THE SUSTAINABLE URBAN DEVELOPMENT READER

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Edited by Stephen M. Wheeler and Timothy Beatley

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"Biophilic Cities"

from *Biophilic Cities* (2011)

Timothy Beatley

Editors' Introduction

Many "green" buildings and communities don't seem particularly green to observers. They may be energy efficient or pedestrian oriented, but have little vegetation or wildlife present. In this selection Timothy Beatley argues that sustainable communities need to incorporate nature in ways that people can come into contact with daily. Building on E.O. Wilson's concept of "biophilia," which in his 1984 book *Biophilia* he defines as "the urge to affiliate with other forms of life," Beatley explores ways that green urban design can bring people into constant contact with other living things.

Beatley is the Teresa Heinz Professor of Sustainable Communities at the University of Virginia, and author of many books, including *The Ecology of Place: Planning for Environment, Economy, and Community* (Washington, D.C.: Island Press, 1997), *Native to Nowhere: Sustaining Home and Community in a Global Age* (Washington, D.C.: Island Press, 2004), and *Green Cities of Europe: Global Lessons on Green Urbanism* (Washington, D.C.: Island Press, 2012). This selection is taken from his book *Biophilic Cities: Integrating Nature into Urban Design and Planning* (Washington, D.C.: Island Press, 2011). Other works on this topic include *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, by Stephen R. Kellert, Judith H. Heerwagen, and Martin L. Mador (Hoboken, NJ: Wiley, 2008), and Sim Van der Ryn's *Design for an Empathic World: Reconnecting to People, Nature, and Self* (Washington, D.C.: Island Press, 2013).

While we are already designing biophilic buildings and the immediate spaces around them, we must increasingly imagine biophilic cities and should support a new kind of biophilic urbanism. Exactly what is a biophilic city, what are its key features and qualities? Perhaps the simplest answer is that it is a city that puts nature first in its design, planning, and management; it recognizes the essential need for daily human contact with nature as well as the many environmental and economic values provided by nature and natural systems.

A biophilic city is at its heart a biodiverse city, a city full of nature, a place where in the normal course of work and play and life residents feel, see, and experience rich nature – plants, trees, animals. The nature is both large and small – from treetop lichens, invertebrates, and even microorganisms to larger natural features and ecosystems that define a city and give it its character and feel. Biophilic cities cherish what already exists but also work hard to restore and repair what has been lost or degraded and to integrate new forms of nature into the design of every new structure or built project. We need contact with nature, and that nature can also take the form of shapes and images integrated into building designs, as we will see.

I have written much in the past about green cities and green urbanism, and I continue to argue for the importance of this broader agenda. Biophilic urban design and biophilic urban planning represent one particular, albeit critical, element of green urbanism – the connection with and designing-in of nature in cities. In recognizing the innate need for a connection to nature, biophilic cities tie the argument for green cities and green urbanism more directly to human wellbeing than to energy or environmental conservation.

For some the vision of green cities is not especially green – placing the emphasis on such things as investments in transit, renewable energy production, and energy-efficient building systems. Again, these are all important topics as we reimagine and redefine sustainable urban living in the twenty-first century. But biophilic cities place the focus squarely on the nature, on the presence and celebration of the actual green features, life-forms, and processes with which we as a species have so intimately coevolved.

Scale	Biophilic Design Elements
Building	Green rooftops
	Sky gardens and green atria
	Rooftop garden
	Green walls
	Daylit interior spaces
Block	Green courtyards
	Clustered housing around green areas
	Native species yards and spaces
Street	Green streets
	Sidewalk gardens
	Urban trees
	Low-impact development
	Vegetated swales and skinny streets
	Edible landscaping
	High degree of permeability
Neighborhood	Stream daylighting, stream restoration
	Urban forests
	Ecology parks
	Community gardens
	Neighborhood parks and pocket parks
	Greening grayfields and brownfields
Community	Urban creeks and riparian areas
	Urban ecological networks
	Green schools
	City tree canopy
	Community forest and community orchards
	Greening utility corridors
Region	River systems and floodplains
	Riparian systems
	Regional greenspace systems
	Greening major transport corridors

Biophilic Urban Design Elements across Scales.

