UNEP

BUILDINGS AND CLIMATE CHANGE

Status, Challenges and Opportunities

UNITED NATIONS ENVIRONMENT PROGRAMME

ASIA PRO ECO II B

EUROPEAID CO-OPERATION OFFICE

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Abbreviations

AIA . . . American Institute of Architects
ASEAN . . . Association of Southeast Asian Nations
BEMs . . . Building energy management systems
BRIC countries . . . Brazil, Russia, India and China
CDD . . . Cooling Degree Day
CDM . . . Clean Development Mechanism of the Kyoto Protocol
CER . . . Certified Emission Reduction
CHP . . . Combined Heat and Power (plant)
CIB . . . International Council for Research and Innovation in Building and Construction
CO2 . . . Carbon dioxide
Cx . . . Commissioning
DMS . . . Demand side management
DX cooling . . . Direct Expansion cooling
EC . . . European Community
ECCP . . . European Climate Change Programme
ECTP . . . European Construction Technology Platform
EE . . . Energy efficiency
EPBD . . . Energy Performance of Building Directive
EPI . . . Environmental Performance Index
EPS . . . Expanded polystyrene
EST . . . Environmentally Sound Technologies
EU . . . European Union
Eurima . . . European Insulation Manufacturers Association
FAO . . . Food and Agriculture Organization of the United Nations
FIEC . . . European Construction Industry Federation
GDP . . . Gross Domestic Product
GEF . . . Global Environment Facility
GHG . . . Greenhouse gas
GNI . . . Gross National Income
HDD . . . Heating Degree Day
HVAC . . . Heating, Ventilation and Air-Conditioning
IEA . . . International Energy Agency
iiSBE . . . International Initiative for Sustainable Built Environment
IPCC . . . Intergovernmental Panel for Climate Change
ISO . . . International Organization for Standardization
ITCs . . . Information and Communication Technologies
JI . . . Joint Implementation Mechanism of the Kyoto Protocol
LEDs . . . Light emitting diodes
LPG . . . Liquefied Petroleum Gas
MToe . . . Million Tons of Oil Equivalent
NG . . . Natural Gas
NOx . . . Nitrogen Oxides
OECD . . . Organization for Economic Co-operation and Development
PER . . . Process Energy Requirement
PPP . . . Public Private Partnership
PRESCO . . . Practical Recommendations for Sustainable Construction
R&D . . . Research and Development
RIBA . . . Royal Institute of British Architects
SME . . . Small and Medium-sized Enterprise
SUD . . . Sustainable urban development
UIA . . . International Union of Architects
UICB . . . Union Internationale des Centres du Batiment
UN . . . United Nations
UNCDR . . . United Nations Center for Regional Development
UNCHS . . . United Nations Centre for Human Settlements
UN/ECE . . . United Nations Economic Commission for Europe
UNEP . . . United Nations Environment Programme
UNFCCC . . . United Nations Framework Convention on Climate Change
UNU . . . United Nations University
XPS . . . Extruded polystyrene
WGBC . . . World Green Building Council
WWF . . . Worldwide Fund
ZEO . . . Zero-energy office

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Executive Summary

Worldwide, 30-40% of all primary energy is used in buildings. While in high- and middle-income countries this is mostly achieved with fossil fuels, biomass is still the dominant energy source in low-income regions. In different ways, both patterns of energy consumption are environmentally intensive, contributing to global warming. Without proper policy interventions and technological im-provements, these patterns are not expected to change in the near future.

On the global level, knowledge regarding the energy use of building stocks is still lagging be-hind. Generally speaking, the residential sector accounts for the major part of the energy consumed in buildings; in developing countries the share can be over 90%. Nevertheless, the energy consumption in non-residential buildings, such as offices and public buildings and hospitals, is also significant.

