2010	**-0.1** 2010	**29** 2010	**16.6** 2007	**78.5** 2010	**42** 2010	**984** 2012	**324** 2011	**112** 2010	**5.2** 2009	**1.7** 2011	**28.9** 2009	**16.2** 2009
ISTANBUL	13.6 2011	13.6 2011	30 2011	18.2 2010	9,368 2010	27.2 2010	3.1 2010	43 2003	31.3 2011	72.4 2000	45 2008	163 GIS-BASED	140 2011	195 2010	2.7 2005	2.3 2010	11.3 2009	19.6 2009
MUMBAI	**12.5** 2011	**21.0** 2011	**54** 2011	**1.8** 2010	**1,550** 2010	**3.8** 2010	**6.7** 2010	**35** 2004	**36.3** 2001	**68.1** 2001	**56.3** 2007	**477** GIS-BASED	**36** 2006	**90** 2008	**0.4** 2008 MAHARASHTRA STATE	**0.8** 2008 MAHARASHTRA STATE	**4** 2009	**14.1** 2009
SÃO PAULO	11.3 2010	19.9 2010	27 2011	10.5 2010	18,116 2010	33.6 2010	3.2 2010	61 2005	31 2010	70.8 2000	33.8 2007	275 GIS-BASED	368 2007	185	1.1 2003	2.0 2006	11.6 2009	89 2009
STOCKHOLM	**0.8** 2010	**1.9** 2010	**3** 2011	**21.2** 2010	**52,267** 2010	**28.9** 2010	**3.5** 2010	**34** 2009	**21.3** 2010	**80.3** 2005	**38** 2006	**405** 2010	**359** 2006	**229** 2011	**3.7** 2010, CO_2E	**1.5** 2009 - SWEDEN	**41.1** 2009	**57.7** 2009
COPENHAGEN	0.5 2012	1.8 2012	1 2012	30.0 2010	48,294 2010	38 2010	2.0 2010	24.8 2012-DENMARK	21.8 2012	76.6 2011	43 2010	600 2008	184 2009	110 2010	3.4 2012	1.3 2010	30.8 2009	24.8 2009
HONG KONG	**7.0** 2010	**7.0** 2010	**8** 2011	**–**	**31,340** 2010	**–**	**3.6** 2010	**53** 2007	**20.1** 2010	**82.5** 2010	**44.7** 2002	**247** GIS-BASED	**56** 2009	**220** 2009	**5.5** 2011	**5.9** 2011	**13.3** 2009	**0** 2009
SINGAPORE	5.3 2012	5.3 2012	5 2011	–	38,307 2010	–	5.7 2010	47.3 2011	23.1 2012	81.1 2011	23 2011	176 2011	121 2009	157 2009	6.7 2008	7.8 2011	29.1 2009	0 2009
PORTLAND	**0.6** 2010	**2.3** 2010	**4** 2011	**0.7** 2010	**42,454** 2010	**0.9** 2010	**4.7** 2010	**49.4** 2011	**21.5** 2011	**77.9** 2005	**14** 2012	**115** 2012	**690** 2011	**440** 2010	**10.4** 2010, CO_2E	**12.1** 2008	**51.3** 2009	**10.6** 2009
BOGOTÁ	6.8 2005	7.9 2005	22 2011	15.9 2010	5,430 2010	26.2 2010	3.6 2010	58 2001	35.1 2005	72 2000	17 2008	0 2012	148 2006	114 2009	2.2 2011, CO_2E	0.1 2011	5.4 2009	72.8 2009

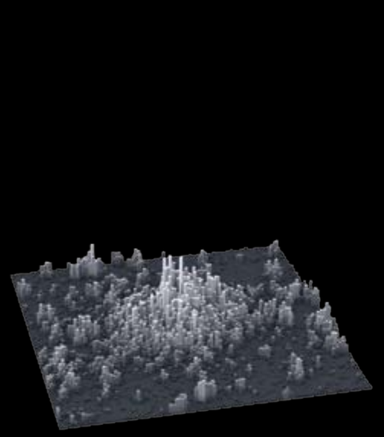
RESIDENTIAL DENSITY

This section looks in more detail at the density and transport systems of six of the twelve case study cities. These six cities are innovators in land-use and transport policies across highly varied social and geographical contexts, and insights can be gleaned through their comparison.

Density is a fundamental measure of urban structure, and here we map the number of residents in each square kilometre of a 100 by 100 kilometres region – the taller the bar on the diagram, the higher the density of people living in a particular area of the city. Lower urban densities apply to suburban-like neighbourhoods, often characterised by houses and garden, or mid- to high-rise buildings surrounded by large areas of open space. Higher urban densities – where tall, medium- or even low-rise buildings are clustered together in a tighter urban grid – can facilitate more sustainable public transport, walking and cycling, improve service delivery efficiency, and promote urban vitality. These advantages depend, however, on high-quality urban design and effective city management to minimise the negative impacts of overcrowding, stress and pollution.

