I'd put my money on the sun and solar energy. What a source of power! I hope we don’t have to wait until oil and coal run out before we tackle that.

Thomas Edison
What do the towns of Güssing, Dardesheim, Varese, Moura, Samso, Thisted, Bourke, Fredrikshavn and Rockport have in common? Few of us may ever have heard of most of them, but they stand out as 21st-century pioneers that have implemented 100 percent renewable energy strategies. These towns are examples of a new world in the making – a modern, comfortable world powered by regenerative energy. This would have been considered unthinkable just a few years ago, but is becoming a reality in an ever-increasing number and variety of places as supportive national policies make investments in renewable energy worthwhile. Some towns are striving to be entirely energy self-sufficient, others are integrating their efforts into regional sustainable energy strategies, while others again are building new regional economies based on exporting surplus energy.

The towns listed above can be found in different parts of Europe, Australia and the USA and they are each utilizing a different combination of wind power, solar energy, biomass, biogas, small-scale hydro or geothermal energy to make them largely self-reliant in electricity and heating. Various innovative storage systems are being utilized to assure a continuous energy supply. What is still an exception in 2009 is likely to become commonplace in the next decade.

In Chapter 1 we listed some of the breathtaking innovations that emerged from the industrial revolution and the ‘carboniferous capitalism’ (Lewis Mumford) it gave rise to. We described how new fossil-fuel-based technologies spread across the world, and how cities of unprecedented size started to emerge in many places in a process that one might call ‘carboniferous urbanization’. The last 300 years have seen the growth of ever-larger cities based on ever-increasing fossil-fuel supplies from ever-larger refineries and power stations, often based on local or regional energy sources. In the second half of the 20th century cities of millions of people started to spring up across the world, increasingly dependent on fuel supplies from distant places. London, for instance, requires the equivalent of two supertankers of oil per week for its 7.5 million inhabitants. Such vast urban structures depend on a continuous supply of energy – for powering high-rise city centres and low-density sprawling suburbs, as centres of production, consumption, services, transport and communication.

19th- and 20th-century technical innovations have made large-scale urbanization possible.
Some 80 percent of people in the richer countries now live in cities and about 50 percent worldwide. Built on just three to four percent of the world's land surface, cities use about 80 percent of its resources. The bulk of the world's fossil-fuel combustion is occurring in and on behalf of cities, and the resulting emissions are contributing very significantly to climate change.\(^3\)

Whilst the per capita energy consumption in developed countries can be higher in rural areas than in cities, the fact that most people there live in cities makes the need to minimize their dependence on fossil fuel crucially important.\(^4\) In developing countries the per capita use of energy is much higher in cities than in rural areas and here, too, the challenge is to assure the most efficient possible energy performance, and increase the use of renewables in urban settlements. According to Anna Tibajuka, Under-Secretary-General of the UN and Executive Director of UN-HABITAT, “any serious attempt at climate change mitigation and adaptation must include our cities as front-line actors.”

Whilst cities all over the world are the primary agents of climate change, they are also likely to become its primary victims – particularly those located near the sea, in river valleys prone to flooding or in areas vulnerable to droughts. A recent assessment suggests that a one-metre sea level rise, which is forecast for the 21st century, will have a direct impact on 150 million people. Indirectly it will affect hundreds of millions more as rising sea levels damage the productivity of farmland in coastal locations.\(^5\)

Until recently, the use of fossil fuels to power cities was simply taken for granted. City planners did not see the need to consider alternative energy sources in their designs. But the start of the 21st century introduces the compelling logic of fundamental change in urban energy supply. Now planners are looking ever more closely at the potential of alternative sources for a secure and carbon-free urban energy supply. Can large ‘carboniferous cities’ exist by being powered by renewable energy instead?

Most cities that will exist at the end of the 21st century have already been built. London is already there, and so are New York, Tokyo, Shanghai and São Paulo, and they need to function differently in the future. It is crucially important to do everything possible to help cities to become zero carbon rated.

The places listed at the start of this chapter are small towns. Unlike traditional towns and villages, which can still be found in many rural regions across the world, they don't rely on firewood, bullocks, horses or water wheels to supply their energy requirements. They are surrounded by open countryside and can take advantage of this for wind and solar installations and for biomass and hydro power. For a comfortable contemporary lifestyle they use electricity supplied by modern renewable energy technologies in combination with efficient energy-demand management – highly insulated buildings, low-energy lighting, etc. Transportation is often not included in the 100 percent renewable energy definition, though with the rapidly growing availability of new electric vehicles, this may also change before long.

**A town called Moura**

In one of the poorest but sunniest regions of Portugal, the municipality of Moura has made headlines recently. Moura and eight nearby villages, with a combined population of 16,500, have found a basis for new wealth in the form of solar energy which is now being used to drive the region's development.

In 2002 Moura’s mayor, Jose Maria Pos-de-Mina, founded a municipal energy company, Ampercentral Solar SA, to meet the region’s
electricity needs in a sustainable manner. As a result the Girassol solar energy plant, one of the largest in the world, began its operation near the village of Ameraleja in March 2008, having cost some €250 million. It covers 112 hectares, equivalent to three-quarters of London's Hyde Park, with 2,520 large solar panels.