The pattern of energy use in buildings is strongly related to the building type and the climate zone where it is located. The level of development also has an effect. Today, most of the energy consumption occurs during the building's operational phase, for heating, cooling and lighting purposes, which urges building professionals to produce more energy-efficient buildings and renovate existing stocks according to modern sustainability criteria. The diversity of buildings, their distinct uses and extended life cycle pose a challenge for the prescription of energy conservation measures. Specific solutions are needed for each situation, such as for the construction of new buildings, for the renovation of existing ones, for small family houses and for large commercial complexes. Energy consumption can be reduced with thermal insulation, high performance windows and solar shading, air-tight structural details, ventilation and heat/cold recovery systems, supported with the integration of renewable energy production in the building. These strategies apply to buildings in both warm and cold climates. Site and energy chain planning also influence the energy efficiency of the individual building. However, technological solutions will only be helpful when building occupants are committed to using energy-efficient systems in an appropriate way. There are many factors that influence the energy consumption behavior of individuals, such as gender, age and socio-demographic conditions. Educational and awareness raising campaigns are therefore crucial in the process of ensuring the energy efficiency of buildings.

The end of the functional service life of a building may inhibit renovation projects – when the building or its parts are no longer suitable for the needs of the building user. In refurbishment proc-esses, basically the same rationale applies as in the construction of new buildings. Since the opera-tional energy is the major cause for greenhouse gas emissions in residential or commercial buildings to be renovated, this should be the first aspect to be taken into account when considering the improvement of the energy efficiency of building stocks. Moving towards the idea of life-cycle responsibility and introducing effective commissioning processes will help to ensure the efficient life-cycle performance of the building.

The high investment costs involved, the lack of information on energy-efficient solutions at all levels, as well as the (perceived or real) lack of availability of solutions to specific conditions, are considered as the major barriers to implementing energy efficiency measures in buildings. In addition, there can be a number of organizational barriers, such as different decision making levels, privatization/deregulation processes, different stakeholders deciding on the energy system and shouldering the energy bill respectively, etc.

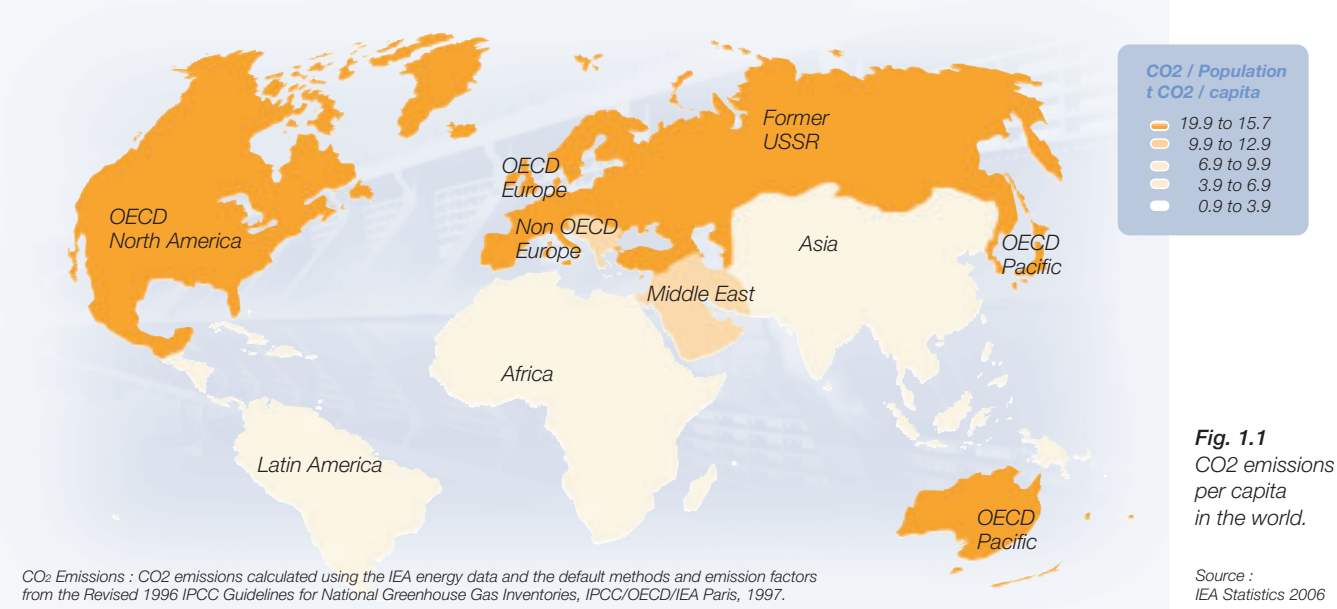
It is clear that there are no universal solutions for improving the energy efficiency of buildings. General guidelines must be adjusted to the different climate, economic and social conditions in different countries. The local availability of materials, products, services and the local level of technological development must also be taken into account.

