COMMISSION ON CITIES AND CLIMATE CHANGE

World Future Council

HCU HafenCity University Hamburg

Regenerative Cities

Written for the World Future Council and HafenCity University Hamburg (HCU) Commission on Cities and Climate Change

With thanks for comments and suggestions by Nicholas You, Peter Droege, Dushko Bogunovich, Ralf Otterpohl, Peter Head and Stefan Schurig.

Cities Commission for Regenerative Cities:

The World Future Council brings the interests of future generations to the centre of policy making. It addresses challenges to our common future and provides decisionmakers with effective policy solutions.

HafenCity University Hamburg (HCU) is Europe's first university that entirely focuses on disciplines of the built environment, such as architecture, urban and regional planning, civil engineering and geomatics.

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Regenerative Cities

Herbert Girardet

Introduction and summary

At the start of the 21st century, humanity is becoming a predominantly urban species and this historic development represents a fundamental, systemic change in the relationship between humans and nature. Urban-based economic activities account for 55 per cent of GNP in the least developed countries, 73 per cent in middle income countries and 85 per cent in the most developed countries.[1]

Modern cities, then, are defined by the concentration of economic activities and intense human interaction. This is reflected in high average levels of personal consumption and the efficient supply of a great variety of services at comparatively low per-capita costs. But the environmental impacts of an urbanising humanity are a great cause for concern. Apart from a near monopoly on the use of fossil fuels, metals and concrete, an urbanising humanity now consumes nearly *half* of nature's annual photosynthetic capacity as well.

Since the industrial revolution the process of urbanisation has become ever more resource-intensive, and it significantly contributes to climate change, loss of soil carbon, natural fertility of farmland, and the loss of biodiversity all over the world. The ravenous appetite of our fossil-fuel powered lifestyles for resources from the world's ecosystems has severe consequences for all life on Earth, including human life.

Cities have developed resource consumption and waste disposal habits that show little concern for the consequences. Addressing this issue is the primary task of this paper.

The larger and the richer the city, the more it tends to draw on nature's bounty from across the world rather than its own local hinterland. Human impacts on the world's ecosystems and landscapes are dominated by the ecological footprints of cities which now stretch across much of the Earth. They can be hundreds of times larger than the cities themselves. In an urbanising world, cities need to rapidly switch to renewable energy and to actively help restore damaged ecosystems.

The WWF states in its Living Planet Reports that in the last 30 years a third of the natural world has been obliterated.[2] 40-50 per cent of Earth's ice-free land surface has been heavily transformed or degraded by human activities, 66 per cent of marine fisheries are either overexploited or at their limit and atmospheric CO2 has increased more than 30 per cent since the advent of industrialisation.[3] Helping to reverse this collision course between humans and nature is a new challenge for most national politicians, but even more for urban politicians, planners and managers, and for architects, civil engineers and city dwellers.

The challenge today is no longer just to create sustainable cities but truly *regenerative* cities: to assure that they do not just become resource-efficient and low carbon emitting, but that they positively enhance rather than undermine the ecosystem services they receive from beyond their boundaries. A wide range of technical and management solutions towards this end are already available, but so far implementation has been too slow and too little.

Most importantly, the transformative changes that are required to make cities regenerative call for far-reaching strategic choices and long-term planning as compared to the short-term compromises and patchwork solutions that characterise most of our political decision making systems at all spheres of government.

In recent years there has been a proliferation of *urban regeneration* initiatives focussed on the health and well-being of urban citizens and the urban fabric – the 'inner-urban environment' – particularly in rich countries such as Britain, Germany and the USA. Such initiatives have received much funding and media attention, and they have improved the lives of millions of people. In various countries *Urban Regeneration Associations* have been established to address problems such as deindustrialisation, depopulation, congestion, aging infrastructure, run-down sink estates and associated matters.

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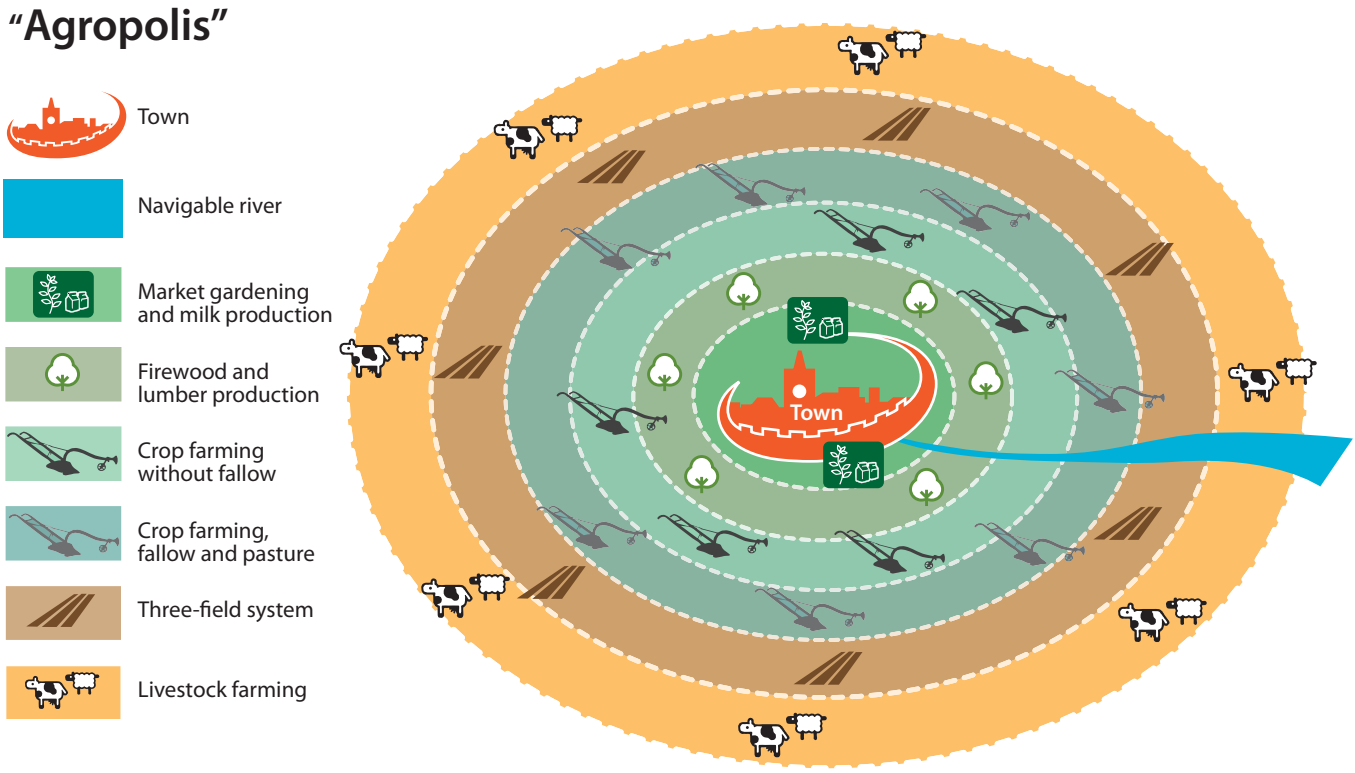
[1] UN Habitat, The State of the World's Cities, 2006/7
[2] WWF, Living Planet Report 2010, wwf.panda.org/about_our_earth/.../living_planet_report/2010_lpr/
[3] Vitousek, P.M., J. Lubchenco, H.A. Mooney, J. Melillo. 1997. Human domination of Earth's ecosystems. Science 277: 494-499

But the concept of *regenerative cities* goes further – seeking to address the relationship between cities and their hinterland, and beyond that with the more distant territories that supply them with water, food, timber and other vital resources. We need to re-enrich the landscapes on which cities depend, and this includes measures to increase their capacity to absorb carbon emissions. Creating a *restorative relationship* between cities, their local hinterland and the world beyond, means harnessing new opportunities in financial, technology, policy and business practice.