The station will have a peak capacity of 62 MW when it is completed in 2010. The solar panels tilt at a permanent 45 degrees using a newly developed tracking system to follow the sun's daily path. The plant will produce 93 gigawatt hours per year, equivalent to the electricity use of 30,000 households, nearly double the needs of the Moura municipality. The solar farm will supply twice Moura's own energy needs half of the time, producing a surplus for export to the grid during the day, and importing electricity during the evening and at night.

To implement the project, the local citizens agreed to take on much of its financial risk, and until 2006 they held 90 percent of the capital in company. However, it has since been sold to the Spanish renewable energy company Acciona SA for a substantial profit which has been shared by all stakeholders.

Portugal, which does not have its own oil, coal or gas deposits, has some of Europe's most ambitious national targets for renewable energy. It is aiming to set up a pioneering low-carbon economy and intends to generate 31 percent of its energy from clean sources by 2020. It wants to develop a renewables industry to rival that of Germany, Denmark or Spain to generate much-needed new employment and expertise. It is Portuguese government policy to insist that foreign renewable energy companies team up with local engineering enterprises to establish new renewable industry clusters.

By the use of a feed-in tariff to assure that renewable energy investment is secure and profitable, Portugal has trebled its hydropower and quadrupled its wind power capacity in just three years, and is also making very substantial investments in wave power and photovoltaic arrays. Encouraged by long-term price guarantees by the state, firms are expected to invest £10 billion in renewables by 2012 and up to £100 billion by 2020.

Moura is an example of a smaller town that has secured its energy future by installing a solar farm in its hinterland. But what about larger cities? Interestingly, even cities of hundreds of thousands of people are now moving towards meeting an ever-growing proportion of their energy supplies from renewables. In Spain, very rapid development of renewable energy is now occurring, again facilitated by enlightened national legislation.

**Solar Seville**

In the vicinity of Seville, exciting things are going on. Rising out of the Andalusian countryside like a gigantic obelisk, a 90-metre concrete tower surrounded by concentric rings of mirrors is Spain's first major solar power station. The tower, known as PS10, is surrounded by 624 mirrors which produce some 60 MW, enough energy to power around 60,000 homes. The mirrors track the sun throughout the year, reflecting its light onto the solar receptor at the top of the tower. Water passes through and is heated up and turned into steam which powers a series of turbines to produce electricity. In addition there is also a nearby photovoltaic power plant consisting of 154 panels which will generate enough electricity for a further 1,800 homes.

Two more concentrating solar power (CSP) plants are already being built as part of a project whose final aim is to provide enough solar energy for 180,000 homes, or most of the electricity needs of the 600,000 people of Seville. The completed project will be able to
produce over 300 MW. In addition to the power towers, there will also be PV arrays and parabolic solar collectors. All these solar power plants will be operational by 2013. All in all, the solar energy schemes near Seville will prevent annual emissions of more than 600,000t of CO₂ into the atmosphere over their 25-year life. During manufacturing and construction the scheme will create more than 1,000 jobs, and an additional 300 service and maintenance jobs.⁷

Apart from the solar energy supplies from the vicinity of the city, Seville City Council is also taking advantage of the region's huge solar potential by installing PV panels on the roofs of municipal buildings all over the city – office buildings, schools, community centres and sports centres. By increasing the solar energy supply from within the city, the municipal electric bill, fossil-fuel dependency and CO₂ emissions are also being reduced, but an important additional aim is to increase awareness among Seville's citizens about the tremendous benefits of solar energy and to encourage them to install solar arrays on their houses as well.

Solar cities

The term solar city is increasingly widely used across the world. In Australia, Adelaide, Alice Springs, Blacktown, Central Victoria, Moreland, Perth and Townsville are all designated as solar cities. All of them have the ambition to rapidly increase their use of renewable electricity.⁸ The same applies to India, where 60 cities have been listed as solar cities as part of a government programme. While none will be fully solar-powered for the foreseeable future, they will benefit from increased funding for solar energy development.⁹

In China, Rizhao City in Shandong Province calls itself a solar city. The city mandates all new buildings to incorporate solar panels in their design, 99 percent of households in the city's central districts have solar water heaters, and most public lighting is PV-powered. In the suburbs, over 30 percent of households use solar water heaters and many have solar cooking facilities as well. In nearby farming villages over 60,000 greenhouses are heated by solar panels. In total, Rizhao has some 500,000 square metres of solar water heating panels,
equivalent to about 0.5 megawatts of electricity. Across the city a combination of regulations and public education has spurred this remarkable development.\(^\text{10}\)

**Solar Valley, Dezhou**

The city of Dezhou, also in Shandong Province, is building an ambitious complex of solar-powered buildings called Solar Valley. In 2010 it will host the 4th international Solar City Summit. China’s solar industry is growing by some 30 percent a year. By 2010 rooftop solar water heaters will save China from burning 22.5 million tons of standard coal a year. This is part of China’s very vigorous renewable energy strategy.\(^\text{11}\) Zhang Xiaoqiang, vice-chairman of China’s national development commission, stated in June 2009 that “China is aiming to have a massive one-fifth of all its energy from renewable sources by 2020.”\(^\text{12}\)

**Whitelee and Glasgow**

Back in the UK, surprising developments are occurring as well. Scottish Power Renewables completed Europe’s largest on-shore wind farm at Whitelee near Glasgow, with a capacity of 322 MW at a cost of £300m in early 2009. (It is interesting to note that the investment cost per watt is about a fifth of that at Moura – wind power is still much more cost competitive than solar energy.) In the coming years Whitelee’s capacity will nearly double to 614 MW, with the whole wind farm of 220 turbines taking up 7,500 hectares, producing about 2 watts per square metre. It will then generate enough electricity for all the homes in Glasgow, a city of around 600,000 people.

