# II

# RESEARCH ARTICLES

# SUSTAINABILITY ON THE URBAN SCALE: 'GREEN URBANISM'—MARK II

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## ABSTRACT

*In the essay entitled 'Towards a Sustainable City Centre' (published in JGB Summer 2006), the author reflected on principles how to best integrate ecologically sustainable development (ESD) into urban design. This second paper reports on his continuing research in the area of 'Green Urbanism'.[1]*

*Among the most significant environmental challenges of our time are global climate change, excessive fossil fuel dependency and the growing demand for energy—all likely to be major challenges of the 21st century and one of the greatest problems facing humanity. In this context, urban design and the fundamental principles of how to shape our cities has barely featured in the greenhouse debate. Much of the debate in related areas has so far circled around ideas about active technology for 'eco-buildings'. This is surprising, since almost half the energy consumed is used in cities and urban built-up areas, and given that avoiding mistakes in urban design at early stages could genuinely lead to more sustainable cities and less greenhouse gas emission. This article reflects upon practical strategies focused on increasing sustainability beyond and within the scope of individual buildings.*

*The paper deals with cross-cutting issues in architecture and urban design and addresses the question of how we can best cohesively integrate all aspects of energy systems, transport systems, waste and water management, passive and active strategies, climatisation and so on, into contemporary urban design and improved environmental performance of our cities. It provides a context for a general debate about the regeneration of the city centre, and discusses how urbanism is affected (and can be expected to be even more affected in future) by the paradigms of ecology.*

*The significance of the research is found in the pressing need for an integration of sustainability principles in the urban design process of cities in South East Asia and the general need for a sustainable city development. It will be of particular relevance to the rapid urban growth of developing cities that have, in the past, frequently been poorly managed. Research in sustainable urban design recommends increased harnessing of the energies manifested in the existing fabrics—for instance, through the adaptive re-use of former industrial (brownfield) sites and the upgrade and extension of existing building structures. It is less environmentally damaging to stimulate growth within the established city centre rather than sprawling into new, formerly un-built areas. Two recent examples for the application of such urban design principles are the author's proposals for the Australian city of Newcastle: the 'City Campus' and 'Port City' projects.*

## KEYWORDS

Urban design principles; climate responsive urbanism; urban sprawl and public transport; compact high-density communities and solar orientation; natural ventilation.

## 1. INTRODUCTION

> *Global Warming is no longer an inconvenient truth, it is an inescapable reality.*
> U.N. Secretary-General Ban Ki-Moon, 2007

Among the most significant environmental challenges of our time are global climate change, excessive fossil fuel dependency and the growing demand for energy (despite limited fossil fuel reserves)—all likely to be major challenges of the 21st century and one of the greatest problems facing humanity [1,2].

The increasingly widespread effects of climate change and continuous uncertainty of conventional energy supplies are causing an increasing demand

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for the transition of our cities through sustainable urban development. However, we are not yet yielding sufficient carbon savings to suggest that adequate action has been taken. The quickest way to reduce greenhouse gas emissions is by being more efficient with the way we consume our energy, by reducing consumption, and by transferring to renewable energy sources. Energy savings require the development and use of more efficient appliances and the retro-fitting of the existing building stock to make the most of natural daylight, rainwater, cooling breezes, and solar exposure—reducing or eliminating the need for artificial lighting, cooling and heating (over the last twenty years, the demand for cooling has most increased).

Of all the design fields, urban design has hereby the greatest direct impact on the nature of cities and city life. However, urban design and the fundamental principles of how to shape our cities has so far barely featured in the greenhouse debate. The urban dimension and the macro-scale of cities were mostly missing in the debate of the 1980s and early 1990s, as sustainability was predominantly discussed as being about 'alternative lifestyles' or 'ecological houses'.

Much of the more recent debate has circled around ideas about active technology for 'eco-buildings' and sophisticated façade technology—rather than about urban issues. This is surprising since almost half the energy consumed is used by cities and urban built-up areas, and given that avoiding mistakes in the urban design layout at early, conceptual stages could genuinely lead to more sustainable solutions. A large amount of energy consumed in the developed world is used to operate buildings (for instance, in Australia: 44 per cent[2]), whereby the relationship between energy-efficiency of buildings and urban design decisions has become a complex issue.

> *Sustainable architecture is only really effective when set in an urban planning context which itself is based on sustainable principles.*
>
> D. Gauzin-Mueller, 2002 [3]

Several big cities in the developed world have now started large projects and initiatives focussed on energy transformation in urban areas, to reduce their dependency on oil and gas sources.

So, what are the practical strategies that focus on increasing sustainability beyond the scope of individual buildings and how can energy transformation be achieved? How can the existing fossil-based energy infrastructure of cities be gradually transformed to confront the environmental challenges of our time; and how can we design urban open spaces and grouping of buildings in such a way that only a minimum of energy is needed to light, ventilate, shade/cool, heat and service them? And by doing so, can we find a poetic architectural response where the building envelope is still informed by simple and strong architectural ideas, rather than by being technologically driven? Will 'Green Urbanism', with its balanced re-integration of landscape, also be fit for hot and humid (tropical) environments, such as in Bangkok, Hong Kong, or Singapore?

This in-progress research deals with cross-cutting issues in architecture and urban design and addresses the question, how we can best cohesively integrate all aspects of energy systems, traffic and transport systems, waste and water management, passive and active strategies, climatisation (ventilation), etc. into contemporary urban design—and by doing so improve the environmental performance of our cities.

From sustainable urban planning projects conducted over the last years, data shows that savings in energy costs of 20 to 50 per cent are possible through integrated planning with carefully considered site orientation and passive strategies (without any further expense); this saving can further increase with on-site renewable energy-producing technologies.

Let's have a closer look at opportunities for regenerating the city centre and the appropriateness of strategies for the various climate conditions, to see how urbanism is affected (and can be expected to be even more affected in future) by the new paradigms of ecology.

## 2. SUSTAINABILITY INTEGRATED WITHIN THE URBAN DESIGN PROCESS

There are green principles that can creatively support the main design concept. When we study the architecture of Louis Kahn or Alvar Aalto, we find that those architects designed buildings based on what they regarded as 'timeless fundamentals', such as the human experience of space. Both masters designed naturally ventilated office buildings and incorporated climate-responsive design principles long before the notion of 'sustainable architecture' was introduced (e.g. Rachel Carson's book 'Silent Spring' was published in 1962). The concepts and knowledge of night-time cooling, evaporative cooling, solar chimneys, cross-ventilation and thermal mass have existed for centuries, even millennia. This supports the notion that sustainability in architecture is about a fundamental attitude of making place and space, and less about the technological solution for 'ventilation'. It is important to recognise that architecture is predominantly about establishing meaning, about the human experience and substance—and not *per se* about technological sophistication.

