



UNEP SBCI
Sustainable Buildings
& Climate Initiative

BUILDINGS AND CLIMATE CHANGE

Summary for Decision Makers

UNITED NATIONS ENVIRONMENT PROGRAMME



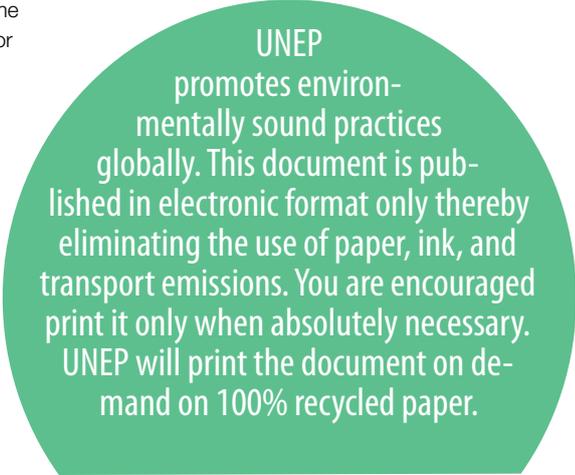
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BUILDINGS AND CLIMATE CHANGE

Summary for Decision Makers



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This report was commissioned by the United Nations Environment Programme – Sustainable Buildings & Climate Initiative.

Preface

Today, it is widely accepted that human activities are contributing to climate change. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) estimated that between 1970 and 2004, global greenhouse gas emissions due to human activities rose by 70 percent (IPCC, 2007). While the full implications of climate change are not fully understood, scientific evidence suggests that it is a causal factor in rising sea levels, increased occurrence of severe weather events, food shortages, changing patterns of disease, severe water shortages and the loss of tropical forests. Most experts agree that over the next few decades, the world will undergo potentially dangerous changes in climate, which will have a significant impact on almost every aspect of our environment, economies and societies.

It is estimated that at present, buildings contribute as much as one third of total global greenhouse gas emissions, primarily through the use of fossil fuels during their operational phase. Past efforts to address these emissions have had a mixed record of success, although there are many examples which show that carefully considered and properly funded policies can achieve significant reductions. The new international agreement which will be negotiated at Copenhagen in December 2009 provides decision makers with an unprecedented opportunity to incorporate emissions from buildings into a global strategy on climate change. However, if the desired targets for greenhouse gas emissions reduction are to be met, Decision-Makers have to tackle emissions from the Building Sector with much greater seriousness and vigor than they have to date. They need to make the mitigation of greenhouse gas emissions from buildings the cornerstone of every national climate change strategy.

This Summary for Decision-Makers presents the current state of thinking on how the potential for greenhouse gas emission reductions in buildings can be realized. It has been compiled by the Sustainable Building and Climate Initiative (SBCI), a UNEP-hosted partnership between the UN and public and private stakeholders in the Building Sector, which promotes sustainable building practices globally. One of UNEP-SBCI's key objectives is to ensure that Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have the information needed to support the mitigation of building-related greenhouse gas emissions. This report is based on research conducted by the UNEP-SBCI under the guidance of its Climate Change Think Tank and in cooperation with the Finnish research institute VTT, the Central European University in Hungary, the Marrakech Task Force of Sustainable Buildings and Construction, and the UNEP Risø Centre on Energy, Climate and Sustainable Development. The results of this research have been published in three reports: *Buildings and Climate Change – Status, Challenges and Opportunities* (UNEP, 2007), *Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings* (UNEP-SBCI, 2007), and *The Kyoto Protocol, the Clean Development Mechanism and the Building Sector* (UNEP, 2008). UNEP-SBCI will continue to facilitate and support the implementation of these recommendations, and welcomes other stakeholders and interested partners to join it in this endeavor.

6 KEY MESSAGES FOR COP 15

1

The building sector has the most potential for delivering significant and cost-effective GHG emission reductions.

2

Countries will not meet emission reduction targets without supporting energy efficiency gains in the building sector.

3

Proven policies, technologies and knowledge already exist to deliver deep cuts in building related GHG emissions.

4

The building industry is committed to action and in many countries is already playing a leading role.

5

Significant co-benefits including employment will be created by policies that encourage energy efficient and low-emission building activity.

6

Failure to encourage energy-efficiency and low-carbon when building new or retrofitting will lock countries into the disadvantages of poor performing buildings for decades.

4 PRIORITIES TO BE ADDRESSED

1

Prioritise the building sector as key to meeting national GHG emission reduction targets.

2

Supporting energy efficiency and GHG emission reduction programmes in the building sector must be recognised as a NAMA.

3

CDM must be reformed to support investment in energy efficient building programmes in developing countries.

4

Develop baselines for building-related GHG emissions using a consistent international approach to performance monitoring and reporting.

Table of Contents

Eight Key Messages for Decision Makers	6
1 The Contribution of Buildings to Climate Change	8
2 “Building Blocks” for Developing Greenhouse Gas Mitigation Strategies for the Building Sector	16
3 Policy Options for Reducing Emissions from Buildings	22
Target 1: Improve the Energy Efficiency of Buildings	23
Target 2: Improve the Energy Efficiency of Household and Business Appliances	27
Target 3: Encourage Energy Generation and Distribution Companies to Support Emission Reductions in the Building Sector	29
Target 4: Changes in Attitudes and Behavior	32
Target 5: Substituting Fossil Fuels with Renewable Energies in Buildings	34
4 International Cooperation for Emission Reductions from Buildings	38
Six Actions to Urgently Consider for the Post-Kyoto Agreement	42
5 Conclusions and Priority Actions for Creating a Carbon Neutral Buildings Sector	44
National and International Policy Makers	46
Municipalities	47
NGOs and Civil Society	47
Private Sector	48
Research and Education Institutions	48
A Final Word	49
6 Bibliography	50

List of Tables

Table 1. Major Barriers to Energy Efficiency in the Building Sector.	12
Table 2. Summary Table of Policies to Reduce Greenhouse Gas Emissions in the Building Sector	24
Table 3. Selected measures eligible for savings under the Energy Efficiency Obligations Schemes in Four Countries	30
Table 4. Countries/States/Provinces Enacting Feed-in Policies	35

List of Figures

Figure 1. CO ₂ Emissions from buildings - IPCC High Growth Scenario	9
Figure 2. Estimated Economic Mitigation Potential by Sector and Region Using Technologies and Practices Expected to be Available In 2030	10
Figure 3. Life Cycle Phases of Buildings	11
Figure 4. Small Savings from Large Numbers of End-Use Units Constitute the Long-Tail Distribution of Building Sector Projects	14
Figure 5. Different Types of Residential Housing in South Africa	18
Figure 6. Outcome of the French Grenelle de l’Environnement	20
Figure 7. Energy Certification of New/existing Buildings	25
Figure 8. A Passive Apartment Building in Finland	36
Figure 9. Commonly Identified Energy Efficiency Technology Needs in the Building and Residential Subsectors	39

List of Boxes

Box 1. Tax Incentives under the U.S. Energy Policy Act of 2005	26
Box 2. Leading by Example: Government Initiatives to Promote Energy Efficiency in Public Buildings	28
Box 3. Cap-and-Trade Scheme for Non-residential Buildings	31

8 KEY MESSAGES FOR DECISION MAKERS

1 Buildings are responsible for more than 40 percent of global energy use and one third of global greenhouse gas emissions, both in developed and developing countries.

The main source of greenhouse gas emissions from buildings is energy consumption, but buildings are also major emitters of other non-CO₂ greenhouse emissions such as halocarbons. While historically the majority of emissions emanated from developed countries, it is expected that in the near future the level of emissions from buildings in rapidly industrializing countries will surpass emission levels from buildings in developed countries.

2 The Building Sector has the largest potential for delivering long-term, significant and cost-effective greenhouse gas emissions.

Furthermore, this potential is relatively independent of the cost per ton of CO₂ eqv. achieved. With proven and commercially available technologies, the energy consumption in both new and existing buildings can be cut by an estimated 30 to 80 percent with potential net profit during the building life-span. This potential for greenhouse gas emission reductions from buildings is common to developed and developing countries, as well as countries with economies in transition.

3 Buildings have a relatively long lifespan, and therefore actions taken now will continue to affect their greenhouse gas emissions over the medium-term.

The full extent of the life-time emissions of a building can best be understood by using the life-cycle (LCA) approach. The LCA approach reveals that over 80 percent of greenhouse gas emissions take place during the operational phase of buildings, when energy is used for heating, cooling, ventilation, lighting, appliances, and other applications. A smaller percentage, normally 10 to 20 percent, of the energy consumed is for materials manufacturing and transportation, construction, maintenance renovation and demolition. In developed countries,

the majority of buildings which will be standing in 2050 have already been built, so policies should encourage building owners to retrofit their buildings in such a way as to optimize emission reductions. In developing countries, particularly those undergoing rapid urbanization, policies should encourage property developers and construction companies to incorporate energy and greenhouse gas emission considerations into the feasibility and design stages of buildings.

4 Most developed countries and many developing countries have already taken steps towards reducing greenhouse gas emissions from the Building Sector, but these steps have had a limited impact on actual emission levels.

This is due to a number of barriers which reflect the nature of the sector, such as the fact that there are many small reduction opportunities spread across millions of buildings; different stakeholders are involved at the various stages in a building's life; these stakeholders have different economic interests in terms of valuing investments in energy efficiency measures; energy efficiency investments are perceived to be costly and risky; and there is still a lack of practical knowledge about how to implement energy efficiency measures.

5 To overcome these barriers, governments must take the lead by prioritizing the building sector in their national climate change strategies and putting in place a number of "building blocks".

These are the essential tools for designing effective policies, and include: credible and comparable energy performance standards; accurate and comprehensive data and information about the Building Sector; the appropriate skills-base and capacity to assess energy performance and implement energy efficiency policies; and systems and frameworks for consultations with all major stakeholders. Governments must work together with the building and construction industry, NGO

and civil society organizations, research and educational institutes, and most importantly, the public, to achieve the common goal of reducing greenhouse gas emissions from buildings.

6 | With these “building blocks” in place, governments are well placed to select and design appropriate policies to reduce emissions from new and existing buildings.

There are five main policy targets: increase the energy efficiency of buildings; increase the energy efficiency of appliances which use energy; encourage energy generation and distribution companies to support emission reductions in the Building Sector; change attitudes and behaviour towards energy consumption; and promote the substitution of fossil fuels with renewable sources of energy. Governments have a variety of policy instruments, including regulatory, fiscal, economic, informational and capacity building measures, to choose from. An assessment by UNEP’s Sustainable Building and Climate Initiative found that there are many policy instruments which are not only effective in achieving emission reductions, but can also result in net savings when the energy saved is factored into the assessment.

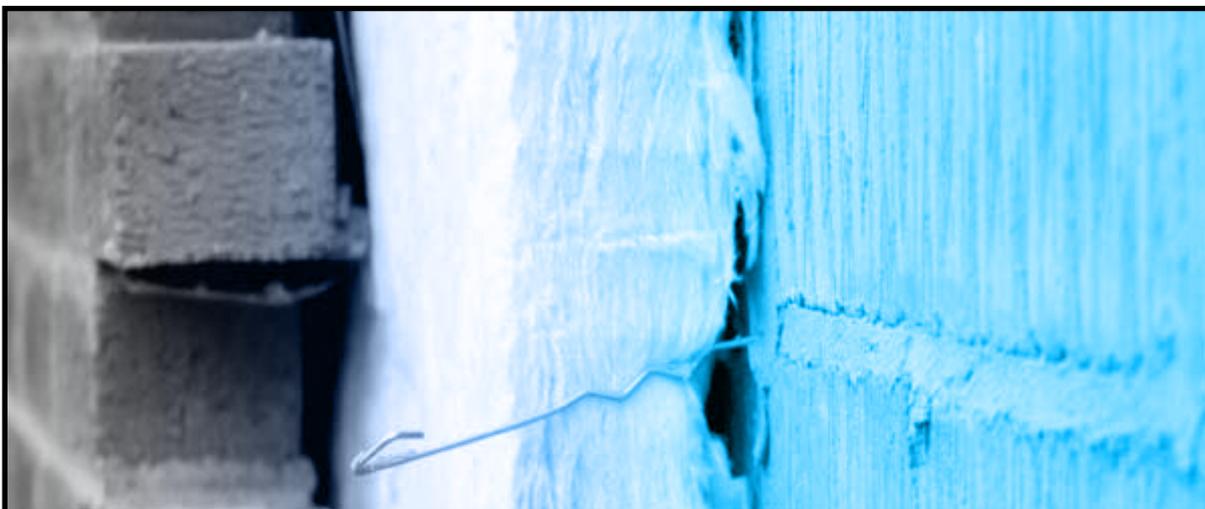
7 | At no other time has the case for international cooperation to address climate change been more pressing than now.

The United Nations Framework

Convention on Climate Change provides the best framework for facilitating this cooperation, but there is an urgent need to make the flexible financing mechanisms of the Kyoto Protocol more effective in addressing greenhouse gas emissions from the Building Sector. In this regard, the current structure of the Clean Development Mechanism (CDM) must be reformed or additional mechanisms created to support developing countries’ efforts to reduce emissions from the Building Sector. Furthermore, energy efficiency and greenhouse gas emission reduction programs in the Building Sector should be recognized as a Nationally Appropriate Mitigation Action (NAMA). At the same time, sufficient incentives to attract private sector financing must be put in place.

8 | Reducing emissions from buildings will bring multiple benefits to both the economy and to society.

The construction, renovation, and maintenance of buildings contribute 10 to 40 percent of countries’ Gross Domestic Product (GDP), and represent on a global average 10 percent of country-level employment. If carefully planned, greenhouse gas mitigation strategies for buildings can stimulate the growth of new businesses and jobs, as well as contribute to other, equally pressing, social development goals, such as better housing and access to clean energy and water. Decision makers should seize the opportunity offered by the climate change crisis to build the foundation for sustainable development today and for the future.



Chapter 1

The Contribution of
Buildings to Climate Change

The Contribution of Buildings to Climate Change

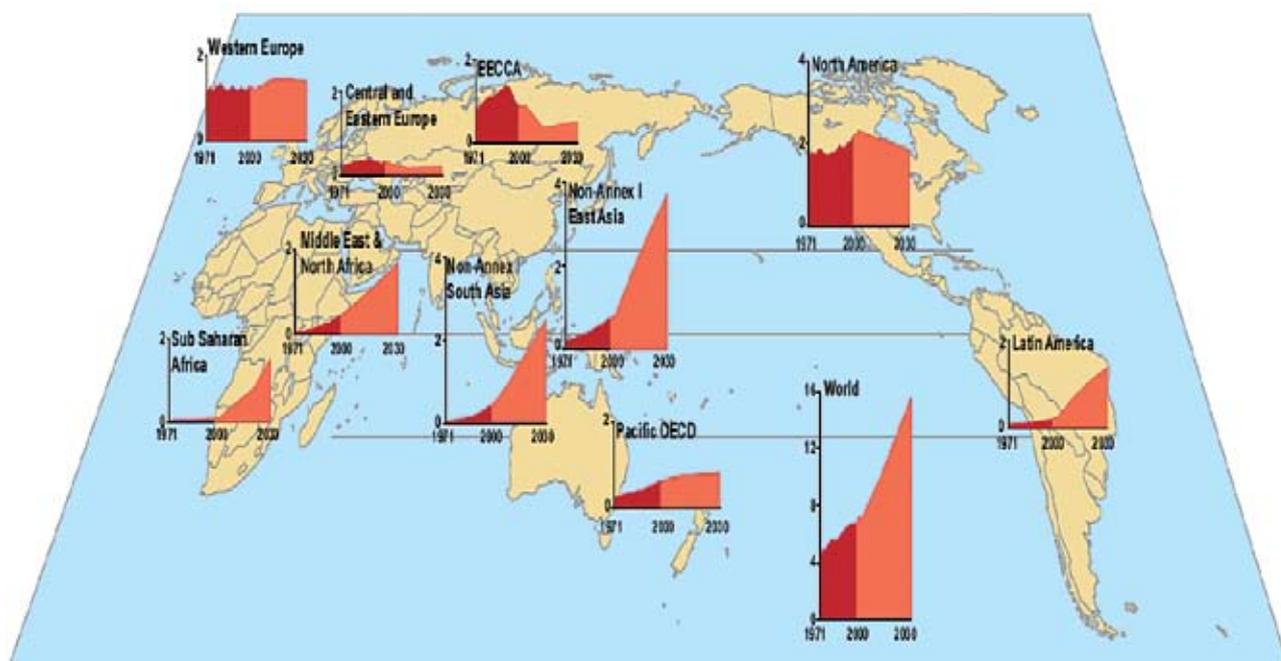
Today, buildings are responsible for more than 40 percent of global energy used, and as much as one third of global greenhouse gas emissions, both in developed and developing countries. In absolute terms, the Fourth Assessment Report of the IPCC estimated building-related GHG emissions to be around 8.6 million metric tons CO₂ eqv in 2004 (Levine et al, 2007). What is particularly worrying is the rate of growth of emissions: between 1971 and 2004, carbon dioxide emissions, including through the use of electricity in buildings, is estimated to have grown at a rate of 2.5% per year for commercial buildings and at 1.7% per year for residential buildings (Levine et al, 2007). Furthermore, the Buildings and Construction Sector is also responsible for significant non-CO₂ GHG emissions such as halocarbons, CFCs, and HCFCs (covered under the Montreal Protocol), and hydrofluorocarbons (HFCs), due to their applications for cooling, refrigeration, and in the case of halocarbons, insulation materials.