Source: Modified from Girling and Kellett, first appeared in Beatley, 2008.

While there is much overlap between biophilic cities and green urbanism, mostly complementary, there may also be ways in which these areas diverge or part. A biophilic city, as I will elucidate below, is even more than simply a biodiverse city: It is a place that learns from nature and emulates natural systems, incorporates natural forms and images into its buildings and cityscapes, and designs and plans with nature. Celebrating an urban building that assumes the shape of a form in nature, or encouraging ornamentation and textures that build connections to place and geology and natural history, are clearly biophilic but likely outside the usual rubric of green cities.

The love of and care for nature, the core value in biophilic cities, extends even beyond its borders to take steps and programs and actions that help to defend and steward over nature in other parts of the globe. And the green elements of cities serve many other important functions – they retain stormwater, sequester carbon, cool the urban environment, and moderate the impacts of air pollution, for example. For me, biophilic urbanism represents a creative mix of green urban design with a commitment to outdoor life and the protection and restoration of green infrastructure from the bioregional to the neighborhood level. The ability to reach on foot, by bicycle, or by transit a park or point of wild nature is essential. Parks are a part of the story, but we need to expand our notion of how a park is used.

Some cities, like New York, now encourage family camping in parks, and in many cities parks have become extended classrooms for schools. How much of a city's budget goes to actively restoring and repairing nature and to educating, celebrating, and actively working to bridge the nature disconnect? These are a few of the potential metrics.

In some cases we have good examples of cities that have established useful biophilic targets and are working toward them. New York has established the goal of providing a park or greenspace within a ten-minute walk of every resident. The city of Singapore has devoted approximately half of its ground area to nature and greenspace, an impressive achievement in what is a very dense city.

It is unlikely that a singular coherent vision of a biophilic city will emerge. Rather, perhaps there are many different kinds of biophilic cities, many different expressions of urban biophilia. And they might be expressed by different combinations and emphases of the qualities and conditions described here. At the simplest level, though, a biophilic city is a city that seeks to foster a closeness to nature – it protects and nurtures what it has (understands that abundant wild nature is important), actively restores and repairs the nature that exists, while finding new and creative ways to insert and inject nature into the streets, buildings, and urban living environments. And a biophilic city is an outdoor city, a city that makes walking and strolling and daily exposure to the outside elements and weather possible and a priority.

But as the above discussion also indicates, a biophilic city is not just about physical conditions or natural setting, and it is not just about green design and ecological interventions – it is just as much about a city's underlying biophilic spirit and sensibilities, about its funding priorities, and about the importance it places on support for programs that entice urbanites to learn more about the nature around them, for instance. A biophilic city might be measured and assessed more by how curious its citizens are about the nature around them and the extent to which they are engaged in daily activities to enjoy and care for nature than by the physical qualities or conditions or, for instance, the number or acres of parks and greenspaces per capita that exist in a city.

Natural and biophilic elements need to be central in everything and anything we design and build, from schools and hospitals to neighborhoods and urban blocks, to street systems and larger urban- and regional-scale design and planning. A "rooftop to region" or "room to region" approach is needed. The best biophilic cities are places where these different scales overlap and reinforce biophilic behaviors and lifestyles – children or adults should be able to leave their front door and move through a series of green features and biophilic elements, moving if they choose from garden and courtyard to green street and municipal forest and then to larger expanses of regional nature. Ideally, in a biophilic city these scales work together to deliver a nested nature that is more than the sum of its parts.

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"The Metabolism of Cities"

from *Creating Sustainable Cities* (1999)

Herbert Girardet

Editors' Introduction

The flow of natural resources into cities and wastes out of them represents one of the largest challenges to urban sustainability. Many argue that cities must "close the resource loop" by recycling, reusing, re-manufacturing, and otherwise diverting materials from their usual destination in landfills and incinerators. Reducing consumption in the first place is also seen as important. Likewise, more efficient urban uses of energy can be sought to reduce dependence on nonrenewable fossil fuels, and renewable energy sources developed such as wind power (the world's fastest growing alternative energy source), solar power, geothermal energy, biomass conversion (the burning of organic materials for energy), and cogeneration (the use of waste energy or steam from one industrial process for heat or power).