As with the other renewable energy schemes listed, Whitelee’s power output will be fed into the national electricity grid and not just solely supply Glasgow. But the proximity of the wind farm to the city will effectively make it its local renewable energy source. About 40 percent of Glasgow’s total electricity consumption will be supplied by the wind farm.\(^\text{13}\)

Keith Anderson, the director of Scottish Power Renewables, describes Whitelee as a landmark for the country because of its size and scale. But much more is to follow. He says: “We’re currently in conversations with the Scottish
Government about the development of an offshore wind farm off the west coast of Scotland which could be anything up to 1,800 MW, at least five or six times the size of Whitelee.”

The London Array

The UK’s largest city, London, is also well on its way to getting a significant dose of renewable energy from an offshore wind farm called the London Array, to be built around 12 miles off the coasts of Kent and Essex. With a 1,000 MW capacity it is expected to become the world’s largest offshore wind farm. It is being funded by a consortium consisting of E.ON UK Renewables, DONG Energy and the Abu Dhabi-based Masdar. The three companies will invest €2.2 billion in building the first 630 MW phase of the London Array. It will be constructed in two phases on a 23,400 hectare site in the Thames estuary and will ultimately supply the electricity needs of 750,000 homes, or a quarter of Greater London households.

The first 630 MW phase of the London Array with 175 turbines is expected to be completed in time for the London Olympics in 2012. The completed wind farm will consist of a total of 341 wind turbines of between 3 and 7 MW capacity. The decision by the three investment partners to go ahead with the project was taken after the UK government recently offered a higher unit price for offshore wind farm electricity. Because the three partners are now satisfied that the project is financially viable they are pushing ahead with construction.

The London Array will displace daily emissions of 1.9 m tonnes of carbon dioxide. It is an important part of the UK’s plan to cut its CO₂ emissions by 80 percent by 2050 and to meet its future energy needs in a sustainable manner. It will be the start of a major expansion of UK offshore wind capacity and will also generate thousands of jobs. Together with other major offshore wind farm projects, such as the 500 MW Great Gabbard scheme off the Suffolk coast, the densely populated south-east of England will be getting a very substantial proportion of its electricity supply from renewable sources by 2015. 

Credit: London Array. Offshore wind power is a crucial energy source for large cities in coastal locations such as London. 25% of the UK’s electricity is to come from offshore wind by 2020, or a total of 29 gigawatts. Higher wind speeds at sea and larger turbines of up to 6 MW offset part of the higher cost of producing electricity offshore.
Megacities and their resource use

For some time much thought has been given to the need for very large cities like London to become environmentally sustainable. The issue is not only how to increase renewable energy supplies but also to reduce overall resource consumption. For London to become an environmentally sustainable city, it would need to reduce its energy and resource throughput by some three-quarters, as suggested below. That is a huge challenge but also a huge new opportunity.  

Nicky Gavron, former Deputy Mayor of London, was one of the creators of the Clinton Foundation’s C40 sustainability initiative which brings together some of the world’s largest cities. At the launch of the initiative in 2005 she said this: “Leadership from national governments is crucial in tackling climate change, but when it comes to practical action on the ground, cities are centre stage. Cities have a special responsibility to cut emissions because they are huge consumers of energy and uniquely vulnerable to the impacts of climate change. And as the urgency for action increases, we cities need to build wider and stronger links across the world. . . . I want to see . . . long-term international city collaboration on climate change.”

There is a growing understanding that such efforts do not just mean ‘pain’, but significant new business and job opportunities from renewable energy – from retrofitting buildings, from creating better transport systems, from waste recycling, and so on.

Excerpts from the C40 Large Cities Climate Summit Declaration, Seoul, May 2009

C40 cities hereby set a common goal of transforming themselves into low-carbon cities, by cutting greenhouse gas emissions to the largest extent possible, by adapting themselves to the various unavoidable climate change consequences, by making cities less vulnerable to climate change, and by enhancing cities’ capacity for remediation.

C40 cities identify their current level of carbon emissions from all city operations and stages of community development including urban planning, design and infrastructure building. Cities reduce emissions wherever possible through policies, programmes and projects and taking steps to negate the impact of remaining emissions.

C40 cities actively work together to accelerate delivery of low-carbon technologies, programmes and financing, including through active coordination in the procurement of specific technologies through the C40 Secretariat.

In the run up to the COP15 United Nations Climate Change Conference in Copenhagen in December 2009, the leading role of cities in the global effort against climate change must be recognized. C40 cities and all cities with shared goals, must be engaged, empowered and resourced, so that cities can work together to deliver on greenhouse gas reduction targets and stop climate change.

The C40 Climate Leadership Group calls upon cities and their citizens to exert their efforts to address the threats caused by climate change for the benefit of all the people and future generations.