Under the IPCC's high growth scenario, this figure could almost double by 2030 to reach 15.6 billion metric tons CO₂ eqv. (Figure 1) (Levine et al, 2007). As Figure 1 shows, historically the majority of emissions were generated from North America, Western Europe, and the Eastern Europe, Caucasus and Central Asia (EECCA) regions, but based on the high growth scenario given in Figure 1, the total emissions from developing countries will surpass these regions by 2030.

The good news is that the Building Sector has the largest potential for significantly reducing greenhouse gas emissions compared to other major emitting sectors. This potential is relatively independent of the cost per ton of CO₂ eqv. achieved (IPCC, 2007). Figure 2, from the IPCC's Fourth Assessment Report, shows that the potential for greenhouse gas reductions from buildings is common to both developed and developing countries, as well as countries with economies in transition. What this means is that with proven and commercially available technologies, the energy consumption in both new and existing buildings can be cut by an estimated 30 to 80 percent with potential net profit during the building life-span.

Figure 1. CO₂ emissions from buildings (including through the use of electricity) – IPCC High Growth Scenario.

Note: Dark red: historic emissions. Light red: projections 2001 – 2030. 2000 – 2010 data adjusted to actual 2000 carbon dioxide emissions. EECCA= Countries of Eastern Europe, the Caucasus and Central Asia. Source: Levine et al, 2007.



▶ ASSESSING EMISSIONS THROUGH A LIFE CYCLE APPROACH

Greenhouse gas emissions from buildings primarily arise from their consumption of fossil-fuel based energy, both through the direct use of fossil fuels and through the use of electricity which has been generated from fossil fuels. Significant greenhouse gas emissions are also generated through construction materials, in particular insulation materials, and refrigeration and cooling systems. Broadly speaking, energy is consumed during the following activities:

- manufacturing of building materials ('embedded' or 'embodied' energy)
- transport of these materials from production plants to building sites ('grey' energy);
- construction of the building ('induced' energy);
- operation of the building ('operational' energy); and
- demolition of the building (and recycling of their parts, where this occurs).

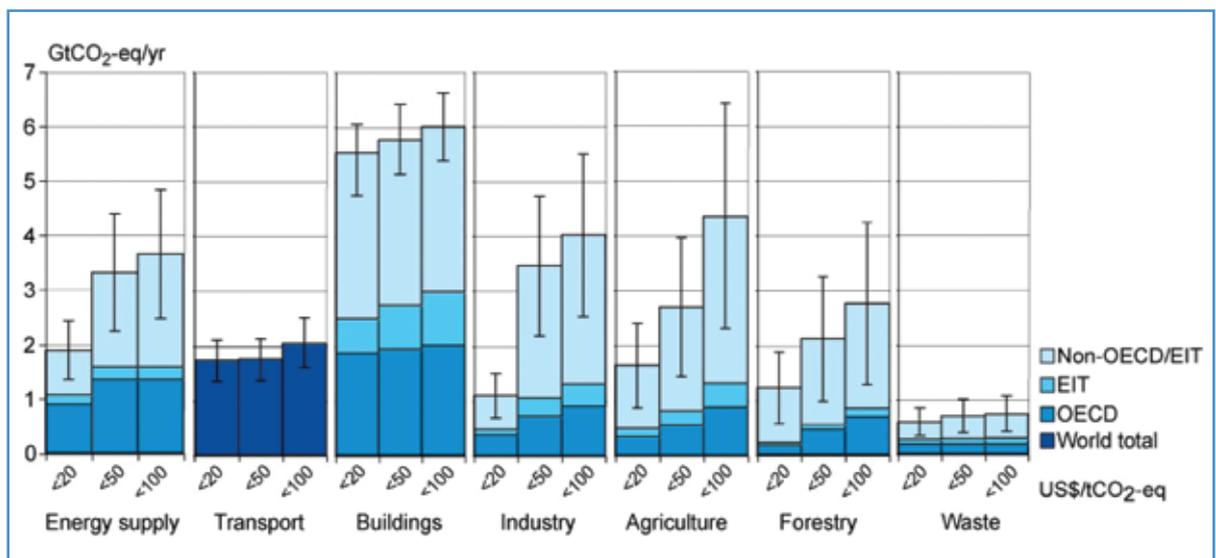
Graham (2003) uses a Life Cycle Approach to link emissions to the different stages of a building's life (Figure 3).

By far, the greatest proportion of energy is used during a building's operational phase. Though figures vary from building to building, studies suggest that over 80 percent of greenhouse gas emissions take place during this phase to meet various energy needs such as heating, ventilation, and air conditioning (HVAC), water heating, lighting, entertainment and telecommunications (Junnila, 2004; Suzuki and Oka, 1998; Adalberth et al, 2001). A smaller percentage, generally 10 to 20 percent, of energy is consumed in materials manufacturing and transport, construction, maintenance and demolition. Governments can therefore achieve the greatest reductions in greenhouse gas emissions by targeting the operational phase of buildings.

▶ ENERGY CONSUMPTION AND ECONOMIC DEVELOPMENT

The energy consumption during the operational phase of a building depends on a wide range of interrelated factors, such as climate and location; level of demand, supply, and source of energy; function and use of building; building design and construction materials; and the level of income and behavior of its occupants. Climatic conditions, and the type of environment in which a building is found,

Figure 2. Estimated economic mitigation potential by sector and region using technologies and practices expected to be available in 2030. The potentials do not include non-technical options such as lifestyle changes. Source: IPCC, 2007a.



affect every aspect of a building's energy use over its lifetime. Most countries, and even states within countries, have multiple climate zones.

More significantly, however, the level of greenhouse gas emissions from buildings is closely correlated with the level of demand, supply and source of energy. In many low-income countries, especially in rural areas, a large proportion of operational energy is derived from burning wood and other biomass, such as dung and crop residues. The IEA estimates that as many as 2.4 billion people use biomass for cooking and heating, and that this number is likely to increase in the future (IEA, 2002). In many countries, the technologies used to burn the biomass, such as cooking stoves, are often very inefficient. In China, for example, rural energy use per capita was three times greater than urban energy use due to the low efficiency of biomass combustion for cooking and space heating (Tonooka, Y. et al. 2003).

As countries develop, and traditional fuels are complemented by and replaced by electricity and gas, the potential for greenhouse gas emissions increases profoundly for two main reasons. Access to electricity can stimulate demand for electrical appliances, thereby increasing demand for energy over and beyond the level it had been before

electricity was available. More significantly, the generation of electricity itself is a major source of GHG emissions, unless it comes from renewable sources such as hydroelectric power plants and solar energy, or from nuclear energy. At the global level, it has been estimated that direct combustion of energy from fossil fuels in buildings released approximately 3 GtCO₂ in 2004, compared with 8.6 GtCO₂ per year from all energy end users (Levine et al, 2007). Similarly, the Carbon Monitoring For Action (CARMA) database of carbon emissions of more than 50,000 power plants and 4,000 power companies in every country suggests that power generation using fossil fuels accounts for 40% of all carbon emissions in the United States and about one-quarter of global emissions (CARMA web site).

In most countries the residential sector accounts for the major share of total primary energy consumption. Nevertheless, the energy consumption in non-residential buildings such as offices, public buildings and hospitals is also significant and growing. China for example is expected to add the equivalent of twice the current U.S. stock of office buildings by 2020 (LBL, 2007). In terms of international averages, most residential energy in developed countries is consumed for space heating (60%, although not as important in some developed countries with a warm climate, but in this case energy may be used for cooling

Figure 3. Life Cycle Phases of Buildings

Source: Graham, 2003.

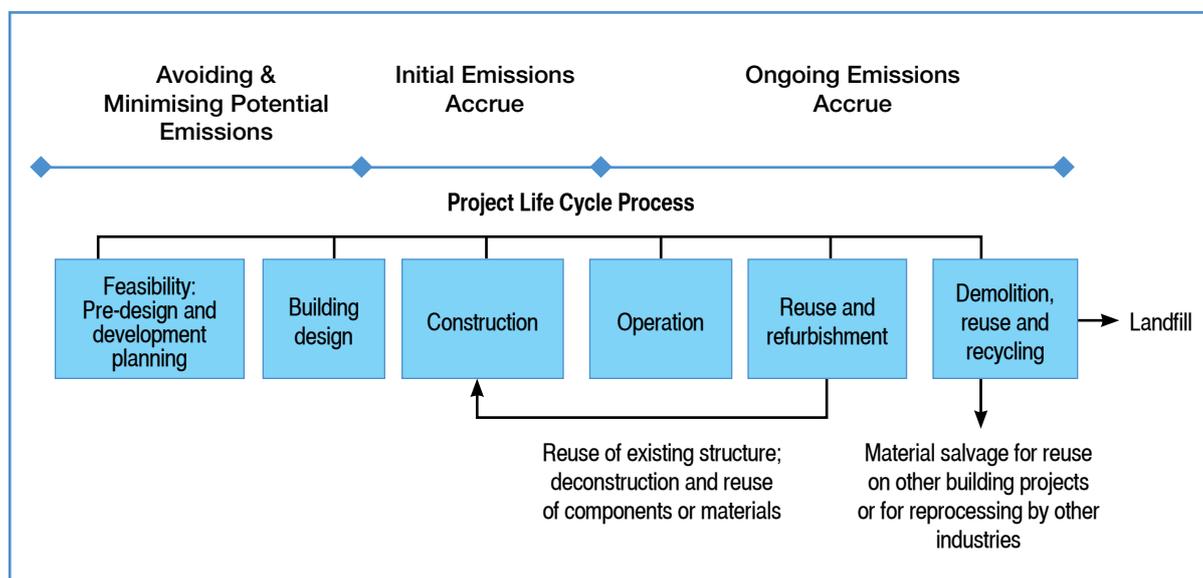


Table 1. Major Barriers to Energy Efficiency in the Building Sector.

Sources: Carbon Trust (2005) & Levine et al 2007 * New categories & columns (UNEP-SBCI, 2007).

Barrier categories	Definition	Examples	Countries*	Possible remedies*	References
Economic/financial barriers	Ratio of investment cost to value of energy savings	Higher up-front costs for more efficient equipment Lack of access to financing Energy subsidies Lack of internalization of environmental, health, and other external costs	Most countries Especially developing, but also developed countries	Fiscal and economic instruments such as tax rebates, Kyoto Flexibility Mechanisms, subsidized loans, regulatory instruments. Or increase energy price, remove energy price subsidies	Deringer et al 2004 Carbon Trust 2005, Levine et al 2007
Hidden costs/benefits	Cost or risks (real or perceived) that are not captured directly in financial flows	Costs and risks due to potential incompatibilities, performance risks, transaction costs etc. Poor power quality, particularly in some developing countries	All countries	Appliance standards, building codes (to overcome high transaction costs), EPC/ESCOs, public leadership programs	Carbon Trust 2005, Levine et al 2007
Market failures	Market structures and constraints that prevent a consistent trade-off between specific EE investment and energy saving benefits	Limitations of the typical building design process Fragmented market structure Landlord/tenant split and misplaced incentives Administrative and regulatory barriers (e.g. in the incorporation of distributed generation technologies) Imperfect information Unavailability of energy efficiency equipment locally	All countries	Fiscal instruments and incentives Product standards Regulatory-normative Regulatory-informative Economic instruments Technology transfer, mechanisms	Carbon Trust 2005, Levine et al 2007

Table 1. Continued

Barrier categories	Definition	Examples	Countries*	Possible remedies*	References
Behavioural and organizational barriers	Behavioural characteristics of individuals and companies that hinder energy efficiency technologies and practices	Tendency to ignore small energy saving opportunities Organizational failures (e.g. internal split incentives) Non-payment and electricity theft Tradition, behaviour and lifestyle, Corruption Transition in energy expertise: Loss of traditional knowledge and non-suitability of Western techniques	Developed countries Developing countries	Support, information and voluntary action: Voluntary agreements Information and training programs	Carbon Trust 2005, Deringer et al 2004, Levine et al 2007
Information barriers*	Lack of information provided on energy saving potentials	Lacking awareness of consumers, building managers, construction companies, politicians	Especially developing, but also developed countries	Awareness raising campaigns, Training of building professionals, regulatory-informative	Carbon Trust 2005, Yao et al. 2005, Evander et al. 2004
Political and structural barriers*	Structural characteristics of political, economic, energy system which make efficiency investment difficult	Process of drafting local legislation is slow Gaps between regions at different economic level Insufficient enforcement of standards Lack of detailed guidelines, tools and experts Lack of incentives for EE investments Lack of governance leadership/ interest Lack of equipment testing/certification Inadequate energy service levels	Most developing (and some developed) countries	Enhance implementation of standards Incentive policy encouraging EE building design, Enhance international cooperation and technology transfer, Public leadership programs	Yao et al. 2005 Deringer et al 2004

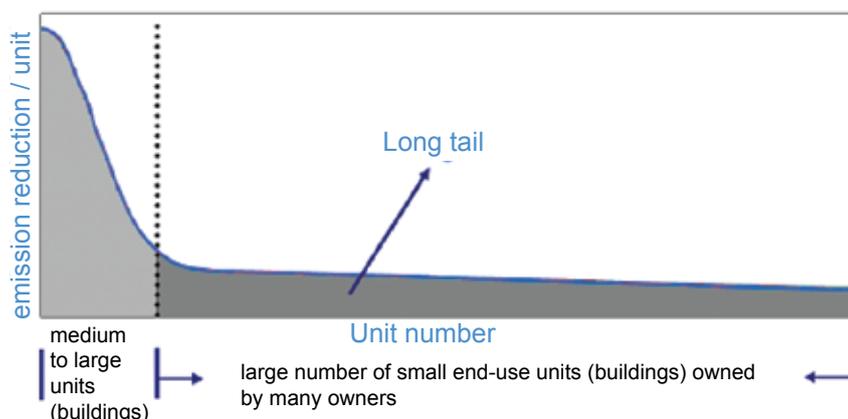


Figure 4. Small savings from large numbers of end-use units constitute the long-tail distribution of building sector projects

Source: Adapted from Hinostroza et al., 2007, in UNEP, 2008.

purposes) with this application followed in order by water heating (18%) and domestic appliances (6% for refrigeration and cooking, 3% for lighting) with other uses accounting for 13% (UNEP, 2007). In hotter climates, much less or no energy is used for space heating but a significant proportion of energy may be used for cooling purposes. However, the relative share of different energy applications varies from country to country, as well as from household to household. This is partly explained by differences in income levels and behavior of building occupants.

