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# Towards Sustainable Building Design

David Grierson

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# Towards Sustainable Building Design

David Grierson, University of Strathclyde, Scotland, UK

*Abstract: Work recently undertaken at the University of Strathclyde, Department of Architecture, is concerned with the articulation of a management system that might support sustainable design. Aligned with the international standard ISO 14001, a system has been piloted in housing development projects around Glasgow, and offers a supporting framework for the implementation of agreed actions and addresses a number of key urban planning and building design tasks incorporating six related themes. This paper will discuss the context and introduce the themes of Human Impact (including consideration of quality of life issues, consultation and social inclusion, development factors, health factors, comfort levels, accessibility, public transportation, facilities for cyclists); Environmental Impact (including consideration of protection of local ecological features/biodiversity, environmental assessment); Pollution Prevention (including consideration of indoor air quality (emissions from equipment, outgassing of toxins/radiations), elimination of toxins, control of pollutants during constructions); Sustainability Management (including consideration of integrated and systemic approaches e.g. sustainability/environmental performance targets, management systems and procedures, construction management, commissioning, dissemination workshops, post-occupancy feedback visits); Resource Efficiency (including consideration of, lean design, material use and recycling, embodied energy, water consumption and conservation); and Energy Efficiency (including consideration of, targets, benchmarks and best practice energy use, passive solar, renewable energy, thermal modelling, insulation, ventilation, heating, CHP, heat recovery.*

Keywords: Sustainability, Urban Planning, Building Design, Management System

## Towards a Sustainable Built Environment

**SUSTAINABLE DEVELOPMENT AIMS** towards improvement and increased quality of life for all on a planet that is finite in its physical resource and its capacity to absorb waste. As defined by the Brundtland Commission report (WCED, 1987) the term implies that a balance can be achieved between human socio-economic activities and the natural environment's capacity to provide resources and absorb waste on a global scale. Recent research indicates, however, that globally our demand began to outstrip the Earth's carrying capacity in the 1980s (Wackernagel *et al*, 2002). Today the ecological footprint of the world population/economy exceeds the total productive area (or ecological space) available on a planet (Rees *et al*, 1996). Essentially we have gone beyond that which the environment can afford. Excessive levels of production and consumption, resulting from economic growth models that equate success with material throughput, are causing excessive levels of environmental impact. Although we cannot say with certainty at what rate or to what extent, evidence suggests that we are now damaging the biosphere, perhaps beyond repair. The application of the precautionary principle (EU, 2003) has been proposed as one way of addressing uncertainty and offering a practical way to pursue environmental sustainability (Tickner *et al.,* 2001).

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Accepting that there can be no sustainable development without a sustainable environment to base it upon recognises the need for a fundamental change in attitude towards prioritising the preservation of an environment capable of sustaining an acceptable quality of life for everyone (Lovins and Lovins, 2001). Agenda 21, the EC's Sixth Environmental Action Programme: *Environment 2010: Our future, our choice*, (EU, 2001) and the UK National Strategy for Sustainable Development: *Securing the future* (DEFRA, 2005) rightly emphasise the need to review development processes in a holistic way moving towards a more balanced relationship between social, economic and environmental factors. Moving away from excessive and damaging activity will mean prioritising ways of life that can operate within the current renewable resources of the ecosystem and the biosphere. Sacrifice will inevitably be part of such a process since we will have to put the biosphere's needs before our own anthropocentric requirements. Remediation will require us to alter our current material relationships with the surrounding environment. Although there are many, often conflicting, definitions of what *sustainability* is, or might become, the move towards the construction a more sustainable society, if it is be achieved at all, will be founded upon a redefined relationship between the built and natural environments. The Sixth EAP identifies four priority areas as climate change, nature and biodiversity, environment and health, and natural resources and waste.

The scale of resource use and environmental alteration currently attributable to the construction industry dwarfs most other industrial sectors. Globally environmental sustainability will depend on the successful implementation of measures to reduce the negative impacts of the built environment on the natural environment. A response to the precautionary principle within architecture lies in the design of buildings that satisfy needs while demonstrating increasing material and energy efficiencies. Buildings consume energy and resources and generate waste on a huge scale. Current construction methods tie us into future patterns of resource and energy use, waste emissions and environmental damage. When poorly designed our buildings leave a lasting legacy for the next generation that extends adverse social, economic and environmental impacts throughout their life cycle. The Scottish Executive's *A Policy for Architecture in Scotland* acknowledges that the complex and challenging sustainability agenda requires fundamental change in our understanding of the nature and purpose of buildings and the role of building design (Scottish Executive, 2006).