Herbert Girardet has written eloquently on urban resource flows particularly as they affect the city of London. He has produced many television documentaries on urban sustainability, and has received a United Nations Global 500 Award "for outstanding environmental achievements." He is the author of *Surviving the Century: Facing Climate Change and Other Challenges* (London: Earthscan, 2007), *Cities People Planet: Urban Development and Climate Change* (Hoboken, NJ: Wiley-Academy, 2008), and *Creating Regenerative Cities* (London: Routledge, 2014). His analysis follows in the footsteps of other "appropriate technology" advocates including the great environmental philosopher E.F. Schumacher, author of *Small is Beautiful: Economics as if People Mattered* (New York: Harper & Row, 1973), and energy guru Amory Lovins, author of *Soft Energy Paths: Toward a Durable Peace* (San Francisco: Friends of the Earth, 1977), *Natural Capitalism: Creating the Next Industrial Revolution* (with Paul Hawken and L. Hunter Lovins, London: Earthscan, 1999), and *Reinventing Fire: Bold Business Solutions for the New Energy Era* (White River Junction, VT: Chelsea Green, 2011).

The growing understanding developed by the natural sciences of the way ecosystems function has a major contribution to make to solving the problems of urban sustainability. Cities, like other assemblies of organisms, have a definable metabolism, consisting of the flow of resources and products through the urban system for the benefit of urban populations. Given the vast scale of urbanization cities would be well advised to model themselves on the functioning of natural ecosystems, such as forests, to assure their long-term viability. Nature's own ecosystems have an essentially *circular* metabolism in which every output which is discharged by an organism also becomes an input which renews and sustains the continuity of the whole living environment of which it is a part. The whole web of life hangs together in a "chain of mutual benefit," through the flow of nutrients that pass from one organism to another.

The metabolism of most modern cities, in contrast, is essentially *linear*, with resources being 'pumped' through the urban system without much concern about their origin or about the destination of wastes, resulting in the discharge of vast amounts of waste products incompatible with natural systems. In urban management, inputs and outputs are considered as largely unconnected. Food is imported into cities, consumed, and discharged as sewage into rivers and coastal waters. Raw materials are extracted from nature, combined and processed into consumer goods that ultimately end up as rubbish which can't be beneficially reabsorbed into the natural world. More often than not, wastes end up in some landfill site where organic materials are mixed indiscriminately with metals, plastics, glass, and poisonous residues.

This linear model of urban production, consumption, and disposal is unsustainable and undermines the overall ecological viability of urban systems, for it has the tendency to disrupt natural cycles. In the future, cities need to function quite differently. On a predominantly urban planet, cities will need to adopt circular metabolic systems to assure their own long-term viability and that of the rural environments on whose sustained productivity they depend. To improve the urban metabolism, and to reduce the ecological footprint of cities, the application of ecological systems thinking needs to become prominent on the urban agenda. Outputs will also need to be inputs into the production system, with routine recycling of paper, metals, plastic and glass, and the conversion of organic materials, including sewage, into compost, returning plant nutrients back to the farmland that feeds the cities.

The *local* effects of the resource use of cities also need to be better understood. Urban systems accumulate vast quantities of materials. Vienna, for instance, with 1.6 million inhabitants, every day increases its actual weight by some 25,000 tons.[1] Much of this is relatively inert materials, such as concrete and tarmac which are part of the built fabric of the city. Other materials, such as lead, cadmium metals, nitrates, phosphates, or chlorinated hydrocarbons, build up and leach into the local environment in small, even minute quantities, with discernible environmental effects: they accumulate

1 *Inputs* (tons per year)	
Total tons of fuel, oil equivalent	20,000,000
Oxygen	40,000,000
Water	1,002,000,000
Food	2,400,000
Timber	1,200,000
Paper	2,200,000
Plastics	2,100,000
Glass	360,000
Cement	1,940,000
Bricks, blocks, sand, and tarmac	6,000,000
Metals (total)	1,200,000
2 *Wastes*	
CO_2	60,000,000
SO_2	400,000
NO_X	280,000
Wet, digested sewage sludge	7,500,000
Industrial and demolition wastes	11,400,000
Household, civic, and commercial wastes	3,900,000

Table 1 The metabolism of Greater London (population 7 million).