The building sector has a considerable potential for positive change, to become more efficient in terms of resource use, less environmentally intensive and more profitable. Sustainable buildings can also be used as a mitigating opportunity for greenhouse gas emissions under the flexible mechanisms of the Kyoto Protocol and should be considered as a key issue for the post Kyoto period.

Decision makers understanding the logic behind the behavior of different actors is important for successful development and deployment of policy instruments and technological options. Provid-ing benchmarks on sustainable buildings is an essential requirement for decision makers to take the correct course of action to encourage energy efficient buildings. Solutions aiming to improve the energy efficiency of buildings and construction activities should be disseminated widely, making use of existing or new technology transfer programmes. Influencing market mechanisms and encouraging research and development projects, as well as public-private partnerships, are of paramount importance for this endeavour.

1 Introduction

THE BUILDING AND CONSTRUCTION sector is a key sector for sustainable development. The construction, use and demolition of buildings generate substantial social and economic benefits to society, but may also have serious negative impacts, in particular on the environment. Areas of key concern include energy use with associated greenhouse gas (GHG) emissions, waste generation, construction materials use and recycling, water use and discharge, and integration of buildings with other infrastructure and social systems.
The building and construction sector typically provides 5-10% of employment at national level and normally generates 5-15% of the GDP. It literally builds the foundations for sustainable development, including housing, workplace, public buildings and services, communications, energy, water and sanitary infrastructures, and provides the context for social interactions as well as economic development at the micro-level. Numerous studies have also proven the relationship between the built environment and public health.
At the same time, the building and construction sector accounts for the largest share in the use of natural resources, by land use and by materials extraction. Energy use, liquid and solid waste generation, transport of construction materials, and consumption of hazardous materials are other examples of negative environmental impacts from this sector. In OECD (Organisation for Economic Co-operation and Development) countries, buildings are responsible for 25-40% of total energy use. In Europe, buildings account for 40-45% of energy consumption in society, contributing to significant amounts of carbon dioxide (CO2) emissions. The building sector thus offers the largest single potential for energy efficiency in Europe: more than one-fifth of the present energy consumption and up to 45 million tonnes of CO2 per year could be saved by 2010 by applying more ambitious standards to new and existing buildings. This would represent a considerable contribution to meeting the Kyoto targets and is also an important contribution towards securing the energy supply of the European Union (Maldonado 2005).
A number of national and international initiatives and efforts have been developed by the building and construction sector itself to promote more sustainable buildings. Nevertheless there is still a clear lack of initiatives aiming at addressing global issues from a life-cycle perspective of the built environment. A prime example of the kind of issues that have fallen behind is the integration of the built environment as an active sector under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. While the built environment contributes with 30-40% of energy use and associated greenhouse gas emissions, there are but few activities in this sector benefiting from incentives provided under the Kyoto Protocol.
CO2 emissions are currently greatest in industrialized countries, although estimates suggest that developing countries will increasingly contribute to global warming in the coming decades (Figures 1.1 and 1.2). In the United States, CO2emissions per capita equal 20.1 tonnes, almost twice those of countries such as China and Brazil, 16 times higher than India and 50 times higher than Nigeria and Sudan. If highly-populated developing countries follow the same unsustainable production and consumption path as developed countries, the consequences will be significant. The challenge is to determine how industrialized countries can manage their environmental impacts, while developing countries can achieve economic growth in a sustainable way (Figures 1.3 and 1.4).