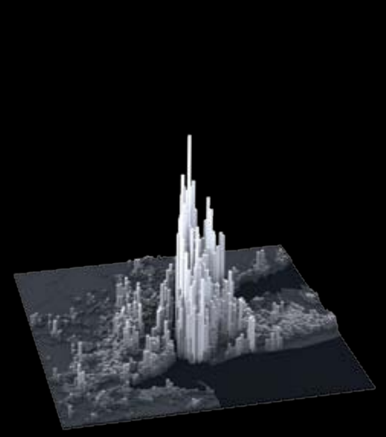
Urban density is driven by topographical constraints, the provision of infrastructure, and by inherited traditions of urban development. The city that stands out in the mapping is Hong Kong, with its extremely high residential densities exceeding 110,000 people per km^2. Here planners have responded to scarce land availability with very tall (over 30 storeys), high-density development. Topography and history have also influenced the development of New York City, where Manhattan densities peak at 59,000 people per km^2. London is, in contrast, more spread out, with a heritage of much lower-density urban living, with peak levels less than a quarter of Hong Kong's. Roughly 8 million Londoners occupy twice the footprint of the same number of New Yorkers.

Bogotá's development has been contained by its mountainous hinterland, and parts of the city reach peak densities at similar levels to New York, although with lower and different building forms. Copenhagen and Stockholm are smaller cities with lower densities and significant areas of open space. The Scandinavian capitals are, however, leaders in integrated regional planning, as shown by the distinct corridors of development radiating along rail lines from their urban centres.



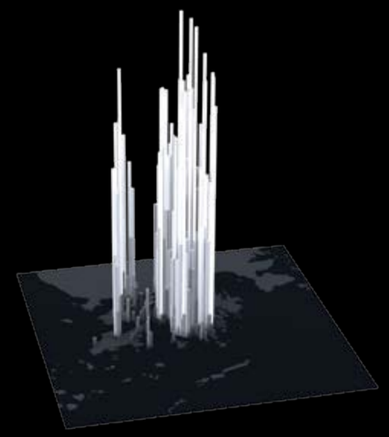
LONDON PEAK 27,100 pp/km^2

London has lower residential densities than other world cities, although current policy focusing on the intensification of available urban land is affecting this pattern. While the most significant changes are occurring in East London (where the 2012 Olympics were held), densities remain highest in the West, in areas like Notting Hill and Earl's Court, but peaking at 27,100 people per km^2 in Pimlico.



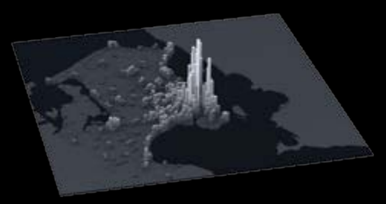
NEW YORK PEAK 59,150 pp/km^2

New York's highest residential densities are in Manhattan, peaking at 59,150 people per km^2 in the Upper East Side. High-density living is prevalent across New York City, with hotspots in the Bronx, Brooklyn and Queens. Outside of the urban core, lower-density suburban patterns dominate in the outer boroughs, New Jersey and Long Island.



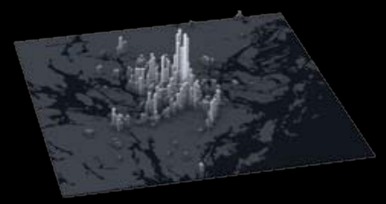
HONG KONG PEAK 111,100 pp/km^2

Hong Kong's hyper-dense tall building typology, which reaches peaks of over 100,000 people per km^2 (double New York City's), is not restricted to Hong Kong Island, but can also be found in West Kowloon, Kwun Tong and the New Territories. Planning authorities have pursued a 'Rail plus Property' development model, with extremely high-density development clustered around public transport nodes.



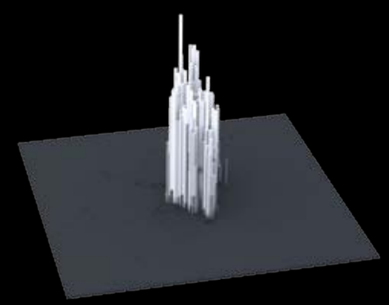
COPENHAGEN PEAK 24,050 pp/km^2

For the last fifty years Copenhagen's regional planning has been based around the 'Finger Plan' of development corridors along rail lines that radiate out from the dense city centre, which are clearly visible in the above map. Peak residential densities reach 24,050 people per km^2, closer to London levels, which are typical of the European compact city model.



STOCKHOLM PEAK 24,900 pp/km^2

Stockholm's form has many similarities to Copenhagen's, with tightly controlled regional development along public transport corridors and generous open areas. Stockholm's peak density is just short of 25,000 people per km^2. Recent population growth has been accommodated in the inner city with the regeneration of dock areas, such as Hammarby Sjöstad.