Source: Compiled by Herbert Girardet (1995, 1996); sources available from author.

in water and in the soil over time, with potential consequences for the health of present and future inhabitants. The water table under large parts of London, for instance, has become unusable for drinking water because of accumulations of toxins over the last 200 years. Much of its soil is polluted by the accumulation of heavy metals during the last 50 years.

The critical question today, as humanity moves to "full scale" urbanization, is whether living standards in our cities can be maintained whilst curbing their local and global environmental impacts. To answer this question, it helps to draw up balance sheets quantifying the environmental impacts of urbanization. We now need figures to compare the resource use by different cities. It is becoming apparent that similar-sized cities supply their needs with a greatly varying throughput of resources, and local pollution levels. The critical point is that cities and their people could massively reduce their throughput of resources, maintaining a good standard of living creating much needed local jobs in the process. I shall now discuss aspects of urban use of resources and energy in more detail.

WATER AND SEWAGE

Our cities consume vast amounts of water: in the UK, typically, some 400 liters per person per day. In the US the figure is as high as 600 litres. In older cities, such as London, water has to be pumped in from elsewhere because it is exceedingly costly to clean it to drinking water standards. Cities externalize the problem. The abstraction of river water, often many miles away from cities, has caused the destruction of river habitats and fisheries; today, many rivers' supply are a pale shadow of their former selves.

Water supplied to households, even if supplied from outside cities, goes through various treatment processes. River water, a source of supply in most countries, has to be cleaned of impurities, including pesticides, phosphates and nitrates from farming. The water is percolated through sand and charcoal filter beds before it is pumped into a city's network of water pipes. Chlorination, which is commonplace, disinfects drinking water, but its unpleasant taste causes many people to switch to bottled drinking water instead. This does not make financial sense, since bottled water, at up to 60p per litre, is often more expensive than the petrol we put in the tanks of our cars. Neither does it make sense environmentally, with vast quantities of bottled water being trucked in from hundreds or even thousands of miles away at great energy cost. It would be desirable to ensure that the quality of urban water could be high enough for it to be commonly used for drinking once again.

Unfortunately, a major function of urban water supply is as a carrier for household and commercial sewage. For this and other reasons, urban sewage systems are of an important issue in the quest for urban sustainability. Their main purpose is to collect human faeces and to separate it from people, to help prevent outbreaks of diseases such as cholera or typhoid. As a result, vast quantities of sewage are flushed away into rivers and coastal waters downstream from population centers. Coastal waters the world over are enriched both with human sewage and toxic effluents, as well as the run-off of mineral fertilizer and pesticides applied to the farmland feeding cities. The fertility taken from farms in the form of crops used to feed city people is not returned to the land. This open loop is not sustainable.

Whilst it is clear that cities need to have efficient sewerage systems, we need to redefine their purpose. Instead of building disposal systems we should construct recycling facilities in which sewage can be treated so that the main output is fertilizers suitable for farms, orchards, and market gardens. It has been too readily forgotten that sewage contains an abundance of valuable nutrients such as nitrates, potash, and phosphates. Returning these from cities to the land is an essential aspect of sustainable urban development.

A variety of new sewerage systems have been developed for this purpose using several new technologies: membrane systems that separate sewage from any contaminants; so-called "living machines" that purify sewage by biological methods; and drying technology which converts sewage into granules that can be used as fertilizer. These technologies can be used in combination with each other, making sewerage facilities into efficient fertilizer factories. These sorts of systems are now beginning to be used in cities all over the world.