This text argues that the established horizon of *urban ecology* should be expanded to include all the territories involved in sustaining urban systems. *Urban regeneration* thus takes on the meaning of *eco-regeneration*.

Creating regenerative cities thus primarily means one thing: *Initiating comprehensive political, financial and technological strategies for an environmentally enhancing, restorative relationship between cities and the ecosystems from which they draw resources for their sustenance.*

Cities as ecological and economic systems



Towns and cities need sustenance for their people and this requires elaborate ecological and economic systems. In his book 'The Isolated State' the prominent 19th century economist Johann Heinrich von Thünen described the way in which human settlements, in the absence of major transport systems, are systemically tied into the landscape surrounding them through various logically arranged modes of cultivation.[4] In fact, they have an active, symbiotic relationship with it: they also assure its continuing productivity and fertility by returning appropriate amounts of organic waste to it. In this text I have chosen to use the term 'Agropolis' for this traditional type of settlement system.

[4] en.wikipedia.org/wiki/Johann_Heinrich_von_Thünen

Von Thünen pioneered the view that the way cultivated land in close proximity to towns and cities is utilised is a logical function of two interconnected variables – the cost of transporting produce to market, and the land rent a farmer can afford to pay. He describes how isolated communities are surrounded by concentric rings of varying land uses. Market gardens and milk production are located closest to the town since vegetables, fruit and dairy products must get to market quickly. Timber and firewood, which are heavy to transport but essential for urban living, would be produced in the second ring. The third zone consists of extensive fields for producing grain which can be stored longer and can be transported more easily than dairy products, and can thus be located further from the city. Ranching is located in the fourth zone since animals can be raised further away from the city because they are 'self-transporting' on their own legs. Beyond these zones lies uncultivated land of less economic relevance to urban living.

In many parts of the world traditional towns and cities, in the absence of efficient transport systems, had these kind of symbiotic relationships to the landscapes from which they emerged, depending on nearby market gardens, orchards, forests, arable and grazing land and local water supplies for their sustenance. Until very recently, many Asian cities were still largely self-sufficient in food as well as fertiliser, using human and animal wastes to sustain the fertility of local farms.[5] Can we learn from these traditional systems in the future whilst utilising more up-to-date methodologies and technologies?

The rise of Petropolis

The industrial revolution caused a virtual explosion of urban growth that continues to this day. Steam engine technology enabled the unprecedented concentration of industrial activities in urban centres. Cities increasingly cut the umbilical cord between themselves and their local hinterland and became global economic and transport hubs. This process has undermined local economies, as new modes of transportation have made it ever easier to supply food, raw materials and manufactured products from ever greater distances. Cities are no longer centres of *civilisation* but of *mobilisation*, with access to global resources as never before.

The phenomenal changes in human lifestyles made possible by the *Age of Fire* were also reflected in new concepts of land use planning, particularly for accommodating the road space needed for motor cars. The vast, low-density urban landscapes that appeared in the USA, Australia and elsewhere are defined by the ubiquitous use of cars or *petromobiles* – the word *automobile* implies that they are self-powered which clearly they are not.

The modern city could be described as 'Petropolis': all its key functions – production, consumption and transport – are powered by massive injections of petroleum and other fossil fuels. But there is ever growing evidence that the resulting dependencies are ecologically, economically and geopolitically untenable, particularly because the fossil fuel supplies on which modern cities depend are, most definitely, finite.

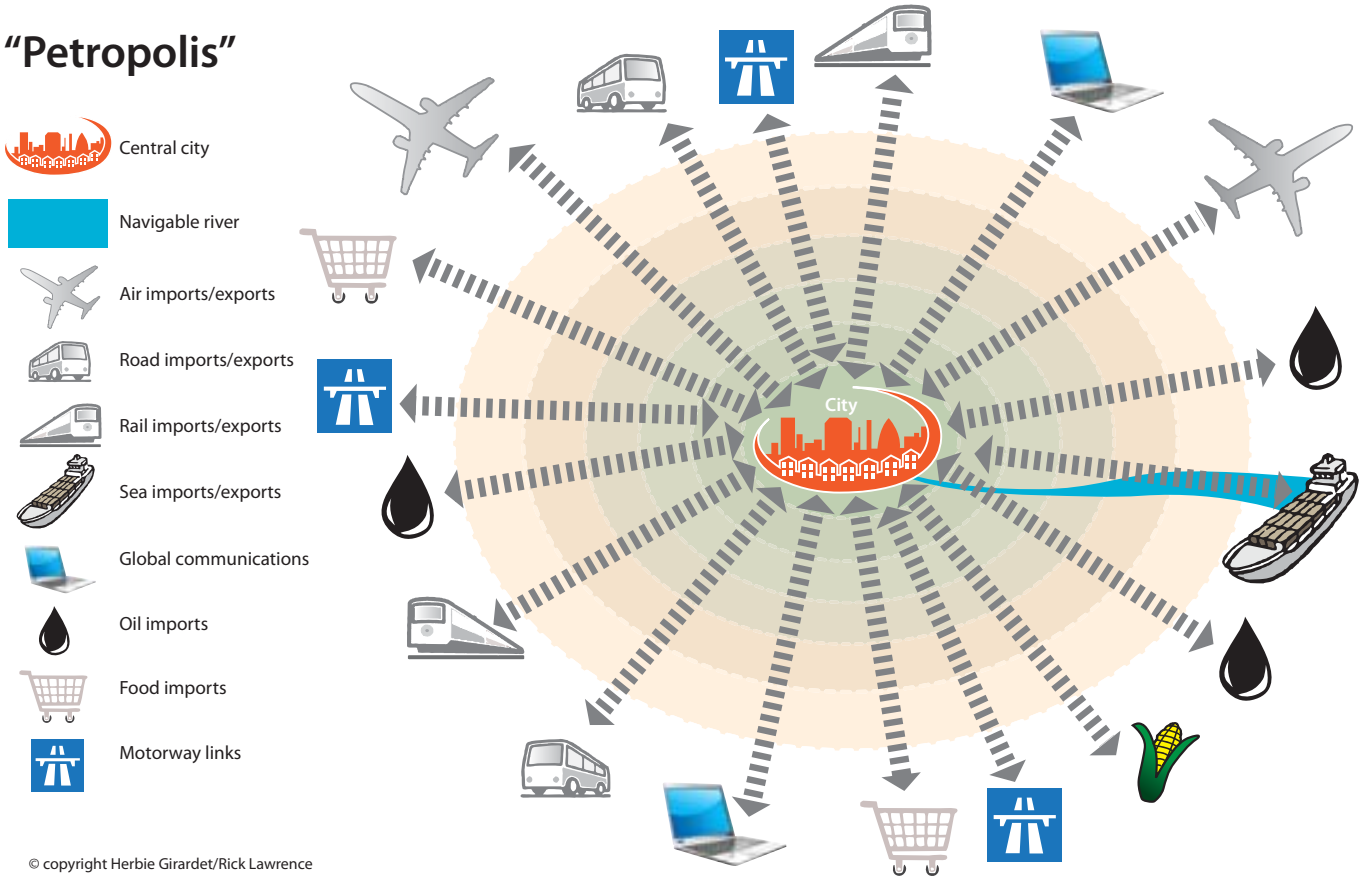
Even though we know that we live on a finite planet, infinite economic and urban growth is still taken for granted. While the world's population has grown fourfold in the twentieth century, urban populations and global resource consumption have increased sixteen fold and are still rising. It took around 300 million years for oil, gas and coal to accumulate in the earth's crust and we are on track to burn much of it in just 300 years – now at a rate of well over a million years per year. Cities are particularly responsible for this: despite taking up only three to four per cent of the world's surface area they use approximately 80 per cent of its resources and also discharge similar proportions of waste. These figures are still increasing.

The highly problematic patterns of fossil-fuel dependent urbanisation are still expanding across the world.