BOGOTÁ PEAK 55,800 pp/km^2

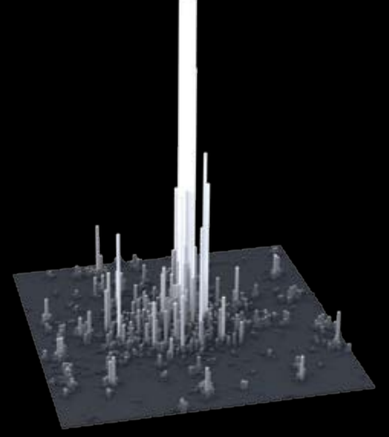
Some of the highest residential densities in Bogotá occur at the city outskirts, to the South, West and North-West of the city centre, with the peak density occurring at Patio Bonito to the West. At the fringe of the city the geography quickly alters into a steep mountainous landscape, constraining horizontal expansion. Data beyond the city boundary are not illustrated.

EMPLOYMENT DENSITY

The mapping of employment densities provides a very different perspective on urban form and dynamics, providing a novel point of comparison with the residential densities illustrated on the facing page. These diagrams capture a dimension of urban economic life by describing how many people work in different parts of the city on typical working days. As with residential densities, the taller spikes in the diagrams represent higher numbers of people concentrated in particular locations (CBDs, shopping high streets, business districts, etc.), while flatter zones suggest more residential neighbourhoods.

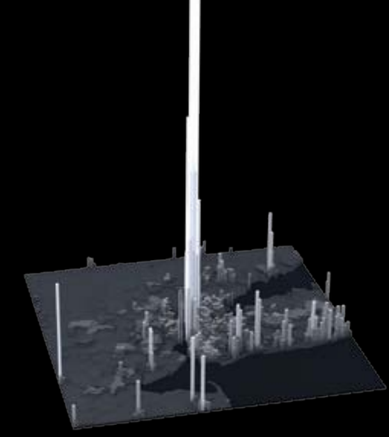
The diagrams reveal that despite the digital revolution, proximity and face-to-face contact remains essential for urban businesses to access labour markets, connect to fast-changing information and engage in direct interaction with clients, customers and partners. Knowledge economy sectors such as financial and business services and creative industries still seek out commercial space in inner city cores, taking advantage of good public transport provision (where they exist) and co-location of shops, food, bars, entertainment and other facilities.

London, New York and Hong Kong graphically illustrate that office workers are drawn to well-connected central locations, with peaks of over 150,000 jobs per km^2 in tightly clustered areas in Midtown Manhattan in New York City. London follows closely behind at over 140,000 jobs per km^2, concentrated in the City of London and the West End. But while in both these cases work densities do not coincide with residential densities – fuelling the need for intense commuting patterns – Hong Kong has a close integration between residential and employment peak densities. This pattern is associated with a strong mix of uses and shorter travel distances. Bogotá, Copenhagen and Stockholm also share integrated forms, in contrast to London where residential and employment densities are highly divergent.



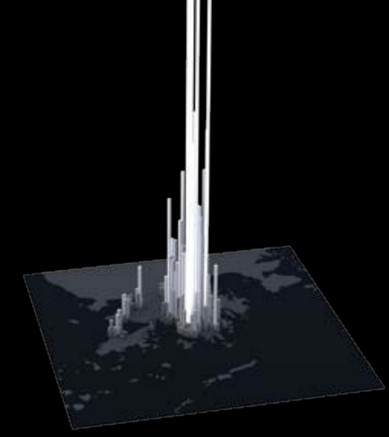
LONDON PEAK 141,600 pp/km^2

Peak employment densities in London occur at the core of the financial district in the City of London around Bank, reaching 141,600 jobs per km^2 and in the West End around Oxford Circus. There are also important employment sub-centres in Canary Wharf, Croydon and Heathrow, all well served by public transport, but not at the same levels of central locations.



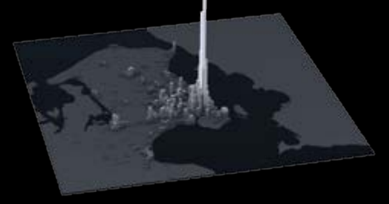
NEW YORK PEAK 151,600 pp/km^2

New York's employment peak of over 150,000 jobs per km^2 is found in Midtown Manhattan above West 42nd Street, close to Times Square. Downtown, the Lower Manhattan business district around Wall Street is returning to pre-9/11 density levels. Outside Manhattan, employment activities are relatively low, with few high-density sub-centres.