Governments cannot achieve sustainable development on their own. Making decisions, and developing policies, that address issues of global environmental sustainability, including the better management of natural, community and economic resources, must be made at all levels of our activity (local, national and international). For many organisations, the international standard for environmental management systems, ISO 14001 (International Organisation for Standardisation, 1996), forms an appropriate template for the management of their environmental performance. Since it was introduced in 1996, and with its subsequent adoption as a key component in the revised Eco-management and Audit Scheme (EMAS Regulation), there has been widespread and growing use in many sectors. Research into the implementation of environmental management systems within the wider context of sustainable development has raised issues of fundamental importance to the understanding of the concept if appropriate action is to be taken. In particular, consideration has been given as to how a practical realisation of such a system might be applied to the lifecycle of a building, including the design phase. We need visions of a more sustainable future that can provide the current generation of designers and planners with sufficient motivation without impairing their capacity to learn

what might be the best direction for change. At the same time we urgently need to improve the energy and environmental performance of the global built environment. An improved building design process aided by appropriate management tools and regulatory frameworks that address sustainable development issues is suggested here as a way forward.

## International Agreements

Viewing sustainability as an integral part of all development has been embedded in international declarations, conventions and other plans for action in recent years. The Earth Summit in June 1992 in Rio de Janeiro was a defining event in the sustainable development movement and resulted in several important international agreements including *Agenda 21* (UNCED, 1992) and the *UN Framework Convention on Climate Change* (UNFCCC 1997). Under Article 12 of the framework many countries attribute greenhouse gas (GHG) emissions from buildings to be in the range 20-30% of their total national emissions. Studies have shown that GHG emissions are increasing at a rapid rate. Even the most optimistic reports expect GHG emissions in the housing sector to have increased by 15% above 1990 levels by 2010.

The *European Union Energy Performance of Buildings Directive* was published on the 4th January 2003 (EU, 2003). The overall objective of the Directive is to promote the improvement of energy performance of buildings within the Community taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness. Each EU member state was required to transpose the Directive into law by the beginning of 2006 with a further three years being allowed for full implementation of specific articles.

## Towards Sustainable Design

The European Commission's policy document *Towards a Thematic Strategy on the Urban Environment (2004)* outlines problems and challenges facing Europe's urban areas focusing on 4 priority themes. These themes, selected in conjunction with stakeholders, are urban environmental management, urban transport, sustainable construction and urban design. The themes are cross-cutting in nature and have strong links with many environmental issues offering scope to make progress in improving the quality of the urban environment. For each theme, the Communication sets out the nature of the challenges, what action has been taken so far at the European level and ideas for what further action should be undertaken to address better the challenges identified. The Commission starts with the premise that the knowledge and techniques needed to bring about significant improvements in environmental performance in urban areas are already known. Whilst there are some gaps in knowledge, the focus of the Strategy should then be on achieving clear changes in urban areas rather than calling for further consideration of the issues. The Commission recognizes that towns and cities themselves are best placed to develop the solutions to the problems they face and proposes that a framework be established to support them in this task. It proposes that targets should be established at the local level through the adoption of environmental management plans and sustainable urban transport plans for urban areas. Appropriate strategic design at the planning scale of any new proposal, particularly where a large volume of housing is involved, is an important aspect of achieving sustainable development goals and in creating the foundations of a sustainable community. Relevant issues at this scale include:

- Building the capacity of local community to participate in the planning process
- Improved transport infrastructure (access to public transport, embodied energy, facilities for cyclists, etc.)
- Improved amenities (housing, retail, education, healthcare, employment, etc.)
- Social mix (density, tenure, etc.)
- Accessibility issues (access for those with disabilities, DDA compliance, etc.)
- Cultural and historical issues
- Site and orientation issues (maximise passive solar design, ventilation, views, etc.)
- Air quality issues (external sources of pollution)
- Land use issues (pollution impact, soil erosion, mixed-use, biomass opportunity, etc.)
- Use of non-renewable resources (appropriate material selection, building components, recycling potential, durability & adaptability, upgrade, etc.)
- Energy consumption (minimise energy demand by design, utilise energy efficient plant, promote renewable energy systems etc.)
- Use of district heating systems (CHP etc.)
- Water consumption (water saving devices, grey water systems, etc.)
- Environmental impact assessment (air pollution, greenhouse gas emissions, etc.)
- Impact on biodiversity (habitat protection, low impact maintenance regime, etc.)
- Management (life cycle planning, facilities management, environmental management system, waste management etc.)