BARRIERS TO REALIZING EMISSION REDUCTION POTENTIALS

Most countries have introduced policies to reduce greenhouse gas emissions from buildings through measures to improve energy efficiency. However, these policies have not resulted in an actual reduction in emissions. Many studies have been conducted to try to understand why the energy savings potential in buildings is so difficult to achieve (see Table 1, p. 12-13; also UNEP-SBCI, 2007; Deringer et al, 2004; Westling et al, 2003; Vine, 2005; IPCC, 2007, WBCSD, 2007 and 2009). Some of the underlying causes for the slow uptake of energy efficiency measures in the sector are discussed below.

A large number of small reduction opportunities

There are hundreds of millions of individual buildings in the world, each one presenting multiple and

diverse energy needs. Unlike energy production and other sectors which have large emission reduction potentials at a small number of intervention points, the buildings sector has many small reduction opportunities spread across millions of buildings. For this reason, some experts have referred to energy efficiency projects in buildings as typical “long tail” projects – it is relatively easy to achieve large emission reductions per unit at the top end of the range of buildings (going from large to small), but becomes increasingly difficult as the size of the buildings gets smaller (Figure 4). Given the large number of buildings, the aggregate savings from the “long tail” are likely to exceed the savings from the top end.

Fragmentation of the building sector

Buildings have a long life cycle with many different stakeholders involved in different phases of a building’s life, such as property developers and financiers, architects, engineers, building managers, occupants and owners. The decisions taken by these various stakeholders will all have an impact on the level of emissions of the building over its lifetime, but there are very few opportunities or incentives for coordination between them. For example, as noted in Figure 4 above, decisions taken during the Feasibility Assessment and Design phases in the early stages of a building’s life will have a major impact on the level of emissions during the Operational Phase, but most feasibility assessments do not account for the life-time running costs of the building because these are not paid for by the property developer.

Perceived “first cost” barrier and split economic interests

Perhaps the largest barrier to energy efficiency improvements in buildings is the “first cost” barrier of energy efficiency measures in existing buildings due to the limited time which an occupant of a building has to recover the cost. In rented properties, many tenants are unwilling to make investments in energy saving features because they do not expect to live in or use that property long enough to recoup their investment through savings in their energy bills. In addition, energy costs are often a comparatively small part of the overall running costs of a building. The economic incentives derived from lower energy costs are therefore too weak to induce owners and tenants to invest in energy efficiency measures.

Lack of awareness about low cost energy efficiency measures

The above barrier is compounded by the perception amongst property developers and contractors that energy efficiency measures add significantly to the overall costs of a building project, in particular through costly technological solutions. There is therefore a need for awareness raising activities across the spectrum of stakeholders about low cost energy efficiency measures that have been proven to be equally, if not more, effective than the application of high cost technologies.

Lack of indicators to measure energy performance in buildings

Most building occupants have little or no information about the energy savings potentials of the buildings they live in and occupy. Furthermore, the lack of clear and verifiable indicators with which to measure and compare energy consumption makes it difficult to gauge the savings derived from energy efficiency improvements. Energy performance requirements and indicators are therefore one of the main “building blocks” for a successful greenhouse gas mitigation strategy for buildings.



THE NEED FOR A LONG-TERM PERSPECTIVE

Due to their long life cycle, it is essential that measures to reduce emissions for both new and existing buildings are designed to have the maximum impact and are costed over the expected lifetime of the buildings. For developed countries and economies in transition, most of the buildings that will be operating in 2050 have already been built, and therefore policies to reduce emissions from the Building Sector should focus on adapting and retrofitting existing buildings to the optimal energy efficiency standard. Initiatives which encourage retrofits at sub-optimal level may “lock in” much of the mitigation potential of buildings, thereby failing to achieve the maximum level of emission reductions. In order to encourage building owners to maximize the emission reduction potential from retrofits, policy tools should be designed to support multiple actions, which, taken as a whole, achieve maximum efficiency performance. The ‘zero rate eco-loan’ introduced for homes in France, for example, was designed so that it can be used in conjunction with tax credits and for a range of retrofitting activities (see Box 2, p. 28).

In developing countries, retrofitting existing buildings at the optimal level is also a priority. In this regard, there is tremendous scope for using this opportunity to update the heating and cooling technologies used in buildings, as well as implementing low cost but effective passive solutions to improve energy efficiencies such as thermal mass and sunshades. Developing countries, particularly those undergoing rapid construction growth, should set optimal energy performance standards if they are to avoid the “lock in” effect described above. It should be noted that global architectural trends, such as the use of glass envelopes in high-rise office buildings, may not be appropriate for their climatic conditions (particularly in hot climates). More research on appropriate building materials, in terms of embodied energy, durability, thermal mass, and cost, for developing countries, is required.

Chapter 2

“Building Blocks” for Developing
GHG Mitigation Strategies for
the Building Sector

“Building Blocks” for Developing GHG Mitigation Strategies for the Building Sector

The experience of countries which implemented energy efficiency measures following the two major energy crises of the 1970s show that current barriers to energy efficiency in buildings can be overcome. To do this, Decision-Makers must first have a number of essential “building blocks” in place. These include energy performance requirements and indicators; appropriate data and information about their Building Sector, the capacity to analyze this data, and the ability to coordinate and facilitate policies which address GHG emissions from buildings.

ENERGY PERFORMANCE REQUIREMENTS AND INDICATORS

Energy performance indicators measure the performance of buildings in terms of their energy use and efficiency. Energy performance requirements are set using these indicators, according to area of space covered, for example in heating space or lighting, and adjusted for building type, location, usage, and so on. While some countries have energy performance requirements, in many countries there are no agreed methodologies or indicators to compare the energy efficiency in buildings against. As energy performance requirements are an essential component of any GHG mitigation strategy for the Building Sector, they should be established at the national, and, where appropriate, the regional and municipal levels. Examples of how energy performance requirements are used summarized below.

Building Codes

Energy performance requirements can be used to set performance targets in building codes. Building codes have been found to be one of the most effective and cost-effective policies in reducing

greenhouse gas emissions from both existing and new buildings.

Building Commissioning

Energy performance indicators are used in the commissioning process of buildings, in other words, to assess whether a building's systems have been designed, installed and made ready to perform in accordance with the design intent and the building owner's operational needs. Because of the lack of energy performance indicators, energy management tools and procedures have not been systematically established and applied to the design and commissioning of buildings, especially in developing countries, and knowledge and expertise remain at a low level.

Self Regulation and Fine-Tuning of Energy Use

Energy performance indicators allow building owners and building users to assess the costs and benefits of energy efficiency investments during the operational phase of the building. During this phase, continuous monitoring and periodic adjustments to design features can lead to substantial savings. For example, close monitoring of a sustainable building site in Oberline, Ohio in the USA led to controls and equipment changes that reduced initial site energy use by 37 percent (Torcellini et al., 2006). Experiences in developing countries show similar results: one study found that fine-tuning during the first year of operation reduced total energy consumption in several sustainable buildings in Kuala Lumpur, Malaysia by 20 to 30 percent (Kristensen, 2007).

National Greenhouse Gas Inventories

Energy performance indicators are critical in compiling reliable national inventories of energy consumption and greenhouse gas emission from the national building stock. Their usage can also expand the range of financing options open to countries, especially under the Clean Development Mechanism of the UNFCCC, because they can be used to compare emissions over time.

Part of the difficulty in setting energy performance requirements come from the great diversity in how buildings use energy. This is why it is important for policy makers to have as much information about the size and characteristics of the Building Sector as possible.

▶ DATA AND INFORMATION ABOUT THE SIZE AND CHARACTERISTICS OF THE BUILDING SECTOR

Most countries have fairly good data about aggregate energy production and consumption at the national level, but not many have sector-level

data on energy use and efficiency. Given the diversity in types of buildings, this is a serious challenge for many countries. In South Africa, for example, residential housing has been divided into four categories: dwelling house < 80 m² (estimated to number 3.8 million, or 30% of the residential building stock in 2006); dwelling-house => 80 m² (estimated at 3.6 million, or 29% of building stock); flats and townhouses (1.0 million or 8% of building stock), and other types, including backyard properties, informal and squatter units, and traditional/rural housing (estimated 4.1 million, or 33% of building stock) (BMI-BRSCU, StatsSA 2008, as cited in Milford, 2008) (Figure 5). Without disaggregated data, such as climate

Figure 5. Different Types of Residential Housing in South Africa

Source: BMI-BRSCU, StatsSA 2008, as cited in Milford, 2008



Dwelling units ≥ 80 m²



Townhouses



Flats



Dwelling units < 80 m²



Informal Dwelling Units



Rural / Traditional Housing

and temperature, size, age, and other characteristics such as construction materials and potential or actual use of natural ventilation, it is extremely difficult to design and implement policies for greenhouse gas emission reduction. The lack of such data has been cited as a major obstacle to estimating the greenhouse gas emission reduction potential in several studies (de Buen, 2008 for Mexico, Milford, 2008 for South Africa).

CAPACITY TO DESIGN AND IMPLEMENT ENERGY EFFICIENCY MEASURES

An important, but often overlooked, determinant of success in reducing greenhouse gases from buildings lies in the capacity of governments and other stakeholders in the Building Sector to design and implement policies effectively. Policies to address greenhouse gas emissions from buildings are usually multi-faceted and involve more than one stakeholder. Capacity-building activities must therefore involve the relevant parties to have the desired effects. Different types of skills are needed as indicated below.

Data collection, analysis and use

As noted above, energy performance indicators are a critical ingredient in a wide variety of policy measures. However, without the capacity to collect, analyse and use data pertaining to energy consumption in buildings, government officials and building professionals alike will not be able to use them. Building this capacity requires both training as well as the availability of equipment to measure energy use. The availability of better data could also facilitate the application of energy use simulation software for buildings, which are proving to be effective tools for building designers and engineers.

Enforcement of regulatory policies

Regulatory policies, such as Building Codes or Energy Efficiency Standards for appliances, will only make an impact on reducing greenhouse gas emissions if they are enforced. Enforcement

requires appropriate training and understanding of what the policies are and what steps are needed if the object which is subject to the regulation falls short of the legal standard. The lack of enforcement has been identified as a major weakness of energy efficiency policies in developing countries.

Technical knowledge and skills

In order to propagate a new technology or building technique, the building professionals involved must be able to actually apply them. In this regard, Baden et al (2006), list the following training needs for the development of personnel to certify a building's performance: qualification of raters; development of code of standards for the field and performance testing verification; definition of quality assurance requirements; and the definition of insurance requirements.

Today, many governments have dedicated agencies and staff working for the promotion of energy efficiency. According to a survey of 70 countries conducted by the World Energy Council and ADEME in 2008, about two thirds of the countries surveyed have a national energy efficiency agency and over 90 percent have a Ministry department dedicated to energy efficiency (WEC, 2008). The European Union has even created an "Intelligent Energy Europe" agency to manage energy efficiency projects including for buildings, as well as help establish local and regional energy efficiency agencies (European Commission Intelligent Energy Europe web site). These agencies often play a coordinating role to facilitate consultative processes and communications between stakeholders, including between different branches of the government itself.

CONSULTATIVE FRAMEWORKS FOR POLICY MAKING AND COMMUNICATION

The Building Sector is so vast, and is dispersed over such a wide area that governments will not be able to bring about greenhouse gas emission reductions from buildings without the active involvement of

all stakeholders concerned. These stakeholders include municipalities, private businesses and the financial sector, NGO and Civil Society actors, research and educational institutions, and of course, ordinary citizens. To harness their collective energies, national governments must take the lead in the coordination and facilitation of greenhouse gas mitigation policies. Various forums can serve to facilitate consultative processes. In France, for example, a multiparty environmental summit was held over several months in 2007 and resulted in several major policy changes with regard to energy use in buildings (Box 2). Meanwhile in the U.K., the government launched a major consultative process in 2008 to agree on how to define zero carbon homes that will apply to all new homes built from 2016, as well as to seek views from both the building and construction industry and non-governmental organizations on the potential to achieve non-domestic, zero carbon buildings from 2019 (UK Department for Communities and Local Government, 2008).

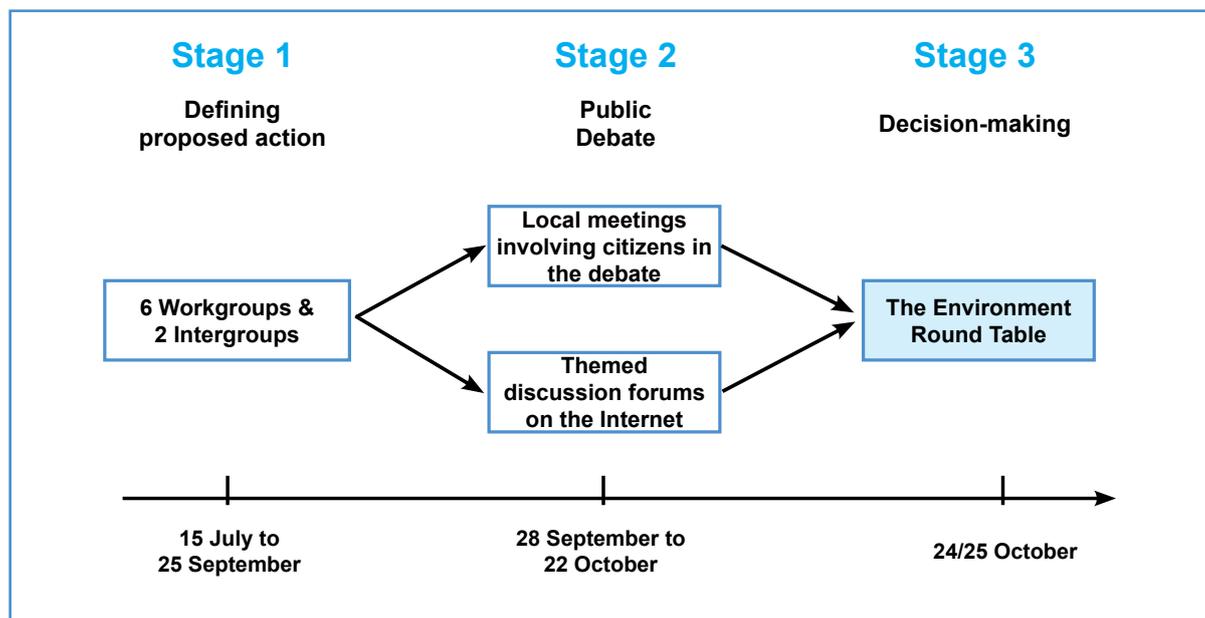
The Grenelle de l’Environnement was a multiparty national summit which took place over several months in mid-2007 and concluded late October

2007. It involved non-governmental organizations, union representatives, employers, local authorities, and French government officials. Workgroups in different environmental policy areas drew the French environmental roadmap for the next few years. The process is shown in Figure 6.

The Grenelle resulted in a number of important recommendations for the building sector, including:

- For new buildings, primary energy use is expected to be under 50 kilowatt hours per square meter per year by the end of 2010 for public and tertiary buildings and for all new buildings by the end of 2012. The ultimate goal for 2020 is for all new buildings to be passive or energy-positive, meaning buildings will generate more energy than they consume.
- For existing buildings, an ambitious target of 38% reduction in overall energy consumption by 2020 was adopted, with a special set of actions for public buildings. To support this process, a complete set of financial schemes has been implemented or reinforced. For example, the “Zero Rate Eco-loan”, which provides loans to property owners of up to €30,000 loan over 10

Figure 6. Outcome of the French Grenelle de l’Environnement



years, was officially launched in April 2009. The objective of this financial tool is to encourage owners to adopt a “global energy performance approach” when refurbishing their properties, either through a combination of energy efficiency investments or by achieving an overall minimum energy performance. As of mid-September 2009, 30,000 zero rate eco-loans have been granted.