Retrofitting existing cities

In an urbanizing world it is becoming apparent that global sustainable development must, above all else, mean sustainable urban development. All over the world the awareness is growing rapidly that modern cities have huge responsibilities – and great new economic opportunities – in reducing their environmental impacts.
The Stern Review, already cited elsewhere, reached the very simple conclusion that the benefits of strong and early action on climate change far outweigh the economic costs of not acting. Decision-makers all over the world have realized that a large proportion of the actions required to deal with climate change need to be taken in cities. Major international efforts, such as the C40 initiative, recognize this fact. It has attracted very substantial funding to retrofit major urban buildings in order to make them much more energy-efficient.

Internationally, UN Habitat complements the work of the C40 initiative. It now focuses much of its work on sustainable urbanization. Its World Urban Campaign "is a platform for member States and Habitat partners to elevate policies and share practical tools for sustainable urbanization. . . . The campaign in this way seeks to position sustainable urbanization as a priority issue of the international community and as a national policy priority for individual member States."¹⁸

The International Council on Local Environment Initiatives (ICLEI), has a programme called ‘Cities For Climate Protection’ that works with some 800 cities and local governments worldwide to support their efforts to reduce their greenhouse gas emissions. The campaign helps them understand how their decisions affect energy use and how appropriate decision-making can mitigate global climate change whilst also improving community life.¹⁹

In Europe, Energie-Cités, the association of local authorities promoting local sustainable energy policy, has more than 150 members, mainly municipalities. There are other regional groupings such as the European Climate Alliance ²⁰ under which hundreds of local authorities are organized. Members have resolved to cut their CO₂ emissions by ten percent every five years in the future.

All these initiatives are starting to make an important contribution to the implementation of policies on sustainable energy development. They are now being complemented by the World Future Council’s Cities and Climate Change Commission that is seeking to accelerate renewable energy supply to cities all over the world. Our starting point is to track really significant reductions in urban greenhouse gas emissions and comprehensive efforts to utilize renewable energy to power cities, as this chapter demonstrates.

In a world facing climate chaos it is crucially important to do everything possible to retrofit existing cities with sustainable energy systems. Much work has already been done across Europe. Cities such as Heidelberg, Freiburg, Vienna, Barcelona, London, Helsinki and Stockholm, to name but a few, have already initiated substantial investment in the energy efficiency of buildings and new infrastructure, as well as renewable energy.

Nevertheless, the global challenges are simply enormous. A recent report by Booz Allen Hamilton, the global strategy and technology consulting firm, suggests that the world’s urban infrastructure systems need an astonishing $40 trillion investment to bring them up to date. According to the report, the vast and complex systems used to deliver water, electricity and transport services in urban areas are inadequate in both older cities that are suffering from decaying infrastructures, as well as in newer cities that are still developing their infrastructures. The report says that water, sewage and electricity schemes should be developed jointly rather than separately to assure maximum synergies.²¹

The report does not even take into account the vast challenge of retrofitting cities to enhance their environmental sustainability rather than simply to improve their service
provision. For cities to meet the environmental challenges of the 21st century requires a global investment programme to make them truly compatible with the integrity of the earth’s fragile ecosystems on which their wellbeing depends and without which they are ultimately doomed.

**CARBON-NEUTRAL COPENHAGEN**

“In Copenhagen, we are looking for solutions that will save the world. Our target is to be an inspirational city and our main goal is to be the world’s first carbon-neutral city by 2025.” So says Claus Bondam, the environment mayor of a city that is already renowned for its enlightened planning policies, with a pedestrian centre, 7 kms of dedicated cycle routes and most electricity supplied by combined heat and power and offshore wind parks.

The new zero-carbon plan for Copenhagen involves 50 initial projects to reduce CO₂ emissions by a further 20 percent by 2015. The business community and the local inhabitants have been invited to work closely with the city’s administration towards achieving this ambitious goal. The city government is making a substantial investment in new wind turbine projects, which will allow citizens to invest in green energy. Other initiatives include the use of hydrogen-powered and electric cars that could be parked for free and recharged on street corners.

Another step towards achieving a carbon-neutral Copenhagen by 2025 is to increase the production of geothermal heat by 600 percent to generate up to 50 percent of the city’s district heating requirements at a cost of about $180 million. A recent survey reports that the ground a few kilometres beneath Copenhagen contains about 70 times more energy than required by Denmark to fulfil its heating, electricity and transportation needs. Jesper Magtengaard, an engineer of DONG Energy, Copenhagen, has said that new calculations show that it is economically feasible to allow building heating systems to absorb heat from water, send the used water back underground, allowing it to be reheated, and then reuse it for district heating.

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**Cities and transport**

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List of cities researched and compiled by Prof. Jeffrey Kenworthy.

From this list of 84 cities it is apparent that low-density cities in the US, Canada, Australia and the Middle East have a much higher per-capita use of transport fuels than European,
Asian and North African cities. Invariably the cities on the left are very low density, and the ones on the right are high density. This is primarily a function of 1) availability of cheap fuel, and 2) deliberate policy decision to invest in public transport. Thus some cities have much more sustainable transport systems than others, but all have to improve in different ways.