CO_2 Emissions : CO2 emissions calculated using the IEA energy data and the default methods and emission factors from the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC/OECD/IEA Paris, 1997.

Fig. 1.1
CO2 emissions per capita in the world.

Source : IEA Statistics 2006

More than half of the world's population lives in urban areas, and over 80% of the population lives in developing countries (UN 2004, see also Annex 1). Due to population growth and economic development, construction activities are now more intense than ever. Total consumption growth increased by 4.6% from 2003 to 2004 and is expected to exceed 5% annually over the next four years, with China and India growing fastest (Davis Langdon, UNEP 2006). Construction output is estimated to vary between 3,000 billion and 4,200 billion dollars per year (Figure 1.5). The aim of this report is to assess how energy use in buildings can become more sustainable, and how related greenhouse gas emissions can be minimized. For this purpose, factors affecting the ability and willingness of building and construction sector stakeholders to adopt energy efficiency are analyzed, as are measures to reduce the stakeholders' share of greenhouse gas emissions.

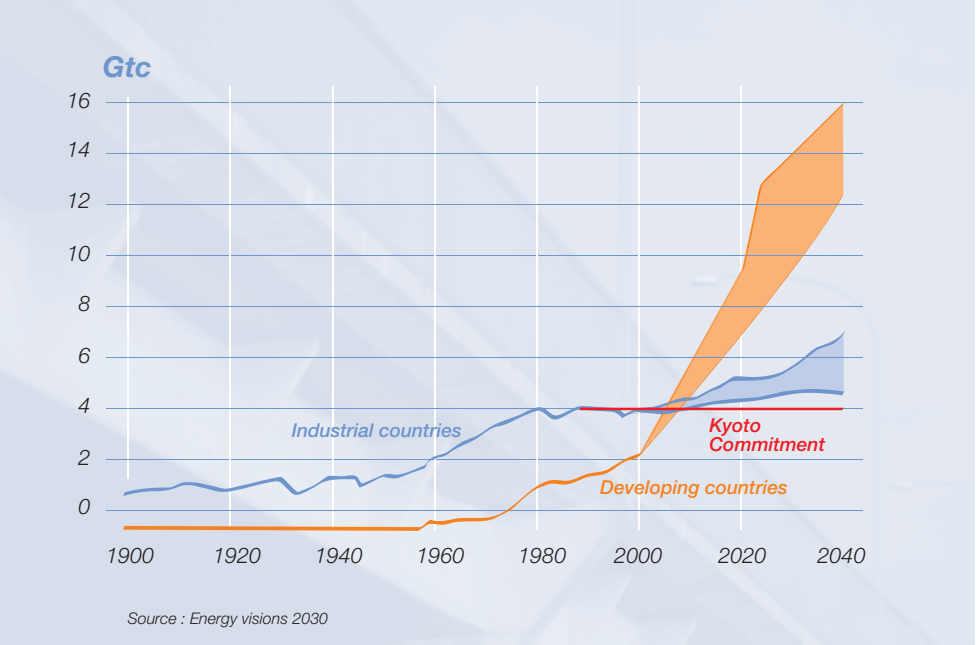


Fig. 1.2
After 2020 major parts of CO2 emissions will come from developing countries.