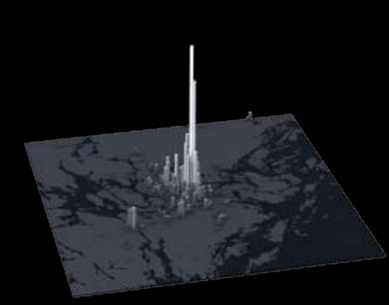
HONG KONG PEAK 120,200 pp/km^2

Peak employment districts in Hong Kong occur at Central and Wan Chai on Hong Kong Island, and Tsim Sha Tsui and Kwun Tong in Kowloon, making the most of a new generation of super skyscrapers occupied by companies and corporations. Hong Kong employment survey data do not include government jobs and the actual peak densities are likely to be higher than shown.



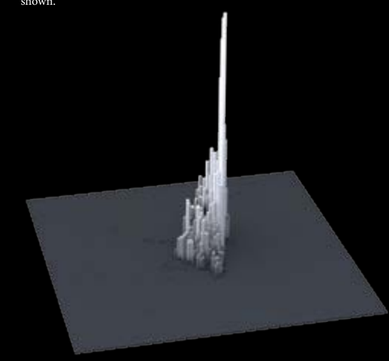
COPENHAGEN PEAK 40,100 pp/km^2

Relatively high levels of employment clustering are also evident in Copenhagen where densities reach 40,100 jobs per km^2, with many office areas easily accessible by rail, underground or bicycle. As well as financial and business services, Copenhagen retains an industrial base, particularly in shipping, which is characterised by lower employment levels than the tertiary sector.



STOCKHOLM PEAK 51,950 pp/km^2

Stockholm's peak employment density exceeds 50,000 jobs per km^2, with the city specialising in financial and business services and IT. With space restricted in the city centre, planners have promoted a degree of decentralisation to well-connected peripheral hubs in regional centres, such as Kista Science City to the North of Central Stockholm.



BOGOTÁ PEAK 61,550 pp/km^2

Bogotá's employment activities are strongly clustered in the city centre, along the main North-South link of Avenue Caracas. While financial and business services and retail are located in central districts with densities exceeding 60,000 jobs per km^2, industrial and manufacturing activities remain significant on the city outskirts.

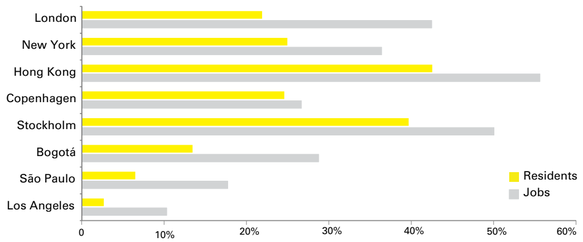
MAPPING ACCESSIBILITY

Connectivity is the lifeblood of cities and urban evolution is intrinsically linked to transport infrastructure. These maps display the multi-modal public transport networks in six case study cities, revealing stark differences in distribution of transport routes with commensurate effects on urban form and accessibility both within cities and to their regional hinterlands.

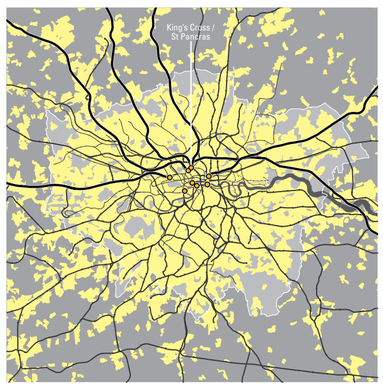
Given that these cities have been selected as exemplars of sustainability, they do not display the dominance of roads and motorways that characterise so many of the world's emerging megacities, as illustrated by São Paulo in earlier pages. Instead they demonstrate close connections between land use and public transport, summarised by the accessibility indicator graph to the right.

Hong Kong and Stockholm have uniquely high accessibility, with over 40 per cent of their respective populations living within 500 metres' distance from a rail or underground station. London, New York and Copenhagen also perform well, exceeding 20 per cent of their populations within 500 metres from a rail or underground station. Bogotá's results are lower, at around 12 per cent, yet it substantially outperforms car-dependent cities such as São Paulo and Los Angeles.

City populations in walking distance of rail and metro stations

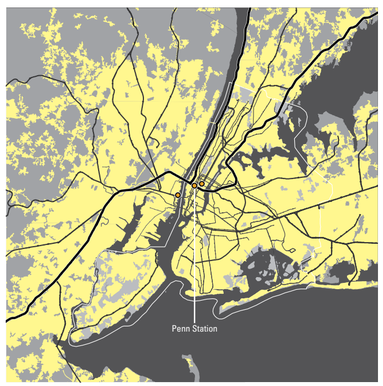


This chart shows the proportion of metropolitan residents and jobs within 500 metres (5 to 10 minutes' walk) of rail, metro and bus rapid transit stations. Indicators produced by LSE Cities through GIS analyses of census and transport networks data.