Of course, a 'green building' is not always automatically a good work of architecture [4,5]. Architecture and urban design have the potential of re-establishing our relationship with nature, the climate and the experience of the sun, rain and wind. As Scott notes, such environmentally responsible design is at its best 'when it achieves an outcome in which the environmentally sensible elements are closely linked to the design process, go beyond being additive and become meaningful parts of an architectural whole [6].' Integration of sustainability aims within the design process demands that the environmental concept and the architecture fully support each other. This requires the identification of environmental strategies that correspond to strong design concepts, support a unique design idea, and reinforce the building's relationship with the landscape and the city. So-called 'exogenous developments'—where improvement comes only from technology, rather than from inside, from society—are only 'quasi evolutionary'.

After more than three decades of environmental debate (starting in 1973 with the oil crisis), there is now an increasing demand to explore and assess the urban design principles and practical strategies for more energy-efficient cities, beyond the scale of the individual building, and to critically examine those strategies for sustainable cities.

Three compelling—and widely-published and discussed—contemporary examples of environmentally inspired individual buildings, where ESD-principles have successfully informed the design, are:

- The Tjibaou Cultural Centre in Noumea (New Caledonia) by Renzo Piano Building Workshop (1998, www.rpbw.com).
- The Training Centre and Town Hall Mont-Cenis in Herne-Sodingen (Germany) by Francoise-Helene Jourda (1999, www.jourda-architectes.com).
- The Research Centre in Wangeningen (Netherlands) by Guenther Behnisch Architects (1998, www.behnisch.com).

However, it will now be essential to work towards equally persuasive projects on the urban-scale, on the level of larger groupings of buildings. The author believes that it is essential and timely to arrive at equally effective proposals of sustainable city projects, even if this may prove to be more difficult.

## 3. THE NEED FOR MORE COMPARATIVE RESEARCH ON CITIES

The significance of the research lies in the need for an integration of ecology and sustainable principles in the urban design process, particularly for the growing cities in fast-developing South East Asia, and the general need for a more sustainable city development. The findings are of particular relevance to the rapid urban growth of developing cities undergoing aggressive and largely unplanned and poorly planned transformation, where new towns get virtually built overnight, such as currently in China.

According to the UN, the annual total population increase is around 90 million people p.a. (UN, 2005)[7]. In future, more and more people worldwide will live in cities. In early 2008, for the first time ever, more people are projected to live in urban than in rural areas. Driven by immigration from the poverty-stricken countryside, soon the number of city dwellers on the globe will reach five billion people. More than 50 per cent of us live in cities, a figure that will rise to 75 per cent by 2050; therefore, the twenty-first century will be the urban epoch. This fact poses entirely new challenges on cities, and the massive influx of rural poor into urban areas in many of the Asian, Indian, and African cities contributes to this challenge (150.000 people a day leave their rural existence behind to start a new life in the city). As a result, most of this increase in population occurs in the big cities of developing nations, where most of the world's poverty is already concentrated, leading to difficulties in water supply.[3] Together with climate change, the future of the city is the challenge of the twenty-first century.

Traditional European city centres, built prior and during to the fossil fuel era, are the product of slow growth and complex ownership patterns, but they have not strictly been laid-out on solar principles, with the aim to transfer to solar power. During the 19th and 20th century, the form of those cities was mainly driven by the Industrial Revolution, to achieve rapid transportation and production, but less sustainability. This leads to the assumption that it is generally easier to build a new sustainable city or a new sustainable urban quarter from scratch, rather than retrofit an existing one (since the existing, fossil-based technical infrastructure becomes a restriction to new sustainable development). Those development patterns which emerged during the Industrial Revolution, frequently cluster and network geometries, have not been the product of irrational thought. To the contrary, governments, developers and citizens have followed a logical course that is the result of centuries of piece-by-piece outward expansion of land use and the more recent neglect of the urban city centres. Today, it is very unlikely that a large-scale urban re-planning on solar principles—where every block could take maximum advantage of passive solar gain—of those traditional European cities will ever occur.

On the other hand, the Asian 'New Towns'—currently being developed and under construction—could offer unique opportunities for 'total urban design' concepts, to really get things right: to design and build to the optimised density and ideal day-lighting conditions, based on master plans including the integration of efficient public transport (efficient light rail transit systems), where each city block gains maximum solar exposure and uses geothermal technology wherever possible, for decentralised renewable energy generation, catches the natural breezes for ventilation, collects rainwater and has well-designed shading devices for the western facades. Indeed, by applying sustainable urban planning principles it could all be achieved for those Chinese new towns! China is hereby (again) a place of extremes: we can find some of the most destructive and some of the most hopeful initiatives going on there today (such as Arup's plans for a new zero-carbon development outside Shanghai, 'Dongtan Eco-City'. Here, energy-directed urban planning is based on issues of optimised energy flows integrated into the urban form).[4]

So, what exactly is the aim of sustainable design? One major aim is to facilitate the revitalisation of pedestrian-friendly city centres, and implement the principles of 'green urbanism'. Most urban designers would generally agree on the following principles:

- Cities and urbanised areas in the developed world need to be our focus, as it will be where (beside the industry sector) most energy is consumed and most waste produced.
- Cities are the main consumers of natural resources and main producers of pollution.
- Sustainability aims are most effectively pursued when clear principles of sustainable urban development are established.
- Urban patterns, density, public transport, water management, solar orientation, day light access, construction systems, and supply chains, are all essential in the process of guiding urban design decisions towards higher levels of sustainability.
- A 'mixed-use, compact city model' promises the optimum use of space and a new city's land use pattern.

Therefore, comparative research in the urban dimension (macro-scale) of sustainability must be intensified if urban development is to become more sustainable.

Research findings into sustainable urban design support an increased harnessing of the energies embodied in the existing fabric—for instance, through the adaptive re-use of former industrially used sites, inner-city brownfield sites, industrial and military areas, or docklands—and the upgrade and extension of existing building structures, rather than their demolition. The placement of buildings, how compactly they are grouped, can have a profound and direct impact on energy consumption, determine traffic patterns and, thus, the production of greenhouse gases. In most cities in the US and Australia, there is a large disparity between where people live and where they work, resulting in longer commuting distances than in comparison for citizens in European or Asian cities.

The author suggests that answers to this problem have long been sought in the revitalisation of existing city centres, where a higher population density and a more compact community would offer everything within walking and cycling distance. Such high density centres close to public transport nodes are the aim of what has been called 'Transport-Oriented Development' (TOD) [8]. Such communities are thought to offer a higher degree of self-sufficiency and, at the same time, good rail links to other areas of the urban region. Densification and Transit-Oriented Design are not always appropriate for all contexts; however, with such strategies, some great improvements were recently achieved in various cities, for instance in Rotterdam, Copenhagen, Barcelona, Lyon, and Freiburg [9]. The question now is: how is 'best practice' precisely defined in these cities, and which part of the experience can be easily transferred to the other project contexts, e.g., to the US, Asia, or Australia?

Pressure on transport, energy and water systems are all likely to further increase. Planning decisions made today in Australian, Indian, or Chinese cities will have immense ramifications in the future. We observe a rapid expansion of neighbouring developing countries and an entirely unprecedented urban transformation process, as currently experienced in the cities in South East Asia, India, along the Pacific Rim, or in the United Arab Emirates. The regeneration of our city centres has become an increasingly pressing task.