While not exhaustive the list above indicates the diverse range of issues to be considered at the planning stage of a proposal. Many of the same issues are relevant at the design and construction stages of individual buildings and structures. Building for sustainable development involves using design and construction methods and practices, which strive for integral quality (including economic, social and environmental performance) in a very broad (or holistic) way. Sustainable building design will consider the entire life cycle of buildings, taking environmental quality, functional quality and future values into account. A respect for all people, demonstrated through the provision of a healthy, functional, accessible and attractive built environment, is vital in promoting social sustainability. Similarly the efficient use of construction budgets, building material and labour within an organized management system will promote economic sustainability. Environmental sustainability will require the rational use of natural resources and the appropriate management of the building stock. This will in turn help to save scarce resources, promote energy conservation and improve environmental quality. Environmentally sustainable buildings aim to lessen their impact on our environment through energy and resource efficiency.

There are a number of assessment methods and tool designed to help UK construction professionals understand and mitigate the environmental impacts of the developments they design and build. BREEAM buildings can be used to assess the environmental performance of any type of building (new and existing). Ecohomes is a version of BREEAM for homes. Balancing environmental performance with quality of life issues it was developed by the Building Research Establishment (BRE) and offers an authoritative rating for new, converted or renovated homes, and covers houses and flats.

In February 2008 the UK Government confirmed that a mandatory rating against the Code for Sustainable Homes would be implemented from 1 May 2008. The Code measures the sustainability of a new home against categories of sustainable design, rating the 'whole

home' as a complete package. It uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home and sets minimum standards for energy and water use at each level and, within England, has replaced the Ecohomes scheme. The Code provides information to home buyers, and offer builders a tool with which to differentiate themselves in sustainability terms. There are mandatory minimum levels of performance across 7 key issues:

- Energy efficiency /$CO_2$
- Water efficiency
- Surface water management
- Site waste management
- Household waste management
- Use of materials
- Lifetime homes (applies to Code Level 6 only)

## Towards Zero Carbon Homes

Alarmed at the level of carbon emissions in the building design and construction industry, the UK Government has produced energy efficiency targets to be met through the Building Regulations and the Energy Performance of Buildings Directive. Housing consumes around 30% of the UK's total energy and generates 27% of it CO2 emissions (DCLG, 2007). If the UK is to continue to meet it's commitment towards reducing CO2 emissions it must not only upgrade existing housing stock but must ensure that new homes are built in a way that works towards this goal.

The UK Government's ambition is for all new domestic dwellings constructed by 2016 to meet requirements for a "zero carbon" home. Zero carbon is defined by the UK Government as a home "that, over a year, the net carbon emissions from energy use in the home would be zero" (DCLG, 2007). A series of incremental requirements are applied. These steps as initially proposed in the *Building a Greener Future: Towards Zero Carbon Development* document require an initial 25% reduction in energy/carbon performance, then 44% by 2013, followed finally by zero carbon in 2016. These dates and performance requirements are currently subject to a consultation process directed by the Department for Communities and Local Government. The greatest difficulty will be in the transition from the 44% to the 100%. This difficulty is compounded by the Code Level 6 requirement of 100% on-site renewable power generation. Micro-generation is difficult at this scale with perhaps the only currently available source of reliable power being biomass CHP. Employing this technology on a national scale is not yet viable.

There are economic challenges to the zero carbon approach. Improving environmental performance will increase capital costs ad inevitably these will have to be absorbed by the home owner. Additional regulation will increase costs for planning and building control. And there will also be increased material costs and assembly costs on site. The UK Government expects that the additional cost of constructing a Code level 3 home to be around 2-3% (around £2000) per dwelling, increasing to 4-7% (around £4000) for a Code level 4 home. It is difficult to estimate the future cost of a Code level 6 zero carbon home in 2016 however some estimates suggest up to 30% cost increase (DCLG, 2007).

## Level 1 and Level 2 Strategies

However implementing many sustainable building design features during the design and construction phases can be justified on cost grounds because they carry little or no additional cost. They can simply be regarded as good design practice and essentially become embedded within the general design decisions of the scheme. In particular decisions taken early in the design stage of a project, with respect to social issues, passive solar and low energy principles relating to site and orientation, the form and fabric of a building, and the selection of appropriate building services, can have a major impact on energy savings throughout the building's life cycle and can address issues of fuel poverty. These broad design aspects have an important role in the energy performance of a building should be considered at the outset when establishing sustainable strategies for the building design. These are described as Level 1 strategies.

Level 2 strategies refer to innovative and technology-based sustainable building design features, and energy saving systems and equipment where there is significant additional capital cost associated and where difficulties can be encountered in the process of implementation (this may include, for example, the application of renewable energy systems such as photovoltaic (PV) panels or biomass heating).