In Bristol, the water and sewage company Wessex Water now dries and granulates all of the city's sewage. The annual sewage output of 600,000 people is turned into 10,000 tons of fertilizer granules. Most of it is currently used to revitalize the bleak slag heaps around former mining towns such as Merthyr Tydfil in South East Wales. In contrast, Thames Water in London is currently constructing incinerators for burning the sewage sludge produced by 4 million Londoners. This is a decision of historic short-sightedness given that phosphates – only available from North Africa and Russia – are likely to be in short supply within decades. Crops for feeding cities cannot be grown without phosphates.

There is an acknowledged problem with the contamination of sewage with heavy metals and chlorinated hydrocarbons. For this reason, there is growing concern about using sewage-derived fertilizer on farmland. However, the reduction of the use of lead in vehicle fuel and the de-industrialization of our cities is reducing this problem, lessening the load of contaminants that are flushed into sewage pipes. Also, more stringent environmental legislation is further reducing contamination of sewage. The quest for greater urban sustainability will certainly lead to a significant rethink on how we design sewerage systems. The aim should be to build systems to intercept the nutrients contained in sewage whilst assuring that it can be turned into safe fertilizers for the farmland feeding cities.

SOLID WASTE

Solid waste is the most visible output by cities. In recent decades there has been a substantial increase in solid waste produced per head, and the waste mix has become ever more complex. Today's "garbologists" see a vast difference between early and late twentieth century rubbish dumps. The former contain objects such as horse shoes, enamelled saucepans, pottery fragments and leather straps. The latter contain food wastes, plastic bags and containers, disposable nappies, mattresses, newspapers, magazines and transistor radios. But garbologists will also find plenty of discarded building materials, and crushed canisters containing various undefined, sometimes highly poisonous, liquids.

Urban wastes used to be dumped primarily in holes in the ground. Much of London's waste, for instance, is dumped in a few huge tips, such as at Mucking on the Thames in Essex. Household waste, as well as commercial and industrial waste, is taken here by central London, and "*co-disposed*" in pits lined with clay. The compacted rubbish is, eventually, sealed with a top layer of clay, which is then covered with soil and seeded with grass. Inside the dump, methane gas from the rotting waste is now intercepted in plastic pipes and used to run small power stations. However, their output is quite insignificant. Mucking receives the rubbish of some 2 million people, but its methane-powered generators supply electricity to just 30,000 people.[2]

More and more cities, including London, are seeing growing resistance from people in adjoining counties on receiving urban wastes; all the environmental implications of fleets of rubbish trucks, potential groundwater contamination, and stench in the vicinity of waste dumps are a growing concern. As the unwillingness to receive rubbish grows, other waste disposal options are urgently required. Dumping ever growing mounds of waste outside the cities where they originate is a waste of both space and resources that be used more beneficially.

We need to think again about the ways in which urban waste management systems work. Many cities all over the world have chosen incineration as the most convenient route for "modern" waste management. Incineration has the advantages of reducing waste materials to a small percentage of their original volume. Energy recovery can be an added bonus. But incineration is certainly not the main option for solving urban waste problems. The release of dioxins and other poisonous gases from the smokestacks of waste incinerators has given them a bad name. There have been great improvements in incineration and pollution control techniques, but only those wastes that cannot be recycled should be considered for incineration.

Recently, new objections to incinerators have been voiced in the United States because research has shown conclusively that incinerators compare badly with recycling in terms of energy conservation. Because of the high energy content of many manufactured products that end up in the rubbish bin, recycling paper, plastics, rubber and textiles is three to six [times] more energy-efficient than incineration. These are very significant figures, given that the energy and resource efficiency of urban systems is regarded as critical for future urban sustainability.[3] Many European cities are now deciding against investing in new incinerators, and in favor of a combination of recycling and composting facilities instead, with minimal incineration for waste products that cannot be further recycled.

It has been said that recycling is a red herring because it is so difficult to match the supply of materials to be recycled with regular demand for recycled products. But experiences in many European cities indicate that market incentives can make recycling economically advantageous and that the right policy signals and incentives at national and local level can transform prospects. Whilst not all waste materials can be recycled, much can be done to move in this direction. As concern grows about the continuing viability of the environments on which cities depend, the reuse and recycling of solid wastes is likely to become the rule rather than the exception. Deliberately constructing 'chains of use' that mimic natural ecosystems will be an important step forward for both industrial and urban ecology.