## 4. RAMIFICATIONS OF PLANNING DECISIONS MADE TODAY

All urban planning decisions made today have of course ramifications in the future. Planning laws provide a framework and control the design of the city. This is why it is important to rewrite the planning framework for cities and architecture, as an environmentally-based planning and design process, with the sustainable city concept as the critical if not sole criterion for determining the architecture we create. Previous scenographically derived, unsustainable building form controls are unsuitable for the design of sustainable cities. As architects and urban designers we must be key players in the process of creating sustainable cities; the sustainable city is one of the most important concepts for the survival of the world.

There is a tendency for engineers to favour technology-based solutions for individual buildings, as the author has experienced on many occasions. And indeed, the larger population, too, expects the quick techno-fix to come to their rescue.

With buildings consuming vast amounts of energy in all developed countries, predominantly for cooling, heating, and lighting—almost half of all energy—and directly contributing around 15% of all $CO_2$ emissions through the construction process, architecture and urban design are often seen as prime technological disciplines in addressing the situation.[5] But the task is too large for architects and urban designers alone; it is a more fundamental issue to be addressed by a series of disciplines, including environmental engineering, urban planning, economics, landscape architecture, sociology, and others. All disciplines working closely together could achieve the goal of the 'City of the Future' which will run entirely on energy drawn from the infinite, unlimited and safe natural sources of renewable energies.[6]

> *While fossil and nuclear industries are fighting to maintain their grip: Renewables are the foundation of the 'City of Tomorrow'.*
>
> Peter Droege, 2007 [10]

Renewable energy is the fastest growing of all energy industries. Renewable energy industries already employ around two million people worldwide, supplying the globe with the renewable energy technologies which are now available (Source: The Australian Conservation Foundation, 2005) [11]. For instance, over the last ten years, 175,000 new jobs were created in the renewable energy industry in Germany alone. Producing renewable, clean energy does not mean a downturn in employment or industry—quite the opposite: it's about a different way of doing business, about a new industry with innovative products.[7]

A general lack of training, education and research activity in sustainability has been identified across the professions involved—just refer to the recent strategic programs by the Royal Australian Institute of Architects (RAIA) and Royal Institute of British Architects (RIBA) in an attempt to deal with this dilemma. There is clearly a need for more research and education in sustainability. Fortunately, the attitude is now about to change: Embracing principles of sustainability has proved for many planners not to be a burden, but a competitive advantage. In future, architects and urban designers are likely to be out of work if they do not know how to deliver environmentally well-performing solutions. Architects must build their own expertise in sustainability, and not simply rely on the expertise of other disciplines. Gaiser has warned of the comfortable mentality to simply hand over responsibility to the building services engineer: 'Architecture could lose or give up its responsibility to perform if we no longer have environmental achievement 'per form', but only 'per system' [12].

The profession has to become an expert in green, energy-efficient planning and design; not only to use more energy-efficient appliances, but to eliminate the future need for artificial heating, cooling and lighting. Increasingly, owners, developers, governments, architects and planners will have to accept, specify or prefer local materials that can be recycled (rather than transporting materials from far away, or using it for landfill)[8], and find ways of re-using and integrating existing buildings over the wish to build new.

## 5. URBAN ECO-SYSTEMS: DENSITY AND CLIMATE ARE KEY ISSUES

Density is a key issue in planning and influences directly the urban climate. So, to what densities should we build? Is the less structured city with a slowly grown and irregular street pattern better for densification than a grid-planned city structure?

City blocks too close together shade each other—something only desirable in (sub)tropical cities like Singapore, Hong Kong, or Bangkok. The urban design principles that apply to cities in hot, humid, tropical conditions (not only in South East Asia, but also in parts of Australia, India, Africa, and Latin America) are entirely different from the urban design principles in temperate climates. As Bay and Ong have pointed out, the effects of urban canyons, natural ventilation and heat entrapment in the city are entirely different for the tropics: 'While sunlight is welcome in the temperate city and buildings are set back to allow sunlight to penetrate to the road level, shade is preferred in the tropics; (...) more wind and ventilation are welcome in the tropical city [13].' This means, in tropical conditions we want to create shade and over-shading between buildings, as long as we ensure the efficient natural ventilation of the spaces between the buildings.

Conventional patterns of urban development that have frequently led to lower densities and greater infrastructure costs are unlikely to remain economically feasible, as the greater dispersion of activity centres leads to an increased automobile dependency.[9] Low density suburbs are incapable of sustaining a public transport infrastructure. Densification is the key—and no inner-city site is too small as to densify and implant good architecture. However, as Gissen notes, 'there is no one formula for a mix of culture and technology that makes cities vibrant and liveable [14, based on 15].'

The aim of a significant amount of new developments is to achieve a rich mix of usage, scale and increased density to create city centres and new urban nodes with a compact and spatially complex model. This model relies heavily on public transport. Hereby, the city centre needs a rich mix of all types of inner-city uses: office buildings, hotels, department stores, university buildings, residential buildings, shops, cinemas, squares, good landscaping, and so on.

Grouping residential units or townhouses together in compact volumes of around four or five storeys—similar to the 19th century 'compact city block' model found in Paris, Barcelona, Athens, Amsterdam, or Berlin—would bring considerable environmental benefits, such as:

- smaller building envelopes, therefore less land use;
- need for less materials, therefore lower construction costs; and
- sharing fire walls, therefore reduced energy consumption.

## 6. THE 'COMPACT CITY' DISCOUSRE: SOCIAL ACCEPTANCE OF HIGH DENSITY?

The characteristics of a compact city model—such as high density, well defined boundaries containing city growth, mixed land uses, urban design encouraging walking and cycling, and heavy reliance on public transport—were already advocated by Newman and Kenworthy in 1989 [16], when a compact urban form was argued to be able to reduce much of the environmental vice of low rise and sprawling cities. The attributes, benefits and disbenefits of compact cities are well discussed in the work such as by Newman and Kenworthy [16], Breheny [8], and Burton [17]. In general, there seems to be a superiority of concentrated forms of settlement over the sprawling forms. It has been argued that many of the problems of traffic congestion, noise and air pollution, and greenhouse gas emission in cities in the developing world were caused by car dependency and single occupancy vehicles, partly due to their low density, sprawled expansion and spatial segregation of land-use functions [8].

The environmental claims of compact-cities policies are not undisputed. However, the issue of density and compactness is a complex one. 'Densification' and 'intensification' need to be reconciled with the risk of lack of urban green space, rising cost of living (reduced housing affordability) and other expenditures associated with denser centres—which may even result in higher energy consumption and carbon emissions, due to lifestyle or embodied emissions—and negative impacts on the quality of life of the inhabitants. Thus, improved socio-spatial equity is an important consideration of sustainable city form.[10]

Higher housing density *per se* does not deliver sustainable advantages; it is the network efficiency that is crucial. The need for compacting and re-engineering the existing cities (after hundred years of de-compacting the 19th century city) poses the question: What form of 're-compacting' should apply? Which density is appropriate?