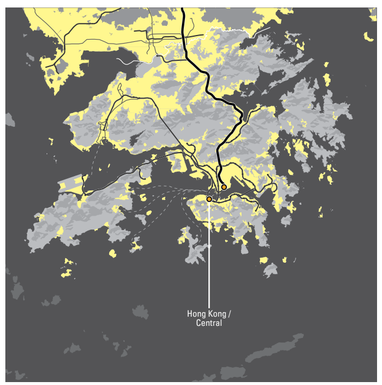
LONDON

A nineteenth-century ban on railways entering central London led to a ring of rail terminals, prompting the development of the underground to link them and support London's outward expansion. London has an extensive, albeit ageing rail-based network. Effective lobbying from the Mayor has ensured investment into rail, underground and bus networks, with improved connections to Continental Europe via St. Pancras and Stratford.



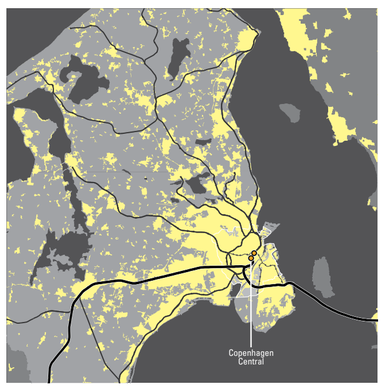
NEW YORK

New York City has long established and intricate public transport networks, connecting the city to its vast urban hinterland inhabited by 19 million people. Penn station is the busiest rail terminal in North America, serving 300,000 passengers a day. Current infrastructure developments include the new World Trade Centre Transportation Hub and further subway and rail upgrades for Manhattan.



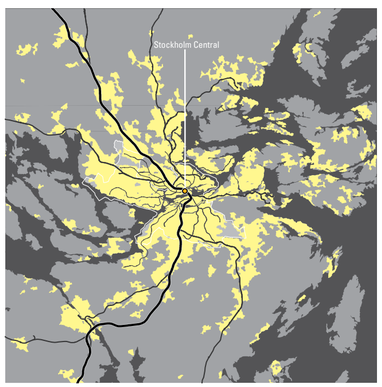
HONG KONG

Hong Kong's relatively young network has quickly developed into a highly efficient system that daily delivers millions of people to their destinations. The region achieves the closest integration between land use and transport of the six cities, as a result of the clustering of very high-density mixed-use development around stations. Future plans include new metro lines, and a high-speed link to Shenzhen and Guangzhou in mainland China.



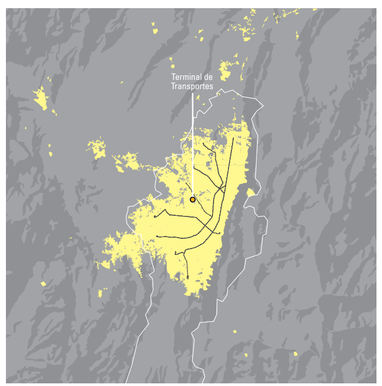
COPENHAGEN

Copenhagen has a well-established regional rail network, closely integrated with linear urban development patterns as well as its extensive cycle network. The city's central station provides high-speed services, including links to Sweden, with Copenhagen acting as a central node in the cross-border Øresund urban region. Copenhagen's recently developed metro system is currently limited to a single line, but new routes are planned.



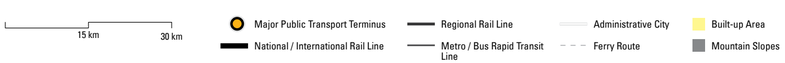
STOCKHOLM

Stockholm has excellent multi-modal public transport, with regional rail, subway, tram and international high-speed rail networks. The result of strong land-use planning and an extensive rail-based service is that 40 per cent of residents live within 500 metres from a metro station. Several subway and tram upgrades are in development, including better orbital access outside of the city centre.



BOGOTÁ

Bogotá is a pioneering city in the development of a Bus Rapid Transit system, which has provided passengers with similar speed and capacity advantages to underground rail systems at a significantly lower cost. Ambitious plans to further expand the network have been slow to implement, though new lines are now under construction. A further challenge is to develop regional connections.



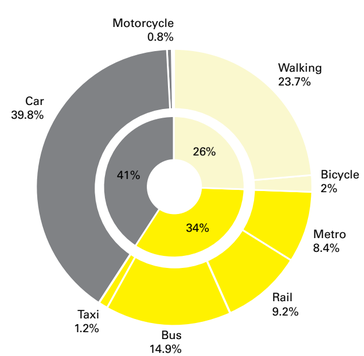
For full references to data sources, please see: http://ec2012.lsecities.net/references/

PATTERNS OF TRAVEL

This section explores the proportion of trips made by different transport modes in the six cities, enabling an understanding of how transport infrastructure and policies translate into real world behaviour for different user groups. The extensive transport networks found in all six cities ensure that public transport use is substantial though varied in the modes of public transport most frequently used. In addition, there are significant variations in walking and cycling patterns as well as car use, resulting from differing planning policies and inherited urban cultures.