BOX 1 How Cairo recycles its waste

Cities in the developing world usually make highly efficient use of resources, particularly if people are supported in their recycling activities. Cairo and Manila actively encourage recycling and composting of wastes. There are a growing number of cities that are actually moving towards being zero-waste systems. Cairo, with 15 million people one of the world's largest cities, reuses and recycles most of its solid waste. Much of it is handled by a community of Coptic Christians called the Zaballeen. With the active support of the city authorities, the Zaballeen were able to acquire recycling and composting equipment. Metals and plastics are remanufactured into new products. Waste paper is reprocessed into new paper and cardboard. Rags are shredded and made into sacks and other products. Organic matter is composted and returned to the surrounding farmland as fertilizer.

The Zaballeen Environment and Development Programme has enabled the 10,000 strong community to substantially increase its income from its recycling and remanufacturing activities. In that way, social and environmental problems affecting Cairo are tackled simultaneously. Had the waste management of the city been given over to a conventional waste management company, thousands of waste collectors would have been out of work. By helping the Zaballeen with appropriate technology, they were able to improve on their traditional waste-handling methods, while Cairo could avoid putting vast waste dumps on the periphery of the city.

In the case of solid waste management, cities in the North have much to learn from the ingenuity of waste recycling in the South. Meanwhile, cities in the South could greatly benefit from the transfer of improved recycling technologies now available in the North.

Some modern cities have already made this a top priority. Cities across Europe are installing waste recycling and composting equipment. In German towns and cities, for instance, dozens of new composting plants are being constructed. In Sweden, Gothenburg has taken matters even further by setting up an ambitious program for developing "eco-cycles," minimizing the leakage of toxic substances into the local environment by helping companies develop advanced non-polluting production processes.[4] Vienna also has an impressive track record, currently recycling 43 percent of its domestic wastes.[5] This sort of figure is common to a growing number of European and American cities.

Most European cities exceed the household waste recycling performance of cities in the UK.[6] In some British cities, such as Bath and Leicester, where recycling has advanced a great deal, the benefits for people and the local environment are clearly apparent. The UK landfill tax, introduced in 1996, has increased recycling throughout the UK, helping to achieve the government target of 25 percent household waste recycling by 2000. This taxation should be extended to approximate a recycling rate of 50 percent, which is the target in other European countries.

In London, where currently only 7 percent of household waste is recycled, a proposal by the London Planning Advisory Council is intended to bring recycling up to unprecedented levels. By 2000, every London home would have a recycling box with separate compartments instead of conventional dustbins. Progressively more and more municipal waste would be recycled, establishing new reprocessing industries and creating 1,500 new jobs.[7] Early in the new century, this figure would increase further. Meanwhile, the composting of organic wastes is advancing well, with 'timber stations' that compost shredded branches of pruned trees and leaf litter being established in various locations.

Throughout the developing world, too, cities have made it their business to encourage recycling and composting of wastes.[8] Cairo, Manila, and Calcutta are interesting cases in point.

ENERGY

Looking down on the Earth from space at night, astronauts see an illuminated planet – vast city clusters lit up by millions of light bulbs as well as the flares of oil wells and refineries. Fossil fuels have made us what we are today – an urban–industrial species. Without the power stations they supply and the vehicles they power, our urban lifestyles and our astonishing physical mobility would not have developed.

Worldwide, fossil fuel use in the last 50 years has gone up nearly five times, from 1.715 billion tons of oil equivalent in 1950 to well over 8 billion tons today. Fossil fuels provide some 85 percent of the world's commercial energy, of which oil currently amounts to around 40 percent. The bulk of the world's energy consumption is *within* cities, and much of the rest is used for producing and transporting goods and people *to and from* cities. This realization is crucial for developing strategies for sustainable use of energy, particularly in the context of global warming.