The French authorities have already begun implementing some of the Grenelle objectives. On April 30, 2008, French Minister of State and Minister of Ecology Jean-Louis Borloo announced the completion of Grenelle 1, a legal framework that translates the Grenelle conclusions into law. The Grenelle 2 law is currently in process and the corresponding finance law has been voted. (Source: UNEP, 2008b. For more information about the Grenelle, go to <http://www.legrenelle-environnement.fr>)

Chapter 3

Policy Options for Reducing Emissions from Buildings

Policy Options for Reducing Emissions from Buildings

In their Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings (UNEP-SBCI, 2007), the authors classify policies for reducing greenhouse gas emissions from buildings into four categories, regulatory and control instruments; economic and market-based instruments; fiscal instruments and incentives; and support, information and voluntary actions, and assess each for its cost effectiveness and its effectiveness in actually reducing greenhouse gas emissions (Table 2 - next page). Many policy instruments were not only found to be effective in achieving emission reductions, but they also resulted in net savings, in some cases of up US\$ 200 per ton of CO₂ eqv avoided, if the benefits of saved energy and the associated avoided expenses are factored into the cost-benefit assessment. As can be seen from Table 2, regulatory and control instruments were found to be effective in terms of emission reductions as well as cost. Economic and market-based instruments also scored fairly well on both counts, as did one fiscal instrument (tax exemptions and reductions).

To select the most appropriate policies for the “carbon emissions” scenario of the Building Sector of their countries, governments should consider what policy objective they wish to target. Broadly speaking, the five major policy objectives, or targets, for reducing greenhouse gas emissions from buildings are:

- Target 1:** Increase the energy efficiency of new & existing buildings (both the physical envelope, and the operational aspects such as energy systems for heating, ventilation and other appliances);
- Target 2:** Increase the energy efficiency of appliances (white goods, entertainment, personal computers and telecommunication equipment);
- Target 3:** Encourage energy and distribution companies to support emission reductions in the Building Sector;
- Target 4:** Change attitudes and behavior;
- Target 5:** Substitute fossil fuels with renewable energies.

The following sections outline the main policy instruments available to governments, grouped by target. In almost all cases, these targets are best achieved through a combination of policies, or “policy packages”, rather than one or two policies implemented alone. Furthermore, there may be overlap between the policy targets, for example, promoting investment in energy efficiency measures (Target 1) while changing consumer behavior (Target 4). Decision-makers can “mix-and-match” their policies to find the optimum solutions to their particular carbon energy scenarios.



TARGET 1: IMPROVE THE ENERGY EFFICIENCY OF NEW & EXISTING BUILDINGS

Broadly speaking, the energy efficiency of a building is determined by the rate at which energy is lost through the physical structure of the building (the building envelope), and the rate at which energy is used to meet the energy needs and physical comfort of the occupants. These two factors are often closely interrelated, because the physical structure and design of a building, interacting with the local climate, strongly influence the choice of energy system and the associated efficiency of that system. When considering policies to improve the energy efficiency of buildings, therefore, it is important to keep both factors in mind.

Building Codes

Almost all developed countries have Building Codes which include energy efficiency standards, while many developing countries are now passing legislation for such codes. In most cases, these codes tend to regulate new buildings, but recently many developed country governments have amended their codes to cover renovations and refurbishments of existing buildings. Most building codes are performance based: that is, they set a maximum limit for level of heat transfer through the building envelope and the level of heating/cooling demand, as well as require building equipment such as heating and air conditioning systems, ventilation, water heaters and even pumps and elevators to meet certain energy performance standards.

Table 2. Summary Table of Policies to Reduce GHG Emissions in the Building Sector
(UNEP, 2007a)

Policy instruments	Emission Reduction Effectiveness	Cost-effectiveness	Special conditions for success, major strengths and limitations, co-benefits
Regulatory and control instruments			
Appliance standards	High	High	Factors for success: periodical update of standards, independent control, information, communication, education
Building codes	High	Medium	Only effective if enforced and periodically updated
Energy efficiency obligations and quotas	High	High	Continuous improvements necessary: new energy efficiency measures, short term incentives to transform markets
Mandatory audit requirement	High, but variable	Medium	Most effective if combined with other measures such as financial incentives
Labelling and certification programs	Medium/High	High	Mandatory programs more effective than voluntary ones. Effectiveness can be boosted by combination with other instrument and regular updates
Demand-side management programs (DSM)	High	High	Tend to be more cost-effective for the commercial sector than for the residential sector.
Economic and market-based instruments			
Energy savings performance contracting (EPC)/ESCO support	High	Medium	Strength: no need for public spending or market intervention, co-benefit of improved competitiveness.
Cooperative procurement	High	Medium/High	Combination with standards and labeling, choice of products with technical and market potential
Energy efficiency certificate schemes/white certificates	Medium	High/Medium	No long-term experience. Transaction costs can be high. Institutional structures needed. Profound interactions with existing policies. Benefits for employment
Kyoto Protocol flexible mechanisms	Low	Low	So far limited number of CDM & JI projects in buildings
Fiscal instruments and incentives			
Taxation (on CO ₂ or fuels)	Low	Low	Effect depends on price elasticity. Revenues can be earmarked for further energy efficiency support schemes. More effective when combined with other tools
Tax exemptions/ reductions	High	High	If properly structured, stimulate introduction of highly efficient equipment in existing and new building.
Public benefit charges	Medium	High	Success factors: independent administration of funds, regular monitoring & feedback, simple & clear design
Capital subsidies, grants, subsidized loans	High	Low	Positive for low-income households, risk of free-riders, may induce pioneering investments
Support, information and voluntary action			
Voluntary and negotiated agreements	Medium / High	Medium	Can be effective when regulations are difficult to enforce, combined with financial incentives, and threat of regulation
Public leadership programs, including procurement regulations	Medium / High	High/Medium	Can be effectively used to demonstrate new technologies and practices. Mandatory programs have higher potential than voluntary ones
Education and information programs	Low / Medium	Medium/High	More applicable in residential sector than commercial. Best applied in combination with other measures
Detailed billing and disclosure programs	Medium	Medium	Success conditions: combination with other measures and periodic evaluation

Building Codes can also be used in conjunction with standards on equipment or materials.

Building Codes are almost always more successful when mandatory rather than voluntary. When they are mandatory, they help overcome the perception that energy efficiency investments are an option. Any additional investment costs carried forward from the investment stage to the user stage are often off-set by lower construction or operating costs.

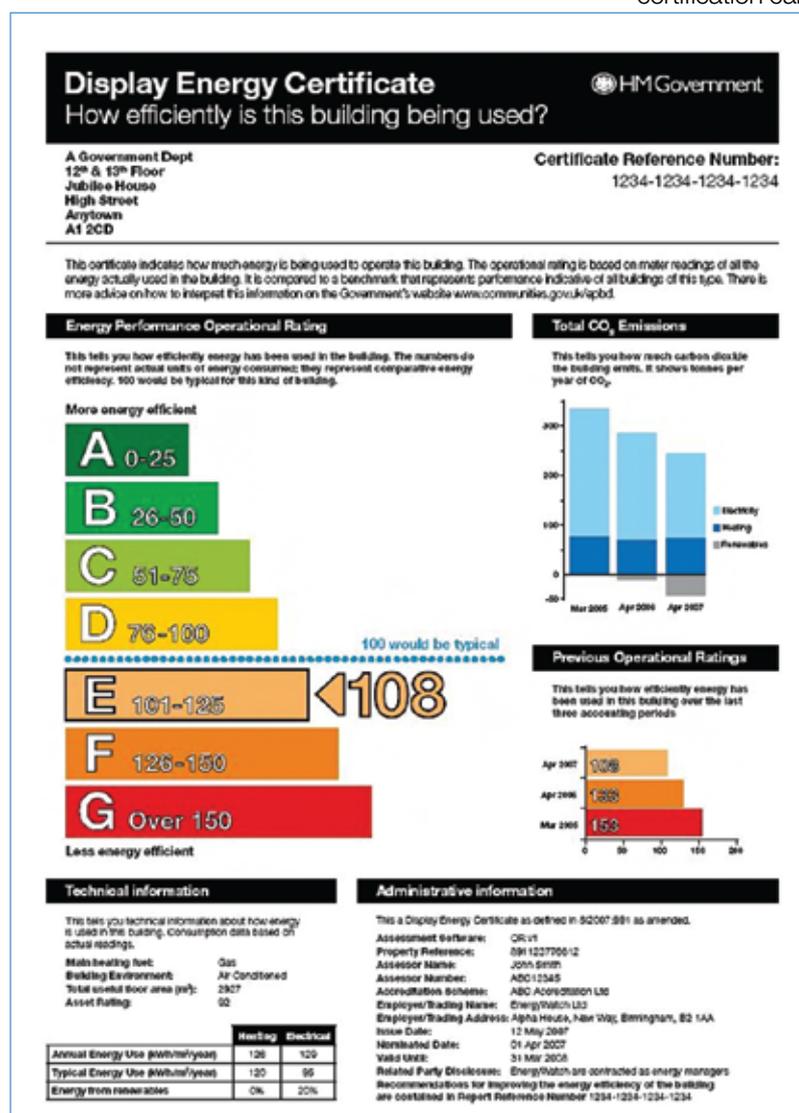
The US and EU member states have stepped up efforts in using building codes to reduce their energy emissions by strengthening existing codes,

Figure 7. Energy Certification of New/existing Buildings UK Department for Communities and Local Government, 2008a.

i.e. increasing their energy efficiency requirements. In its revision of the 2002 Energy Performance of Buildings Directive (2002/91/EC), for example, the EU harmonized the standards for energy performance and certification in buildings and now requires a mandatory revision of these standards to be conducted every five years (European Commission, 2008). Some governments combine codes with other information based instruments or introduce additional incentives, such as tax rebates or other concessions. The Energy Performance of Buildings Directive in the EU (2002), for example, required the obligatory energy certification of new and existing buildings as well as prominent display of this certification and other relevant information in public buildings (Geissler et al. 2006; Figure 7). Building certification can help overcome the “first cost” barrier

of energy efficiency measures by integrating the operational costs of each building into its market value.

The enforcement of building codes is a challenge for both developed and developing countries. According to a survey in Germany, for example, energy savings achieved in recent dwellings were found to be only 35 percent compared to dwellings built before the first regulations, whereas they were expected to be around 70 percent according to the building standards (WEC, 2008). It has also been found that while codes may be enforced in urban areas, they are not applied as rigorously in smaller cities and rural areas: in China, for example, one study found that enforcement of building codes was above 80 percent in major cities but much lower in smaller cities and rural areas (Huang, 2007). Furthermore, the enforcement of building codes requires significant technical capacity among government



agencies. Training must be continuous and flexible, as building codes are likely to change over time as energy performance requirements are raised and building designs and technologies evolve.

Building commissioning and mandatory energy audits

Building commissioning is the systematic testing process conducted to ensure that a building's systems have been designed, installed and made ready to perform in accordance with the design intent and the building owner's operational needs. In the same way that regular servicing extends the lifespan of an automobile, the proper commissioning of the energy systems in buildings is crucial to the efficient operation of the building later in its life cycle. According to case studies in the USA, proper building commissioning has yielded impressive results, with energy savings of up to 38% in cooling and/or 62% in heating, and an overall energy savings average higher than 30% (Levine et al, 2007).

Mandatory energy audits are an extension of Building codes and commissioning processes. In many European and other countries, governments have made energy audits mandatory for their public

buildings as well as other major energy consuming sectors, such as specific industrial and large commercial consumers. In the EU, these audits also stipulate that energy consuming equipment such as heating boilers be properly maintained. While detailed energy audits are relatively costly and require a high level of technical skill to conduct, they have a big advantage over other policies in that they provide practical data and reach a large number of customers in a short time. In developing countries in particular, more attention needs to be given to raising the quality of auditors through training and providing practical and financial support to the owners and occupiers of audited buildings to implement the recommendations of the audit.

Including information on consumption (e.g. in annual kWh per building area or per occupant) and emissions (e.g. in annual CO₂e per building area or per occupant) on utilities bills supports mandatory and voluntary audits and provides the users of buildings with information about how to reduce energy consumption and improve efficiency. However, the users still need to act on this information. For this reason, such measures are most useful when combined with other strategies such as subsidies for the recommended energy

Box 1. Tax Incentives under the U.S. Energy Policy Act of 2005

The *U.S. Energy Policy Act of 2005* (EPACT) offered businesses tax deductions for the costs of improving the energy efficiency of commercial buildings. The Emergency Economic Stabilization Act of 2008 extended provisions in EPACT. The following tax incentives are available under this act.

Deduction of the Cost of Energy-Efficient Property Installed in Commercial Buildings

A tax deduction of up to \$1.80 per square foot is available for buildings that save at least 50% of the heating and cooling energy of a building that meets ASHRAE Standard 90.1-2001. Partial deductions of up to \$.60 per square foot can be taken for measures affecting: the building envelope, lighting, or heating and cooling systems. This act extends the deduction through December 31, 2013.

Extension of Energy Investment Tax Credits

The 30% investment tax credits (ITC) for solar energy and qualified fuel cell properties are extended to January 1, 2017. The 30% ITC now also applies to qualified small wind energy property. The cap for qualified fuel cells increased to \$1,500 per half kilowatt of capacity. Finally, a new 10% ITC is available for combined heat and power systems and geothermal heat pumps.

Accelerated Depreciation for SmartMeters and Smart Grid Systems

Currently, taxpayers generally recover the cost of smart electric meters and smart electric grid equipment over a 20-year period. This act allows taxpayers to recover the cost of this property over a 10-year period, unless the property already qualifies for a shorter recovery schedule.

Source: http://www1.eere.energy.gov/buildings/tax_commercial.html

efficiency measures, training and awareness raising activities, or fiscal incentives to encourage the replacement of old equipment. Audited buildings may also be given awards or certification, thereby increasing public recognition for the successful implementation of energy efficiency measures.

Capital Subsidies, Grants, Subsidized Loans and Rebates

Many governments use financial incentives such as capital subsidies, grants, subsidized loans and rebates to encourage building owners and occupants to invest in energy efficiency measures and equipment. In particular, governments have targeted space heating and cooling because of the high degree of energy wastage through poor insulation and air leakage in existing buildings. In this regard, financial incentives to promote the insulation and retrofitting of exterior walls, ceilings, attics, lofts, floors, window frames, and band joints, as well as water heater storage tanks, boilers and water pipes, are most common.

Subsidies are very common in the residential sector in order to overcome the major barrier of high first costs (ECS, 2002; WEC, 2008). They have been used to finance better insulation such as roof insulation in the U.K., more efficient equipment such as refrigerators in Germany, and energy audits in France. The German and Slovenian subsidy schemes have been very effective, while in Brazil, the PROCEL program provides grants to state and local utilities, state agencies, private companies, universities and research institutes, which resulted in cumulative savings of 5.3 TWh (169 ktCO₂) per year at a benefit-cost ratio of 12:1 from 1986 to 1998 (WEC, 2004). Limiting subsidies either to a short period of time to facilitate market introduction of new technologies or to a specific target group in need enhances the effectiveness of the instrument (Jeeninga and Uyterlinde, 2000). Some governments have also introduced soft loans schemes whereby loans for installing energy efficiency equipment are offered at a subsidized interest rate.

Some governments prefer to use fiscal measures such as tax incentives to encourage investment in energy savings and efficiency measures in buildings. For the residential sector, tax credits and tax deductions are most popular, while for the commercial sector tax concessions and accelerated depreciation are used. Almost 40 percent of OECD countries offer tax credits for energy efficiency measures: the U.S. Energy Policy Act of 2005 (EPACT), for example, offers businesses tax deductions to cover the cost of measures which save at least 50 percent of the heating and cooling energy of a building that meets certain standards (Box 3). The WEC found that fiscal incentives are considered better than subsidies in that they cost less, but that they usually have a poor performance in an economy in recession or in transition (WEC, 2008).