Today urbanisation and economic and financial globalisation are closely connected. Cities have become globalised centres of production as well as consumption, with throughputs of unprecedented quantities of resources and industrial products being the norm in the wealthier countries. In emerging countries, too, urbanisation is closely associated with ever increasing per-capita use of fossil fuels and with impacts on ever more distant ecosystems. The rapid growth of cities such as Dubai with its vast airport, world record skyscrapers, artificial islands and low-density desert suburbs, is the latest and most astonishing example of this.

[5] F. H. King, Farmers of Forty Centuries: Organic Farming in China, Korea, and Japan, Courier Dover Publications, 1911

We are seeing ever more extraordinary contraptions appear across the face of the Earth to extract fossil fuels from the Earth's crust, to refine them and to deliver them into our cities and homes. With most of the 'easy' coal, oil and gas now used up, new kinds of highly problematic extraction methods have come to underpin the existence of our urban systems. Mountain top removal in places such as West Virginia has become the basis for ever larger scale open-cast coal mining operations. In Alberta, tar sand mining pollutes vast amounts of water that is used to melt the tar contained within the sands. Off-shore oil platform operators are now drilling as much as 10 kilometres down into the Earth's crust in ever more hostile waters. Is this foolhardiness or the epitome of human ingenuity?



Modern cities have often been established on former forest and farmland. City people rely on a steady supply of natural resources from across the planet and consumers are often oblivious to the environmental consequences. Yet there is much evidence that urban resource consumption is fundamentally undermining ecosystems across the world on whose integrity cities ultimately depend.

And much of what goes in must come out again. Contemporary urban systems discharge vast quantities of solid, liquid and gaseous wastes. Where do they end up? We all have a vague idea that the *solid waste* we throw away is buried in landfills in the urban vicinity or may be trucked away to distant locations. But few of us know what is contained in the *liquid waste* we discharge from our homes and what ultimately happens to it.

And what about air pollution? In mega-cities such as Mexico City or Beijing people are still being forced to breathe horrendously polluted air. As long as people experience pollution directly as a local health problem they demand efforts to clean it up. But the detrimental effects of acid fumes such as sulphur and nitrogen oxides on forests and farm crops downwind from cities and power stations is outside most people's everyday experience. And greenhouse gas emissions affecting the global climate imply a shift of concern from impacts on *human health* to impacts on *planetary health* which is much more difficult for us to face up to. And the global *ecological footprints* of our cities are an even more abstract concept, well beyond the personal experience of most citizens.

The challenge now is to insure that we will face up to the environmental impacts of urban living before they start to hit home in the form of health problems, higher food or energy prices, storms and sea level rises.

Communicating the dangers of such *boomerang effects*, which could soon undermine the very existence of our modern cities, is a huge challenge for educators and policy makers.

Petropolis and planetary boundaries

The 'planetary boundaries' that are becoming evident in the face of global industrialisation, urbanisation and population growth have major implications for urban planning and governance. We must face up to the fact that cities are *dependent systems* whose reliance on external inputs for their sustenance is likely to become ever more precarious. The process of *entropication* – of combining resources into products and producing wastes faster than they can be converted back into useful resources – has to be dealt with by deliberate measures of policy and management. Our living planet cannot cope with the ever increasing accumulation and degradation of natural resources in our cities without appropriate measures being taken to replenish the global biosphere and to reduce our impacts on the atmosphere.

WWF Living Planet Report 2010

Since 1970 the global Living Planet Index has fallen by 30 per cent, which means that, on average, species population sizes were 30 per cent smaller in 2007 than they were in 1970. Following current trends, by 2030 humanity will need the capacity of two Earths to absorb CO2 waste and keep up with natural resource consumption. Higher income nations have an average per capita environmental footprint that is around five times larger than that found in poorer nations.

The implications are clear. Rich nations must find ways to live much more lightly on the Earth, to sharply reduce their footprint, in particular their reliance on fossil fuels. World leaders have to deliver an economic system that assigns genuine value to the benefits we get from nature: biodiversity, the natural systems which provide goods and services like water, and ultimately our own well-being.

A large part of the increase of carbon dioxide in the atmosphere is attributable to combustion in and on behalf of the world's cities. 200 years ago atmospheric CO2 concentrations were around 280 parts per million, but since then they have risen to 390 ppm. Until recently it was widely assumed that we could get away with doubling pre-industrial concentrations. But gradually it has become clear that this could cause the planet to overheat, with dire consequences for all life. Climatologists then gradually brought the target figures down from 550 to 450 ppm, particularly as they discovered the extent of warming that has already occurred in the Arctic Circle. Whilst global temperatures have increased by an average of 0.8 °C, in the Arctic they have gone up much more.

The Arctic regions appear to be exceedingly sensitive to anthropogenic CO2 emissions. According to the Intergovernmental Panel on Climate Change (IPPC) "Arctic temperatures have increased at almost twice the global average rate in the last 100 years (...) Temperatures at the top of the permafrost layer have generally increased since the 1980s (...) by up to 3 °C."[6] An increase in arctic temperatures could further accelerate greenhouse gas discharges into the atmosphere, particularly due to methane release from melting permafrost. This positive feedback loop could fuel global warming even more.[7]

In the Arctic, the rapid collapse of Greenland glaciers has become a particular focus of concern.[8] This is a major reason why many climatologists are now calling for an actual *reduction* of CO2 concentrations from 390 to 350 parts per million.[9] This, in turn, has huge implications for the way we design and manage our cities, how we power them, where we locate them and how they relate to the world's ecosystems.

In recent years the most dramatic population growth has occurred in giant coastal cities, particularly those in Asia and Africa. In fact, with expansion of global trade, coastal populations and economies have exploded on every continent. Of the 17 megacities of over ten million people around the globe, 14 are located in coastal areas. 40 per cent of the world's cities of 1-10 million people are also located near coastlines. Careless development practices have caused important habitats such as wetlands, coral reefs, sea grasses, and estuaries to be degraded or destroyed.[10] And with substantial sea level rises expected by the end of the 21st century, major northern coastal mega-cities and greenhouse gas emitters such as London, New York and Shanghai, could well become the primary victims of their fossil fuel burning, whilst also affecting southern low-lying mega-cities such as Calcutta, Dhaka and Lagos.[11]

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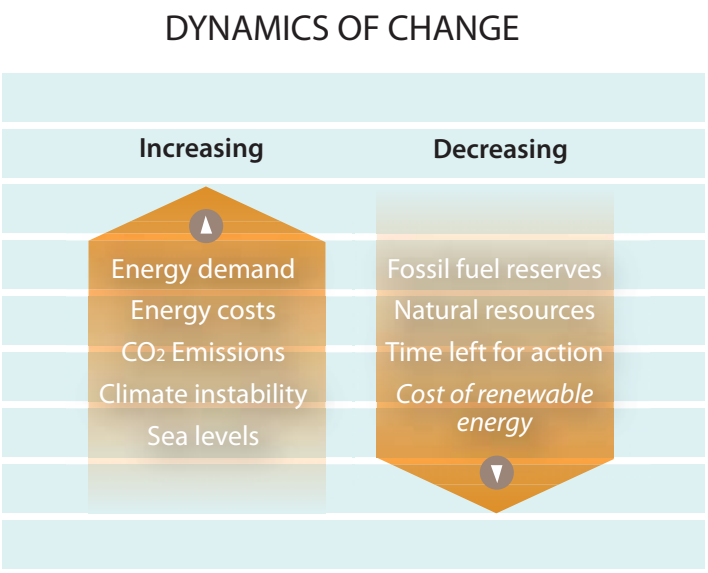
[6] www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf
[7] www.ipcc.ch/publications_and_data/ar4/syr/.../mains1.html
[8] www.worldwildlife.org/.../WWFBinaryitem15234.pdf - United States
[9] www.350.org/about/science
[10] www.inweh.unu.edu/Coastal/PolicyBrief.pdf
[11] www.timesonline.co.uk/tol/news/environment/article6938356.ece

The concept of Petropolis, the fossil fuel powered city which is the current global 'urban archetype', needs to be challenged fundamentally as its systemic flaws become increasingly evident.