Energy use is something most of us take for granted. As we switch on electric or gas appliances, we are hardly aware of the refinery, gas field, or the power station that supplies us. And despite publicity about acid rain and climate change, we rarely reflect on the impacts of our energy use on the environment because they are not experienced directly, except when we inhale exhaust fumes on a busy street.

Yet reducing urban energy consumption could make a major contribution to solving the world's air pollution problems. At the 1997 Kyoto conference on climate change, the industrialized nations agreed to cut CO_2 emissions by 5 percent by 2010, but a worldwide cut of some 60 percent is needed to actually *halt* global warming. As indicated in the Introduction, large cities and high levels of energy consumption are closely connected, particularly where routine use of motor cars, urban sprawl and air travel define urban lifestyles. Yet the potential exists for cities to be efficient users of energy.

London's 7 million people, for instance, use 20 million tons of oil equivalent per year (two supertankers a week), and discharge some 60 million tons of carbon dioxide. All in all, the per capita energy consumption of Londoners is amongst the highest in Europe. The city's electricity supply system, relying on remote power stations and long distance transmission lines, is no more than 30 to 35 percent efficient. The know-how exists to bring down London's energy use by between 30 and 50 percent without affecting living standards, and with the potential of creating tens of thousands of jobs in the coming decades. Significant energy conservation can be achieved by a combination of *energy efficiency* and by more efficient *energy supply systems.*

In the UK, national planning regulations have already substantially improved the energy efficiency of homes, but much more can be done. At the domestic level, two out of three low-income families lack even the most basic insulation in their homes. Eight million families cannot afford the warmth they need in the winter months. Treating cold-related illnesses costs the National Health Service over £1 billion per year.[9] Only one in twelve domestic properties in Britain have the level of energy efficiency currently required by law.[10] Yet energy efficiency's advantages are impressive:

- reduced fuel bills for everyone;
- benefits to the trade balance through curbing the need for imports;
- the creation of new jobs in the energy efficiency industry;
- the preservation of fossil fuel reserves;
- the alleviation of environmental problems, such as air pollution and global warming, contributed to by energy generation.

There are many examples, particularly from Scandinavia, of how energy efficiency combined with efficient supply systems can dramatically reduce the energy dependence of cities. There is no doubt that the energy supply systems in many cities of the world can be vastly improved. Take electricity: most cities are supplied by power stations located a long way away, fired mainly by coal, with electricity being transferred along high-voltage power lines. On average, these stations are only 34 percent efficient. Modern gas-fired stations are slightly better, at 40–50 percent efficiency. Combined heat and power (CHP) stations, in contrast, are about 80 percent efficient, because instead of wasting heat from combustion, they capture and distribute it through district heating systems.[11]

CHP systems are a very significant technology indeed. They can be fueled by a wide variety of sources – gas, geothermal energy, or even wood chips. CHP systems provide heat and chilled water, as well as electricity to urban buildings and factories. They are now commonplace in many

European cities. In Denmark 40 percent of electricity is produced by CHP; in Finland 34 percent, and in Holland 30 percent.

Helsinki has taken the development of CHP further than most cities. Waste heat from local coal-fired power stations is used to heat 90 percent of its buildings and homes. Its overall level of energy efficiency of 68 percent was achieved because its compact land use patterns made district heating a viable option. The compactness of the city also made the development of a highly effective public transport system economically viable.

In the development of CHP, the UK has been off to a slow start. Small-scale systems are being installed in some office blocks, schools, hospitals, and hotels, improving their energy efficiency considerably. All have the same high level of efficiency as large-scale systems.

The challenge for national governments and local authorities in the developed world is to put in place new energy policies, particularly to improve urban energy efficiency. The scenario includes the creation of municipally owned and operated energy systems. In some cities, such as Vienna and Stockholm, energy systems are operated by the "city works," which also supply water and run the transport and waste management systems. The synergies possible between these services are much harder to achieve in cities where privatization of services is the norm. It appears that the largest improvements in power distribution and consumption are realized by cities with a municipality-owned electricity company, such as Toronto and Amsterdam.[12]

The UK is just seeing the first schemes where greenhouse cultivation is being combined with CHP, utilizing their hot water and waste CO_2 to enhance crop growth for year-round cultivation.[13] Policies for encouraging CHP could thus also be used for enhancing urban agriculture, bringing producers closer to their markets instead of flying and trucking in vegetables from long distances. Once again, local job creation would result.