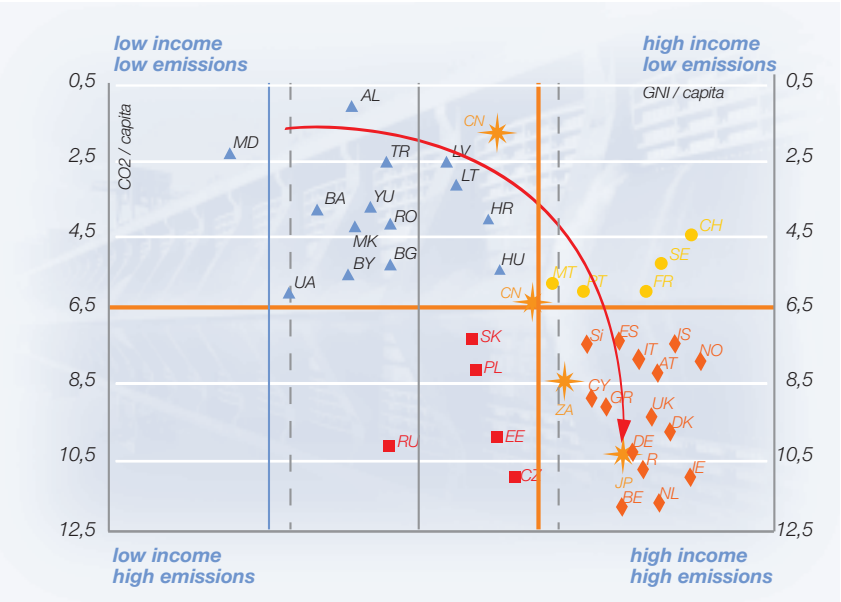


Fig. 1.3
The correlation between GNI/capita and CO2 emissions per capita in different countries.

Source : Asia Pro Eco 2005

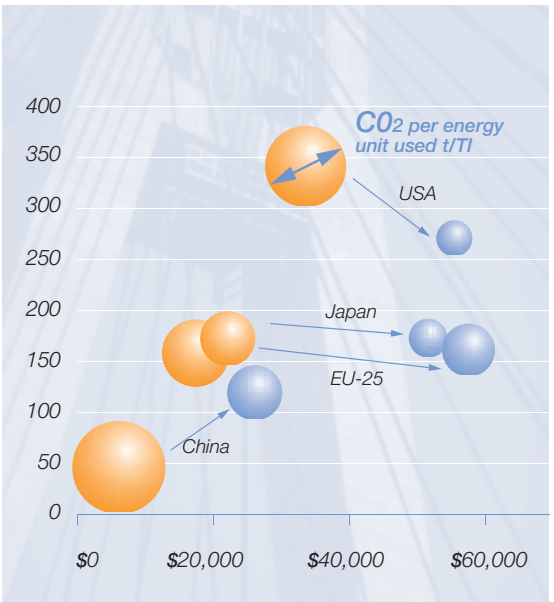


Fig. 1.4
The extent of change needed in energy efficiency (represented by the position on the graph) and carbon intensity (represented by the size of circles).