These are some of the dominant trends: demand for fossil fuels, energy costs, carbon emissions, climate instability and sea levels are increasing, whilst global reserves of natural resources and the time left for action is steadily decreasing. But, crucially and hopefully, so is the cost of renewable energy!



Creating the solar city

Some people simply want large modern cities to go away. But given that for the time being urbanisation is a global trend, ways have to be found for cities to minimise their systemic dependence on fossil fuels and their unsustainable use of natural resources. A rapid switch towards powering our cities with renewable energy is a crucially important starting point. The key question to which an urgent answer is needed is: how can cities that are the product of fossil fuel-based technologies be powered by renewable energy instead? We have addressed this issue in some detail on our recent publication, Peter Droege's report '100% Renewable Energy – and beyond – for Cities'.[12]

Our planet derives its energy supply from the sun and the Earth's core and, ultimately, these two primary energy sources need to be used to power our cities. The good news is that in the last few years rapid strides have been made with a wide spectrum of renewable energy technologies.

Technology and policy go closely hand-in-hand: Germany, Spain and another 50 countries and regions around the world have chosen to introduce feed-in tariffs which make the installation of renewable energy systems a cost effective proposition. Owners of solar PV roofs in Germany, Spain, Portugal or Greece are entitled to sell the electricity they produce back to the grid at up to four times the price of conventional power stations. The benefits for national economies have been significant, reducing fossil fuel imports, carbon emissions, as well as environmental damage. In Germany the total cost per household to implement these renewable energy schemes is just five Euro per household per month. As a result of feed-in legislation, 18 per cent of Germany's electricity now comes from hydro power, solar power and wind farms and 300,000 new jobs have been created in ten years. This approach to energy policy has also led to significant breakthroughs in technology, and in the design of buildings.

Recently constructed building complexes such as the Solarsiedlung in Freiburg, for example, are designed to produce more energy than they actually require.[13] The highly energy efficient 'plus-energy' buildings with south facing solar roofs are a model for intra-urban renewable energy production. Outside Seville 'concentrated solar power' technology has been pioneered which utilises an array of mirrors that focus beams of sunlight onto the top of towers through which liquid is circulated which drives steam turbines and generators. Seville is well on its way to become the world's first large city to power itself with solar energy supplied from its hinterland, as well from installations on roof tops within the city.[14]

A major new technological breakthrough is thin-film solar electric cells. These can be produced in printing machines which apply a photo-sensitive ink onto an aluminium or plastic foil. These new thin film technologies are bringing the cost of solar electricity ever closer to full cost competitiveness with conventional power generation. In Germany arrays of thin-film solar power stations can be found around a growing number of towns and cities.

[12] www.worldfuturecouncil.org/fileadmin/user_upload/PDF/100__renewable_energy_for_citys-for_web.pdf
[13] www.solarsiedlung.de/
[14] www.inhabitat.com/2007/05/21/sevilles-solar-power-tower/

Solar thermal technology has been used for many years in the Mediterranean. It is also becoming common place in less sunny countries such as Austria and Germany. Now it is also making rapid strides in China. In fact it has become the world leader. Solar hot water systems are now used by 20 per cent of its households many of whom never had the benefit of hot water before. "Experts project that by 2010 the number of solar water heaters installed in China will equal the thermal equivalent of the electrical capacity of 40 large nuclear power plants. Globally, solar water heaters have the capacity to produce as much energy as more than 140 nukes."[15]

In September 2010 this ground-breaking building hosted the 4th World Solar Cities Congress.[16] The 75,000 square metre 'sun-dial' building includes exhibition centres, scientific research facilities, meeting and training facilities and a hotel. It is a Chinese government sponsored showcase of energy efficient solar design and solar technology that is likely to highly influential in a country so far better known for its rapid expansion of coal fired power station capacity.

Wind power is also a solar technology because the Earth's air currents are driven by sunlight. The technological breakthroughs in this field have been facilitated by government policies. Denmark was the first country to introduce feed-in tariffs for wind energy 25 years ago. The advances in this technology have been astounding. In 1985 50 KW wind turbines were the norm, but by 2010 their energy output has risen to as much as 5 megawatts - 100 times greater. In countries with long coastlines such as Britain, large scale wind farm development is now well under way. The Thames Array of 500 large turbines will start construction in the Thames Estuary in early 2011, and its 1000 megawatt capacity will supply some 30 per cent of London's domestic electricity.[17]

While it is desirable for cities to produce much of their energy from within their own territory or from their immediate hinterland, very large cities may require additional renewable energy supplies from further afield. Networks of interconnected solar, wind, hydropower and geothermal systems are now under development. The Desertec project which is supported by major European companies is intended to link the renewable energy resources of Europe, the Middle East and North Africa, and elsewhere similar projects are proposing to supply electricity across continents like North America and Asia via new direct-current 'smart supergrids'.[18]

[15] www.environmentalgraffiti.com/...solar...water-capacity.../822
[16] www.chinasolarcity.cn/Html/dezhou/index.html
[17] London Array, www.londonarray.com
[18] Desertec, www.desertec.com

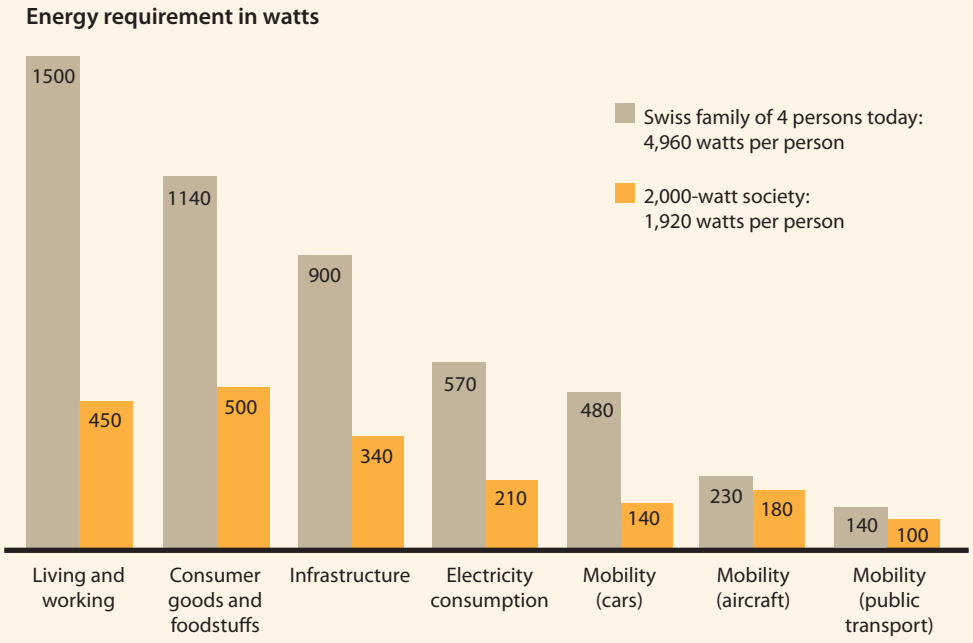
However, none of these efforts will be sufficient without simultaneously introducing comprehensive energy demand management systems for our cities. For more efficient energy use new insulation materials will enable the retrofit of buildings from within without a significant loss of interior space. Three centimetres of 'vacuum insulation panels', for instance, have much the same performance as 30 cm of conventional insulation materials.

Meanwhile the argument for increasing urban density has been gaining much credence. We can enhance transport energy efficiency through designing for *proximity*. We need to get people walking and cycling rather than driving their cars wherever possible and in this we have much to learn from the compact layout of traditional cities. Meanwhile transport technologies are also changing. Just ten years ago car manufacturers could barely imagine making cars that did not run on petrol or diesel. Today, all mainstream manufacturers are working on hybrid or electric or fuel cell-powered cars which are promising to become the norm in a matter of years.

