Energy and Cities – Sustainable Building and Construction

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SUMMARY OF MAIN ISSUES

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"Energy and Cities: Sustainable Building and Construction"

Summary of Main Issues

1. Background

GHG emissions and energy demand are high on the global environmental agenda. With the uncontrollable pace of urbanisation and the consequent rise in energy demand for private and public consumption and for economic activities, there is an urgent need for energy efficient urban planning and construction.

In 1999, construction activities contributed over 35% of total global CO_2 emissions – more than any other industrial activity. Mitigating and reducing the impacts contributed by these activities is a significant challenge for urban planners, designers, architects and the construction industry, especially in the context of population and urban growth, and the associated requirement for houses, offices, shops, factories and roads. It is therefore important to encourage environmentally sound management of urban areas through more energy and resource efficient eco-design, architecture and construction practices, taking into account sustainable development objectives.

2. Sustainable Development and Construction

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In every country, the construction industry is both a major contributor to socio-economic development and a major user of energy and natural resources; therefore its involvement is essential to achieve sustainable development in our society. For example, the construction industry is the European Union's largest industrial sector, contributing approximately 11% to GNP, with more than 25 million people directly and indirectly involved. However, buildings **account for more than 40% of total energy consumption**, and the construction sector as a whole is responsible for approximately 40% of all human-produced wastes. Hence, the provision of adequate housing and infrastructure for transport, communication, water supply and sanitation, energy supply, and commercial and industrial activities poses a major challenge.

What is Sustainable Building?

The concept of sustainability in building and construction has evolved over many years. The initial focus was on how to deal with the issue of limited resources, especially energy, and on how to reduce impacts on the natural environment. Emphasis was placed on technical issues such as materials, building components, construction technologies and energy related design concepts. More recently, an appreciation of the significance of non-technical issues has grown. It is now recognised that economic and social sustainability are important, as are the cultural heritage aspects of the built environment.

Still, sustainable construction adopts different approaches and is accorded different priorities in different countries. It is not surprising that there are widely divergent views and interpretations between countries with developed market economies and those with developing economies.

Countries with mature economies are in the position of being able to devote greater attention to creating more sustainable buildings by upgrading the existing building stock through the application of new developments or the invention and use of innovative technologies for energy and material savings, while developing countries are more likely to focus on social equality and economic sustainability.

3. Eco-Design, Urban Form and Function

Sustainable integration of buildings and infrastructure requires a major change in urban form and building design. In some new communities, elements of urban infrastructure systems are moving much closer to and even inside the buildings themselves. Increasingly, there is a blurring of the traditional boundaries that separate buildings from their civil infrastructure. In some communities, large distribution grids and remote treatment and generation facilities are giving way to a network of distributed or "on-site" infrastructure systems, with shared elements integrated into the fabric of the built environment. More diverse land use and building types can complement these on-site infrastructure systems, creating self-reliant, mixed developments of housing, commercial space and industry. In these communities, each new housing development is seen simultaneously as a centre of employment, communications and food production, as well as a facility for power generation, water treatment, stormwater management and waste management.

In existing older communities, this type of sustainable integration is more difficult. The rate of technological change needs to be matched to natural turnover rates for the building stock and infrastructure and functional integration of systems must evolve incrementally. The performance of existing systems must be carefully evaluated and forecast in order to allocate resources between maintenance, refurbishment or replacement.

Designers and engineers are faced with an increasing range of options. The life cycle impacts and energy and material flows need to be assessed for very diverse technologies, and for a greater variety of scales and locations. Decision makers need comprehensive models in order to combine the flows from different stocks (i.e., buildings, roads, pipes, wires, etc.) and allow meaningful comparisons between integrated and less integrated systems.

4. Biodiversity and the Urban Environment

The presence of nature within the built environment can take many forms, depending upon the history and geography of the site and the density of buildings or infrastructure. The existence of natural features such as rivers, geological contours and land unsuitable for building is another factor that allows nature to persist in the urban setting. In some cities, zoning regulations call for plenty of open space, which is often developed as green space. In other cities, there is an unbroken array of buildings, connecting roads and parking areas, leaving little room for nature.

There are typically two types of green space within the urban environment - natural areas and cultivated areas. Natural areas, where human intervention has been limited, are composed of a high proportion of indigenous species. Cultivated areas, deliberately created by humans to embellish the city, are composed of introduced species or horticultural plantings and usually require human intervention. There is considerable overlap between these two types of green spaces, which is important as urban areas continue to evolve in ways that integrate the natural and built environment.