Energy Performance Contracting (EPC)

Energy performance contracting (EPC) means that a contractor, typically an energy service company (ESCO), guarantees certain energy savings for a location over a specified period; implements the appropriate energy efficiency improvements; and is paid from the estimated energy cost reductions achieved through the energy savings (EFA 2002). EPC is becoming increasingly popular as a vehicle for implementing and financing energy efficiency projects in buildings because no public spending or market intervention is needed to capture the cost-effective energy-efficiency potential and competitiveness can be improved.

However, a number of conditions must exist for an effective ESCO industry to thrive, such as a mature financial sector willing to lend for energy efficiency projects; unsubsidised energy prices; and supportive legal, financial and business environments. To date, ESCOs have been shown to work effectively in Germany, the United States and Hungary, as well as in China and Brazil, but have been less successful in some other countries such as India (Urge-Vorsatz et al, 2007, Koepffel, et al. 2007b). Most ESCO projects in developing countries have been financed by bilateral and multilateral donors.

Box 2. Leading by Example: Government Initiatives to Promote Energy Efficiency in Public Buildings

Governments are major consumers of energy, and therefore public sector buildings therefore offer a tremendous opportunity for action on reducing greenhouse gases. On the one hand, they can significantly reduce energy consumption and thereby save energy costs in the public sector, while on the other hand they can demonstrate new technologies and provide an incentive to the private sector to follow (Harris et al 2004). They also demonstrate to the taxpayers that government revenues are spent in a useful way.

Many governments have already introduced programs to reduce their own greenhouse gas emissions, such as public leadership programs and green procurement policies (see Table below). Public leadership programs are energy efficiency initiatives in public administrations. Public leadership programs are usually effective and cost-efficient, and experience has shown that mandatory programs are more effective than voluntary ones. For example, in the U.S., federal agencies were obliged by executive orders from the President to reduce their energy use by 35% by 2010 compared to 1990 levels. leading to energy savings of 4.8 GWh annually (equivalent to 2.3 ktCO₂) and to cost savings of \$5.2 billion (U.S. DOE 2006). Meanwhile, France, Germany, Italy, the Republic of Korea, Sweden and the U.K. have taken steps to “green” their public procurement policies.

Program Categories	Program Examples
<p>Policies and Targets Energy saving goals; tracking and reporting progress Government organisation (lead responsibility for energy savings, interagency committees etc.) Budget policies (e.g. life-cycle costing, separate budget line for energy, energy cost saving shared with agencies)</p>	<p>Argentina (reporting) Dominican Republic (goals) Ecuador (goals) Mexico (saving goals and reporting requirements) Philippines (GEMP goals)</p>
<p>Energy-Saving Capital Projects Energy audits Retrofit projects: lighting, HVAC, building envelope, controls Financing: third-party (ESCO) funding, loan funds, leasing Efficiency standards/guidelines for new buildings Design assistance, software tools, architect training New technology demonstrations, showcase facilities Public services – efficient systems and equipment (water supply and treatment, street lighting, LED traffic signals)</p>	<p>Brazil (low-interest loans to retrofit public buildings) Colombia and Argentina (street lighting) Mexico (Web-based lighting audits, “100 Public Buildings” and APF) Russian Federation (pilot audits and retrofits)</p>
<p>Facilities Operation and Maintenance Building system commissioning: pre-occupancy + continuous Energy metering/monitoring, benchmarking, operator feedback Facility manager training and certification Operator incentives and recognition (awards) Employee information and outreach campaigns O&M for government vehicles; promote ridesharing and transit</p>	<p>Dominican Republic Mexico (building O&M, operator training, ‘Ports of Attention’ for outreach + technical assistance) Thailand (mandatory measures in public buildings)</p>
<p>Purchasing energy-efficient products Specify efficient building equipment, office equipment, motors, lighting, appliances, etc. Efficient and alternative fuel vehicles for government fleets Green power purchasing</p>	<p>Republic of Korea Philippines (GEMP)</p>

Source: Van Wie McGrory et al 2002.

TARGET 2: IMPROVE THE ENERGY EFFICIENCY OF HOUSEHOLD AND BUSINESS APPLIANCES

While space heating is the main end-use in buildings in OECD countries, appliances are driving the growth of energy consumption (IEA, 2006). The most common types of end-uses are:

- Heating, ventilation and air conditioning (HVAC) systems;
- Water heating;
- Lighting;
- Personal computers, data centers and electronic appliances;
- Cooking;
- Refrigerators, freezers, washing machines, dryers and dishwashers (“white goods”).

This section will focus on three policy instruments which aim to support the diffusion of energy efficient appliances on the market: appliance standards, fiscal incentives for the purchase of energy efficient equipment, and procurement policies.

Appliance Standards

Most developed and many developing countries have enacted appliance standards for energy-using products, such as lighting, heating and cooling equipment, and personal computers. For example, the Top Runner Program in Japan, which required all new products to meet an efficiency level (of the most efficient product at the time the standard was set) by a specified date resulted in energy efficiency improvements of over 50% for some products (Geller et al 2006). Fluorescent lights and Light Emitting Diode (LED) technologies are 75 percent more efficient than traditional incandescent lights. There have also been major advances in the efficiency of air conditioners, ventilation systems, and other appliances.

Appliance standards are cost effective because they reduce transaction costs for consumers and producers. This is confirmed in numerous countries: for 2020, savings for appliance standards evaluated by studies range between \$65/tCO₂ (i.e. a net benefit of USD 65/tCO₂) in

the USA, and \$190/tCO₂ in the EU (IEA 2005, Schломann et al. 2001, Gillingham et al. 2004, Energy Charter Secretariat 2002, WEC 2004, Australian Greenhouse Office 2005, IEA 2003). In this regard, appliance standards are most effective when used in conjunction with appliance labeling program. However, one of the weaknesses of standards is that they do not provide incentives for innovation beyond the target and therefore need to be periodically updated. In countries which import all electrical appliances, local testing and certification is very expensive as it requires capital investment in testing equipment and training. It would be beneficial to have an international system for testing and certification, so that laboratory tests conducted on products in one country can also be used in another country.

Fiscal Incentives for the Purchase of Energy Efficient Equipment

Though less common than appliance standards, some governments have tried to encourage the dissemination of energy efficient appliances through fiscal measures. The most popular is on reductions on import tax or VAT on efficient equipment. The compact fluorescent lamp is the most common equipment for this type of measure outside of the OECD, such as in Ghana, Morocco and Israel (WEC, 2008).

Procurement Policies

Cooperative procurement or technology procurement is another example of how consumers can flex their market power. It is a voluntary tool, used in both the public sector and the private sector, whereby customers who procure large quantities of energy-using appliances and equipment cooperate in order to influence the market for more efficient products. Their requirements usually include energy efficiency specifications which correspond to, or even exceed, world best practice instead of only first-cost considerations (EFA 2002). The goal is the commercial availability of new technologies for all buyers, not just the initial group, and ultimately the sustained market acceptance of efficient new products. Public procurement regulations are also a very powerful tool for transforming appliance markets towards greater efficiency (Box 2).

TARGET 3: ENCOURAGE ENERGY GENERATION AND DISTRIBUTION COMPANIES TO SUPPORT EMISSION REDUCTIONS IN THE BUILDING SECTOR

Energy companies play a key role in reducing emissions in the Building Sector because they oversee the generation of electricity and its distribution, as well as the distribution of natural gas and other forms of energy. In this regard, they are natural partners for government efforts to reduce energy consumption, improve efficiency, and increase the share of renewable sources in the Building Sector. Many governments have already introduced policies to encourage the energy sector to improve the efficiency of their networks as well as to support customers to reduce energy wastage, such as energy efficiency obligations and demand-side management programmes.

Utility Demand-side Management, or DSM

Utility demand-side management programs (DSM) are planning, implementing, and monitoring activities of energy efficiency programs among and by utilities on a voluntary or mandatory basis. Such activities include counseling services for individual consumers (for example, advice regarding new heat pump or electrical installations, energy management and auditing), public information campaigns aiming to change energy behaviour or promote new appliances (such as meters and low-energy bulbs); informative electricity bills; and technical campaigns (such as street lighting and technology procurement) (Hein Nybroe 2001). In the past, DSM programs were usually initiated as a means to ease pressure when energy demand exceeded production capacity, so they were often discontinued when market conditions or regulatory environments changed.

Following the restructuring and liberalization of electricity markets from the mid-1990s, for example

Table 3. Selected measures eligible for savings under the Energy Efficiency Obligations schemes in four countries (source: Adapted from WEC, 2008).

Measure	Flanders	France	Italy	U.K.
Cold appliances			XX	XX
Wet appliances			X	XX
Cogeneration			XX	
Compact Fluorescent Lamps (CFL)	XX	X	XX	XX
Condensing boilers	XX	X	X	XX
Fuel switching			XX	X
Glazing	XX	X	X	X
Heating controls		X	X	XX
Heat pumps	X	X	X	X
Insulation: Attic	XX	X		XX
Insulation: draught proofing				X
Insulation: Hot water tank				X
Insulation: Wall		X		XX
Low flow showerheads	XX		XX	
PV panels			X	X
Solar water heating	X	X	X	X

XX Widely used. X used.

Note: the data for France was collected at a time which was too early to differentiate between used and highly used measures.

in the EU, utilities reduced the number of voluntary DSM programs as they feared losing competitiveness. However, the liberalization of electricity markets has also provided opportunities for new policy initiatives in this area (Palmer 1999; Eyre 1998), especially when accompanied by energy efficiency policies. Jamaica (1994 – 1999) and Thailand have had successful DSM programs (MITEC 2007, Evander et al 2004); in the Thai case, DSM was combined with appliance labeling projects for lighting, refrigerators and air-conditioners. This has contributed to market transformation by stimulating local manufacturers, importers and distributors to consider the production and import of more efficient appliances and by encouraging consumers to buy these new products (Brulez et al 1998).

Energy Efficiency Obligations

Energy efficiency obligations (EEOs) and quotas are a legal obligation for electricity and gas suppliers and distributors to save energy in their customers' premises through energy efficiency. Savings targets are set by the government or, in the case of Ireland, by the regulatory body. In 2007, this instrument was enacted in the U.K., Flanders, Denmark, Italy, France and Ireland, while several other European countries are expected to introduce similar activities. All of the countries which have introduced EEOs include the residential sector as a target customer. Energy suppliers who fail to meet the target set by government face a penalty, usually a fine in proportion to the size of the miss. In most cases, energy suppliers can purchase the difference between achieved savings and targeted savings through a White Certificate scheme (see below).

There is some variation between countries as to the type of measures which are eligible to be considered as part of the savings calculation, but the most common are lighting and heating measures such as co-generation, solar water heating and other renewable forms of heating. As can be seen from Table 3, the UK covers the most extensive range of applications. In order to avoid "double counting" of energy savings, only savings which are achieved above the minimum energy performance standards are usually counted. Some countries target the

Box 3: Cap-and-Trade Scheme for Non-residential Buildings

Existing measures aimed at improving the energy performance of existing non-residential buildings have been regarded by some in the industry as being largely ineffective: the impact of government grants is limited to the grant projects; and, depending on their design, white certificate schemes are either limited to equipment replacement schemes according to a pre-approved list, or are priced beyond all but the largest facilities because of the whole building audit required. Finally, because of their voluntary nature, they have tended to do little more than reward 'business as usual'.

In response, SBCI member Lend Lease together with WSP Lincolne Scott and Advanced Environmental, with legal advice from Freehills have proposed the Efficient Building Scheme, a cap and trade emissions trading scheme for non-residential buildings that works by providing an incentive to maximise energy efficiency improvements in buildings when they come up for re-lease or earlier, balanced by penalties for inaction on inefficient buildings.

The Scheme would be identical to an emissions trading scheme except that it recognises energy efficiency improvements in non-residential buildings, rather than emissions avoided. Simply put, it treats one tonne of greenhouse gas emissions (tCO₂e) that is not emitted because energy is not used in the same way that a conventional Emissions Trading Scheme treats one tonne of tCO₂e that is not emitted due to a change in energy generation.

It provides a competitive return on investments in emissions reduction initiatives, which would drive significant greenhouse gas abatement through energy efficiency improvements. For industry players who improve the energy efficiency of their buildings there would be a financial return. But, unlike other policy measures, an Efficient Building Scheme – like an Emissions Trading Scheme - would provide a "carrot" and a "stick", balancing permit allocation with an obligation to acquire permits. This would stimulate the whole sector to upgrade.

An Efficient Building Scheme could operate as a complementary measure to an Emissions Trading Scheme, but it could also operate independently. The City of Tokyo incorporated a similar trading scheme into its 'Ordinance on Environmental Preservation' in June 2008 (Ikuta, 2009). The Efficient Building Scheme was introduced to the Australian Senate in the Safe Climate (Energy Efficient Non-Residential Buildings Scheme) Bill in September 2009.

For more information:

- www.lendlease.com/sustainability/pdf/Efficient-BuildingScheme.pdf
- http://greensmps.org.au/webfm_send/233

primary energy saved, while others consider also the carbon content of the fuel saved.

Energy efficiency obligations have several advantages: they are cheap to administer and relatively simple; they need not count as government expenditure; and despite usually leading to an increase in energy prices from 1 to 2%, they can be designed to avoid regressive social impacts, for example by allocating part of the energy saving target to low income consumers. Energy efficiency obligations have not yet been used in developing countries, but it has been proposed that they be linked with CDM or carbon offsetting in order to help them to target energy demand.

Energy efficiency certificate schemes (“white certificates”)

Recently, some countries have linked their energy efficiency obligations to tradable certificates for energy savings. Energy efficiency certificates, or “white certificates”, are a relatively new policy measure, first applied in New South Wales, Australia in 2003, followed by Italy in 2005 and France in 2006. White certificates are issued by independent certifying bodies confirming the claims of market actors for savings of energy, as a consequence of energy end-use efficiency measures (Bertoldi and Rezessy 2006, cited in Capozza 2006).

Certificates can be awarded for carbon sequestration projects, demand-side abatement, low emission electricity generation or industrial projects reducing GHG emissions. They are also used to facilitate the purchase of energy savings under Energy Efficiency Obligations schemes, though to date the White Certificates traded under such schemes are usually between companies participating directly in those schemes. In the U.S., the “White Tag” energy efficiency trading program, launched by Sterling Plant, a leading U.S. retailer renewable energy trader, functions in a similar way by calculating energy savings derived from energy efficiency measures. While white-certificate programmes can provide incentives, their effectiveness has been found to depend upon the rigour applied to setting

energy efficiency requirements, and systems for verification and enforcement (Ries et al., 2009).

Public Benefit Charges

Public benefit charges are a new mechanism defined as raising funds from the operation of the energy market, which can then be directed into DSM and energy efficiency activities (Crossley et al. 2000). They are therefore similar to an energy tax whose revenues are typically invested partially or completely into energy-efficiency. To finance DSM, many U.S. federal and state restructuring bills also include a mechanism for funding DSM initiatives such as through public benefit charges (also referred to as an electricity surcharge), or by imposing a spending target.

In Brazil, all distribution utilities are required to spend at least one percent of their revenues on energy efficiency improvements, while at least one-quarter of this amount has to be spent on end-use efficiency projects. Public benefits charges can be raise funds for energy efficiency measures and possibly accelerate market transformation. However, their effectiveness in terms of the total amount of GHG saved is moderate: studies for the US found that 0.4 percent of all electricity sold was saved, at a negative cost which was probably due to limited demand elasticity (Kushler et al 2004).

TARGET 4: CHANGES IN ATTITUDES AND BEHAVIOR

A major barrier to energy efficiency investments is the trade-off between the immediate cost of the investment and the savings which can be expected in the medium to long term. When energy prices are high, the expected savings can be recouped in a shorter period of time and the trade-off is less, while when energy prices are low, the time taken to recoup the savings is much longer.

High energy prices also usually dampen demand for energy, though the elasticity of demand for energy varies from household to household and from country to country. On the whole, however, price is a major influencing factor in how individuals

use (and save) energy. Governments have therefore used energy and/or carbon taxes to raise the price of energy and increase the value associated with every unit of energy consumed. Other ways of raising consumer awareness about energy efficiency are through advertising campaigns and the provision of detailed information about energy use (for example, with meters and in energy bills).