News from the US

In 1932, John Nolen, a prominent Harvard-educated urban planner and landscape architect, said, “The future city will be spread out, it will be regional, it will be the natural product of the automobile, the good road, electricity, the telephone, and the radio combined with the growing desire to live a more natural, biological life under pleasanter and more natural conditions.” This was the idea behind suburbs, and it’s still seductive. But it’s also a prescription for sprawl and expressways and wasteful use of energy.

‘Smart growth’ is a 21st century response to the problems associated with suburban sprawl. In 1996 the Environmental Protection Agency helped establish the Smart Growth Network in conjunction with environmental groups, historic preservation organizations, professional organizations, developers, real estate interests and city and state governments. The purpose of smart growth planning is the reduction of sprawl and car-dependency, and the promotion of liveable and more sustainable communities. Its specific propositions are:

1. New developments that are connected to public transport;
2. Park and ride at public transport stations;
3. Bicycle parking at public transport stations;
4. Car-free walkable city centres;
5. Increased density, and mixed used developments.

Across the USA smart growth principles are being employed by an ever-growing number of cities. Under the Obama presidency, it is likely that national smart growth legislation will help local authorities to speed up smart growth initiatives.

Ironically, New York City, seen by many as an urban jungle, is increasingly cited as a model of smart growth. It was recently called the “greenest city in the US” because so many of its residents live in compact multi-storey buildings, and use public transit, bicycles or their own feet to commute to work. City residents also consume about half as much electricity as those who live in more spread-out suburban areas elsewhere in the United States.

Smart growth is also part of the agenda of hundreds of US mayors. In 2005, lack of commitment by the Bush administration forced the US Conference of Mayors – representing towns of over 30,000 people – to initiate the US Mayors Climate Protection Agreement. Its stated goal is to help all towns and cities to counter climate change. By November 2007, 710 mayors from all 50 US States had signed the Agreement. The participating cities are committed to take the following three actions:

- Strive to meet or beat the Kyoto Protocol targets in their own communities, through actions ranging from anti-sprawl land-use policies to urban forest restoration projects to public information campaigns;
- Urge their state governments, and the federal government, to enact policies and programs to meet or beat the greenhouse gas emission reduction target suggested for the United States in the Kyoto Protocol – 7 percent reduction from 1990 levels by 2012; and
Urge the US Congress to pass the bipartisan greenhouse gas reduction legislation, which would establish a national emission trading system.

The mayors recognized that by implementing energy efficiency and renewable energy schemes, and with better transport planning, cities can become a key part of the solution to climate change – as well as becoming better places to live. It can be expected that under a new US government much more effort will be taken to assure that national policy brings about such changes at the local level.

Regarding solar development, major projects are underway across California. In February 2009 Southern California Edison announced a deal with solar company BrightSource to provide 1,300 megawatts of solar power, which is enough to power almost 845,000 homes. Upon approval by the California Public Utilities Commission, construction will begin on seven projects to install the solar arrays which drive steam turbines (Concentrating Solar Power, or CSP). The first project is scheduled to be completed by 2013. The system is used in desert locations, such as the Mojave desert which has had CSP since the 1970s.

Meanwhile wind power development is becoming big business in the US and particularly in Texas, partly due to the efforts of one T. Boone Pickens, a well known oil man. The town of Sweetwater, until recently a high unemployment trouble spot, has become the Wind Turbine Capital of the US and it is claimed that newcomers have a job in the green industry before they can even unpack their bags. Texas is the top wind energy producer in the US, with over 4,000 megawatts installed. In July 2007, the Texas Public Utility Commission approved additional transmission lines that can deliver as much as 25,000 megawatts of wind energy to urban centres by 2012. By then all Texans will be able to access the state’s vast wind resources.

Towards the solar suburb

For decades, Americans have fled to the suburbs in search of clean air and open space. But is this trend under threat? In 2004 a documentary was made in the USA called The End of Suburbia which was a stark warning to urban planners as well as citizens: the suburb cannot survive in an era of expensive gasoline.

It is certainly true that the growth of suburbia since the Second World War is largely a function of cheap private transport. Millions of people invested their newfound wealth in suburbia. As suburban populations exploded, so did the use of the motor car. What started out as the American Dream soon also became the dream of Australians, Canadians and Europeans. But at the start of the 21st century, serious questions about the viability of this way of life are being asked. As global demand for fossil fuels begins to outstrip supply, what is the future of suburbia?

Credit: Tessera Solar. Solar dishes with sterling engines are a technology of major potential for low-density locations, suitable for public spaces within suburbia.

The End of Suburbia paints a nightmare scenario of suburbia which has run out of
gasoline. And an ever-growing number of planners and developers are seeing the logic of creating compact settlements that emphasize the opportunities inherent in local community living. Meanwhile wherever possible existing low-density suburbia should be augmented with new retail and office clusters and activity centres which offer new opportunities for both community living and public transportation nodes.

Meanwhile it is possible also to think of the solar suburb: retrofitting the fossil-fuel suburb into renewable energy systems, with solar systems and wind power within the suburb to power not only houses themselves but also to power electric vehicles.