This type of urban biological diversity also has an important role in sensitising humans to the importance of green spaces and natural systems that balance the "inorganic" reality of buildings and urban infrastructure. To enhance and reinforce the benefits of urban biodiversity, co-operation is needed between city managers and scientific institutions. New partnerships must be established to provide cities with the benefits of know-how and advances in the biological sciences, our understanding of natural systems, and the integration of sustainable solutions.

5. Issues and Challenges

5.1 Sustainable Building Design and Construction

Sustainable construction is a way for the building industry to move towards achieving sustainable development, taking into account environmental, socio-economic and cultural issues. Recognising this, in 1995 the Comission Internationale des Bâtiments (CIB), the leading international organisation for research collaboration in building and construction, decided to make sustainable construction the focal point of its multifaceted activities. This involved the establishment of an international agenda on sustainable construction to help guide the implementation of sustainable development principles in the construction sector. This international agenda on sustainable construction is based on Agenda 21 and provides a conceptual framework for linking the global concept of sustainable development and the construction sector with other agendas and activities that are appropriately responsive at the local level. The main issues and challenges for sustainable construction are described below.

- *Management and Design*

Management and design are key aspects of sustainable construction, not only in terms of technical matters, but also in relation to social, legal, economic and political issues. This is a complex and difficult area to address, due to the large number of stakeholders involved in the building and construction sector. Building activities range from development to deconstruction, demolition and disposal, and include the operational aspects of each component of the built environment and each phase of the construction process. Some of the requirements for progress in this area include:

- the development of new architectural, engineering and building concepts
- the development, education and training of human resources
- improvement in the environmental quality of construction,
- improvement in the energy efficiency of construction, and
- further research.

Some of the barriers include:

- the demands and expectations of building owners and clients not always taking into account energy efficient building criteria
- the lack of awareness and knowledge of planners, designers and engineers regarding energy and resource efficient building solutions
- the lack of public awareness and involvement
- the inadequacy of standards, regulations and decision making processes, and
- limitations within the design process itself.

- *Product and Building Performance*

Optimising the performance characteristics of buildings and products is a fundamental requirement for improving sustainability. With respect to product manufacture, it is important to reduce the embodied amount of material and energy of the products, to lower emissions from the use of products, to improve their energy efficiency while in use, and to improve the potential for recycling and reuse. With respect to the buildings themselves, environmental objectives are more likely to be met by applying suitable indicators of building performance. In doing this, it is essential to take into account factors such as climate, culture, building traditions, and stage of industrial capacity. Indoor environmental quality is another important consideration to ensure healthy, productive living conditions inside buildings.

- *Energy and Resource Consumption*

Efforts to conserve ecosystems and to reduce resource consumption require the use of renewable or recycled materials and the selection of materials taking into account life cycle "cradle to grave" costs. Energy saving measures, retrofit programs and transportation issues constitute major challenges for the construction sector. Alternative energy solutions such as district heating systems can lead to significant energy and resource savings. Water efficiency and demand management are also required. Other important considerations are the choice of site, the designation of land use, the longevity of buildings, and the use of land for production of building materials.

5.2 Urban Development and Eco-Efficiency

Continuing urbanisation reinforces the importance of creating a built environment that contributes to economic development and social wellbeing and is sustainable for future generations. Hence, the provision of adequate infrastructure, buildings and utilities, taking into account quality of life, urban governance, environmental quality and sustainability is essential. Sustainable approaches to urban development can help build healthy and safe communities and alleviate poverty while facilitating employment creation, human resources development and the realisation of financial benefits for the community. Successful strategies for promoting sustainable urban development must take into account socio-economic and cultural factors, building traditions, and environmental issues. Regulations, energy pricing, market demand and enabling approaches such as incentives and demonstration projects are some of the measures that need to be considered. This requires longer term perspective involving a number of challenges, as highlighted below.

- *Urban Eco-Efficiency*

The term "eco-efficiency" refers to the efficiency with which society uses environmental, natural and other resources to generate quality of life. Improving eco-efficiency is an important strategy for sustainable development and the provision of services within cities and communities. Important elements of an urban eco-efficiency strategy include:

- integrating building and infrastructure design in harmony with the characteristics and constraints of local ecosystems
- following best environmental practices in materials selection, recycling and reuse, and technology, taking into account life cycle environmental implications
- designing water flows to conserve resources, optimise efficiency and reduce pollution
- reducing pollution through prevention and source reduction practices, and ensuring maximum reuse and recycling of materials through integrated on-site waste treatment

- encouraging improvements in environmental performance for individual communities, companies and facilities throughout the city by operating a city-wide information system that informs citizens of local environmental conditions and provides feedback on environmental performance.