Source : WGBC 2005

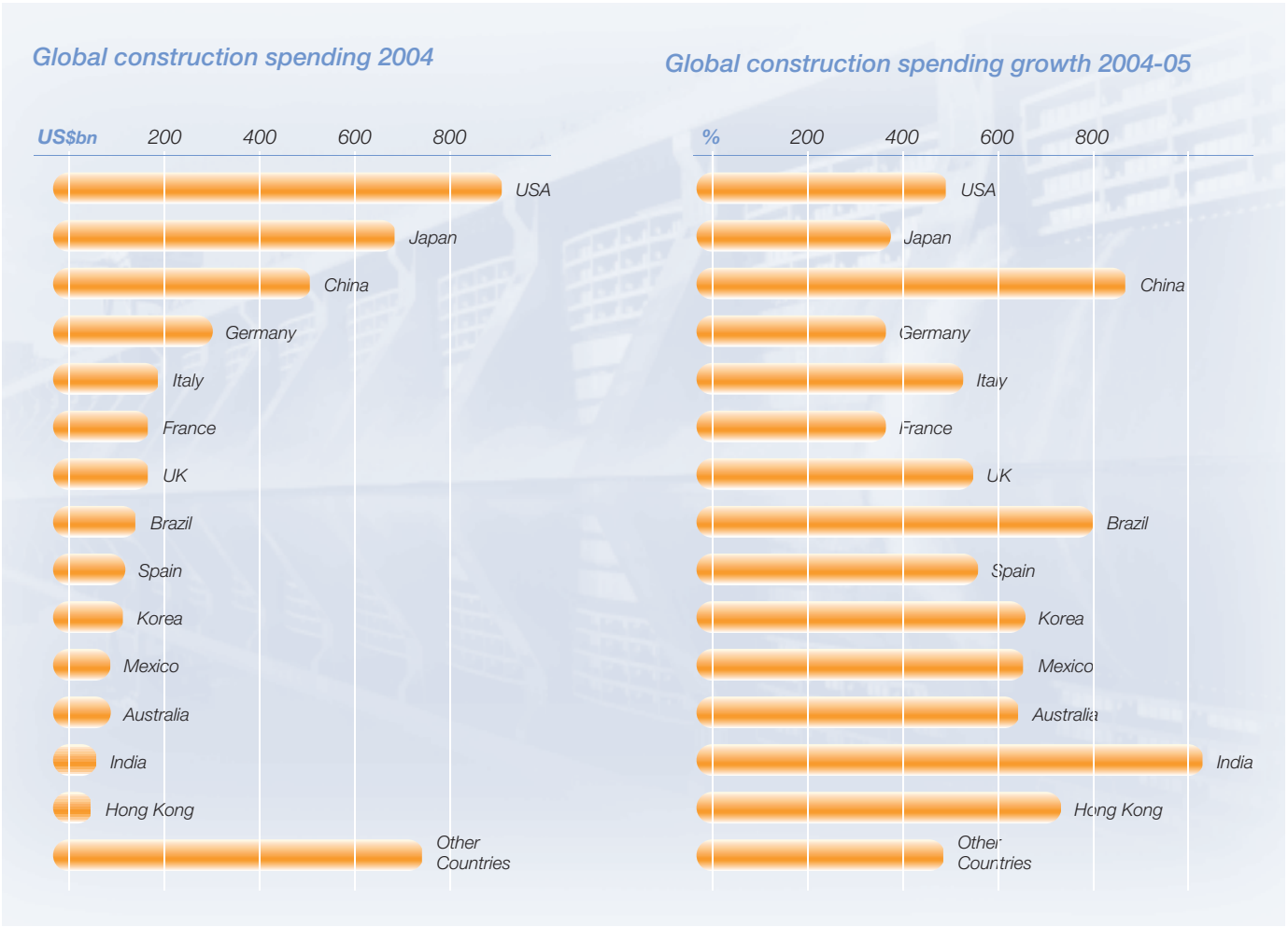


Fig. 1.5
Global construction spending and growth 2004-2005.

Source: Davis Langdon 2005.

This report consists of seven chapters. Chapter 1 is this introduction. Chapter 2 “Baselines” aims to provide an overview of how energy is used in buildings, discussing the distribution of the energy used over the building’s life cycle, the shares of different energy end-use purposes and the distribution of energy consumption among different building sectors and types. Chapter 3 “Opportunities for Energy Efficiency in Buildings” explores how energy efficiency in buildings can be boosted by improving different components of the buildings. Components such as building materials, envelope, energy systems, human behavior are described, as are site planning and energy chain planning. Chapter 4 “Energy Efficiency Models” introduces a number of energy efficient solutions, such as passive and low- and zero-energy buildings. Chapter 5 “Encouraging Energy Efficiency” explores policy aspects of sustainable and energy-efficient buildings. Analyses of possible ways in which energy efficiency of buildings can be integrated under the instruments of the Kyoto Protocol are presented in chapter 6 “Buildings and the Kyoto Protocol”. This chapter is followed by a set of recommendations in chapter 7, references and annexes. Throughout the report, empirical case studies and country-specific examples have been included in boxes to better illustrate the dynamics in place.

As will be explained in later chapters, this report considers the use of energy in five phases of the building’s life cycle: (i) the manufacturing of building products and components; (ii) the transportation of building products and components to the construction site; (iii) the construction itself; (iv) the operational phase; and (v) the final demotion and recycling. Although energy consumption is significant in all these phases, in this report emphasis is given to the operational phase of the building, the most energy-intensive phase.