The decision on whether or not to adopt level 2 features, systems and equipment in a building will often made on an economic basis, generally by assessing a rate of return on an investment. A typical way to calculate this has been to use the simple payback period calculated from the following formula:

$$\text{Payback period (y)} = \frac{\textit{Capital cost of energy saving feature (£)}}{\text{Value of energy savings per year (£/y)}}$$

To be deemed worthwhile industry usually requires a payback period of less than 3 years

## Towards a Sustainable Design Management System

Work undertaken in Scotland at the University of Strathclyde, Department of Architecture, in recent years has explored the articulation of a generic system for sustainable design on two specific and interrelated scales; dealing with both planning issues and building design strategies. The sustainable design management system (SDMS) is aligned with the international standard ISO 14001and involves the development of a template for managing an organisation's performance set against pre-determined policy and priority. The basis for the system has been recently piloted in a number of housing development projects around Glasgow. It is important to acknowledge that the system is not a replacement for the creative design process but offers a supporting framework for the implementation of agreed actions by the design and construction team, and various stakeholders.

ISO 14001 (Environmental Management) was first published in 1996 and specifies the actual requirements for an environmental management system. It applies to those environmental aspects which an organization has control and over which it can be expected to have an influence. Similar in intent with regard to wider issues of sustainability, the SDMS is applicable to any organization that wishes to:

- implement, maintain and improve a sustainable design management system

- assure itself of its conformance with its own stated SD policy (those policy commitments of course must be made)
- demonstrate conformance
- ensure compliance with appropriate laws and regulations
- seek certification of its SDMS by an external third party organization
- make a self-determination of conformance

The system involves general requirements, policy, planning, implementation and operation, checking and taking corrective action, and management review. A design & construction organisation would identify elements that impact on issues of sustainability and access relevant legislation. Objectives for improvement and a management program to achieve them would be produced with regular reviews for continual improvement. An auditing authority can periodically assess the system and, if appropriate, register the organisation as SDMS compliant. The system, as it is currently defined, addresses a number of key *urban planning issues* and *building design strategies* while considering six key related themes as follows:

- Human Impact (including quality of life issues, consultation and social inclusion, development factors, comfort levels, health factors, accessibility, public transportation, facilities for cyclists, etc.)
- Environmental Impact (including protection of local ecological features/biodiversity, environmental assessment, etc.)
- Pollution Prevention (including indoor air quality (emissions from equipment, out gassing of toxins/radiations), elimination of toxins, control of pollutants during constructions, etc.)
- Sustainability Management (including integrated and systemic approaches e.g. sustainability/environmental performance targets, management systems and procedures, construction management, commissioning, dissemination workshops, post-occupancy feedback visits, etc.)
- Resource Efficiency (including, lean design, material use and recycling, embodied energy, water consumption and conservation, etc.)
- Energy Efficiency (including, targets, benchmarks and best practice energy use, passive solar, renewable energy, thermal modelling, insulation, ventilation, heating, CHP, heat recovery, etc.)

The above themes are aligned with aspects of the international standard ISO 14001 and offer a basis for the development of a *sustainable buildings management system.* This allows for the identification a number of tasks that need to be undertaken relating to the design, construction and the operation of sustainable environments. In line with the UK Government Department of Environment, Food and Rural Affairs (DEFRA) description of sustainable building sustainable design strategies for urban development should:

- fit well with the needs of the local community
- leave as small an environmental footprint as possible
- be economic to run over its whole life cycle
- be designed and constructed to enable occupants to use less water, through, for example, the involve the installation of more efficient fittings and appliances

- provide good access to public transport in mind
- minimise waste in construction
- maximise re-use of on-site materials such as waste soil
- be energy and carbon efficient, designed to minimise energy consumption, with effective insulation and the most efficient heating or cooling systems and appliances
- make recycling easy for the occupants

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## About the Author

*Dr. David Grierson*

Dr Grierson is both an architect and academic. He is Director of Research at the Department of Architecture, University of Strathclyde. He also currently runs the Faculty's Postgraduate Programme in Sustainable Engineering, and is Director of the University-wide David Liv-

ingstone Centre for Sustainability. His teaching and research interests are in sustainable architecture and urban design. Dr Grierson is a Fellow of the Higher Education Academy (FHEA) and a visiting lecturer in sustainability at Manchester Metropolitan University, the University of Rome, and the University of Florence. His own architectural work has been exhibited at the Royal Academy Exhibition in London and he has gained a number of architectural awards including two Glasgow Institute of Architecture (GIA) Design Awards and a Sir Rowan Anderson Silver Medal for Architectural Design (RIAS). He has an active role in both the architectural and engineering professions, being listed on the UK Register of Architects (ARB), acting as the Royal Academy of Engineering Visiting Professor (Engineering Design for Sustainable Development) contact for Faculty, and representing the University as a member of the Glasgow Urban Design Panel which advises Glasgow City Council's Planning Committee on planning decisions.

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