- *Urban Energy Efficiency*

Given the magnitude of GHG emissions from cities, urban energy efficiency is a significant challenge that requires special consideration. Energy issues range from transportation to building planning and refurbishing, and from industrial production to household practices. The role of city planners and the construction industry is essential as they create the necessary pre-conditions for energy savings opportunities to be realised. Some important aspects of energy efficient urban infrastructure include:

- maximising the energy efficiency of building and infrastructure operations through the use of renewable resources, decentralised co-generation and energy cascading techniques in a manner which optimises integrated energy flows and minimises potential global environmental impacts such as GHG emissions
- linking producers and consumers of energy and materials throughout the community, city and surrounding regions to facilitate resource exchanges and recycling networks.

- *Planning and Decision Making Processes*

Building owners, developers and agencies are faced with the need to make decisions in the short term with the possibility of huge consequences, yet they lack a sound basis for making these decisions. Similarly, the design and engineering community lacks the basic principles and rules to help guide the selection of integrated, sustainable solutions. They need practical tools, techniques and training to promote awareness and to encourage sustainable urban planning and development.

To better equip decision makers to assess the environmental impacts of their technology choices, new integrative approaches to urban planning and development need to be evaluated using comprehensive models that can estimate mass and energy flows and their effects, as well as life cycle costs. While researchers may understand these concepts, they are not yet well accepted by planners, system designers and decision makers. Furthermore, despite recent progress in modelling, we are still a long way from understanding the complex interrelationships between the various elements and flows that exist within the urban environment.

Attachment 1: Current DTIE Priorities with respect to Urban Environmental Management

Cities are pollution sources and sinks, and people living in them utilise resources and generate waste. Cities also import resources and export pollutants, although these activities have limits and the cities themselves have limited carrying capacities. Sustainable cities should not use resources faster than they can be replenished or substituted for, nor generate pollution faster than it can be assimilated. Rather than devouring water, food, energy, and processed goods, and discharging the remains as pollutants, cities should align their consumption with realistic needs, produce more of their own food and energy, and put much more of their waste to use.

Ideally, a sustainable city must have adequate infrastructure and flexibility to support the needs of its population, particularly its poorest citizens, as well as those of the ecosystem as a whole. If the infrastructure of a city is eroded, it becomes increasingly difficult, if not impossible, to achieve sustainable environmental objectives.

Without new urban environmental management methods and approaches, there is a danger that past problems of environmental degradation and ecological impoverishment will continue. Given that these environmental problems have arisen primarily because of inappropriate management and a lack of understanding of the impact of management practices upon the environment, it is essential for new management methods to be researched, developed and implemented. Unless cities change their management practices, the resources they expend on protecting the environment will be wasted.

To address these issues, DTIE is working in the following areas:

- **Environmentally sustainable buildings and infrastructure –** Buildings, infrastructure and the environment are inextricably linked. Energy, materials, water and land are all consumed in the construction and operation of buildings and infrastructure. These built structures are also part of our living environment, affecting our living conditions, social well-being and health. It is therefore important to explore environmentally and economically sound design and development techniques to ensure that buildings and infrastructure are sustainable, healthy and "affordable". DTIE's involvement in this area is focused on improving and strengthening the capacity of administrators and decision makers in local authorities, institutions, NGOs and communities in the identification, assessment, evaluation and selection of appropriate building technologies and infrastructure. This involves working in partnership with other organisations to develop and implement programs and activities at the municipal and local level for the adoption and use of environmentally sustainable, healthy building and infrastructure technologies, practices and systems.

- **Energy management –** As climate change has become the world's most pressing environmental challenge, energy management has become a priority issue for city managers. DTIE focuses on two particular aspects of energy management in cities: energy efficiency in city operations, including lighting, public services, and public buildings; and energy demand management, which includes raising public awareness about ways and means to save energy.

- **Transportation –** Transportation is one of the main sources of carbon dioxide emissions. As more people migrate to cities, particularly in developing countries, the design of transportation and communications systems to mitigate GHG emissions is crucial. DTIE is a key partner in the mobility forum that UNEP is establishing with the automotive industry. An important focus in this area relates to traffic management and transportation planning.