Great cities have obviously identifiable characteristics offering a high quality network of a public space where it's enjoyable to walk around. A strong focus on how pedestrians move around and the quality of the public domain is therefore essential. Public space is the fundamental basic order of the city, and the author suggests that urban designers need to increase their focus on the public domain, e.g. with a '6-green-star public domain' rating system (which does not yet exist). Quality public space is not just 'what is left over'—it is essential for well-being and social interaction. Given the previously described correlation between compactness and sustainability benefits, higher density requires more careful design of public space within the limited space available.

**FIGURE 1.** The block model of the European city: Five-storey blocks as we can find them in Paris, Berlin, Barcelona, and in other cities, have proved as a solid model for energy efficiency and dense living. These cities possess already the urban characteristics of a compact city model. The strategy of saving from passive-building technology is well accepted: a compact built form with high level of thermal insulation reduces energy losses through transmission.

## 7. APPROACHES TOWARDS THE ENERGY-EFFICIENT 'CITY OF THE FUTURE'

With a continuous increase in climate change, the world's climate scientists recently unveiled the IPCC Report (report by the UN's Intergovernmental Panel on Climate Change, 2007 [7]),[11] which forecasts a grim future. According to the findings in the report, design criteria for major infrastructure (such as bridges, ports, campuses, shopping centres, etc.) will need to be urgently re-defined to facilitate the transformation of cities towards renewable sources, and re-adjusted for extreme climatic events, like floods, storm surges, global temperature increases, sea-level rise, water shortages and droughts. This again illustrates the need to implement climate-responsive 'Green Urbanism' and to transform the existing fossil-based energy infrastructure of our cities.

Many of the planning concepts suggested in this chapter are not new; some have traditionally been known as methods of how to plan and build vital cities. However, these concepts simply haven't been much implemented anymore in the mainstream urban design of the 20th century.

According to the latest IPCC Report, the following three activities will deliver the largest potential to stop climate change and be most effective:

- Saving energy at the point of consumption (energy conservation);
- Increasing energy efficiency; and
- Developing carbon-free renewable technologies, using renewable energy to power, heat and cool cities.[12]

Fossil-based energy generation is the world's largest $CO_2$ emitter, with almost 30 per cent of all $CO_2$ and other heat-trapping gas emissions worldwide (data 2005), caused by coal-fired power stations. This is more than through any other source, such as

**FIGURE 2.** The impact of industry and fossil-based energy production on the population and landscape: Image of a coal-fired power station in China; the country overtook the US as the world's biggest emitter of greenhouse gases already by end 2007. China is the world's largest consumer of coal, and is likely to continue using massive amounts of coal for many years.

through industry (approx. 20%), or forestry (approx. 18%), through traffic and transport (approx. 13%), or agriculture (approx. 14%). It makes energy production the major cause of global warming. Unfortunately, in countries such as China, India and Australia, coal still accounts for the majority (over 75%) of all energy sources. (source: UN, 2005).

Therefore, today, all aspects of the environment have to be considered. In an urban context, the quality of space and light, the compositional questions of urban form and grouping, and the choice of materials all have to be considered as an integral part of an ecological, well-balanced proposal. Sensible, climate-responsive urbanism will result in huge energy savings. Shading the building's western facades with external window awnings or adjustable shading devices, well-placed trees or pergolas for shading, will effectively help keep heat gain down.

However, the greatest challenge in terms of sustainable building still lies in the area of energy consumption through operation.

List of findings: So far, some of the most effective and available urban design approaches identified, include:

- minimising the consumption of land through compact development, and densification by containing the footprint;
- using existing and renewable urban resources such as brownfield sites, integrating underused buildings, structures and sites;
- designing urban quarters where walking and cycling is highly attractive, with good landscaping and a diversity of uses;
- utilizing under-used sites within walking distance of public transport nodes to reduce reliance on the automobile and to increase pedestrian activity;
- developing urban areas where efficient infrastructure systems and public transport are already in place, to reduce the need for the automobile;
- creating a sense of urbanity through density and the design of real places;
- developing sites in a way that the consumption of energy, non-renewable materials and pollution is reduced;
- better considering the building's placement on the site, orientation and density issues, with a focus on public space and good landscaping;
- designing developments in ways that increase access to affordable housing and transportation choices;
- designing spaces with direct access to natural light and air, and better orientation to take advantage of passive solar design principles;
- optimising orientation and solar exposure to maximise the use of renewable resources in the operation of buildings and complexes;

**FIGURE 3.** Sustainable cities integrate brownfield sites and structures: The integration and adaptive re-use of existing buildings, and up-grading of our building stock are important parts of this strategy (Image: London Docklands, 2003; courtesy by MLC).

- and applying the following eight key principles for urban sustainability:
  — low-rise, high density compact communities;
  — functional mix with local and culture-specific uses;
  — eco-buildings which better harness sun, daylight, wind, rain;
  — integration and re-use of existing buildings with elements of local identity;
  — fine grain, with attention to architectural detail and smallness;
  — high quality public space network;
  — reliance on public transport and use of bicycles;
  — variety of urban greenery, integrated in the building.

## 8. DESIGNING BUILDINGS WITH THE CLIMATE—RATHER THAN AGAINST IT

So far, our focus was on urban design, and an understanding that which urban form is most favourable to sustainable development depends much on the different climate zones.

On the scale of energy-efficient buildings, the envelope (façade) plays obviously a crucial role. Most of the time, the façade is the driver for how services in a building are integrated; the skin should allow fresh unconditioned air into the building when possible, optimise daylight to reduce artificial lighting, and minimise heat gains and losses. Such an optimised building can stay comfortable all year long without mechanical air-conditioning system.

In the past, higher investment costs have been repeatedly identified as the major barrier to green design. But since building components (for instance, the new generation of PV-cells, which are increasingly used for city-integrated, decentralised energy generation)[13] have become much more efficient and affordable, as they are produced in high quantities, capital investment in renewable technology can pay for itself over a shorter period of around eight to ten years.

High operating costs of buildings require our attention, less so construction costs. Fortunately, renewable energy technologies are now mature and reliable, with components built to last for decades and requiring minimal maintenance. During the life cycle of a building the costs of maintenance and operation can amount up to four times the original construction costs. In future, the demand for energy-efficient buildings will inevitably increase. Demonstration projects with a positive energy balance over the year (e.g. new office buildings, or large housing complexes) will serve as important pilot projects and are proof that architects have started to assume responsibility beyond aesthetic aspects.

**FIGURE 4.** A new generation of affordable PV cells (e.g. silicium-free thin film technology) will soon enter the market. There is a wide variety for architecturally integrated installation in facades, on roofs or canopies, to generate the energy decentralized and close to where it is needed. (image: courtesy by Conergy).

A sensible trend is to shift away from buildings with intensive technical installations to low-tech passive solutions, with structures using efficient but simple façade technology offering operable windows for natural ventilation (as mixed-mode systems). The location for large window openings depends on the orientation and need for protection against overheating and excess of solar energy: greater heat gains internally may lead to the use of less energy in winter, but can create problems in summer.