In addition to CHP, other significant new energy technologies are becoming available for use in cities. These include heat pumps, fuel cells, solar hot water systems and photovoltaic (PV) modules. In the near future, enormous reductions in fossil fuel use can be achieved by the use of PV systems, a technology particularly suited to cities. In the late 1990s there are only a few thousand buildings around the world using electricity from solar panels on their roofs or facades. Solar electricity could meet some of a building's requirements, with the rest of the power coming from the grid.

According to calculations by the oil company BP, London could supply most of its current summer electricity consumption from photovoltaic modules on the roofs and walls of its buildings. While this technology is still expensive, large scale automated production will dramatically reduce unit costs. And the only maintenance they require is cleaning once or twice a year.

Currently, solar energy is about eight times more expensive than conventional, but it is expected to be competitive as early as 2010 as the technology develops and the market grows. Major development programs have been announced in Japan, the USA, the Netherlands and the European Union to stimulate market growth. The technical potential for the generation of electricity from building integrated solar systems is very large indeed and could contribute significantly to the building energy requirements, even in a northerly climate like that in the UK. Of course, not all buildings will be suitable for the installation of a solar roof or facade, and adoption will be more rapid in countries with the highest sunshine level.

BOX 2 Solar energy in Saarbrücken, Germany

Saarbrücken, a city of 190,000 people, has a major investment program in solar energy. Since 1986 US$1.7 million has been spent on solar heating, PV systems, and other renewable energy sources. The state offers a 50 percent subsidy for technical assistance, and the local savings bank offers residential energy users favorable lending terms for the installations. The local energy utility owns the PV array, but the inhabitants of each house benefit from the solar electricity supply. In addition to domestic systems, there are also municipal PV installations, incorporated into highway noise barriers. The solar initiative has the support of the entire community because it is helping to lay the foundation for a sustainable future. A former coal-mining center, Saarbrücken has now become a center for the development of urban applications of solar energy systems.

Experimental solar buildings are springing up all over Europe. The new German government, elected in 1998, has a national program for installing 100,000 PV modules. PV programs in Japan and the USA are on a similar scale. In the UK, experimental systems have proved to be very promising. The Photovoltaics Centre at Newcastle University, a 1960s building recently clad with PV panels, has proved to be a great success. In Doxford, near Newcastle, Europe's largest solar-powered office building was completed in 1998.

In the new millennium, building designers will routinely incorporate this technology when designing a new building or refurbishing an existing one. In the meantime, to get experience with the technology, governments and urban authorities should vigorously encourage the installation of PV modules in our cities, enhancing the capacity to install PV systems. Every city should have buildings to test the potential of PV and to develop the local know-how.

Another energy technology of great promise, *fuel cells*, is fast coming of age. Fuel cells convert hydrogen, natural gas, or methanol into electricity by a chemical process without involving combustion. Fuel cells, like photovoltaic cells, have taken a long time to become commercially viable. Their development is now accelerating as the world searches for practical ways to produce cleaner electricity. Several companies have made great strides in making fuel cells competitive, in a variety of applications: from running generators and power stations, to buses, trucks and cars. Large-scale commercial production of fuel cells will be getting under way early in the new millennium. The combination of photovoltaic cells and fuel cells is a particularly compelling option. Electric energy from PV cells could split water into oxygen and hydrogen, and the latter could be stored and then used to run fuel cell power stations, or generators for individual buildings.

It is plausible that even large cities, whose genesis depended on the routine use of fossil fuels in the first place, may be able to make significant use of renewable energy in the future. To make their energy systems more sustainable, cities will require a combination of energy-efficient systems such as CHP with heat pumps, fuel cells and photovoltaic modules, and the efficient use of energy. Regulating the energy industry to improve generating efficiency, reduce discharge of waste gases and to adopt renewables will profoundly reduce the environmental impact of urban energy systems.

NOTES

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