Another, more holistic approach, which internalizes the cost of energy efficiency measures into the value of the building is “green” mortgages. Although their primary objective is not to change attitudes and behaviour, they are included in this section because in the longer run they may alter the way in which building owners perceive energy efficiency improvements.

Energy/Carbon Taxes

While the relation between energy demand and energy prices is complex, the price of energy is a major influencing factor in energy user attitudes and behavior. Some countries have developed direct taxes on household fuels or carbon emissions as a tool for discouraging the consumption of energy. In most cases, the final consumer pays (for example, households), but a tax may be levied at any point in the supply chain (Crossley et al, 2000). Several European countries tax energy use or energy-related CO₂ emissions. In most cases, implicit taxes applied to fossil fuels are inversely related to carbon content.

Taxes have a number of advantages: they directly affect the whole life-cycle of buildings and can reinforce the impact of other instruments such as standards and subsidies, or make energy efficiency investments more profitably. Energy or CO₂ taxes are also a useful means to raise finances for other energy efficiency programs, such as through rebates for energy efficient programs, loans or special assistance for low-income households to increase their energy efficiency. For example, countries can use such taxes to create an energy efficiency investment fund which provides the funding for increased initial investments for energy efficiency in buildings, meeting the minimum energy

use benchmark for that particular building type in the country.

The effectiveness of energy taxes has also been contested, particularly as they do not specifically address barriers to energy efficiency and potentially have serious social and political impacts (Crossley, et al, 2002). Similarly, governments have been reluctant to remove energy subsidies, which, like taxes, would raise the price of energy. However, low, subsidized energy prices translate into longer payback periods for energy efficiency investments, rendering them unprofitable in the medium term. Some observers attribute differences in government commitment to energy efficiency to their national energy prices, with net energy importers according a higher priority to energy efficiency policies than net energy exporters. Governments must therefore weigh the social costs of policies which affect energy prices for the end-user, against the potential benefits which will be derived from them. To cushion the negative social effects, governments can use the funds saved or raised through these policies to create other energy saving mechanisms.

Information Programs to Change Consumer Behavior

Information programs to encourage consumers to use less energy as well as adopt energy efficiency measures are most effective when combined with other policy instruments. For example, the effectiveness of appliance standards is enhanced when accompanied by **mandatory labeling programs**, as shown in China, which has one of the most comprehensive standards and labeling programs in developing countries (Lin 2002). Mandatory and voluntary labelling programs are used in many countries all over the world, including numerous developing countries. More than half of the countries in Asia and 90% of the countries in South America have labeling programs.

The US Energy Star Program is an example of a successful **voluntary labeling program**, with expected cumulative savings of 833 Mt CO₂ equivalent by 2010 (Gillingham et al 2004). In general, mandatory labeling is more effective than

voluntary labeling because it avoids the problem of having inefficient appliances which are not labeled on the market (thus undermining more efficient, but sometimes more expensive, products) (UNEP, 2007a).

Detailed **billing and disclosure programs** have also been found to encourage energy users to adjust their consumption downwards. Studies have found that displaying energy use on appliances is more effective than providing energy consumption data on bills. This is one reason why in some countries, governments are encouraging the private sector to install appliance energy meters in new buildings.

Finally, **public information campaigns** are also common in many countries, including programs which provide “energy tips” and counseling, energy consumption feedback and assessments, elementary school programs, and mass media motivational campaigns. They are often more effective for the residential than the commercial sector. For example, in Brazil the cost-effectiveness of information programs exceeded those of most other policy instruments, with negative costs of \$66/tCO₂ (Dias et al. 2004). Information programs are especially important in developing countries, where a lack of information has been identified as a major barrier for energy efficiency and renewable energy investments (Evander et al. 2004).

Green Mortgages

Energy Efficient Mortgages (EEMs) or Energy Improvement Mortgages (EIMs), often referred to as “green mortgages”, are loans which provide the borrower a money-saving discount, lower interest rates or a bigger loan than normally permitted as a reward for making energy-efficient improvements or for buying a home that meets particular energy-efficiency standards. The economic rationale behind green mortgages is that energy-efficient homes will save money for the home-owner, resulting in a higher income which qualifies the beneficiary to borrow more.

It is too early to say whether green mortgages will become the norm in the future, as their attractive-

ness to both lenders and borrowers depends in some part to the value of savings and therefore the price of energy. However, they are a good example of how the financial sector can accommodate the risk of the capitalization of energy savings if there is a credible verification system in place. One of the prerequisites for the introduction of “green mortgages” is therefore the existence of nationally recognized energy performance standards.

TARGET 5: SUBSTITUTING FOSSIL FUELS WITH RENEWABLE ENERGIES IN BUILDINGS

While renewable energy sources still generate less than 20% of the world’s electricity, the capacity continues to grow steadily and more and more countries are developing renewable energy installations. In 2008 the supply of renewable energies grew all around the world, led by growth in the U.S., China, Germany, Spain and India. After large hydropower, the main sources of renewable electric power are wind power, small hydropower, and biomass power.

If the aim of the Building Sector is to become carbon neutral in the medium to long run, then renewable energies will have to play a much bigger role in meeting energy needs in buildings. This can be achieved through two avenues: first, by substituting fossil fuels with renewable energy sources at the point of electricity generation; and second, through the use of renewable energy technologies at the point of consumption, i.e. off-grid applications of renewable energy. Clearly, both approaches must be followed simultaneously. Recent trends suggest that demand for appliances which use renewable energies will continue to grow rapidly, particularly when supported by favorable government policies.

Policies to Increase the Share of Renewables in Energy Markets

Many countries are trying to speed up the diffusion of renewable energy provision through direct

regulation: by early 2009, at least 73 countries had policy targets for renewable energy (REN, 2009). Of the major energy producers and consumers in the world, China's 2005 Law on renewable energy stipulates that 10 percent of total power consumption should come from renewable sources by 2020, while the EU has set an even more ambitious target of 20% by 2020 (European Commission, 2009). While the US and Canada do not have national targets, 46 federal states and provinces currently have their own policy targets on renewable energy (REN, 2009).

Regulatory targets are usually complemented by price-based instruments such as feed-in tariffs. Governments require their energy utilities or suppliers to purchase electricity from private suppliers at a rate set by the government, usually higher than that paid for electricity generated from conventional sources. 2008 saw a flurry of policies and legislation relating to feed-in tariffs, bringing the total number of countries with feed-in tariffs at 45 and states/provinces/territories at 18 in early 2009.

Table 4 lists the countries and states which have implemented feed-in tariffs over the past ten years. Recently, municipal and local governments have been exploring ways to introduce feed-in tariffs at the local level.

Renewable energy markets have also been boosted by the enactment of **Renewable Portfolio Standards (RPS)** in several major energy consuming countries, notably the United States. These consist of electricity generation requirements, imposed on electric utilities by state legislatures, to provide either a specific amount of electric capacity or a percentage of total capacity from renewable sources. Utilities can also purchase renewable energy credits from external sources to fulfill these obligations. As of early 2009, 9 countries had enacted national RPS policies, while 29 U.S. states, 3 Canadian provinces, 5 Indian states and Wallonia and Flanders in Belgium had introduced RPS at the state/provincial level (REN, 2009). Although the transaction costs of these schemes are initially high, and advanced institutional structures are

Table 4. Countries/States/Provinces Enacting Feed-in Policies

Year	Country/state
Prior to 1999	US, Germany, Switzerland, Italy, Denmark, India, Spain, Greece, Sri Lanka, Sweden
1999	Portugal, Norway, Slovenia
2001	France, Latvia
2002	Algeria, Austria, Brazil, Czech Republic, Indonesia, Lithuania
2003	Cyprus, Estonia, Hungary, Republic of Korea, Slovak Republic, Maharashtra (India)
2004	Israel, Nicaragua, Prince Edward Island (Canada), Andhra Pradesh and Madhya Pradesh (India)
2005	Karnataka, Uttaranchal and Uttar Pradesh (India); China, Turkey, Ecuador, Ireland
2006	Ontario (Canada), Argentina, Thailand
2007	South Australia (Australia); Albania, Bulgaria, Croatia, Macedonia, Uganda
2008	Queensland (Australia); California (U.S.A.); Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Kenya, the Philippines, Poland, Ukraine.
2009 (early)	Australian Capital Territory (Australia); South Africa

Note: Several feed-in policies shown here have been discontinued, while others have been revised or reformulated in years subsequent to the initial year shown. India's national feed-in tariff from 1993 was substantially discontinued but new national feed-in tariffs were enacted in 2008. Source: REN 2009.

required, Renewable Portfolio Standards enable the establishment of a marketplace for trading certificates and thus provide a tangible incentive for investments in renewable energy.

Finally, many governments are providing direct support to renewable energy producers through subsidies, and indirectly through tax credits and import duty incentives. Most notable is China's new policy to provide subsidies for building-integrated PV for installations larger than 50 kW. This has helped to create a grid-connected solar PV market in China (REN 2009). Some countries have also taken important steps to remove institutional and legislative barriers for independent renewable energy producers: Portugal, for example, simplified licensing for small renewable producers, while under a recent renewable energy law passed in the Philippines, renewable generators are given connection and transmission priority.

Policies to Encourage Off-Grid Applications of Renewable Energy in Buildings

In many ways, the uptake of equipment and appliances which use renewable energy in buildings face many of the same barriers as energy efficient appliances, most notably the first cost barrier. To overcome this, some countries have simply chosen to make the use of renewable energy appliances, such as solar space and water heating, mandatory for new buildings. For example, solar water heaters have been mandatory for new buildings in Israel since the 1970s, while in 2005 and 2006 Spain passed legislation requiring new buildings to have photovoltaic electricity generation and solar water heaters respectively. In 2006, Australia also made solar water heaters mandatory for some types of new construction, while more recently the German state of Baden-Wurtemberg enacted a law requiring that all new buildings produce 20 percent

Figure 8. A passive apartment building in Finland. Photo: Mikko Saari, VTT



of their water and space heating requirements with renewables, while existing buildings have two years to meet a 10 percent target. Meanwhile at the federal level, Germany has enacted a new minimum requirement for both hot water and space heating supply from renewables in new buildings from the start of 2009, while Norway requires renewable hot water heating in public buildings greater than 500 m² (REN 2009).

However, by far the most common approach to encourage the uptake of renewable energy appliances at the building level has been through the use of subsidies, grants, and fiscal incentives. For example, Japan has increased national solar PV subsidies for schools, hospitals and railway stations from 33 to 50 percent, in addition to providing subsidies for households. Ireland, Germany, and Luxembourg provide subsidies or grants to install solar water (and sometimes space) heaters in residential, public and commercial buildings. Eskom, the South African utility company, has also recently started a solar hot water subsidy program that provides \$200 – 350 per household.

In developing countries, particularly those with relatively low electrification rates, there has been tremendous progress in disseminating renewable energy appliances, sometimes in conjunction with rural electrification programs. A major Dutch/German project called “Energising Development”, initiated in 2004, exceeded its target of providing 5 million people with full access to modern energy through improved cookstoves and electricity access by 2008. Under a World Bank energy access project in Ethiopia, nearly 1 million improved efficiency cooking stoves were sold. As part of India’s Remote Village Electrification Program, more than 435,000 home lighting systems, 700,000 solar lanterns and 7,000 solar-power water pumps have been established. Several other donor-financed projects are underway: notably two new World Bank projects to install 1.3 million solar home systems in Bangladesh, which were among the first to use off-grid PV carbon finance (REN, 2009).

Towards Zero-Carbon Buildings

As renewable technologies become more affordable and flexible, interest is growing in their applications in both new and existing buildings. “Green building” or “sustainable building” designs combine design and technology, usually renewable energy systems, to meet the needs of the occupants with very low or even zero carbon emissions. For example, passive houses are houses which maintain a comfortable interior climate without active heating and cooling systems (Figure 8). Their additional energy requirements may be completely covered using renewable energy sources.

Meanwhile, zero-energy buildings are buildings where energy provided by on-site renewable energy sources is equal to the energy used by the building. In addition, energy can be stored on site, in batteries or thermal storage. Zero energy buildings are usually connected to the main electricity grid, in order to cope with possible fluctuations in demand, especially as some buildings will produce more energy in the summer and use more in the winter. Several exciting model projects have been built in the last few years, including the WWF’s zero-energy housing project in the Netherlands and the Malaysia Energy Centre (Pusat Tenaga Malaysia) headquarters in Kuala Lumpur. But perhaps the most interesting projects taking place today are energy-plus buildings – buildings that produce more energy than they consume over a year. The extra energy is usually electricity, produced with solar cells, solar heating and cooling, insulation as well as careful site selection and orientation.

While in most countries, “green buildings” are still in the demonstration phase, they are expected to become the norm in the near future. In Germany, for example, passive building technologies are spreading rapidly, while in France, the Grenelle de l’Environnement in France recommended that all new housing be passive or energy-positive by 2020 (UNEP, 2008b).

Chapter 4

International Cooperation for
Emission Reductions from
Buildings

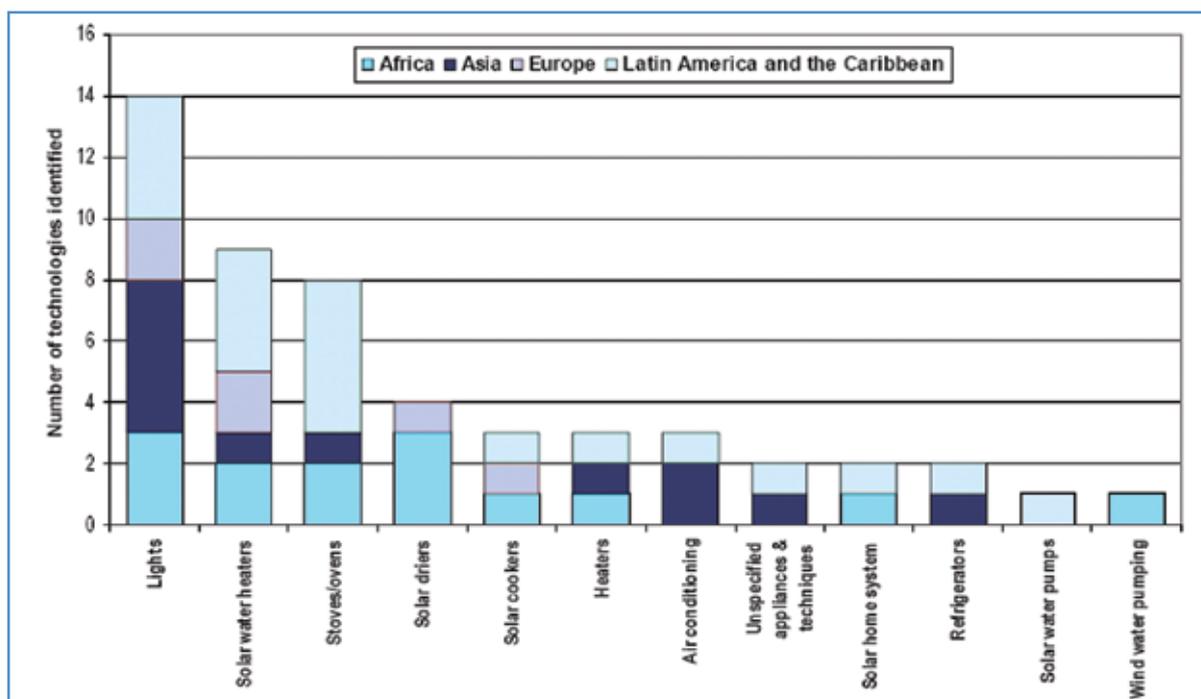
International Cooperation for Emission Reductions from Buildings

At no other time has the case for international cooperation to address climate change been more pressing than now. The catastrophic effects of the warming climate are already being felt in coastal areas as well as through the increasing incidence and intensity of extreme weather events such as cyclones, flooding and drought. Given that the aggregate emissions from rapidly industrialising countries such as China, India and Brazil are expected to overtake the current level of emissions from industrial countries in the next few years, it is paramount to find effective and mutually beneficial forms of cooperation today.