- **Urban water –** The conventional approach to water supply management tends to define water usage as a requirement that must be met, and not as a set of demands that are variable and changeable. This can and often does lead to overuse of water resources, over-capitalisation of infrastructure, waste and other problems. Governments are now beginning to understand that solving these types of problems requires fundamental change. Increasingly, the water demands themselves, not structural supply solutions, are becoming the focus of policy and decision-making. This alternative policy approach focuses on water demand management and relies on proven, cost effective approaches for modifying water demand patterns and lowering these demands substantially. It also involves innovative strategies for augmenting water supply through techniques such as rainwater harvesting and wastewater reclamation and reuse, as well as through a mix of incentive structures, public education and regulations. Freshwater is a central element of UNEP's mandate and DTIE is working closely with other organisations to promote sustainable management of freshwater in developing countries.

- **Waste collection and treatment –** Providing adequate services for domestic and commercial waste is an ongoing challenge for city managers. In many countries, dumpsites represent an environmental and health threat. There is an increasing requirement for support and training related to waste collection systems and various waste treatment alternatives, including incineration, biological treatment, sanitary landfills, recycling and materials recovery.

- **Environmental management systems for cities and local authorities –** For cities and local authorities, an Environmental Management System (EMS) provides a systematic way to ensure environmental issues are managed consistently and systematically. Effectively applied, an EMS can help integrate environmental considerations with overall operations and set out environmental policies, objectives and targets with pre-determined indicators that provide measurable performance goals. An EMS focuses attention upon a number of critical organisational factors, including productive processes and technologies, management styles and systems, worker education and participation, internal communications, and relations with regulatory agencies, other governments, and neighbouring communities. The successful implementation of an EMS can create positive change, environmental awareness and continuous improvement within a city.

Attachment 2: Checklist for Environmentally Responsible Building Design and Construction (Adapted from "Environmental Building News")

Design

- Smaller is better: Optimise use of interior space through careful design so that the overall building size and resources used in constructing and operating it, are kept to a minimum.
- Design an energy efficient building: Use high levels of insulation, high performance windows, and tight construction. In southern climates, choose glazing with low solar heat gain.
- Design buildings to use renewable energy: Passive solar heating, day-lighting and natural cooling can be incorporated cost-effectively into most buildings. Also consider solar water heating and photovoltaics, or design buildings for future solar installations.
- Optimise material use: Minimise waste by designing for standard ceiling heights and building dimensions. Avoid waste from over-design by optimising engineering and simplifying building geometry.
- Design water efficient, low maintenance landscaping: Conventional lawns have a high impact because of water use, pesticide use and pollution generated from mowing. Landscape with drought resistant native plants and perennial groundcovers.
- Make it easy for occupants to recycle waste: Make provision for storage and processing of recyclables (i.e., recycling bins near food processing areas, under-sink compost receptacles, etc.).
- Examine the feasibility of graywater reuse: Water from sinks, showers or clothes washers (graywater) can be recycled for irrigation in some areas. If current codes prevent graywater recycling, design plumbing systems for easy future adaptation.
- Design for durability: To spread the environmental impacts of building over as long a period as possible, the structure must be durable. A building with a durable design and "timeless architecture" is more likely to realise a longer life.
- Design for future reuse and adaptability: Make the structure adaptable to other uses, and choose materials and components that can be reused or recycled.
- Avoid potential health hazards (i.e., radon, mold, pesticides): Follow recommended practices to minimise radon entry into the building and provide for future mitigation if necessary. Provide detailing to avoid moisture problems that could cause mold and mildew growth. Design and incorporate insect resistant detailing to minimise pesticide use.

Land Use and Site Issues

- Renovate older buildings: Conscientiously renovating existing buildings is the most sustainable construction.
- Create communities: Development patterns can either inhibit or contribute to the establishment of string communities and neighbourhoods. Creation of cohesive, integrated communities should be a high priority.
- Encourage in-fill and mixed use development: In-fill development that increases density is inherently better than building on undeveloped sites. Mixed use development, in which residential and commercial uses are intermingled, can reduce automobile use and help to create more healthy communities.
- Minimise automobile dependence: Locate buildings to provide access to public transportation, bicycle paths, and walking access to basic services. Commuting can also be

reduced by working from home, therefore, home office needs and wiring should be considered.