In Australia a quiet solar revolution is starting to sweep suburbia. The concept is simple – buy solar panels in bulk and rally fifty or so households in a geographic area to get together to share the cost of installing a 1KW photovoltaic panel system for each house. Solar communities have started popping up around Australia. In addition to householders, local councils and community groups have also got on board, as have commercial programmes. The panels are ordered in bulk to reduce shipping and labour costs. The homeowners have been taking advantage of the Federal Government’s rebate scheme that makes the PV panels affordable. Over 100 solar neighbourhoods are already established in Victoria, and NSW, South Australia and Queensland are following suit.

Whilst at present solar panels are mainly being installed for a limited electricity supply, future solar suburbs could supply a much larger proportion of its people’s energy needs, even electricity for limited travel with electric cars. The very spaciousness of the suburb holds the potential for electricity supply from solar arrays and wind turbines that would be much harder to achieve in densely built-up areas. And in the suburbs the potential for local fruit and vegetable supply can be much more easily realized once it becomes part of suburban culture as originally envisaged by Frank Lloyd-Wright who, like John Nolan, developed his concept of the ‘Broadacre City’ in 1932 at the height of the Great Depression.27

**MASDAR CITY**

What about creating new solar cities from scratch? Abu Dhabi has started to build what it says is the world’s first purpose-built new zero-carbon, zero-waste, car-free city which will be powered by the sun. Masdar City, which will extend to 6 million square metres, will cost $22 billion, take eight years to build and be home to 50,000 people and 1,500 businesses. It uses traditional planning principals of a compact, walled city, together with new technologies, to achieve a carbon-neutral community. The shaded walkways and narrow streets will create a pedestrian-friendly environment suitable for...
Abu Dhabi’s extreme climate. Residents will move around on foot or in travel pods running on magnetic tracks. The city forms part of an ambitious plan the government of Abu Dhabi has to develop clean energy technologies, including Masdar PV, which is to become one of the largest solar technology companies in the world. Masdar City will consist mainly of low-rise low-energy buildings. They will be constructed to allow air flow in but to keep the sun’s heat out. Wind towers will ventilate homes and offices using natural convection. Water will be provided through a solar-powered desalination plant. The city will need only a quarter of the power required for a similar-sized community, while its water needs will be 60 percent lower. The land surrounding the city will contain photovoltaic arrays, wind farms and food-growing areas. Master planned by Foster + Partners, the initiative has been driven by Dr. Sultan Ahmed Al Jaber, CEO of the Abu Dhabi Future Energy Company.

The metabolism of cities: from linear to circular

Given that for the time being urbanization is a global trend, this means first and foremost that ways have to be found for cities to minimize their systemic dependence on fossil fuels and the unsustainable use of resources. Their need to develop sustainable relationships to the ecosystems from which they draw their resources – be they farmland, forests or marine ecosystems – has already been raised in Chapter 2.

Whilst the sustainable energy supply to cities is a crucially important issue, efforts to make them into fully sustainable systems need to go beyond that. The metaphor of relevance here is that of the metabolism of cities.

Like other organisms, cities have a definable metabolism. The metabolism of many modern cities is essentially linear, with resources flowing through the urban system without much concern about their origin, or about the destination of wastes. Inputs and outputs are considered as largely unrelated. Fossil fuels are extracted from rock strata, refined and burned, and the waste gases are discharged into the atmosphere. Raw materials are extracted, combined and processed into consumer goods that ultimately end up as rubbish which cannot be beneficially reabsorbed into living nature.

In distant forests, trees are felled for their timber or pulp, but all too often forests are not replenished. Similar processes apply to food: nutrients and carbon are taken from farmland as food is harvested, processed and eaten. The resulting sewage, with or without treatment, is then discharged into rivers and coastal waters downstream from population centres, and usually not returned to farmland. Rivers and coastal waters all over the world are polluted by both sewage and toxic effluents, as well as the run-off of mineral fertilizer applied to farmland feeding cities. This linear, open-loop approach is utterly unsustainable.

The linear metabolic system of most cities is profoundly different from nature’s circular metabolism, where waste does not exist: every output by an organism is also an input which replenishes the whole living environment. Planners seeking to design sustainable urban systems should start by studying the ecology of natural systems. On a predominantly urban planet, cities will need to adopt circular metabolic systems to assure their own long-term viability as well as that of the rural environments on which they depend. Outputs will need to become inputs into the urban production system. It is certainly true that in recent years a very substantial increase in recycling of paper, metals, plastic and glass has
occurred. But as suggested in Chapter 3, much more needs to be done to convert organic materials into compost, and to return plant nutrients and carbon to farmland to assure its long-term fertility.

The local effects of urban resource use also need to be better understood. Cities accumulate large amounts of materials within them. Vienna, with 1.6 million inhabitants, every day increases its actual weight by some 25,000 tonnes. Much of this is relatively inert materials, such as steel, concrete and tarmac.

Other materials, such as heavy metals, have discernible environmental effects as they gradually leach from the roofs of buildings and from water pipes and accumulate in the local environment. Nitrates, phosphates or chlorinated hydrocarbons build up in soils and water courses, with potentially negative impacts for the health of future inhabitants.

The critical question today, as humanity continues to urbanize, is whether living standards in our cities can be maintained whilst their local and global environmental impacts are brought down to a minimum. To answer this question it helps to draw up balance sheets comparing the resource flows of cities across the world. It is becoming apparent that similar-sized cities supply their needs with a greatly varying throughput of resources. Most large cities have been studied in considerable detail and in many cases it won’t be very difficult to compare their use of resources. It is certainly clear that large cities in developing countries have a much lower per capita resource throughput, and much higher recycling rates than cities in the richer countries.