Under the United Nations Framework Convention on Climate Change, the Kyoto Protocol set legally binding emission reduction targets for four greenhouse gases, namely carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and sulphur

hexafluoride, as well as for two groups of gases called hydrofluorocarbons (HFCs) and perfluorocarbons. Past experience has shown, however, that the mechanisms designed to facilitate this cooperation under the Kyoto Protocol have not been effective so far in supporting projects in the Building Sector, despite the clear interest on the part of developing countries. At its fourth session, the Conference of the Parties (COP) invited non-Annex I Parties to submit their prioritized technology needs, especially those relating to key technologies, for addressing climate change (SBSTA, 2006). Of the countries who responded, 88 percent considered “Energy use – buildings and residential” as an important area. Energy efficient appliances and green buildings and materials were most selected options in the end-use sector. The priority needs for energy efficiency were for lighting, solar water heating, and stoves and ovens, with solar driers also important for Africa and air-conditioners, heaters and refrigerators for Asia (Figure 9).

Figure 9. Commonly identified energy efficiency technology needs in the building and residential subsectors.
Source: SBSTA, 2006



There is an urgent need to reconsider the various mechanisms which have existed under the Kyoto Protocol and to find ways of adapting them to the particular characteristics of the Building Sector. In particular, ways to overcome the barriers to accessing the flexible financing mechanisms created under the Kyoto Protocol, such as the Clean Development Mechanism, must be found. The following sections outline the major points to be considered under the post-Kyoto agreement.

Nationally Appropriate Mitigation Actions (NAMA)

The establishment of Nationally Appropriate Mitigation Actions, or NAMA, under the Bali Action Plan is a significant step towards this end because greenhouse gas emission reduction in buildings offers an obvious opportunity for developed and developing countries to cooperate in achieving common but differentiated action to realize significant energy efficiency improvements. The Building Sector is an area that is particularly appropriate to develop NAMA within, for the following reasons:

1. **The potential for large emission reductions in buildings exists in all countries** and is therefore relevant for all countries.
2. The level of implementation of energy efficiency measures in buildings is at different stages in different countries. **The opportunity for country-to-country technology sharing agreements and international capacity building support is obvious.**
3. Emission reduction from buildings can be relatively easy monitored, through energy consumption in individual buildings or groups of buildings, converted to greenhouse gas emissions through emission factors. **If the metrics used for energy efficiency and emission reduction in buildings can be internationally agreed, the actions undertaken by countries will also be internationally measurable, reportable and verifiable.** It should be noted that this approach encourages a whole-building approach to emission reduction instead of promoting specific technologies, which also opens the door for innovative approaches to be applied and recognized.
4. **The financing need for energy efficiency improvements in buildings can to a large extent be offset by reduced energy costs during the life time of buildings.** Financial mechanisms for redirecting funds freed up through reduced energy consumption, to energy efficiency investments in buildings can be developed as presented above. In addition, the current financial crisis offers a unique opportunity to guide the stimulus financing that in any case to a large part is destined for infrastructure investments, towards energy efficiency investments in buildings. This would also support a wider shift towards a low carbon society where sustainable consumption and production patterns are better valued.
5. **A targeted energy efficiency in buildings effort under NAMA would not only reduce greenhouse gas emissions but would also contribute towards other national priorities** including employment generation and upgrading of skills in the existing workforce, provision of more sustainable, affordable and healthy buildings, and improved energy security through reduced overall energy demand. International technology transfer agreements and support to national capacity building would thereby provide an additional incentive for developing countries to undertake NAMA in this area.

UNEP SBCI is therefore proposing that emission reduction in buildings is recognized by the parties to the convention as an appropriate area for NAMA and that the development of frameworks required to monitor, report and verify such actions are

mandated in support thereof in the Copenhagen Agreement.

Reforming the Clean Development Mechanism

The Kyoto Protocol of the UN Framework Convention on Climate Change established three flexible mechanisms by which Annex I countries are able to meet their national commitments to reducing greenhouse gas emissions through measures taken in non-Annex I countries. One of these is the Clean Development Mechanism (CDM), which awards Certified Emissions Reduction credits to developed countries investing in projects that reduce emissions in developing countries if additionality requirements are fulfilled. The CDM is regarded as one of the most important internationally implemented mechanisms to finance emission reduction projects and to support sustainable development in developing countries.

With the CDM's strong financial and technology transfer incentives, the Building Sector would seem well-positioned to become a primary target for CDM project developers. Despite this potential, only 14 projects out of more than 4,500 projects submitted for review (as of April 2009) address energy efficiency in buildings. The "CDM requirements", or conditions, which must be met to be considered for CDM funding, create a number of barriers to their implementation for buildings, including the following:

1. CDM has an **additionality requirement** that calls for projects to demonstrate that they reduce emissions above and beyond what would have been reduced without the additional support from the CDM project. For this, the proposed project must be compared to a reference case or baseline. Due to the fragmentation of the building market, it is almost impossible to prove what building design would have been selected in the absence of the CDM project. Furthermore, where building projects provide access to modern energy when none existed before (for example, amongst low income groups), the provision of energy efficient housing would increase absolute levels of energy consumption, thereby violating the additionality requirement.
2. CDM projects targeting building sector energy efficiency generate **insufficient economic revenue** in terms of Certified Emissions Reduction credits to justify the rather high implementation and monitoring costs. Therefore, given the choice between a building project and another more short term profitable one, countries tend not to plan building sector efficiency projects.
3. CDM requires a project to have real and measurable climate change benefits, which are difficult to demonstrate in many cases because of the **lack of baselines**. In most countries, there is a lack of established or enforced standards on energy efficiency that could be used when a reference case is not available, and without baselines, it is not possible for project developers to prove the emissions impact.
4. Energy efficiency projects for buildings are typically small in scale and use a variety of measures to decrease overall energy consumption, such as improved energy systems, better design, higher quality insulation and more efficient user behaviour. CDM is not well-equipped for these kinds of projects because of its **detailed monitoring requirements**. CDM requires evaluation of each technology and measure, which results in high administrative and economic costs to the implemented entity. In addition, some of the common energy efficiency improvement measures for buildings cannot be verified with existing CDM methodologies: for example, in the case of buildings, changes in behaviour and energy management are where many savings can be achieved.

SIX ACTIONS FOR THE POST-KYOTO AGREEMENT

In order to overcome the barriers mentioned above and utilize the CDM mechanism effectively, UNEP has identified the following actions for **urgent consideration** for the post-Kyoto agreement.

1

Use performance-based indicators, such as energy consumption per square meter, for project approval and monitoring in conjunction with or separately from technology-based indicators, as is currently used under the CDM methodologies. Even if technology-based indicators are appropriate for single-technology emissions mitigation projects, in the case of the building sector where many technologies are used simultaneously, such an approach is not appropriate. With performance based indicators, building projects will be able to employ the full range of measures available to reduce energy consumption.

2

Develop common performance-based baselines for different types of buildings to support and allow performance based building sector CDM projects. This will provide accessible reference cases so energy savings can be more easily proven. Such baselines should be established by designated national authorities to account for local building types and climate zones.

3

Allow CDM to more easily support projects aiming at providing poor people with sufficient access to energy to meet their basic needs. For example, Certified Emissions Reduction credits could be issued with a premium for projects having a strong sustainability component (such as providing poor people with energy efficient housing), given that a certain energy efficiency standard is met.

4

Allow CDM to generate Certified Emissions Reduction credits for projects meeting national standards for energy efficiency in buildings. Such an arrangement would encourage developing countries to establish such standards. In countries where such standards are weakly enforced, this measure would help promote compliance. Such an agreement could be for a temporary period in order to give the market time to assimilate new technologies and new design knowledge.

5

Strengthen the role and capacity of designated national authorities to promote CDM. This would also help governments to manage increased volumes of demand-side energy efficiency projects.

6

Use statistical management tools in addition to technology-based methods for verification and monitoring and replace direct monitoring with sampling. These measures will reduce overhead costs for projects with a large volume of smaller individual measures, where each one is too small to justify separate monitoring and verification.

Chapter 5

Conclusions & Priority Actions
for Creating a Carbon Neutral
Building Sector

Conclusions and Priority Actions for Creating a Carbon Neutral Building Sector

The Building Sector has tremendous potential for reducing greenhouse gas emissions, and at relatively low cost. This report has shown that Decision-Makers have a vast array of policy options available for each of the main policy targets, namely improving the energy efficiency of buildings; improving the energy efficiency of appliances; improving the energy efficiency of energy suppliers and distributors; changing attitudes and behavior towards energy use in buildings; and substituting fossil fuels with renewable sources of energy.

As governments increasingly regulate the use of energy in buildings and promote the growth of renewable energies, new employment and business opportunities are emerging. There are already examples of hundreds of thousands of new jobs in renewable energy production in China and Spain, in energy efficiency programs for buildings in Germany and France, and in the bio-energy and recycling sectors in Brazil (Sanchez, A. B. and Poschen, P. 2009). In the U.S., a study by The Pew Charitable Trusts found that jobs in the “clean”

energy economy grew by over 9 percent between 1997 and 2007, faster than overall jobs (Pew Charitable Trust, 2009). Indeed, the term “green collar worker” is being used to describe people employed in these sectors.

Partly in response to the global financial crisis, many national governments have increased the availability of public finance for renewable and “clean” technologies. The New Green Deal Group of the U.K. went as far as calling on the government to devise a program which makes “every building a power station” through a crash programme of investment, as well as training a “carbon army” of workers to fill high-and lower skilled jobs in the UK (nef, 2008).

For developing countries, a much broader range of financing options need to be explored, including through international mechanisms such as the CDM and public-private partnerships. Many developing countries must grapple with the dual challenge of greenhouse gas mitigation and climate change adaptation in their Building Sector. However, developing countries may also combine their efforts at addressing the challenges that climate change poses with their overall sustainable development goals, such as those outlined in the Millennium Development Goals.

PRIORITY ACTIONS

Clearly, there is a role for everyone in the fight against climate change. In this regard, the priority actions for each major stakeholder group are summarized on the following pages.

PRIORITY ACTIONS

National & International Policy Makers

1

Establish national regulations that make energy efficiency investments mandatory in new buildings and in renovation of existing buildings.

2

Conduct inventories of energy consumption, energy efficiency and emissions from the national building stock to establish base-lines and set performance goals to reduce greenhouse gas emissions in existing and new buildings in accordance with their location, type and use.

3

Establish an energy efficiency in buildings investment fund that can be used promote initial investments and renovations for energy efficiency in buildings, meeting the minimum energy use benchmark for that particular building type in the country. Such a fund can be financed through taxations of energy use above the national average, thereby always providing additional incentives to high energy users to reduce energy use. It can also be funded by redirecting investments in additional energy production that will be avoided by reduced energy demand in buildings.

4

Support the inclusion of measures in the new global climate-change treaty that encourage investments in both new building and building renovation projects that reduce or eliminate emissions.

5

Include in the technology transfer framework/measures, support to capacity building to enable and increase energy efficiency in existing and new buildings.

6

Support the development and reform of all flexible mechanisms to encourage investment in reducing the energy demand and greenhouse gas emissions from building operations.

7

Retrofit all publicly owned buildings for high-level energy efficiency and deep GHG emission reductions. Ensure all new public buildings constructed achieve the highest possible energy efficiency, the lowest possible GHG emissions and do not 'lock-in' inefficiencies and GHG emissions burdens over their life-span.

PRIORITY ACTIONS

Municipalities

1

Lead by example: conduct retrofitting programs that deliver deep energy consumption and GHG emission cuts.

2

Support climate adaptive measures and goals through twinning programmes between cities and towns in developed countries and in developing countries and economies in transition.

3

Develop climate change strategies and action-plans with strategic goals to be achieved by 2020.

4

Make all publicly owned buildings climate neutral, and all new buildings energy-positive by 2020.

5

Agree on a common assessment and evaluation process to monitor progress on tackling climate change.

PRIORITY ACTIONS

NGO & Civil Society

1

Advocate, communicate and share information.

2

Train professionals and trades-people currently working in the building sector and educate the next generation of professionals to implement sustainable building principles and practices.

3

Facilitate leadership and bridging efforts.

4

Help monitor quality assurance and standards of low GHG emissions building performance.

5

Help communities adopt climate-friendly behaviours and lifestyles.

PRIORITY ACTIONS

Private Sector

- 1 Work with governments to develop policies that make a difference & act as agents of change.
- 2 Work to introduce a carbon trade mechanism for buildings.
- 3 Renovate buildings to maximize the reduction in their emissions and improve climate adaptability.
- 4 Demonstrate technology and know-how frontiers on their own buildings and rented offices.
- 5 Move to holistic and system solutions to sustainable buildings.
- 6 Dedicate Research & Development to climate neutral, zero net buildings.
- 7 Educate the supply chain.

PRIORITY ACTIONS

Research & Educational Institutions

- 1 Renovate and build schools to reduce greenhouse emissions and foster long term responsible lifestyles.
- 2 Implement interdisciplinary curriculum and research on energy, greenhouse emissions and social performance.
- 3 Collaborate to provide a data repository and ongoing analysis of the climate impact of buildings.
- 4 Develop curriculum and tools for building energy efficiency and environmental responsibility.
- 5 Develop regional and sub-regional centers of excellence, focusing on buildings role in climate change mitigation & adaptation.

WORD**A FINAL**

No one group of stakeholders can do everything, but everyone can, and must, do something. Recognizing the different conditions, in terms of climate, culture, tradition, economic systems, availability of materials, and so on, which apply to the Building Sector in different countries, it is obvious that there can be no universal solution or recommendation that can be given for reducing greenhouse gas emissions from buildings. However, there has never been a time when interest in addressing the issue of emissions from buildings has been greater, and Decision Makers should draw on the good will, support and expertise of all stakeholders to implement their greenhouse gas emission reduction strategies.

Bibliography

Adalberth, K., Almgren, A. and Petersen, E. H. (2001) Life cycle assessment of four multi-family buildings, *International Journal of Low Energy and Sustainable Buildings*, Vol. 2. Royal Institute of Technology, Stockholm, Sweden. pp. 1-21.

Australian Greenhouse Office, 2005. *When you keep measuring it, you know even more about it. Projected impacts 2005 – 2020*. National appliances and equipment program. Report nb. 1920840 82 6.

Baden, S., P. Fairey, P. Waide, P. de T'sercaes and J. Laustsen, 2006. "Hurdling Financial Barriers to Low Energy Buildings: Experiences from the USA and Europe on Financial Incentives and Monetizing Building Energy Savings in Private Investment Decisions", Proceedings of 2006 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington DC.

Bertoldi, P. and S. Rezessy, 2006. *Tradable Certificates for Energy Savings (White Certificates)*. ISPRA: Joint Research Centre of the European Commission. Institute for Environment and Sustainability.

BMI- BRSCU (Building Research Strategy Consulting Unit) (PTY) Ltd., <http://www.bmi-brscu.co.za>

Brulez, D., and Rauch, R. 1998. Energy Conservation Legislation in Thailand: Concepts, Procedures and Challenges. In: *Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region*. UNESCAP.

Capozza, M., 2006. "Market mechanisms for white certificates trading". Task XIV final report. OECD/IEA, Paris.

Carbon Monitoring for Action (CARMA) website, <http://greencodeproject.org/en/carma-power-plant-emissions>

Carbon Trust 2005. *The UK Climate Change Programme: Potential Evolution for Business and the Public Sector*. Technical Report available online: www.carbontrust.co.uk.

CLASP (Collaborative Labelling and Appliances Standards Program), 2007. *Standards and Labelling Programs Worldwide*. [online]: www.clasponline.org.