It is crucial to get the relationship between building volume and façade surface (the degree of 'compactness') right. Of course, to a large degree, all urban strategies depend on the geographical location and the local climate. In a temperate climate there is a significant advantage in having long west and east facades, using the summer sun to create a stack effect that draws air from one (cooler) side of the building through to the other (warmer) side. This effect could further be supported by a wind roof such as a 'Venturi spoiler', which uses the prevailing winds to create negative pressure on the façade. A concrete structure can provide better heat storage (thermal mass), while flexible solar shading can protect the interior from too much light and heat gain in summer (in combination with the use of high-performance glass), and allows to open-up in winter to harness the sun's energy for heating [18,19].

On the other hand, in a hot and humid (tropical) climate, there are clearly other priorities. Here, it is much more important to ensure good cross-ventilation, and to keep material mass such as concrete floors or masonry walls fully shaded to avoid storage of unwanted heat in the building mass [20,21,22]. But in both cases, from the standpoint of energy consumption and avoidance of heat gain, it is generally seen as an advantage to have compact volumes with a reduced façade surface area.

This is significant for urban planning and suggests that well laid-out subdivisions, are ones where homes and offices are oriented to enhance passive solar heating and cooling, for the use of solar hot water heaters, for maximum natural day light, and for taking advantage of the local prevailing wind direction to catch cooling breezes. When the building facades are made specific to their orientation, with the intentional placement of closed wall surfaces and small window openings, it will result in substantially lower energy consumption—as well as reducing the dependence on air-conditioning. For office buildings, this means: Moving away from the air-conditioned sealed building type and deep plan layout, to buildings with all windows operable and shallow plans (less than 15 metres width) for optimum day lighting. Those office buildings take full advantage of natural day light for all regularly occupied spaces, which reduces energy consumption and excess heat from electric lighting. As a consequence, there are demonstrable cost benefits in operating such buildings.

The implementation of sustainable design measures frequently implies some additional initial construction costs, although it is well documented that life-cycle costs are reduced. Scientist Greg Kats has extensively researched the costs and benefits of green buildings, and has demonstrated conclusively that sustainable architecture and urban design is a cost-effective investment [22].[14]

## 9. LANDSCAPE AND BUILDING: RE-INTEGRATING GREEN AND MAINTAINING BIODIVERSITY

In recent years, we have seen exciting examples of new public landscapes being developed, combined with increased urban density, and new recreational landscapes utilising derelict urban sites. Even formerly contaminated sites and rubbish dumps have been successfully rehabilitated and turned into public parkland (e.g. the park at Port Forum in Barcelona, 2006).

There is a great potential for urban greenery and gardens to achieve identity and a sense of place. Much research is done into ways to better incorporate landscape as part of urban design, and to integrate new forms of green in the buildings (refer to the recent work by architects and landscape designers such as MVRDV, Ken Yeang or West 8). In other words, exploring better solutions as to how we can achieve a closer symbiosis between building and nature. These can provide inspiring micro-climates for daily interaction with nature. In this context, landscape can be understood as the 'urban edge' where methods of water management and maintenance of biodiversity is crucial. [23]

Despite increased density, the city could still contain small urban gardens for recreation or even food supply, in combination with green roofs to collect the rainwater for irrigation of those gardens. The installation of rainwater tanks, the development of more effective recycling water programs (grey water usage), recycled sewage, and the ability to harvest the storm water runoff, all need to be part of an urban water strategy.

It is generally important to ensure the 'hard' appearance of new development is lessened by soft landscaping, tree planting and vegetation. Innovative ideas of vertical landscaping and the re-creation of ground conditions to roof gardens ('cool roofs') are now being applied by many designers. Today, most cities have established policies on the principle that removal of potential green area at ground level should be offset by planting the equivalent area at roof level.

## 10. TRAFFIC PLANNING TO IMPROVE PUBLIC TRANSPORT

Good traffic planning will be essential for the sustainable 'City of the Future', and there are now plenty of innovative ideas and traffic concepts to reduce our car dependency. While it is not possible with buildings, given the appropriate legislation, almost all motorised vehicles could be replaced by environmentally friendly ones within a decade.

Some concepts have become standard in many European cities; however, they have not yet been fully embraced by North American or Australian traffic planners. In fact, inflexible traffic planners seem to frequently be the weakest part in the multi-disciplinary planning chain, hanging on to old ideas, conventions and institutional arrangements. Just to mention a few of the concepts that could be applied:

- genuine improvement of integrated public transport, where rail/bus/tram/subway/ferry timetable schedules are all coordinated with each other;
- improved coordination of timing between various red lights to avoid unnecessary halts of traffic flow;
- step-by-step reduction of inner-city car parking spaces through improvement of parking facilities at the fringe of the historical centre, combined with park-and-ride concepts for rail/light railway stations;
- street profiles to integrate cycle paths that are sufficiently safe and wide (e.g. Melbourne increases now the width of cycle paths from 1.5 to 2.5 metres), offering bike stations to park and repair bikes (as is common in Netherlands and Japan);
- constructing subway systems is extremely expensive and time consuming. Larger, polycentric cities (cities with several centres but no efficient subway system, such as Sydney, Sao Paulo or Los Angeles) need to find ways to connect their various centres with an efficient, high-speed linkage, such as a monorail or light railway system; and
- adopting a general attitude based on the fact that 'pedestrians are more important than vehicles'.

Australians travel over 7,500 kilometers annually by road (RTA data, 2006). Their reliance on the private car for transport is having a huge impact on the environment. The situation in the US is similar. Therefore, urban planners need to create more compact, denser cities with a vastly improved and integrated public transport system combined with localized and well-designed pedestrian and cycle networks.


**FIGURE 5.** The automobile is not the only source of emissions, but a major one. Most $CO_2$ emitted by global traffic comes from cars (44.5%) and from trucks (25%). Cars will not disappear that soon, therefore we need to develop more appropriate, energy-efficient models, e.g. electrical or hydrogen fuel-cell powered automobiles (Image: study by Media Lab, MIT, 2006; the Media Lab concept relies on electricity).

**FIGURE 6.** Improving public transport with a modern light railway system to reduce our car dependency. Pedestrian friendly landscaping is possible with integrated light railway tracks.


**FIGURE 7.** The alternative to light railway: Upgrading the bus network (Curitiba, Brazil) with efficient, high-tech express buses which can transport up to 120 people.

The electrical-driven light railway (tram) system is clearly combining a series of advantages: it only requires a quarter of energy compared with buses, and can transport in one go around four times the amount of people (without blowing exhaust fumes in the air). These are good reasons why currently the tram is running in around 400 cities worldwide and another 250 cities are introducing it as the inner-city public transport system (this includes cities, such as Athens, Sydney, Istanbul, Paris, Lyon, Berlin, Saarbruecken, Edmonton, Bergen, etc.).