All of these measures, taken together, can dramatically change the energy production and consumption patterns of our cities whilst also creating major new economic sectors in our urban regions.

2000 watt society

The 2000-watt society concept was originated at the Swiss Federal Institute of Technology in Zurich in 1998. It proposes limiting the overall per capita energy use in developed countries to 2,000 watts, or 17,520 kilowatt-hours per year, by 2050 without lowering standards of living. Together with this energy limit, it also envisages a one ton of CO2 emissions limit per person/year. The twofold aim is to implement energy sufficiency whilst commercialising the relevant technologies.



Switzerland currently uses a per capita average of some 5,000 watts, but in 1960 each Swiss citizen used around 2,000 watts, today's world average. Current per capita energy use is around 12,000 watts in the United States, 6,000 watts in Western Europe, 2,000 watts in China, 1,000 watts in India and 300 watts in Bangladesh. The scenario further envisages a reduction in the average use of carbon fuels to 500 watts per person, a quarter of the total 2,000 watt allocation, within 50 years.

The Swiss Council of States wants to move the whole nation towards a 2,000 watts per person goal by dramatically improving the energy efficiency of all aspects of life. In 2001 the Basel metropolitan region was the first to adapt the 2,000 watt concept in a partnership between city authorities, industry and research institutes. Zurich joined up in 2005 and Geneva declared its interest in 2008.

www.novatlantis.ch/en/2000-watt-society.html

The metabolism of cities: from linear to circular

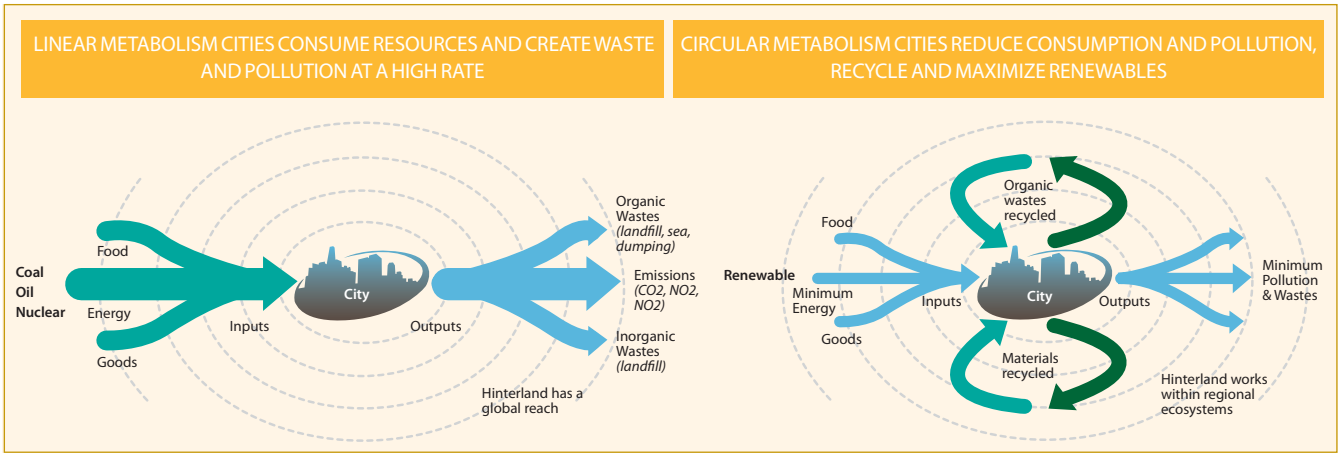
Similar to nature's organisms, cities as 'eco-technical super-organisms'[19] have a definable metabolism – the transformation of resources into vital functions. Nature essentially has a circular zero-waste metabolism: every output by an organism is also an input which replenishes and sustains the whole living environment. In contrast, the metabolism of many modern cities is essentially linear, with resources flowing through the urban system without

[19] Herbert Girardet, Cities, People, Planet – Urban Development and Climate Change, Wiley, London 2004 and 2008

much concern about their origin, and 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 'enriched' both with sewage and toxic effluents, as well as with the run-off of mineral fertiliser applied to the farmland used for feeding cities.

This linear, open-loop approach is utterly unsustainable. In an urbanising world aiming for long-term viability it cannot continue. The environmental externalities of urban resources use can no longer be ignored. Unless we learn from nature how to create *circular systems*, an urbanising world will continue to be an agent of global environmental decline.



A key component of the sustainable city is a 'circular metabolism' which assures the most efficient possible use of resources
© Herbert Girardet / Rick lawrence

Planners seeking to design resilient 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 local and regional production system. Whilst in recent years a very substantial increase in recycling of paper, metals, plastic and glass has occurred, much more needs to be done. Most importantly, it is crucial to convert organic waste into compost, and to return plant nutrients and carbon to farmland feeding cities, 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 some 1.6 million inhabitants, every day increases its actual weight by some 25,000 tonnes.[20] 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.

Creating a circular urban metabolism can create resilient cities and create many new local businesses and jobs.

A critical issue today, as cities become the primary human habitat, is whether urban living standards can be maintained whilst the local and global environmental impacts of cities are brought down to a minimum. To get a clearer picture of the 'performance' of cities, it helps to draw up balance sheets comparing urban resource flows across the world. It is becoming apparent that similar-sized cities supply their needs with a greatly varying throughput of resources.

[20] Prof. Paul Brunner, Technical University, Vienna, personal communication

One estimate suggests 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 its industries. In comparison, an Indian city of this size would require just 2,800 square kilometres, or less than ten per cent of an American city. [21]

Most large cities across the world have been studied in considerable detail and usually it won't be very difficult to compare their use of resources. In developed country cities, disposability and built-in obsolescence still permeates collective behaviour. In contrast, in developing countries large cities have a much lower per capita resource throughput and much higher recycling rates, since recycling and re-use are an essential part of local economies.

Food for cities

In many parts of the world, urban growth has been directly linked with mechanisation of farming and rural depopulation. Food is supplied to cities by ever more energy intensive production systems. For example, in the United States one farmer, with his complex array of fossil fuelled equipment, typically feeds 100 urban people. But ten times more fossil fuel energy goes into this type of food production system than the calories that are actually contained in the food we get to eat.

Urban Food: The Case of Cuba

According to Cuba's Ministry of Agriculture, some 150,000 acres of land is being cultivated in urban and suburban settings, in thousands of community farms, ranging from modest courtyards to production sites that fill entire city blocks. Organoponicos, as they are called, show how a combination of grassroots effort and official support can result in sweeping change, and how neighbours can come together and feed themselves. When the food crisis hit in 1989, the organoponicos were an ad hoc response by local communities to increase the amount of available food. But as the power of the community farming movement became obvious, the Cuban government stepped in to provide key infrastructure support and to assist with information dissemination and skills sharing.

Most organoponicos are built on land unsuitable for cultivation. They rely on raised planter beds. Once the organoponicos are laid out, the work remains labour-intensive. All planting and weeding is done by hand, as is harvesting. Soil fertility is maintained by worm composting. Farms feed their excess biomass, along with manure from nearby rural farms to worms that produce a nutrient-rich fertiliser. Crews spread about two pound of compost per square yard on the bed tops before each new planting.

www.i-sis.org.uk/OrganicCubawithoutFossilFuels.php

We need to find much more efficient ways of supplying food for our cities. This includes a new emphasis on local food production. It is well documented that in Cuba, 'intra-urban' organic agriculture now supplies large amounts of food to cities such as Havana. China has a national policy of surrounding its cities with belts of cultivated land. Such 'peri-urban' food growing systems are also reappearing in the US where farmers' markets supplied by local growers are becoming popular again.