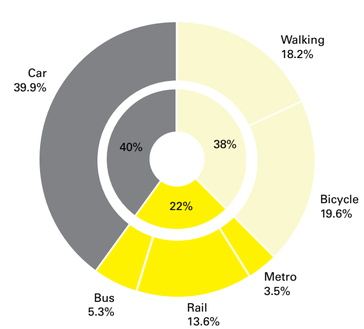
After many decades of neglecting walking and cycling as serious transport modes, current planning policies view active travel as a key part of creating a vibrant city environment and promoting healthier lifestyles. Copenhagen and Stockholm have strong traditions of providing high quality infrastructure for walking and cycling, with Copenhagen in particular being a world leader in cycling infrastructure provision. London and New York are attempting to repeat these achievements on a larger scale, though still have a long way to go to meet these standards. Hong Kong in fact has the highest proportion of pedestrian movements, with an impressive 45 per cent of trips. The city has developed a three-dimensional approach to urban mobility, with an extensive walking network on linked bridges above limited road space.

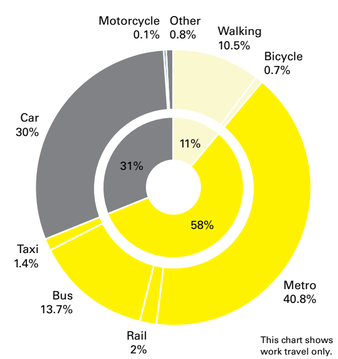
As cities improve from a low economic base, pressures for car use often increase. Bogotá is a low-income city, yet is developing quickly and car trips have increased by nearly 50 per cent in the last five years, despite investments in public transport. Cities seeking to limit car use can do so through a range of policies, including congestion charging and taxation (London and Stockholm), high fuel taxes (employed across Europe) and car ownership taxes (Hong Kong).



LONDON

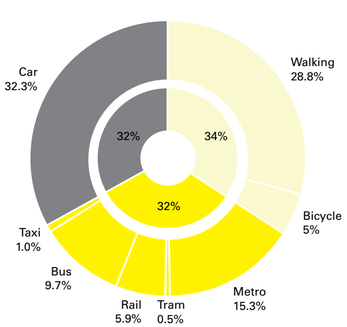
In terms of total trips, buses provide the most important public transport mode in London, and the network has been substantially upgraded in the last ten years. While car use has fallen in the last decade, it remains substantial, especially in outer London. The success of congestion charging suggests it should be expanded further, though this issue has proved politically controversial. Bicycle travel is relatively low, but is increasingly rapidly.

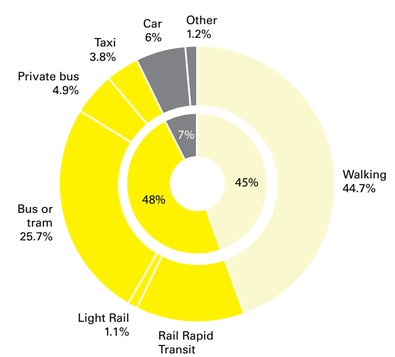




NEW YORK

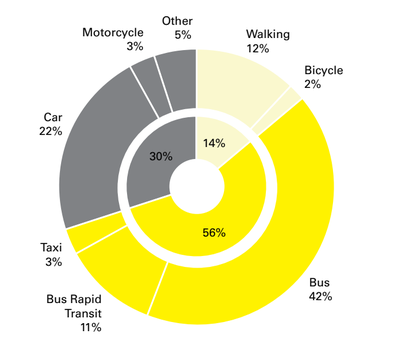
The subway is the most important public transport mode in New York, carrying over 40 per cent of commuters. Detailed survey data on non-work travel for New York was not available, though we can assume that car and walking trips will be considerably more frequent for non-work travel. Like London, New York is investing in cycling infrastructure and this is having an impact, from a low historic base.





HONG KONG

Hong Kong has one of the lowest rates of car ownership in the world and consequently the proportion of car trips is incredibly small at 6 per cent. As in London, bus travel is an important means of linking public transport networks, and bus and tram trips account for 26 per cent of the total. The proportion of walking trips is very high at 45 per cent, making Hong Kong a leader in active travel.



COPENHAGEN

Copenhagen is one of the world's leading cycling cities with 20 per cent of all trips by bike, including 36 per cent of work trips. The authorities are investing further in improving these figures. Public transport travel is proportionately lower than in the other example cities. The metro system is very new and will likely expand in the near future. Car use across the region is increasing and improved orbital public transport and demand management measures are being considered.

STOCKHOLM

Both walking and cycling trips are popular in Stockholm, with the city second out of our six case studies in both categories. The metro is the most frequently used public transport mode at 15 per cent of trips. Car use remains significant and Stockholm has severe congestion problems, even after the introduction of the city's congestion tax. Proposed remedies include improved public transport and a new bypass.