## 11. TWO EXAMPLES FOR URBAN REGENERATION: THE 'CITY CAMPUS' AND 'PORTCITY' PROJECTS

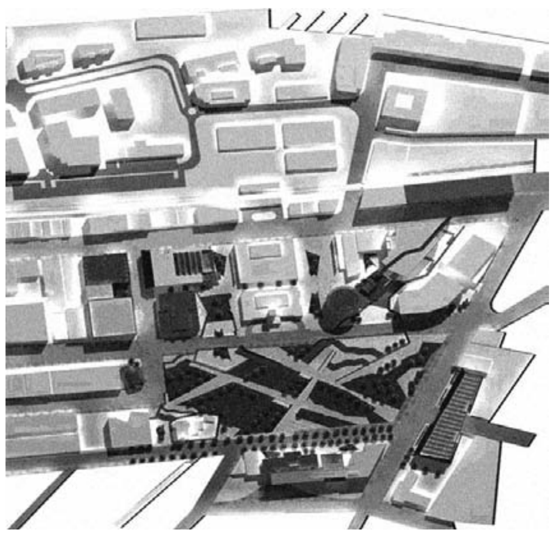
Following is the description of two case studies which are both based on the findings described earlier. These two projects are examples for the application of sustainable urban design principles[15], both urban design proposals for the city of Newcastle (Australia). 'City Campus' and 'PortCity' were developed in the 4th year architectural design studio at The University of Newcastle. The designers were interested to apply the sustainability criteria previously mentioned and to test these criteria in real projects; the author believes there are some generic lessons to be learnt from these studies.

The city of Newcastle is located about seventy miles north of Sydney, where the Hunter River flows into the Pacific. Newcastle is the sixth largest and the second oldest city in Australia, and the second largest in the state of New South Wales. Newcastle is also one of the largest coal export harbour in the world and boasts coal deposits which cover much of the Hunter region. Newcastle city has a population of around 150.000 people. It has a temperate maritime climate with four distinct seasons (average maximum temperature is 26, minimum 7 degrees Celcius).

Coal mining in Newcastle started in 1804, and the city grew with its mining, steel production and other industrial activities. Newcastle was opened to free settlement in 1823 and quickly expanded into the Hunter Valley area.[16] The post-industrial development of Newcastle from a former district of heavy industry into a contemporary, 21st century city poses a significant challenge to change management.

Today, most of the steel manufacturing plants and smelters have been closed (e.g. BHP closed its steel production finally in 1997), and large areas of formerly industrially used land—frequently brownfield sites in prime waterfront location—became available for sustainable urban development or conversion into parkland. This process is accompanied by tremendous environmental challenges, such as heavily con-

**FIGURE 8.** The 'City Campus—Strategies of Urban Infill' Studio, proposal I (2007) by the author and students. The central public parkland and its high quality is an essential part of the urban ecology.



taminated soil, mine subsidence, and the legacy of two hundred years of industrial pollution.

Following is a short description of the two urban design projects, the 'City Campus' and the 'PortCity'.

- Project 1: 'City Campus', has a focus on regeneration of the city centre as a key principle of the sustainable city.
- Project 2: 'PortCity', has a focus on transformation and redevelopment of the harbour area as a model for sustainable expansion of the city.

Both projects are based on a balanced approach, high ambition regarding urban ecology and the aim to run the city centre on renewable energy. They offer a great opportunity for Newcastle to grow and regenerate over the next twenty years through an energy transition in the right direction.

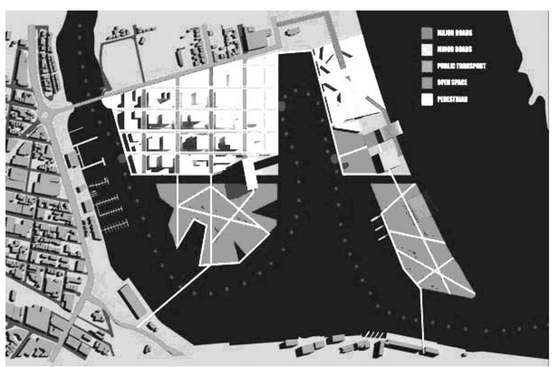
The City Campus uses careful strategies for urban infill and regeneration of the neglected downtown. The aim is to look beyond the site boundaries, at the ecological footprint of the city centre. The brief asks for university facilities for 3,000 students, including a new public library, drama theatre, School of Architecture and Fine Arts, Faculty of Business and Law, as well as the integration of existing buildings. The proposal suggests relocating significant parts of the university from its 1960s suburban campus, combined with student accommodation, back to the city centre. A new landscape design for the central park (Civic Park) is part of the project, to get high quality green spaces, green roofs and biodiversity within a sustainable neighbourhood and eco-buildings. 'Sustainable neighbourhood' was hereby defined as 'a compact community cluster using as little natural resources as possible, with careful consideration of public space.' The City Campus will facilitate the revitalisation of the centre and stop its further decline.

The second proposal is the 'PortCity'[17] project, which is based on an overall strategy for reclaiming post-industrial waterfront land. It is a mixed-use urban waterfront development of ten hectares prime waterfront land, of which about half will be dedicated to public parkland. Once the industrial working harbour has moved up the Hunter River (in around six to eight years, by 2015), Dyke Point could be connected with the centre by a new pedestrian and cycle bridge, so that the now underutilized land can be turned into a sustainable city precinct.

The 'PortCity' is aimed to be a 90 per cent emission–free development, where all energy is provided by distributed power from a variety of sources—photovoltaics, wind, biomass and consideration of geothermal—to demonstrate that it is affordable and achievable today to make all major new urban developments carbon-free and based on renewable energy sources. Questions of density, scale, urban public transport (a light railway 'super connector' system was suggested), solar orientation, and the maritime heritage of the working harbour are all critical to the design, as well as the integration of the established Carrington community. The staging of the 'PortCity' development is used to drive the design approach,

**FIGURE 9.** The 'PortCity—Reclaiming the post-industrial Waterfront' Studio, proposal (2007) by the author and students. This is a zero-emission city extension with the historical city centre in walking distance.

**FIGURE 10.** The 'PortCity—Reclaiming the post-industrial Waterfront' Studio, master plan (2007) by the author and students.



and activates the existing Pump House as catalyst and starting point.

Newcastle's port is the place where large engineering infrastructure is juxtaposed with the cityscape—a great and poetic inspiration to all architects and urban designers, to reinvent infrastructure and to face up to future challenges.[18] In the post-industrial city there is typically a large potential of undeveloped inner-city areas for the generation of renewable forms of energy,

## 12. BEYOND CONCERNS OF AESTHETICS: SOME CONCLUDING REMARKS

During the last century, we spent most of our time developing methods to adjust to the consequences of pollution and global warming rather than to deal with the root causes. The scientific evidence and consensus of international scientists on human-induced global warming is no longer denied.[19] There are also rising public expectations about environmental issues, and with the right leadership we are now in the position to take huge steps forward. Interestingly, the public seems to be ahead of politicians—the 'public' is really in support.

Today, we understand that the most significant environmental challenges of our time are global climate change and excessive fossil fuel dependency. Related to this are rising greenhouse gas emissions and water, soil and air pollution, all of which have significant environmental, social and economic consequences. Out of this has emerged a new focus of sustainability on large-scale complexes and the need to transform our cities.

Climate change demands action now if we are to make the dramatic and necessary cuts to greenhouse pollution levels. Climate change demands that we change the conventional concepts and layouts of cities as we have known them, and to implement sustainable 'Green Urbanism'. We already have the technologies to commence the rapid transition to an energy future based on renewable energies and new standards in energy efficiency.