In the United States significant 'intra-urban' agriculture initiatives are also under way. Detroit, once a city of two million people, has contracted to less than 900,000 people, with vast areas of land now lying derelict. Its 139-square-mile surface area is larger than San Francisco, Boston, and Manhattan combined. After studying the city's options of reusing derelict land within Detroit at the request of civic leaders, the American Institute of Architects came to this conclusion in a recent report: "Detroit is particularly well suited to become a pioneer in urban agriculture at a commercial scale." Similar options are now being considered for New Orleans, St. Louis, Cleveland and Newark.[22]

In Denver the Living City Block project goes beyond urban agriculture. It is aiming to create an example of a replicable, scalable and economically viable framework for the resource efficient redevelopment of existing cities. "Starting with a block and a half of Denver's historic Lower Downtown district, Living City Block will create a demonstration of a regenerative urban centre. LCB will draw on selected partners from around Denver, the U.S. and the world to develop and implement a working model of how one block within an existing city can be transformed into a paradigm for the new urban landscape." [23]

Even very large cities can source substantial amounts of the vegetables and fruit they require from the urban territory and the surrounding countryside. However, grain supplies require much larger areas of land and most will have to be supplied from farmland further afield.

[21] The International Institute for Sustainable Development, Urban and Ecological Footprints, www.gdrc.org/uem/footprints/
[22] www.smartplanet.com/business/blog/...detroit...urban.../4232/
[23] www.livingcityblock.org/

The ecosystems beyond

But renewable energy, urban agriculture and resource efficient redevelopment are only part of the story of creating truly regenerative cities. Above all else we need to address the relationship between cities and the ecosystems beyond their boundaries on which they will continue to depend even if major redevelopment initiatives are taken within cities.

This brings us back to the ecological footprint concept. Calculating the ecological footprint of densely populated areas, such as a city or small country with a comparatively large population – such as New York, Singapore or Hong Kong – invariably leads to the perception of these cities as 'parasitic' because they have little intrinsic bio-capacity, and instead must rely upon large territories elsewhere.[24]

The ecological footprint of a city is a measure of its demand on the Earth's biologically productive land and sea area. It compares that demand with the entire planet's ecological capacity to regenerate, and to absorb critical waste outputs such as carbon dioxide in the Earth's living fabric. The footprint methodology enables us to estimate how many Earths would be needed to support humanity if everybody lived a particular lifestyle. In 2006, the biologically productive area per person worldwide was 1.8 global hectares (gha). But since the per capita footprint of a large European city such as London was 5.6 gha per person at that time, three planet Earths would be required if all the Earth's inhabitants lived like Londoners. Since it is not so easy to make new planets, reducing London's per capita footprint is obviously a rather important undertaking.

The largest section of an ecological footprint is the area required for food production. A key problem with the farming systems supplying the bulk of food, and particularly grain, to urban populations is that both carbon and plant nutrients are removed from farmland as food is harvested and these are not returned back to the land. Agricultural land is kept productive by applications of artificial fertilisers which have been shown to have negative effects both on soil structure and soil organisms. Meanwhile the plant nutrients contained in urban sewage are flushed into rivers and coastal waters, or intercepted in sewage systems, never to be returned to the land. In a regenerative city, new ways have to be found to intercept these nutrients, as well as the carbon content of food waste and sewage.

Sanitation for Soil

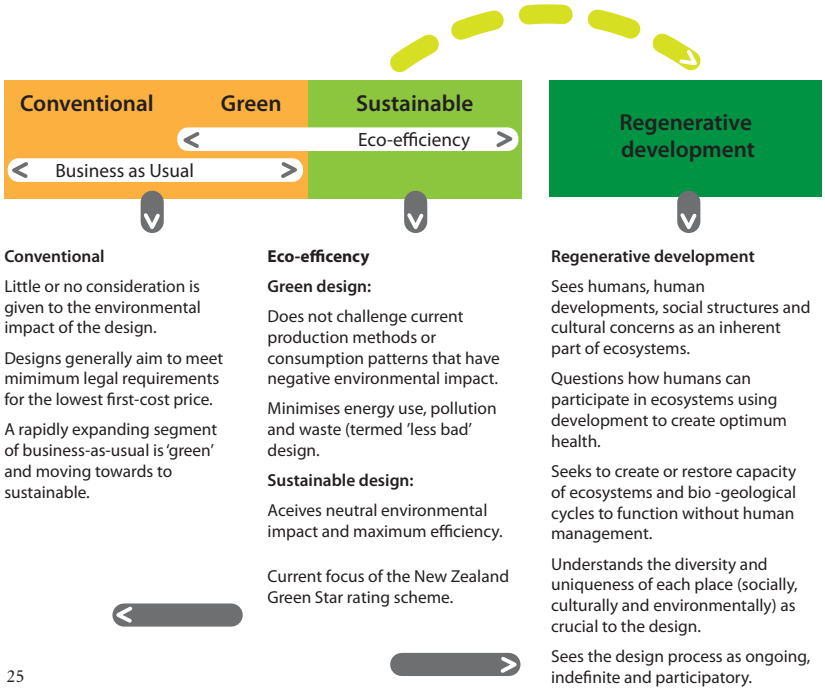
Fertile soil is the most crucial factor in sustaining huge populations on Earth. Not only food supply, but also water renewal, regional and global climate as well as drought and flood prevention depend directly on rich living soil. Political support of short term profits of powerful multinational companies, earning from the ultimately destructive use of synthetic fertilisers and pesticides, have destroyed millions of farms that could otherwise have produced food in a sustainable way with keeping their soil fertile. Industrial agriculture has led to a global depletion of soil quality at an alarming extent. Another major global problem is lack of sustainable sanitation. The dominant flush toilet system transports plant nutrients from our stomachs to the seas and is not capable of recovering them. Even the sludge from sewage treatment plants, that are in place for only around 10 per cent of the wastewater worldwide, is always very low in major nutrients. Phosphate is no longer available to plants after precipitation. Sludge is still high in pollutant concentrations, too. In addition, flush sanitation is causing millions of child deaths though contamination of surface waters with faecal matter.

Both problems - loss of soil fertility and sanitation/water pollution - can be solved together in a rather simple way. This was demonstrated by ancient civilisations in the Amazon: All they left was the best soils in world, as well as very beautiful ceramics. The terra preta soils where made from organic waste including excreta. A number of very feasible high- and low-tech options for sanitation producing rich fertile soils are now available. In turn this can result in zero sewage discharges into water bodies whilst helping farmers to work with organic agriculture the natural way. Their soils will create healthy food. Societies should not allow the agro-chemical industry to turn ever more farmers across the world into total dependency any longer. If we want a future for People and Planet we need to make every effort to take re-establish the connection between urban organic waste and soil fertility and to shift globally towards Terra Preta Sanitation for our cities.

Prof. Ralf Otterpohl, Technical University, Hamburg-Harburg

Shifting from urban systems that damage and degenerate ecosystems to ones that renew and sustain the health of ecosystems on which they depend requires a fundamental rethink of urban systems design. The following diagram which shows the transition towards regenerative development was developed in New Zealand. The ideas presented here are relevant to regenerative economic development as well as, specifically, to regenerative *urban* development:

[24] en.wikipedia.org/wiki/Ecological_footprint



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The regenerative development of cities is a comprehensive approach that goes beyond established concepts of sustainable development. Cities need to proactively contribute to the replenishment of the run-down ecosystems – including farm soils, forests and marine ecosystems – from which they draw resources for their survival. And while cities continue to burn fossil fuels, they also need to find ways of assuring that their carbon dioxide emissions are reabsorbed through 'bio-sequestration' in soils and forests. [26]

The CO2 output of cities is far too large for trees within their territories to be able to absorb. Every year we are now discharging nearly 10 billion tonnes of carbon per year [27] of which four to five billion tonnes are not being reabsorbed into the world's ecosystems but which are accumulating in the atmosphere. This is the primary cause of the climate change problem that we are faced with.