Overleaf is a transition scenario for London which also has relevance for other wealthy cities across the world:
The ecological footprints of cities

Human impact on the planet today is primarily from urban consumption patterns. Cities have an enormous ecological footprint on the global environment. They take up huge areas outside their own territories in order to supply the food and materials we take for granted in our daily urban life.

Concentration of intense economic processes and high levels of personal consumption increase the resource demands of an urbanizing humanity. Apart from a monopoly on the use of fossil fuels and metals, humans now consume nearly half the world’s total photosynthetic capacity as well. Cities are the home of the ‘amplified man’, an unprecedented amalgam of
biology and technology, transcending our biological ancestors. Beyond their limits, cities profoundly affect distant ecosystems as a result of their demand for exotic timber, rare plants for domestic display, caged birds and unusual pets. The annual turnover of illegal wildlife trade, emanating from cities, is second only to the drugs trade.

As city people we need to know what levels of production and consumption are sustainable, i.e. within the earth’s environmental limits. In order to assess our impacts, the Canadian ecologist William Rees and his colleague Mathis Wackernagel developed the concept of the ecological footprints of nations and cities. They define these as the areas required to supply them with food and forest products, and to absorb their output of wastes, and particularly their output of CO₂.

They estimate that a North American city with 650,000 people requires some 30,000 square kilometres of land to meet domestic needs, without even including the environmental demands of industry. In comparison, an Indian city of this size would require just 2,800 square kilometres, or less than ten percent of that required by an American city.

Using this methodology, in 1995 I (H.G.) made a study to attempt to quantify London’s footprint. I found that this extended to around 125 times its surface area of 159,000 hectares, or to nearly 20 million hectares. I calculated that London, with 7 million people, or 12 percent of the population of the UK, required the equivalent of its entire productive land. Of course, in reality this area stretches to far-flung places such as the wheat prairies of Kansas, the tea gardens of Assam, the forests of Scandinavia and Amazonia, the soy fields of Mato Grosso and the greenhouses and orange groves of Spain. According to my figures, each individual Londoner had a footprint of some three hectares of land.

London is one of the world’s most thoroughly researched cities, and a second study called ‘City Limits’ conducted in 2000 went into much more detail than my own. It also calculated the energy used in agricultural production, transportation and processing, the land surface required for producing pet food, and the ocean regions required to supply London with fish. If these additional areas are included, London’s footprint actually extends to more than double that of my original estimate, to twice the UK’s surface area, or 6.63 hectares per Londoner.

If all 6.8 billion people now living on this planet were to have the same footprints, this would add up to three times the productive land on earth: we would need three planets rather than the single one we have. Canadian, Australian and American cities have even larger footprints, extending to between eight and ten hectares of productive land per person. If everybody lives like Los Angelinos, we would need five planets.

Says WWF’s Living Planet Report 2002: “The ecological footprint of the world average consumer in 1999 was 2.3 hectares per person, or 120 percent of the earth’s biological capacity of 1.9 hectares per person. In other words, humanity now exceeds the planet’s capacity to sustain its consumption of renewable resources. We are able to maintain this global overdraft on a temporary basis by eating into the earth’s capital stocks of forests, fish and fertile soils. We also dump our excess carbon dioxide emissions into the atmosphere. Neither of these two activities are sustainable in the long term – the only sustainable option is to live within the biological productive capacity of the earth.”

The 2008 WWF Living Planet Report states that “over three-quarters of the world’s population live in nations that are ecological debtors – their national consumption has outstripped their country’s biocapacity. Thus,
most of us are propping up our current lifestyles, and our economic growth, by drawing (and increasingly overdrawing) upon the ecological capital of other parts of the world.”

These processes are largely driven by urban consumption patterns. A growing number of studies have been conducted in recent years focussing on the ecological footprints of cities. The Swedish academic Carl Folke and his colleagues make this important point: “The capacity of ecosystems to sustain city development is becoming increasingly scarce as a consequence of rapid human population growth, intensified globalization of human activities, and human overexploitation and simplification of the natural resource base. The web of connections linking one ecosystem and one country with the next is escalating across all scales in both space and time. Everyone is now in everyone else’s backyard.”

Folke and his colleagues have done particularly interesting work on fishing. They have established that the bulk of fish that is eaten is consumed in cities remote from the sea. In 1996 the largest 744 northern European cities consumed 25 percent of the world’s annual sea fish catch. For their resource consumption and waste assimilation, the cities of Baltic Europe appropriate an area of forest, agricultural, marine and wetland ecosystems that is 565-1,130 times larger than the area of the cities themselves.

Clearly people across the developed world have a major job on their hands to significantly reduce their ecological footprints. The concept of One Planet Living developed by the BioRegional Development Group and WWF aims to get to grips with the need to reduce our ecological footprints is described in Chapter 8.

**New opportunities for cities**

It is often said by urban analysts that cities should be seen as the places where solutions to the world’s environmental and climate problems can most easily be implemented because as places where most people live...
closely together they have the potential to make efficient use of resources. Recycling materials, conserving rather than burning fossil fuels and tapping into renewable energy can create many new local jobs. As described in Chapter 7, low-carbon urban development can be good for local business, the environment and citizens.