BOGOTÁ

Despite having a relatively modest infrastructure, Bogotá has the highest rate of public transport travel in all the example cities. The TransMilenio BRT network accounts for 11 per cent of trips, bolstered by 42 per cent of trips using the standard bus network. There have been significant reductions in road casualties through improved transport planning, although further progress is needed to improve Bogotá's pedestrian environment.

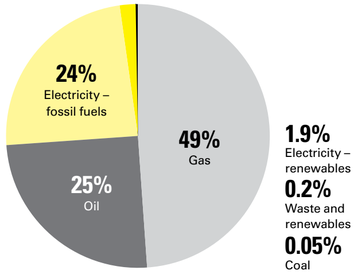
Walking and Cycling
Public Transport
Cars and Private Motorised Transport

CHANGING LONDON

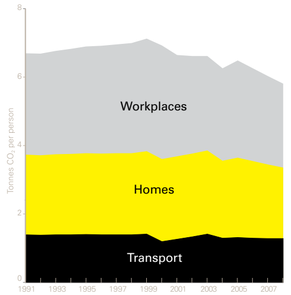
ENERGY

London has bold ambitions in the energy sector, with a goal of reducing emissions to 60% below 1990 levels by 2025. But London today relies heavily on fossil fuels and just 2% of total energy comes from renewable sources. London's residents produce significant carbon emissions – an annual average of 5.8 tonnes per capita. As in many cities across the developed world, carbon emissions have fallen in recent years thanks to de-industrialisation, efficiency improvements and shifts from coal to gas for heating and generating electricity.

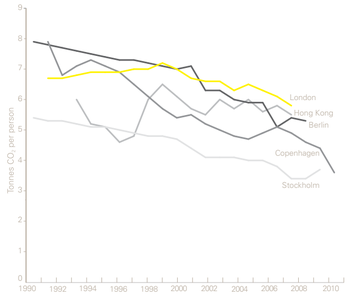
Declining emissions in wealthy cities hide carbon associated with growing consumption of imported goods. Counting imported emissions in food and manufactured goods, conventionally neglected, doubles Londoners' overall carbon footprint to 12.1 tonnes per person. A closer look at energy use across London shows that average per capita measures hide important variations. Mapping household energy use across the city reveals higher-income; suburban areas have the highest consumption, while the lowest use is in denser inner London areas.



London's total energy use by fuel type
Source: Greater London Authority



London's carbon emissions by sector
Source: Greater London Authority



Carbon emissions trends compared
Source: See http://ec2012.lsecities.net/references/

Cities' carbon emissions per person compared
Source: See http://ec2012.lsecities.net/references/

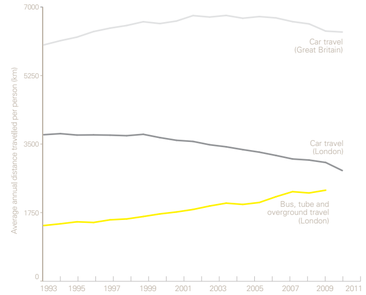
Direct and embedded emissions
Source: Greater London Authority

Domestic energy and gas use (2010 kWh per capita)
Source: Department of Energy and Climate Change Sub-National Energy Statistics 2010

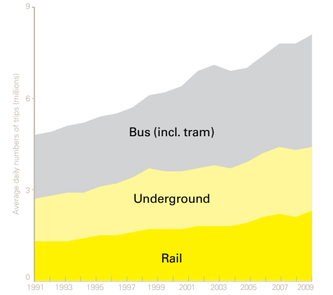
TRANSPORT AND PLANNING

London has seen a marked shift in the way people travel. Car kilometres travelled per person are now 25% lower than in 1999, while public transport passenger kilometres have grown by 40% over the same period on a per capita basis. London's shift towards more sustainable transport results from coordinated governance strategy and increased investment. Buses now offer 33% more service kilometres than in 2000, and tube and rail upgrades are making up for decades of under-investment.

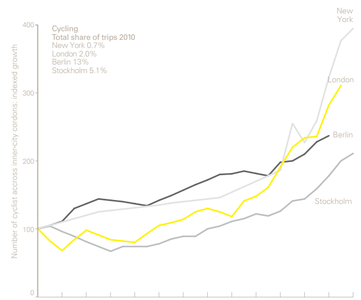
Cycling has also experienced a renaissance with inner-city cyclist numbers tripling since the late 1990s. Cities in continental Europe still lead with much higher proportions of transport by bicycle – in London only 2% of all trips are by bicycle compared with 20% in Copenhagen. Reflecting the commitment to the compact city model, vast majority of new building development over the past decade has been located close to railway and underground stations, making the most of London's extensive public transport system and anticipating further improvements such as Crossrail.