Can this issue be addressed by cities? Well, some have made a start: In Adelaide, South Australia, large-scale reforestation has been initiated to assure that the surrounding countryside can absorb a substantial proportion of its carbon emissions. Some two million trees have been planted in the last seven years for carbon sequestration, erosion control and general environmental improvement.[28] Another million will be planted by 2014. A few other cities are now involved in similar initiatives. Internationally, the 'Billion Trees Campaign' initiated by UNEP in 2007 recorded that over 10 billion trees had been planted by 2010, a quarter of these by urban community groups, NGOs and local or national governments.[29]

From Petropolis to Ecopolis

One of the primary tasks at the start of the 21st century is to try and map out what is *necessary* in order to try and expand the boundaries of what becomes politically *possible*.

The challenge is to find ways of making cities function differently from the way they do today without increasing the costs to financially challenged city administrations.

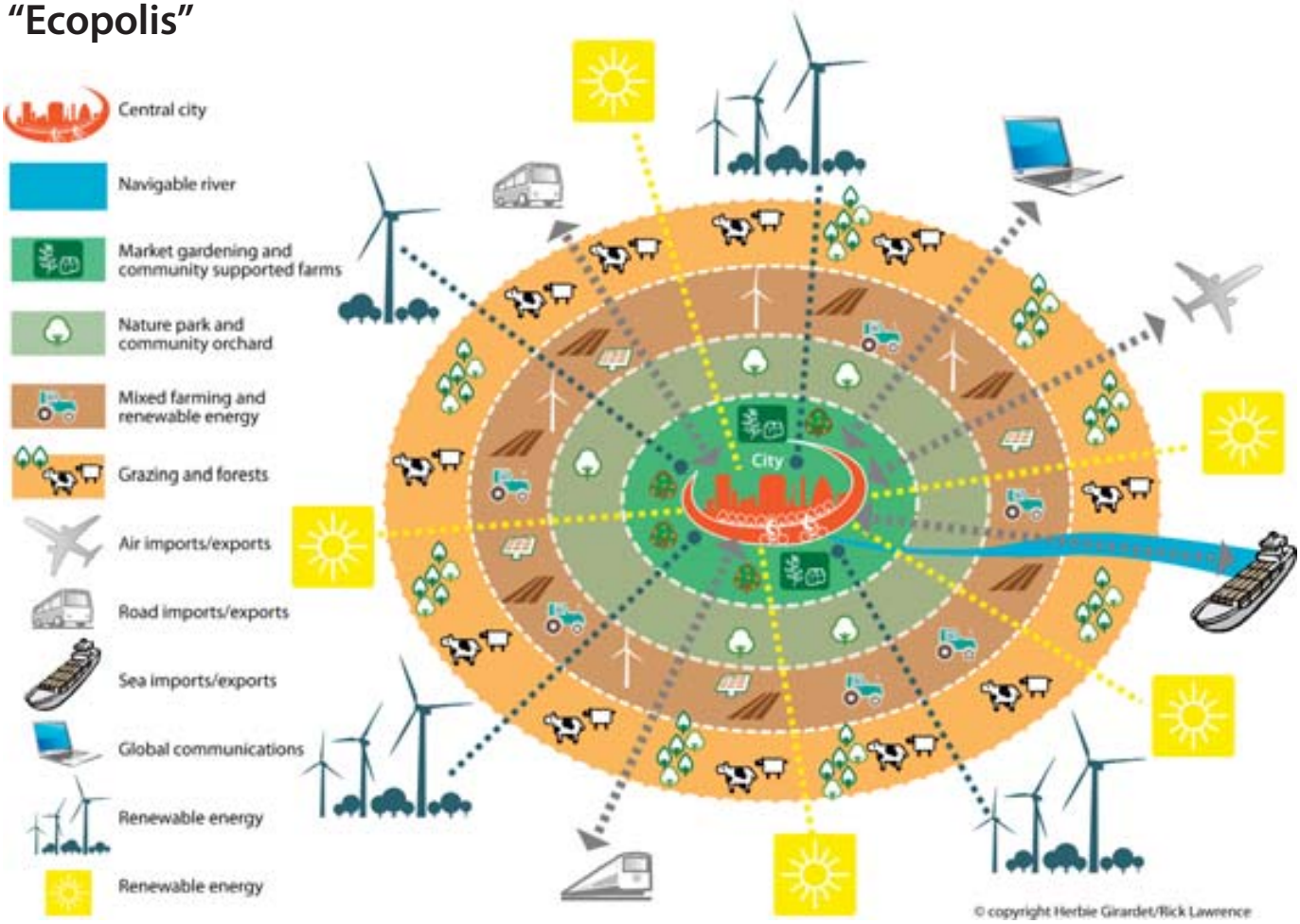
The new task facing of urban planners, civil engineers and managers, in close cooperation with the general public, is to create spatial structures that satisfy the needs of city people whilst also assuring their ecological and economic resilience. We need to provide secure habitats that allow us to move about our cities efficiently, and we want them to provide pleasant spaces for work, recreation and human interaction. We want urban environments that are free from pollution and waste accumulation. But we also need to get to grips with the impacts of cities beyond their boundaries.

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. It is also in cities where people interact most strongly and where key decisions, and particularly financial decisions, are being made all the time.

This is where the concept of 'Ecopolis' – the ecologically as well as an economically restorative city – needs to assert itself, drawing together the various themes discussed in this text into one comprehensive concept.

[25] www.mfe.govt.nz/publications/sus-dev/towards-a-sustainable-future/page3.html
[26] Herbert Girardet and Miguel Mendonca, A Renewable World, Green Books, Dartington, 2009; see chapter 2
[27] www.sciencedaily.com/releases/2008/09/080925072440.htm
[28] www.milliontrees.com.au/
[29] www.unep.org/billiontreecampaign/CampaignNews/BTCjune2010.asp

"Ecopolis"



Of course, modern cities tend to be much larger than traditional human settlements and this makes reintegration into their local hinterland much more difficult. The reality is that far more people have to be accommodated in cities today than a couple of hundred years ago and this needs to be taken account of in developing concepts for creating resilient human settlements fit for the 21st century.

In recent years there has been much talk about *peak oil*. Are we also heading for *peak globalisation*? Many cities have a problem of job scarcity due to the relocation of manufacturing jobs to other parts of the world as a result of economic globalisation. In addition, vast amounts of money are still spent on importing fuels to our cities from distant places. Could the creating of resource efficient cities, largely powered by renewable energy, help rebuild urban economies and bring jobs back to our cities?

Creating environmentally regenerative cities is a challenge that urban administrators and educators have not really had to deal with until now. This challenge has been made more difficult since the privatisation of services in recent years has reduced the capacity of city administrations to create integrated urban systems. But the awareness is growing that integrated, restorative planning and management of cities presents major new opportunities for reviving urban economies and creating new businesses and jobs.

Policy makers, the commercial sector and the general public need to jointly develop a much clearer understanding of how cities can develop a restorative relationship to the natural environment on which they ultimately depend. The underlying incentive is that positive outcomes are likely to be beneficial for both global ecology as well as the urban economy. Many reports indicate that a wide range of new businesses and many new job opportunities could be created from a steady move towards efficient use of resources.

To initiate projects for restoring the health of forests, soils and aquatic ecosystems that have been damaged by urban resource demands certainly goes beyond strictly urban policy initiatives. Creating parameters for appropriate action will involve both political and business decisions – with a spectrum ranging from transnational, to national and to urban levels of decision making. It involves drawing up novel legal frameworks and addressing the profit logic of companies involved in natural resource extraction.

The value of ecosystems services

We cannot manage what we do not measure and we are not measuring either the value of nature's benefits or the costs of their loss. We seem to be navigating the new and unfamiliar waters of ecological scarcities and climate risks with faulty instruments. Replacing our obsolete economic compass could help economics become part of the solution to reverse our declining ecosystems and biodiversity loss.