By taking early action on climate change and focusing on more sustainable centres, a number of cities have already succeeded in significantly reducing their energy demand and, therefore, greenhouse gas emissions (e.g. Freiburg in Germany). While the development industry must take a big share of the responsibility for contributing to the current state of our environment, it is the same industry which is now also in a position to do something about it. Businesses can provide the solution as long as government sets the right standards; however, both together have to face up to the challenge. Several developers and contractors have already started to embrace this paradigm shift and are increasingly changing their practices to incorporate such ideas, as financial investors value ethical and environmentally friendly projects.

We need more intensive investment in sustainability to ensure the rapid application of those new, available technologies—a combined effort like the 'Apollo Program' once triggered forty years ago.[20] We already possess the scientific and technological know-how to solve carbon and climate problems, we have practical ways to cut emissions. Those new systems need to be applied in a way that will not only stop the $CO_2$ emissions that take place, but will also contribute to repairing some of the damage. It's clear that we need to act now, based on practical ways forward.

The city's transition towards renewable energy and compact communities will reduce the dependency on energy and water providers, and reduce the demand on public infrastructure [24]. It is obvious; such sustainable designs need to go far beyond concerns of aesthetics. Cities are built resources with high primary energy content. Renewable forms of energy, and the strategies outlined earlier in this chapter, are available, achievable and affordable. They present an opportunity to make inner-city life more attractive. Affordable housing and liveable, mixed-use neighbourhoods (with a mix of housing types, prices and ownership forms) are all essential elements of sustainable urban development. Design plays hereby a major role in achieving liveable, affordable inner-city models.

The findings of the research leads to the conclusion that sustainable building development means, first of all, to apply technical solutions sparingly and to make the most of all passive means provided by the building fabric and natural conditions. In a second step, active and mechanical systems can be integrated. Therefore, for a sustainable city centre, it is imperative to first develop an overarching vision that counters sprawl, curbs commuting, reduces automobile dependency, and promotes improved public space with increased urban density.

There is clearly a need for a better planning and urban design education, combined with increased research activities. Students show a great interest in the subject of sustainable design, and all architecture and planning schools should introduce the subject in their teaching. Education and research is a major factor in fighting climate change. Radford points out that design decisions for the sustainable city 'must be based on both an ethical position and a coherent understanding of the objectives and systems involved.' [25] In education, there is a need for a humanistic, socially responsible approach, with environmental sustainability as a non-negotiable underlying ethos. It is important to teach students in architecture and urban design that 'green' is not something to be bolted on once the design is completed, but is to be integrated already in the conceptual phase.

Accompanying the shift towards renewable energy sources, more exchange of experiences between cities is necessary. As we begin to understand that the traditional model of urban development will no longer work for the future, we are still grappling with the difficult task of defining new models, objectives and systems involved. Acknowledging that the overall development patterns of our urban areas are the result of a complex and difficult process, we accept that current patterns of outward-spreading development cannot be sustained economically, environmentally and socially. The increase of densities, combined with urban regeneration strategies for neglected inner-city areas, are therefore valid solutions: It is less environmentally damaging to stimulate growth within established city centres, rather than sprawling into new, formerly un-built areas.

Key aspects on our path towards the sustainable city will be an increase of community awareness and incentives for renewables. No doubt we will see a further rise of the renewable energy economy gradually replacing conventional energy technologies with renewable systems.

If we get this right, the city—often thought of as being the most wasteful user of resources—could emerge as the new model of sustainability.

## ACKNOWLEDGEMENTS

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## NOTES

1. The 'Journal of Green Building', Volume 1 / Number 3, summer 2006, 'Lehmann, Steffen: 'Towards a Sustainable City Centre', pp. 85-104.
2. Australia is the 12th-largest emitter of carbon dioxide ($CO2$). However, on a per capita basis it is the leading polluter because of its reliance on coal for power; e.g. 93% of electricity in New South Wales is supplied by burning coal. The Australian Business Roundtable on Climate Change (2007) recently showed that it was possible for countries such as Australia to deliver significant reductions in greenhouse gas emissions at an affordable cost, while maintaining strong economic growth.
3. Increasing environmental damage as a result of humanity's addiction to coal and oil, and declining resources will further lead to conflicts over water. Desertification, soil erosion and shrinking rainfall mean that many developing countries will not be able to continue supporting its human and livestock population.
4. China's rapid urbanisation process makes it an interesting case study. Since the economic reform in the eighties, cities in China have undergone phenomenal changes; the sustainability impacts of these transformations are yet to be assessed. According to its government, around 400 million Chinese people need new houses in the next 12 years. For instance, cities like Chongqing and Shenzen grow annually by around 300,000 people (2006) - at an unprecedented speed. There are also many new towns in planning: Between now and 2020, China will need to build 400 new towns, nearly 30 a year. Two of such new towns, both supposed to become carbon-neutral cities, are: 'Dongtan Eco-City', a new city to be entirely based on ecological sustainable principles, with a fist stage to be built by 2010 on an island in the Yangtze River close to Shanghai; the city will grow to 500,000 people by 2040 (planner: Arup, London; www.arup.com). The other is 'Yimin', a new town for 100,000 people, mainly ethnic minority groups in Mongolia (planner: Allen, Jack & Cottier, Sydney; www.architectsajc.com). These rapid growth processes are not the only occurring change: As Dr Peter Herrle (Berlin) points out, 'expansion and shrinking processes of urban areas can occur at the same time in closely neighbouring city districts. The city of Detroit (USA) is an example for a shrinking downtown area which is accompanied by growth and expansion processes in the outskirts' (Herrle, 2007).

   The principles developed at Dongtan include: all energy provided by distributed power from a variety of sources—photovoltaic, wind, biomass; use of water recycling and natural treatment systems; a focus on multi-modal public transport and direct and convenient cycle and pedestrian routes as opposed to ring road distribution.
5. Roughly half of all the energy consumed in the developed world is used to run buildings (especially for cooling). For instance, in Australia, buildings consume around 44 per cent of all energy (Source: OECD Report, Challenges and Policies, 2003). A building's air-conditioning system is typically responsible for half the base building's energy consumption; here are the most significant reductions in energy and carbon emissions possible.

The Australian property industry contributes approximately 30 per cent of Australian greenhouse gas emissions. A further 25 per cent of all energy consumed is accounted for by traffic and transport. A large quantity of non-renewable fossil fuel is needed to generate this energy, and the process involved in the conversion of fuel into energy has a lasting negative effect.

6. At present in Europe, renewable energy sources account for only 7 per cent of the total EU energy mix. In Germany, renewable energy currently contributes 11 per cent to the energy mix, mainly generated by wind power. However, renewable energy already accounts for 25 per cent of the installed capacity of California, and half of Norway's; a new clean energy boom is about to start.

   *Wind:* Off-shore wind parks have probably the largest growth potential at the moment. Wind power is the least expensive of the renewable sources of electricity. Denmark has become a world leader, with wind set to generate at least 25 per cent of Denmark's total energy by 2009. The city of Copenhagen, for instance, recently installed 20 large wind generators off-shore in front of its port.