- Value site resources: Early in the siting process, carry out a careful site evaluation (i.e., solar access, soils, vegetation, water resources, important natural areas, etc.) and use this information to guide the design.
- Locate buildings to minimise impact: Cluster buildings to preserve open space and wildlife corridors. Avoid especially sensitive areas including wetlands, and keep roads and service lines short. Leave the most pristine areas untouched, build on areas that have been previously degraded, and restore damaged ecosystems.
- Provide responsible on-site water management: Design landscapes to absorb stormwater instead of putting in storm sewers to carry it off-site. Consider roof-top water catchment systems so that rainwater can be used.
- Situate buildings to benefit from existing vegetation: Trees on the east and west sides of a building can dramatically reduce cooling loads. Hedge-rows and shrubbery can block cold winter winds or help channel cool summer breezes into buildings.
- Protect trees and topsoil during site work: Protect trees from construction damage by fencing off the "drip line" around them and avoiding major changes to surface grade.
- Avoid use of pesticides and other chemicals that may leach into the groundwater: Look into less toxic termite treatments, and keep exposed frost walls free from obstructions to discourage insects. When backfilling a foundation or grading around a house, do not bury any construction debris.

Materials

- Use durable products and materials: Because manufacturing is very energy-intensive, a product that lasts longer or requires less maintenance usually saves energy and reduces waste.
- Choose low maintenance building materials: Where possible, select building materials that require little maintenance (i.e., painting, retreatment, waterproofing, etc.) or whose maintenance will have little environmental impact.
- Choose building materials with low embodied energy: Heavily processed or manufactured products and materials are usually more energy intensive. As long as durability and performance will not be sacrificed, choose low embodied-energy materials.
- Buy locally produced building materials: Transportation is costly in both energy use and pollution generation. Look for locally produced materials.
- Use building products made from recycled materials: Building products made from recycled products reduce solid waste problems, cut energy consumption in manufacturing, and save on natural resource use. A few examples of materials with recycled content are cellulose insulation, floor tile made from ground glass, and recycled plastic lumber.
- Use salvaged building materials where possible: Reduce land-filling and save natural resources by using salvaged materials (i.e., lumber, millwork, certain plumbing fixtures, hardware, etc.). Make certain these materials are safe (i.e., test for lead and asbestos) and do not sacrifice energy efficiency or water efficiency by reusing old windows or toilets.
- Seek responsible wood supplies: Use lumber from independently certified, well managed forests. Avoid lumber products produced from old-growth timber unless they are certified. Engineered wood can be substituted for old-growth timber.
- Avoid materials that emit pollutants: Solvent-based finishes, adhesives, carpeting, particleboard, and many other building products release formaldehyde and volatile organic compounds (VOCs) into the air. These chemicals can affect workers' and occupants' health as well as contribute to smog and ground level ozone pollution. Avoid materials that emit HCFCs, such as extruded polystyrene and certain types of foam insulation.

- Minimise use of pressure treated lumber: Use detailing that will prevent soil contact and rot. Where possible, use alternatives such as recycled plastic lumber. Take measures to protect workers when cutting and handling pressure-treated wood. Scraps should never be incinerated.
- Minimise packaging waste: Avoid excessive packaging, such as plastic-wrapped plumbing fixtures or fasteners unavailable in bulk. Tell suppliers why you are avoiding over-packaged products. Note however that some products must be carefully packaged to prevent damage and potential waste.

Equipment

- Install high efficiency heating and cooling equipment: Well-designed high efficiency furnaces, boilers, air conditioners and distribution systems not only save building occupants money, but also produce less pollution. Install equipment with minimal risk of combustion gas spillage.
- Avoid ozone-depleting chemicals in mechanical equipment and insulation: CFCs have been phased out, but their primary replacement, HCFCs, also damage the ozone layer and should be avoided where possible. Reclaim CFCs when servicing or disposing of equipment.
- Install high efficiency lights and appliances: Fluorescent lighting has improved dramatically in recent years and is now suitable for homes. High efficiency appliances offer both economic and environmental advantages over their conventional counterparts.
- Install water efficient equipment: Water conserving toilets, showerheads and faucet aerators reduce water use as well as the loading to septic systems and sewage treatment plants. Reducing hot water use also saves energy.
- Install mechanical ventilation equipment: Mechanical ventilation is usually required to ensure healthy indoor air. Heat recovery ventilators should be considered in cold climates to reduce energy requirements.