We need a new compass to set different policy directions, change incentive structures, reduce or phase out perverse subsidies, and engage business leaders in a vision for a new economy. Holistic economics or economics that recognise the value of nature's services and the costs of their loss is needed to set the stage for a new "green economy".

www.guardian.co.uk/commentisfree/cif-green/2010/feb/10/pavan-sukhdev-natures-economic-model

Pavan Sukhdev, drawing on his report The Economics of Ecoystems and Biodiversity

The national policies needed to set parameters for regenerative urbanisation include both 'sticks' such as waste disposal taxation and carbon taxes, and 'carrots' such as feed-in tariffs for renewable energy and support schemes for local food production.

Cities need to take advantage of the opportunities inherent in environmentally restorative development, harnessing the huge variety of talents and experiences present in cities for better decision making.

For instance, the city government of Porto Alegre, Brazil, decided some years ago to involve the general public in the processes of budget-setting. This creative process challenges citizens to actively contribute their views. All citizens can now have a say about what their tax money should be spent on – better schools, better transport, playgrounds, parks, renewable energy installations, and so on. Through this novel participatory process Porto Alegre has become a truly dynamic, participatory city, and the ideas pioneered there are being copied in cities across the world.[30]

The ecological, economic, social and *externalities* of our urban systems need to be addressed in new ways. We need creativity and initiative at the local level, but we also need appropriate national policy frameworks to enable useful things to happen locally. Without national policy initiatives, enhanced by lively public debate, the necessary changes won't happen fast enough, if at all. For example, feed-in tariffs for renewable energy in Denmark and Germany came out of vigorous public demand that was turned into national policy which was then implemented primarily at the local level.

It is important to emphasise, then, that the creating of regenerative cities as described in this text will require not just changes in approaches to land use and resource use planning at the local level but that national and trans-national policies have to be initiated.

Cities take resources from nature. The new challenge is for cities to find ways to continuously help regenerate natural systems from which they draw resources.

Internationally, cities need to work closely together to develop and implement policies for regenerating regions across the world that have been damaged and depleted by urban consumption patterns. One or two organisations, such as the Climate Alliance of European Cities[31], which brings together 1500 towns and cities across Europe, have made a tentative start at helping cities to take responsibility for their global climatic and environmental impacts. Much, much more needs to be done.

Policies for creating regenerative cities

Enshrining regenerative urbanism as an organising principle for urban development practice seems compelling because it offers a number of major new opportunities for local social and economic well-being:

[30] www.sustainablecities.dk
[31] www.klimabuendnis.org

Key principles

- National policy: Frameworks for enabling regenerative urban development
- Urban policy: Integrated, regenerative urban planning as key organising principle
- Green Savings: reducing waste, recycling materials and cutting costs
- Green Economy: new businesses and jobs by environmental protection and restoration
- Green Talent: investing in technical, entrepreneurial and workforce skills

Energy sufficiency

- Use the 2000 Watt Society concept as an operative policy principle
- Modify building codes to make resource efficient building practice the norm

'Solar city' development

- Mandate solar city development as national policy priority
- Prioritise feed-in legislation for renewable energy systems, allowing owners to sell electricity at advantageous rates
- Support renewable energy as an important new manufacturing industry
- Create enabling policies for renewable energy development in the urban hinterland

Water security

- Balance urban, agricultural and commercial uses of water, and their relative social, economic and environmental benefits
- 'Waterproof' cities by encouraging water efficiency and rainwater collection in households and businesses
- Make waste water recycling and storm water reuse a central plank of water policy

Implementing zero waste

- Develop new enterprises for processing organic wastes into soil enhancing materials
- Make sewage reprocessing and nutrient capture a central plank of waste management
- Implement policies for the cost effective reprocessing of all technical wastes
- Use zero waste policy to create new green businesses and jobs

Local Food

- Encourage local peri-urban food production for local markets
- Encourage the development of community supported agriculture and farmers markets
- Ensure the use of composted, city-derived bio-waste for urban farming

Sustainable transport

- Create new pedestrian zones wherever possible
- Create a comprehensive network of dedicated cycle lanes across cities
- Encourage public transport by improving its attractiveness, frequency and flexibility
- Stimulate development of new electric and fuel cell vehicle technology
- Encourage car sharing as a key feature or urban transport

Nature and the city

- Encourage tree planting for biodiversity and soil erosion control in and around the city
- Make carbon sequestration a key aspect of tree planting initiatives
- Develop initiatives to help restore forests and wetlands in remoter areas

Green business

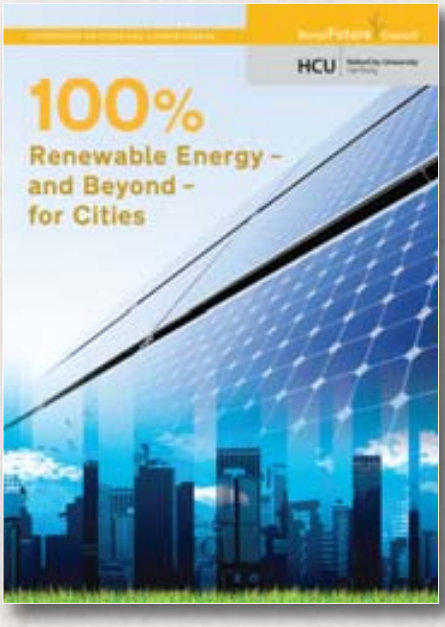
- **Boost the creation of green business by effective use of government procurement**
- **Encourage resource efficiency in all businesses**
- **Create 'green business incubators' across the city**
- **Make environmental resilience the basis for new businesses and jobss**

A culture of restorative urbanisation

- **Utilise both global networks and local expertise in developing restorative urbanisation**
- **Ensure that it is addressed in the education system, and through meetings and events**
- **Encourage imaginative reporting on urban restoration measures by the media**
- **Produce regular reports on implementation of eco-restoration policies and practices**
- **Ensure that all citizens take a stake in restorative development**

The challenge now is to initiate a mutual learning process in which cities across the world can exchange experiences and information about best policies and practices of regenerative urbanism. The Cities and Climate Commission of the World Future Council and HafenCity University Hamburg (HCU), intends to make a major contribution to this vitally important process.

Herbert Girardet, October 2010



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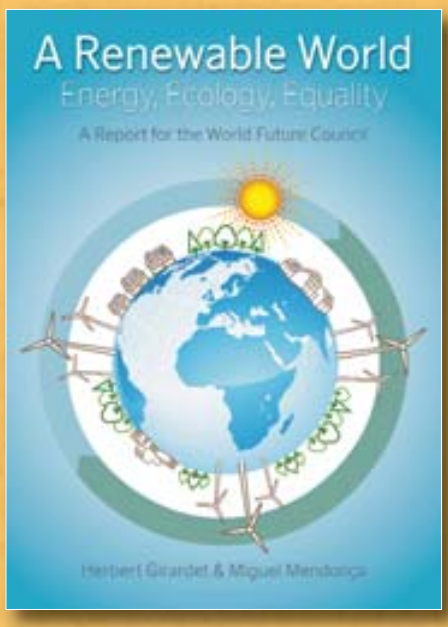
Download from the World Future Council website:

www.worldfuturecouncil.org/fileadmin/user_upload/PDF/100_renewable_energy_for_citys-for_web.pdf

Peter Droege is Professor at the University of Liechtenstein and the University of Newcastle, Australia. His books include *100 Percent Renewable - Energy Autonomy in Action; The Renewable City - A Comprehensive Guide to an Urban Revolution*; and *Urban Energy Transition - From Fossil Fuels to Renewable Power.* He is a member of the World Future Council/HafenCity University Cities and Climate Change Commission.



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Herbert Girardet is an author and consultant focusing on sustainable development. He is a co-founder and Director of Programmes of the World Future Council.

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