Crossley, D., M. Maloney, and G. Watt, 2000. *Developing mechanisms for promoting demand-side management and energy efficiency in changing electricity businesses*. Hornsby Heights, Task VI of the IEA Demand-Side Management Program.

de Buen, Odon, 2009, "Regional Report on Greenhouse Gas Reduction Potentials from Buildings: Mexico", Study prepared for UNEP SBCL, *in-press*.

Deringer, J., Iyer, M. and Yu Joe Huang, Y. J. 2004. *Transferred Just on Paper? Why Doesn't the Reality of Transferring/Adapting Energy Efficiency Codes and Standards Come Close to the Potential?* Proc. 2000 ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA, August 2004.

Dias, R., C. Mattos and J. Balesieri, 2004. "Energy education: breaking up the rational energy use barriers", *Energy Policy*. 32 (11): 1339 – 1347.

ECOFYS, 2008. "REEEP Global Status Report on Energy Efficiency", December 2008. http://www.ecofys.com/com/publications/documents/Report_global_status_report_on_energy_efficiency_2008.pdf

- EFA (Energy Futures Australia), 2002. *Mechanisms for promoting societal demand management*. Sydney, Independent Pricing and Regulatory Tribunal (IPART) of New South Wales, research paper no. 19.
- ECS (Energy Charter Secretariat), 2002. *Fiscal policies for improving energy efficiency. Taxation, grants and subsidies*. Brussels: ECS.
- European Commission, 2008. "Proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings", 2008/0223 (COD), 13.11.2008, Brussels (<http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0780:FIN:EN:PDF>).
- European Commission, 2009. "Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.
- European Commission Intelligent Energy Europe website (accessed August 2009), http://ec.europa.eu/energy/intelligent/index_en.html.
- Evander, A., G. Sieböck, and L. Neij, 2004. "Diffusion and development of new energy technologies: lessons learned in view of renewable energy and energy efficiency end-use projects in developing countries", Lund: International Institute for Industrial Environmental Economics, report 2004:2.
- Eyre, N. 1998. A golden age or a false dawn? Energy efficiency in UK competitive energy markets. *Energy Policy* 26 (12): 963–972.
- Geissler, M., A. Waldmann, and R. Goldmann, 2006. "Market development for energy services in the European Union". In: *Proceedings of the 2006 ACEE Summer Study on Energy Efficiency in Buildings*. 14 – 18 August 2006. Asilomar, CA, U.S.A.
- Geller, H., P. Harrington, A. H. Rosenfeld, S. Tanishima and F. Unander, 2006. "Policies for increasing energy efficiencies. 30 years of experience in OECD countries". *Energy Policy*. 34 (5): 556-573.
- Gilligham, K., R. Newell, and K. Palmer, 2004. "The effectiveness and cost of energy efficiency programmes". *Resources*. Resources for the Future. Technical Paper.
- Graham, P. (2003) *Building Ecology: First Principles for a Sustainable Built Environment* Blackwell, Oxford, U.K.
- Harris, J., M. Brown, J. Deakin, S. Jurovics, K. Khan, E. Wisniewski, J. Mapp, B. Smith, M. Podeszwa, and A. Thomas, 2004. "Energy-efficiency Purchasing by State and Local Government: Triggering a Landslide down the Slippery Slope to Market Transformation". In *Proceedings of the 2004 ACEEE Summer Study*. Asilomar, CA, U.S.A.
- Hein Nybroe, M., 2001. "DSM in Denmark after liberalization". In: *Proceedings of the ECEEE Summer Study 2001*. Stockholm: ECEEE. Paris: ADEME Editions.
- Hinostroza, M., Cheng, C., Zhu, X., Figueres, C., & Avendano, F., 2007. *Potentials and Barriers for End-use Energy Efficiency under Programmatic CDM*, UNEP Risø Centre.
- Huang, J., 2007. "Energy efficiency building standards in China". Report for APEC.

- IEA (International Energy Agency), 2002. *World Energy Outlook 2002*.
- , 2003. *Cool appliances report*. Policy strategies for energy efficient homes.
- , 2005. Key world energy statistics.
- , 2006. "Fact Sheet: Buildings and Appliances", Energy Technology Perspectives: Scenarios & Strategies to 2050, Paris, France.
- IPCC (Intergovernmental Panel on Climate Change), 2007. *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Metz, B., O.R. Davidson, P.R. Bosch, R. Dve, L.A. Myer (eds)], Cambridge, U.K. and New York, NY, U.S.A., Cambridge University Press, 2007.
- IPCC, 2007a: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.
- Jeeninga, H., and M.A. Uyterlinde, 2000. "The sky is the limit! Or why can more efficient appliances not decrease the electricity consumption of Dutch households. In *Energy Efficiency in Household Appliances and Lighting*, Eds. P. Bertoldi, A. Ricci, A. Almeida. Heidelberg: Springer.
- Junnila Seppo. 2004. An Environmental Impact of an Office Building throughout its Life Cycle. Espoo, Helsinki University of Technology Construction Economics and Management (Doctoral Dissertation).
- Kristensen, P.E., 2007. UNEP-SBCI Workshop, 1-3 November 2007, Kuala Lumpur, Malaysia.
- Kushler, M., D. Work and P. Witte, 2004. "Five years in: an examination of the first half decade of public benefits energy efficiency policy". American Council for an Energy Efficient Economy. Report U041.
- Lawrence Berkeley National Laboratories LBL, (2007): *Energy use in China, sectoral trends and future outlook. in Energy Efficiency in Buildings – Transforming the Market*. World Business Council for Sustainable Development, Geneva.
- Levine, M., Urge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., Land, S., Levermore, G., Mongameli Mehlwana, A., Mirasgedis, S., Novikova, A., Rilling, J., Yoshino, H., 2007, Residential and commercial buildings, Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, U.K. & New York, NY, U.S.A.
- Lin, J. 2002. Made for China: Energy Efficiency Standards and Labels for Household Appliances. *Sinosphere*, Nov. 2002.
- Milford, R, 2009, South African Report on Greenhouse Gas Emission Reduction Potentials from Buildings, Study prepared for UNEP SBCI, in-press.
- MITEC (Ministry of Industry, Technology, Energy and Commerce, Government of Jamaica), 2007. Energy Division Website: www.mct.gov.jm/new_energy_division_1.htm (accessed 01/06/2009).

nef (new economics foundation), 2008. *A Green New Deal - Joined-up policies to solve the triple crunch of the credit crisis, climate change and high oil prices*. nef: London.

Palmer, K. 1999. Electricity Restructuring: Shortcut or Detour on the Road to Achieving Greenhouse Gas Reductions? *Resources for the Future Climate Issue Brief 18*.

Passive House Institute. [online]: <http://www.passivehouse.com>

Pew Charitable Trusts, 2009. "The Clean Energy Economy: Repowering Jobs, Businesses and Investments across America". [online]: http://www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf.

REN (Renewable Energy Policy Network for the 21st Century), 2009. *Renewables Global Status Report, 2009 Update*.

Ries, C. P., J. Jenkins, and O. Wise, 2009. "Improving the Energy Performance of Buildings: Learning from the European Union and Australia", Technical Report, Rand Corporation.

Sanchez, A.B. and P. Poschen, 2009. "The social and decent work dimensions of a new Agreement on Climate Change", ILO Technical Brief, Geneva, Switzerland.

SBSTA (Subsidiary Body for Scientific and Technological Advice to the United Nations Framework Convention on Climate Change), 2006. *Synthesis report on technology needs identified by Parties not included in Annex I to the Convention, FCCC/SBSTA/2006/INF.1*. New York: United Nations.

Schlomaan, B., W. Eichhammer, and E. Gruber, 2001. "Labelling of electrical appliances – An evaluation of the Energy Labelling Ordinance

in Germany and resulting recommendations for energy efficiency policy. In *Proceedings of the European Council for an Energy Efficiency Economy (ECEEE) Summer Study 2001*.

Statistics South Africa (StatsSA), 2008. *General Household Survey 2007*, online: <http://www.statssa.gov.za/publications/statsdownload.asp?PPN=P0318&SCH=4187>

Suzuki, M. and Oka, T. (1998) Estimation of life cycle energy consumption and CO2 emission of office buildings in Japan, *Journal of Energy and Buildings*, Vol 28 pp. 33-41.

Tonooka, Y., Hailin Mu, Yadong Ning, Yasuhiko Kondo, 2003. "Energy Consumption in Residential House and Emissions Inventory of GHGs, Air Pollutants in China". *Journal of Asian Architecture and Building Engineering*. May 2003, issue 100.

Torcellini, P., S. Pless, M. Deru, B. Griffith, N. Long, and R. Judkoff, 2006. "Lessons learned from Case Studies of Six High-Performance Buildings", National Renewable Energy Laboratory Technical Report, NREL/TP-550-37542, June 2006.

UK Department for Communities and Local Government, 2008. "Definition of Zero Carbon Homes and Non-Domestic Buildings", Consultation document, London.

UK Department for Communities and Local Government, 2008a. Department for Communities and Local Government (U.K.), 2008. "Improving the Energy Efficiency of Buildings – A Guide to Display Energy Certificates and advisory reports for public buildings London. <http://www.diag.org.uk/media/44188/display%20energy%20certificates%20and%20advisory%20reports%20guide.pdf>

UNDESA (United Nations Department of Economic and Social Affairs), 2008. *Climate Change: Technology Development and Technology Transfer*, Background document prepared for the Beijing High-level Conference on Climate Change: Technology Development and Technology Transfer, Beijing, China, 7-8 November 2008.

UNEP (United Nations Environment Programme), 2007. *Buildings and Climate Change: Status, Challenges and Opportunities*, lead authors P. Huovila, M. Ala-Juusela, L. Melchert, and S. Pouffary, 2007, UNEP Sustainable Buildings and Climate Initiative, Paris.

-----, 2007a. *Assessment of Policy Instruments for Reducing Greenhouse Gas Emissions from Buildings*, lead authors D. Urge-Vorsatz, and S. Koepfel. UNEP, Paris, France.

-----, 2008. *The Kyoto Protocol, The Clean Development Mechanism and the Building and Construction Sector – A Report for the UNEP Sustainable Buildings and Construction Initiative*, lead authors C. Cheng, Pouffary, S., Svenningsen, N., Callaway, M. UNEP, Paris, France.

-----, 2008a. *Green Jobs: Towards decent work in a sustainable low-carbon world*.

-----, 2008b. *UNEP SBCI Members' and Partners' Update*, May 2008

Urge-Vorsatz, D., S. Köppel, C. Liang, B. Kiss, G. G. Nair, and G. Celikylmaz, 2007. "An Assessment of Energy Service Companies Worldwide". [online]: http://www.worldenergy.org/documents/esco_synthesis.pdf

US DOE (Department of Energy), 2006. *Fact Sheet: Federal Energy Management Program*.

Van Wie Mc Grory, L. Harris, J., Breceda Lapeyre, M., Campbell, S., Constantine, S., della Cava, M., Martinez, J. G., Meyer, S., Romo, A. M. 2002. *Market Leadership by Example: Government Sector Energy Efficiency in Developing Countries*. Proceedings of the 2002 ACEEE Summer Study. Asilomar, CA. Report LBNL-5098.

Vine, E. 2005. An international survey of the energy service company (ESCO) industry. *Energy Policy*, 33(5): 691-704.

WBCSD (World Business Council for Sustainable Development), 2007. *Energy Efficiency in Buildings: Business Realities and Opportunities*, Switzerland.

-----, 2009. *Energy Efficiency in Buildings – Transforming the Market*, Switzerland (accessed through <http://www.wbcSD.org>)

WEC (World Energy Council), 2004. *Energy Efficiency: A Worldwide Review*. London.

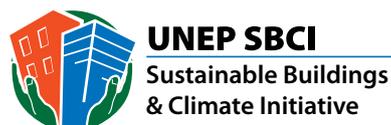
WEC (World Energy Council), 2008. *Energy Efficiency Policies around the World: Review and Evaluation*. London.

Westling, H. 2003. *Performance Contracting*. Summary Report from the IEA DSM Task X within the IEA DSM Implementing Agreement. International Energy Agency, Paris.

Yao, R., Li, B., and Streemers, K. 2005. Energy policy and standard for built environment in China. *Renewable Energy* 30: 1973-1988.

About the Sustainable Buildings and Climate Initiative

Launched in 2006 by the United Nations Environment Program (UNEP), the Sustainable Buildings and Climate Initiative (SBCI), formerly the Sustainable Buildings and Construction Initiative, is a partnership between the private sector, government, non-government and research organizations formed to promote sustainable building and construction globally.



SBCI harnesses UNEP's unique capacity to provide a convening and 'harmonizing' role to present a common voice from the building sector on climate change issues. More specifically UNEP-SBCI aims to:

1. Provide a common platform for and with all building and construction stakeholders to collectively address sustainability issues such as climate change;
2. Establish globally consistent climate-related building performance baselines and metrics for monitoring and reporting practices based on a life cycle approach;
3. Develop tools and strategies for achieving a wide acceptance and adoption of sustainable building practices throughout the world;
4. Implementation - Promote adoption of the above tools & strategies by key stakeholders.

For more information,
see www.unepsbci.org

About Sustainable United Nations (SUN)

Sustainable United Nations (SUN), is a UNEP initiative that provides support to UN and other organisations to reduce their greenhouse gas emissions and improve their sustainability overall. SUN was established in response to the call from UN Secretary General Ban Ki-Moon at the World Environment Day 2007 (5 June), to all UN agencies, funds and programmes to reduce their carbon footprints and “go green”. This call was echoed in October 2007 in a decision of the UN Chief Executives Board (CEB/2007/2, annex II) to adopt the UN Climate Neutral Strategy, which commits all UN organisations to move towards climate neutrality. SUN is in this context working with the UN Environment Management Group – the UN body coordinating common environmental work within UN – to provide guidance, and develop tools and models for emission reduction within organisations.



SUN is using a “whole-organisation” approach in identification of sources and causes for emissions and opportunities for reduced emissions and improved sustainability. In this way opportunities for improvements are typically found within one of the three major focus areas for SUN:

1. Physical assets: building, equipment, vehicles...
2. Management processes: procurement, travel, management systems...
3. Organisational Culture: day-to-day office behaviour, “corporate” culture, green meetings...

SUN operates in synergy with existing initiatives and networks such as the Sustainable Buildings and Construction Initiative, the High Level Committee on Management Procurement Network, the UN Global compact, or the Marrakech Task Force on Sustainable Public Procurement and many others.

For more information, see
www.unep.fr/scp/sun

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

- > sustainable consumption and production,
- > the efficient use of renewable energy,
- > adequate management of chemicals,
- > the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

- > **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disaster management programmes, focusing in particular on Asia.
- > **Sustainable Consumption and Production** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
- > **Chemicals** (Geneva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
- > **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
- > **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
- > **Economics and Trade** (Geneva), which helps countries to integrate environmental considerations into economic and trade policies, and works with the finance sector to incorporate sustainable development policies.

*UNEP DTIE activities focus on raising awareness,
improving the transfer of knowledge and information,
fostering technological cooperation and partnerships, and
implementing international conventions and agreements.*

For more information,
see www.unep.fr

It is estimated that at present, buildings contribute as much as one third of total global greenhouse gas emissions, primarily through the use of fossil fuels during their operational phase. Past efforts to address these emissions have had a mixed record of success, although there are many examples which show that carefully considered and properly funded policies can achieve significant reductions.

This “Summary for Decision-Makers” presents the current state of thinking on how the potential for greenhouse gas emission reductions in buildings can be realized. It has been compiled by the Sustainable Building and Climate Initiative (SBCI), a UNEP-hosted partnership between the UN and public and private stakeholders in the Building Sector, which promotes sustainable building practices globally.

One of UNEP-SBCI’s key objectives is to ensure that Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have the information needed to support the mitigation of building-related greenhouse gas emissions. Decision-Makers have to tackle emissions from the Building Sector with much greater seriousness and vigor than they have to date. This “Summary for Decision Makers” provides significant support to achieve a post-Kyoto agreement which takes full advantage of the potential for energy savings in buildings.

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ISBN: 978-92-807-0000-0
DTI/0000/PA