   Germany and Spain are the world's biggest producers of wind energy, slightly ahead of the US (source: Windustry, 2007). Both countries adopted the system of 'tariff premiums', which provides energy producers with a guarantee that all the electricity they produce will be purchased by distribution companies at premiums over the market price. Both countries are also frontrunners in solar power and bio fuels. Wind turbines produce now more than 25 per cent of Spain's total electricity supply; more than nuclear, coal or any other single energy source.

   Europe's biggest solar power plant is outside Seville (Spain): in its centre is a tower 115 metres high that captures the solar energy reflected by a field of giant mirrors and stores it as steam. It already generates enough energy to supply 6.000 houses in the first stage.

   *Solar:* The potential of the solar power source is enormous. For instance, the amount of solar energy that hits Australia in one day is about half the world's total annual energy use. The area required by solar PV panels to generate enough energy for all of Australia's energy needs is 6,600 square kilometres in size, roughly the area of greater Sydney.

   Covering 4 per cent of the world's deserts with photovoltaic cells would theoretically provide enough energy for the entire global population - without adding any carbon dioxide to the atmosphere.

   Solar technologies harness the energy either directly as heat (solar hot water systems), or for conversion into electricity, selling the excess power back into the electricity grid. Particularly promising is the Sliver Cells technology and thin-film technology (which is silicium-free). Germany is currently by far the biggest user of solar panels worldwide, even more than Japan. Refer also to the carbon-neutral project 'Solar City' in Linz, Austria, at: www.linz.at/solarcity

   The further development and utilization of non-conventional resources like chemical energy from organic waste or thermal energy from wastewater, and the development of decentralised technologies, will come to the focus within the next years.

   A study by the German Advisory Council on Climate Change has shown that it is technically feasible for solar energy to provide 25% of all primary energy by 2050.

   It is hereby unlikely that large energy companies with business based on fossil-fuel (such as Shell or BP) will easily transfer to the renewable energy market. Shell, for instance, spends currently only 3 per cent of its investment on the development of renewable technologies.

   According to Sir Nicholas Stern's review (2006), delaying the shift to clean energy will cost us more in the long run. To weaken or delay the clean energy shift would be poor economic management. And there are things we should all do immediately:

   - buy 100 per cent green power (see: www.greenelectricitywatch.org).
   - install solar hot water systems (In Sydney: over 80 per cent of the energy required for hot water can be delivered by a solar hot water heater).

7. Many countries, such as Australia, still lack legislation to support recycling. For instance, 'land filling' with electronic waste has to urgently stop; the old computers and monitors create, among other things, lead pollution.

   Ideas about better recycling create considered products, where materials can be used again for a post-life, as eco-effective products. Some manufacturers have started to produce their products of biodegradable materials; e.g.: company Nike proclaims to be waste-free by 2020. Already today, the manufacturer of sports equipment takes used shoes back for disassembly and recycling. Company Trigema produces now a collection of compostable T-shirts. Refer to: the 'Cradle-to-Cradle' protocol by William McDonough and Michael Braungart, at: www.mcdonough.com and www.braungart.com.

8. The automobile is, unfortunately, not going to disappear soon. However, of all transport methods, the car is the largest CO2 emitter in the developed world: approx. 45 per cent (whereas trucks contribute around 25%, airplanes 11%, ships 10%, and railway 1.5%). This explains the urgent need to develop smaller, more energy-efficient city car models. The Smart Mercedes was only the beginning. MIT's Media Lab currently develops a new generation of micro cars. The $CO_2$ emissions from air travel are likely to triple over the next 50 years (refer to: Report by Nicholas Stern, Oct. 2006, published January 2007).

   The anti-sprawl critique was raised by Jane Jacobs in the early 1960s leading to a mainly negative image of suburbanisation. The implementation of more compact cities needs to deal with emerging issues and challenges that come along with higher densities, such as social changes and conflicts in inter-neighbourhood relationships, e.g. of multi-apartment housing. In Sydney, for instance, some 25 per cent of the population now live in multi-unit housing. This proportion is still low in comparison with European cities, but is predicted to grow to 45 per cent by 2030.

9. Global agreement on scientific evidence confirming the man-made nature of climate change has been established through four reports by the IPCC, the UN's Intergovernmental Panel on Climate Change: reports published between December 2006 and May 2007 (Fourth Assessment Report, May 2007).
10. Researchers at the ETH Zurich have developed the '2000-Watt-Society' model. This model can only be achieved by increasing efficiency of buildings and machines, and by a shift towards renewable sources of energy. For a country like Switzerland, constant energy needs of 2,000 watt per person would be adequate to ensure economic growth and to maintain the current quality of life. In comparison, energy needs in Africa are 500 watt per person, and in the US 12.000 watt.
11. Decentralised energy production, for instance with solar PV-cells or wind farms, has many advantages compared to large-scale centralised power plants; centralised coal and nuclear power plants require expensive backup in case the entire plant breaks down. Currently developed organic photovoltaic-cells, or flexible miniature solar panels, could dramatically reduce the cost of conventional solar power generation.
12. Refer to: Kats, Greg, et al (Oct. 2003): '*The Costs and Financial Benefits of Green Buildings*'; a report to California's Sustainable Building Task Force. American scientist Greg Kats of Capital E is the nationally known author of the most widely referenced study of the costs and benefits of green buildings. This study has demonstrated conclusively that sustainable building and the use of renewable energies is a cost-effective investment.
13. In 'The Fatal Shore', R. Hughes tells the story of Newcastle's settlement and development from a tiny convict outpost to an important port town (Newcastle today: the world's largest coal exporting harbour, 2007). Refer to: Hughes, Robert (1987). 'The Fatal Shore'. Vintage, London, pp. 425-439.
14. A definition of 'sustainable' is derived from the Latin verb 'sustinere', which describes relations that can be maintained for a very long time, or indefinitely (Judes, 1996). The idea of 'sustainable urban development' originated at the 1992 UCED-Conference and Earth Summit in Rio de Janeiro. It is based on the concept of balanced environmental planning instruments and methods, of which a great variety of visions for urban development has been created. However, fifteen years after Rio, there is still no global mandatory commitment to a cap on carbon emissions.
15. In preparation of this urban design project, similar port redevelopment projects, such as in Hamburg, Rotterdam, Genoa, Vancouver and Barcelona have been analysed.
16. The USA Government is increasingly criticised for having ignored for too long the scientific evidence on climate change impacts. Industry-sponsored greenhouse sceptics—with 'research' funded by the mining, automobile and coal industry—were trying to undermine the credibility of scientists through the 1990s. Today, such censorship is not working anymore, as events like hurricane Katrina (destroying New Orleans, in August 2005) lead the American people to their own conclusions. Administration accepts now the mainstream science of climate change, which had been so openly challenged by senior government members only a year ago.
17. Huge investment efforts will be needed to solve the climate change issue—which is entirely appropriate for saving the environment. In the same way, we invest in all kind of other areas, such as in security, poverty, military, or tourism.

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