In many cities, and particularly in very large conurbations, large numbers of people cannot find jobs because economic globalization has caused the relocation of manufacturing jobs to other parts of the world. In addition, vast amounts of money are spent on importing fuels from distant places. Creating resource-efficient cities, with a substantial component of renewable energy as part of their energy supply, invariably means relocating jobs back to cities.

A US initiative called ‘Climate Prosperity’ sees three major new opportunities:
1) Green Savings – reducing waste and cutting costs;
2) Green Economy – expanding businesses and jobs by increasing market share;
3) Green Talent – investing in technical, entrepreneurial and workforce skills.37

To deal with these opportunities, we need a new form of comprehensive urban planning concerned with making cities environmentally sustainable, but also to enhance cultural sustainability. It is crucially important to harness the great variety of human experiences into city planning. In a world faced with a huge variety of challenges, it is critically important to use the huge variety of talents present in cities for better decision-making.

For instance, in the Brazilian city of Porto Alegre the city government decided to involve the general public in the processes of budget-setting. All citizens can now have a say about what their tax money should be spent on – better schools, better transport, playgrounds, renewable energy installations, and so on. This creative process challenges citizens to actively contribute their views. Through this novel participatory process Porto Alegre has become a truly dynamic city, and the ideas pioneered there are being copied in other cities.

We need creativity and initiative at the local level, but we also need appropriate national policies to enable useful things to happen locally. Without enlightened national policy, the necessary changes won’t happen fast enough. The more promising developments that are occurring in cities around the world are often the result of enlightened national policy driven by lively discussions within a country. For example, feed-in tariffs for renewable energy in Denmark and Germany came out of public discussion and from vigorous public demand.

Towards the renewable city

The great challenge for city planners, architects and developers today, is to internalize the message that we cannot take the resource and energy supply to our cities for granted.

The characteristic of a truly sustainable city is, first and foremost, that it switches to renewable

Credit: Herbert Girardet. Half the people in developing countries live in squatter settlements such as the vast Kibera slum in Nairobi. Poverty and unemployment results in much more resource-efficient lifestyles than in richer cities and city districts. To improve living conditions and to provide renewable energy is one of the great challenges for places like Kibera in the coming years and decades. (See also Chapter 4.)
energy systems. What has been happening in and around Moura, Seville, Glasgow and even London is now starting to happen in many parts of the world. More and more towns and cities, and their regions, are working towards increasing their energy supply from the sun, the wind and other renewables. It is easier for smaller settlements to achieve energy self-reliance than very large cities, but it is becoming apparent that even cities of millions of people are aiming to become ‘solar cities’.

The evidence from an ever-growing number of cities, as presented here, shows that cities of varying sizes can supply their energy needs from within their own territory and, beyond that, from their hinterland. Very ambitious renewable energy and energy efficiency schemes, such as the one now being undertaken in Copenhagen, are being envisaged by more and more cities. The evidence suggests that national enabling policies, such as feed-in tariffs, are best implemented at the local level where the energy is actually used.

In many cases such efforts cannot strictly be described as energy self-sufficiency because towns and cities are linked to electricity grids which can supply power from elsewhere. In the case of Moura, it is commercial companies rather than the cities and citizens themselves that can end up as the ultimate owners of renewable energy installations. Like it or not, this trend seems unavoidable in an era of privatization and economic globalization.

Of course, environmental sustainability is not everything – a pleasant urban environment with clean air, public meeting places, many parks and gardens and safe streets is also essential for a good urban quality of life.

Nevertheless, without substantial supplies of energy cities cannot exist. One of the great challenges of our time is to build a modern civilization based on renewable energy. Pioneering countries like Germany and Spain are striving to become 100 percent renewable by 2050. A very ambitious agenda is also being pursued by Al Gore for the United States as well: he has proposed that the USA can supply the bulk of its energy supplies from renewables within ten years or so. It still remains to be seen whether the Obama administration can see the sense of working towards this goal.

These are the main challenges:

- Raising public awareness of the role of cities in climate change
- Assuring effective knowledge exchange within and between cities
- Enabling renewable energy and energy efficiency development through new approaches in urban governance and planning
- Assuring widespread public understanding of opportunities for more efficient use of resources
- Creating public awareness of the economic benefits of sustainable urban development

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All eyes on China

Pudong, Shanghai’s new business district, is China’s Manhattan, symbolizing its ever-increasing economic prowess. In this business heart of a country of 1.2 billion people, many investment decisions about the world’s future energy use, about cement production and iron ore mining, about logging and/or reforestation, are being made. Will China face up to the systemic environmental problems and impacts linked to its rapid economic growth?

Pudong is also a symbol of China’s urban growth. Each year the country is currently building about 7.5 billion square feet of commercial and residential space, more than the combined floor space of all the malls in the United States, according to the US Energy Information Administration. Many buildings do not meet China’s own codes for energy efficiency, requiring twice as much energy to heat and cool as those in similar climates in Europe or America. What will it take for China to become a leader in eco-technology? Will Pudong put Manhattan to shame by mainstreaming investment in industrial ecology projects?