Car and public transport travel compared
Source: UK Department for Transport, Transport for London



Public transport trip trends
Source: Transport for London



Cities' cycling trends compared
Source: See http://ec2012.lsecities.net/references/

Proximity of new development to public transport
Source: London Development Database (2012), Greater London Authority

London urban development 2004 – 2011
Source: London Development Database (2012), Greater London Authority

ENVIRONMENT

Environmental policy programmes have led to some success. A comprehensive policy approach over the past decade saw average levels of household waste declining by 28% on a per capita basis, while recycling and composting rates increased over threefold. Today 34% of household waste is recycled or composted, although leaders in the field Austria and Germany have rates of over 60%. Air pollution remains a problem for Londoners, with only a modest improvement over a decade. It threatens health and quality of life, with the European Environment Agency suggesting pollution may be responsible for 3,000 premature deaths each year in London. Mapping the location of air pollution shows that transport emissions are the major source, with concentrations evident around arterial roads and on Heathrow airport's runways. Average NO_2 levels exceed EU standards over most of inner London, and along all major roads. PM_{10} levels are a more localised problem, regularly exceeding standards along major roads, but background levels are generally within guidelines.

Trends in solid waste management
Source: DEFRA, EuroStat

European cities' air pollution compared
Source: Citeair, www.airqualitynow.eu

Air pollution: nitrogen dioxide
Source: London Atmospheric Emissions Inventory 2008

DIGITAL ECONOMY

London is home to the biggest concentration of digital firms in Europe. Over 23,000 firms, 390,000 employees, and an estimated GB£1.7 (US$2.73/€2.1) billion of exports can be attributed to software development and other tech industries. (See essay by Max Nathan, pp. 11-12)
Policy attention has recently focused on a cluster of digital firms centred on what is dubbed the Old Street 'Silicon Roundabout'. Both national and local level policymakers aim to build on the existing cluster to establish a technology centre to rival California's 'Silicon Valley' and New York's 'Silicon Alley'. Despite these ambitions, growth in the digital economy's employment share appears to have stalled between 2005 and 2010. Recent studies of firms in the Inner East London cluster have identified various constraints to continued growth, including access to skilled staff and Internet connectivity issues. Indicators allowing for global comparisons of broadband quality are limited, however a 2010 study shows London's Internet infrastructure may slightly lag top European cities, and is of a lower standard than in some East Asian cities.

Digital economy employment share
Source: 'London's Digital Economy' (2012), Greater London Authority

ICT jobs density
Source: Business Register and Employment Survey 2008 – 2011, NOMIS

Cities' broadband speeds compared
Source: 'Broadband Quality Study 2010' in Greater London Authority 'London's Digital Economy' (2012)

For full references to data sources, please see: http://ec2012.lsecities.net/references/

New forms of energy generation are powering cities and their institutions (Combined heat and energy plant, Guy's Hospital, London)

URBAN AGE

The Urban Age Programme, jointly organised by LSE Cities at the London School of Economics and Deutsche Bank's Alfred Herrhausen Society, is an international investigation of the spatial and social dynamics of cities centred on an annual conference, research initiative and publication. Since 2005, more than ten conferences have been held in rapidly urbanising regions in Africa and Asia, as well as in mature urban regions in the Americas and Europe. The conferences operate as mobile laboratories, testing and sampling the social and physical characteristics of global cities through expert presentations and testimonials, research, site visits, mapping and informal information exchange.

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LSE Cities is an international centre at the London School of Economics and Political Science that carries out research, education and outreach activities in London and abroad. Its mission is to study how people and cities interact in a rapidly urbanising world, focusing on how the design of cities impacts on society, culture and the environment. Through research, conferences, teaching and projects, the centre aims to shape new thinking and practice on how to make cities fairer and more sustainable for the next generation of urban dwellers, who will make up some 70 per cent of the global population by 2050.

Alfred Herrhausen Society, The International Forum of Deutsche Bank

The non-profit Alfred Herrhausen Society is the international forum of Deutsche Bank. Its work focuses on new forms of governance as a response to the challenges of the twenty-first century. The Alfred Herrhausen Society seeks traces of the future in the present, and conceptualises relevant themes for analysis and debate. It works with international partners across a range of fields, including policy, academia and business, to organise forums for discussion worldwide. It forges international networks and builds temporary institutions to help to find better solutions to global challenges. It targets future decision-makers, but also attempts to make its work accessible to a wide public audience. The society is dedicated to the work of Alfred Herrhausen, former spokesman of the Deutsche Bank board of directors, who advocated the idea of corporate social responsibility in an exemplary manner until his assassination by terrorists in 1989. The Alfred Herrhausen Society is an expression of Deutsche Bank's worldwide commitment to civil society.

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LSE is a specialist university with an international intake and a global reach. Its research and teaching span the full breadth of the social sciences. Founded in 1895 by Beatrice and Sidney Webb, and set up to improve society and to "understand the causes of things", LSE has always put engagement with the wider world at the heart of its mission.

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